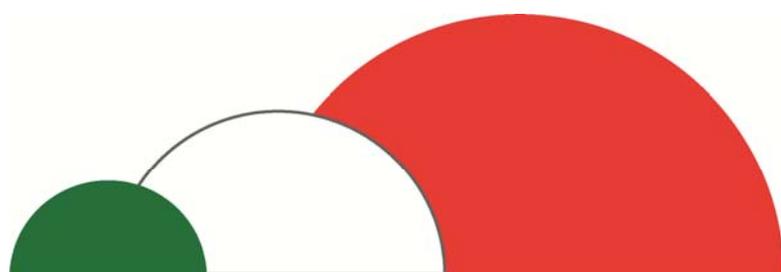


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Volume 4, 2011



Geoitalia 2011

**VIII Forum Italiano di Scienze della Terra
Torino, 19-23 settembre 2011**



**REGIONE
PIEMONTE**



**MUSEO REGIONALE
DI SCIENZE NATURALI**

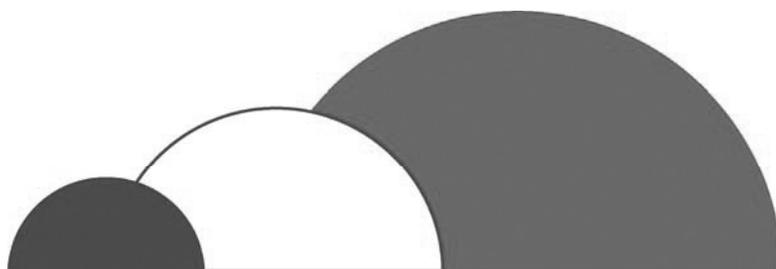
Geoitalia

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Scienze della Terra, Onlus

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Il Museo Regionale di Scienze Naturali di Torino

Le collezioni mineralogiche, geologiche e paleontologiche oggi conservate al Museo Regionale di Scienze Naturali di Torino sono costituite essenzialmente dalle raccolte storiche dei Musei universitari di Mineralogia e Petrografia e di Geologia e Paleontologia, con cospicue integrazioni, a partire dal 1980, con materiali acquisiti direttamente dalla Regione Piemonte.

Le raccolte traggono le loro origini da alcuni nuclei di oggetti raccolti, nella prima metà del XVIII secolo, intorno al primo Museo dell'Università e da allora, attraverso continue aggiunte, donazioni, lasciti, acquisti, raccolte, si è giunti, nei primi anni del XX secolo, a costituire uno dei Musei naturalistici più prestigiosi d'Italia e d'Europa.

Dopo le distruzioni legate alle vicende belliche e il blocco nello sviluppo delle collezioni e delle esposizioni a causa dei nuovi orientamenti della Scienza (eventi comuni alla maggior parte dei Musei italiani), nel 1980, in un periodo di grande risveglio d'interesse per le istituzioni scientifiche e culturali, anche in senso storico, la Regione Piemonte istituì il Museo Regionale di Scienze Naturali di Torino con il compito di proseguire la *mission* degli ottocenteschi Musei universitari nelle attività di conservazione, incremento e divulgazione scientifica delle raccolte. Un compito che il personale del MRSN in trent'anni ha svolto con impegno, riordinando e recuperando per la scienza centinaia di migliaia di minerali, fossili, rocce, ma anche reperti zoologici, erpetologici e malacologici, incrementando le raccolte con nuove acquisizioni che, in molti casi, hanno quantitativamente e qualitativamente superato le collezioni storiche, ed infine contribuendo alla conoscenza delle raccolte e allo sviluppo delle scienze attraverso varie centinaia di saggi scientifici, centinaia di monografie, di cataloghi ragionati e di guide naturalistiche, varie decine di mostre scientifiche temporanee, spesso integrate da filmati e da cataloghi documentari, ecc.

Un lavoro immane di divulgazione scientifica che si è mosso di pari passo con l'allestimento delle esposizioni definitive, a loro volta sottomesse al restauro dell'edificio che ospita il Museo. In questa luce il MRSN ha sempre appoggiato e supportato le attività culturali effettuate sul territorio piemontese attinenti ai propri scopi istitutivi, quale è, in questa occasione, il Congresso GEOITALIA 2011, un'importante occasione di incontro e approfondimento tra operatori di Scienze della Terra provenienti da tutto il mondo.

Ermanno DE BIAGGI
Direttore

Lorenzo Mariano GALLO
Conservatore di Mineralogia

WORKSHOP W4

Tecniche di fotogrammetria digitale e laser scanning per lo studio della stabilità dei versanti in roccia

W4-1 Orale Roskopf, Carmen Maria

10.1474/Epitome.04.0001.Geoitalia2011

ASSESSING RECENT LANDSCAPE EVOLUTION BY USING DIGITAL PHOTOGRAMMETRY: A CASE STUDY FROM THE UPPER VAL D'ORCIA (TUSCANY, ITALY)

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Key terms: Denudation processes; Badland evolution; Digital photogrammetry; GIS; Tuscany

Soil loss due to water erosion and mass wasting is a serious environmental problem in Italy, where many areas are widely affected by accelerated erosion, promoted by the peculiar geological setting, land use and climatic features. Hence, it is important mapping and evaluate the space-time development of denudational processes. Digital photogrammetric techniques represent a powerful tool for the assessment of landscape evolution and related erosion rates.

This work presents a digital photogrammetric analysis performed in a test area of central Italy, a small catchment of ca. 4.4 km² located within the Upper Orcia River Valley (Tuscany). Here accelerated slope dynamics related to concentrated surface runoff heavily affects the dominant clayey substratum. As a result, typical badland landforms, well-known as "calanchi" and "biancane", occur, often coupled with gravity induced slope movements consisting of soil creep, solifluction and various types of landslides.

A digital photogrammetric analysis of morphologic changes due to erosion processes was performed on three series of black and white aerial photographs dating to 1954 (1:36 000 scale), 1976 (1:13 000 scale) and 2003 (1:33 000), respectively. These photographs were elaborated by using a digital photogrammetric workstation and a specific software (Z-map) which provided for the generation of digital stereo models, image exploration and interpretation tools and supported the generation of digital elevation models, digital orthophotographs and vector databases. The creation of stereo models, based on aerial triangulation, was carried out following the usual steps of interior and exterior orientation. The interior orientation of the aerial photographs was accomplished through the input manual of the fiducial marks data. To increase relative stability of the non-metric image blocks, on 30 tie points? per stereo pair were computed through semi-automatic operation, which significantly improved aerial triangulation results. The exterior orientation was based on 9 ground control points (GCPs) for each stereo pair, selected within and around the test area by using a Differential Global Position System (DGPS). The main targets used for GCPs refer to stable points such as building corners that could be univocally identified in the aerial photographs. The root-mean-square-error of the selected GCPs ranged from a few to several centimeters for the considered block images. For the 1976 and 2003 aerial photographs, triangulation (x, y, z) adjustments to the ground control points were smaller than 50 cm, more than 150 cm, instead, for the 1954 aerial photographs.

After the creation of the stereo model, digital orthophotographs with a resolution of 1 m were produced for each set of stereo pairs (1954, 1976 and 2003). These orthophotographs were then used to map terrain features and to measure their planimetric evolution. Data analysis and data management were performed within a Geographic Information System (GIS).

Photo interpretation, carried out for each set of aerial photos, allowed to map the land use and the main denudation processes that affected the landscape respectively in 1954, 1976 and 2003. To evidence morphological changes, topographic features such as calanchi headwater retreat and sidewall failures were quantified based on the comparison of their plano altimetric shape.

Comparing the denudation process maps obtained for various periods, important morphological changes occurred from 1954 to 2003 could be ascertained. The areas affected by badlands, as expected, highlighted the most severe landform modifications. In particular, a maximum headwater retreat reaching up to 10-15 cm yr⁻¹ was recorded. The proposed method can be considered very useful to better define denudation landforms and associated processes and to assess related erosion rates.

WORKSHOP W9

Rischi geologici e salvaguardia del patrimonio culturale

W9-2 Orale Brandolini, Pierluigi

10.1474/Epitome.04.0002.Geoitalia2011

GEOMORPHOLOGICAL RISK AND CULTURAL HERITAGE: THE CASE OF THE ROMAN BRIDGE IN PONCI VALLEY (WESTERN LIGURIA)

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Key terms: geomorphological risk; flash flood; sinkhole; Finalese karstic area; Roman bridge

This study presents the geological and geomorphological outlines and the related hazard phenomena of Ponci Valley - which is located in hinterland of Finale ligure (Italy). The relationship with the presence of an important archaeological site of Roman age are analysed in order to define its state of vulnerability.

This site shows the remains of Via Julia Augusta, an internal alternative to the Via Aurelia, built along this valley 2000 years ago. The road is crossed by five bridges, at between 150 m and 300 m of altitude, run along almost the entire axis of the Ponci Valley. These constitute the most important and monumental evidence of the Roman communication routes in Liguria. These bridges involve the Ponci Stream and, in one case, the Landrazza Stream, its left bank tributary. These are all single arch bridges: three arches are still perfectly preserved and some vestiges of the abutments and ramps are visible from two others. Since the Pietra di Finale auct. is largely found in this area, this rock is mostly used for building structures, whereas dolomitic limestones, quartzites and other schists rock masses are secondarily used.

The area - which is mainly composed of bioclastic limestones and secondarily of underlying dolomite limestones - is included in the more extensive Finalese karstic area. The lithological features, geomorphological evolution and morpho-structural relationships between the outcropping lithotypes - through a great rainfall infiltration and an underground water flow - caused the formation of karstic surface and hypogean phenomena. Its geomorphological features are well-known being characterized by a series of plateau and ridge zones with a number of peaks at limited altitudes, however mainly representing rocky towers isolated by deep canyons. This area includes several karstic springs and is crossed by a few water courses, some of which flow underground; terraces landforms, flood plains and karstic depressions, swallow-holes and caves are found here. The study highlights the geological, environmental and cultural value of this site, that can be acknowledged as a geosite of Mediterranean importance, with respect to geomorphological risk scenarios. A strongly hazard reduction measurements in needed, in particular related to flash flood and sinkhole events that could involve the Roman bridges remains.

W9-3 Orale Colalto, Alessia

10.1474/Epitome.04.0003.Geoitalia2011

HISTORICAL POLYPHASED LANDSLIDES IN THE LOWER SARCA VALLEY (TN, ITALY). NEW STUDIES.

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Key terms: Marocche; Sarca; Roman relics; Neolithic remnants

Large landslides (up to 1000 x 106 m³ and 13 km²) occur in the lower Sarca glacial valley between the village of Sarche (altitude 249 m) to the North and the village of Dro (altitude 124 m) to the South, over 8 km in length in SW Trentino. This site is known as "Marocche" for the presence of several megaboulders of limestones and of the small lakes Cavedine and Solo, biotopes for pioneer plants as Phragmitetum Australis e Cladietum Marisci.

The landslide deposits, derived in order from Monte Casale (1634 m), Cima Granzoline (1549 m) and Monte Brento (1544 m), on the western side of the valley are cut across by the Sarca River.

This area was mapped by Trener in 1924, who distinguished 3 principal landslides and other 9 smaller, during the geological works for the construction of two galleries from the Cavedine dammed lake to the hydroelectric power of Fies. Some Roman relics ("frammenti di tegolo" sensu Trener 1924) were found during the excavation across the KAS landslide deposit at the progressive 92-101 from the northern entrance of one gallery. On the base of these findings Trener suggested a post roman age for the KAS landslide fallen from the Monte Brento eastern wall.

In the recent years Perna (1974; 1996; 1997) tried to date the "Marocche" landslide deposits using paleo-karst as rillen Karren (up to few cm), rinnen Karren (up to 10 cm in depth) and kamenitza, suggesting a post-Last Glacial Maximum age for the landslides.

Recently this area has been mapped by Bassetti (1997) who has distinguished only 6 different landslides. Behind this he has found neolithic (Bronze age, XII-IX b.C.) remnants at the top of Sant'Abbondio deposit, interpreted by the author as the oldest deposit of the lower Sarca Valley, confirming the possible historical time of the landslide events.

New structural and geomorphological maps are in preparation to improve the knowledge of deposit stratigraphy and of the tectonics.

Furthermore, new 36Cl exposure datings of carbonatic megaboulders (Dolomia Principale, Calcarei Grigi Formation, Scaglia Rossa) of different deposits are in progress.

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W9-4 Orale Colalto, Alessia

10.1474/Epitome.04.0004.Geoitalia2011

THE CASTEL PIETRA LANDSLIDE. IS THIS THE LANDSLIDE EVENT MENTIONED BY DANTE ALIGHIERI IN THE DIVINA COMMEDIA (INFERNO, XII, 4-9)?

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Key terms: Castel Pietra; Finonchio; Cengio Rosso; S. Cecilia

The Castel Pietra landslide deposit is located between Trento and Rovereto, near Calliano village on the left side of the Adige River, between 400 and 200 m a.s.l.. The niche of detachment, at about 600 m a.s.l., is located on the western side of the Finonchio peak (1608 m a.s.l.), between Mount Padella (962 m a.s.l.) and Mount Coston (1200 m a.s.l.),

in the district of Vallagarina. The landslide occurs at the foot of the Cengio Rosso wall (900 m), near the hill of Castel Beseno. This body corresponds to that landslide mentioned by Dante Alighieri in the Divina Commedia. The landslide seems derived from a unique event, however a new mapping suggests the possible existence of previous deposits in the northern portion because of a very thick vegetation cover. The landslide is composed by mega-boulders of Dolomia Principale covered by abundant woods and vegetation.

The first Castel Pietra Castle was built on the XII century over a mega-boulder, afterwards it was implemented during the XIII and partly rebuilt during the XIV century. In front of its walls was fought the famous battle of Calliano in 1487, then in 1796 the castle itself and the Austrian troops faced the Napoleonic ones.

At about 750 m a.s.l. in the rocks below Cengio Rosso, in 1611 was built the Hermitage of S. Cecilia, where, according to the literature, people do a pilgrimage on the 5th of August. The date corresponds to that of the famous votive offering made by Rovereto inhabitants to Mary Help of Christians for saving them from the invasion of French devastating troops under General Vendôme in 1796. Other sources report, however, that this pilgrimage has nothing to do with the invasion, but that relates to the Summer drought.

The Cengio Rosso wall is characterized by the presence of a sub-horizontal discontinuity at about 500 m a.s.l. and by a sub-vertical N-trending discontinuity, as shown in the Schio 1:100.000 geological map, which facilitated the landslides.

At present the landslide deposit and the Cengio Rosso wall show new falls, since we can distinguish the new whitish dolomitic boulders from the oldest grey-coloured ones, and we can recognize their detachment area. New exposure data of the mega-boulders are in preparation to check the time of the older landslide events.

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W9-5 Orale Del Lungo, Stefano

10.1474/Epitome.04.0005.Geoitalia2011

RECKLESS FOUNDATIONS, NATURAL DISASTERS OR DIVINE PUNISHMENT IN THE ITALIAN CULTURE IN THE 14TH CENTURY (THE STORM OR TSUNAMI OF AMALFI IN 1343). [FONDAZIONI INCAUTE, DISASTRI NATURALI O PUNIZIONE DIVINA NELLA CULTURA ITALIANA DEL XIV SECOLO (LA TEMPESTA O IL MAREMOTO DI AMALFI NEL 1343).]

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Key terms: reckless foundations; natural disasters; divine punishment; 14th century; Amalfi

It is now evident what value could have a correct historical and topographical reconstruction of events in a real place and the solutions done by its inhabitants. This is very important to understand and define which type of disaster and damage degree has been or will be there. The Italian cultural heritage is directly involved every time a disaster happens like eruptions, earthquakes, landslides, floods, collapses. If there isn't a sure knowledge of its entities, that it has understood only during a crisis, it's possible to do some questions: if the event has caused so much damage to the monuments and to the whole of the city that contains them, is this the first time that it occurs or it's also happened in the past? If so, why it has been so far ignored? And, as a last resort, is it possible that in the past it has been so careless to choose a place then revealed dangerous or unstable?

An unpredictability event is represented by Monte Nuovo volcano (Phlegrean fields), which in 1538 borns and erases the town of Tripergole, although founded in a dangerous area. Human errors, on the other hand, could be summarized by the case of the Leaning Tower (Pisa), where a structure has been projected too heavy, in spite of the knowledge of the place and the ability to assess, however, the strength and with the consequences that everybody can see since today. Recent experience has also revealed critical condition of an hypothetical reckless, or else wrong, foundation: L'Aquila (in 1254) and the seismic activity between 1315 and 1462. A prior example was in Umbria: Carsulæ, in spite of the toponym should make clear the awareness for the dangers that could be hiding in the subsoil (and now Ischia, with 2,400 years from a violent tsunami). Amalfi has even a name whose etymology gets to a large and dangerous geographical area, where the rural heritage remembers us about disasters in pre- or proto-historical times, by its special and ancient vocabulary (from Melfa in Molfetta and the Vulture) that other following cultures have tried to fix in the landscape memory, to avoid, and therefore to consecrate, some harmful places (around the valley of the Ampsanto, for example).

In the 14th century ancient beliefs and superstitions resurge with arrogance in Italy, but not only, to focus on miraculous events already known by St. Francis (and his meeting with the wolf of Gubbio). It is a going back of the divine punishment idea whenever there is a phenomenon so big to go beyond the human understanding. But we know what it means when "the reason sleeping produces monsters". Think, for example, to the conflict between certain statements about the 2011 earthquake in Japan and the wisdom of the past, that had set the 'Stones of the Tsunami' (Aneyoshi, prefecture of Iwate). History, therefore expressed by written and oral sources (legends, traditions, rites and rituals), monuments and place names, which we must be able to find, read, understand and interpret, can serve to not remake the mistakes of the past. Focusing on the 14th century, it could be useful to proceed with an overview of the phenomena in chronicles and annals, going up the way followed in the medieval imagination (then the snake in Abruzzo and the places of dragon, trying to understand geological phenomena on the surface).

Fear and wonder are in the written sources, compared to a curious absence of any reference about practical works on coeval Statutes (L'Aquila, Amalfi), against the disasters that marked the local urban history. In Amalfi a terrible and however destructive phenomenon like a storm is magnified in the following centuries by the impression and economic interests more or less connected. Then it has been transformed into a tsunami, concluding his history as 'false event' in the Italian Tsunami Catalog now available online.

W9-6 Orale Delle Rose, Marco

10.1474/Epitome.04.0006.Geoitalia2011

THE VAJONT DAM DISASTER AS A PARADIGM OF A BUILDING NATIONAL IDENTITY

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Key terms: hydrogeological catastrophe; post-disaster policy; uncertainty

The Vajont dam disaster is a world-known case of man-made hydrogeological catastrophe. On 9 October 1963, an about 2 kmq rock mass, detached from a side of the Mount Toc (placed between Veneto and Friuli regions, Italy), sliding into an artificial dam lake. It moved laterally some 360 m, and 140 m upward on the opposite valley flank. The great part of the landslide moved as a whole, propagating water waves which eroded soils of Vajont valley up to 235 m above the reservoir level. The adjoining villages of Erto and Casso had been "touched lightly" by waves. Toward Pieve valley, water swept across the dam and down the Vajont Gorge, reaching an estimated wave height of 80 m. Inside the gorge, the water mass provoked air compression that, in turn, was energetically pushed out of the gorge mouth. The airflow energy has been evaluated to be about twice than that occurring at Hiroshima with the explosion of the atomic bomb. Then, the water wave reached the Pieve valley. Longarone and other villages (Pirago, Villanova, Rivalta, Faè) were destroyed and almost 2000 persons died and many others were injured. Notwithstanding the impressive development of energy, the Vajont dam remained undamaged. Two opposing interpretations have been proposed in literature: the disaster was completely foreseeable (see for instance: Roubault, Peut-on prévoir les catastrophes naturelles?, 1970) or, vice-versa, nobody would have been able to predict it (Selli and Trevisan, Caratteri e interpretazione della frana del Vajont, 1964; Semenza, Sintesi degli studi geologici sulla frana del Vajont dal 1959 al 1964, 1965).

According to current concepts of environmental policy and epistemology of geology, a review of both the decision making process which led to the disaster and the consequent post-disaster policy, are proposed. It can be argued that uncertainty about: (i) the depth of the slip surface (i.e. the volume of the landslide), (ii) the compactness of the slide (that involved a presumed division into two parts of the mass movement) and (iii) the low shear strength of the beds at the slip surface (and so a rate of the sliding higher than the predicted one), had been reduced at a time consistent with a change of management strategy oriented toward the safety people. The scientific debates which followed the disaster had influenced by State's interest, reaching a level of a true ideological conflict which reflected exasperated tensions growing inside the Society. The cultural context was that of a post-agricultural society commit oneself to build a new national identity. An identity of a rising industrial power. The post-disaster policy had biased data interpretation, data production, memory and scientific communication of experts and researchers. Dealing with the drawing of guidelines about environmental policy and hazards managements, can be useful to try to understand the reasons of such errors. A number of general features must be considered and, among these: the hydraulic paradigm and the idea of dominion of the nature, the hegemony of the ruling bloc and the making of a social justice concept, the historical conjuncture and the political practices. In 1976 Erto was denoted as "national monument" by virtue of its architectonic value. Nevertheless, the Vajont dam and its surrounding landscape, including the homonym gorge and the destroyed villages, currently represent, as a whole, the "intangible expressions" (cf. Vecco et al., A definition of cultural heritage: from the tangible to the intangible, 2010) of the human action which led to the disaster. They have acquired a preeminent socio-political value and, as a consequence, need to be known and protected. Moreover, the management of the interactions systems of Landscapes, Heritage and Culture (cf. e.g. Mascari et al., Landscapes, Heritage and Culture, 2009) must to be improved.

W9-7 Orale Delli Santi, Maurizio

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A GEOGRAPHICAL INFORMATION SYSTEM FOR THE SAFEGUARD OF THE ARCHITECTONIC AND ARCHAEOLOGICAL HERITAGE IN VAL D'AGRI (BASILICATA).

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Key terms: GIS; Cultural Heritage; Basilicata

The recovery and the electronic fruition of documentary material in architectonic heritage, the development of digital technology methodologies for cultural heritage and the use of new technological and informative systems are more and more diffused. The potential of these technologies for the planning and the subsequent management of information in cultural heritage fields is various and, above all, the digitalization of data is considered now an essential part in a course to heritage valorization. Particularly, among the new applied technologies the Geographical Information Systems, that come up as instruments for the control of territory and are so flexible that they can be applied in different research areas, are more and more frequent.

This work is part of a research project called "The safeguard of the territory and the conservation of cultural heritage in Basilicata in relation to landscape evolution and geo-morphological risk factors", that IBAM-CNR is carrying out in Val d'Agri.

Nineteen centers in the valley have been chosen to analyze and to catalogue their whole cultural heritage, that will be after implemented in a geodatabase, which is expressly structured following tab "A" criteria of ICCD. New fields to evaluate the seismic hazard for architectonic heritage have been added to this tab, specifically in reference to the damages of monuments during the Irpinia earthquake in 1980. Then the complete research will be available on a WEB-GIS portal of the IBAM-CNR. The final aim of the project is the definition of a "Risk Map" of the architectonic and archaeological heritage in Basilicata, as fundamental base for the planning of safeguard and conservation interventions for cultural heritage that is subjected to natural risks.

W9-8 Orale Galadini, Fabrizio

10.1474/Epitome.04.0008.Geoitalia2011

NATURAL RISKS AND ARCHAEOLOGICAL SITES IN THE ABRUZZI APENNINES (CENTRAL ITALY)

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Key terms: natural risks; archaeological stratigraphy; geomorphological analyses; central Apennines

The regulatory framework and the documents produced by different institutions and associations (es. Icomos, Mibac, ARCO) related to the preservation of the cultural heritage stress in different ways ii) the need for precautionary measures and ii) the key-role of an appropriate historical knowledge of the various events (natural or anthropic) which affected the heritage. In practical terms, i) the actions for preservation cannot be performed without an estimation of the risks related to the natural environment and ii) the risk has to be assessed by defining the natural events which interfered with the site of interest. This means, for example, that a typical aspect of the utilization of the cultural heritage - the creation of in situ museums - has to be faced also in terms of feasibility within the framework of the natural/environmental dynamics. Referring to the above mentioned issues, the present note will describe some cases of archaeological sites in the Abruzzi Apennines, characterised by natural criticality evident in the archaeological stratigraphy and detectable in the local geomorphological framework. These aspects represent potential elements of territorial weakness and evident problems for the actions related to the preservation of the archaeological sites. Having this perspective, we will analyse the effects of i) an ancient earthquake at the archaeological site of Alba Fucens; ii) the toppling of limestone blocks at Luco dei Marsi (Angitia); iii) the colluvial and alluvial events at Alba Fucens, San Benedetto dei Marsi and Castel di Ieri. The characterization of these events produces information necessary to the action plan for the defense against natural catastrophes at those sites which are being transformed for cultural and tourist purposes or which are used in this perspective since several decades.

W9-9 Orale Gizzi, Fabrizio Terenzio

10.1474/Epitome.04.0009.Geoitalia2011

SAFEGUARDING THE HISTORICAL CENTRES EXPOSED TO HIGH SEISMIC HAZARD: CLUES FROM STRONG EARTHQUAKES OF THE PAST

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Key terms: cultural heritage; seismic risk; historical earthquake; written source

The analysis of the effects of recent earthquakes (es.: 1980 Italy, 1985 Mexico, 1994 Northridge) shows that the building damage can change strongly within short distances.

Scientific investigations have demonstrated that these effects are the consequence of the geological-geomorphological properties of the soil, that can cause seismic amplification phenomena, and/or of the vulnerability of the shaken buildings.

Even if the theoretical basis useful to explain these phenomena are quite recent, an overview of the sources regarding the main historical seismic events reveals that the influence of the territorial features on damage was known at least from the XVIII century (e.g.: Lallement (1785), Pilla (1846), Baratta (1910)). These works, that can be considered as a sort of rudimentary study of microzonation, indirectly raise the need of an a-priori approach in the evaluation of the seismic effects.

To identify in advance the areas where an increase of damage can be expected is the essence of the modern studies aimed to mitigate the seismic risk. This approach is crucial especially for Italian historical towns that are exposed to high seismic hazard and contain an invaluable and highly vulnerable cultural heritage.

From the point of view of the preventive approach, the in-depth analysis of the effects already experienced in the past by urban conglomeration is an important task to be pursued especially for recent-historical earthquakes for which the documents usually show high quality and completeness of the information, useful to delineate the patterns of damage in detail.

Macroseismic data play a key role in supporting the analysis of the local seismic response because they contribute to identify the geological/geophysical features of a site (e.g.: Guidoboni et al., 2003). Starting from these preliminary remarks, this contribution deals with the investigations performed about the damage suffered by several towns of the southern Italy hit by strong recent-historical earthquakes. The events considered are happened in the XX century: 23 July 1930 Iripinia (Me=6.7), 21 August 1962 Iripinia (Me=6.2), and 23 November 1980 Iripinia-Basilicata (Me=6.9).

For each town analysed are supplied maps reassuming the spatial relationship among the damage levels. These data will be part of the Atlas of the Italian Seismic Scenarios, a collection of damage maps for towns affected by strong earthquakes. This tool will be of usefulness for person acting in the fields of seismic risk evaluation and reduction.

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W9-10 Orale Lazzari, Maurizio

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A NEW SPATIAL STATISTIC METHOD IN LANDSLIDE SUSCEPTIBILITY ASSESSING FOR CULTURAL HERITAGE CONSERVATION

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Key terms: Geostatistics; landslide susceptibility; cultural heritage; GIS; geomorphological risk

This work proposes the use of a new method for landslides susceptibility

assessing, by adopting a local spatial analysis approach, contrasting with bivariate statistical analysis (global) largely used in literature. To use spatial analysis to reconstruct hazard scenarios is surely an innovative instrument for territorial analysis, because it takes in count first and second order effects in spatial distribution of phenomena (in this case landslides) and so it allows to obtain more realistic informations.

The method in this way introduced has many practical implications on territories, such as in the field of Urban, Landslide and Emergency Planning and in the field of Cultural Heritage. In fact, it allows to identify with more precision, compared to global methods, areas with a priority of intervention for conservation. Moreover, it becomes possible to construct maps with areas hydrogeologically bonded for the study of natural hazard applied to heritage conservation, in particular when it is exposed to hazard with geological (seismic risk) or geological nature (landslides and floods). An important applied use of the cultural heritage risk map could be focused on the individuation of the intervention priorities (structural and economic) for the safeguard of the historical and architectonical buildings characterized by a high risk level respect to natural hazards occurring in such mountain areas.

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W9-11 Orale Lazzari, Silvestro

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GEOLOGICAL AND GEOMORPHOLOGICAL HAZARD IN HISTORICAL AND ARCHAEOLOGICAL SITES OF THE MEDITERRANEAN AREA: KNOWLEDGE, FORECASTING AN MITIGATION

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Key terms: Hazard; Mediterranean areas; Urban centres; Archaeological sites

This work is part of a research programme promoted by the National Group for the Defence against Hydrogeological Catastrophes (CNR - G.N.D.C.I.) in order to evaluate the effects caused by high risk landslide movements in the historical-monumental urban centres. This work gives rather representative examples individualized in some regions of the Mediterranean sea (Italy, Greece, Spain, Crete, Albania), seats of important historical and archaeological settlements and structures, interested by a progressive degradation due either to structural or to natural causes (geological, geomorphological and seismic). It has been carried out an analysis of the geological and geomorphological conditioning factors and have been proposed the recovery solutions for the risk mitigation and preservation of the historical heritage, furnishing also useful technical elements for the conservation and protection of the historical heritage.

The experiences and researches produced by several authors, as Bonilla (1959), Sarma (1975), D'Elia (1983), Keefer (1984), Harp et al. (1986), Ishihara et al. (1986), Maugeri and Motta (1986), have shown in these areas a rather narrow relationship between earthquakes and mass movements, that occur in some typical climatic, geomorphological and geotechnic configurations.

The danger level increases when these phenomena are simultaneous in the same site, so that their knowledge represents a very important preventive measure.

From a preliminary picture, it's possible to point out a not casual coincidence between perimediterranean zones, where the landslide are more evident, and those ones where the seismic activity is more frequent and intense (Algerian Tell, centre-southern Apennine, southern-Dynaric and Hellenic belt, Aegean Arch and Anatolic belt). The most recent and incoherent clastic deposits of the Pliocene and of the Quaternary, filling in the Euro-Asiatic and African basins emerging, show a considerable propensity to instability. The slope dynamics turns out more active in particular rainy and geological-structural configurations. The deep morphogenetic phenomena are mobilized in consequence of high intensity rainy events which occurs in short-time periods of temperate-dry Mediterranean climates. The deposits more vulnerably are those prevalently clayey deposits subject to compressive and distensive stress, which have notably modified their structure and consistency. In the studied areas are very frequent either the erosional or the landslide phenomenon but there are also evidences of deep gravitative motions, involving whole slopes.

Historical and bibliographical notes and direct experiences have enabled to check that several mass movement have been induced or reactivated by high intensity earthquakes, characterising the whole mediterranean areas. In conclusion, it has been pointed out that the landslides and earthquakes have conditioned whole civilizations, which paid for natural calamity with a stop of the economic and social evolution and development with considerable and irrecoverable structural damage.

The mitigation measures could be represented either by right consolidation interventions or by preliminary studies of the physical environment and characteristics of the single structures.

W9-12 Orale Loperte, Antonio

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INTEGRATED GEOPHYSICAL AND INFRARED THERMOGRAPHY METHODOLOGIES APPLIED ON SAN FRANCESCO A FOLLONI CONVENT, MONTELLA (SOUTHERN ITALY)

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Key terms: infrared thermography; GPR; Geophysics; Montella

In order to reconstruct architectural changes during the centuries often we are forced to trust merely on the evidences of documentary and iconographical sources which could sometimes supply the description of the monument or of a specifically building phase. Such approach does not solve all the questions related to the interpretation of historical data (graphics, descriptions) useful for finding previous configurations of the building.

The historical building structure and shape, as they appear at the present are often the final result of a stratification of different phases deeply connected with artistic and technological features of the age during which the building has been designed and realized. Stylistic features, building techniques and functional aspects change in time leaving often written traces in archive sources such as on the building masonry texture (sometimes hidden by plaster) or under the floor.

In such situation the Non Destructive Testing investigations by means of infrared thermography and GPR could be useful to characterize masonry, to survey inhomogeneities in the masonry as well as to detect buried walls belonging to ancient building phases.

This paper deals with the emblematic study case of San Francisco in Folloni convent near Montella in Southern Italy. Its complex vicissitudes experienced in last centuries have been the reason of radical transformations of the church and its surrounding buildings. Historical research has provided important information on structural interventions and planimetric transformations carried out between the 17th and 18th century, following also natural hazard events. Such data have been correlated with the results obtained by infrared thermography surveys on plastered facades of the convent and GPR profiles carried out under the stone paved floor of the church and cloister, thus improving the knowledge of historical building phases of the monument. The integrated use of building analysis techniques based on NDT techniques together with historical and archaeological records show the enormous potential of the use of this interdisciplinary approach.

W9-13 Orale Moscatelli, Massimiliano

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THE PALATINE PROJECT - AN EXAMPLE OF INTEGRATION OF GEOLOGICAL, GEOPHYSICAL, AND ARCHAEOLOGICAL METHODOLOGIES FOR EVALUATING GEOHAZARD IN ARCHAEOLOGICAL AREAS

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Key terms: geohazard; archaeological areas; ERT; GPR; Palatine hill

A research project supported by the Government Commissioner for the archaeological areas of Rome and Ostia Antica and the Italian Civil Protection National Service (DPC) was carried out to evaluate the geohazard level affecting Palatine hill, Roman Forum, and Coliseum. The project was planned to achieve two main goals: (i) map the bottom surface of the anthropic covering, and characterize the archaeological layer susceptible to instability; (ii) characterize the geological bedrock in terms of geometries and of physical-mechanical properties.

The subsoil setting of the study area (less than 1 km²) was preliminarily defined by means of already available 200 geotechnical boreholes. By the way, a new drilling campaign was performed to better investigate the geological and archaeological layers of Palatine hill and surrounding areas. Twenty-five continuous coring vertical boreholes (total depth between 20 and 60 m) were drilled. All the boreholes crossed the anthropic layer, which ranges in thickness between 1 meter (at the hilltop) and 18 meters (along the slope and at the base of the rise). Several boreholes also crossed the network of tunnels dug in the tuff rocks underling the anthropic layer.

Lithological and stratigraphic logs of boreholes, integrated with information from local archaeological stratigraphy, allowed to strongly constrain (i) the bottom surface of the archaeological layer, and (ii) the boundaries between geological units. A geophysical survey was then planned (i) to extend correlations all along the study area, and (ii) to characterize internal variability of subsoil units.

Twenty-four ERT were performed at Palatine hill and Roman Forum. Resistivity field data were collected using different array configurations (Wenner-Schlumberger and Dipole-Dipole) and electrode spacing (from 1 to 10 m), obtaining different investigation depth (from about 8 to 80 m). In all cases, the resistivity values range from 10 to more than 1280 ohm.m. As regards the archaeological layer, in general, relatively high resistivity values (>400 ohm.m) are associated to voids and/or cemented conglomeratic walls, while low to moderate resistivity values (<400 ohm.m) are related to anthropic silty sandy backfill material.

With GPR method a high-resolution data acquisition technique was adopted to reconstruct a global image of five areas. For the measurements a 500 MHz bistatic antenna with constant offset, a 70 MHz monostatic antenna and a 35 MHz monostatic antenna, were employed. The horizontal spacing between parallel profiles at the site was 0.5 m, employing the 500 and 70 MHz antennas and 1 m employing the 35 MHz antenna. Some signal processing and representation techniques were used for data elaboration and interpretation. With the aim of obtaining a planimetric image of all possible anomalous bodies detected in the ground, the time-slice representation technique was applied using all field profiles. Amplitude of reflections recorded in the time-slices is mainly referable to the distribution of archaeological structures. High amplitude reflections are

referable to archaeological remains and, locally, to voids located in the anthropic layer. Low amplitude reflections can be related to the anthropic backfill and, in few cases, to the geological bedrock.

The main goals of the project were achieved at the end of the study. The application clearly demonstrates the potential for full integration of geological, geophysical, and archaeological methodologies in order to better characterize the geological and anthropic layers in archaeological areas. As a matter of fact, results show that: 1) both buried topography and internal complexity of the archaeological layer are detectable; 2) main boundary surfaces between geological units are laterally traceable; 3) presence of voids in the geological bedrock, locally crossed by boreholes and constrained by archaeological information, is presumable.

W9-14 Orale Stoppani, Francesco

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MAINTENANCE OF CULTURAL GEO-MINERALOGICAL HERITAGE

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Key terms: safeguard; heritage; legislation; mineralogical; collection

Summary of the arguments:

1) Geological risks and anthropological risks (definitions and characteristic features).

2) Cultural heritage (definitions and characteristic features).

3) Safeguard of cultural heritage, legal instruments. Safeguard used as protection and valorization. The notion of cultural property as constituent of the cultural heritage.

Cultural properties according to the D.Lgs.n.42/2004 -"Codice dei beni culturali". Landscape plans. Cultural and anthropic heritage and natural cultural heritage. Cultural geo-mineralogical heritage.

4) The D.Lgs.n.42/2004 "Codice dei beni culturali" - artt.1,2,3,6,7,8, 10 lett.h),12,13 and 15.Art.136-1°co.lett.a) and all.ti A- punto 13 lett.a) and B punto 13. Analysis and commentary on the reference to "mining sites of historical or ethno-anthropological interest". Analysis and commentary on the reference to "geological singularity". Analysis, criticism and commentary of the definition of "collections and specimens from zoological, botanical, mineralogical or anatomical collections" and its consequences.

5) The differences between "mineralogical " and "mining", as set out legally for the first time in the sentence n.1108 of the Constitutional Court 12-20/12/1988 given on the conflict for the allocation of powers between the Lombardy Region and the State, about the former L.R. n2/1989 ex art.117 of the Constitution and D.P.R. n.616/77. Analysis of the relevant parts of the sentence. Impact on legislation. Regional laws.

6) Parks and nature reserves, as means of protection and increase of the value of natural and cultural heritage. Examples of Gran Paradiso, Adamello, Veglia and Devero, Sardinia, the island of Vulcano, Vesuvius and the Island of Elba. Instituting and implementing rules. Comparison, in particular, concerning mineralogical sampling with collecting and scientific purposes.

Relationship with artt.9 and 33 of the Constitution.

7) Mines and quarries. Existing legislation. State and regional powers. The L.n. 42/2009 ("federal state property") and the implementing D.Lgs n.85/2010. Right given to provinces to receive free of charge abandoned mines in their heritage under state jurisdiction. Hypothesis for valorization.

8) Mineral professional and amateur collecting. Respective roles and synergies. Results obtained. Meaning in the context of cultural heritage. Possible definition of "natural cultural property". Need and function. Definition of "collection" according to the E.U. Definition of "mineral for collection" and "mineralogy collection". Lack in the Italian legal system. Needs.

9) Legislative hypothesis for a "sustainable" mineralogy. Please note that if deemed of interest, a more detailed and exhaustive text on the topics covered can be provided.

W9-15 Orale Tilio, Lucia

10.1474/Epitome.04.0015.Geoitalia2011

MITIGATION OF URBAN VULNERABILITY THROUGH A SPATIAL MULTICRITERIA APPROACH

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Key terms: Resilient cities; Seismic Risk; Seismic Vulnerability; Urban Vulnerability; Spatial Multicriteria Analysis

Seismic risk management is generally carried out through strategies aiming to reduce building seismic vulnerability, working on structural features, and not considering that the concept of vulnerability can be adopted also referring to the whole urban system.

Therefore, at least in Italy, it has been highlighted that civil defense manages all activities of prevention and protection, lacking of a good dialogue with other institutions. Municipalities should adopt an Emergency Plan, in order to define actions to be undertaken after a disaster event, but not considering actions in peace time. Finally, seismic risk is not considered so crucial to influence development strategies and policies. Since cities are complex systems, where physical environment, society and government activities interact each other, and where global functioning depends on functioning of each element of the system, as in a network, where each node contributes to global system, seismic risk prevention should be treated at urban scale, introducing the concept of resilience, as the capacity of a system to adapt itself to new, generally negative conditions, in order to re-establish normal conditions. Therefore, when an earthquake occurs, and cities are subjected to several kinds of damage, beyond structural ones, and affecting activities carrying out, normal conditions must be re-established as soon as possible.

In the beginning, resilience concept has been developed in the field of ecology, as the property of a system that measures its ability to absorb changes and to return to an equilibrium state after temporary disturbance; in the last years, resilience has become a usual term in the field of risk management, so that also the International Strategy for Disaster Reduction, Hyogo Framework for Action 2005-2015, not casually called "building the resilience of nations and communities to disasters", adopted the concept as a property of a community or a society, and affirmed that it is the capacity to adapt by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure, and that it is strictly related to the capacity of a social system of

organizing itself, learning from past disasters.

According to the goal of managing seismic risk reducing urban vulnerability, it is strategic to identify in peace time (before disastrous events) which elements, which activities, which functions of a city have prior importance after the event, to guarantee a rapid response and the reestablishment of normal conditions: this means identifying resilient city. This new approach should recognize that single components work as a whole system: such components, that are not only physical ones (such as buildings and streets), but that refer to social, economic and political functions, strongly contribute to urban seismic vulnerability. Reducing urban vulnerability, therefore, means maximizing system resilience. This research aims to define a methodological approach to identify resilient city, adopting spatial multicriteria techniques, and establishing resilient system identification considering functional, social, morphological, geological and dimensional characteristics of the considered urban system. In particular, some tests have been carried out on several towns in Basilicata Region (southern Italy), considering a first set of criteria including accessibility, closeness to urban centres and main facilities, closeness to hydrographical networks, slope, map of seismic hazard, areas at high hydro-geological risk, and seismic vulnerability of buildings. Multicriteria analysis has been led adopting an additive rule, based on a simple additive weighting method.

W9-16 Orale Toffolo, Luca

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THE LOVIGNANAZ CU-FE SULPHIDE MINE: SAFEGUARD OF A PRE-ROMAN MINING SITE

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Key terms: Lovignanz; Fe-Cu mine; Clavalité

The antique Lovignanz mine (also known as Molina mine) is located in the western side of the Clavalité valley (1350-1425 m a.s.l.), to the South of the Fénis village, in the southern side of the Aosta Valley (Italy). The mine galleries are developed within chloriteschists, talcschists and metagabbros transposed with calcschists belonging to the Piedmont nappe (Zermatt-Saas zone). The rocks hosting the Fe-Cu sulphide mineralization show blueschist to eclogite facies mineral associations like those studied in Saint-Marcel rocks (Martin *et al.*, 2008, and ref. therein). The mineralization is characterized by disseminated chalcocite and pyrite associated with minor ilmenite, rutile, pyrrhotite and magnetite (*Fénis. Une communauté au fil de l'histoire*, 2000 and ref. therein). The oldest galleries were dug with techniques described by Agricola in *De Re Metallica* (1556) and have been attributed to the Romans. These techniques consist in excavation along mineralized layers after "fire-setting", that is after weakening the rocks with a fire (*De Re Metallica*, book V).

Other galleries have been excavated with more recent techniques, revealing the use of explosives, and have been attributed to XVIII-XIX centuries mining activity (Gerboire E. E., *in: Fénis... op. cit.*). The remnants of a furnace for rock-roasting have been found along the right side of the Clavalité river (lat. N 45° 41' 46"; long. E 7° 29' 51"). In the same site, slags with charcoal and red burnt soil, probably related to an old activity, were observed during the field work. Several glassy slags, maybe produced during XVIII-XIX centuries mining activity, were found below a large landslide that partly covers the mine adits. Near the oldest mine entrances traces of old working instrument have been found.

These mines were also used to extract millstones: few metres from the mine entrances in the Mouilè locality (*Fénis... op. cit.*), some of these stones are still unexcavated on the rock walls. In the lower part of the valley, in correspondence of Miserègne village (*Fénis*), there is a dump where many large slags with charcoal fragments are piled up. Some of these fragments were analyzed with 14C method and one of them has been dated to IV century B.C.. This age is the oldest found for charcoal associated to slags of the Cu mines in the Aosta Valley. Other slags from the Saint Marcel valley yielded early medieval ages (Tumiati *et al.*, 2005).

The Lovignanz mining site has been destroyed by landslide events, the last one having occurred in 2000, which partly covered mine entrances and other structures linked to mining activity. The presence of structural lineaments and the practice of "fire-setting" during mining activity may have contributed to trigger the landslide.

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WORKSHOP W12

Storia e archeologia per la Scienza della Terra

W12-17 Orale Bottari, Carla

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THE ABANDONMENT OF THE ARCHAEOLOGICAL SITE OF CARSULAE (TIBER BASIN- CENTRAL ITALY): GEOARCHAEOLOGICAL EVIDENCE AND POSSIBLE CAUSES.

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Key terms: geoarchaeology; dolines; ground water circulation; Roman ruins; Carsulae

The Roman town of Carsulae rises along the Consular Flaminia road, built between 220 and 219 BC by the Censor Caius Flaminius the Older. It was 295 km long and was built in order to connect Rome with the Umbria region and the Adriatic coast. Moreover, it had also a strategic and military value and it was well-known as a safe and treated road.

The archaeological site of Carsulae is located on a wide travertine deposit (early Pleistocene- middle Pleistocene) at the bottom of the Martani Ridge at about 440 m a.s.l., north of the Terni tectonic basin (Tiber Basin). The Ridge is made up of Mesozoic and Cenozoic limestone and forms an important and wealthy hydrographic basin that feeds many springs along the piedmont area; the most important one is the San Gemini that is placed near the ancient Roman town, well-known since ancient times. In fact, the importance of Carsulae, mentioned by different historical sources, is related to its strategic geographic position along the Flaminia road characterized by local healthy waters and fertile soil.

Historical sources attributed the decline and the abandonment of Carsulae mainly to the construction of the eastern tract of the Flaminia road. Recently, some scholars debated about the possibility that Carsulae decline was caused by occurrence of strong seismic events which produced the collapse and the deformation of archaeological remains with consequent abandonment of the site.

A preliminary geomorphologic survey, performed on the archaeological site and its surroundings, and the interpretation of aerial photographs revealed the presence of some dolines even of great extension. Of them, one of the largest has been found under the Roman theatre and amphitheatre, a smaller one has been located north of the decumanus which collapsing caused the deformation and the sliding of the Consular road.

Among other possible causes (such as geopolitical context, landslides, earthquakes, etc.), that brought to site abandonment, a sudden change in the ground water circulation could be considered a trustworthy hypothesis. In the course of centuries, it is quite likely that the presence of dolines and the progressive travertine dissolution strongly affected the hydrogeological setting with consequent variation of the water table depth. As a consequence, probably in Late Roman times, a progressive reduction of water supplying to the site's springs led to a gradual decline and depopulation of the Carsulae town.

W12-18 Orale Branca, Stefano

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THE CATALOGUING OF THE GAETANO PONTE PHOTOGRAPHIC FUND (1876-1955): THE ERUPTIVE AND MORPHOLOGICAL HISTORY OF ETNA AND STROMBOLI RECONSTRUCTED THROUGH PHOTOGRAPHY

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Key terms: Gaetano Ponte; data base; historic photography; Etna; Stromboli

Gaetano Ponte (1876-1955), professor of volcanology at the University of Catania from 1919 to 1951, represents a figure of remarkable scientific and cultural importance in the world-wide panorama of Earth sciences studies. The ideas and results of the scientific researches conducted by Gaetano Ponte are well-known through his immense scientific production; less renowned instead is his photographic legacy made up of more than 2500 images, taken from the end of 1800 until 1950. This valuable photographic collection, that represents a unique heritage of historical documentation of the activity of active Sicilian volcanoes, has been recovered and enhanced by collaboration between the Archivio Fotografico Toscano and the ING-V-Osservatorio Etno, to then compile an on-line digital catalogue. The images have been acquired digitally and catalogued following the ICCD standard and thanks to the complementary quality and rigour of both the photographic and volcanological scientific interventions. The computerised catalogue integrated with images and volcanological data has considerable added value that is very rarely found in photographic catalogues, above all when comprising images of a scientific character. Altogether, the overwhelming majority of the images that constitute the fund's data base

(<http://fondoeponte.aft.it/fondoeponte/temi.jsp>) mainly refer to the various aspects of Etna volcano and secondly of the Aeolian Islands. In particular, regarding the images taken on Etna, the lateral eruptions occurring during the first half of the 20th century are documented, beginning with the short eruption of 1908 till the major eruption of 1950-51, comprising the dramatic images of the destruction of Mascali during the eruption of 1928. This eruption represents the only eruptive event after that of 1669 to cause the destruction of an inhabited centre. The development of the lava field is documented with photographs, shots from the ground and from overflights, that show the last moments of the existence of the village of Mascali and the destruction of the main communication routes of Etna's eastern flank. Furthermore, the fund's images document the spectacular eruptive activity of Etna's summit craters and its main morphologic changes. Indeed, the summit of the volcano crater until the beginnings of the 20th century was made up of a large single crater, called the Central Crater. On 27 May 1911, a large pit crater was formed on the NE slope of the terminal cone of Etna at a height of approximately 3100 m. This crater, named the NE Crater, when formed was approximately 100 m wide and 80 m deep and soon became the location of important eruptive phenomena, of a particularly explosive nature, such as the lava fountain event on the night of June 24, 1917. The numerous photographs, taken both from the ground as well as from above during pioneering overflights specifically commissioned by Ponte, illustrate with great detail and beauty the eruptive activity of the NE Crater and its morphologic evolution. They show the gradual growth of a volcanic cone inside the crater depression during the first half of the 20th century, and likewise, the variable explosive activity of the Central Crater that in this long period was characterized by periods of Strombolian activity and lava fountains and by a subplinian episode occurring on March 16, 1940.

The monitoring activities organized by Gaetano Ponte comprised, besides Etna, the study and volcanological observations of the volcanoes of the Aeolian Islands, particularly Stromboli and secondarily Vulcano. In particular Stromboli, during the first half of the 20th century, apart from the common Strombolian activity from the summit craters, was affected by numerous paroxysmal events that are documented in the photographic fund. Among these were the events occurring in January 1907, June 1916 and May 1919, where severe damage to housing is highlighted.

W12-19 Orale Camerieri, Paolo

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EXTREME NATURAL EVENTS DURING THE EARLY ROMAN REPUBLICAN PERIOD: LAND'S HYDROGEOLOGICAL SAFEGUARD IN THE NERA-VELINO RIVER BASIN.

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Key terms: centuriation; hydrological hazard; drainage; flood; nera-velino rivers basin

This paper presents the results of an interdisciplinary study on the drainage of damp and humid areas, the control of surface water, the centuriation, the road system and the land reclamation operated in the plain of Rieti by the roman consul Manius Curius Dentatus during the conquest of the Sabina region in the third century BC. This research brings more awareness to consider the work of 'Gromatici Veteres' as an inseparable unity of various processes concerning the agrarian organization and the prevention of natural disasters like the flood of the Nera-Velino rivers basin. Some parallels could be established between the cases of Rieti, Pianura Pontina and the latin colony of Spolietum. This study could bring us to a better and deeper understanding of the contribution of historical and topographical analysis about the impact of extreme natural events during the early roman republican period.

W12-20 Orale Cubellis, Elena

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MYTH, ARCHAEOLOGY, HISTORY AND VOLCANOES IN THE BAY OF NAPLES

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Key terms: Eruptions; Earthquakes; Floods; Archaeology; Bay of Naples

The Neapolitan region for its geological history is an excellent laboratory for testing the validation of new paradigms for the natural phenomena. The geological structure of the Neapolitan area is formed by the succession of effusive and explosive rocks as lavas and pyroclastic products erupted by polygenic and monogenic volcanoes. Moreover this area is characterized by shallow seismicity capable to produce high intensity in small epicentre areas. The succession of rock layers, with different permeability, promotes, during heavy rainfall, the formation of devastating landslides and debris avalanches. Eruptions, earthquakes, flooding, occurred in the Neapolitan area, have produced myths, legends, historical documents, archaeological findings and results of recent surveys.

When the historical data are poor, to enlarge the time series of events for a deeper knowledge of the natural history of investigated sites, it is common practice to spread to research on earthquakes, tsunamis, eruptions, floods through historical times by analyzing documentary fonts and relics left by ancient peoples.

The name Campi Flegrei (Fields of fire) of the district between the town of Naples with its western suburbs and the Tyrrhenian coastline suggests that manifestations of volcanism were evident in Ancient Times. This area was once a preferred location to the entrance to Hades. It is caldera complex, formed by collapse of the ground following two giant eruptions; the landward floor is peak marked by tens of volcanic cones. Campi Flegrei attracted special attention during the nineteenth century, thanks to the Serapeo, ruined roman market in Pozzuoli, which had been submerged by and then re-emerged from the sea, due to slowly sinking and rising of the land (Bradyseism).

Vesuvius has acted like a powerful magnet from time immemorial, drawing people to settle on the fertile soils (Bronze Age), to wonder at the beauty of the landscape as tourists, or to undertake scientific investigations. Its most famous eruption is that of A.D. 79, responsible for the destruction of Pompei and Herculaneum. The earlier observations and interpretation of its activity were often influenced by religious beliefs. In eighteenth - and nineteenth - century a wide range of visual images of Vesuvius were produced to satisfy a diverse market of art collectors, tourists and scientists. The images of Vesuvius produced in this period owed much the artistic conventions of topographical and picturesque views and many of these images simultaneously served the needs of art, science and tourism. The publications which had the most profound influence on visual and verbal records of Vesuvius and Campi Flegrei in the eighteenth and early nineteenth centuries was Sir William Hamilton's "Campi Phlegraei" 1776-1779.

The island of Ischia was the site of the earliest known Greek settlement in Italy. In the fourth century BC a violent cataclysm is reported which drove away the first Greek peoples. Pliny the Elder, in his Naturalis Historia writes that on the island of Ischia, the earth swallowed up a town and that after this catastrophe a lake was formed (Lago del Bagno?). This eruption was dated by the sixth and fifth century BC pottery remains.

About historical seismicity more comprehensive accounts are available for Ischia island since 1228. There is an exhaustive literature related to the 1881 and 1883 earthquakes of Ischia, pointing out to the relationship between seismicity and the volcanic history of the island.

On September 1854, under the initiative of the Bourbon Ferdinand II (1830-1859), King of the Two Sicilies, the opening of the new harbour of Ischia was celebrated. The technicians cut the isthmus to join the lake (Lago del Bagno) with the sea as in the nearby Campi Flegrei, where Lucius Coceius Auctus in 37 BC, cut the isthmuses separating the Lucrine Lake from the sea and from Lake Avernus to build Portus Iulius for the Roman fleet.

W12-21 Orale Giustetto, Roberto

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SYNTHESIS, STABILITY AND STRUCTURAL CHARACTERIZATION OF A COMPOSITE Palygorskite/Methyl Red "Mayan" Pigment

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Key terms: palygorskite; acid Red 2 (methyl red); dye encapsulation; dye stabilization; Maya Red pigment

It is well known that palygorskite and sepiolite clay minerals, mixed and moderately heated (< 200°C) with the indigo dye, form the extraordinarily stable Maya Blue, an ancient blue pigment used by Mayas in Pre-Columbian America (VI-XV century a.D.). Maya Blue can be considered an ancestor of modern nanocomposite materials as the guest indigo molecule is encapsulated and bound within the narrow micro-tunnels crossing these clays structure, thus being adequately sheltered and protected from external agents. Analogous compounds, granted by the same exceptional stability but showing different chromatic hues, could possibly be produced through diffusion and fixation of other dyes in the same microporous matrices.

A stable, red-purplish host/guest composite was obtained by grinding and heating (140°C for several hours) palygorskite with 2 wt% acid Red 2 (methyl red). Such a compound proved to possess the very same chemical stability of original Maya Blue, as neither its colour nor its structure undergo any significant variation in spite of severe chemical attacks with both acid or alkali agents.

The structural features of the palygorskite + methyl red (2 wt%) composite, as well as the supramolecular host/guest interactions responsible for the compound stability, were investigated by means of several techniques such as UV-vis and FTIR spectroscopies (both in air and controlled environmental conditions), XRPD and TGA analysis. Experimental evidences proved that the heating treatment applied during the composite preparation causes loss of the zeolitic H₂O fraction, thus allowing diffusion of methyl red molecules inside the palygorskite micro-tunnels.

The encapsulated molecules, in the form of specific zwitterionic tautomers, tend to bind with the clay matrix by means of several interactions including H-bonding to Mg-coordinated OH₂ and possibly Coulombic attractive forces. Presence of methyl red as different zwitterions is consistent with adsorption on an electrostatic unbalanced hosting matrix such as the palygorskite framework. Encapsulation and bonding inside the clay micro-tunnels stabilize the azo dye molecules, sheltering them from external environment and preventing both deterioration and/or colour changes. Fixation in the inorganic matrix, in addition, enhances both resistance to solar/UV-A irradiation and stability at increasing temperatures of the clay-solvated methyl red molecules if compared to the pristine dye.

This innovative palygorskite + methyl red (2 wt%) composite is therefore reputed to be fit for use as a stable, economical and environment-friendly (due to absence of heavy metals) "Maya Red" pigment. The hosting matrix of palygorskite was so far used, due to its structural strength, but the possible use of sepiolite offers further fascinating perspectives for the sorption of different guest dyes. Presence of wider micro-tunnels in sepiolite (10.6 Å), despite reducing the composite stability, could allow encapsulation of bigger molecules unfit to diffuse inside the narrower palygorskite pores (6.7 Å).

W12-22 Orale Pannaccione Apa, Maria Ilaria

10.1474/Epitome.04.0022.Geoitalia2011

CONTRIBUTE TO A SCIENTIFIC APPROACH ON LANDSCAPE ARCHAEOLOGY STUDIES: THE CASE OF TENERIFE ISLAND (CANARY ARCHIPELAGO, SPAIN)

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Key terms: Landscape archaeology; Tenerife; Guanche; Volcanic activity

Generally, the landscape archaeology is important to suggest that environment played a key role for the establishment of permanent settlements, as well as the archaeological sites can provide information about the ancient landscape.

The example of the prehistoric colonization of Tenerife island by the Guanche culture is an interesting case of a balanced ecological relationship between landscape and hunter-gatherer groups.

The almost complete lack of technology was supplemented by know-how and land use without apparent landscape remodeling.

The island of Tenerife date his genesis between 12 and 11 million years ago [Carracedo, 2006]. This large triangular island is composed of a complex of overlapping Miocene-to-Quaternary stratovolcanoes that have remained active into historical time.

The soil of volcanic origin also gave rise to very fertile soils, which permeability allowed the constant supply of natural water, producing the basis for the establishment of permanent settlements of Guanche groups proceeding from Lanzarote and Fuerteventura which probably colonized Tenerife around the IX century B.C.

The social structure was chiefdom based, poor on technology, strongly related to natural resources and implemented by a hunting-fishing-gathering and sheep-farming economy.

This social primary structure appears to be a successful pattern facing the constant volcanic activity.

The lands most exposed to natural hazards were quite populated. There was a total adaptation to the landscape, which was confirmed by the high percentage of settlements in ancient volcanic tubes adapted to the community needs.

W12-23 Orale Torre, Rosario

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THE MESSINA STRAITS TSUNAMIS: FROM THE HISTORICAL TEXTS TO THE OPEN QUESTIONS

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Key terms: Analysis of Historical Texts; Straits of Messina, Southern Italy; Tsunami Hazard

Due to its complex geological structure and peculiar position between the Ionian and Tyrrhenian basins, the Straits of Messina in southern Italy was historically affected by several moderate tsunami events, often invisible to the people, whose anthropic activities were not influenced.

Several authors have tried to reconstruct and analyze the phenomena that have been registered in this area.

Studies have mainly focused on the two events generated by the earthquakes on February 5 and 6, 1783 and December 28, 1908.

A thorough analysis of historical literature provides an outline of the scope of different importance, in terms of numbers and intensity, of the recorded events both in the Straits of Messina and in the surrounding areas. This objective evidence continues to testify the geodynamic evolution of the Straits of Messina.

It is important to point out that the cause of tsunami phenomena is not attributable only to the tectonic activity of the Straits, but also to other tsunamigenic areas, such as the submerged area of Etna, the Aeolian volcanic Arc, the Hyblean-Maltese escarpment, and to remote areas of the Aegean Sea and the Central and Eastern Mediterranean Basin. Gravitational collapse and volcanic Tyrrhenian Seamount areas can be also included.

To date the tsunami hazard related to the earthquake or marine and submarine landslide in the Messina Straits remains an open question. From the analysis of old texts it is very difficult to focus on these types of phenomena.

For the known event of 1908, the catastrophic effects of which have well been documented and illustrated by a rich literature and record, there are value parameters of magnitude, epicenter and seismogenic fault for the earthquake, and other valuable parameters for the tsunami waves, despite a lack of instrumental data.

This work provides an overview on the current understanding of the cyclic occurrence of this physical phenomenon. On the basis of the extensive historical information on this theme, the research also contributes to assessing both the results of coastal and oceanographic data and the indications carried out by the most significant documentary texts through a correct interpretation of them.

The loss of so-called historical memory of old events is a serious and irremediable risk factor, for the populations of the affected areas.

The catastrophic effects of the recent tsunamis on December, 26 2004 in the Indian Ocean and on March, 11 2011 in Japan, considerably higher in energy than old Mediterranean tsunamis, are further evidence for this underrated natural risk.

WORKSHOP W13

Effetti del cambiamento climatico sulle risorse naturali e sui rischi: stima degli impatti e sviluppo di misure di adattamento

W13-24 Invitato Bocchiola, Daniele

10.1474/Epitome.04.0024.Geoitalia2011

CLIMATE CHANGE IN THE ALPS AND FUTURE WATER RESOURCES: A CASE STUDY

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Key terms: climate change; Alpine catchments; water management

Global warming is affecting the climate of mountain areas in temperate regions and the water resource distribution therein. Within the European Alps thermal shift since the 1980s, albeit synchronous with global warming, seems at least twice as much as the global climate signal, leading to substantially unchanged precipitation, but with a marked decrease of snowfall, and modification of the hydrological cycle therein. Southern, i.e. Italian, Alps display considerable sensitivity to climate change according to recent studies. Expected hydrological changes within Alpine catchments include modified average in channel discharge, as well as modified incidence of extreme events, either low flows or flood flows, thus impacting water management strategies in the lowlands, as needed for agricultural, and flood mitigation purposes. As a case study of modified hydrological cycle falling out into modified water resources management within the Italian Alps, I investigate here how to re-operate the

multipurpose Lake Iseo, fed by the Oglio (1800 km²) Alpine watershed, to cope with prospective climate change in the area. Future precipitation and temperature (A2 storyline, 2045-2054) from some GCMs available within the IPCC's data base are chosen for the purpose based upon previous studies. The downscaled fields are then fed to a minimal hydrological model to build future hydrological scenarios.

To illustrate the effect of modified hydrological cycle upon water resources management I use the obtained scenarios as boundary conditions for management of Iseo lake, by way of multipurpose management strategies, and special emphasis upon i) lake floods, ii) crop yield, and iii) ecological flows. Results indicate that possible changes of the hydrological regimes fallout considerably upon water management, and exasperate conflict between multiple uses of water. Adaptation strategies are only partially suitable without specific modification of water demand in time.

W13-25 Invitato Brunetti, Michele

10.1474/Epitome.04.0025.Geoitalia2011

EVOLUTION OF TEMPERATURE EXTREMES IN A WARMING CLIMATE

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Key terms: extreme events; daily temperatures; Europe; probability density function

Changes in the variability and the distributional shape of daily temperatures are expected to play a prominent role in explaining the enhanced occurrence of extremely warm events, either on a global or local scale. Variations in the probabilities of warm and cold extremes, indeed, may result from non-trivial variations in the underlying temperature distribution, e.g. the interplay between a simple shift in the mean and more complicated changes in scale or shape. In this context, we investigate variations of daily maximum (TX) and minimum (TN) temperature over Europe during the last half century, with the aim of identifying the nature of changes in the probability density functions and the probability of moderate extremes, induced by a warming climate. Detailed comparison with observations over the past decades puts forward the dominant role of the mean in explaining exceptionally hot events, and rules out contributions from potential changes in variability and higher distributional moments. The key strength of the present approach is its ability to relate isolated, severe events to long-term trends in a statistically meaningful manner, enabling present and future evolution of

temperature extremes to be reliably estimated on the basis of average distributional properties of temperature anomalies.

W13-26 Orale Dematteis, Niccolo

10.1474/Epitome.04.0026.Geoitalia2011

PRECIPITATION DATA DOWNSCALING AT LOCAL SCALE AND THEIR VERIFICATION OVER THE VALLE D'AOSTA

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Key terms: statistical downscaling; climate change; regional model

The first part of the study was focused on the analysis of the global climate model projections included in the IV IPCC assessment report and regional climate model projections for Europe from specific projects such as PRUDENCE and ENSAMBLES.

A feature common to all projections is a global increase of the average temperature, larger over the Alpine region, and a variation of the precipitation quantity and spatial distribution. Furthermore, analyses performed by means of regional climate models (RCM) for the Alps sectors outline a double pattern for precipitation levels: in the northern sector, models forecast an increase in precipitation levels, whereas for the southern sectors precipitation will decrease. The limit between these sectors is expected to move during the year: over the Alps, in winter, and over the central Europe, in summer. Such pattern seems to indicate that, for the future climate at local scale, the Italian Alps will experience a general increase in temperature and a small increase (drastic reduction) of precipitation in winter (in summer).

These changes, combined together, result in an increase in rainfall (also during the cold season) and evapotranspiration. Also, melting of the snow cover is expected to occur one month earlier than at present.

As a consequence, it is possible to expect in the future climate an increment of flooding risk, due to the approaching of melting snow period with the peak of spring precipitation, and of drought risk, because of the diminution of precipitation and the evapotranspiration increase.

Therefore, the study about extreme events and related hydro-geological phenomena, whose frequency and magnitude are projected to increase, deserve a paramount importance.

To optimize this kind of analysis, it is necessary to consider that the definition of precipitation change shows less agreement than temperature predictions, due to its higher interannual variability, and the same consideration can be extended to extreme events versus average values. This fact does not surprise, especially considering the difficulty to represent phenomena that occur at smaller scales than those used in global climate models (GCM), such as those which are responsible for intense rainfall.

W13-27 Orale Fioraso, Gianfranco

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GEOMORPHOLOGICAL STUDIES FOR HAZARD ASSESSMENT IN GLACIAL AND PERIGLACIAL AREAS (WESTERN ITALIAN ALPS)

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Key terms: Little Ice Age; Geomorphological map; Glacier inventory; Western Alps

The aim of this study is the localization and characterization of glacial and periglacial areas of the Little Ice Age of the Piedmont's Alps (Cuneo and Torino provinces), with the aim of identifying typology and location of geomorphological hazardous processes. 85 glaciers, listed in the 1959's national glacier inventory (Catasto dei Ghiacciai Italiani of the Glaciological Italian Committee), have been considered.

By means of aerial photogrammetry, integrated by field surveys, detailed geomorphological maps (1:10000 scale) have been realised. Main geomorphological landforms and active processes, typical of glacial areas, have been represented, with special regard to instability phenomena and glaciers snout fluctuations. A particular attention has been given to glacial lakes, which formation and evolution are very important for hazard assessment.

Aerial photo interpretation, jointly with field surveys and historical documents' analysis, allowed a multitemporal reconstruction of glaciers area, length and width variations from Little Ice Age until now, debris and rock surface ratio variations, localization and evolution in time of instability phenomena.

For each glacier a brief description of his main features and variations occurred on long term period, based on the World Glacier Inventory, enriches the thematical cartography.

A few case studies from the investigated areas will be presented.

This paper is carried out in the framework of CNR-IRPI activities for the Alcotra 2007-2013 project N. 056 "GLARISKALP".

W13-28 Orale Pelosini, Renata

10.1474/Epitome.04.0028.Geoitalia2011

THE MULTI-HAZARD WARNING SYSTEMS AS A "SOFT" ADAPTATION TOOLS TO A CHANGING CLIMATE

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Key terms: adaptation; risk; warning system; climate change

The climate change leads to gradual changes in average variables such as the temperature, sea level, precipitation amount and distribution.

Moreover it modifies the climate variability contributing to more frequent, severe and unpredictable hazards linked to extreme weather events. This results in a strengthening of the potential impact of climate-related risk - e.g. floods, drought, heat waves, landslides - also due to the increase of vulnerability and exposure of people and their assets. The vulnerability

can be climate driven, through the degradation of ecosystem and ecosystem services, the reduction in water and food availability, the changes to livelihoods and the decrease the community's ability to cope with the even existing levels of weather-induced hazard, when the climate change adds stress to environment degradation and affects well-being of individuals and societies. Among the adaptation strategies, aimed to reduce vulnerability and enhance community resilience, the adaptive capacity, considered as the sum of the ability of institutions and social systems to learn, store knowledge and experience, adopt flexibility in decision making, assure the access to resources and build a responsive governance, is recognized as the main non-structural pro-active adaptation option able to grant more general environmental, economical and social benefits on a large scale. The adaptive capacity building and increasing is required by a correct and integrated approach to disaster risk reduction and prevention too, able to cope with the specific environmental and social context, to manage the residual risk and the acceptance concept, to account for the multidisciplinary and multiscale effects. Besides, the results from the risk management community, in terms of knowledge, tools, capacities to adapt to, effective risk communications expertise and the prevention measures inclusion in the policy, represent a robust framework for the climate change adaptation strategies development. In this work an heuristic approach to evaluate the regional climate-related risk enhancement is applied and the role of the natural hazard early warning systems and prevention related plans as soft adaptation options is shown. Mutual benefits in reducing the impact of weather and climate driven hazards can derive from the integrated analysis scenario and common tools improvement.

W13-29 Orale Von Hardenberg, Jost

10.1474/Epitome.04.0029.Geoitalia2011

AEROSOL OPTICAL DEPTH IN THE HINDU KUSH - KARAKORUM - HIMALAYA REGION: STATION AND SATELLITE DATA VERSUS GLOBAL MODELING RESULTS

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Key terms: Aerosols; Climate impacts; Mountain areas

The Hindu Kush - Karakorum - Himalaya (HKKH) region is characterized by large loads of atmospheric aerosols which can change the regional climate dynamics and the properties of the Indian monsoon. In this area, observational data on the atmospheric Aerosol Optical Depth (AOD) are available both from satellites (MODIS AQUA and TERRA) and from ground station data (the EV-K2-CNR Pyramid Laboratory in Nepal, at about 5000 meters a.m.s.l.).

Owing to the importance of the aerosol load in determining the properties of the regional circulation, of precipitation, of snow and ice melt and consequently of water availability, it is essential to reliably represent atmospheric dynamics and aerosol concentration in this area by global and regional climate models.

Here we consider results provided by a global atmospheric circulation model coupled with a module for aerosol transport dynamics. We compare model output with the available measurement data, to elucidate successes and pitfalls and to possibly improve the model performances. In particular, we focus on the period 2004-2009 and consider the output from the global atmospheric circulation model ECHAM5 with the aerosol module HAM, considering a range of different emission datasets (AEROCOM, IPCC and REAS) and different dynamical schemes for desert dust uptake.

W13-30 Key Lecture Vuillermoz, Elisa

10.1474/Epitome.04.0030.Geoitalia2011

ATMOSPHERIC MONITORING IN HIMALAYA: IMPACT OF ATMOSPHERIC POLLUTION ON GLOBAL WARMING AND HUMAN HEALTH

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Key terms: black carbon; ozone mountains; monitoring

NCO-P (Nepal Climate Observatory at Pyramid) station, installed in 2006 at 5.079 m asl in the Mt. Everest Region of Nepal, within the high altitude climate and environmental monitoring project SHARE (Stations at High Altitude for Research on the Environment), is providing continuous measurements of aerosol and trace gases, in particular Black Carbon and tropospheric ozone, considered among the most important anthropogenic contributors to the global warming, with direct impacts on human health and environment.

Concentrations detected at NCO-P during monsoon season have shown seasonal average values of 50 ng m⁻³ for BC e 39 ppbv for ozone, while in the premonsoon season these concentrations have reached seasonal average values similar to the concentrations normally measured in urban areas: 317 ng m⁻³ for BC and 61 ppbv for ozone. BC deposition on Himalayan snow and ice surface modifies albedo values with consequent effect on glacier melting dynamics. BC premonsoon concentrations have in fact allowed to estimate an albedo reduction of 2 - 5.2% and an increase of 24% of the typical seasonal runoff of a Tibetan glacier.. BC and ozone emission reduction could have a relevant impact in the definition of mitigation strategies, thanks to the short period of BC and ozone presence in the atmosphere (weeks and months). Such reduction could have also a consequent effect on radiative forcing decreasing. The availability of these scientific data could therefore provide an important support in the preparation of proper environmental mitigation measures by the local governments.

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SESSIONE A1

Metodologie integrate idrogeologiche, idrogeochimiche e geofisiche come strumento per la gestione degli acquiferi

A1-1 Key Lecture Francani, Vincenzo

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HYDROGEOLOGICAL SOLUTIONS FOR GROUNDWATER POLLUTANTS CONTAINMENT

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Key terms: BARRIER WELLS; HYDROGEOLOGIC ASSET; SEMIPERMEABLE WALL

The groundwater protection can be achieved by means of enhancing the hydrogeologic analysis, first of all of the optimal localisation of barrier wells, on the basis of an accurate description of the main parameters of the aquifer. We can demonstrate that the breadth of the capture zone of the barrier wells depends on the spatial distribution of transmissivity of the aquifer and of the impermeable limiting terrains. Furthermore can be demonstrated that the barrier wells efficiency depends mainly on the distance of the impermeable limits, and of the supply areas. This paper, analysing the possible solutions of this problem, deals with the changes that can be reasonably proposed in order to focus the accuracy of the projects on the importance of a correct interpretation of hydrogeologic asset, and of the definition of hydrogeologic parameters. Are moreover presented some earthwork that can satisfy with low costs the design of pollution containment, mainly of the recharge wells of groundwater, and of semipermeable barriers, that integrate the barrier wells. The paper debates in conclusions with the suitability of costs of this approach that guarantee the safety against the pollutions spreading.

A1-2 Orale Suozzi, Enrico

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PRELIMINARY STUDY ON THE SNOW-MELT FOR THE GROUNDWATER RECHARGE ESTIMATED BY ADVANCED METEOROLOGICAL STATION

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Key terms: snow-melt; groundwater; spring; Snow Water Equivalent; hydrogeological balance

In the hydrogeology field understanding groundwater recharge is essential for many purposes like: the successful management of water resources, the modeling fluid and contaminant transport within the subsurface. Groundwater is a critical source of freshwater through the world. Comprehensive statistics on groundwater abstraction and use are not available, but it is estimated that more than 1.5 billion people worldwide rely on groundwater for potable water (Clarke et al., 1996). Other than water stored in ice caps and glaciers, groundwater accounts for approximately 97% of freshwater on Earth (Nace, 1967; Shiklomanov and Rodda, 2003). As the world population continues to grow, in the future more people will need to use groundwater sources, particularly in arid and semiarid areas (Simmers, 1990). In many regions of the Alps, snowfall and the resulting seasonal snow cover represent an important source of water. When the snowpacks melt, it recharges the groundwater and replenishes surface water storage. Excessive snowmelt runoff can cause flooding, while inadequate snowmelt is often the prelude to later drought. In this preliminary study about the snow melt process we have tried to understand like is possible to measure the snow water equivalent (S.W.E.). Thanks to a collaboration project between the Politecnico di Torino and Regione Autonoma Valle d'Aosta, sponsor corporate, is born one of the advanced meteorological stations in Italy. It situates in Mascognaz Valley a little lateral valley in Ayas Municipality. This site is important because at least of 1 km from the station there are two springs so it's possible compared the different data about the snow melt and the flow rate, defining the time of travel from the infiltration point to springs. In the springs are installed two different probes one to measure the water level and temperature, in the second that is situated below, water level, temperature and also conductivity. In the advanced meteorological station is installed the best available technologies (B.A.T.), chosen from many factories in the world to study the snowmelt process. The station is composed by different instruments to measure the S.W.E., these are: snow scale product by Sommer Mess-Systemtechnik that is the evolution of snow pillow, the Pluvio 2 from OTT Hydromet that is a new generation of rain gauge, it is defined like the consistent advancement of the weighing precipitation gauge and, lastly, the buried rain gauge, a Prof. Vigna's project modified for this installation. Then we are used a Natural Resources Conservation Service (NRCS) methodology to calculate the S.W.E. modified after a long study on Alps snow density. The result shows like the instruments give a very good data, all are comparable between they self. The buried rain gauge is the best because it gives data about quantity and the time when the snowmelt process start. We have a increase of the flow rate, measured by buried rain gauge, eight day after the snow depth sensor starts to decrease. This time between the start of acquisition of the two instruments last named depends on the mountains aspects. The results of this project improve the knowledge about the snow melt phenomena, allowing, a better estimation of groundwater recharge and runoff.

A1-3 Orale Ortombina, Mirta

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ESTIMATION OF HYDRAULIC CONDUCTIVITY BY SLUG TEST METHOD IN A SHALLOW AQUIFER IN VENETIAN PLAIN (NE, ITALY)

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Key terms: hydraulic conductivity; slug test; middle plain

The following study is part of the Strategic Project of University of Padova

called GEO-RISK. The area at issue is located in the 'fontanili' zone of the middle Venetian Plain (Villaverla, VI). Topographically, the height of the area is between 56 and 50 m a.s.l., sloping from NW to SE.

As regards to the local hydrography are present a plain spring named 'Boiona' and the channels 'Boiona' and 'Beverara', which are the drainage network of the related plain springs. The subsol composition, and consequently the hydrogeological features, shows high heterogeneity with gravel horizons alternating with sandy, silty and clayey levels. In this area we study the shallow unconfined aquifer, essentially recharged by rainfall (Ortombina e Fabbri, 2011).

The analyses concern an hydrogeological study in an experimental site of 1.5 ha placed inside the drinking water supply area of ACEGAS-APS. The results regard the application of slug tests to calculate hydraulic conductivity (K) being that a fundamental parameter to model groundwater flow in an aquifer. The experimental data obtained were processed by Hvorslev (Hvorslev, 1951) and the Bouwer-Rice methods (Bouwer and Rice, 1976).

The tested piezometers have a depth ranging between 8.5 and 1.6 m and a diameter ranging between 3 to 2 inches.

A slug test involves the instantaneous injection or withdrawal of a volume of water; the water levels are measured at timed intervals as the water level goes back toward the static water level.

Using the Hvorslev method, if the length of the piezometer is more than 8 times the radius of the well screen ($L/R > 8$), the following formula is applied:

$$K = \frac{r^2 \cdot \ln\left(\frac{L_e}{R}\right)}{2 \cdot L_e \cdot t_{37}}$$

Where r is the radius of the well casing (m), L_e is the length of the well screen (m), R is the radius of the well screen (m), t_{37} (s) is the time for the water level to rise or fall to 37% of the initial change h_0 (m) (which represents the maximum difference respect the static level).

Instead, using the Bouwer-Rice method the relationship is:

$$K = \frac{r^2 \cdot \ln\left(\frac{R_e}{R}\right)}{2L_e} \cdot \frac{1}{t} \cdot \ln\left(\frac{h_0}{h_t}\right)$$

Where R_e is the radius of influence (m), R is the radius of gravel envelope (m) and t is the time since $h=h_0$.

Slug tests were carried out at the site, between 2010 and 2011, repeating more times the test for every piezometer to obtain an average value. An automatic pressure transducer (Mini-Diver) was used to record the water level changes into the well, allowing an acquisition data every 0.5s. The monitored data through Hvorslev and Bouwer-Rice methods were processed, obtaining a permeability value ranging from $7.5 \cdot 10^{-4}$ m/s for the downstream piezometer (P28) to $2 \cdot 10^{-4}$ m/s for the upstream piezometer (GP2). The calculated values by the two considered methods are comparable, although the Bouwer-Rice method tends to slightly underestimate the permeability results. The wide range of hydraulic conductivity found, is supported by the high stratigraphical heterogeneity observed also during the coring (Facinelli, 2010).

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A1-4 Orale Pera, Sebastian

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IMPROVEMENT OF GROUNDWATER VULNERABILITY MAPS BY USING ELECTRICAL TOMOGRAPHY.

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Key terms: electrical tomography; vulnerability; springs

Electrical and electromagnetic geophysical methods are widely used in groundwater investigation because of good correlation among electrical properties, geology and fluid content. Those techniques were successfully applied to heterogeneous media like hard rocks to the identify water bearing fractures (Sharma and Baranwal, 2005). In Switzerland, aquifers developed in hard rocks are the most important by surface. And related springs fulfill almost 44% of industrial and drinking water demand (UFAPP, 2004).

Swiss federal legislation establish, among other measures, wellhead protection areas for springs and wells serving public aqueducts. That, provides the legal basis to enforce restrictions to potentially hazardous activities. They are delimited considering the hydrogeological context and based on two key concepts: flow velocity for porous and/or homogeneous media, and vulnerability for highly heterogeneous fissured and karst media. Concerning vulnerability, specific methods were developed to assess it (UFAPP, 1998, UFAPP, 2003). Despite the wide use of vulnerability maps, one of the major uncertainties about water flow through heterogeneous rock masses, is the location of preferential pathways for water circulation developed by tectonics, weathering and/or karst processes. Knowing those preferential paths, improve water protection since land use restrictions can be specifically applied. In this work electrical resistivity tomography (ERT) was used to obtain 2D resistivity profiles within the basins of selected springs. Profiles intersected, and were performed in different directions (parallel and orthogonal to the hypothetical flow direction). Resistivity measurements were performed using an IRIS-SYSCAL PRO System, with a multielectrode cable consisting of 48 electrodes interspaced of 10 m. Full length (470 m) allows us to investigate about 100 m of depth at the center of the 2D

profile. Two different configurations: Wenner-Shlumberger (WS) and Dipole-Dipole (DD) were tested, observing always better results with the WS configuration. The apparent resistivity data were filtered, conveniently removing the noise effects, and topography incorporated into the model by the PROSYS software while, for the inversion of the field data, we used the RES2DINV software (Locke, 2004). Low resistivity areas associated with groundwater presence were identified on some sections of the obtained 2D profiles. A 3D representation of the profiles allowed us to reconstruct the subsurface structures and the preferential flow pathways. The result was used to improve vulnerability maps, assessed on the basis of surface information only. Loke M.H.; 2004. Tutorial: 2-D and 3-D electrical imaging surveys. Copyright (1966-2004) M.H. Loke, 136pp. Sharma S.P., Baranwal V. C.; 2005. Delineation of groundwater-bearing fracture zones in a hard rock area integrating very low frequency electromagnetic and resistivity data. Journal of Applied Geophysics 57 (2005) 155 - 166. Ufficio Federale dell'ambiente delle foreste e del paesaggio (UFAPP), 2004. Istruzione pratiche per la protezione delle acque sotterranee. Ufficio Federale dell'ambiente delle foreste e del paesaggio (UFAPP), 1998. Cartographie de la vulnérabilité en régions karstiques. Ufficio Federale dell'ambiente delle foreste e del paesaggio (UFAPP), 2003. Délimitation des zones de protection des eaux souterraines in milieu fissuré.

A1-5 Orale Rossi, Matteo

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STOCHASTIC ANALYSIS OF CROSS-HOLE GPR DATA FOR SUBSURFACE CHARACTERIZATION

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Key terms: Ground Penetrating Radar; Geophysics; permittivity; stochastic

GPR is a technique used to estimate soil moisture content. The easiest approach to obtain hydraulic parameters is the direct-wave approach, where point ZOP travel times are converted into ϵ_r . This approach does not take into account volume averaging and critical wave refractions. So the principal aim of the present work is to have a more complete view of how ZOPs are informative of the subsurface geometry and distribution of permittivity. An electromagnetic wave simulator has been applied within a stochastic Monte Carlo framework, so both averaging and critically refracted wave effects are taken into account. The simple direct-wave method is compared with the results obtained from the stochastic inversion. The aim of the stochastic approach is to reconstruct the dielectric properties distributions that can produce the measured ZOP signal. Every realization generates a random 1D ϵ_r geometry. For each ZOP shot, real and simulated travel times (TT) are statistically compared using chi-squared factor. For TT saved from the analysis, the Fresnel volume is calculated in an interactive method: the ellipsoid minor axis is obtained. The distribution of ϵ_r values related to each detected vertical segment is stored. Where overlapping segments are present, ϵ_r -distributions are intersected. In the end, an uncertainty quantification of ϵ_r in function of depth is possible, computing median, mean and data variance. We first considered a synthetic case made of an alternating sequence of thin layers (highest ϵ_r values) and thick layers (lower ϵ_r values). The synthetic profile, taken as the true field-measured ϵ_r profile, is a one-dimensional ϵ_r distribution. The permittivity geometry of the system is made to vary in a Monte Carlo manner with 20000 realizations. The results show that a large discrepancy is present between the curve obtained directly from the true first-arrival travel times and the true ϵ_r profile: the sharp geometry is smoothed. The finer high permittivity layer at is not reproduced in its features or is completely invisible for the direct-wave profile, in spite of its possible relevance in hydrogeological characterization. The variance of ϵ_r , derived from the stochastic approach, is about centred around the real profile, meaning that the results are close to the real physics of the system. The statistical analysis demonstrates that thin layers can be invisible to investigation, underestimated or misinterpreted, in spite of their high relevance in hydrological processes. The considered experimental dataset comes from a field site located at Gorgonzola, east of Milan. The unsaturated zone are composed of Quaternary sediments with a fairly coarse sand-gravel grain size distribution. Analysis of a soil core has provided direct knowledge of the site stratigraphy. We applied to this real dataset the same procedure described above. The direct-wave approach is not able to reproduce the sharp heterogeneities. The core log and the ϵ_r profile from the stochastic approach are in perfect accordance, reproducing the geometry of the system. The comparison between the geophysical inversion and the core log gives us confidence on the validity and applicability of the stochastic approach in this heterogeneous and complex subsurface system. The detection of the cemented layer as a high permittivity material is a key point for the identification of the subsurface hydrological behaviour. Both real and synthetic datasets illustrate how the often employed direct-wave approach is not able to take into account the complexity of the system, underestimating or overestimating the real permittivity values. Care must be used when inverting ZOP data for physical parameter estimation, misleading assignment of material properties could make the hydrological evaluation diverge from reality. The evidence is that thin clay layers are not well defined, large uncertainty.

A1-6 Orale Fiorucci, Adriano

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CORRELATIONS BETWEEN THE GEOLOGICAL SETTING AND GROUNDWATER FLOW: THE BOSSEA KARST UNDERGROUND LABORATORY

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Key terms: karst; Bossea cave; monitoring; thrust

The study of the Bossea karst system (Val Corsaglia - Southern Piedmont) began from the 80s through the installation of a scientific station located inside the cave, equipped with a set of instruments to monitoring the main hydrodynamic and hydrogeochemical parameters of the main collector water. Over time, many data logger have been installed for the automatic monitoring of flow in the fractured network that characterize the unsaturated zone of Bossea. Since 2000, it has began studies on the presence of radon in the natural cave, through the monitoring of this gas in the atmosphere and in the water. The geological structure of the Bossea area has heavily influenced the groundwater flow and the presence of radon.

The karst system is set in Briançonnais terrain of Ormea Unit - Element Navonera-Bossea-Prel. This element consists of a sequence of middle Triassic carbonate and Malm limestone, low-cut through a thrust surface, from the original substrate formed by Permian volcanics, Permian conglomerates and quartzites and Scythian pelites. The thrust, with a ramp-flat geometry and associated folds with convergence SW, is surrounded by late-alpine sub-vertical faults, that dislocate the surface. Consequently, the structural situation of the area has influenced the development of the karst network and the cave, that is set along the tectonic boundary between the impermeable substrate and the overlying carbonate succession. The cave is developed in the EW direction, in the first part, with a series of large collapse big halls, from an altitude of 826 to approximately 940 m a.s.l. Above this sector, the cave continues with a wide horizontal gorge sets along discontinuities also aligned in EW direction. The cave ends with two siphons connected by a series of full head gallery, that are explored up to -70 m from diver-speleologists. The catchment area is located between Maudagna and Corsaglia valleys and it is characterized by a karst covered by eluviations-colluvial deposits, with a series of karstic loss valleys. The infiltration water feeds the main karst collector (Mora torrent), which flows along the cave and issues with several springs near the Corsaglia torrent bed, at 800 m a.s.l. The main collector receives a lot of secondary inputs located along the cave. These contributions are related to underground flow in the rock mass discontinuities. The hydrodynamic and hydrogeochemical monitoring of these seepages has allowed us to collect useful data and information on the water network and the mechanisms that regulate the circulation of water in the unsaturated zone of a karst system. These inputs with discharges ranging from a few liters per minute to less than 0.5 l/s, may be temporary and are activated within several hours after the beginning of precipitation.

The monitoring of these points has highlighted the close relationship between the major inputs and the water flow in the fractures in the unsaturated zone, characterized by impulse increases of the flow. This kind of response is related to the growing of the hydraulic load in the aquifer network and consequently of the transfer of water pressure throughout the system (pressure waves). This phenomena, known as piston effect, is highlighted by marked and temporary increases in water temperature and electric conductivity. Particularly interesting is the study of the concentration of radon in water. Through new instruments, still used at an experimental level, the concentration of the gas is captured in the water of the main drain and a secondary tributary. The data show the close correlation between this parameter and the trend of system discharge.

A1-7 Orale Canora, Filomena

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HYDROCHEMICAL AND STABLE ISOTOPIC INVESTIGATION TO DETERMINE HYDROGEOLOGICAL PROCESSES IN THE "MADONNA DEL POLLINO" KARSTIC SYSTEM, SOUTHERN ITALY.

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Key terms: Hydrochemistry; Stable isotopes; Groundwater recharge; Madonna del Pollino

The contribution of oxygen and hydrogen stable isotopes to the hydrogeological research is well known: their use of, coupled with hydrochemical data, demonstrated useful in recognizing recharge areas, evaporation and groundwater mixing processes. The aim of the study was to assess the capability of these groundwater stable isotopes for refining the knowledge on recharge areas of the Madonna del Pollino fractured carbonate aquifer (Southern Italy), which represents an important groundwater resource of the region. The study area is placed in the high valley of the Frido River along the northern hillside of the Pollino Mountain; it is characterized by a complex geomorphological packing, resulting from of the litho-stratigraphic and structural features of outcropping terrains. Two separate geological Units, the "Pollino Unit" and the "Frido Unit", widely outcrop in the area showing tectonic contacts. The successions of the "Pollino Unit" consist of a lower part represented by carbonate formations outcropping in monoclinic structures, following the Pleistocene extensional and transcurrent tectonics. The "Frido Unit" limits the carbonate morpho-structure of "Madonna del Pollino": the Unit is constituted by metamorphic terms, as clay shales, and formations afferent to terrigenous ophiolites units. The western hillside of "Madonna del Pollino" is bordered by faults that brought this carbonate structure (fractured and karstic) to tectonically overlie the terms of the "Frido Unit". The geometric configuration of the aquifer is well defined by discontinuities and stratigraphic contacts: groundwater flow follows preferential pathways, defined by the net of fractures and karst channels. The ground waters of the "Madonna del Pollino" aquifer gush forth at about 1040 m a.s.l., in correspondence of a front constituted from at least ten springs, captured for supplying drinking water to a wide area of the Basilicata region. The spring front is situated in correspondence of the tectonic contact between the permeable Mesozoic limestone and the clayey-marly formations of the "Frido Unit". A large collection of hydrological, hydrogeological and hydrochemical data allowed a first evaluation of the hydrogeological balance, and recognition of recharge areas and main groundwater flow circuits. The depletion curve of the Frido springs was generated for determining the depletion coefficient and the underground storage. Groundwater samples were collected over a three-year period

(2003-2006) from several springs of the "Madonna del Pollino" aquifer, emerging at different elevations; sampling included groundwater inflows inside the Frido drainage trench.

Spring water samples were subject to hydrochemical and isotopic

analyses. The correlation between $\delta^{18}O$ and elevation, based on the spring elevation and the oxygen isotopic composition of precipitation (from literature data), and supported by the interpretation of the hydrochemical features of the same springs, allowed defining the altitude gradient and outlining the most probable altitude of the recharge areas for the examined springs.

Results of the hydrogeological, hydrochemical and isotopic studies outline the complexity of the karstic system, indicating spatial separation of groundwater pathways and presence of different drainage axes: groundwaters emerging within the drainage trench come from the highest elevations of the massif, where recharge occurs by rapid infiltration with little evapotranspiration prior to recharge.

A1-8 Orale Menichini, Matia

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MULTIDISCIPLINARY APPROACH TO PROVIDE DETAILED CONCEPTUAL MODEL OF THE AQUIFER SYSTEMS: AN EXAMPLE IN THE VERSILIAN COASTAL PLAIN (NW TUSCANY)

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Key terms: coastal plain aquifers; hydrostratigraphic cross-sections; hydraulic parameters; piezometric surface; geochemical and isotopic data

Detailed conceptual models of the aquifer systems are an essential base working for groundwater modelling and for a correct groundwater resources management. At the same time the right approach to obtain reliable conceptual models is certainly interdisciplinary, which guarantees the knowledge of geological, hydrogeological and geochemical features of the aquifer systems.

In this contribute an example of multidisciplinary study carried out on the Versilian coastal plain aquifers (NW Tuscany) is presented, underlining as the comparison between geological framework and hydraulic, hydrodynamic, chemical and isotopic data allowed at understanding the feeding mechanism of groundwater flow and at defining the seawater-freshwater mixing process.

The study area has an extension of about 55 km² and it has delimited by Poveromo and Motrone ditch, northward and southward respectively, and by shoreline and Apuan Alps, in the western and eastern parts. The Versilian plain constitutes a recent succession of alternating continental and marine deposits. Hydrostratigraphic cross-sections reaching a depth of about 80-100 metres were elaborated. Aquitards/aquicludes are locally interbedded to the prevalent aquifer terms, which are mainly made up by sand and gravel. Gravel is shallow in the inner portion of the plain, where the alluvial fan of Versilia River is present. Seaward gravel deepens and is overlain by sands. For this framework the aquifer results throughout a phreatic monolayer, although the local presence of superficial silty-clayey or peaty deposits may determine confined or semi-confined conditions. Moreover, the presence of a discontinuous subsurface layer of conglomerate and silty-clayey lenses may locally separate the groundwater flow in multiple levels.

In order to achieve the purpose of the present work, multiple types of hydrogeological and hydrodynamics surveys and chemical and isotopic analyses on water samples were performed. In details, two piezometric surveys and physical-chemical analyses (temperature, electrical conductivity, pH, Eh) were carried out in April 2009 (high level condition) and in September 2009 (low level condition). On the whole, 192 wells and 14 stream water points were examined.

Piezometric and iso-conductive maps suggest as the recharge area of the coastal plain is mainly the alluvial fan. Afterwards, more detailed hydrogeochemical analyses were performed. Major elements (Ca, Mg, Na, K, Cl, NO₃, SO₄, HCO₃), some minor elements (Br, F, B, As, Fe, Mn, Pb, Cr, Cu, Ni, Zn) concentration and some isotopic ratios ($2H/1H$, $18O/16O$ for water and $13C/12C$ of total inorganic carbon dissolved) were estimated. Vertical logs were also performed in order to measure the electrical conductivity and temperature into 10 wells next to the coastline. In addition, in the apex of the fan a long term pumping test was executed, determining the aquifer hydraulic parameters (K, T, S). The last, together with the potentiometric surface, allowed us estimating the groundwater flow rate at the section corresponding to the Versilia River entrance into the plain.

Finally, comparing all data, it was possible to identify the principal component which supplies the coastal aquifer system starting from the upper part of the plain, where the Versilia River feeds the groundwater hosted in its alluvial fan. Secondary contributes are linkable to the local rainfall infiltration, well recognized in the dune sand, and to the groundwater flow coming from some fractured complexes bordering the plain. Freshwater-seawater mixing processes were also individuated.

A1-9 Orale Preziosi, Elisabetta

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NATURAL BACKGROUND LEVEL ASSESSMENT AT THE GROUNDWATER BODY SCALE FOR MUNICIPAL DUMP IMPACT EVALUATION IN CENTRAL ITALY

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Key terms: Ground Water Directive; Aquifer; Natural Background Level; Threshold Value; Municipal Dump

Ground Water Directive (2006/118/EC) requests to EU Member States to derive appropriate threshold values (TV) for several potentially harmful substances, taking into account natural background levels (NBL) when necessary, in order to assess the chemical status for groundwaters. In Italy, several TVs have been set at the national level (Decree 30/2009); however TVs can be increased by Regions when local NBL are found to be higher. Additionally, when a ground water body is threatened by potentially polluting activities such as a dump filling, monitoring is mandatory at the site in order to evaluate possible negative effects on

groundwater quality: in such a case specific threshold values ("CSC") are regulated by Decree 152/2006 with sometimes more stringent values; the existence of NBL is also considered by this Act. In Lazio region,

concentration values exceeding CSCs have been detected at several municipal dumps for some substances including As, Fe and Mn. However, the natural origin of these substances is well known in central Italy due to the widespread distribution of volcanic formations of Plio-Pleistocene age. In these cases CSC derivation cannot disregard local NBLs. In this paper we present the first results of an on-going research project concerning NBLs derivation for several potentially harmful substances for ground water bodies in Lazio Region (Central Italy), in which municipal dumps are located.

The first considered is the Inviolata site, East of Rome, where a water table aquifer, circulating mainly in Pliocene deposits (clays with sandy horizons), is encountered at a depth varying from a few meters up to 30-40 meters, partially overlain by volcanics.

Sampling and laboratory analysis were conducted following IRSA-CNR methodology (APAT-IRSA 2003) in order to allow for repeatability. NBL assessment has been performed by two methods: 1) probability distribution functions (PDF) and 2) the pre-selection (PS) methods. PDF methods are grounded on the principle that the superposition of different sources (e.g. geogenic and anthropogenic) generates different data populations which can be distinguished by means of a statistical procedure: the break point between the natural population and the contaminated one is taken as NBL. On the other hand, PS methods propose to remove from the initial data set those samples which are characterised by e.g. high nitrate contents or other markers of human activities. In the residual data set one value (e.g. 95th percentile) is chosen as representative of the NBL, meaning that all concentrations exceeding that level should be ascribed to anthropogenic sources. Results of the two methods are compared and discussed.

In both procedures the identification of a unique value separating the "natural" values from the "anthropic" ones, can be difficult. Critical issues include: 1) the selection criteria for the PS methods: as an example, the suggested nitrate threshold of 10 mg/L seems too restrictive. In the case study a less stringent value (50 mg/L) was chosen to get a statistically significant number of samples (at least 30). 2) The choice of the percentile in PS method can lead to important differences in the NBL when the data distribution is strongly right skewed. 3) On the other hand, PDF methods seems to be more influenced by subjectivity, and individuate a range of values rather than a definite concentration. In the case study, values issued by PDF are generally lower than the PS ones. As a conclusion, the PS method seems more appropriate for the administrative definition of TV. However, exceeding one parameter at one control point may trigger the characterisation procedure. TV assessment in these cases is a particularly delicate matter as it makes a sharp divide between natural and anthropogenic contamination. The percentile rule (whatever the percentile be) could result inadequate and the problem of the effective representativeness of the sampling remains a critical point.

A1-10 Orale Pietrini, Ilaria

10.1474/Epitome.04.0040.Geoitalia2011

PROCESSING OF A HYDROGEOCHEMICAL APPROACH BASED ON THE METHODOLOGIES OF COMPOSITIONAL FINGERPRINTING TO CHARACTERIZE THE CONTAMINATION IN THE ITALIAN SITES.

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Key terms: hydrocarbons; compositional fingerprinting; groundwater contamination

Petroleum hydrocarbons and chlorinated solvents are the most frequently discovered chemicals of concern at contaminated sites. Petroleum is a complex mixture of a thousand of different organic compounds formed primarily by hydrocarbon and hydrogen and each crude oil has an own specific "fingerprint". Moreover, fingerprints of the different oil products present differences that come from the different crude oil of origin and also from the oil refinery cracking processes that undergo. These fingerprints are obtained as Total Ion Chromatogram (TIC) by the employ of a proven laboratory technology, based on the combination of the two instruments GC (gas chromatographer) and MS (mass spectrometer), that allows to a rapid separation and identification of compounds in complex mixtures. TICs represent also a tool suitable to determine the degree of compounds alteration leading to the dating of contamination. In fact, once in the environment, the structures of crude oil and his derivatives change under the effects of different physical, biological and chemical processes with the loss of n-alkanes, isoprenoids and the more easily degradable biomarkers. These compounds are lost following a specific sequence, then some compounds are degraded first while compounds more recalcitrant to degradation increase their relative concentrations. These changes are reflected in the fingerprints and give a trace to dating contamination and to identify the grade of biodegradation, if it is occurred. Thus, fingerprinting is defined as a methodology to characterize the type of the oil contaminant, quantify the concentration of the compound and identify the composition of all compounds within the oil contaminant that can be used to reliably determine the source and understand the fate and the transport of the oil contaminant.

For all these reasons, fingerprinting methodology can also represent a tool to determine responsibility in legal context. Our legislation assess that those who are responsible for contaminating the environment have the duty to pay for the remediation of the contaminated area or, in civil contest, pay for the environmental damage. In fact, it is often very difficult to find those responsible of contamination especially if there are more plants suspected to be responsible and historical changes of plant's owners. In addition, most of the contaminations present in Italy are very old and, as stated above, structures of the pollutants present in the environment change under the effect of different processes.

Despite all these evidences, few studies have been carried out in Italy to identify sources of contamination using a multidisciplinary approach coupling compositional fingerprinting analyses with classic hydro geochemical investigations. Experiences gained in the past years give evidences of the importance of this tool and, on the other hand, underlined the necessity to contextualize it in the Italian reality. Our scope is to reach this purpose by testing and then choosing the best methodology of sampling and analysis to obtain a reliable fingerprint of the contaminant and by the identification of the characteristics of the petroleum products mainly diffused in our country. This research is carried on by the group of Applied Geology and by the Department of Chemical Engineering of the Politecnico di Milano.

To achieve the main objective of this research project, that is the

identification of the best sampling procedure and methods of analysis, we are currently performing several tests in a site contaminated by hydrocarbons. Especially we have identified two different areas: a "test area" with a known contamination of diesel to validate the sampling procedures and the methodology of analysis and an area with an unknown contamination where this methodology can be employed coupled with the usual hydro geochemical analysis to reliably define the contamination. In this occasion we are presenting our preliminary results.

A1-11 Orale Bonetto, Sabrina

10.1474/Epitome.04.0041.Geoitalia2011

GROUNDWATER QUALITY AND FLUORIDE CONCENTRATION IN THE WEST ARSI ZONE (OROMIA REGION, ETHIOPIA)

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Key terms: Ethiopian Rift Valley; groundwater resource; water quality

This study focuses on the quality definition of groundwater supply in the Lake Region of the south-centre of the Main Ethiopian Rift Valley. In particular, the study area is located south from Addis Abeba and included three administrative divisions (woredas) of the West Arsi Zone (Oromia Region): Shashemene, Arsi Negelle and Siraro Woredas. Despite of the presence of many lakes, water supply is completely dependent on the rainfalls because of both the short number of perennial streams, the low quality of superficial water and the lack of water supply facilities.

The geology of the study area is characterized by volcanic rocks such as trachyte, rhyolites, ignimbrites, ashes and tuffs that belong to the Nazareth series of Neogene age group (Ethiopian Government, Geological map of Ethiopia, 1996). Thick soil deposits cover the rocks in most parts of the study area. The trachytes and rhyolites are moderately weathered but highly fractured. An abundance of parameters indicates the ongoing volcanic activity in the area. Generally the area has gentle slopes and in most cases it is flat lying.

Due to the geological features and permeability conditions, volcanic rocks could be considered as a fractured aquifer in presence of open fractures and faults or porous aquifer in case of highly fractured rocks; permeability decrease with alteration degree. The hydrogeological model of the area include two main aquiferous formations: a superficial porous aquifer (loose fluvial and lacustrine deposit and/or highly fractured-altered volcanic rocks) and a deeper aquifer mainly represented by fractured volcanic rocks or, occasionally, by coarse grained fluvial deposits.

Due to the variation in the regional geology and water/rock interactions, high concentration of many chemical elements can occur in such waters. In particular, after many years of use of drinking water from drilled wells in the Rift Valley, dental and skeletal fluorosis has become a serious medical problem. The fluorosis is due to a high intake of fluoride from drinking waters.

The research included a field work which consisted in water samples collection from wells and springs in small villages and settlements, scattered throughout the Shashemene, Arsi Negelle and Siraro Woredas. The wells were divided into "deep drilled wells" and "shallow hand-hug wells". The majority of drilled wells thus draw water from bedrock, while the majority of the hand-hug wells draw water from sediments. To obtain a more complete pictures of water quality in the area, a few additional samples from rivers were also collected and analysed. In the laboratory of the University of Turin, the samples were prepared and used for anions and cations analysis. Electrical conductivity, pH and fluoride concentration were directly measured on the field.

As regard to the fluorides, the World Health Organization recommend as maximum acceptable concentration limit for fluoride the value of 1,5 mg/l. For warm waters (above 25°C) or in tropical countries with a high daily intake of drinking water an action level of 0,7 mg/l of fluoride has been suggested in literature (WHO, 2006). More than 45% of the collected samples surpass the level of 0,7 mg/l F: 69,7% of the deep and shallow wells; 5% of the springs.

The 24,5% of analysed samples returned values exceeding the European and the WHO Maximum Acceptable Concentration of 1,5 mg/l F: 36,4% of deep and shallow wells; 5% of the springs.

The maximum concentration recorded in this study is 28,575 mg/l for thermal spring and 13,083 mg/l for borehole. Values of the analysed chemical parameters show a variability in the hydrochemical features of groundwater both with geographical location and depth.

A1-12 Orale Zhao, Ye

10.1474/Epitome.04.0042.Geoitalia2011

HEALTH RISK OF PESTICIDE INTAKE OF VERCELLI PLANE RESIDENTS THROUGH GROUNDWATER

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Key terms: pesticide; risk; groundwater

The study area, Vercelli is situated on the river Sesia in the plain of the river Po between Milan and Turin. It is an important centre for the cultivation of rice, and is surrounded by paddy fields.

As a result of agricultural practices, pesticides and nitrate have been detected in many aquifers and surface waters. Contamination of groundwater by agrichemicals (pesticides and fertilizers) is recognized as an extremely important environmental problem in this area.

Continuous use of pesticides results in damage to the environment and can cause human health problems, which could have a negative impact on agricultural production and reduce agricultural sustainability. Several pesticides including bentazon, molinate, propanil and especially atrazine have been detected in wells, rice field and surface water in this region, although some of them are forbidden to use for many years.

The contamination of air, soils, surface and ground waters has evident negative impacts on public health, and on biological diversity. Atrazine is typical candidates of herbicides and have been applied in a large scale with a great deal of consumption. However, atrazine and its metabolites would end up in natural waters, which have to be considered as a serious problem for environmental safety and human health.

In order to assessment health impacts of atrazine and other toxic trace elements in well water in Vercelli plane, groundwater and surface water samples were collected in this area. With the soft RISC, human health risk from exposure to contaminated media were estimated, simple fate and transport modeling were performed, meanwhile, risk-based clean-up

levels in various can be calculated.

In this study, several intake route of pesticides were considered, including ingestion of soil, dermal contact with soil, inhalation of indoor air, ingestion of surface water, ingestion of home-grown vegetables irrigated with groundwater, ingestion of irrigation water and dermal intake with irrigation water.

A1-13 Orale Lasagna, Manuela

10.1474/Epitome.04.0043.Geoitalia2011

HYDROGEOLOGICAL SETTING AND GROUNDWATER SAFETY IN AN OVEREXPLOITATION SITUATION: THE VALLE MAGGIORE CONTEXT (PIEDMONT, ITALY)

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Key terms: groundwater; overexploitation; well field; hydrogeologic model; Piedmont

The well field in the Valle Maggiore, at which about 14,000,000 m³/year are extracted by means of 37 water wells, play a fundamental role in supplying drinking water to a large territory of the Asti district (Central Piedmont, Italy).

Since 1996 to present, a groundwater withdrawal of about 1,000,000 m³/year has been recorded at the well field, because of a continuous increase of water demand. This situation has caused an overexploitation of the deep aquifer, evidenced by the progressive lowering of the piezometric level (locally up to 0,8 m/year) and the consequent spatial reduction of the artesian zone.

The study of the geologic setting and the hydrogeologic reconstruction of a wide area around the Valle Maggiore were the first step of this work. From these elaborations, three hydrogeologic complexes have been recognized:

- ° a superficial unconfined aquifer, constituted by Pleistocene-Olocene gravelly-sandy unit and sandy-silty unit, whose water table is directly connected to the hydrographical network; the aquifer has been individuated in the Po plain and Poirino Plateaux;

- ° a particularly thick and permeable deep confined or semi-confined aquifer, represented by a Villafranchian unit (middle Pliocene-lower Pleistocene) and a lower Pliocene sandy unit (Sabbie di Asti);

- ° an aquiclude, at the bottom of the aquifer sequence, consisting of a lower Pliocene silts-clays unit (Argille di Lugagnano) and a Pre-pliocenic clays-marls unit.

The Pliocene sandy unit, with a hydraulic transmissivity of about 10⁻³ m²/s, is largely exploited by the well field of Valle Maggiore.

A piezometric map of the deep aquifer has been elaborated starting from water level measurements of August 2009. In the wide area around the Valle Maggiore, the groundwater flow is generally directed toward east; the piezometric surface shows a pronounced cone of depression in the well field, because of the intensive groundwater pumping. On the basis of the hydrogeologic conceptual model, the recharge area of the deep aquifer is located toward the Po Plain, west of the study area; most likely the deep aquifer is recharged by Po river.

On the contrary, the superficial aquifer is generally directed westward; this aquifer is recharged by precipitations and locally by superficial waters. In order to decrease the overexploitation, four different scenarios for a better groundwater management at Valle Maggiore well field have been proposed, by utilizing Modflow code:

- ° in three cases a withdrawal decrease of 20% has been simulated, considering or not the displacement of some wells out of the well field zone of influence;

- ° the fourth case simulates a significant withdrawal reduction of 150 l/s, as a result of the possible connection with the water supply of the Monferrato Aqueduct, located north of the study area.

All the simulations provide an increase of the piezometric level, even up to 30 m. The fourth scenario seems to ensure the better performances: the piezometric level rises up to 27 m in the Valle Maggiore area and the current amount of drinking water would be preserved without having to build new wells.

A1-14 Orale Garetto, Anna

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VAPOR INTRUSION AT A CHLORINATED SOLVENT SITE - SAMPLING TECHNIQUES COMPARISON AND MONITORING CHALLENGES

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Key terms: vapor intrusion; ambient air; sub-slab gas; attenuation factor

Degradation of air quality into a building due to vapor intrusion is a source of concern for all the sites affected by groundwater or soil contamination. In particular, vapor intrusion is a potential exposure pathway at sites with the presence of volatile chemicals and there is an increasing number of sites with significant vapor intrusion impacts. While aerobic biodegradation of the vapor phase has proven to be an effective risk reduction mechanism at many petroleum hydrocarbon contaminated sites, vapor intrusion is increasingly becoming the main risk driver at sites contaminated by chlorinated solvents, due to their high volatility, low or negligible degradation in the vapor phase, complex and hard to remediate source zones and low toxicity thresholds.

The case study presented is related to an industrial site located into a residential area in a town in northern Italy. At the Site, soil and groundwater are impacted by chlorinated aliphatic hydrocarbons. A remediation system combining pumping of groundwater and soil vapor extraction (SVE) is active since a few years. Further comprehensive Site investigations carried out using a Membrane Interface Probe "MIP" coupled with a traditional Soil Gas Survey (SGS) detected the presence of soil vapors in areas outside of the SVE system area of influence.

Recently, a new program for soil vapor monitoring activities has been put in place including sub-slab soil vapor sampling through fixed sampling probes and ambient air sampling. Twenty three leak-tested permanent soil gas probes were installed in order to carry out routine monitoring, using summa canisters for ambient air sampling and sorbent tubes for soil gas and sub-slab gas.

The case study focuses on the differences between the results of different

soil gas investigations (SGS, MIP and sub-slab vapor sampling) and analyses the variations of the vapor attenuation factor α in different areas of the building and in different periods of time, in function of the geometry of the plume, of the site hydrogeology, of the construction and structural design of the building and of the temperature and barometric pressure differences.

A1-15 Poster Corniello, Alfonso

10.1474/Epitome.04.0045.Geoitalia2011

HYDROGEOLOGY AND HYDROGEOCHEMISTRY OF THE GARIGLIANO RIVER PLAIN (SOUTHERN ITALY)

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Key terms: *Garigliano River plain; HYDROGEOLOGY; HYDROGEOCHEMISTRY*

The Garigliano River plain (about 170 km²) is a NE-SW oriented graben filled with upper Miocene-Quaternary infralittoral, deltaic and continental clastic deposits, containing in the uppermost part volcanoclastic sediments from nearby Roccamonfina. Along the SW border two sand dunes run parallel to the coastline. These sand dunes in the past created secluded ponds and coastal lagoons filled by groundwater, runoff and direct rainfall which could not reach the sea. Nearby, in Latium and Campania, there were other wetland plains, very unhealthy and affected by malaria. Land reclamations plans began in 1856.

Stratigraphic reconstruction of the main aquifer obtained by interpolating stratigraphic data from more than 80 boreholes allows to draw up the Hydrogeological map, Hydrogeological cross-sections and the 3D lithologic model (using the software ROCKWORKS 2006). The main aquifer consists of marine and alluvial deposits, often of relevant thickness; the piezometric pattern, defined by the piezometric network consisting of more than 60 sites measured in April-May and December 2009, shows the groundwater flow directed toward the sea and the Garigliano river. Between the first and the second field campaign measurements, piezometric differences were low in the flat area; more considerable differences (ranging between 0.5 and 1.0 m) were recorded along the slopes of the Roccamonfina volcano and at the foot of the calcareous mountains bounding the Garigliano Plain.

In the two campaigns, hydrochemical sampling was conducted in the same wells used for the piezometric measurements. Chemicals analysis allowed to draw up the "Hydrochemical Facies Map" and to verify the consistency over time of the Hydrochemical Facies. Otherwise, the total ion content depends on the amount of the recharge.

NO₃ and Fluoride contents often and widely exceed the drinking-water quality guidelines of 50 and 1,5 mg/L. The Fluoride content is strictly related to the piezometric pattern. Close to the Garigliano river, lower nitrate content is related to reducing conditions, testified by low values of SO₄ and high content in Fe and Mn. Afterwards, the isotopic analysis (15N/14N and 18O/16O ratios of dissolved nitrate) were carried out by the CNR-Roma in groundwater of some wells.

Starting from this broad hydrogeological knowledge, the following maps to evaluate the "Contamination risk" were drawn up:

• The "Pollution Vulnerability Map", evaluated by the SINTACS parametric system;

• The "Agricultural Hazard Map", rated by the parametric models IPNOA (Danger Index by Nitrates of Agricultural Origin).

All the data and the maps were stored in a geographic database and managed by GIS.

The good correlation between the "Potential Agricultural Nitrate Contamination Risk Map" and the nitrate content distribution suggests that the source of the groundwater nitrate is chiefly related to intensive cropping or livestock. The results of isotope analysis confirm the hypothesis of the agricultural origin of nitrates and the validity of the use of parametric methods at medium/small scale to individuate the source of nitrate in groundwater.

A1-16 Poster Vespasiano, Giovanni

10.1474/Epitome.04.0046.Geoitalia2011

PRELIMINARY HYDROGEOCHEMICAL CHARACTERIZATION OF A GNEISSIC-METAMORPHIC ACQUIFER IN THE SILA MASSIF (CALABRIA)

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Key terms: *hydrogeochemical; aquifer; water-rocks interaction*

The aim of this research is the geochemical and hydrogeological characterization of a gneissic-metamorphic aquifer in the Sila massif. The Sila massif represents the main morphostructural high of northeastern Calabria and constitutes a widespread groundwater reservoir. In the eastern margin of Calabria, crystalline and metamorphic units of the Calabride complex crop out, comprising the tectonic units known as the Polia-Copanello-Garigliano unit and the Sila Plutonic complex. The studied area consists of biotite-sillimanite-garnet gneisses with massive or migmatite texture.

A preliminary characterization is carrying out on springs and well waters. Temperature, pH, Eh and electrical conductivity were measured in the field by means of portable instruments. Waters were filtered in situ through a

0.4 μ m pore-size polycarbonate membrane filter and acidified by addition of suprapure acid.

The concentrations of Cl⁻, Br⁻, SO₄²⁻, F⁻, NO₃⁻, and PO₄³⁻ were determined by HPLC, whereas Ca²⁺, Mg²⁺, Na⁺, K⁺, Si and some trace elements, were analysed by a quadrupole ICP-MS (Perkin Elmer/SCIEX) with collision reaction cell capable of reducing or avoiding the formation of polyatomic spectral interferences. Data quality for major components was evaluated by charge balance while for minor and trace elements it was checked running the NIST1643e standard reference solution.

The chemical composition of springs and well waters was characterized in terms of relative Cl, SO₄ and HCO₃ concentrations and Na+K, Ca, and Mg contents by using triangular plots. Inspection of the data show that, in groundwaters from

gneiss, the dominant cation is Mg.

The high contents in Mg results from the dissolution of mineral phases rich in Mg.

For this aim, petrographic investigations are being conducting by means of optical microscope on thin-section and XRD analysis. These preliminary investigations indicate that gneisses are characterized by a mineralogical assemblage of biotite + sillimanite + garnet + plagioclase + quartz \pm orthoclase \pm cordierite \pm muscovite.

Other analysis for the investigation of water-rocks interaction are still in progress.

A1-17 Poster Gambillara, Roberto

10.1474/Epitome.04.0047.Geoitalia2011

HYDROLOGICAL AND GEOPHYSICAL APPROACHES FOR THE CHARACTERIZATION OF LIVIGNO VALLEY AQUIFER (NORTHERN ITALY)

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Key terms: *Livigno; hydrology; geophysics; mountain aquifer*

In the last few years, a progressive impoverishment of water resources took place in the mountain; this is due to the increase of anthropic activity and to the change in the precipitation regime. In this context, the preservation of every aquifer will acquire great importance. In particular, the mountain fissured aquifers could play a relevant role in the water supply for the mountain people, although they have a limited productivity. In the mountain environment, for a better reconstruction of groundwater system is suggested the multidisciplinary approach, because it permit to maximize the merit of both methods.

The aim of this study is the characterization of Livigno Valley aquifer integrating two approaches: hydrological and geophysical.

The Livigno area represents a good test for the groundwater system reconstruction in the mountain environment because it has a complex geological and tectonical setting and because, in this area, the density of population varies greatly during the year and this generate a shortage of water in some seasons. The better management of the water resource of the Spol Valley (Livigno Valley) is important to increase the contribution in the water supply.

The Livigno area is located at 1800 m a.s.l. in the central Alps (northern Lombardy - Italy). For the tectonic setting this area is comprise between the Err Bernina system (Lower Australpine) and the Ortles-Quaternals system (Upper Austroalpine). The most important regional fault is represented by Zebù fault. This fault divides the sedimentary rocks constituted by Fraelle and Monte Motto limestone (Lias) to crystalline basement, which is constituted by "Bormio phyllades" and "Punta Rossa Formation". To the north of Zebù fault system the Alpisella fault system outcrops and divides the Monte Motto limestone by Triassic dolomites and limestones.

The hydrological approach consists of the series of Spol flow rate measurements along the river transept: 9 measurements twice a year (on July, during the snowmelt, and on September, during the dry spell). The instrument used (CORRENTEK) detects the speed of the propeller for a period equal to 10 s, returning a value of speed. The measurement is taken perpendicularly to the section and the result is punctual. Taking a summation, the flow rate of the entire section of river bed is obtained. The results show a flow rate depletion at Tresenda-Campacciolo area.

The geophysical approach gives informations about the valley subsoil and allows to distinguish different layers of deposits. This approach is constituted by the seismic refraction and ERT surveys along the Spol transept: six areas are investigated (Alpe Vago, Tresenda-Campacciolo, S. Rocco, Livigno, Case di Pemonte, Ponte del Bram). These methods have been calibrated at Tresenda-Campacciolo area, where exists the well section. For the seismic refraction the instrumentation used is a PASI, which includes a computer-seismograph (model 16S12-N), 24 channels (geophones) to acquire the signal, and a source of seismic waves consists of a hammer of 10 kg. In seismic refraction survey maximum depth investigated is about 40 meters, and only in one case the bedrock was detected.

For the ERT was used the PASI instrumentation (model 16GS32, Figure 3.20), which includes a computer-resistimeter, connected to a battery 12 V - 75 A, 32 electrodes for measuring potential.

The first integration of all data demonstrates that the Spol river feeds the underground aquifer at Tresenda-Campacciolo area, and downstream this area, at S. Rocco, the multi-aquifers are detected. In particular the deep aquifer is found by the investigation; this is separated from the others by alluvial deposits.

A1-18 Poster Rapti, Dimitra

10.1474/Epitome.04.0048.Geoitalia2011

STRUCTURAL CONTROL ON GROUNDWATER FLOW AND VULNERABILITY OF AN AQUIFER SYSTEM

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Key terms: *vulnerability; karstic aquifer; structural control; hydrochemistry*

In the Mediterranean area, carbonate aquifers represent an important drinking water resource, which is, however, particularly vulnerable to contamination. The Castelluccio area, Basilicata Region, is one of the most important carbonate aquifer systems in southern Italy. This aquifer is formed in limestone and dolomitic limestone and shows different degrees of fissuring and, in places, karstic features. The considerable groundwater flows with mean discharges of about 500 l/s and outcrops from several scattered springs. The main spring is located at San Giovanni di Castelluccio and it is represented by some resurgences outpouring along an important high angle fault plane, which places side by side the high permeability fissured limestones and the low permeability fluvial-lacustrine sandy-to-muddy deposits, so generating a typical fault-spring case. In the present research, hydrological, hydrogeological and hydrochemical data integrated with several structural surveys are analysed in order to a) evaluate the influence of the principal structural elements to groundwater flow and b) define the conceptual hydrogeological model and the intrinsic vulnerability to pollution of the aquifer system.

SESSIONE A3

Applicazione delle tecniche isotopiche allo studio, valutazione protezione delle risorse idriche

A3-1 Invitato Gonfiantini, Roberto

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THE BEGINNINGS OF ISOTOPE HYDROLOGY. FIRST SCIENTIFIC BACKGROUND, MEASUREMENT TECHNIQUES, AND FIRST INVESTIGATIONS AND APPLICATIONS TO NATURAL WATERS. THE BEGINNINGS IN ITALY.

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Key terms: Isotopes; Hydrology; Analytical techniques; Italy

In XX Century hydrology has finally completed its transformation from empirical activity to science, with the help - sometimes decisive - of isotopes. Isotope hydrology begins shortly after discovery of the stable isotopes of oxygen (1929) and hydrogen (1932), and of tritium and carbon-14 in nature after the WW2. It then develops in the first fifties under the guidance of Harold Urey and Willard Libby, both at the Institute of Nuclear Physics of Chicago University, later renamed after Enrico Fermi. The IAEA support through Brian Payne was also essential.

About at the same time, the determination of water isotopic composition reached adequate analytical quality and capacity. For stable isotopes, we moved from the laborious density measurements of the thirties, to the rapid and precise differential determinations with the gas mass spectrometer developed by Nier. For radioactive isotopes, proportional counter were constructed capable of identifying tritium and carbon-14 decays from the released energy, and eliminating cosmic radiation by means of external coincidence counters. Subsequent refinements improved more the efficiency than the accuracy of measurements. Among new techniques, laser spectroscopy for stable isotopes in water and accelerator mass spectrometry for carbon-14 are worth mentioning. With the latter technique, the quantity of material needed for the measurements has been reduced to few mg, so promoting the use of carbon-14 in dating groundwater from remote regions.

Natural waters contain several isotopic species, among which ¹H²16O is by far the most abundant (99.73%) and slightly more volatile of the rare species ¹H²H¹⁶O and ¹H²18O. Therefore rains and fresh waters, all deriving from repeated evaporation and condensation processes starting from ocean water, are depleted in heavy isotopes. These isotopic fractionations were discovered already during the thirties, but two decades elapsed before they found systematic application in studying precipitation and continental waters, and Quaternary climatic changes recorded by the isotope variations in polar ice. Harmon Craig, Willi Dansgaard, Sam Epstein, Irving Friedman, Etienne Roth were the founders of these studies. Probably tritium would have had limited application in hydrology without the atmospheric thermonuclear tests, which drastically affected the natural tritium cycle: in fact, during the 1952-1962 decade 650-700 kg of thermonuclear tritium were injected mainly in the stratosphere, compared to a natural production of about 3.5 kg/a. In this way a global tracing experiment of meteoric water was performed, which during four decades supplied a tremendous amount of information on the atmospheric and continental cycles of natural waters. The beginners of these studies were Libby, Fritz Begemann, Robert Brown, Erik Eriksson.

Carbon-14 is used in hydrology for studying groundwater dynamics in deep aquifers. It is one of the few methods available for dating waters recharged thousands of years ago - often in climatic and rain amount conditions drastically different from the current ones. Karl-Otto Münnich, John Vogel, Hans Oeschger, Jean-Charles Fontes were the founder of the method.

The cradle of isotope hydrology in Italy was the Nuclear Geology Laboratory created in Pisa by Prof. Ezio Tongiorgi around 1955. The laboratory attracted scientists from all over the world for studying periods and training. Isotope investigations were performed in Pisa on precipitation and polar ice (the Laboratory participated in Belgian-Italian expedition to Antarctica), runoff and lake water, cold and hydrothermal groundwater, leaf water, evaporating salt water. In those early times, many aspects of the isotopic cycle of water were not well known, and several new facts were discovered.

A3-2 Invitato Kloppmann, Wolfram

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NEW ISOTOPES FOR NEW WATERS: GEOCHEMICAL TRACING OF UNCONVENTIONAL WATERS IN REGIONAL CYCLES

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Key terms: unconventional water resources; water management; environmental isotopes

Increasing pressure on global water resources has led to worldwide search for alternative water management options including the use of unconventional water resources as saline waters or waste waters. Artificial recharge, is gaining importance as a means to actively manage the balance of groundwater resources exploited for human needs, mainly drinking water and agriculture. During the next decades, "man-made" freshwater produced by desalination and waste-water treatment is expected to become a predominant water source in water-scarce areas of countries where demand exceeds natural replenishment and where the economic framework allows appropriate water treatment and management.

Chemical and isotopic fingerprints of the new types of water introduced intentionally or not in natural systems are needed to enable us to backtrack their pathways and estimate their contribution to the water balance of over-stressed water resources. Environmental isotopes have proven their exceptional efficiency and versatility when applied to natural and polluted water resources. The isotopic toolbox at the disposal of hydrogeochemists has been considerably completed over the last years due to new techniques like multi-collector ICP-MS. These new tools are now increasingly applied to groundwater systems where unconventional recharge components prevail.

We present examples of multi-isotope tracing (B, Li, Sr, O, H, S) of desalinated water and treated wastewater in aquifer systems in Israel and

Belgium. Measurement in commercial reverse osmosis (RO) desalination plants in Israel and Cyprus revealed distinctive geochemical and isotopic fingerprints of fresh water generated from desalination, in particular for boron (Kloppmann et al., 2008a). For the first time this specific signature has been found in effluents of the Tel Aviv area, partly supplied since 2007 by freshwater from desalination (Kloppmann et al., 2011). This wastewater is reused after treatment for artificial recharge into the coastal sandstone aquifer. Water is then pumped and used in the Negev for irrigation and it can be expected that the observed signatures will be traceable throughout the system.

In Belgium (Kloppmann et al., 2008b), municipal effluents are treated through secondary and tertiary treatment including reverse osmosis, then infiltrated into a sandy coastal aquifer, pumped and then distributed as drinking water after a final treatment. Isotope systematics reveal and quantify the lateral penetration of unconventional recharge into the aquifer, prove the confinement of the whole system, even vertically as the site is underlain by paleo-waters of Pleistocene origin.

In sum, in the global water cycle, "man-made" freshwaters will gain increasing importance. In some way, entire sub-cycles of the water cycle will be artificial and environmental isotopes reveal a powerful tool to elucidate the superposition of natural and artificial water flows.

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A3-3 Orale Martinelli, Giovanni

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ISOTOPIC GEOCHEMICAL FEATURES OF THE EMILIA-ROMAGNA GROUNDWATERS

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Key terms: stable isotopes; radiometric age; palaeoclimate; groundwater pollution

Isotope geochemistry of Emilia Romagna groundwater has been studied. In particular ¹⁸O/¹⁶O, D/H, ¹³C/¹²C, ¹⁵N/¹⁴N ratios have been considered as well as Tritium and ¹⁴C content.

About 400 wells characterized by well known stratigraphic log and filter position have been selected in the plain area of the southern part of the Po valley.

The Emilia-Romagna Region has a surface area of 22,123 km² and is geographically located in the southern part of the Po Valley. It is bounded by the Northern Apennines to the South and by the Adriatic Sea to the East. The Po valley sedimentary basin has been subsident during the Neogene, allowing the fulfillment by sediments coming from Apennines and from Alps. Quaternary sediments are mainly continental and gravels correspond to the apenninic alluvial fans while sandy-clay layers have been chiefly transported by the Po river. They lie on a pre-Holocene substratum constituted by impermeable marine formations of Calabrian-Pliocene age. In the upper plain thickness of the alluvial deposits varies from 50 to 200 m. It reaches 400-500 m. east of Parma while, south of the Reno river, gravel fans are less extensive and they dip under the Adriatic Sea near Rimini. The middle part of the plain is characterized by clay sediments intercalated with sandy layers, which represent the finest and most distal suspended sediments of the Apennine rivers.

Thickness of the Quaternary alluvial cover is over 700 m. in this area and is interfingering with Alpine-derived sediments. Homogeneous hydrostratigraphic units corresponding to different phases of fulfillment of the Po sedimentary basin and characterized by thickness of about 200 m. were recognized by Emilia Romagna-ENI-AGIP and conventionally named A (ages ranging by present to 350 kyrs), B (ages ranging 350-650 kyrs) and C (ages 650-3600 kyrs). In the northern part of the plain alluvial deposits derived from the Po river occur. They consist of alpine thick interbedded sandy and clayey layers. The Emilia Romagna plain lies on a series of fold-faulted Apenninic terrains dipping northward in a tectonic regime characterized by a NE compression. This terrain was partially emerged during Pliocene period. The thickness of Quaternary sediments is limited to < 100 m. in the Mirandola area, north of Modena. The region's population of over 3 million inhabitants uses large amounts of water for public, industrial and agricultural purposes, with over 60% of the supplies withdrawn from about 100,000 wells whose depths range between 5 and 700m. Most of the wells lie in the foothills of the Apennine chain in aquifers of a non-confined, semi-confined and confined type in areas of conoid generated by the course of the rivers of Apennine origin. A large number of wells is also situated in the low plain areas to the south of the Po river that withdraw water from confined aquifers. The high consumption levels (703 million m³/y) have generated subsidence phenomena of 10-40 mm/year in main towns along with a deterioration in the quality of the underground waters. This has made it even more important to gain a better knowledge of the methods for feeding and recharging the Emilia-Romagna aquifer by means of isotopic techniques. Isotopic investigations allowed also description of palaeoclimatic trends in the Po valley and evidenced that underground waters may act as a natural archive of recent and past palaeoclimatological trends.

Nitrogen isotopes indicate that the pollution from Nitrates detected in numerous zones of the regional territory mainly comes from sources of organic nature. Effective reforms in the productive structure can contribute to limiting the excessive water consumption of the underground waters and to safeguarding the quality characteristics of the underground water-bearing bodies.

A3-4 Orale Petrini, Riccardo

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ISOTOPIC EVIDENCE OF CR(III) OXIDATION IN SOILS AND THE OCCURRENCE OF HEXAVALENT CHROMIUM IN THE HIGH FRIULI PLAIN AQUIFER (NORTHERN ITALY)

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Key terms: chromium isotopes; hexavalent chromium contamination; alluvial aquifers

The Cr(III)-Cr(VI) cycling in soils and groundwaters is of great environmental concern. In particular, Cr(III) is an essential micro-nutrient and is considered to be the stable form in soils where it forms precipitates and is strongly sorbed on the charged surface of solids. Cr(VI) is toxic and a suspect carcinogen, stable under oxidizing conditions in aqueous forms and mobile as soluble oxyanions at the pH of natural waters. Under the redox and pH conditions usually found in the environment, Cr(VI) has the tendency to be reduced to Cr(III), e.g. on the surface of Fe(II)-bearing minerals or in the presence of aqueous Fe(II) or organic matter, acting as electron donors, and in this form it is scavenged from solution. However, it has been documented that in the presence of various forms of Mn-oxhydroxides in soils Cr(III) is readily oxidized and the conversion of Cr(III) to Cr(VI) represents a potential pollution hazard, critical to predict the fate of hexavalent Cr contamination in waters.

Cr isotopes have been demonstrated to be sensitive tracers of the Cr redox changes in aqueous media through both equilibrium and kinetic (Rayleigh-type) fractionations occurring during Cr(VI) reduction. A limited isotopic fractionation has been so far reported during Cr(III) oxidation experiments and small effects are also expected during oxidation of Cr(III) in soils, even if a larger fractionation was inferred from BIF in ancient redox environments and attributed to Cr(III) oxidation catalyzed by Mn oxides. However, the changes in the Cr isotope composition during Cr(III) oxidation require further investigations, due to the different pathways reactions with possible intermediate Cr(IV) and Cr(V) species.

In the present study the Cr-isotope systematics has been applied to groundwaters from the phreatic aquifer in the High Friuli Plain (northern Italy), an area which underwent extensive Cr(VI) contamination from manufacturing during 1997 with Cr(VI) concentrations in waters reaching 4 mg/l. Afterward, the industrial activity was made environmentally protective and a natural decay of contamination occurred over the years due to Cr(VI) reduction. Nevertheless, since 2002 and until the last survey at the beginning of 2011, new spikes in the Cr(VI) content reaching 1.6 mg/l have been observed in groundwaters. The measured ⁵³Cr/⁵²Cr isotopic ratio in contaminated waters, expressed in delta notation, show uncommon negative values ranging between -0.60 and -3.00 per mil. A negative value of -2.99 was also measured in Cr(VI) extracted from the sediments which characterize the contaminated site. The isotopic data are interpreted as tracing the oxidation of Cr(III) not from geogenic sources but originated by the reduction of Cr(VI) released during the pristine anthropogenic contamination, which accumulated onto Mn-oxide rich alluvial sediments. The mechanism of Cr(III) oxidation on Mn-oxides has been investigated by using HRTEM and micro-Raman techniques. These results indicate that the conditions favourable for Cr oxidation are likely to occur in the field soils of the study area, favoring the Cr(VI) plume migration and implying that suitable management activities are necessary for remediation.

A3-5 Poster Nisi, Barbara

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WATER CHEMISTRY IN THE AREZZO BASIN (CENTRAL ITALY)

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Key terms: Arezzo; Water chemistry; Stable Isotopes; Heavy metals; CO₂

The Arezzo Basin, formed since Upper Pliocene, is a structural depression limited to the North and to the East by the Pratomagno and Chianti belts, respectively, and to the South and to the East by two tectonic lineaments (Val d'Arbia-Val Marecchia transversal and Chitignano normal faults). Along these tectonic discontinuities CO₂-rich manifestations either seep out or are exploited by private companies down to the depth of 1000 m. Three main aquifers are recognized: i) a relatively deep aquifer hosted in Tertiary sandstone formations; ii) an intermediate aquifer hosted in Quaternary fluvio-lacustrine sediments and iii) a shallow aquifer in recent alluvial sediments.

In the framework of a joint project between the Unit of Environment and Health of the Municipality of Arezzo and the Department of Earth Science of the University of Florence, a geochemical and isotopic characterization of the superficial and ground waters of the municipal territory of Arezzo was carried out to establish the main sources of the solutes including natural and anthropogenic processes. The available geochemical data-base consists of about 80 samples that were collected at the end of the dry and rainy seasons in 2009. Physical parameters (temperature and electrical conductivity), major, minor and trace dissolved species (pH, Ca, Mg, Na, K, NH₄, HCO₃, SO₄, NO₃, Cl, Br, F and heavy metals), oxygen and hydrogen isotopes in the water molecules and dissolved gases (including ¹³C-CO₂) were analyzed. CO₂-rich waters from deep wells and gases discharging in the municipality of Arezzo were also included. Furthermore, on a bimonthly basis the main chemical and isotopic composition in rainwater from three stations positioned at different altitude (200, 500 and 800 m) were collected. Finally, 13 sediment samples from the main streams that cross-cut the Municipality of Arezzo were analyzed for determining the abundance of heavy metals, by aqua regia dissolution.

On the basis of Total Dissolved Solids (TDS) the waters from Arezzo can be considered mainly oligomineral and medium-mineral, whereas mineral waters are almost exclusively associated with the CO₂-rich wells. From a classificative point of view, Ca(Mg)-HCO₃ is by far the most representative geochemical facies, followed by Na(K)-HCO₃, Ca(Mg)-SO₄ and Na(K)-Cl types. It is noteworthy to point out here that the Na(K)-HCO₃ waters, whose origin is likely related to the presence of CO₂-rich waters that favor cation exchange processes with the clay minerals contained in the sedimentary formations, are aligned along the Val d'Arbia-Val Marecchia transversal tectonic system.

The O and H isotopic composition suggests that the Arezzo waters have a meteoric origin and occasionally, isotopic exchange between CO₂ and H₂O is observed for those waters discharged from the CO₂-rich wells. This CO₂ has an isotopic composition clustering around -6 permil and strongly differs from that measured in the shallower wells where the isotopic values are <-15 permil, suggesting a biogenic origin.

A3-6 Poster Delconte, Carlo Andrea

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ORIGIN AND DYNAMICS OF DISSOLVED NITRATE IN THE LOWER OGILIO RIVER

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Key terms: nitrate contamination; nitrate isotopes; surface waters

In the Oglio River watershed, elevated nitrate pollution of surface and groundwater result in a large fraction of land classified as vulnerable to nitrate contamination. We present the results of hydrochemical and isotopic analyses (water and nitrates) aiming to identify the nitrate origin and dynamics, and trace the interactions between the Oglio River, its tributaries, groundwater and soil.

Sampling was performed during low-flow conditions, in July 2010. The Oglio River can be divided in different parts based on nitrate concentration trends and on nitrate isotope composition. From the Iseo Lake to km 24, the River has low N-NO₃ concentrations (below 0.5 mg/l). Between km 24 and 50, the concentration increases up to 7.5 mg/l. Down to km 75, a decrease in concentration is observed first, followed by a second increase up to value similar to that observed at km 50. From km 75 to the Po River confluence, a decreasing trend is observed, with rather constant values between 94 and 125 km. The main decrease occurs from km 132 to the closing section, where concentrations are lower than 2 - 3 mg/l.

The ¹⁵N and ¹⁸O measured in one sample collected in the upstream reach indicate an origin from atmospheric deposition or a contribution from synthetic fertilizers. An organic contribution to nitrates characterizes the reach where a concentration increase is observed, down to km 45. Finally, from km 50 to the closing section, the ¹⁵N in the Oglio River is enriched with respect to previous values, but with no clear trend. Also the ¹⁸O values are rather similar and tend to be nested, with no clear distinctive signature of the nitrate origin.

In the upper part of the watershed we collected three groundwater samples characterized by high nitrate concentrations. The nitrate isotope composition of groundwater is similar to that measured in the Oglio River water in that part of the watershed. Concentration trends and nitrate isotope composition suggest the presence of mixing between Oglio River and groundwater. In order to validate this assumption, we calculated the amount of groundwater input to the river using the ¹⁸O values of water molecule. Based on this amount, we recalculated both the nitrate content and the ¹⁵N of river water samples and compared them with the measured values. According to this calculation, during summer, in the area where springs and natural outflows are present and the nitrate increase in the Oglio water is observed (24 - 50 km), the contribution of groundwater to the Oglio River could account for up to about 60-70% of the total flow. Calculated nitrate concentrations are in reasonable agreement with the measured values. On the other hand, the ¹⁵N values measured in samples are generally slightly higher than theoretical values, suggesting a contribution from other nitrate sources or the presence of nitrate that has been recycled in the environment. The coupled use of nitrate isotopes does not show the presence of denitrification processes in this reach of the Oglio River.

On the contrary, in the middle (75 km) and final reach of the River, a decrease in concentration and an enriched nitrate isotope composition suggest the presence of denitrification. Nevertheless, no clear trend in the isotopic composition is observed with distance. Even if present, isotopes do not allow to distinguish if denitrification is occurring in the riverbed itself or laterally, in soils and groundwater feeding the river. Indeed in this part of the watershed denitrification in groundwater is testified by low nitrate concentrations coupled to the common occurrence of Fe and Mn. Isotopes allow to quantify denitrification to remove at most 20% of nitrate.

We wish to acknowledge CNR-IGG, Regione Lombardia and Ing. M. Buizza, Oglio Consortium director.

A3-7 Poster Delconte, Carlo Andrea

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STABLE ISOTOPES OF DISSOLVED NITRATE AND BORON AS INDICATORS OF THE ORIGIN AND FATE OF NITRATE CONTAMINATION IN GROUNDWATER: RESULTS FROM THE WESTERN PO PLAIN (NORTHERN ITALY)

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Key terms: groundwater contamination; nitrate isotopes; boron isotopes; Po plain; Lombardy

Nitrate concentration in surface and groundwater is an environmental concern. Distinction between different sources of nitrates can be made coupling hydrochemistry with nitrate isotopes. However, these do not allow distinguishing manure-derived from sewage-derived nitrates. In this case, the combined use of ¹⁵N and ¹¹B is useful, since manure and sewage have high concentrations of boron and distinct ¹¹B imprints. In addition, while redox

conditions control the N isotope evolution, B isotopes are not sensitive to this process.

The area covered by this study is of approximately 15,000 km², crossing the Po plain from its correspondence to the Piedmont-Lombardy administrative boundary.

Groundwater data obtained since 2005 were compiled in a single geo-referenced database, containing more than 300 records and including anion concentrations and stable isotopes of dissolved nitrates.

The nitrate isotopic composition identifies several sources and processes occurring in groundwater. According to the geographical distribution of the samples, a regional map is produced, highlighting the more vulnerable areas. Combining the information provided by nitrate isotopes with land use and other soil parameters, groundwater contamination results to be governed by the hydraulic characteristics of the unsaturated zone, the agricultural input and irrigation practices.

A B isotopic investigation was undertaken on selected samples, all located in a nitrate vulnerable zone, showing a high concentration of nitrates and with an isotopic composition of dissolved nitrate indicating contamination from mixed or anthropogenic organic matter sources, or denitrification. For comparison, two wastewater samples were also considered. B concentration in groundwater samples is very low, generally ranging from

15 to about 50 µg/l. Higher concentrations are measured in wastewater

samples (80-85 µg/l) and in two groundwater samples (155-540 µg/l). A $\delta^{15}\text{N}$ of +14.6‰, compatible with a natural origin of B, characterises the sample with the lowest B concentration. As B concentration rises, its isotopic composition evolves towards both negative values, which are typical for wastewater and sewage, and towards positive values, indicating a contribution from animal manure. Accordingly, samples can be considered as a mixture in variable proportions of these end-members. Results indicate that, even in areas mostly devoted to agriculture, a contamination from sewage is observed. Indeed, in rural areas, households are sometimes not connected to sewers. Surprisingly instead, samples from the suburban area of Milan, where sewage was considered

the most likely source of contamination, show a $\delta^{15}\text{N}$ typical for cattle manure. In this case, nitrates in groundwater are likely related to a contamination occurred in the past, when the area was still mostly devoted to agriculture.

In conclusion, at the regional scale, the impact of intense agriculture activities on groundwater resources is mostly related to the use of synthetic fertilisers, and little contamination seems to originate from manure spreading. Peak concentrations in B and nitrates are instead associated to point source pollution and attributed to leaking septic tanks or sewage network. Results indicate that the undertaken actions for nitrate pollution mitigation do not target the main nitrate sources to groundwater. In addition the present study demonstrates that the attribution of the contamination to a source based solely on present-day land use may lead to inappropriate conclusions, which needs instead to be supported by isotopic data as well.

This research project is co-funded by CNR-IGG and Regione Lombardia, Department of Agriculture. We wish to acknowledge all the partners involved in the investigation, namely ERSAF (S. Brenna), ARPA Lombardia and Provincia di Milano (C. Arduini).

A3-8 Poster Marchina, Chiara

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THE GEOCHEMICAL FEATURES OF PO RIVER WATER IN THE MANTOVA, FERRARA AND ROVIGO PROVINCES

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Key terms: Po river; water; geochemistry; stable isotopes; environment

Although Po is the main Italian River data on the chemical and isotopic composition of its running water are scarce and difficultly accessible. For this reason we started a monitoring project within a framework of a university thesis. In this contribution we present the preliminary results, i.e. major and trace element composition as well as oxygen/hydrogen isotope analyses of the Po River water sampled in different sites of the Mantova, Ferrara and Rovigo provinces. The analyses are compared with the rare data available in the literature as well as with the composition of groundwater of the surrounding aquifers.

The investigated waters display a Ca-HCO₃ hydrochemical facies, with limited seasonal variation. As concerns dissolved heavy metals V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Se, Mo, Cd, Sb, Pb never exceed the drinking water tolerance threshold. Anomalous concentration of iron (1.2 ppm), aluminum (0.65 ppm) and manganese (89 ppb) is recorded only in one site at the confluence with the "Canal Bianco", whereas arsenic is generally high (15-21 ppb) throughout the whole sample population. Considering that the river water is a dynamic multi-component system, whose bulk chemical composition varies as a function of time and distance from the source, the recorded composition provides a geochemical background that is useful for an environmental monitoring. In this view, the oxygen/hydrogen isotopes provide a snapshot of the current climatic conditions to be compared with the literature data and with the future composition to provide a hydro-archive that should be updated, as a proxy to evaluate on-going climatic changes (Zuppi and Sacchi, 2004; Global Planet. Change 40 79-91).

The recorded $\delta^{18}\text{O}$ values ranging between -10.79 and -8.59, and δD values ranging between -69.4 and -62.5 are compared with the local groundwaters (Rapti Caputo and Martinelli, 2008; Hydrogeol. Jour. 17, 467-480) and with the Northern Italy Meteoric Water Line (Longinelli and Selmo, 2003; Jour. Hydrol. 270, 75-88).

These data will be implemented with further isotopic tracers in the framework of a cooperative project with the IGG-CNR of Pisa, to investigate and detect potential industrial, agricultural and urban contaminations, to define mixing processes with the connected alluvial aquifers, and to study the extent of sea-water intrusion and salinization in the terminal (delta) part of the river.

A3-9 Poster Petrini, Riccardo

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IRON GEOCHEMICAL CYCLING IN COASTAL AQUIFERS EXPLORED BY STABLE ISOTOPE SYSTEMATICS: THE FRIULI VENEZIA GIULIA CASE-HISTORY (ITALY)

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Key terms: iron isotopes; iron cycling; coastal aquifers

Iron isotopes have revealed to be extremely useful in the study of the geochemical cycling of this element in near-surface environments. Iron oxides and hydroxides are ubiquitous in soils and sediments and the redox equilibrium between soluble Fe(II) and sparingly soluble Fe(III) species influences the Fe distribution between the solid matrix and aqueous solutions, with implications on its biological availability. In coastal aquifers the dissolved iron concentration is strongly influenced by the non-conservative behavior of this element during mixing between freshwater and seawater, yielding the rapid flocculation and precipitation of dissolved Fe as solid particles at the proper Eh-pH conditions. Subsequent remobilization by reductive dissolution of iron oxides may occur, allowing Fe to return to the water column by diffusion through pore water. In this cycling, redox-associated Fe isotope fractionation occurs, resulting from the preferential partitioning of the heavy iron isotopes into the oxidized forms. The iron isotopic composition is commonly represented

by the $\delta^{56}\text{Fe}/^{54}\text{Fe}$ ratio, and expressed through the $\delta^{56}\text{Fe}$ notation as per mil deviations with respect to a standard. Igneous iron sources are isotopically homogeneous to ± 0.05 per mil, representing a suitable baseline to interpret Fe isotope variations in nature. The dissolved riverine

flux has $\delta^{56}\text{Fe}$ values between about 0 and -1 per mil, and progressively

negative values of $\delta^{56}\text{Fe}$ can be established in the aqueous phase throughout repeated Fe dissolution-precipitation reactions of ferrous and ferric iron.

In the present work, the iron isotope systematics has been applied to groundwaters collected by a network of piezometers in the site of national interest for anthropogenic impact (SIN) "Laguna di Grado-Marano" in the Friuli Venezia-Giulia Region (Italy), a near-shore area characterized by metallurgical activities and groundwaters with high iron concentration, with the aim of investigating possible anthropogenic sources. The studied waters range in composition between the Ca-bicarbonate and Na-chloride hydrofacies, reflecting the progressive mixing between freshwater and a seawater end-member. The process of seawater intrusion has been quantified using the conservative isotopes of H and O, yielding up to the 98% of seawater admixed to freshwater inputs originated from both resurgence belt river fluxes and local meteoric precipitations. Sr isotopes support the role of seawater intrusion, highlighting additional processes of cation exchange and suggesting that alteration of silicate minerals represents the potential source of lithogenic Fe in groundwaters. The Fe

isotopic data show large variability, with $\delta^{56}\text{Fe}$ ranging between -6.93 and

+0.99 per mil, with the exception of a single sample characterized by a $\delta^{56}\text{Fe}$ value as high as +2.54 which deserves further investigations.

Progressively negative $\delta^{56}\text{Fe}$ values are observed with decreasing the Fe content, suggesting the occurrence of repeated natural cycles of iron dissolution and precipitation with consequent enrichment of an isotopically light component in porewaters. The Fe cycling also affects the fate of potentially toxic elements in the aqueous environment, in particular As and Ni.

A3-10 Poster Pennisi, Maddalena

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ISOBORDAT (HTTP://ISOBORDAT.IGG.CNR.IT/): AN ONLINE DATABASE ON BORON ISOTOPES

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Key terms: On-line database; Boron isotope; Natural waters; Contaminants

From 1986, boron isotope data in natural substances increased sharply in scientific publications. Analytical difficulties derived from complex geochemical matrices have been faced and interlaboratory calibrations reported in the boron literature. Boron isotopes are nowadays applied to investigate boron origin and migration in natural waters, sources of boron contamination, water-rock interactions, and also contribute to the water resource management. This is especially important in those areas where boron content exceeds the local regulations for drinking water supply, and boron sources need to be identified. On the basis of its twenty years experience in boron isotope geochemistry, the Istituto di Geoscienze e Georisorse di Pisa has started to compile a database aimed to include all the isotopic data on boron in natural waters reported in the scientific literature. The database includes currently values on 'cold' natural waters, but its extension to medium and high enthalpy fluids from volcanic and geothermal areas is anticipated. We give below some basic information on the structure of the database. The data are grouped in five categories, according to the sample nature: rainwaters, surface waters - rivers, surface water - lakes, groundwater, natural and anthropogenic contaminants.

ISOBORDAT web pages has been created with open CMS Joomla! 1.5 and Jx List Files v1.3 on small xampp server (thanks to all open communities for support).

For each sample, the data reported in ISOBORDAT, are: (i) - Sampling site: main characteristics. E.g.: for groundwater: well, spring, shallow or deep (confined) aquifer (ii) - Geographic location (iii) - $\delta^{11}\text{B}$ ‰, expressed vs. the reference material NBS SRM-951. No measurement uncertainty is quoted, however, data of questionable quality will not be included in the database (iv) - B concentration, expressed for waters in mg L⁻¹ and for solid compounds in mg Kg⁻¹ (v) Analytical technique. E.g.: PTIMS, NTIMS, etc. - (vi) - Bibliographic reference(s).

Isotopic data on potential boron contaminants of natural waters are gathered together in a section of the ISOBORDAT database. These contaminants include: detergents, chemical fertilizers and manures, mining tailings and wastes of industrial processing of boron minerals. The isotopic composition of potential contaminants, which spans over a wide range, helps in identifying boron contamination sources and geochemical processes undergone in natural waters. Data on natural waters collected

in ISOBORDAT show variations on 11B/10B ratio of almost 60‰ in categories Rainwaters, Rivers, Lakes, that reach 90‰ in category Groundwater. The observed span is huge for an element not undergoing redox reaction in nature. The variations on 11B/10B ratio observed for the category "Contaminants" is also wide, and span about 25‰ for inorganic products and 110‰ for organic products. A simple statistical elaboration of more than hundred boron isotopic data on Italian groundwaters from disparate geological settings is presented.

The $\delta^{11}B$ values scan from -30 ‰ to +50 ‰, i.e. over a 80 ‰ range. All data have been obtained by positive thermal ionization mass spectrometry (PTIMS) in our institute in the last two decades and are perfectly comparable.

Compilation of a database is by nature a permanent "work in progress". In order to have a database as complete as possible, the collaboration of the whole boron isotope community is necessary. We believe that such a database will be of great help to boron isotope hydrologists and geochemists by speeding up the research of, and the comparison with, data already existing in the scientific literature.

SESSIONE A4

Geologia e dinamica degli acquiferi porosi: dalle discipline di base all'idrogeologia

A4-1 Orale Giudici, Mauro

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SEDIMENTS' CONNECTIVITY AND TRANSPORT PROPERTIES: EXAMPLES FROM ALLUVIAL AQUIFER ANALOGUES

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Key terms: ground water flow; connectivity; alluvial aquifers; tracer transport; mathematical modeling

The heterogeneity of alluvial sediments at fine scales has a direct impact on water flow and contaminant transport in the subsurface at larger scale. In particular the spatial distribution of hydrofacies controls the spatial variation of hydraulic conductivity (K), which in turn controls, together with the hydraulic gradient and the stresses on the aquifer system, groundwater flow and the fate of contaminants in the subsurface. However, the connectivity of permeable materials could be more important than the local K values to determine the behaviour of solute transport. In fact it controls the existence of preferential flow paths or of hydraulic barriers and induces local distortions of the flow field. In order to reach a deeper insight on this topic, several aquifer analogues, namely alluvial sediments exposed along vertical faces, e.g. in sand and gravel quarries, have been examined in the last years. The sedimentological and hydrostratigraphical analysis of the sediments and of their architecture, together with laboratory tests on samples (grain size distribution, conductivity of fine-grained almost undisturbed samples, etc.), has been the basis for the classification of hydrofacies, the reconstruction of hydrofacies distribution at scale lengths from centimetres to decimetres on the exposed faces and the identification of K for each hydrofacies. The 3D spatial distribution of hydrofacies, and therefore of K, has been obtained with the application of stochastic simulations tools (SISIM, T-ProGS, MPS). Then the equivalent conductivity tensor has been computed at larger scales, by 3D groundwater flow modelling. Moreover, numerical experiments of convective transport of conservative solutes have been conducted and have been interpreted with single and dual domain models, thus obtaining equivalent hydrodispersive parameters. The values of the equivalent hydrodynamic and hydrodispersive parameters and the general behaviour of the breakthrough curves have been compared with several connectivity indicators, which are related either to the spatial distribution of hydrofacies or to flow and transport statistics. This evaluation has provided an important confirmation of the role of connectivity to characterize transport processes in alluvial saturated sediments. Moreover the results have shown similarities and differences of connectivity and transport characteristics among various kinds of sedimentary facies with variable hierarchy and scales.

A4-2 Orale Forno, M. Gabriella

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STRATIGRAPHIC RECONSTRUCTION OF THE CASCINA GIARREA WELL FIELD: A STRATEGIC SITE FOR THE SUPPLY OF THE MONFERRATO AQUEDUCT (CENTRAL PIEDMONT PLAIN, ITALY)

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Key terms: Stratigraphic reconstruction; Hydrogeology; Subsoil; Po Plain; Piedmont

The research regards the stratigraphic reconstruction of a wide area surrounding the well field of Cascina Giarrea, situated in the central Piedmont plain, near the confluence of the Dora Baltea River in the Po River. The well field (groundwater mean discharge of about 1 m³/s) constitutes the main water supply for the inhabitants of the Monferrato Hills (developed South of the plain area), through a supply network around 2000 km long.

Nine detailed stratigraphic cross sections has been elaborated, interpolating well and piezometer data logs. Despite the large number of stratigraphies, difficulties have been encountered during the subsurface reconstruction owing to the inaccuracy of some technical and lithological data.

The top of the examined plain area is represented by the Middle Pleistocene-Holocene glaciofluvial and fluvial sediments: a complex of highly permeable sandy gravel, 30-60 m thick, constituting a superficial unconfined aquifer.

The underlying sediments are essentially constituted by the Middle Pliocene-Lower Pleistocene deltaic and fluvial Villafranchian Succession. This complex consists essentially of alternating layers of silt (rich in vegetable rests) and sand, 50-100 m thick, hydraulically interpretable as a multilayered aquifer.

Locally, the Lower Pliocene littoral clayey sand and deep sea clayey silt (Sabbie di Asti and Argille Azzurre, respectively) occur at the bottom of the examined succession. These heteropic sediments (rich in marine fossils) show a general low permeability constituting an aquitard from a hydrogeologic point of view.

In the Monferrato Hills, South of the investigated plain sector, pre-Pliocene deep sea sediments (marl and silty clay) outcrop. Their low permeability characterizes such complex as an aquiclude.

The geo-structural setting is complicated by a lot of faults and thrusts that divide the subsiding Po Plain from the uplifting Monferrato Hills.

In the subsoil of the intermediate area, developed between the subsiding plain and the Monferrato Hills, a remarkable buried erosion surface named "platea", separates the pre-Pliocene and Pliocene marine sediments and the Pliocene Villafranchian Succession, below this unconformity, from a thin cover of Pleistocene glaciofluvial and fluvial sediments above.

The groundwater flow of both superficial unconfined and deep multilayered aquifers is southeastward, as well as the general trend of the topography and the flow of the Dora Baltea River.

The new collected data report a particularly thick Villafranchian Succession in the Cascina Giarrea site, connected with the filling of a wide depression. This depression consists both in a foredeep basin, connected with the Padane Thrust Front that border the Monferrato Hills, and in the ancient incision of the Aosta Valley. This context creates a favorable condition for the occurrence of the well field, main supply of the aqueduct of the hilly Piedmont central sector.

A4-3 Orale Bersezio, Riccardo

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MODELING COMPLEX HYDROSTRATIGRAPHIC GEOMETRIES AT THE SCALE OF THE ALLUVIAL ARCHITECTURAL ELEMENTS

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Key terms: alluvial sediments; aquifer analogues; hydrostratigraphy; interpolation techniques; geostatistical simulations

Realistic representations of the sedimentary heterogeneity of alluvial aquifers are necessary to solve flow and transport problems. The improvements of mathematical tools to simulate the heterogeneity distribution in these sediments permit to handle 3D fields at fine scales. At this purpose, the textural and geometrical components of heterogeneity must be reproduced efficiently. Nevertheless, the current mathematical methods are still far from yielding satisfactory results concerning complex geometries and facies distributions (i.e. textures and the related porosity/permeability properties). This is the case of alluvial aquifers that are characterized by: i) complex curve and oblique geometries of the sedimentary bodies bounded by complex truncation surfaces, ii) highly variable and non-stationary facies associations and iii) complex nesting of sedimentary units with contrasting permeability (scour pools, accreting bars, channel fills, terraced valleys and flood plains). Modeling this complexity in the real subsurface aquifer stratigraphy is difficult when fine-scale models are required. The study of exposed aquifer analogues permits to try and improve the geostatistical techniques for simulation of aquifer stratigraphy (pixel or object based methods), using complete sedimentological data-sets. Aiming to combine the best possible reproduction of complex geometries with the accurate simulation of the textural distribution, we investigated a sediment block (7 m x 4 m x 1.5 m) dug into a gravel-sand quarry that is open into the Upper Pleistocene sandur of the Verbano glacier amphitheater. The block shows a complex network of scour-pool fills, made of curve and planar cross-bedded gravel and sand (Trough Gravel Unit, TGU), cut into overbank very fine silt and sand (Sandy Unit, SU). The complexity of this setting includes also deformation structures due to undermining and failure of the pool banks, with gravel fills pinched in between projecting limbs of the silty-sands. A preliminary geophysical investigation and the subsequent progressive dissection permitted full inspection of the block volume, so that the data-set includes: geoelectrical and GPR surveys on the top of the block; sedimentological logs, photomosaics and facies maps at cm-scale accuracy along vertical and horizontal intersecting planes; infiltration tests with a spacing of about 50 cm; grain-size distribution measurements on samples; estimates and measurements of hydraulic conductivity on samples of the sandy gravel, sand and silty-sand facies to work out an hydrofacies classification from the facies association. This approach permitted to check the geostatistical model of the volume, that was obtained combining the interpolation of the boundaries of the individual scour pools with the geostatistical simulation of their sedimentary fill. At the scale of the highest order elements (TGU and SU units) the comparison of our results with the real block shows that the simulated model respects both the geometry of sedimentary units and the vertical vs. horizontal association of facies. At the scale of the individual scour pools, a good result was obtained concerning proportions and juxtaposition of (hydro)-facies, i.e. the permeability contrasts were reproduced in their correct locations, respecting the shape of these minor units. Differently, the curve geometry of the boundaries and of the internal fill of the pools were partly lost. In spite of its small size, the studied volume represents a realistic analogue both for comparable sediments in real aquifers and for the large-scale basin fills that are formed by concave-up channel fills cut into low-permeable fines, hence the results can be used to critically analyze and improve the simulation techniques even at this scale.

A4-4 Orale Ducci, Daniela

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THE ROLE OF 3D LITHOSTRATIGRAPHICAL MODEL AS A TOOL IN GROUNDWATER VULNERABILITY MAPPING

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Key terms: Aquifer Vulnerability to Pollution; 3D models; GIS

The aim of this paper is to apply a computer based methodology in order to reconstruct a lithostratigraphical 3D model of an aquifer so as to define some parameters involved in the evaluation of the aquifer contamination vulnerability.

The last twenty years have seen the widespread use of point count system methods in the evaluation of 'Aquifer Vulnerability to Pollution', such as DRASTIC (Aller et al. 1987), widely used in the USA, and SINTACS (Civita & De Maio 2000), based on the same seven parameters, but with some modifications due to the most commonly found Italian hydrogeologic settings.

Moreover, the advent of GIS, permitting the inventory, archiving, retrieval and display of spatial data and the link to numerical rating systems, made the use of point count system methods easier and encouraged the development of new specific methods as the AVI method (Van Stempvoort et al. 1993).

The SINTACS method has been applied to an alluvial coastal aquifer of the Southern Italy (Corniello et al. 2011). The stratigraphical reconstruction has been obtained by interpolating stratigraphical data from more than one borehole per 2 square kilometres. The software used for the lithostratigraphical model creation is Rockworks 2006, which allows the reconstruction of a 3D model for tridimensional or bidimensional representation. The reconstruction allowed to identify the main aquifer in the thick alluvial and marine clastic sediments. The piezometric pattern (defined by the piezometric surface monitoring) shows the groundwater flow direction toward the sea.

In the studied river plain, the layers of depth to water, impact of the vadose zone and hydrogeological characteristics of the aquifer media have been evaluated not by the interpolation of the single boreholes and piezometers, but by the 3D model, assigning the scores of the parameters of each layer of the 3D model. The comparison between the hydrogeological characteristics of the aquifer media constructed from the weighted values in each borehole and from the attribution of the aquifer media value of each layer of the 3D model, highlights that the second representation avoids or minimizes the plume effect linked to the presence of boreholes with higher or lower values.

In the same alluvial plain also the AVI method (Van Stempvoort et al. 1993) has been applied. This method uses only two variables to formulate a vulnerability index, these being: the thickness of each sedimentary layer above the uppermost saturated aquifer (d) and the estimated hydraulic conductivity of each of these layers (k). The "hydraulic resistance" (c) of each layer is then calculated as the quotient of thickness and conductivity ($c = d/h$). The total hydraulic resistance for several sedimentary layers is established by summing the values for each layer. Authors suggest to make this calculation for each borehole, and then to interpolate the c values (inversely proportional to the Vulnerability). In this study the c values have been easily assigned to each layer of the 3D model. The Vulnerability map thus calculated is as effective as applying SINTACS, but here the evaluation is speedier and suitable also at a regional scale.

The resulting vulnerability maps demonstrate that parameter layers prepared using the 3D model generate gradually changing boundaries between vulnerability classes. Sudden changes caused by data points are avoided. The main stratigraphical variations are along vertical paths, as expected in the sedimentation phenomena.

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A4-5 Orale Cavalli, Emmanuele

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3D MODELLING HYDROSTRATIGRAPHIC GEOMETRIES FROM REGIONAL TO LOCAL SCALE

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Key terms: alluvial sediments; hydrostratigraphy; 3D modelling; quantitative geology

Realistic hydrostratigraphic models are necessary to compute the hydrological balance of surface vs. ground waters. In this perspective a key-sector of the Lombardy alluvial plain NE of Milan was selected to study the relations between Adda river and the phreatic nappe. The study focuses on a 10x10 km area close to Cassano d'Adda, that includes the local uppermost alluvial terraces (Middle Pleistocene glacio-fluvial sediments), the intermediate "Livello Fondamentale della Pianura" (Late Pleistocene sandur) and the lowermost post-glacial terraces within the Adda valley. In the subsurface, the transition between the northern glacio-fluvial alluvial fans and incised valleys, and the southern braided river deposits, occurs. This hinge corresponds to the transition from a single phreatic aquifer (North) to a stack of partly confined aquifer complexes (South), that is accompanied by emergence of the phreatic nappe along a belt of plain springs ("fontanili"). In this area many canals derive up to 95% of the discharge of the Adda river. In this work, the new geological and hydrostratigraphic model of the area is presented. The work is based on surface geology and subsurface stratigraphy, in a GIS environment linked with a 3-D modelling software, that allowed for a "try and error" procedure of stratigraphic correlation.

The results show the architecture of a large T-R sequence, from the marine Early Pleistocene to the present-day fluvial setting, punctuated by low-order cycles. The lowermost Geological Unit (GU-O, Early Pleistocene) is formed by gently tilted marine shales with sporadic gravel and sand lenses. Three complex channelized sequences, with erosion relationships (GU-1a, GU-1b, GU-1c) are incised into, and stacked above the marine deposits. These sequences are interpreted as the local effect of Middle Pleistocene eustatic cycles and uplift of the Alpine substratum. In this time the coastline moved at least three times from N to S, temporarily exposing the previous coast and shelf environments. The resulting incised valleys were filled by the three GU-1 sub-units. The subsequent regional regressive pulse is witnessed by the glacio-fluvial sandur of GU-2 (Middle Pleistocene), which buries the GU-1 sequences, after a large south-eastward shift of the coastline. GU-2 and the overlying GU-3 (Middle p.p. - Upper Pleistocene amalgamated gravels and sands) are separated by a very Pleistocene red paleosol throughout the entire study area. During latest Pleistocene (LGM) decametric silt layers cover the ancient fluvio-glacial gravely sediments. The Postglacial (PG) to recent sediments are confined within the Adda valley.

This geological reconstruction leads to a hydrostratigraphic scheme that includes: 1) Basal Aquiclude (GU-0), laterally continuous at regional scale with local, small, confined and partitioned Aquifer systems; 2) Intermediate Aquifer Group (GU-1a, GU-1b, GU-1c) with a complex alternation of fining upwards sequences and juxtaposed gravel and fine-grained bodies due to erosion; 3) Uppermost Aquifer Group (GU-3, GU-4), decametric amalgamated gravel and sandy gravel units, locally separated fine-grained layers (preserved palaeosols); 4) Shallow Aquitard (GU-5) forming a discontinuous sandy silt cover above the underlying aquifers.

The geological and the hydrostratigraphic units have been modeled in 3-D, obtaining the maps of their boundaries, the location of their pinch-outs and the distribution of the internal genetic units (fining and coarsening upwards sequences). A descriptive statistic approach was used to characterize the sediments of these units. Multivariate analysis permitted to quantify the vertical and lateral variation trends of lithofacies and poro-perm properties.

The quantitative geological model yields the shape of the highest-order stratigraphic units within which the internal architecture and the permeability, porosity and electrical field gradients can be interpolated and/or simulated.

A4-6 Orale Mazza, Roberto

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ANALYSIS OF RELATIONS BETWEEN THE CARBONATE AQUIFER OF LEPINI MOUNTAINS AND THE ADJACENT AQUIFER SYSTEMS, AIMING AT THE WATER RESOURCES MANAGEMENT

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Key terms: Carbonate aquifer; groundwater circulation; Conceptual hydrogeological model

In this speech a scheme of groundwater flow circulation between the structures of Lepini Mountains, Albani Hill and Pontine Plain is offered, developed through a research program sponsored by Roffredo Caetani Foundation and funded by the Province of Latina and the Latium Region. In this analysis great importance is given to the geological and structural setting because these elements give an invaluable support to the conceptual scheme of groundwater circulation between aquifers belonging to the domains of carbonate, volcanic and fluvial-lacustrine geological facies.

The authors, following the surveys and original interpretations, have produced a 1:50,000 scale geological map and several cross sections referring to entire study area.

The map highlights that the structural setting is more complex than noted in the past by other authors.

The geological study has identified areas where the groundwater flow is blocked by subdivision due to compressive and distensive tectonic movements that affected the chain of Lepini Mountains.

As the carbonate structure dips below the Pontine Plain, the groundwater flow appears partially at the contact with fill deposits of the plain and on the other end flows through calcium deposits submerged that are upperly confined by lithological complex with low permeability.

The cross sections of the Pontine Plain were constructed on the basis of geophysical, gravimetric and geoelectrical surveys and on the basis of stratigraphy obtained from geomechanical surveys.

For the entire study area, the geological map and cross sections has been read with hydrogeological approach obtaining complex with similar groundwater circulation behavior

Of particular interest is the cross section parallel to Via Appia (SS 7), it provides important information on the carbonate bedrock trend and on the volcanic complex trend towards SE, which is going to leap with the silty sand complex of fluvial-lacustrine facies.

These results provide the 3D hydrogeological model which allows us to formulate the hydrogeological kind of boundaries existing between the units concerned.

From the hydrogeological model carried out as stated aquifers behavior numerical model implementations and distributed hydrogeological balance assessments are derived by a method not contained in this presentation.

A4-7 Orale Mele, Mauro

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HYDROGEOLOGICAL IMAGING OF THE CASALPUSTERLENGO AND ZORLESCO RELIC RELIEFS (LOMBARDY, ITALY)

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Key terms: Hydrogeophysics; Aquifer characterization; Vertical Electrical Soundings; Electrostratigraphy; Lodi plain

Hydrogeophysical imaging is an approach to efficient representation of alluvial aquifer heterogeneity. The integration of hydrostratigraphy with ground-based Direct Current resistivity methods can be effectively used to fill the gap between borehole data and to obtain valid representations of sedimentary heterogeneity from the scale of depositional systems to the scale of basin fills.

Such an approach was applied to the Quaternary aquifers of the southernmost Lodi plain (Lombardy, Italy) where syn-depositional tectonics acted by shaping the depocentral areas and the hydrogeological divides between the uplifted and folded Pliocene-Lower Pleistocene marine-transitional sequence, composed by clays and sand to gravel/conglomerate lenses, and the Middle to Upper Pleistocene alluvial sequence, composed by gravely-sands to sands and sandy-silty clays. 35 Direct Current (DC) Schlumberger Vertical Electrical Soundings (VES) and 7 Time-Domain Electromagnetic Soundings (TDEM) were collected over a 37 km² area across the Casalpusterleno and Zorlesco relic reliefs. Here, the weathered alluvial units are exposed due to the structural culmination of Apenninic two ramp anticlines.

Electrostratigraphic interpretation of 1D VES resistivity models, calibrated with deep subsurface data (water wells) including groundwater chemistry, and supported by TDEM models, yielded the identification of the

electrostratigraphic sequence and of the local geoelectrical heterogeneities.

N-S and W-E oriented electrostratigraphic sections, more than 50 km long, enabled to detail the aquifer compartmentalization. Electrical resistivity was used as a "proxy" of the hydrofacies association at depth, thus identifying the electrostratigraphic units (EsUs) in the subsurface, i.e. the geophysical signature of hydrostratigraphic units. These units are meters to tens-of-meters high and thousands of meters long, defined as sedimentary volumes identified by resistivity contrasts that spatially preserve the vertical polarity by i) the horizontal variation of the electrostratigraphic sequence, and ii) the increasing thickness at increasing depth, according to the equivalence principle.

Lithology logs near the Casalpusterleno and Zorlesco reliefs enabled to integrate electrostratigraphy and hydrostratigraphy through the identification of the resistivity contrasts produced by the vertical stacking of the Middle to Upper Pleistocene alluvial sequence above the uplifted and folded Pliocene-Lower Pleistocene marine-transitional sequence.

From top to bottom, an association (T1) of N-dipping, alternating resistive and conductive EsUs association, up to 140 m thick, corresponds to Middle to Upper Pleistocene freshwater aquifers. The major resistivity contrast bounding the base of T1 reach the shallowest depth in correspondence of the Casalpusterleno and Zorlesco reliefs, where T1 wedges out and partially covers the top of an association (T2) formed by a widespread, high-conductive EsU which contains resistive, lens-shaped EsUs, tens of meters thick, corresponding to the freshwater aquitards and aquifers hosted in the Pliocene-Lower Pleistocene sequence. The inferred geometry and the hydrostratigraphic interpretation are well supported by the exposition of the weathered, low-resistive alluvial units, which smooth the fold hinge.

To the South, the deepest detectable resistivity contrast at the base of T2 association marks the presence of a widespread, very high-conductive EsUs (association S). The low values of electrical resistivity at depth are well constrained by electrical logs in deep wells drilled for hydrocarbon exploration and by a deep dipole-dipole DC survey across the San Colombano anticline and can be correlated to the presence the fresh-saltwater interface.

A4-8 Orale Canepa, Paola

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THREE - DIMENSIONAL NUMERICAL MODEL OF GROUNDWATER FLOW IN THE LOMBARDY PLAIN (NORTHERN ITALY): GROUNDWATER BUDGET ANALYSIS

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Key terms: 3D numerical model; Groundwater budget; Lombardy plain

Groundwater sustainability must be based on a detailed knowledge of the aquifer system and the groundwater budget. Computer science and numerical models allow scientists to integrate and process a large amount of different data regarding hydrogeological settings and groundwater budget sources and sinks. Consequently, numerical models can be useful to support decision makers in water management.

This report describes the development and first results of a 3D numerical model that reproduces groundwater flow and budget in the Lombardy plain (Northern Italy) which extends from eastward from the Ticino river to the Oglio river. The study area is about 6,900 Km². The aquifer system consists of Quaternary alluvial sediments; its geometry is defined according to the depositional surfaces as described in "Geologia degli acquiferi Padani della Regione Lombardia" (Regione Lombardia, Eni Divisione AGIP, 2002). Furthermore, a complex network of surface water (streams, canals and "fontanili") characterizes the study area and influences the piezometric levels.

The model was developed using MODFLOW - 2005. It integrates 8,429 stratigraphic logs (stored in a customized well database, TANGRAM) and monitoring data of groundwater budget inflows and outflows. A specific method was used to calculate the spatial distribution and temporal fluctuations of aquifer recharge: Soil Water Balance code (SWB). SWB calculates recharge on a rectangular grid congruent with the MODFLOW grid. It uses commonly available land-surface data (land use, flow direction, hydrologic soil groups and AWC) and climatological information (chiefly, precipitation and temperatures). It easy to manage these data in a Geographic Information System.

The aquifer was discretized into 207 rows, 333 columns and 107 layers of non-uniform thickness. Cells are 500 x 500 m. 3D geostatistical reconstructions of aquifer heterogeneity, based on georeferenced stratigraphic logs, were used to define the distribution of aquifer hydrologic properties (hydraulic conductivity and effective porosity). In this way, properties values vary cell to cell. Model boundary conditions represent natural and anthropic elements that affect the groundwater budget such as streams (head-dependent flux boundary), recharge from infiltration of precipitation (specified-flux boundary) and pumping wells (specified-flux boundary).

The model was calibrated to steady-state conditions by using average heads (2001-2005) from the Lombardy Regional Monitoring Network. The calibrated model simulation adequately reproduces the elevations and trends of the regional water table, but the results also suggest that more information about withdrawals and rates of stream loss or gain would appreciably improve the fit in some places. Rates of stream loss or gain could be used as flux targets to also calibrate the model strictly. In this way, simulated volumetric budget would compare better with measured inflows and outflows.

A4-9 Orale Capacci, Fausto

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NUMERICAL FLOW MODELLING OF THE POROUS AQUIFER FOUND IN THE ALLUVIAL SEDIMENTS OF THE RIVER ROJA IN VENTIMIGLIA (LIGURIA, ITALY)

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Key terms: Aquifer; Hydrogeology; Roja; Flow

The part of the aquifer studied is contained within the Quaternary alluvial and detrital sediments that crop out to the north of the city of Ventimiglia (Liguria, Italy) and extends for around 2 km² in the area of confluence

between the rivers Bevera and Roja.

The geometrical/structural reconstruction of the subsurface was carried out on the basis of the lithostratigraphic data obtained from geostatic drilling and of the geophysical surveys performed in the ambit of the "Eurobasin" and "Risknat" European Community Projects. The presence was thus revealed of a single unconfined aquifer, mainly composed of sandy gravel with pebbles, with an average thickness of 32 m and characterized by a high degree of permeability. This aquifer is confined below by a substratum with low permeability, composed of Ventimiglia Flysch.

The hydrodynamic characterization of the aquifer was carried out by means of a piezometric survey of 20 measurement points (wells and piezometers) which made it possible to represent the groundwater flow field in the period between June 2010 and June 2011.

Thanks to this background knowledge (appropriately integrated with data regarding anthropic impacts), it was possible to develop a conceptual model of the aquifer that allowed us to determine the inflows (river Roja, river Bevera and infiltration) and outflows of the system (pumping and river Roja), from which, despite the strong impact water pumping, a positive hydrogeological balance was seen.

Moreover, it emerges that the majority of the aquifer is very susceptible to waterborne pollution, which gives rise to the necessity for suitable measures for its safeguard, also because of its great importance to both the Italian and French communities as a strategic source of drinking water.

In order to reach the objective of a correct and integrated management (quality/quantity) of this water resource, in both space and time, once the conceptual model had been elaborated we proceeded with the construction of a numerical model which, by means of a process of iteration, made it possible to verify the hypotheses formulated regarding the aquifer's hydrogeological and hydrodynamic properties.

The aquifer system was represented by means of a three-dimensional numerical model with finite elements (FEM), with the use of the FEFLOW 6 numerical code (Finite Element subsurface FLOW system), capable of combining powerful and versatile calculus algorithms that interface with GIS systems.

A4-10 Orale Forte, Giovanni

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3D GEOLOGICAL MODELLING AND GROUNDWATER MANAGEMENT IN THE CAMPANIAN PLAIN (SOUTH ITALY)

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Key terms: 3D geological modeling; Groundwater management; Flow model

Three-dimensional geological modelling is a key topic in hydrogeological studies and has significantly developed in last decade. Despite the constant improvement of knowledge and technologies in 3-D mapping, the predictive function of groundwater models is often constrained by the lack and dishomogeneity of competent existing data.

The present paper points out an integrated approach, combining sedimentological, stratigraphical and hydrogeological analyses, to construct a better and more reliable groundwater flow model in complex geological areas, such as the coastal campanian plains.

The sample area is a sector of Campanian Plain, located between the Sarno River Plain and the southwestern extremity of the low Solofrana River Valley, wide approximately 10 km².

The site is an area of intense exploitation of groundwater resources, because of many industrial and agricultural activities.

The existing boreholes data, integrated with geomorphological and structural information, have been used to build and bind an hydrogeological block diagram. The subsurface model has been used to better define the complexity of this plane sector and to identify the most accurate boundary conditions for the flow model.

The setting up of groundwater mathematical model has been calibrated using an iterative approach based on a try and error procedure.

As a result the simulation of a specific pumping scenario follows a real observed state (recorded in July 2006) and shows the great control of anthropic activities on the groundwater flow conditions of plain aquifer systems.

So an optimized approach to perform an integration between geological and hydrogeological issues is discussed with reference to a real case.

A4-11 Poster De Luca, Domenico Antonio

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HYDROGEOLOGY OF THE VIVERONE LAKE AREA (PIEDMONT, NW ITALY).

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Key terms: hydrogeology; Ivrea Morainic Amphitheatre; Viverone Lake; Pleistocene

The research regards the hydrogeological reconstruction of the left frontal sector of the Ivrea Morainic Amphitheatre (IMA). In detail the studied area includes the internal depression in which the Viverone Lake develops, the frontal morainic relief that borders the lake and the proximal sector of the external glaciofluvial plain. The local stratigraphy was reconstructed based on the interpretation of the water well logs. The pre-glacial succession consists in ancient Dora Baltea fluvial sediments (Lower Pleistocene). The overlying glacial succession includes the Dora Baltea Glacier subglacial and marginal sediments (Middle-Upper Pleistocene), forming the morainic hills. At the top of the sequence different glaciofluvial covers form the external plain (Middle Pleistocene) and the internal depression (Middle-Upper Pleistocene).

Some hydrogeological complexes are defined according to their textural features and stratigraphic position.

The Hydrogeological Complex A consists of the pre-glacial fluvial sandy-gravel with high permeability and hydraulic conductivity estimated greater than 10-5 m/s. A layer of reddish silty clay is probably referable to a buried paleosol developed at the top of the unit. This complex constitutes a deep confined aquifer.

The hydrogeological Complex B consists in numerous overlapped lenticular bodies of prevalently matrix supported deposits, belonging to the IMA

glacial succession. Coarse gravel with blocks in a sandy-silty matrix are referable to marginal deposits, with hydraulic conductivity greater than 10-5 m/s. Laminated silty sand and clayey silt correspond to glaciolacustrine fine sediments with low permeability (conductivity 10-5÷10-7 m/s). Finally, over-consolidated massive silty sand with gravel corresponds to subglacial till with low permeability (conductivity 10-7 m/s). This complex constitutes a multilayer aquifer.

The Hydrogeological Complex C is represented by sand and gravel, with hydraulic conductivity greater than 10-5 m/s. In detail it includes sandy gravel glaciolacustrine deposits of the external plain, constituting a shallow aquifer, and a sandy fan-delta glaciolacustrine lower body filling the internal depression, constituting a semi-confined aquifer.

The Hydrogeological Complex D consists of a fan-delta glaciolacustrine and glaciolacustrine upper body of the internal depression, and of the recent lacustrine deposits at the floor of the Viverone Lake. This complex, with hydraulic conductivity between 10-7 and 10-9 m/s, constitutes an aquitard.

The collected hydrogeological data were obtained by two piezometric surveys (October 2009 and August 2010). Three flow systems (surficial, intermediate and deep) have been recognized. The deep flow system develops below 180 m a.s.l., the intermediate one between 230 (Viverone Lake surface) and 180 m a.s.l. (Viverone Lake floor) and the surficial flow system higher than 230 m a.s.l.

The surficial flow system (contained in the B and C complexes) flows generally from the morainic reliefs to the Viverone basin, feeding the lake. The intermediated aquifer (contained in the B and C complexes) feeds the lake, except at the lake floor (180 m a.s.l.) where the flow is directed from the lake towards the aquifer.

The deep flow system, contained in Complex A, is directed from the lake floor to East, while a westward flow is impeded by the presence of Complex D deposits. A drainage axis into the Complex A develops with NNW-SSE direction at the East of the Viverone Lake, from Roppolo to Alice Castello.

The lake and well waters belong to a bicarbonate-Ca Mg hydrochemical facies. Both surficial and deep waters result of the same type with different compositional maturity, owing to a connection between the lake and the aquifers.

The hydrogeological balance of Viverone Lake is highly influenced from groundwater, with an input of 6.21 Mm³/y and output of 0.86 Mm³/y.

A4-12 Poster Fedoryshyn, Oleksandr

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ELECTROMAGNETIC EFFECTS GENERATED BY FILTRATION OF FLUID IN PERMEABLE POROUS LAYERS

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Key terms: porous layers; filtration theory; magnetic field

In this work the theoretical study of electromagnetic effects associated with the movement of liquid in saturated porous media is presented. There are enough examples of occurrence of such effects in real rocks. Anomalous magnetic field always appears around working artesian and oil wells. The nature of this field is not fully understood, but there is reason to believe that it arises as a result of electrokinetic effects in the saturated rocks. For describing the motion of viscous fluids in porous media it is necessary to use the filter equations. These equations can be obtained from the equations of motion in viscous-elastic inhomogeneous solids by statistical averaging. As a result we obtain the dependence between fluid flow and pressure gradient, so-called the Darcy's law

$$\text{grad } p = -\frac{\eta}{k} \bar{q}$$

and the filter equation

$$\Delta p - \frac{\eta}{kk} \frac{\partial p}{\partial t} = 0.$$

The coefficient k is a permeability of medium, it does not depend on fluid

properties, but only on the geometrical structure of pore space, η is the viscosity of fluid. Based on these equations we can be obtained pore fluid pressure distribution in the layer $p(r, t)$, and fluid flow $q(r, t)$. At the separation surface between solid and liquid phases of rock electric charges always appear. Liquid moving in consequence of filtration captures these charged particles generating thereby current which is not generated by an external electric field. This phenomenon was called seismo-electric effect of the second kind. Seismo-electric current generates a magnetic field. This field on the order of magnitude is much smaller than the natural magnetic field of the Earth, but modern high-precision measurement methods allow you to fix it.

Saturated rocks under certain conditions can generate electromagnetic radiation under mechanical actions (electromagnetic emission). The nature of this radiation is the same as the nature of the magnetic field caused by fluid filtration i.e. it represents a capture of charged particles moving fluid. Based on Biot model for saturated porous media can be found fluctuations of velocity inside of the medium. If the pores are interconnected i.e. the medium is permeable, these fluctuations represent the relative velocity of movement between liquid and solid phases, i.e. that velocity of the particles of the body that is responsible for the appearance of

electromagnetic emissions. We introduce the dimensionless parameter ξ tortuosity of the pores, which represents the ratio of surface area of porous medium with random porosity to the surface area of porous

medium with spherical porosity, this will be $1 \leq \xi < \infty$. This parameter depends only on the geometrical structure of pore space. Theoretical estimates show that the fluctuation rate is proportional to the amplitude of excitation wave. The coefficient of proportionality depends on both

frequency as Ω^2 and the tortuosity $(\xi^2-1)/\xi^2$. From electrodynamics it is known that the intensity of the moving charge is proportional to the square of its acceleration,

$$P = \frac{2e^2}{3c^3} \dot{v}_c^2.$$

Thus we can be concluded that the intensity of electromagnetic emissions

will depend on the amplitude of excitation wave in proportion to Ω^4 . The given mathematical model gives us the qualitative description of the seismic-electric effect in saturated porous media. Based on this model we can plan doing laboratory experiments on real samples of rocks.

A4-13 Poster Pugnaghi, Sergio

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ANALYTICAL SOLUTIONS OF THE RICHARDS EQUATION FOR A FINITE-THICKNESS DOMAIN

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Key terms: Richards equation; Finite thickness domain; Porous aquifer; Aquifer recharge; Soil water content

Numerical methods are very powerful in solving complex nonlinear problems but, in contrast, analytical solutions of differential equation, well describe the physical mechanisms of the involved phenomena. For this reason the analytical solutions of the linearized Richards equation are searched and compared with the numerical ones. The linearization of the nonlinear differential Richards equation simplifies the model but the solutions are related to the considered domain. The authors determined a procedure computing the solutions of the linearized one-dimensional Richards equation for a half-space domain for any discrete soil volumetric water content initial vertical profile and any discrete flux boundary condition. Here it is shown a method to solve the same linearized Richards equation, but for a finite-layer. Both the initial condition (vertical profile) and the two boundary conditions (at the top and at the bottom) are any discrete step functions; that is the measured soil water content at a hydrological station. These solutions represent the time evolution of the profile of the soil water content reading measured in the first two meters surface layer (Parma-Taro area) better than the solutions obtained using the half-space domain procedure.

SESSIONE A5

Idrologia dei sistemi fratturati e/o carsici: stato dell'arte e applicazioni per la gestione delle acque sotterranee in tempi di variazioni climatiche e di incremento del fabbisogno idrico

A5-1 Orale Cambi, Costanza

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INFLUENCE OF THE GEOLOGICAL SETTING ON THE RESPONSE TO CLIMATIC CHANGE AND TO INCREASING PROLONGED DROUGHT PERIODS OF FRACTURED LIMESTONES SYSTEMS

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Key terms: Climatic change; Drought; Fractured aquifer; Spring; Recharge area

It is widely known that, in Southern Europe and the Mediterranean area, in the last hundred years, the temperature has risen by about 1°C, and the average annual precipitation has increased. The analysis at different time scales of historical thermo-pluviometric series recorded in South/Central Italy shows a higher frequency and duration of droughts in the last few decades: the number of three years lasting dry periods recorded since 1990 are as many as those recorded in the interval 1921-1989. The hydrogeological processes regulating both ground and surface water availability are greatly influenced by climate change. If the present trend should continue, a reduction of total yield of 10-20% with respect to present should be expected in the next 50 years. This work shows that the response of a specific hydrogeological system to climate change closely depends on the geological and lithological characteristics of the system. The aquifers hosted in the karst/fractured limestones extensively outcropping in the mountain areas of Central Italy, which supply several mountain springs with high-quality water, are taken as examples. The recharge areas of the springs fed by these aquifers are unaffected by human activity: the analysis of spring discharges is therefore useful to understand the effect of climate change on groundwater regimes. Some of the springs of the Umbria-Marche Apennines, (e.g., Bagnara, Scirca, Pescara di Arquata del Tronto) have long, continuous discharge data sets which show statistically significant negative trends of mean annual and monthly discharges. The Bagnara spring, which is of great importance on the water supplying point of view, is an example of "local system" representing the "overflow" of a deeper regional groundwater circulation, connected with larger "base springs", the quality of which is often poor due to interactions with evaporitic sediments of Triassic age. Springs of this kind are quite frequent in the Umbria-Marche region. A dynamic groundwater divide, the position of which depends on the amount of recharge, separates the recharge areas of the regional flow from those of local springs as Bagnara: low recharge periods correspond to a low level of the piezometric surface, with the piezometric divide shifted towards the systems located at higher elevations and a consequent reduction of their recharge areas. On the contrary, the other system taken as an example in this work, the Lupa spring, although similar to Bagnara for lithological, topographical and climate characteristics and for mean annual discharge (about 120 l/s), has a geologically defined recharge area the extension of which does not depend on the recharge. The analysis of the recession curves of these two springs showed that the response to prolonged drought periods is more severe for the Bagnara than for the Lupa spring; this result can be extrapolated to all the springs connected to a deep regional groundwater circulation, which are more vulnerable to climate change than those with invariable geologically defined recharge areas.

A5-2 Orale Cherubini, Claudia

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A LABORATORY PHYSICAL MODEL TO ANALYSE FLOW AND TRANSPORT PROCESSES IN POROUS AND FRACTURED ROCK SAMPLES AT BENCH SCALE LEVEL

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Key terms: experiments; bench scale; drainage/recharge; tracer tests; numerical modeling

The knowledge of flow and transport phenomena in porous media and fractured rocks is very important in hydrogeologic engineering in order to optimize clean up and monitoring strategies, to carry out risk assessment and to manage interventions in aquifers.

Recently, understanding, characterizing and modelling physical and chemical interactions within fractured aquifers has acquired increasing importance, especially with regard to the question of water resources development and groundwater contamination. Sometimes the equivalent porous medium approach fails to reproduce flow and transport patterns in such complex geological formations.

In this paper are presented different experimental studies carried out at bench scale in both porous and fractured rock samples having different shapes and covered in different ways.

Mainly these laboratory activities focus on the role of solution features within the media on flow and transport processes. High permeability non consolidated media with low permeability discontinuities and fractured rock samples have been analyzed.

The porous medium is located inside a watertight pond of 0.76x0.18x0.50 m dimensions with two ports located at the northstream and southstream sides at different heights while the fractured rock samples of parallelepiped (0.60x0.40x0.8 m) and cylindrical (0.25x0.25 m) shape have different ports in correspondence of the fractures and are submitted to different boundary conditions configurations by changing the entry and exit ports.

Hydraulic loss for drainage/recharge tests and breakthrough curves for saline tracer pulse are measured in transient and steady state flow field through the covered samples.

The above experiments are aimed at understanding the relations existing between the applied boundary conditions, the geometry of the system and the occurring flow and transport phenomena. Even the effects of non linearity have been investigated both for porous and fractured media. The observed data have been compared with numerical model results in order to show the divergence between experimental evidence and conventional models.

A comparative analysis of measured and simulated results has given information about the properties of the investigated sample on the one hand, and about the possibilities and limitations of the chosen model concept on the other.

A5-3 Orale Magro, Gabriella

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WATER MIXING IN KARST SYSTEMS TRACED BY DISSOLVED NOBLE GASES

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Key terms: Helium isotopes; dissolved inert gases; karst; hydrology

The complex hydrodynamics of three selected karst systems in Europe (Baget and Larzac in France, Drama in Greece) was investigated by means of dissolved noble gases (He, Ne, and Ar) and N₂ in spring waters. The molar ratios and isotopic composition of these conservative compounds help to trace mixing processes in karst systems and to identify the occurrence of air excess and deep He excess in spring waters.

The dissolved gases were extracted from sampled water by means of the space head method and the measured concentrations were recalculated to spring water conditions using Henry's law.

N₂ and Ar were analyzed by gaschromatography, He and Ne by a quadrupole mass spectrometer after separation in an all metal high-vacuum line. The He isotopic composition (expressed as R/Ra = (3He/4He)_{sample}/(3He/4He)_{air}) was obtained by means of a magnetic mass spectrometer for rare gases.

Most of the spring water samples show N₂/Ar and He/Ne ratios higher than those expected for water equilibrated to air (ASW) in the temperature interval of cold springs (0° to 15°C). The presence of excess of air in water is a common event, mainly due to small bubbles of air entrapped by recharge water at the undersaturated-saturated interface. For all of the samples the shift of N₂/Ar from theoretical values is well explained by addition of air. The presence of N₂ excess derived from sources different of air cannot however be excluded.

The presence of air excess by itself does not explain the He/Ne ratios higher than asw/air typical ratios in a few Larzac and Baget samples and in most of the Drama samples.

Three main conclusions can be drawn on the basis of the He isotopic composition. Samples from Baget show a dominant air and air saturated water origin; Larzac samples have a slight mantle-derived He excess, while a crustal He excess is evident for Drama.

The Larzac samples result from the mixing of a dominant air/asw end-member with a deeper 3He-enriched component, as it occurs in the nearby thermal spring of Auvergne, along the Rhone Graben, marked by R/Ra up to 2.5.

The Drama samples result from the mixing of an air/asw end member with 4He crustal-derived enriched fluids.

The influence of deep waters enriched in He was more evident during the dry season. Karst waters are the result of a complex hydrologic circulation of several reservoirs with different water residence times that exchange water mainly during floods.

A5-4 Orale Menichini, Matia

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ISOTOPIC RATIOS AS FUNDAMENTAL TOOL IN KARST AQUIFER STUDIES: SOME RESULTS FROM ISOTOPIC APPLICATIONS IN THE APUAN ALPS CARBONATIC COMPLEXES

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Key terms: karst aquifers; isotopic ratios; Apuan Alps

Karst rocks may be considered among the most important aquifer complexes, but their vulnerability and wide variability in flow rate pose some problems to the water resources management. An useful tool to

know karst aquifers and their hydrodynamic behaviour is represented by isotopic ratios, like as 18O/16O and 2H/1H of H₂O and 13C/12C of TDIC. In mountain environment, where karst aquifer systems are often located and conventional hydrogeological surveys are not easily carried out, the isotopic approach allows to provide information related to the whole basin drained by the analysed springs. An isotopic screening can also constitute a valid basic working for specific surveys such as tracer tests, showing the areas from which the tracer will likely reach the springs under study. Water-stable isotopes contents in groundwater are linked to meteoric precipitations ones, which are characterized by variability with altitude and seasonal periods, although their annual weighed average value is rather constant in a determinate site; the 13C/12C ratio depends chiefly on biogenic CO₂ input and on water-rock interaction. Consequently, isotopic analyses can be helpful to define the feeding area and the hydrodynamic response to the rainwater infiltration. To achieve the best results by means of the isotopic techniques is important to know the vertical isotopic gradient of the studied area, as well as to compare the isotopic results with the hydrostructural features.

Major results of isotopic applications in hydrogeological studies carried out on the Apuan Alps carbonatic complexes are here discussed. The aquifers taken into account are chiefly developed in the metamorphic carbonate rocks of the Apuan Unit and secondary in the equivalent not metamorphic ones belonging to the Tuscan Nappe Unit. Karst springs with average flow rate in the range 30-100 L/s were sampled in the River Carrione basin (NW Apuan Alps) in low, high and transitional flow conditions, in any case after a sufficient time from storm events. Similar springs in the same flow regime conditions were sampled in the River Versilia basin (S Apuan Alps) in 2003 and recently, in graduate and Phd programs. Sampling was also carried out during storm events for both karst springs and rainfall, in order to evaluate the short-term effect of the infiltration. From an isotopic point of view the ratio 18O/16O, 2H/1H of H₂O and 13C/12C were determined.

In both areas also several low flow rate springs (1 L/s or slighter) flowing out from less important aquifers were analysed. These are widespread on large altitude intervals and are representative of short groundwater circuits with average feeding altitudes close to outflow ones. In this way, altitude vs. 18O/16O regression lines were obtained, allowing us to evaluate the average feeding altitudes of the high flow karst springs, for which 18O/16O was analysed. This information, together with 13C/12C data, hydrostructural features, flow rate regime and chemical data, allowed to delimitate the feeding areas of several karst springs, in some cases identifying hydrogeological basins wider than hydrographic ones. Isotopic data highlighted other important aspects: i) karst springs very close to each other, and showing the same chemical features, are characterized by important differences in average isotopic contents, which point out the presence of different circulation systems substantially separated; ii) some karst springs show a constant isotopic composition during the year, despite their high variability in discharge (high flow rate up to 200% greater than the low flow rate), thus highlighting a peculiar hydrodynamic behaviour of the aquifer, which is linkable to local hydrostructural features; iii) the kind of isotopic variations registered for some springs during storm events indicated the principal area from which quickly water circuits occur, reaching in a short time the same springs and altering their flow-base.

A5-5 Poster Fiorillo, Francesco

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ANALYSIS OF THE TANK-RESERVOIR DRAINAGE AND SIMULATION OF KARST AQUIFERS

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Key terms: spring hydrograph; drainage; recession coefficient; karst

Drainage of a cylindrical water-filled tank- reservoir has been analysed by different physical models, providing relative discharge-time equations. The process has been simulated (1) in a condition of free-flow discharge, where no energy is lost during the process, and (2) where friction forces and water viscosity take effect. Simulation (1) is considered to be a Torricelli reservoir, characterised by a linear decrease of discharge; (2) is based on Darcy's law or on Poiseuille's law, where discharge decreases exponentially with time, giving a straight line in the semilogarithm plot. For the Darcy's law simulation, the tank tube was filled with sand. The cylindrical water-filled tank-reservoir drainage analysis has been applied to simulation of the actual shape of karst spring hydrographs. It has been determined that the recession coefficient, α , is proportional to a hydraulic constant, c , which represents the hydraulic characteristics during the baseflow recession, and α is inversely proportional to the product of the water-table area with the effective porosity. This product expresses the area of the aquifer filled by free-flowing water along the water table and can vary during the aquifer drainage.

A5-6 Poster Gambillara, Roberto

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VIGOLANA MASSIF (TRENTO - NORTH OF ITALY): WATER CIRCULATION IN A KARST AND FRACTURED AQUIFER

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Key terms: Vigolana; hydrogeology; water circulation; fractured rock; dual porosity

The Vigolana massif is located at South-East of the city of Trento, North of Besenello. This massif is delimited by four valleys: Valsorda to the North, the valley of the Centa river to the East, the Adige Valley to the West and the Gola Valley to the South.

The study area covers the South-West of the massif, where a tunnel, having a W-E direction was excavated.

This massif is characterized by the presence of numerous springs, including seven in the western sector. The spring, located inside the tunnel in Murazzi area (200 m a.s.l.), arises from the rock (dolomite) and it would seem, by the continuous monitoring since February 2009, with such perennial average flow of 80 l/s. The maximum flow rates (about 140 l/s) were found in May and minimum (50 l/s) in November and in March. The Vigolana massif is characterized by both highly fractured rocks and karst conduits that developed in the limestone and dolomite. The difficulties that have occurred in the study of this area were: the high

vegetative cover, the inaccessibility of many areas inaccessible and steep, a problem typical of mountain areas, and complexity in the reconstruction of the conceptual model for the presence of an extensive network of karst conduits within the rock mass.

The calculation of water balance showed a surplus of precipitation equal to $8.18E+07$ m³/year; this indicates that in the basin, delimited by the structural analysis, enters more water than what flows from the springs. By the characteristics of the Vigolana massif it was considered a rock mass, to scale the catchment area of the spring in a tunnel, as a medium of dual-permeability. In this massif the two media with different permeability are the portion of the fractured rock around the spring conduit and the karst conduit where the spring in the tunnel arises. The fact of considering the contribution by fractured rock mass and by the karst conduit, allowed a better quantification of phenomena and showed that the integration between different models, with a careful choice of the scales of analysis brings to good results applicable to management of water resources.

The estimation of the changing flows between the portion of the fractured rock around the conduit and the conduit gives indications on the possible exploitation of water resources and maintaining a base level, which derives from the fractured rock.

It was calculated a rate of exchange of $1.03E-05$ m/s per meter of variation in hydraulic load and per unit of area: this flow will be in favor of conduit when the load on the matrix will be greater than the conduit (Hm major than Hc), during periods when you have less rainfall, in the depletion phase of the flow curve; on the contrary, during charging period, you will find that this flow will be in favor of the fractured rock mass (Hm minor than Hc); no exchange takes place in the case of equilibrium (Hm equal Hc).

A5-7 Poster Menegon, Alan

10.1474/Epitome.04.0078.Geoitalia2011

GEOTHERMAL ANOMALIES OF ITALIAN ALPINE CHAIN REGIONS: FEATURES OF THERMAL SPRINGS AND WELLS

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Key terms: THERMAE; SPRINGS; GIS-DATABASE

Volcanoes and hydrothermal phenomenon are evidence of the Earth inner heat flowing outside. In particular, hot water springs highlight deep thermal anomalies. Every study concerning geothermal phenomenon begins from the mapping of these evidences.

This study is part of a research project concerning thermal claims in northern Italy. The aim of this study is to create an updated database of northern Italy thermal springs and wells, gathering bibliographic and technical information from universities and authorities. All data collected in the database are displayed in a GIS project that provides a global view of all data, and are exported in a GoogleEarth® application. This application allows to have a sudden overview of all the objects of study, displayed with their main features (location, physical, chemical and isotopic features), in a way easy to be read by everyone.

The Alps do not host particular thermal anomalies or abnormal heat flow, but show many examples of thermal springs. Thermal rate, discharge and chemistry of thermal waters are rather different. Since roman times (2000 years B.P.) thermal springs were exploited for their curative properties all over Italian territory but, thanks to recent technologies, hydrothermal resources aren't important only for body wellness but also to produce electricity. Binary cycle can produce electricity using temperature from about 75 °C and discharges of at least 30 l/s.

The database counts over 350 springs and wells with a temperature over 20 °C, including 137 deep petroleum probe drilling in Po Plain. In particular, 7 thermal springs, 28 thermal wells and 40 petroleum probe drillings show a temperature over 60 °C, a parameter that is important to evaluate if the geothermal resources has a potential also for power generation. Most of these wells and springs are include in six main geothermal areas. In these main anomalies, peculiar geological assessment brings hot waters to the surface or at low depths, so thermal water can be exploited by wells.

Even if it is not possible to find similar geological origin alpine thermal springs, many recurrent items can be recognized. The greater number of Italian alpine thermal springs are not related to particular thermal anomalies, according to chemical, isotopic and geo-structural data. In presence of approximately normal geothermal gradient, the geological assessment is a decisive factor in water heating. Meteoric waters leak in the underground, until they reach temperatures of 20 ÷ 90 °C; then, due to favourable structural conditions, hot waters rise quickly to the surface to create thermal springs.

Thermal resources, in northern Italy, are nowadays very well exploited but a possible development of this study is to identify past thermal places, now forgotten or abandoned, and to identify possible new favourable conditions: for example, in Veneto region, the drilling of some wells (deep up to 300 meters) brought to the development of some new thermal activities.

A5-8 Poster Ortombina, Mirta

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FIRST RESULTS OF AN HYDROGEOLOGICAL STUDY IN THE VAIONT AREA

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Key terms: Vaiont; springs; karst; cross correlation

The aim of this research is the hydrogeological characterization of the Vaiont area, especially that of the M. Toc, and the development of an hydrogeological conceptual model.

The analysed area is located in Erto e Casso (Friuli Venezia Giulia Region) and Longarone (Veneto Region), in the south-eastern part of the Dolomites area. The zone is bounded by M. Salta (2039 m a.s.l.) and M. Borgà (2215 m a.s.l.) to the North, by Gallina valley to the South, by the Piave river to the West and by Zemola and Mesazzo Valleys to the East. In this area crops out mainly Mesozoic carbonate formations, while the quaternary deposits consist chiefly by slope and alluvial deposits. The Zemola valley shows several significant springs, while the M. Toc area is characterized by surface water scarcity and few springs, most of which

with a small-discharge. This situation should be due to a karstic groundwater circulation. This hypothesis come from field observation and the presence of dolines in the area above the Vaiont landslide; in this zone most of rainwater infiltrate without producing a significant surface water flow. Any way the presence of karst phenomena and the surface hydrography scarcity is already mentioned in literature (Handron & Patton, 1985).

In the studied area twenty springs were identified. Most of them have very low discharge (<1 l/s) and similar physico-chemical parameters. Chemical analyses were carried out on eight springs (Na, K, Ca, Mg, total hardness, TDS, Fe, Mn, methyl orange alkalinity, Cl, sulphates, carbonates), and they could be classified as oligomineral (135 < TDS < 210 mg/l), cold (6.7 < T < 10 °C) and calcium magnesium bicarbonate-type waters; furthermore all the springs have a slightly basic pH ranging between 8 and 8.4, an Eh ranging between 182 and 274 mV and an electrical conductivity

ranging between 162 and 281 µS/cm, this last information roughly indicates young waters with short circuits.

After the first field analyses two springs with monitoring appropriate features were chosen; since July and September 2010 two data loggers (Diver) were installed monitoring hourly discharge, electrical conductivity and temperature of spring waters. "Ega Nass", on the West of M. Toc (Dogna, Longarone), and "Le Spesse", on the opposite side of the Vaiont landslide (Le Spesse, Erto e Casso) were the chosen springs. Monitoring data were compared with rainfall from two different weather stations (ARPAV, Servizio Idrografico Regione FVG), in order to have an idea of the spring behaviour after rainy events and comparing rainfall discharge, temperature and electrical conductivity between them. A cross-correlation analysis was carried out to estimate linkage between rainfall and spring water discharge, conductivity, temperature and so on. All data analysis were made by the R code (R development Core Team, 2011), which is a free software environment for statistical computing and graphics. The first results show a clearly karst behaviour of the springs with a recharge circuit very short, indeed the time delay from the rainy event to the increase of the spring discharge is very small. Four cross-sections (two N-S and two E-W) through the two observed springs were carried out, improving the hydrogeological conceptual model of the area. The outcropping formations were also divided into five groups, according to their permeability (from very high to very low permeability) to identify subsequently the possible groundwater flow paths (Aa.Vv., 2002).

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A5-9 Poster Pilla, Giorgio

10.1474/Epitome.04.0080.Geoitalia2011

ASSESSMENT OF THE CONCEPTUAL MODEL OF GROUNDWATER FLOW SYSTEMS IN FRACTURED TURBIDITE AQUIFERS: THE CASE OF MOUNT ANTOLA LIMESTONE (NORTHERN APPENNINES-ITALY)

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Key terms: Fractured rocks; Turbidites; Spring monitoring; Vulnerability; Northern Appennines

Even though different studies about the groundwater resources are available for karst systems that are affected by relevant discharge springs, few studies have been carried out on fractured media systems, as the turbidites formations of the Northern Appennines, affected by low discharge springs. Nevertheless, these springs represent the primary resource for drinking and domestic water supplies for little villages. Furthermore, the quality of these groundwaters is generally excellent. In fractured media systems studies, it is fundamental to carry out a detailed analysis of the hydrogeological frame to define suitable methods, aim at protecting the groundwater resources.

In order to achieve this objective, we tested some investigation methods applied on the Gaggina spring system, located in the south of Oltrepò Pavese region, on the eastern slope of Mount Lesima. We selected this spring as a representative model of the great amount of small springs related to fractured turbidites aquifers in the Appennines. The key element is the working out of a hydrogeological conceptual groundwater-flow model to assess the spring vulnerability.

The first step was a detailed field survey to reveal the geological structure of the spring catchment area and to understand the emergency setting. Through geological and structural survey we defined the aquifer properties of the Mount Antola Limestone.

In particular, these surveys established the shallow hydraulic conductivity, by two different approaches. We also carried out a hydrochemical characterization of surface waters and groundwaters of the area.

Then, the study focused on Gaggina spring. Important parameters, such as the discharge, the water temperature and the specific electric conductivity, have been monitored by means of an automatic gauge, acquiring measures every two hours, during a hydrological year. This step was fundamental to characterize the groundwater hydrodynamic system and the behavior of springs during recharge events. We found out two different kind of hydraulic circulation during recharge events. The "piston flow" occurs as a clear response to each significant meteoric event, while the "prevailing replacement" phenomenon, that represent the quick arrival at the spring of freshly infiltrating waters takes generally place during the spring and autumnal groundwater renewal. We got, however, some clues about the arrival at the spring of freshly infiltrating waters even during secondary rainy events. These two phenomena could therefore occur simultaneously in some occasions.

The different kind of surveys carried out in this study have allowed to estimate the aquifer and spring vulnerability, with the aim of planning suitable groundwater protection strategies.

A5-10 Poster Vespasiano, Giovanni

10.1474/Epitome.04.0081.Geoitalia2011

HYDROCHEMICAL CHARACTERIZATION OF THE METAMORPHIC-SERPENTINITIC ACQUIFER OF THE CORECA BASIN (CALABRIA, SOUTH ITALY)

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Key terms: hydrogeochemistry; aquifer; metamorphic-serpentinitic

A preliminary study of the metamorphic-serpentinitic aquifer of the Coreca Basin (Calabria, south Italy) is carrying out. In the studied area rocks belonging to metamorphic and sedimentary units outcrop in tectonic window. Basal unit is constituted of Triassic dolostone and limestone overthrust by ophiolitic sequence of Gimigliano and Frido units. The latter mainly consists of metapelites and slates. Metamorphic units are sealed by Late Miocene sedimentary sequences consisting in calcarenites, clays, marls, Messenia limestones on the upper part. Pleistocene terraced deposits rest on the top. The main aquifer of the Coreca area consists of serpentinites, metabasalts, phyllites and carbonates. The structural assemblage of the area suggests the presence of a perched metamorphic aquifer represented by the ophiolitic rocks, suspended by slates of the Frido Unit. A second aquifer consists of Miocene mainly carbonate rocks and results separated from the metamorphic aquifer by high angle faults. The study has been carried out following the classic techniques of the hydrogeological prospecting, which have specifically concerned: 1) a preliminary mapping study; 2) the characterization, in terms of hydrogeology, of the outcropping rocks; 3) the sampling and analysis of 24 springs and wells. Preliminary results allowed to identify the groundwaters and water table characteristics in the basin and to reconstruct the hydrogeochemical model of the area. Two groups of waters can be identified: the first one falling in the Ca²⁺ field, suggests that the chemical composition of these springs is controlled by the dissolution of Ca-rich phases present in metabasalts; while an interaction of meteoric water with serpentinitic rocks may explain the second group of Mg-HCO₃ groundwaters. Geological, hydrogeological and geochemical data confirm the existence of two distinct aquifer in the Coreca Basin.

A5-11 Poster Piscopo, Vincenzo

10.1474/Epitome.04.0082.Geoitalia2011

SUSTAINABLE GROUNDWATER DEVELOPMENT IN A NATURALLY ARSENIC-CONTAMINATED AQUIFER: THE CASE OF THE CIMINO-VICO VOLCANIC AREA (CENTRAL ITALY)

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Key terms: Arsenic; Volcanic aquifer; Sustainability; Cimino-Vico volcanic area

In the volcanic areas of central and southern Italy the presence of arsenic in groundwater has been documented for about thirty years. After the recent revision of legislation concerning the drinking water standard, i.e. lowering of the MCL from 50 to 10 µg/L, arsenic is now not only a health problem but also a socioeconomic issue. As a consequence, water management companies and authorities must invest in water management to ensure drinking standards in line with the new regulatory context.

This study concerns the occurrence of arsenic in groundwater of the Cimino-Vico volcanic area (Central Italy), widely used for the local drinking water supply and irrigation. The purpose is to provide a hydrogeological support for addressing the groundwater resource management.

From current knowledge on the hydrostratigraphic and structural setting, potential recharge and discharge rates of the system, groundwater quality, type and nature of the aquifers, the arsenic content in groundwater has been examined. Afterwards, the local response of aquifers has been analysed to evaluate the present systems of groundwater abstractions. A complex groundwater system results, including several perched aquifers and a continuous, unconfined or leaky basal aquifer in the volcanites. In some areas a relatively deep aquifer in the volcanites, or in its fractured sedimentary substratum, is characterized by thermal waters. Interactions between shallow and deep groundwater flow were frequently found. The occurrence of arsenic in groundwater is mainly connected with the deep-rising fluids that characterize the active hydrothermal system. The highest arsenic concentrations (from 180 to 370 µg/L) were found in the thermal springs and wells fed from relatively deep groundwater flow. In the shallow volcanic aquifer, the arsenic concentrations in groundwater (from 2 to 100 µg/L) are related to the local hydrostratigraphy, structural setting, hydraulic parameters and nature of the different overlapped aquifers. Where the volcanic aquifer is open to the upward flow through the fractured, semiconfining substratum, relatively high arsenic concentrations (from 20 to 100 µg/L) were found. Where the volcanic aquifer is recharged only by infiltration and the aquifer base is sealed by a high thickness of low-permeability sedimentary rocks, arsenic concentrations less than 20 µg/L were found. The lowest concentrations (less than 10 µg/L) were found in the wells and springs of the perched aquifers. For the continuous basal aquifer arsenic concentration seems also to be related to the type of volcanic products which differ from one another in composition, age, porosity, and hydraulic conductivity. At present, the groundwater resources of the volcanic aquifers supply the local demand of drinking water (about 150,000 inhabitants) through numerous wells and springs, whose location is based on proximity to the users and on rate of flow. A new approach to groundwater management should be implemented to contain the impact on human health. Specifically, the nature and structure of the substratum of the volcanic aquifer must be included among the criteria to identify the location and manner of the groundwater withdrawals. Hydrothermal areas and faulted zones in the units underlying the volcanic aquifer represent the more vulnerable situations for the pumping of drinking water. Around these more vulnerable zones, it should always be verified that the pumping effects on the horizontal and vertical flow contain the mixing between the relatively shallow and deeper groundwater units. From a simulation conducted in one of the areas where the arsenic concentrations in the present tapped groundwater are between 15 and 40 µg/L, it results that the costs of water treatment are decidedly higher than those necessary to building of new wells according to the previous above criteria.

A5-12 Poster Dragoni, Walter

10.1474/Epitome.04.0083.Geoitalia2011

IMPACT OF THE PRESENT CLIMATIC TRENDS ON THE DISCHARGE OF BAGNARA SPRING (UMBRIA - MARCHE APENNINE, ITALY)

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Key terms: hydrogeology; springs; climatic change; modeling

Analysis of the most reliable meteorological datasets for Central Italy reveal that most of the series have trends. Their presence and intensity vary according to statistical technique, to quality of data and geographical location, but the general picture is quite clear: in practice, all stations showing significant trends report a decrease in rainfall and an increase in temperature. Temperature increase and rainfall decrease inevitably reduce the water yield of hydrological systems: indeed, analyses of discharge data series of some hydrogeological systems in Central Italy show negative trends. Although in some systems it is not easy to define in which proportions this trend is to be related to climatic variations or to exploitation or land use, there are some systems - particularly mountain catchments and springs - which can be considered as not influenced by human activity and which show a decrease in yield over the last 40-50 years. One of these systems is Bagnara Spring which has been studied in order to obtain some reasonable scenario about the discharges during the next 30 years, assuming that the climatic trend of the last decades will persist. Bagnara spring is fed by the Monte Pennino anticline, which is a typical Apenninic structure, an east-vergent asymmetric anticline, with a main thrust structure and some secondary thrusts on the eastern slope, and back thrust structures on the western slope. The rocks outcropping in the area belong to the Umbria-Marche geological sequence, which is mainly made of limestone formations within which some marl formations occur. According to the geological setup, the potential recharge area of the spring is about 7.5 km² wide. In spite of their poor quality, the analysis of the meteorological data in the area indicates that during the period 1982-2009 the water surplus (defined as the difference between rainfall and evapotranspiration) decreased of about 15 - 20 % compared to the 1954 - 1981 period. In order to have an idea about the future discharges of the spring, a set of lumped models of the rain-discharge process transformation was applied. All the models were on a monthly basis. Under the assumption that the present trend will continue and in spite of their different performance, the models indicate a decrease of the discharges higher than the decrease of the water surplus. This should be taken in account in the future water management plans. Sounder results and better modeling could be obtained if the meteorological data were more reliable: it is imperative that a reliable data net for the measurement of evaporation, piezometric heads, rain, snow and temperature is established.

SESSIONE A6

Bilanci idrici: modellistica e gestione sostenibile delle risorse idriche sotterranee

A6-1 Orale Di Salvo, Cristina

10.1474/Epitome.04.0084.Geoitalia2011

IMPLEMENTATION OF GROUNDWATER NUMERICAL MODELS IN URBAN AREAS: THE CASE OF ROME

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Key terms: Hydrogeology; numerical models; Rome; urban areas

This study is part of the Urbisit project, led by Igag-CNR and Roma Tre University and funded by the National Civil Protection, which purpose is to investigate the geological risks in urban areas. This research represents the first attempt to modeling the roman aquifer system at a regional scale; a hydrogeological numerical model in an urbanized area can be fundamental to check the impact of subterranean works on the geological and groundwater system. The study was developed in several phases:

- Data collecting (from Roma Tre - the LINQ database and the IGAG-CNR database) and archiving in the URBISIT project database; the total number of collected data in the study area is 2950.
- Data elaboration; building cross sections.
- Translating the geological setting into hydrogeological setting and conceptualization of the aquifer system.
- Elaboration of the top surfaces of the main hydrogeological complexes by mean of ArcGis@ tools.
- Implementation of a numerical model by mean of the finite-difference code MODFLOW2000@

The "ROMA" numerical model is a basin-scale, steady state model; it is made by 8 layers with uniform cell dimension of 50 x 50 meters, over an area of about 237 km². Hydraulic conductivity values were derived by about 130 field data and by laboratory test, already archived in the LINQ database. Because of the small number of tests respect to such heterogeneous complexes, k values from literature), from numerical models previously developed by the LINQ and from technical reports were also considered. To calculate the recharge, two different cases were distinguished, "natural" and urbanized areas. In natural areas, the average recharge for years 1997-2007 calculated by the distributed water budget method (Capelli et alii, 2005, updated with rainfall data up to year 2007). In strongly urbanized areas, as in the historical center of Rome, the recharge was calculated taking into account both the sealed surfaces (reducing the rainfall infiltration and increasing the runoff) and artificial recharge sources (coming from over irrigation in municipal gardens and water leakage from mains. The rivers and streams stage were simulated by using RIVER and DRAIN cells; rivers stages are taken from the SIMN (Servizio Idrografico e Mareografico Nazionale). In some areas of the historical center, the streams are nearly-completely hidden by urbanization and partially substituted by artificial mains (as in the case of ancient cloacae), which were simulated as DRAIN cells. In the city of Rome, withdrawals are mainly due to: industrial uses, irrigation of municipal gardens, car washing plants, domestic uses in not-strongly urbanized areas, agricultural and zootechnical uses, fire hydrant. Withdrawals were quantified by mean of three databases collecting data from Rome municipality. The total estimated withdrawal is 29097.5 m³/d. The boundary conditions were implemented on the model border in order

to simulate inflows and outflows which are compatible with the estimated water budget within an established tolerance threshold. The model has been calibrated by a trial-and-error method based on the target residuals statistic, which is the discrepancy between observed and simulated values. Five "Autosensitivity" analyses were performed in order to establish which parameters would give a better solution in a calibrated model; the most sensitive variables were identified and subjected to calibration. Then, the calibrated model was verified by a comparison with observed water levels (for year 2008) and water budget for years 1997/2001. At the current stage of development, the model "ROMA" can be used for quantitative evaluations of the groundwater resource at basin scale; it is possible to simulate different steady-state scenarios, by varying rivers stage, withdrawals and recharge. Moreover, the model can be used to derive boundary conditions for local-scale models, that can be obtained by a "grid refinement" starting from the regional model.

A6-2 Orale Taviani, Sara

10.1474/Epitome.04.0085.Geoitalia2011

APPLICATION OF THE MODFLOW GROUNDWATER NUMERICAL MODEL TO BRACCIANO HYDROGEOLOGICAL VOLCANIC UNIT

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Key terms: groundwater model; volcanic deposits; lake

The hydrogeologic system studied is located in the north of Rome (Sabatini area) and is characterized by volcanic deposits. There is a main aquifer inside volcanic deposits and Bracciano lake has a direct exchange with the aquifer.

Bracciano hydrogeologic basin includes: four volcanic calderas, two of these still occupied by lakes (Lake Bracciano and Lake Martignano), there are two big water abstraction sites: one from lake (Paolo aqueduct) and the other fed by drains on the northwest side of the Lake Bracciano (Traiano aqueduct). At the same time the area is exposed to a continuous exploitation and dewatering from effect of the several public and private pumping wells from the groundwater aquifer put in action in the last twenty years.

It was built a conceptual model: geological and hydrogeological framework has been investigated, a volumetric reconstruction of the aquifer has been made, were areas with different hydraulic behaviour were identified and media type defined (porous media and fractured). Then the identification of the sources and sinks were summarised in the elaborated water budget.

It was applied a methodology, suggested by Sonnenborg & Henriksen (2005), to determine the uncertainty of observational head data in relation to the model. The purpose of quantifying the uncertainty of

observational head data (σ_{obs}) is to achieve a measure of how accurately the model can reproduce the data. This should in principle be an objective criterion for how data weighted approximation and more importantly, how data of different types must be relatively weighted (important when using objective functions).

Volcanic deposits are characterized by a high heterogeneity which conditions groundwater flow patterns, so it was considered the effect of the heterogeneity on the uncertainty estimation.

It was revealed that the component due to geologic heterogeneity on the whole observational head uncertainty value, played a major role for such performance assessments and that the lack of experimental data suggested that this aspect should be further analyzed in more depth when doing future model analysis of volcanic aquifers.

From the conceptual model a numerical groundwater flow model (mathematical model) was set up using a finite-difference code MODFLOW2000; using the graphical interface of Groundwater Vistas@5.41 (ESI), which allowed incorporation of the implemented lake package, thus it was possible explicitly to include Lake Bracciano and its interaction with the underlying volcanic aquifer within this package.

Calibration tests were carried out, PEST was used for the inverse calibration, with head and flux targets. During calibration process, the water budget values were constantly compared with the volumes estimation coming out from simulations to evaluate the results. The management of a complex system is challenging, and could surely benefit of the predictive capacities that a calibrated and validated model would enable and provide. It should be an interest and preference of the public administration to implement a stronger tool as a groundwater model, since a quantitative understanding of the whole system and its interactions are needed in order to exploit the groundwater aquifer in a sustainable way. Also for the different water users it is important to manage their own wells based on a better understanding of the whole system, and how their groundwater abstraction and land use affects the recharge, water balance of the aquifer, interaction with lake, wetlands near the lake and runoff from the area.

A6-3 Orale Pranzini, Giovanni

10.1474/Epitome.04.0086.Geoitalia2011

HYDROGEOLOGICAL BUDGET OF THE MONTE AMIATA VOLCANIC AQUIFER

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Key terms: Volcanic aquifer; resource depletion; hydrogeological budget

The Monte Amiata aquifer holds the most important water resource of Southern Tuscany, exploited for the civil water supply of Southern Tuscany and Northern Latium. In the last decades a remarkable reduction of the springs flow rate has been observed, as well as a dramatic lowering of the water table, as resulted by a recent geomagnetic survey. It has been put forward the hypothesis that such resource reduction would be caused by the geothermal cultivation by ENEL: the pressure reducing in the below carbonate reservoir would cause a water recall from the volcanic aquifer. Instead, some others believe that the impoverishment of the resource is only due to the reduction of the aquifer recharging, due to climatic change, owing that the geothermal reservoir is isolated from the volcanic one by clayey units of the Ligurian Units.

To give a contribution to the solution of this problem, the groundwater budget relative to three sub-periods of the interval 1939-2008 was drawn up, as well as that of the entire period 1939-2008:

1. the period 1939-1956, preceding the geothermal exploitation;

2. the period 1957-1980, with geothermal cultivation and characterized by an artificial exploitation of the aquifer (boring of draining tunnels);

3. the period 1981-2008, characterized by a dramatic reduction of the sources flow rate.

Due to the lack of measures of the superficial outflow, the water budget was limited to the comparison between the infiltration in the volcanic outcrop (I) and the total flow of springs and wells (Qs).

The infiltration rate of each volcanic unit outcropping was calculated, by means of GIS processing, with the formula $I = (P - E) * C_{ie}$. The actual infiltration coefficients C_{ie} was preliminarily assumed high (80-90%) according to previous budgets of the aquifer.

Most of the springs have only few measures of flow rate. The completion of the time series of all the springs was made through correlations mostly based on the only source monitored with continuity, the Ermicciolo spring. With the values of I and Qs calculated, the first two budgets show a fairly good accordance between infiltration and outflow from underground.

Instead, the flow of the sources in the third period results greater than meteoric recharging, putting forward the hypothesis that the drainage of the tunnels is still reducing the geological reserve. Considering that in the same period the geothermal cultivation has increased, we can conclude that the feared impact of the exploitation by ENEL on the groundwater resource is null or negligible. In this context, the drop of the water table highlighted by the recent geophysical campaign (drop significantly overestimated) would be caused by the drainage of the tunnels above mentioned and not by the losses to the geothermal reservoir.

Apart for this conclusion, it must be said that our budget, as well as those made by others, is clearly inaccurate: in fact, the runoff would be only 2% of precipitation, which conflicts with the direct observation of the stream's flow during heavy rainfall. The reason is that the meteoric inflows do not take account of the snow, as there are no stations equipped to register the snow; and the M. Amiata is a ski resort! Assuming that the height of snow accumulated in each winter of the period 1939-2008 is equal to the average of the 20 winters from 1986-1987 to 2005-2006 - this is the only data available on the snow -, we estimate an increase in infiltration of 102 mm/year. This leads to a reduction in C_{ie} to 0.81-0.82, leaving room for a runoff close to 10% of rainfall.

A6-4 Orale Curcio, Chiara

10.1474/Epitome.04.0087.Geoitalia2011

3D NUMERICAL MODELING OF THE PISA COASTAL PLAIN (NORTH-WESTERN TUSCANY)

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Key terms: hydrogeology; seawater intrusion; numerical modelling; Pisa coastal plain; Tuscany

Since prehistoric times, the Pisa coastal plain, lowest portion of the Arno and Serchio Rivers basins, was the preferred site for human settlements. It was therefore involved in important drainage and hydraulic reclamation works. They began before Roman Empire and produced an almost entirely artificial hydrographic network, including significant modifications to large part of the main river courses. In the last two centuries, population quick rise, urban centers, tourist and industrial activities growth raised both water and dry land demand. Irrational water pumping near the coast produced severe seawater intrusion in the coastal aquifers.

3D finite differences numerical simulations (Visual Modflow 4.2) were applied to the phreatic aquifer of the Pisa coastal plain (Wide Area Model - WAM), with dedicated zooms on the densely inhabited areas of Marina di Pisa and Tirrenia. In particular, the WAM has its boundary at the Arno River to the North, the Navicelli Canal to the East, the Scolmatore Canal to the South and the seashore to the West. The WAM output was used as boundary condition to implement the zoomed models of Marina di Pisa and Tirrenia (Visual Modflow Seawater code).

The work required a first step of acquisition, systematization and processing of bibliographic and field data, in order to build the geological and hydrogeological conceptual model; the conceptual model was then translated into numerical input.

The implementation of the numerical model based on the hydrostratigraphic structure, rainfall pattern, thermometric and piezometric data collected from October 2007 to December 2009 (calibration stage), as well as on the unconfined and first confined aquifer salinity data logs, and on the main hydraulic parameters (hydraulic conductivity, porosity, storage coefficient) of the studied aquifer. The unconfined aquifer, 10-15 m thick, is hosted in sandy coastal dunes, characterized by medium-high hydraulic conductivity ($K \approx 10-2$ cm/s) and overlies an aquiclude ($K \approx 10^{-7}$ cm/s) generally constituted by clay and silty clay.

Besides numerical modeling the correlation between rainfall and piezometric level data was analyzed in order to identify the phreatic aquifer recharge time. For almost all the monitored piezometers, a high correlation coefficient ($0.75 < R_2 < 0.85$) between rainfall and water table data was detected for a span of 75 days. The identified correlation helped the model simulations interpretation.

The WAM was implemented and calibrated in order to analyze the water flow system, while the zoomed models of Tirrenia and Marina di Pisa were carried out and calibrated to calculate the extent and saline content of the seawater intrusion. The results reached a significant statistical correspondence to observed data sets. Regarding Marina di Pisa and Tirrenia models, simulation was also performed to forecast possible future scenarios relating the water table trends and seawater intrusion.

Both models show a modest degree of seawater intrusion near the shoreline. In particular, in the Marina di Pisa area, close to the dune system, the seawater intrusion is just a thin level below a thick freshwater body. On the other hand, in the Tirrenia area the salt water completely saturated the unconfined aquifer. In the internal portion of the study area, between the dune system and the Navicelli Canal, in ancient times characterized by lagoons, marshes and swamps, the salt content raises, from high to very high for the whole thickness of the aquifer.

In conclusion, the simulation models show the important role of the natural dune system as freshwater pseudo-hydrostatic barrier, effectively contrasting the seawater intrusion in the unconfined coastal aquifer.

Moreover, simulations identified the main cause of the seawater intrusion in massive pump driven dewatering by the artificial drainage network, which causes a significant lowering of the water table, from 1.70 to 2.50 below the sea level.

A6-5 Orale Cattaneo, Laura

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MODELING GROUNDWATER RESOURCES IN AN ALLUVIAL AQUIFER OF SOMALILAND

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Key terms: water resources; alluvial aquifer; mathematical modeling; dry land

Water for the city of Hargeisa (Somaliland) is supplied by wells drilled in the alluvial aquifer of the Ged Deebale (GD) basin. The well fields were started in the 1970's by the Chinese cooperation and some new wells were drilled later. The water production, after the drop due to the civil war, raised again to the pre-war levels (around 6000 m³/day) in the first years of the millennium, and up to 10.400 m³/day at the beginning of 2010. This trend reflects in the variation of the water table depth with time. An EU project allowed to perform some exploration activities from 2003 to 2007, including: a detailed geological survey, a geoelectrical campaign, a series of pumping tests, a continuous monitoring activity prolonged for two years. The data permit a first reconstruction of the basin shape, of the hydrological structure and of the mechanisms of the aquifer recharge. The aquifer consists of unconsolidated sediments deposited in lacustrine or fluvial environments and is bounded by a Precambrian crystalline bedrock. From a structural point of view, the basin is the result of the intense tectonic thrusts that gave birth to the Gulf of Aden rift: it probably formed by two major tectonic trenches, E-W oriented, connected by a long fracture with N-S alignment. A wide outlet was found at the N-E edge which connects the GD basin to the Laas Dhuurre-Damal (LDD) basin. The available data were used to apply a FORTRAN90 original code for the simulation of 2D groundwater flow. The mathematical model considers a 2D hydraulic flow approximation, pseudo-steady conditions corresponding to the average annual flow, no-flow boundary conditions in correspondence of the crystalline bedrock and fixed head at the edge with the widespread and thick LDD basin. The calibration of the mathematical model was quite difficult for the uncertainties on the old data, but showed some results that improved the knowledge of the physical system and gave some practical answers to the questions posed by the water management agency. From the hydrogeological point of view, there is a division of the basin in two sections, separated by an area of low permeability; the recharge in the upstream (southern) section probably comes from an underground fracture-fault network, whereas in the downstream (northern) section comes from the LDD basin. From the point of view of resource management it appears that the GD basin alone cannot satisfy the future water demand of the city without a further, more dramatic depletion. However, a shift of the production from the wells in the southern section to those located in the northern one or even to the much wider LDD basin could support the growth of the city water demand.

A6-6 Orale Borsi, Iacopo

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MODELING SURFACE WATER AND UNSATURATED/SATURATED ZONE INTERACTIONS: MODIFICATIONS TO MODFLOW-2005 FOR SOLVING 3D VARIABLY SATURATED FLOW, CASCADING FLOW AND STREAM/AQUIFER LEAKAGE.

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Key terms: unsaturated zone; surface/subsurface water interactions; modelling and coding

This work is part of the research project SID&GRID, started April 2010 and funded by Regione Toscana (Italy) under the POR FSE 2007-2013 program.

Our focus deals with the modification of the well-known code MODFLOW-2005, in order to extend its capability of the unsaturated zone investigation. The better understanding of the vadose zone is very important for practical applications (the study of agricultural fields, for instance), but also in any general picture in which the modeler aims at investigating the coupling between surface and subsurface water: indeed, the unsaturated zone is the main interface between groundwater and surface water.

We addressed the problem of using MODFLOW-2005 to this purpose by modifying or extending some part of the code. In particular:

1. We updated the packages of MODFLOW2000-VSF, Variably Saturated Flow (Thoms et al., 2006), in order to be used within MODFLOW-2005 endowed with the LGR capability, known as Local Grid Refinement (Mehl and Hill, 2005). This modification allows to describe the unsaturated zone in a deeper way only in those regions of the domain where this investigation is really important; in the other regions, the vadose zone is simulated by means of the package UZF, Unsaturated Zone Flow, (Niswonger et al., 2006).
2. A new algorithm to route the overland flow inside the domain had been developed: whenever in a cell of the model top is saturated, the excess flow, representing the sum of Hortonian and Dunniann runoff, is routed according to the slope end the exposure of the cells and, eventually, it is added as input to rivers and/or lake. This method results in a slight modification to the UZF package, and the implementation of the same concept within the VSF packages PND (ponding) and SPF (seepage flow), (Thoms et al., 2006).
3. The stream package SFR2 (Niswonger and Prudic, 2005) had been updated to compute the transient routing and the leakage to/from the aquifer in a semi-couple way, using a method already developed in other codes like PARFLOW-CLM (Maxwell and Miller, 2005).

The main features of the new model definitions will be presented, along with the results of preliminary tests.

To be updated about code development, please, follow our work at the website: <http://sidgrid.isti.cnr.it>

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A6-7 Orale Bonomi, Tullia

10.1474/Epitome.04.0090.Geoitalia2011

EVALUATION OF GROUNDWATER RECHARGE IN HIGHLY URBANIZED AREAS

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Key terms: Groundwater recharge; Runoff; MACRO; Curve Number

The evaluation of groundwater balance is an indispensable goal in the hydrogeological studies aimed to correctly manage groundwater exploitation, in a particular way in urbanized areas, for which groundwater is the only drinkable water source. In these cases the water pumping rate from wells should be controlled and planned in such a way that groundwater abstraction doesn't exceed groundwater recharge, which depends on many variables among which precipitations and soil permeability.

This study analyzes groundwater recharge in the River Seveso watershed, located in the northern lombardian plain, over the period 1985-2010. It is an attempt to evaluate the influence of the factors that contribute to the infiltration towards groundwater and/or to the runoff towards rivers, which give rise to frequent floods in some urbanized areas during high intensity rain.

A double (numerical and empirical) approach has been used for this purpose, which includes the use of the numerical MACRO code (Jarvis, 1994) to evaluate the soil hydrological balance, and the Curve Number method to evaluate the soil runoff, which is considered as a lost recharge rate.

This approach allows to consider how multiple variables such as climate change, soil and subsoil hydrological characteristics and land use influence the recharge rate.

The results, on a daily scale, allow to define the variability of the hydrological balance on the watershed over a 25 years period, and to analyze the changes driven from both climate and land use planning on the soil hydrology, and on the hydrological balance as a consequence. The recharge rate in the area, 60% of which is urbanized, is up to 400 mm/year, with respect to an average precipitation rate of 1108 mm/year. The average runoff rate, in the same period, is up to 400 mm/year in intensively urbanized areas, and up to 800 mm/year on the paved streets and roads, as a function of their different permeability.

Concerning the groundwater reservoir, the water table variations in the considered period are consistent with the model results.

The proposed methodology could support water management studies, such as groundwater reservoir evaluations, hydrogeological model implementations aimed at groundwater managing, land use planning aimed at preventing both a runoff increase and a groundwater recharge decrease.

A6-8 Orale Remonti, Michele

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DEVELOPMENT OF A REGIONAL GROUNDWATER FLOW MODEL FOR A PUBLIC WATER COMPANY IN BERGAMO PROVINCE, ITALY

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Key terms: MODFLOW; Groundwater modelling; Water resources; Bergamo

The territory between Rivers Adda and Serio, in the Bergamo province plain - Northern Italy, have one of the highest population density in Italy and is characterised by intensive industrial and agricultural activities.

Water resources, both superficial and groundwater, historically have been, and still are, strategic for the development of the area: natural streams and irrigation channels are abundant and the alluvial aquifers have high productivity. Particularly the latter are extensively exploited, through more than 1.000 water wells that abstract about 20 m³/s of water.

In the last decades, several severe groundwater contaminations occurred in the area, determining relevant social and economical effects for the resident population. Moreover, water abstraction from the numerous wells raised the attention of Public Authorities and water managing companies to the needs of a more efficient quantitative and qualitative control of the aquifers.

In 2010, a regional groundwater flow model has been realised for the water managing company Cogei S.p.A., serving 16 municipalities and more than 90.000 inhabitants in Western Lombardy. The model has been developed with the finite difference code MODFLOW 2005, is quasi-3D and represents the unconfined aquifer between the ground elevation and 30-45 m b.g.l., the semiconfined aquifer, until 45-75 m b.g.l. and the deep confined aquifer, that reaches the depth of 300 m b.g.l., in an area 2.400 kmq wide.

The hydrogeology of the area is complex, due to the presence of tectonic buried structures of regional importance, which conditioned the sediment deposition, the aquifer thickness and the distribution of the lithologies within the aquifer. This factors affects the groundwater direction and hydraulic gradient, resulting in a complex groundwater flow net. The realisation of the model required a wide data collection and interpretation, which allowed a deeper understanding of the hydrogeological conceptual model of the area. The calibrated model represents a quantitative tool that will help the water managers to optimise the distribution of the well pumping rates and will allow estimating the environmental fate of the groundwater contaminations.

A6-9 Orale Doglioni, Angelo

10.1474/Epitome.04.0092.Geoitalia2011

POTENTIALITIES AND ACHIEVEMENTS OF EVOLUTIONARY MODELING AS AN INNOVATIVE APPROACH TO GROUNDWATER

DYNAMICS ANALYSISDOGLIONI Angelo¹, SIMEONE Vincenzo¹

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Key terms: Data-Driven; groundwater; evolutionary modeling; hydrogeology

Data-driven techniques are commonly considered among the most powerful approaches to the modeling of environmental phenomena. Their popularity can also be attributed to the increasing availability of monitoring information. These provide a reliable mathematical description of the relationship between the physical variables of the systems. Among the evolutionary modeling technique, Multi-Objective Evolutionary Polynomial Regression, EPR-MOGA proved particularly effective at modeling the dynamics of groundwater, in terms of response to rainfall. Evolutionary Polynomial Regression (EPR) is an evolutionary modeling technique (Giustolisi and Šavic, 2009) successfully applied to multiple problems related to natural systems (Doglioni et al., 2010; Giustolisi et al. 2008). It proved effective at modeling the dynamic relationship between groundwater levels and rainfall heights for specific cases, related both to porous and karst aquifers (Doglioni et al., 2011; Giustolisi et al. 2008, Mancarella and Simeone, 2008). Although, EPR-MOGA is a data-driven model based on a regressive approach, the returned models are explicit polynomial equations, and this allows for conjecturing on the relationship between the main variables of the investigated phenomena. This allows for highlighting some unclear or unknown relations and to indirectly get information about the physics of the phenomenon at stake. EPR-MOGA already proved to be particularly fit to those cases where the input to the process and the boundary conditions are not easily accessible, as for the case-study. EPR-MOGA identified simple and significant models, which provides knowledge on the aquifer behavior, based on simple variables used to study the dynamic response of the aquifer.

The aquifers investigated by the authors are representative both of karst and porous scenarios. In both the cases, EPR-MOGA identified models, which were consistent with past studies and with the physical knowledge of the system, allowing for explicating the main rainfall components influencing the water table and the lag between rainfall and water table oscillations. These show that EPR-MOGA can be a really powerful and reliable for the study of the dynamics of aquifers, also in complex scenarios.

Specifically, EPR-MOGA was applied to three aquifers located in south Italy: the deep karst aquifer of Lecce (Doglioni et al., 2011a), the shallow porous aquifer of Brindisi (Doglioni et al., 2010; Giustolisi et al. 2008, Mancarella and Simeone, 2008) and the shallow porous aquifer of Metaponto plateau (Doglioni et al., 2011b). Brindisi and Lecce are located in Salento Peninsula, south of Puglia region, extreme southeast of Italy. The investigated aquifer of Metaponto is located on the south coast of Basilicata, south Italy, between the rivers Basento and Cavone. Doglioni A, Mancarella D, Simeone V, Giustolisi O (2010) Inferring groundwater system dynamics from time series data. *Hydrolog. Sci. J.*, 55(4), 593-608.

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A6-10 Orale Romano, Emanuele

10.1474/Epitome.04.0093.Geoitalia2011

GENERATING SYNTHETIC TIME SERIES OF SPRINGS DISCHARGE IN RELATION TO STANDARDIZED PRECIPITATION INDICES. CASE STUDIES IN UMBRIA (CENTRAL ITALY)ROMANO Emanuele¹, DEL BON Andrea¹, PETRANGELI Anna Bruna¹, PREZIOSI Elisabetta¹

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Key terms: CARBONATIC SPRINGS; STANDARDIZED PRECIPITATION INDEX; WATER RESOURCES MANAGEMENT; CLIMATE CHANGE

In the Umbria region (Central Italy) water for human, agricultural and industrial uses arises from different kind of resources: surface water (streams, lakes and reservoirs) and groundwater (karstic and volcanic springs and wells tapping mainly alluvial aquifers). As a consequence, the water system integrates a number of sources different in size, recharge time and storage capacity. In this context it is fundamental for management purposes to study the relations between the evolution of the rainfall input overall the basin and the distribution in time and space of the stored resources, in relation to the present or future basin climatic conditions. This information, combined with data concerning the water demand evolution by means of suitable management models, permits to foresee possible conditions of water scarcity. Additionally, modeling the water availability necessitates of real or realistic surface and groundwater time series as an input to management models. However, especially for springs, the lack of sound and representatively long time series represents an obstacle, as very often only few information on their flow regimen is available. Hence one of the problem that the modeler has to face concerns the reconstruction of reliable spring discharge time series consistent with the observed rainfall regimen.

In this communication, we focus our attention to the relation in time and space between the precipitation and the springs discharge, that currently constitutes about 75% of drinking water consumption in the study region. The final aim is to determine suitable parameters for generating realistic weekly hydrograms for the main springs, consistent with the observed precipitation evolution.

For this goal, the available data for the outflow of 15 carbonatic springs located in the Umbria Region have been analyzed for the period 1998-2010 (except one of them, whose data are available from 1971). These springs share the same hydrological behavior: a recharge period (approximately winter and spring) characterized by a steep quasi-linear increase and a discharge period characterized by a decrease of the outflow

which can be approximated by an exponential function. The statistical relation between the seasonal and annual Standardized Precipitation Index (SPI, McKee et al., 1993) computed at local and basin scale and the main parameters of the springs hydrogram at the annual scale (minimum, maximum and mean outflow, recharge and discharge duration), has been analyzed.

The comparison between precipitation index and spring discharge indicates that: 1. basin scale values of SPI are better related to actual minimum and annual mean discharge than local values. 2. Minimum and mean annual discharges are more conveniently related to a precipitation index, that takes into account only the autumn, winter and spring. 3. The recharge duration is deterministically related to the winter SPI. The statistical relations between SPI and spring discharge parameters have been used in an algorithm able to generate the weekly outflow of the springs consistent with the time evolution of precipitation at the basin scale. Such synthetic hydrograms are the input for a management model that simulates the hydraulic behavior of the whole water system of the Umbria Region (Preziosi et al., 2011). Finally, precipitation time series from climate change scenarios A2 and B2 of the GCM HadCM3 of the Hadley Centre (Brocca et al., 2010; Camici et al., 2011) have been considered for generating synthetic hydrograms of springs for the period 2010-2070.

SESSIONE A7**Gestione e tutela delle risorse idriche sotterranee delle pianure alluvionali****A7-2/3 Orale Passaglia, Elio**

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POTENTIAL CONTRIBUTION OF NATURAL ZEOLITE TO QUALITATIVE PROTECTION OF THE HYDROLOGIC SYSTEMPASSAGLIA Elio¹

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Key terms: NITRATE POLLUTION; SOIL AMENDANT; WASTEWATER TREATMENT; ZEOLITE; ZEOLITITE

Pyroclastic rocks (tuffs, ignimbrites), diagenized with dominant (> 50%) zeolite content (clinoptilolite, mordenite, chabasite, phillipsite) and defined as "zeolitites", show peculiar chemical-physical features (reversible dehydration, high cation exchange capacity distinctly selective for ions with low energy of solvation such as NH₄⁺, high water retention, low apparent density, lithic nature, permeability). These properties, along with a large and widespread availability in nature, especially in Italy, as deposits of great potential and low extraction cost, justify their increasing use in application areas that require large amounts of material (building; separation, purification and dehydration of natural gases; purification of industrial, civil, and zootechnical sewage; animal feeding and fish farming; agriculture and flower growing; as alternative to pesticides in the fight against crop micropathogens; antiparasitic action on food). The results of laboratory and full field studies, subject of an extensive and qualified literature, widely demonstrated the key role of zeolitites in qualitative protection of surface and subsurface water resources, at high risk in the Po Plain mainly because of the disposal of sewage from livestock farms and the increasing intake of synthetic fertilizers in current agricultural practices.

Also in accordance with the recent EU directive on nitrates that provides a maximum limit of 170 kg / ha / year of nitrogen for the disposal of livestock manure in zones vulnerable to nitrate pollution, the use of 2-3% of zeolite in swine diet produced a significant reduction (20-30%) of NH₄⁺ content in sewage and, as a result, in the emission of smells; the NH₄⁺ content of sewage is further reduced (20-25%) by means of static treatments with a moderate (25 g/l) amount of low cost zeolite (quarry semi-finished material).

In the agronomic field, the addition to soils of zeolite characterized by low Na content, high selectivity for the NH₄⁺ ion, and high water retention, allows a drastic decrease of irrigation water, and above all of synthetic fertilizers, with a consequent remarkable reduction of the leaching of their nitrogen component, and thus of the current increasing and worrisome nitrate transfer in the aquifer.

Besides these relevant environmental advantages, the results of several experiments on greenhouse and full field cultivations of cereals and vegetables (rice, corn, sorghum, spinach, chard, lettuce, basil, celery, radish, tomato, pepper, courgette, melon, watermelon, strawberry, kiwi), as well as of turf on soils and substrates amended with natural zeolite (5-10 Kg/m²) and concomitant reduction (30-40%) of ferti-irrigation, evidenced either an increase or a quasi-quantitative maintenance of the agricultural production.

It is of economic and strategic importance that once zeolitites are added to the soil, they become an integral and indestructible part of it, thus being always able to perform their specific positive effects; furthermore, fertilizer saving and consequent reduction of the environmental impact are possible by adding as amendment NH₄⁺-charged zeolite, which can be obtained either artificially or, even better, by means of a previous use in the treatment of urban, industrial, and zootechnical wastewater.

A7-4 Orale Paduano, Pasquale

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ENVIRONMENTAL STATUS OF GROUNDWATER RESOURCES IN THE SOLOFRANA RIVER VALLEYFABBROCINO Silvia¹, PADUANO Pasquale¹

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Key terms: groundwater pollution; aquifer; water systems

Heterogeneity of natural systems governs the pathway of pollutant in the environment, mostly in groundwater resources. A large number of hydrogeological research aims to parametrize and model these processes. The spatial variability of the hydrogeological properties of the rock can be defined from geologic observation and local measurements.

The Solofrana River Valley is a real natural laboratory to improve understanding of the behaviour and transfer of pollutants on large scale, because of its geological and structural complexity combined with a strong

industrial and agricultural activities.

A multidisciplinary approach has been employed to delineate aquifer/aquard unit and characterize scale-dependent heterogeneity using geological, hydrogeological and geochemical techniques. The paper describes firstly the experience carried out in an area characterized by a high anthropic impact. Besides, it reports about relevant geological and hydrogeological aspects of the Solofrana River Valley and presents some interesting aspects related to field operations and quantitative evaluation of pollution flow and transport.

A7-5 Orale Pranzini, Giovanni

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NITRATE CONTAMINATION RISK FROM AGRICULTURE AND HOUSEHOLD DISCHARGES IN THE MIDDLE VALDARNO (TUSCANY, ITALY)

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Key terms: Groundwater; Contamination risk; Nitrate; Agriculture; Household discharge

The study, conducted with the contribution PRIN 2007, concerns the risk assessment of nitrate pollution to groundwater in a plain with high density of population and productive activities. In the alluvial plain of Florence-Prato-Pistoia farming is subordinate with respect to industrial, with the exception of the Pistoia territory, where nursery is the main productive activity. Groundwater is used for all purposes: civil supply, agriculture, industry.

As for nitrate from agriculture and livestock, the risk was assessed by combining the vulnerability SINTACS (Civita and De Maio, 2000), with the IPNOA (Agricultural Nitrate Hazard Index, Capri et al, 1999). About half of the plain has a vulnerability to "high" to "extremely high". The IPNOA map shows, for the agricultural areas, a prevalence of the "low" and "medium low" indexes. The Risk Map, however, indicates a prevalence of areas with risk "high" or "very high": clearly, the vulnerability weighs more than the hazard index.

For nitrate from household discharges, the vulnerability was combined with the IPNOA (index of hazard by nitrates from household origin, Frullini and Pranzini, 2008). The SINTACS map has been revised to reflect the fact that the pollutants are dispersed directly underground: we considered the depth of one meter for the discharge of scattered houses, two meters for the loss of the sewer.

The calculation of the hazard by nitrates from household discharge was done with the methodology developed in the coastal plain between Rosignano and San Vincenzo (Frullini and Pranzini, 2008).

For discharges not connected to sewerage systems, the Index was calculated considering, for each area unit of one hectare, the number of inhabitants and its production of nitrogen (5.5 kg / year per inhabitant). For leakage of sewers, the index is derived from the combination of the nitrogen load carried by any duct (risk factor) with a coefficient of wear and breaking, depending on the material they are made and their age (controlling factor).

The average IPNOA index in the plain is "low." Nevertheless, the risk of nitrate pollution is "high" to "very high" in most of the plain, apparently because of the high vulnerability.

424 water samples from wells were analyzed in the country for the determination of ammonia, nitrites and nitrates. The maximum admissible concentration for drinking water was exceeded by 18% of the samples for Ammonium (CMA 0.5 mg/L), by 6% for Nitrites (CMA 0.5 mg / L), and 8% for Nitrates (CMA 50 mg / L). The contaminated wells are found mainly in urban areas, which means that the losses of the sewer are the major risk in the plain studied. In particular, in the urban area of Pistoia most of the wells exceed the CMA for both the Ammonium and Nitrates. This depends on the age of the sewer system, and the presence of groundwater at shallow depth, so that the sewer pipes are often flooded.

On the contrary, a fairly good water quality was found beneath the city of Florence, where almost all the samples were classified as "low concentration". The fact is surprising when one considers that in the years between 1975 and 1990, all the wells for civil water supply were abandoned because of contamination from nitrogen compounds. Clearly, the improvement of the sewerage system of Florence has paid off.

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A7-6 Orale Affatato, Alessandro

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HYDROGEOLOGICAL, PETROPHYSICAL AND GEOPHYSICAL CHARACTERIZATION OF DEEP AQUIFERS IN THE WESTERN FRIULI PLAIN

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Key terms: Deep aquifer; Lateral heterogeneity; Unconfined aquifer; Seismic survey; Time-Domain Electromagnetic Method

The Friuli plain is crossed by a complex river system which is closely linked to the hydrogeological and geomorphological characteristics of the area where the river flows. In the high plain, the high permeability of the sediments is the cause of the disappearance of the surface water, which flows in depth. The area of Torrate di Chions, located on the Tagliamento megafan between Pordenone and Portogruaro, is covered by a sequence of mostly incoherent Quaternary deposits at least 700 m thick. The hydrogeological structure of this area poses the area of Torrate in the range of the medium plain, characterized by a progressive decrease in gravel which alternates with impermeable clay horizons. In this area, the

water table crops-out, creating a characteristics belt of springs, which crosses the park of Torrate di Chions (PN).

This report illustrates the geophysical part of a more complex research project, aiming to characterize the hydrogeological, geophysical and petrographic setting of two deep aquifers, located at 270 and 480 meters below the ground, as they were considered strategic reservoir for the quality and abundance of their waters.

The architecture of these aquifers was reconstructed through a combination of seismic and geo-electric investigations, taking into consideration the available geological and stratigraphic information. Two 1.5 km-long, SW-NE-trending seismic reflection lines were recorded, with a DMT-SUMMIT registration system and 10 Hz single geophones, deployed with a 10 m interval. A Time-Domain Electromagnetic Method (TDEM) survey was also performed with the execution of a loop transmitter located at the end of seismic line with a loop of size 100x200. The equipment used to energize the transmitter coil is the TEM 47 Geonics Ltd. Only two surveys have provided the best data (best signal-to-noise ratio) where the interpretation of the data inversion (obtained through parallel-plane mode) has allowed to identify three resistivity strata at different depths. Seismic processing revealed the presence of two strong reflectors, which showed that the aquifers A2 and A4 have good lateral continuity to the south-western part of the Friuli plain according with the results from the electromagnetic model.

Our results show that both methods, properly combined, offer the best results for the characterization of these deep aquifers in alluvial powerful blankets, and for the indirect estimation of petrophysical parameters (e.g., porosity, saturation, etc.).

A7-7 Orale Martelli, Grazia

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HYDRODYNAMIC OF WEST LOW FRIULI PLAIN DEEP AQUIFERS: A MANAGEMENT TOOL FOR STRATEGICAL GROUNDWATER RESOURCES

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Key terms: West Friuli plain; multilayered aquifer system; monitoring network; lithostratigraphic data; geochemical facies

The Friuli Plain on the right side of the Tagliamento River is characterised by the presence of a relevant detrital sedimentary body of Quaternary age, whose thickness increases from E (about 100 m at the foot of the Carnic Prealps) to W (more than 900 m at the border with the Veneto region). Such area is divided into two distinct sectors:

- the High Plain (AP), formed by coarse-grained and hence highly pervious sediments, prevalently gravels, as a consequence of the progradation, union and partial coalescence of the Cellina, Meduna and Tagliamento Rivers' alluvial fan system;

- the Low Plain (BP), characterised by sand and gravel lenticular bodies intercalated with impervious, wide and continuous silty-clay layers; such structure gives the reason for a multistrata aquifer system to be present. Along the transitional stretch between the BP unconfined aquifer and the AP multilayered system, part of the High Plain groundwater surfaces, giving rise to the springs' area that feeds the Low Plain's hydrographical network.

Owing to the PRIN 2008 financing for the BP multilayered system survey, a census of the BP water-wells has been taken in order both to outline the underground hydrogeological structure and to plan a quali-quantitative monitoring network for the groundwater characterisation.

The lithostratigraphic data coming from 120 water-wells formed the basis of a hydrogeological cross-sections set, that allowed to single out 12 aquifer levels ranging between 37,4 and over -371 m of depth; the deepest level has been recognised between 528,5 and 564,2 m bsl.

The monitoring network has been arranged relying on 124 water-wells suitable for pressure and qualitative measurements of all the recognised aquifer levels. Water samples coming from 18 springs and the main rivers have also been collected.

The preliminary results of the first series of measurements show pressures ranging between 0,1 and 2,8 bar (increasing with the aquifer levels' depth), a prevailing Ca-bicarbonate geochemical facies (with bromine characterising some levels) and high sulphate concentration values in the BP eastern sector aquifers. The radiocarbon isotope contents and the isotope composition of hydrogen ($\delta^2\text{D}$) and oxygen ($\delta^{18}\text{O}$) have not yet attained.

A7-8 Orale Di Sipio, Eloisa

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SALT WATER INTRUSION IN COASTAL AQUIFERS OF THE VENICE COASTLAND

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Key terms: salt water intrusion; groundwater; Venice lagoon; geophysic; geochemistry

The investigations carried out since the early '970 showed that salt water intrusion affected most of the Venetian coastal area. However, at that time, phenomena such as land subsidence and flooding (known as "acqua alta") had the priority in relation to the city protection, thus the study of the salt water intrusion process assumed a secondary role.

During '990, the salinization process became the subject of a research project performed by the Institute of Marine Science (ISMAR CNR-National Research Council). The results revealed a severe hydrological situation, particularly critical in the southern region. Aware of saline contamination effects on the environment and the agricultural activities, mainly horticultural crops well developed around Chioggia, the Venice Province started in 1998 the "Saline Wedge Project" to understand the consequences of the salt water intrusion in the subsol, in connection also to land subsidence, at the southern part of its territory.

The knowledge acquired by the two institutions (Venice Province Authority, ISMAR-CNR) constituted the common basis for new research and monitoring projects. Several meetings were promoted to involve all

the authorities and institutions responsible for land management to raise awareness of the saline contamination and its environmental and socio-economic impact, and to highlight the need of establishing appropriate monitoring networks in critical areas.

In the southern sector, where the possible damages for the agricultural-horticultural activities could be economically relevant, two projects (Saline Wedge 1998-2000; ISES Project 1999-2002) were initiated in the late '90, involving all the authorities managing the territory. The aims of these projects were a) to increase the knowledge on the factors enhancing the salt water intrusion; b) determine the areal extent of the saline contamination; c) assess the critical conditions in relation to the economic activities, mainly of agricultural and tourist type. Once obtained a detailed hydrogeological representation, specific actions to limit the process have been planned (Brenta Project, 2003-2004). Preliminary investigations were performed to realize a mobile gate at the mouth of the Brenta-Bacchiglione river to prevent the encroachment of sea water into the river bed during high tides. More recently, scientific efforts have been devoted to better understand the process dynamics. Mathematical models have used to investigate the effects of other possible mitigation strategies (CORILA Project 3.10 2004-2007; VECTOR-Cliven Project 2007-2010).

In the northern sector of the Venice territory, between the Piave river and the lagoon margin, researches aimed at improving the comprehension on the salt water intrusion phenomenon started in 2004, through the cooperation between the University Ca' Foscari of Venice and the University of Padua (PRIN Project "The deep aquifers of the Po Valley as regional resource: aquitard in hydrodynamics, generating of water chemically and thermally anomalous, a suitable place for the CO₂ atmospheric trapping").

The combined use of adequately validated geophysical and geochemical tools conferred a multidisciplinary character to the research and allowed for the definition of the phenomenon's superficial extension. Geophysical analysis based on Vertical Electrical Sounding (VES) and conductivity logs have been performed together with water table measurements and geochemical analysis on samples collected from selected wells. Moreover, a critical review of old geophysical data allowed for the verification of a possible saline contamination changes in time. Interesting results have been obtained specifically within territory of Jesolo. In this case, considering the influence of the Piave and Sile rivers and the presence of a coastal sand dune, a map of salt water contamination was created to evaluate the agricultural use of superficial water. The effective origin of salt water found in the aquifers, its distribution, extension and its preferential way of movement within the territory were defined relating all the information acquired to the geological, geomorphological and stratigraphic characteristics of the area.

In addition, the presence of salt water contamination in the shallow aquifers below the city of Venice has been highlighted by recent studies developed at the IUAV University.

A7-9 Orale Greggio, Nicolas

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IS IRRIGATED AGRICULTURE A BUFFER AGAINST SALTWATER INTRUSION? EFFECTS OF NATURAL RECHARGE AND IRRIGATION ON GROUNDWATER SALINITY IN A COASTAL UNCONFINED AQUIFER, LIDO DI DANTE, RAVENNA, ITALY.

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Key terms: un-manage aquifer recharge; salt water intrusion; shallow coastal aquifer; irrigation; infiltration

In the coastal aquifer of Ravenna, high rates of anthropogenic (gas extraction) and natural (sediment compaction) subsidence and artificial drainage (land reclamation canal system and pumping machines) have caused groundwater salinization.

We have studied a 10km-long transect extending, normal to coast, from the shoreline using 10 fully penetrating piezometers. This transect is one of the most representative for the coastal aquifer of Ravenna. Different land uses are represented along the transect: beach dunes, pineforests, irrigated and rain-fed agricultural land, and gravel quarries. The maximum elevation is 5m in the most recent dune belts, whereas the areas around the quarries are at 2m below sea level. In addition to the transect normal to coast, we have recently focused our attention on a small area (6ha), behind the coastal pineforest (500m from sea), where there is an irrigation channel which, during the growing season, is filled with freshwater from the Po river to irrigate the nearby fields. In February 2011 we drilled other 2 fully penetrating piezometers one to the west and one to the east of the irrigation channel. In order to obtain thickness and dimensions of the freshwater lens in the aquifer, we performed 3 series of 16 Vertical Electrical Sounding (VES) aligned along a cross section normal to the irrigation canal, in different season. In this way, we can compare the state of the salinization of the aquifer where only natural recharge is present and where there is also a contribution to recharge from irrigation in different season.

A quarterly aquifer monitoring along entire transect, was conducted with Straddle Packer to collect geochemical parameters of the water: pH, Eh, Temperature, Electrical Conductivity (EC) and Dissolved Oxygen. We also measured monthly rainfall and infiltration rates, by four pluviometers and drain gauges placed along the transect.

The lithological 3D aquifer model shows that the aquifer is unconfined only below the pineforest and in a few adjacent areas.

Here we report the results of year 2010-11 monitoring of the evolution and dimension of the freshwater lenses floating on top of the saltwater in the coastal phreatic aquifer along the whole transect studied.

The EC data show, along the transect, a dynamic fluctuation of the freshwater lenses in every season. In the well, inside the coastal pineforest and closer to sea, the aquifer is salty and there is only 0.5m of freshwater lens at the top of the water table. In a second well localized within irrigated agricultural land at 2km from sea, EC data indicate a counter-intuitive trend: in summer we measure lower EC value than in the winter probably because of the high irrigation rate during the growing season. Inside the historical Classe Pineforest, at 4km from the coast, the groundwater is mostly saline (10g/l) with 1m of freshwater lens at the top. Fresh groundwater lenses within the quarry belt at 7km from sea, have a large thickness (2m) but at the bottom saltwater is still present. At 10km from the coast, in our last monitored well, groundwater EC values were under 1g/l along the entire depth-profile of the well indicating almost exclusively the presence of freshwater.

The rainfall distribution shows, during the summer, 50% of differences between one pluviometric station and the next at a small scale (2km);

accordingly, the infiltration rate was dissimilar and also groundwater recharge was not homogeneous along the whole section. During the Summer, the EC data measured in the wells around the irrigation canal and VES profile shows a rather thick freshwater lens of 5m. In this same area the amount of Summer rainfall and irrigation measured was 4 times as much as that measured in other pluviometers far away from irrigated land. During the winter, VES records show different results from the summer situation: a freshwater lens 300m wide and 2m thick in the eastern part of the canal and a completely saline aquifer in the western part.

A7-10 Orale Capo, Donato

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SEASONAL VARIATIONS IN SALINIZATION WITHIN THE COASTAL PHREATIC AQUIFER OF RAVENNA (ITALY): GEOPHYSICAL CHARACTERIZATION

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Key terms: Adriatic coast; Salinization; Geophysical characterization; Seasonal variations; Coastal aquifer

The coastal phreatic aquifer of the Ravenna province is salinized up to several kilometers inland. In order to characterize and assess the extent of the salinization, we have monitored the presence of fresh-water at the top of the watertable and the depth of the interfaces between fresh and brackish water and between brackish and salt water with particular attention to the seasonal changes and the variations in recharge. The study area is located between the Reno river estuary in the north and the Savio river mouth in the south; the investigated area extends landwards (west) up to 5 Km from the coast. A large part of the study area is below sea level. Several land uses and a complex morphology are present in this coastal zone: urban area, agricultural land, forests, quarries, and tourist establishments. There are also rivers, drainage canals, wetlands, lagoons and surface water bodies. The aquifer is mostly made up of sand and overlies a clay substrate at 25 m depth. Some pro-delta fine-grained deposits are found between 5 and 20 m depth. The study area has an average annual rainfall of 625 mm and an average temperature of 14.4 °C. The field work was carried out by means of Vertical Electric Soundings (V.E.S.) in a Wenner array configuration; the sampling points have been taken at a distance of 200-500 m on transects perpendicular to the coastline. The VES penetration depth varies, from case to case, between 8-9 m and 10-15 m. In order to avoid interpretation mistakes, we have calibrated the apparent resistivity with detailed stratigraphy logs obtained from several boreholes in the study area. Our work has shown, that where the top of the aquifer has a large hydraulic conductivity (sand) there is a freshwater lens (between 0.1 and 2.25 m in thickness) floating on saltwater and a thick mixing zone (between 1.00 and 12 m in thickness) whereas if the top of the aquifer has low hydraulic conductivity (silty sand, clayish sand) the freshwater lens is absent and the mixing zone is thin. The freshwater lens in the aquifer is promoted by the presence of a well-developed coastal dunes system and by the lack of drainage canals or surface water bodies. The VES were repeated in different periods of the year with different rainfall and they were compared to the precipitation data published in the DEXTER system of the ARPA Emilia-Romagna. The comparison of these data shows a strong seasonality in freshwater and mixing zone thickness. In particular it is observed that in the dry periods of the year (monthly average 30 mm) the freshwater thickness decrease (up to 0.1 m), whereas in the wet periods of the year (monthly average 80 mm) the freshwater thickness grows (up to 2.25 m). The thickness of the mixing zone has a similar behavior. This seasonality is observed almost exclusively where there are sandy deposits outcrop at the surface.

A7-11 Orale Marcaccio, Marco

10.1474/Epitome.04.0102.Geoitalia2011

STATISTICAL ASSESSMENT OF NATURAL BACKGROUND LEVELS OF HEAVY METALS AND INORGANIC COMPOUNDS IN THE DEEP GROUNDWATER BODIES OF THE PO RIVER ALLUVIAL PLAIN (EMILIA-ROMAGNA, ITALY)

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Key terms: Groundwater Bodies; Po River Alluvial Plain; Natural Background Levels; Threshold Values; Arsenic

Providing a robust estimate of natural background concentrations of heavy metals and inorganic compounds in groundwater bodies has become increasingly important in Europe after the adoption of the EU WFD (Water Framework Directive) 2000/60/CE and the GWDD (Groundwater Daughter Directive) 2006/118/CE. These directives have been implemented in Italy by the D.Lgs. 30/2009, which requires the identification of natural background levels (NBLs). Thus should then lead to provide an estimate of the threshold values (TVs) of the concentrations of chemical species that might compromise the good chemical status of the system. The choice of the proper methodology to estimate the natural background level depends on the type of available data and the objectives to be achieved. Amongst different existing methodological approaches, we select a framework which is based on the statistical analysis of the distribution of concentrations monitored over time. We analyze and compare the preliminary results associated with two different methodologies, i.e., Component Separation and Pre-Selection. Both frameworks make use of monitored information within a given water body to provide (a) estimates of the level of natural background concentration, and (b) the threshold values of target chemical species. Component Separation evaluates NBLs by discriminating a natural and an anthropogenic component, jointly contributing to the monitored concentration values. This is achieved by modeling the observed concentration frequency distribution as a mixture of Gaussian and/or Log-normal distributions. Pre-selection estimates the NBL by excluding a priori from the available data-set the samples that

could be considered as subject to human influence. These are assessed from indicator species associated with concentrations which are above a given value. We applied these methods to the 91 groundwater bodies delineated within the Emilia-Romagna region (Italy) in compliance with the EU WFD and D.Lgs 30/2009. The analysis is based on concentration time series recorded at several monitoring locations included in the extensive network of observation wells managed by the ARPA - Regional Agency for Environmental Protection. The groundwater bodies analyzed are located within the following porous aquifer complexes: the Apennine rivers alluvial fans, the floodplains Apennine, Po Valley and coastline. Free surface and confined groundwater bodies have been distinguished. The monitored distributions of Arsenic, Boron, Ammonium and Chlorides were then analyzed within the delineated groundwater bodies. The estimated values of NBLs and TVs indicate that in the cases examined the two methodologies provide comparable results, rendering background concentrations and, consequently, threshold values of the same order of magnitude. Both methodologies lead to estimates of Arsenic NBLs which, in this preliminary study, are not consistent with the observation that the largest arsenic concentrations are found in the deep groundwater bodies and only to a minor extent in the upper aquifers. We conclude that the results of these statistical methodologies should be jointly considered with a profound understanding and quantitative modeling of the physical processes that dominate the (hydro-geo-chemical) space-time evolution of the species analyzed in the groundwater system.

A7-12 Orale Rotiroti, Marco

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GROUNDWATER QUALITY CHARACTERIZATION OF CREMONA AREA (NORTHERN ITALY) AFFECTED BY AS, FE AND MN CONTAMINATION, COMBINING HYDROCHEMICAL ANALYSIS AND AQUIFER TEXTURE MODELING

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Key terms: Arsenic; Iron; Manganese; Groundwater contamination; Aquifer texture modeling

This study was developed within the framework of a scientific collaboration between the University of Milano-Bicocca and the Province of Cremona. The main aim is to identify the quality of the groundwater hosted by the multi-layer aquifer of the Cremona area, affected by As, Fe and Mn contamination.

The specific study area is situated near the confluence between the Adda and Po rivers. It covers a 50 km² area around the urban territory of Cremona. The considered depth is around 200-250 m, corresponding to Aquifer Group A (Regione Lombardia & ENI, 2002), which hosts in this area both shallow and confined aquifers.

The applied methodology involves the (a) collection of historical data related to water quality, water levels and well logs, (b) storage of collected data in specific databases, (c) construction of a 3D model of the aquifer structure, (d) design and execution of a field survey of water levels and water quality, (e) analysis of the hydrodynamic properties of the system, (f) spatial and time analysis of water quality data considering the hydrodynamic properties and the lithological and textural structure of the aquifer, (g) elaboration of a general hydrogeochemical conceptual model, incorporating some hypothesis about the mechanism and the origin of the contamination.

The 3D hydrogeologic model simulates the textural distribution of the aquifer deposits. It was built by means of kriging interpolation of the percentages of fine (clays, silts, peats), medium (sands) and coarse (gravels, pebbles) deposits, derived from the numerical coding of well data logs. The resulting model underlines the abundance of fine deposits and puts in evidence the significant presence of peat lenses. The water quality measurements, executed in July 2010, indicate that the groundwater is characterized mainly by a calcium-bicarbonate facies, with higher chloride and sulfate in the shallow aquifer. pH increases with the depth of sampling, ranging from 7.0 to 7.5 in the shallow aquifer and from 7.5 to 8.5 in the deeper aquifers. Redox potential assumes positive values only in the shallow aquifer while in the confined aquifers it has negative

values (-100/-200 mV). Conductivity ranges from 300 to 1000 μ S and it increases with the depth of sampling. These values indicate a medium/medium-high level of water mineralization.

With respect to the most important chemical parameters, bicarbonates ranges from 200 to 600 mg/L and they increase with depth. The highest bicarbonate values could be generated by the equilibration of the CO₂ derived by the degradation of the organic matter of the aquifer. Nitrates and sulfates increases with the depth of sampling, with higher concentrations of the former than the latter. Ammonia has been detected with low concentrations in the shallow aquifer and generally with high levels (1-5 mg/L) in the underlying aquifers. Iron and manganese has been measured at high levels: they range

respectively from 100 to 6000 μ g/L and from 10 to 1200 μ g/L. Generally the higher levels has been found in the surficial aquifers. It is possible to identify a decrease of concentration with depth, probably connected to the pH increase.

Arsenic has also been measured at high levels (it ranges from 1 to 180 μ g/L) especially in the range of depth of 30-100 m. Consideration of the textural model and water quality data yield hypotheses regarding the processes which control on the degradation of natural organic matter and its relation to general groundwater quality. Degradation of peat, that can explain the high ammonia levels, is associated with the progressive reduction of O₂, NO₃⁻, Mn(IV), Fe(III), SO₄²⁻, CO₂. These processes could explain the measured high levels of Fe and Mn, but also the high levels of As, which is generally sorbed on the surface of iron and manganese oxides, subject to release during their reductive dissolution.

A7-13 Orale Cremonesi, Daniele

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INTERACTION BETWEEN ROCK MOUNTAIN AND ALLUVIAL PLAIN AQUIFERS IN THE SERIO RIVER BASIN (BERGAMO - ITALY)

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Key terms: Hydrogeological balance; recharge; Serio River

Lombardy is one of the most important Italian Regions for availability of water resources, both on surface and underground. However, urban growth, industrial and agricultural spread caused a change in these resources, both in terms of quality and quantity, especially in the alluvial aquifer.

Therefore a correct management of water resources in the plain area assumes a correct comprehension of the recharge processes, in particular the relationship with Prealpine aquifers.

This study purposes to improve the knowledge about the groundwater circulation in mountain and piedmont areas of Lombardy, in order to define the recharge of hydrogeological plain system. To purpose this aim a hydrogeological balance-based method was utilized and applied to the Serio River basin (Bergamo District). The studied area has an extension of about 450 km² and it is characterized by great difference in altitude (from 361 m a.s.l. in Cene to about 2900 m a.s.l.). The Serio River basin mainly consists of carbonate rocks, where large fractured-karst aquifers have developed. The presence of a well developed epikarst layer on surface bring about an important infiltration capacity in all the basin. A number of springs are supplied by this hydrogeological system, among them the most important one is the Nossana Spring, having an average discharge of about 3 m³/s. The waters coming from the Serio River basin supply the plain area enclosed between the Adda and Oglio rivers.

The results obtained by the hydrogeological balance underline that the contribution to recharge of alluvial plain area arising from mountain rock masses is consistent, approximately about 6.5 m³/s, corresponding to 5% of total rainfall. Considering that the amount of water pumped from the alluvial aquifer of the Adda-Oglio basin (90 km²) is about 5.78 m³/s, the recharge coming from mountain aquifer is quite significant. At regional scale, the contribution of recharge from mountain rock aquifer is more consistent (about 48.5 m³/s), corresponding to the 15% of rainfall and to the 142% of the groundwater drawings.

This result confirms that at the regional scale, the recharge is important to maintain and preserve the plain aquifer.

The hydrogeological balance presented in this study can be the first important step to implement numerical models capable of simulating the water exchanges between the plain and the mountain areas, in order to obtain quantitative information on outflows and relationship between surface and groundwater aquifers. Another possible improvement is to use these models like provisional instruments.

Furthermore, in order to quantify the availability of water resource related to climate change scenarios, neural networks architectures have been built and trained. They are capable to relate the rainfall data (the input to the mountain system) to outputs, separating them in springs flows (for the mountain zone) and water table levels (for the plain area). Operating in this direction, it has been possible to evaluate the effects of climate change on water availability both in mountain and in plain area.

A7-14 Orale Cameron, Enrico

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AQUIFER VULNERABILITY: AN ANALYTICAL PERSPECTIVE

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Key terms: aquifer vulnerability; impact; transport equations

Theoretically it should be possible to predict the impact of a polluting event on an aquifer from the knowledge of the aquifer vulnerability and of the features of such event (i.e. chemicals involved, volumes released etc.); the most common vulnerability assessment methods, however, does not allow such a prediction to be made.

Starting from the examination of analytical solutions to transport equations it will be discussed under what conditions and to what extent it is possible at all to properly speak of aquifer vulnerability and how a class of reference vulnerability measures may be constructed.

A7-15 Orale Torrese, Patrizio

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GEOPHYSICAL AND HYDROCHEMICAL SURVEYS WITHIN THE STUDY OF THE SALTWATER UPSISING OCCURRING IN THE OLTREPÒ PAVESE PLAIN AQUIFER (NORTHERN ITALY)

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Key terms: saltwater uprisings; Vogherese Fault; geophysical survey; VLF-EM; electrical tomography

The alluvial aquifer of the Oltrepò Pavese plain sector (Po Valley, Northern Italy) is characterized by a natural pollution by Na-Cl rich paleowaters (Messinian) that up-rise from the tertiary marine bedrock and mix with the shallow groundwater. This phenomenon is associated to the presence of the "Vogherese Fault", a buried tectonic discontinuity along which the saline waters are mainly distributed. Mapping of these chemically anomalous groundwater is greatly useful. Indeed, extreme mineralization is often a barrier to its use, not only for drinking water supply but also for industrial and agricultural use. Given that saltwaters mapping cannot be undertaken on the sole basis of wells hydro-chemical monitoring as these are often insufficient or absent in some areas, a geophysical survey was carried out. VLF-EM technique was tested to achieve an expeditive mapping of the conductive bodies over the entire area, involving 35 lines for a total length of 71 kilometers. Seventeen resistivity depth soundings were undertaken along a cross section of the "Vogherese Fault" to reconstruct the bedrock geometry and the different hydrogeological units. These were undertaken in a sub-area that is considered representative of the entire study area and were necessary for the different geophysical techniques calibration. The geometrical complexity of the contaminated areas located in proximity to the fault, was also studied at the local scale within a selected experimental site, during a more detailed phase of investigations: a resistivity profile, 5 resistivity depth soundings, 5 long spread and 1 short spread 2D-ERT (Electrical Resistivity Tomography) surveys, two 3D-ERT surveys and a closely spaced grid VLF-EM survey were undertaken along an approximately 3000 m long profile crossing the fault zone with a N-S direction and overlapping a significant length of the

VLF-EM surveys. The geophysical survey revealed that the morphology of the bedrock, the spatial distribution of the structural discontinuities and the hydraulic conductivity of alluvial deposits are likely to be controlling the areal distribution and in depth geometry of salty groundwater within the alluvial aquifer. Hydro-chemical investigations were carried out as well. These involved a 4 years water level monitoring of groundwater and sampling from contaminated water wells in order to determine chlorides concentration and its variation in time. This allowed to detect the 3 areas where the phenomenon is more intense and diffused, that are located along the "Vogherese Fault", even if evidence of the phenomenon was found also in other zones, placed near the Apennine margin. This fact could be explained by the presence of the "Marginal Fault" that intersect the marine substratum and probably contribute to vehicle the saltwater to the shallow aquifer. The distribution of saltwater into the aquifer is very complex as geophysical surveys revealed and varies not only horizontally, but also vertically, being conditioned by the aquifer's different times of recharge, with the arrival of new fresh water. The saline water-fresh water interface and its variation were detected by means of electrical conductivity and temperature logs over some wells. To assess the instant aquifer's reaction to the recharge events, a continuous monitoring system on some significant wells was undertaken using a multiparametric probe. This kind of investigation pointed out an increase of water's mineralization simultaneous with alluvial water level maxima. We interpreted this apparently anomalous behavior as a consequence of an intense recharge that affected the near Apennine fractured aquifers, connected to the deep circuits that controls saltwater uprising into the plain aquifer, on which a "pressure transfert" acted to determine a "mass transfert" of the deep mineralized waters and a salinity increasing of the shallow aquifer.

A7-16 Orale Zhao, Ye

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THE TRANSPORT MODEL OF PESTICIDE IN SOIL AND GROUNDWATER IN VERCELLI PLANE, ITALY

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Key terms: pesticide; groundwater contamination; model

As a result of agricultural practices, pesticides have been detected in many aquifers and surface waters. Contamination of groundwater by agrichemicals (pesticides and fertilizers) is now widely recognized as an extremely important environmental problem. Despite the extensive scientific attention paid to this contamination, the fate and transport of pesticides in the area is not well understood. In particular, little is known about how, despite their low solubility, significant quantities of these chemicals have been transported to groundwater. Various attempts to evaluate groundwater vulnerability to surface contaminants have been made over the past two decades. Generally, they can be classified as (1) direct observations of pesticides or other agricultural contaminants in groundwater, (2) simulation methods, or (3) index methods.

Index methods are usually used to make groundwater vulnerability maps, which delineate the land surface according to the potential for pollutants to reach groundwater resources, have been generated using a variety of ranking or scoring methods to produce qualitative or semi qualitative output. These maps usually assess the overall potential for chemical contamination of aquifers and are not specific to individual compounds or classes of. Although these maps are useful for supporting policies with regard to the general protection of water resources, they are not suitable for driving detailed monitoring programs for pollutants. The mathematical models help to understand the mechanism of pesticide leaching in soils towards groundwater, which are useful tools for assessing the risk of groundwater contamination resulting from the agricultural use of pesticides. These models are cost-effective methods as compared to field sampling studies.

Pesticides applied at or near the soil surface can leach to considerable depths. Pesticide fate models account for a variety of processes including soil water flow, solute transport, heat transport, pesticide sorption, transformation and degradation, volatilization, crop uptake, and surface runoff. A particular modeling challenge is to predict pesticide transport at very low leaching levels important for pesticide registration. Groundwater is widely used for drinking, agriculture, industry, urban development, wetlands and recreation. Due to high crop productivity in this region, there is extensive use of pesticides including insecticides, herbicides, fungicides and defoliant. The wide use of pesticides contributes to the groundwater contamination. Several pesticides including bentazon, molinate, atrazine, propanil and quinclorac have been detected in wells, rice field and surface water in this region, although some of them are forbidden to use for many years. The purpose of the groundwater module is to predict the concentrations of agricultural pesticides reaching the water table of any groundwater unit Vercelli likely to be abstracted by small, locally used, wells. The objective of this study is to investigate quantitatively the transport of pesticides in the Vercelli region. Data are presented on concentrations of pesticides in groundwater, river water, and farm field in the area. These data are utilized alongside the findings of past studies to develop numerical and analytical models of groundwater flow and transport, with the aim of evaluating the nature of contaminants and their distribution in groundwater. Hydraulic and chemical data were collected in the area, helping in defining the conceptual models of flow and transport, and serving as model calibration targets.

A7-17 Orale Cavallin, Angelo

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3D HYDROGEOLOGICAL MODEL OF THE PO PLAIN: A PROPOSAL

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Key terms: 3D; hydrogeology; Po plain

Last year the Po River Basin Authority (ADBPO) requested the national scientific community to formulate comments on the draft of the River Basin Management Plan as well as to propose integrative actions aiming to

increase the efficiency of open problems solving solutions.

The Department of Environmental and Territory Science (DISAT) of the University of Milan Bicocca (UNIMIB) proposed the realization of a unitary 3D hydro-geologic model of the full Po plain as an integrative measure.

The model rationale is to build a homogeneous shared knowledge of the plain subsoil as a unitary basis for evaluating the groundwater resource, identifying critical areas, protecting its quality, planning its strategic development in front of change of precipitation regime and water demand increase. It has to be considered as a tool to harmonize, coordinate and integrate the information patrimony on the subsoil presently distributed among scientific community, river Authority, and various territorial institutions.

The measure was included by the Authority in the list of those judged as urgent and of high priority for the Management Plan implementation, with specific reference to the water balance Plan.

An ad hoc Memorandum of Intent has been recently signed by the three Institutions (CNR; ADBPO and UNIMIB) to operationally manage the measure realization.

Fundamental element of the knowledge is the 3D reconstruction of underground reservoir features, made up of alluvial deposits with lithofacies and textures (gravels, sands, clays) highly heterogeneous in space. The aim is the definition of the groundwater bodies geometry, of the permeability limits, of boundary conditions.

A specific database of water wells (TANGRAM), with special regard to their stratigraphic features, has been developed and used for uploading data related to some pilot areas (e.g., more than 25,000 data already available for the Lombardy territory).

The physical model of plain underground is built from the wells stratigraphies by means of a methodology which integrates databases, GIS systems and GOCAD (Geologic Object Computer Aided Design).

The methodology, applicable in a multi-scaling context up to a regional level, allows to define the space basic knowledge which along with the hydrologic dynamic data, related to balance and flow, are used for the hydro-geological numerical modelling simulation (e.g. Modflow) as a supporting tool to groundwater resources management.

Under the coordination of ADBPO, an ICT node will manage, according remote standard procedures, information flows from/to the peripheral web services of territorial institutions. Information exchange will concern both processed data of the 3D subsoil model and evaluations derived from simulation models.

The measure will allow to upgrade the efficacy and efficiency of information released from monitoring networks by means of a progressively adaption to a unitary vision of the natural groundwater system operation and of the impacts related to human activities.

The measure is being developed by the three specialized research Institutes of CNR, namely Water Research Institute (IRSA), Environmental Processes Dynamics Institute (IDPA) Environmental Geology and Geo-Engineering Institute (IGAG), along with DISAT/UNIMIB.

Collaborations will be also established with the Universities localized in the Po basin. The measure is strategically managed by ADBPO and CNR, while scientific coordination is in charge of DTA- CNR.

A pilot realization of the measure is actually applied to a test area located in the Lombardy plain, in between the rivers Oglio and Adda, with a 3D model developed by DISAT/UNIMIB.

A7-18 Orale Fetisov, Vyacheslav

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THE AOSTA PLAIN ZONING ON CONDITIONS OF INTERCONNECTION OF SURFACE WATER AND GROUNDWATER

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Key terms: groundwater/surface-water relations; mountainous regions; Aosta plain

Alluvial deposits of mountain valley are characterized by considerable inhomogeneity which is reflected in their filtration properties. It is caused by features of alluvium formation and also by presence of sediments of various genesis in alluvial stratum at different depth (remains of ancient alluvial fans, dealluvial trails, rock fall, landslides and etc.). In some cases they carry out a role of local weak permeable or almost impermeable interlayers, in others cause worsening of filtration properties of alluvium. Sharp variability of mountain alluvium facies can lead to considerable errors, first of all at substantiation of the filtration scheme. If conclusions about filtration properties of alluvium are based only on results of the aquifer test analysis carried out in small volumes on local site, then it is possible to get any and casual results.

Therefore at the preliminary stage previous to modelling, performance of zoning of the plain on conditions of interconnection of surface water and groundwater which define filtration properties of alluvial deposits is expediently.

Taking into account the data of groundwater and surface water monitoring, there was executed the Aosta plain zoning between two morphological narrow sites of the Dora Baltea valley (commune Villeneuve in the west, commune Pontéy in the east).

The average slope of the Dora Baltea river between gauging-stations PF1 (Trépoint) and PF6 (Ponte vecchio Saint-Marcel) which restrict Aosta plain in the west and the east makes 6,4 0/00 (according to LiDAR survey of the Dora Baltea river). It is possible to mark out two sections with different slope surface and accordingly different speeds of the river: the first section is situated between stations PF1 and PF3 (Passerella Gressan) with an average slope 9,3 0/00; and second - between stations PF3 and PF6 with average slope 4,4 0/00. The first initial section of plain was raised during neotectonic development of the territory, the second section was exposed to depressing and widening.

Complexity of geomorphological conditions is expressed in the sharp variability of width of the alluvial aquifer and its thickness that finds direct reflexion in directivity and intensity of water exchange between the alluvial stratum and the river. The flow section of the groundwater stream of the Aosta plain, according to the accepted geologic model, changes on the average from 20 thousand M2 in narrow parts of the plain to 120 thousand M2 and more in its central widest part.

The initial narrow section of the valley between gauging-stations PF1 and approximately to the boundary of communes Aymavilles/Jovencan is characterised by alimentation of the Dora Baltea river by aquifer. Further downstream, the plain begins to widen and as a result of the sharp increase in the alluvial aquifer cross-sectional area is a constant alimentation of alluvium by river waters. Here it is possible to mark out a section with intensive alimentation of the alluvial aquifer from the river and a section with moderate alimentation located lower the Buthier alluvial fan. An intensive alimentation from the river is accompanied by

filling of pore spaces of coarse alluvium by fine-grained materials transferred by the river. That causes a worsening of filtration properties of the upper part of the alluvial aquifer. This is confirmed by the data of the granulometric analysis of alluvial sediments from the wells S3 drilled in this site (De Maio et al., 2010). The content of argillo-arenaceous fractions in diameter less than 2 mm in samples which have been taken above and below the groundwater level is increased from 43 to 62%. Approximately from the site of gauging-stations PF5 (Ponte Pollein), where there is narrowing of the groundwater flow cross-section area, the discharge occurs into the river, that prevents the entrance of argillo-arenaceous fractions into the alluvial stratum.

A7-19 Orale Boccardo, Delia

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OXYGEN SUPERSATURATED WATER INJECTION SATURATED FOR MTBE AND HYDROCARBON BIOREMEDIATION

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Key terms: Oxygen supersaturated water; injection; hydrocarbon; MTBE; bioremediation

In-situ enhanced biodegradation is a well established technique for the remediation of sites impacted by petroleum hydrocarbon. The majority of the remedial approaches used involve however a series of traditional technologies such as Pump and Treat, air sparging or use of oxygen-delivery compounds.

Due to historical leaks from underground storage tanks, soil and groundwater at the Site described in the study were impacted by light and heavy hydrocarbons and MtBE. Biodegradation was observed to be an important process at the Site, but with a kinetic too slow to allow for a remediation under an acceptable timeframe. Being oxygen, the limiting factor, air sparging was considered but abandoned due to the generally low hydraulic permeability and the high degree of vertical stratification of the soil. Based on a feasibility analysis, a mixed remediation technique was selected and comprising of injection of super-oxygenated water (SOW) and traditional P&T.

The system is composed of an oxygen source, a recirculation system (extraction/injection wells, pump), an hydraulic barrier for the protection of the sewer and an SOW generation system, which was developed by Golder in 2003 and constantly improved since then.

The injection of SOW offers significant advantages over conventional technologies for direct injection of air into the groundwater:

- ° the completely oxygen dissolved prevents the generation of gas bubbles and avoids the need to install a vapor recovery system;
- ° contact oxygen-ground water is not made in the form of bubbles in the soil, because oxygen is already being fully dissolved; the injected water, unlike air bubbles, follows the same path of groundwater and is therefore less influenced by different preferential pathways;
- ° high concentrations of oxygen in the injected water generate a high concentration gradient that allows the diffusion of oxygen even in areas with low permeability;
- ° injection may be continuous and controlled by traditional P&T, overcoming the difficulties represented by the emplacement of oxygen delivery chemicals in socks or injections.

Considering that, in these low permeability soils, the SOW injection creates a rising of the groundwater level and significantly modifies the groundwater direction, a P&T system was added in order to provide for groundwater flow control, limiting potential contaminant displacement and further mass reduction.

After 18 months of operation of the PAT, in conjunction with the plant P&T, a strong decreasing of contamination was measured and a considerable increase of the MtBE- and hydrocarbons-degrading bacteria in monitoring wells.

MtBE in the sampling conducted in September 2010 is lower than the remediation targets in all samples analyzed, while benzene and total hydrocarbons has shown respectively a very strong and a significant decrease. The increase of bacteria was detected in many monitoring wells, near the injection wells. This increase, compared to the low injection flow of supersaturated water (about 1 l/min well), confirms that the reduction of the contamination is not attributable to dilution/P&T removal. The results obtained have shown that the SOW injection, combined with P&T, can be effectively used for the remediation of groundwater contaminated with hydrocarbons and MtBE.

When compared with the traditional P&T addition, the acceleration of the biodegradation generated by the SOW injection has consequently increase in the duration of the activated carbon, due to lower contaminant mass load to the P&T filters.

The residual contamination of benzene and total hydrocarbons will be treated by the continued operation of SOW injection and P&T to achieve the objectives of remediation. The injection of oleophilic nutrients is currently also considered to further increase the biodegradation of the heavier hydrocarbons.

A7-20 Poster Fetisov, Vyacheslav

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SCHEME MAP OF THE PROTECTION (UNSATURATED) ZONE OF THE UPPER KAMA SALTS DEPOSIT

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Key terms: groundwater; vulnerability; salt deposit

The Upper Kama potassium salts (sylvinitic, karnallit) deposit is situated within the bounds of the Perm Krai on the left bank of Kama river. The deposit is the largest in Russia and the second in the world. Sylvinitic is raw materials for production of potash fertilizer (contains about 75% of halite). Karnallit is raw materials for the magnesian industry.

The upper layer of the territory is presented by Quaternary deposit (consists in sand, sandy loams, loams, clay); next layer is the bedrock of the Perm system: presented by speckled stratum (sandstones, clay, aleurolites, argillite), terrigenous-carbonate stratum (limestones, marl), salt-marl stratum (marl, clay, gypsum). Under that the directly salt deposit is allocated. Development of the deposit is carried out by underground mining, depth of mine changes from 100 to 500 m.

After flotation the halite and clay are taken place above the ground surface as the waste products, in form of technogenic massifs from solid

halite waste (80-93 %) and clay-salt sludge (7-10 %). (The altitude makes 100 m and more.) They are the main source of salinization of ground and surface waters, soils and rocks in the zone of active water exchange.

On the observable territory there are available more than 20 large water supply point, they take groundwater from aquifers above salt stratum. Every day they pump out about 150 - 200 thousand m³ of groundwater. In this connection, the estimation of groundwater vulnerability is the actual problem.

The assessment of groundwater vulnerability is carried out in two stages. The quality assessment of groundwater vulnerability based on a complex of available map (soil map, map of the Quaternary deposits, geological map, the depth to water table, relief of the territory) is carried out at the first stage. That means, the map of the protection zone is made by superposition of these maps. The sites with identical characteristics are allocated on the map of the protection zone. And at the second stage the time required for particular contaminant to reach the aquifer is calculated for each of these concrete sites.

The typical sites which characterised the same structure of soils and rocks of the unsaturated zone are allocated on the schematic map of the protection zone.

Making of this map was carried out in ArcGIS by superposition of the next above-mentioned maps: a soil map, a map of Quaternary deposits and geological map.

In the investigated territory it is possible to mark out two category of the groundwater protection. The least favorable protection conditions are: the not deep groundwater level (from less 1 to 5), insignificant total thickness (0,5-3,5) of weak-permeable sediments in the aeration zone. Such conditions are developed in the western and northwest parts of the deposit where there are mainly sandy fluvio-glacial sediments with small of weak-permeable rocks.

A7-21 Poster Davit, Jean Pierre

10.1474/Epitome.04.0112.Geoitalia2011

PASSIVE VS. TRADITIONAL GROUNDWATER SAMPLING METHODS: A COMPARATIVE ANALYSIS

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Key terms: Hydrasleeve; Passive sampling; Chemical analysis results comparison; Sampling cost reduction

Groundwater passive sampling is a method which is becoming increasingly accepted by most of North American Environmental Agencies given its reliability, reduced waste generation as well as time and cost effectiveness. The method is still basically not applied in Italy because pre-sampling purging is required by the ISPPA guidance and local ARPAs are reluctant to rely on a no-purge sampling technique.

The aim of this study was to conduct a comparative analysis of two different groundwater sampling methods and provide a basis for a technical proposal for passive sampling applicability.

A passive groundwater sampler is defined by ITRC as one able to acquire a sample from a discrete position in a well without active media transport induced by pumping or purge techniques. The sampling device is exposed to media in ambient equilibrium during the designated sampler deployment period. In wells, the water is expected to be in natural exchange with the formation water (Robin and Gillham 1987).

Two different sampling practices were compared:

- ° No-purge passive sampling, using a Hydrasleeve sampler; and
- ° Traditional purge and sample, using a low-flow pump or a traditional subsurface pump.

The groundwater samples were collected in different Sites impacted by dissolved contaminants such as chlorinate solvents and hydrocarbons (diesel gas oil and gasoline).

The comparison of the two sampling methods dealt with the following aspects:

- ° comparison with concentration of contaminants detected;
- ° sampling operation cost-effective analysis;
- ° environmental compatibility; and
- ° compliance with the legislation.

Regarding the chlorinated solvents, the two sampling methods gave comparable results; both detected the same contaminants with similar concentrations, in almost all the wells.

Hydrasleeve and traditional sampling results showed a good linear correlation and an average Relative Percentage Differences values lower than 40%.

In the sites impacted by hydrocarbons contamination, the concentration values detected were:

- ° comparable for benzene, toluene, ethylbenzene xylenes and for MtBE; and
- ° higher for TPH in Hydrasleeve samples.

The main advantages related to Hydrasleeve sampling are:

- ° sampling cost reduction by 50%-80%, obtained by saving field time and material and additional costs for disposal of purged water;
- ° good environmental compatibility, by displacing a minimal amount of water;
- ° suitability of sampling for most physical and chemical parameters; and
- ° compliance with Italian legislation for low yield aquifers sampling.

The limitations of Hydrasleeve are:

- ° it requires a minimum water column above bottom of monitoring wells;
- ° it has limited sample volume and does not allow for field measurement of physico-chemical parameters; and
- ° in general it is not accepted by Italian Authorities in substitution of traditional sampling methods.

Although site-specific results comparative analysis is recommended prior to replace the traditional sampling methods, this comparative analysis showed the suitability of Hydrasleeve as a passive sampling method for monitoring of groundwater contamination.

SESSIONE B1

Previsione e monitoraggio delle frane

B1-1 Orale Apuani, Tiziana

10.1474/Epitome.04.0113.Geoitalia2011

3D STRESS-STRAIN ANALYSIS OF THE ETNA VOLCANO: A CONTRIBUTION TO DEFINE THE HAZARD ASSOCIATED WITH FLANK DYNAMICS

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Key terms: Etna Volcano; flank instability; numerical modelling; FLAC

As many active volcanoes, Mount Etna shows clear evidence of flank instability, and different mechanisms were suggested to explain this flank dynamics, based on the recorded deformation pattern and character. Shallow and deep deformations, mainly associated with both eruptive and seismic events, are concentrated along recognized fracture and fault systems, mobilising the eastern and south-eastern flank of the volcano. Several interacting causes were postulated to control the phenomenon, including gravity force, magma ascent along the feeding system, and a very complex local and/or regional tectonic activity. Nevertheless, the complexity of such dynamics is still an open subject of research. Being the volcano flanks heavily urbanized, the comprehension of its gravitative dynamics supports hazard and risk evaluations, and must guide the civil protection actions. The present work addresses the problem by integrating field data, laboratory tests and numerical modelling. A bi- and tri-dimensional stress-strain analysis was performed by a finite difference numerical code (FLAC and FLAC3D), mainly aimed at evaluating the relationship among geological features, volcano-tectonic structures and magmatic activity in controlling the deformation processes. The analysis is well supported by dedicated structural-mechanical field surveys, which allowed to estimate the rock mass strength and deformability parameters. To take into account the uncertainties which inevitably occur in such a complicated model, many efforts were done in performing a sensitivity analysis, devoted to evaluate the effect of topography, geometry and rheological behaviour of the structural units, along the WNW-ESE section crossing the volcano summit and the Valle del Bove depression. Then a 3D numerical model, extended 40x60 km, was implemented to simulate the volcano deformation pattern. First, the role of the Pleistocene subnean clays was investigated, then, two "structural weakness zones" - the Pernicana fault system and the NE rift - were introduced and their effects on the flank instability evaluated. Two extreme hydrogeological conditions, drained and undrained, were analyzed. The results are expressed in terms of stress-strain field, displacement pattern, plasticity states, shear strain increments. Two main instability mechanisms were identified: the first deep seated, and the second one at shallow depth, with the sliding surface located inside the subnean quaternary clay. Both mechanisms contribute to explain the present deformation pattern and some of the main structures of the Etna flank. The effect of magma pressure exerted on the active dyke walls during eruptions was then simulated, and relations between magmatic activity and flank instability were investigated.

B1-2 Orale Maerker, Michael

10.1474/Epitome.04.0114.Geoitalia2011

A FUNCTIONAL ENTITIES APPROACH TO PREDICT SOIL EROSION PROCESSES IN SMALL PLIO-PLEISTOCENE MEDITERRANEAN CATCHMENTS

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Key terms: Erosion Processes; Land slides; spatially explicit prediction; Classification and regression trees; Chianti

In this paper we evaluate different methods to predict soil erosion and shallow landslide processes. We derived different layers of predictor variables for the study area in the Northern Chianti, Italy, describing the soil-lithologic complex, land use, and topographic characteristics. We mapped erosion processes by interpretation of aerial photographs and field observations. These were classified as erosional response units (ERU), i.e. spatial areas of homogeneous erosion processes. The ERU were used as the response variable in the soil erosion modelling process. We applied two models i) bootstrap aggregation (Random Forest: RF), and ii) stochastic gradient boosting (TreeNet: TN) to predict the potential spatial distribution of erosion processes for the entire Orme River catchment. The models are statistically evaluated using training data and a set of performance parameters such as the area under the receiver operating characteristic curve (AUC), Cohen's Kappa, and pseudo R². Variable importance and response curves provided further insight into controlling factors of erosion. Both models provided good performance in terms of classification and calibration; however, TN outperformed RF. Similar classes such as active and inactive landslides can be discriminated and well interpreted by considering response curves and relative variable importance. The spatial distribution of the predicted erosion susceptibilities generally follows topographic constraints and is similar for both models. Hence, the model-based delineation of ERU on the basis of soil and terrain information is a valuable tool in geomorphology; it provides insights into factors controlling erosion processes and may allow the extrapolation and prediction of erosion processes in unsurveyed areas.

B1-3 Orale Doglioni, Angelo

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AN INNOVATIVE APPROACH FOR THE IDENTIFICATION OF GEOMORPHOLOGICAL ANOMALIES BASED ON WAVELET TRANSFORM

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Key terms: DTM; wavelet; engineering geomorphology; quantitative geomorphic analysis

Landform analysis for detection of terrain anomalies constitutes a hot topic, which is often faced by exploiting digital models of the surface topography, which are usually quite accurate as well as geographically exhaustive. Digital Terrain Models (DTM) embody representations of the earth surface as rectangular grids or as mesh of triangles. However, these representations can be seen as matrixes of real numbers, which can be processed according to the approaches of signal processing.

Numerical geomorphic analyses of DTMs represent an interesting approach to these kind of studies, allowing for a detailed and pretty accurate identification of hidden topographic anomalies that may be related for instance to large landslides. The hierarchical analysis of DTMs permits a multi level identification of geomorphic entities, which constitute an inventory of landforms and natural resources.

Applications to 1D topographic data show useful results, including the identification of changes in topographic structure with scale. Extension to 2D analysis allows for the quantification of characteristic shapes, scales and orientations in the landscape.

Wavelet analysis of DTM was undergone for the identification of anomalies of unique features of the surficial topography. Application of wavelet analysis to morphotectonic lineament investigation, i.e. tectonic faults, associated with characteristic geomorphological features such as linear valleys, ridgelines and slope breaks are known from literature. In particular, these are used for the delineating the characteristic spatial frequencies of deep-seated landslide morphologic features such as ridges, scarps, and displaced blocks of material. In fact, spectral power shows characteristic frequency bands of spatial patterns, thus highlighting past slope instabilities and allowing the delineation of landslide terrain.

An approach for geomorphic numerical analyses is herein presented. The hierarchical representation of the DTM, can provide evidences of anomalies or singularities of the land surface, which are not directly evident from the DTM as it is, or from a simple slope and curvature analysis. In particular, 2D wavelet transform preserves the average values of the elevation at different scales, and this is particularly suitable for grid-based DTM. The grid-based DTM can be assumed as a matrix, where a discrete wavelet transform is performed columnwise and likewise, which basically represent horizontal and vertical directions. The significant outcomes of this analysis are low-frequency approximation coefficients and high-frequency detail coefficients. The detail coefficients in particular are analyzed, whereas sudden and wide variations of these coefficients are related to the variations and discontinuities of the DTM. Detailed coefficients are therefore 2D-plotted both on the horizontal and vertical direction, thus allowing to visualize and quantify potential anomalies of the land surface. Moreover, a further level wavelet analysis can be performed on the matrix of the approximation coefficients, which represent a smoothed representation of the land surface. This allows for the construction of a further level detail coefficients matrix, which can provide further information about the land surface. In this kind of approach, the choice of a proper wavelet is a tricky point, since it conditions the analysis and then their outcomes. Therefore multiple levels as well as multiple wavelet analyses are guessed.

Here the introduced approach is applied to some interesting cases study of south Italy for which detailed DTMs are available. These analyses show the performance of results in terms of different wavelets and different DTM resolutions. Moreover, the wavelet transforms are performed on multiple levels, thus trying to address the problem of which is the level extent for an accurate analysis fit to a specific problem.

B1-4 Orale Infante, Marco

10.1474/Epitome.04.0116.Geoitalia2011

THE TERRESTRIAL LASER SCANNER (TLS) SURVEY OF VIGNANOTICA'S BAY (GARGANO, APULIA, SOUTHERN ITALY): DETAILED MODEL OF A CLIFF

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Key terms: laser scanner; survey; model; cliff; apulia

The Terrestrial Laser Scanner (TLS) allows, at a distance of several hundreds metres from the stationing position, the acquisition of points belonging to a surface of inaccessible area.

In order to study the geomorphological and the mechanical features, the TLS is used to survey the sea cliff sited at the foot of Vignanotica valley, in southern coast of Gargano peninsula.

The main characteristic of the slope is its uprightness, up over 100 meters, with a front, divided by the valley mouth, which spreads for about 900 meters on the Adriatic coast.

The great interest in this site is due to its geological setting and to the effects of tectonic uplift that causes visible structural changes.

Since the sea cliff rises up to great altitude with a vertical slope, an high accurate, georeferenced digital model provided by TLS surveys is used in order to approach a qualitative and not interpretive study of discontinuities in rock.

Despite the cliff height, which rises over 120 meters in the eastern side, the lack of data acquisition was never counterchecked as consequence of the instrument space range. Instead, the digital model is not complete for shadows (i.e. areas invisible to the laser) due to brushes or morphological features noise. In order to minimize shadows during the later combination, straight scans overlap of about 50% according to the complicated geometry of the exposed rock face.

The generated virtual surface model is then queried to gain detailed measures up to 2 centimeters, precision chosen during the scans combination. The 3D model clearly shows all geomorphological and sedimentary evidences of the cliff, which are visible in place only in the lower part, and it allows appreciating these features at a height in the whole rock face. Herein, the Calcarei a Maiolica formation outcrops (limestone with chert beds and nodules) characterized by the presence of syndimentary deformations (slumps). The effects of tectonic uplift, as fractures and faults, are visible along the whole outcrop and they often mark the entire slope. The karst features are noticeable as carvings, which may overlap the pre-existing structural lineaments, and as vertical caves that widespread along the cliff notch; these last features let's hypothesize the superimposition of waves action on the chemical solution of the limestone.

The model depicts the real distances on the rock face and then it allows to measuring the void and caves in order to assess the amount of missing rock material.

Moreover, the DGPS georeferencing of collected data let's detect the fractures orientation in order to identify the main discontinuity groups and to pick out boulders that could move down to the slope.

B1-5 Orale Ambrosi, Christian

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MIARIA - ADAPTIVE IDROGEOLOGICAL MONITORING SUPPORTING THE AREA INTEGRATED RISK PLAN. THE CASE STUDY OF THE CANARIA VALLEY (TICNO, SWITZERLAND)

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Key terms: rockslide; modeling; monitoring; lidar; radar

MIARIA is a project funded as part of the Italy/Switzerland Operational Programme for Trans-frontier Cooperation 2007-2013 (INTERREG Italy/Switzerland).

The project aims to build innovative systems and technologies for the distributed acquisition of regional data and the communication of that data to second-generation operating control rooms; the aggregation of the information on a phenomenological basis, and the generation of dynamic integrated risk scenarios in trans-frontier Alpine environments, with particular regard to domino effects (Area Integrated Risk Plan-denominated scenarios).

Within this frame the Institute of Earth Sciences of the Applied University of the Southern Switzerland (IST-SUPSI) is responsible for the application of the project in the case study of the Canaria valley. This region is particularly susceptible to landslides and consequent domino effects that could cause severe damage to population and to infrastructures of North-South axis of San Gottardo.

Numerous active landslides are present in the valley involving both right and left slopes. In particular two phenomena are particularly active with measured displacements up to 20 cm/year: the Rutan di Sassi deep rotational slide in the left flank of the main river and the Ce complex rockslide in the right flank.

On October 2009 a rockfall has occurred in the front of Ce complex rockslide involving a volume of 350'000 m³. The accumulation has partially dammed the main river of the valley. A new similar event could be totally dam the river with heavy hazard of structures and infrastructures located at the toe of the valley. We present results of in situ geodetic lidar and ground based radar measurements to predict the potential scenarios and the results of run-out model applied on the Ce rockslide. The dam break modeling has recently conducted by damflood model (Cannata & Marzocchi, 2009), a 2D numerical model for the dam break flooding simulation.

B1-6 Orale Lucà, Federica

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EVALUATING LANDSLIDE SUSCEPTIBILITY AND HAZARD THROUGH CELLULAR AUTOMATA: FIRST RESULTS ON LATTARI MTS. (SORRENTO PENINSULA, ITALY)

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Key terms: Landslide susceptibility; Hazard; Cellular automata

The ultimate aim of many landslide studies is the assessment of the risk to population and/or infrastructures. To achieve this goal, information on landslide hazard is required; it involves the evaluation of the location and timing of occurrence of the events, and also the magnitude or intensity of the potentially hazardous phenomena.

These issues are addressed in our study, which highlights the preliminary results of a method for evaluating landslide invasion hazard on the basis of numerical simulation through Cellular Automata coupled with geological-morphological field survey and GIS techniques. The method has been tested on the northern sector of M. Pendolo (Sorrenro Peninsula) where proclastic covers, blanketing Mesozoic carbonate massifs, were affected by debris slides-rapid earth flows in the last decades.

By assuming that landslides will occur in the future because of the same conditions that produced them in the past, a logistic regression method was implemented to predict the geographical location of future landslides. The approach allowed to investigate the relation between landslide location and predisposing factors, adopting a stepwise procedure to select the optimal landslide susceptibility model.

Temporal probability of landslide occurrence was obtained from catalogues of historical landslide events occurred in the study area and by adopting a Poisson distribution model for the occurrence of the landslide events, while we used the thickness involved in the initial detachment as proxy for landslide magnitude or intensity.

For landslide invasion hazard purpose, several possible source areas have been hypothesized; for each of them, a simulation has been carried out by assuming the total entrainment of the cover thickness, whose distribution was drawn up in detail by field measurements. Simulations were performed by using the latest release of SCIDDICA, a Cellular Automata model previously calibrated on past events. Among other characteristics, the model is able to take into account phenomenological specifications such as energy dissipation, erosion and inertial effects. Ultimately, for each point affected by simulation, an overall hazard was calculated by overlapping the simulations and summing the product of relative probabilities of: (i) spatial occurrence (susceptibility), (ii) occurrence of slope failures in any give year (time), and (iii) landslide magnitude. Preliminary results clearly portray the most susceptible and hazardous sectors.

B1-7 Orale Vitale, Valerio

10.1474/Epitome.04.0119.Geoitalia2011

PRELIMINARY RESULTS OF LANDSLIDE SUSCEPTIBILITY ASSESSMENT IN THE SHEET N. 348 - ANTRODOCO (CARG PROJECT)

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Key terms: landslide susceptibility assessment; logistic regression; rare

events

The aim of this work is to present the preliminary results of landslide susceptibility assessment performed by ISPRA (Institute for Environmental Protection and Research) in a test area represented by the sheet n. 348 - Antrodoco of the geological map of Italy at the 1:50.000 scale (CARG Project).

To carry out the analysis and make it more possible generalizable it was decided to use data available throughout the country such as the Digital Elevation Model (Istituto geografico Militare Italiano), the Corine Land Cover coverage and a landslides inventory produced by the IFFI Project. The work intends to focus attention on the statistical methods adopted, using two different type of spatial discretization representing by grid cells and unique condition units (UCU).

Because of their limited spatial occurrence, the landslides in the study area can be considered as "rare events". Then it was adopted the statistical methods able to keeping the rarity of the landslide events. In particular, it was used a logistic model for rare events. Finally it was compared the results with those obtained through "conventional" analysis such as discriminant analysis.

B1-8 Orale Palladino, Michela Rosa

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RAINFALL THRESHOLDS FOR THE INITIATION OF SHALLOW LANDSLIDES AND MUD-DEBRIS FLOWS IN LOMBARDY: FIRST RESULTS

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Key terms: Shallow Landslides; Mud-debris flows; Hazard; Threshold; Lombardy

The Lombardy Region, like all Alpine regions, is highly susceptible to natural instability processes. In the last 25 years the great deal of geo-hydrological processes has resulted in severe economical and societal damages. A recent study has emphasized that 687 municipalities of Lombardy (44% of the total) have to be considered at medium-high geo-hydrological risk level.

Hazard mitigation and damages reduction require an accurate forecasting of phenomena, especially in relation to rapid processes such as shallow landslides and mud-debris flows. The role of rainfall for the initiation of such movements is pivotal, to the extent that many research groups worldwide from several decades are looking for a correlation between rainfall thresholds for the initiation of landslides. Nevertheless such a prediction is made difficult because of the multiple provoking factors and the lack of a complete knowledge of the triggering mechanisms.

The aim of the present study, carried out by CNR-IRPI of Turin on behalf of Lombardy Region, is to characterize the relationship between shallow landslides and mud-debris flows occurrence and rainfall, in order to determine the amount of rainfall needed to trigger this processes and to provide a forecasting tool. The considered area consists of the Lombard Provinces of Bergamo, Como, Lecco and Varese (a total area of 6030 km²).

A total number of 378 shallow landslides reports have been collected between 1950 and 2010. Nevertheless only 89 of them (24% of the total) have provided the rainfall quantities required for succeeding analysis.

Collected data have been gathered in a catalogue. Both reported phenomena and rain gauges location on the study area have been represented in a map using a GIS. This operation has allowed to define the relevant rain gauge stations for the triggering events and to obtain cumulative rainfall (P), duration (D) and intensity (I) for each of them. The I-D values associated to triggering rainfall appears to vary in a quite wide range, but they seem to balance one each other. Summer landslides appear to be more relied on event duration than the spring-autumn ones. The threshold curves, which delineate the minimum I-D values able to trigger shallow landslide, are obtained from the empirical rainfall data using a linear regression analysis. To cope with the climatic and hydrologic differences in the different catchments, the rainfall information has been normalized using MAP (Mean Annual Precipitation) as a climate index. Collected data shows that for the most of the listed processes (41% of cases) P/MAP ratio ranges between 10% and 15%. No cases of P/MAP exceeding 25% are reported. Two normalized Intensity-Duration thresholds have been proposed in order to take into account the different trends shown by triggering-precipitation with durations (D) minor or superior to 10 hours.

B1-9 Orale Secci, Romina

10.1474/Epitome.04.0121.Geoitalia2011

CHARACTERIZATION OF THE DETRITAL LAYERS USING GEOSTATISTICAL TECHNIQUES

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Key terms: detrital layers; principal component analysis; cluster analysis; depth of incoherent deposits; kriging

The problem of identifying areas having a higher propensity for the triggering of shallow landslides during extreme weather events is crucial in land use planning. The danger is defined as the probability that a particular landslide occurs in a given area and in a given period of time, is calculated and then graphed (using cards from the slope stability), through the use of different methodologies. In the last decade, the continuous progress of information technology has allowed the application of methods for assessing increasingly complex landslide hazard, although the possibility of a correct implementation is subject to a thorough knowledge of their limits of validity as well as a choice and effective representation of the spatial distribution and characteristics of the factors presumed to affect the processes of slope instability.

The possibility to implement a realistic and accurate representation of the depth and geomechanical properties of incoherent deposits would greatly improve the calibration of deterministic models for landslide hazard assessment.

This research aims to develop statistical models on the spatial distribution as well as the characteristics of the geomechanical slope deposits and layers of granite alteration on a fairly large area near the village of Capoterra (Cagliari); often subject to flooding and debris flow phenomena of great magnitude. These models have been developed through analysis

of correlations between the depth of the detrital layers, the their geotechnical, geo-mechanical, hydraulic, and several other variables (morphological, geological, structural, physiographic, vegetation, etc.). Following a classification of the areas previously affected by sediment transport and on the basis of Standard Penetration Tests (SPT) and field surveys have been analyzed the characteristics of stability and strength of the identified areas by building a geodatabase full of over 500 sample points.

Once normalized data was applied geostatistical technique of PCA (Principal Component Analysis). In combination with PCA was also used cluster analysis. The combination of these techniques have obtained some correlation between the data values calculated for each sample. At the end of the analysis is obtained as the dependent variable the thickness of the deposits was carried Kriging of the data obtained. The possibility to implement a realistic and accurate representation of the depth and geomechanical properties of incoherent deposits will greatly enhance the calibration of deterministic models for landslide hazard assessment. Through a better stratigraphic, pedological, hydraulic and mechanical characterization of the studied basin, the location and timing of initiation of the phenomena of sliding surface of the detrital layers are determined, in the context of a meteoric event of a certain intensity and duration.

B1-10 Orale Giordan, Daniele

10.1474/Epitome.04.0122.Geoitalia2011

MORPHOMETRIC EVOLUTION OF A LARGE EARTHFLOW: THE MONTAGUTO LANDSLIDE, SOUTHERN ITALY

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Key terms: landslide monitoring; LIDAR; Robotized total station; Montaguto landslide

In the spring 2006 a large earthflow moved in the Montaguto municipality (Campania region, southern Italy). This was a partial reactivation of an older mass movement occurred in the same general area. In April 2010, the earthflow reached the Cervaro valley advancing at a rate of up to 6 meters/day partially damaging the provincial road SP-90 connecting Naples to Foggia and covering about 300 m of the railroad track. Traffic along the railroad and the road was interrupted for about four months, causing severe problems chiefly to the local residents and the local economy, but also to the national railway system with consequences in southern and central Italy. To re-open the railway and to re-construct the provincial road, the Italian national Department of Civil Protection (DPC) organized a large-scale effort to mitigate the effects of the moving landslide on the road and the railroad.

In this study, we investigate the geomorphological and kinematical evolution of the Montaguto mass movement. Starting from the first phase of the emergency (April 2010) the IRPI GeoMonitoring Group supported the DPC activity studying the long-term evolution (2004-2010) of the landslide through a multi-temporal analysis based on high-resolution DEMs derived from a regional map and the results of four airborne LIDAR surveys. With LIDAR data, we estimated the volume of materials that have been transferred downwards the valley and we support the DPC for the planning of landslide mitigation activity. In addition, we considered the short-term evolution of the landslide by analysing the actual surface displacements measured via a network of three robotized total stations. This system provided near real time measurements of the surface displacements to the civil protection authorities responsible for the safety of the workers that operated on or near the active landslide. We show that the joint consideration of geodetic techniques allowing the long- and short-term observation of the surface deformation is a convenient approach for the interpretation of the morphometric and kinematic evolution of complex landslide phenomena.

B1-11 Poster Aiello, Gemma

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DEEP GRAVITATIONAL PROCESSES IN THE MARATEA VALLEY (SOUTHERN ITALY): EVIDENCE FROM HIGH RESOLUTION REFLECTION SEISMIC PROFILING OF THE SURROUNDING OFFSHORE

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Key terms: deep gravitational deformations; Maratea Valley; submarine landslides; morpho-bathymetry; Basilicata

Deep gravitational deformations (DGPV; sacking, gravitational spreadings, gleistung) are interpreted in terms of superficial landslides and gravitational tectonics. These movements have been singled out in many outcrops of Italy, mainly referring to their distribution on the territory and to geomorphological aspects (Dramis et al. 1983), in particular in the regional examples of the Central Alps, western Sicily and central and southern Apennines (Forcella et al. 1982; Agnesi et al. 1987; Calamita et al. 1982; Guerricchio and Melidoro 1979). Among their main characteristics there are the great volume of the involved masses, the very ancient age of the deformations, the slow evolution during geologic time (of a deep-seated creep type), the persistence of gravity instability conditions through time and the movement reactivations during seismic and meteoric events. The Maratea Valley (Basilicata) is characterized by deep gravitational movements involving the Meso-Cenozoic calcareous-dolomitic formations (tectonic units "Alburno-Cervati" and "Bulgheria-Verbicaro") interpreted as sacking-type phenomena. The complex morpho-structural setting of the area has been influenced by the Pleistocene extensional tectonics, probably still active. The tectonic dislocations, characterized by a strike-slip component at a regional scale, have caused the superimposition of the Bulgheria-Verbicaro Unit on the Crete Nere Formation and the tectonic contact of the last formation on the Alburno Cervati unit, cropping out on the right flank of the valley. Normal faulting, block rotations and structural widening of the valley are produced as an effect of differential velocity during strike-slip tectonics. The Crete Nere flysch (Liguride Units) takes on a plastic behaviour due to high water contents. It is affected by a flow-type, relatively deep process (30-50 m) within the valley and near the sea. High resolution multichannel seismic profiles, coupled to Subbottom Chirp sections have provided new insights

on offshore prolongation of the Maratea Valley and related landslides. Late Pleistocene-Holocene slope sequences deposited in an intra-slope basin and then appear to be tectonically uplifted in correspondence to complex morpho-structural highs controlled by normal faults. Three main seismo-stratigraphic units, representing the sedimentary cover overlies a rocky acoustic basement, characterized by two main acoustic facies and truncated by a wide erosional surface, referred to the isotopic substage 5e have been recognized (Aiello et al. 2010).

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B1-12 Poster Calcaterra, Stefano

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THE UPGRADE OF AN INTEGRATED MONITORING NETWORK FOR THE KINEMATIC STUDY OF THE LAGO DSGSD (CALABRIA, ITALY)

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Key terms: Landslide; GPS Network; Geotechnical Network; DSGSD; Displacements

Multidisciplinary approach to study a deep-seated gravitational slope deformation (DSGSD) and a number of ancillary landslides of different types, affected the Greci slope (Lago, Calabria), have been performed since 1996 (SORRISO-VALVO et al., 1999; BONCI et al., 2010). The study case concerns a moderately urbanized area affected by mass movements, where lithological-structural and hydrogeological complex conditions favor slope instability. The geological settlement of the area is characterized by the presence of different thrust nappes forming an allochthonous tectonic building piled up in the Oligocene - Lower Miocene, upon which Quaternary alluvial and colluvial deposits lie. Metamorphic fissured deposits outcrop widely; in addition the scenario is complicated by the presence of deep-seated, medium deep, and superficial instability resting on the DSGSD.

The investigation of the kinematics of the slope was based on integrated monitoring network: the geotechnical network (2 inclinometric verticals and 6 piezometric verticals), the geodetic network (20 GPS vertices). Besides, the integrated network is completed by a rain gauge inside the instability area. With several campaigns carried out from 1996 to 2006, the Integrated Monitoring Network (IMN) has highlighted a complex situation characterized by different slope displacements (BONCI et al., 2010). The Greci slope is affected by a DSGSD moving with maximum velocity of 0.5 cm/y for thicknesses of about 100 meters. In the area affected by the DSGSD some medium (Piscopio) and deep (Acqua Fredda) mass movements have been detected, prevalently translational slide mechanism, with constant velocities of 1 cm/y and 10 cm/y respectively. Deep and medium depth landslides, sometimes occurring in areas affected by deep-seated slope deformations, may rapidly accelerate and significantly affect structures and infrastructures, as confirmed by recent instability phenomena which damaged some building works.

Based on the results achieved from 1996 to 2006 the INM of the Lago DSGSD was upgraded. Since 2007 the INM includes: 5 GPS permanent control stations inside the unstable area, and one permanent reference station external the unstable area; 4 inclinometric verticals; 2 piezometric verticals, with transducers; a meteorological station.

The GPS permanent stations are equipped with dual frequency GPS receivers with choke ring antenna in the reference station while geodetic antenna with groundplane is used in the monitoring points. The control centre, located in Rome (Geophysical Service of ISPRA), acquires the data via ADSL from the local centre, located in the Lago Town Hall, where the data are preliminary processed automatically. The GPS data have been acquired with different modality to test the system and to define the current configuration.

The displacements detected by the permanent GPS stations, that are in agreement with the inclinometric measurements, show a trend that seems to depend by cumulated rainfall in 2008-2009. The greatest superficial displacements are confirmed in the central portions of the slope studied (Acqua Fredda), where inclinometric data indicate displacements until a maximum depth of 60 m.

The preliminary results acquired by the upgraded Integrated Monitoring Network, enable a fine-tuning of geotechnical model for the Greci slope and show the improvement of the control performances of the monitoring system.

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B1-13 Poster Castagna, Sara

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GEOLOGICAL STUDY OF THE SERRI LANDSLIDE (ACCEGLIO, NW ITALY) AIMED AT THE RISK MITIGATIONCASTAGNA Sara¹, BUGNANO Mauro¹
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Key terms: complex landslide; Acceglio; monitoring systems

This paper shows the results of a multi-disciplinary study concerning a deep landslide located near Acceglio (Cuneo, NW Italy), which aims to provide a more update knowledge about the local geological context and a geological - hydro-geological interpretation of the landslide movement: this study is preliminary with respect to the design choices aimed at the slope stabilization and the construction of weirs along the underlying Mollasco river.

As a consequence of heavy rainfalls, such as those on may 2008 and on april 2009, several landslides occurred within Acceglio territory, and among them also the reactivation of the Serri landslide, on the left side of Mollasco valley.

The Serri landslide, quite extensive and deep, covering a vertical drop of about 300 m, with an area of the main body of 0.22 km², is a complex type movement including soil slip and rotational slide types.

From the geological point of view, the outcropping rock formations belong to the two main tectonic domains of the Western Alps, the Piemontese Zone with green-stones and calcschist and the Permian-Triassic sequence of the so-called Brianzonese Zone.

The landslide hazard and the geological risk assessment are connected with the possibility of a collapse of the landslide main body or of a part of it, and a consequent mass-transport phenomena toward Acceglio, along the Mollasco river.

The current landslide is a reactivation of a previous and larger instability movement, including seemingly stable areas on the both sides of the lower portion of the active main body; in its lower portion, are observable several signs of movement (scarps, crowns, small trenches).

The landslide caused on spring 2010 the complete destruction of a weir and the damage of some of the others along the Mollasco river.

This paper shows the results of the following investigation methods employed to describe the local geological model with particular regard to the Serri landslide's triggering mechanisms:

- field survey focused on the identification of main rock types and their structural relationships, combined with GPS techniques.
- Data Processing in GIS
- Analysis and interpretation of geognostic available data (2001 and 2008-2009 surveys)
- Analysis and interpretation of inclinometer data
- aerial photographs interpretation technique
- Correlation between meteorological, hydrological and piezometric data in order to identify the triggering mechanism

Field surveys showed that the landslide is set at the main tectonic contact between the Piemonte Zone calcschist and the Brianzonese Zone rock formations, as a result of the high degree of deformation and of the local structural conditions.

The presence of water inside the landslide body is the main cause of the landslide triggering, as found on the basis of piezometric data. Monitoring data surveying carried out in June 2009 showed that compared to the past there was a sudden and sharp increase in movements, a phenomenon that appears to be related to snow melt process.

In fact, while there are not so obvious correlations between the rainfall data and the average groundwater level, a good correlation is observed between this one and snowfall.

The snow melt process seems to be the real responsible for the sudden increase in the water level within the main landslide body.

The inclinometer data confirmed the presence of a main surface of rupture, about 30 m deep; minor sliding surface are even located at shallower depths, due to differential movements within the main body.

On the basis of the study's results was finally possible to project and plan some engineering solutions aimed at the mitigation of geological risk along the slope involved in the landslide movement and the construction of some damage weirs along the Mollasco river, in order to consolidate the slope foot and to steady the riverbed itself.

B1-14 Poster Cuzzocrea, Domenico

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AN ESTIMATE OF DEFORMATIONS WITH TLSPAPAGEORGIOU Georgios¹, MEDURI Giuseppe M.¹, CUZZOCREA Domenico¹, BARRILE Vincenzo¹

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Key terms: ICP; LS3D; deformation

Several methods are developed to allow accurate and automated measurements of landsliding slopes. Such a method is the terrestrial laser scanner (TLS), which offers notable advantages in terms of speed, accuracy and replication of the experiments.

In the present study, we used a TLS to study deformations and displacements of some parts of a hill in the area "Feo di Vito" at the Northeast side of the city of Reggio Calabria, which is specifically located between the Engineering and Agricultural campuses of the University of Reggio Calabria. We processed the data using two different approaches: i) with the first approach we measured deformations by subtracting two DEMs that correspond to a pair of observation time points of the area of interest, and ii) with the second approach we measured deformations through the global registration of the point clouds corresponding to the two time points of the area of interest, rendering DEMs unnecessary. The scans were performed over an area of around 24000m² in two time points t1 and t2 with the terrestrial laser scanner Riegl LMS-Z420i. The morphology of this area required the use of two instrumental stations and the monumentation of suitable supports for the placement of the targets used in the two epochs.

In the first method, the registration of the two scans required for the generation of the whole point cloud in each epoch was operated with the use of the algorithm ICP (Iterative Closest Point) that applies in an interactive way a rigid roto-translation in space for one of the two clouds considered mobile, so that it overlaps in the best possible way with the other stationary cloud. Once data registration, clearing and filtration with the purpose to circumscribe the areas of interest and to eliminate the present vegetation are done, the next step is to generate the DEM that segments the whole point cloud in small regions of 2.5D. Specifically, to generate the DEM we used the algorithm Ransac (RANdom Sample Consensus) in a voxel approach that generates a pyramid that allows the extraction of planar elements. Subsequently, these planes are aggregated through hierarchical clustering to build a plane of larger dimensions.

Finally, from the aggregated planes and with a further step of clustering we get more structurally compact portions. Therefore, turning the point clouds of every epoch into DEM under the form of a square grid lattice

with DEM resolution, we proceeded with the analysis of the differences between the two epochs t1 and t2.

In the second method, the registration of the point cloud for both instrumental stations in each epoch was performed using the algorithm "Least Square 3D surfaces matching" (LS3D) that does not need the use of targets even though they were there. This process is called "global matching". Once the registration of the scans for the generation of the whole point clouds for each epoch t1 and t2 was completed, we again applied global matching using parts of the point cloud assumed to be stable while eliminating parts of the point cloud characterized by possible deformations. The two whole clouds of the two epochs are therefore transformed in a common coordinate system. The final step is to estimate displacements of some parts of the hill using LS3D, but this time we applied "local matching." These parts are identified in the point cloud t1. For each part, the correspondence on the point cloud t2 is automatically searched by LS3D and the 7-parameter transformation (3 translations, 3 rotations and a scale factor planned unitary) is estimated, which is the deformation.

The use of TLS as already demonstrated has made a major contribution to the deformation analysis of landsliding slopes. The first method provided us a single value as the average of displacements observed, and a deformation map with the results of the significance analysis. The second method, LS3D, provided us with the 6 parameters of the deformation and thus the direction of displacements.

B1-15 Poster Devoto, Stefano

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COASTAL FLYSCH INSTABILITY ON THE SLOVENIAN COASTS: THE ROLE OF LITHOLOGY AND FRACTURE PATTERNDEVOTO Stefano¹, SEGINA Ela², FURLANI Stefano³, KOMAC Blaž⁴, BIOLCHI Sara⁵, CUCCHI Franco⁶

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Key terms: cliff instability; coastal geomorphology; Slovenian coast

Coastal cliff stability is undermined by the sum of the sustained action of marine and continental factors. Therefore, their stability depends on the interrelations of the geological and environmental settings of the area. In particular, this work aims at evaluating the role of lithology and fracture pattern and at creating a map of instability of the coastal area. A detailed characterization of the geomechanical properties, the quality of rock masses and the susceptibility to rock falls have been used to study the area.

The characterization of geomechanical features of rock masses, using the GSI method, has been carried out in 15 stations along the Slovenian coasts, in the Northeastern Adriatic Sea. The Slovenian cliffs are cut in the Eocene Flysch, a turbiditic succession composed by centimetric-metric sandstones with millimetric-centimetric interbedded silty marlstones, almost horizontal in the study area. The low resistance of the rock mass allows the rapid retreat of the cliffs and the development of wide shore platforms.

The results of the GSI analysis in the studied stations show that the quality of rock masses is little influenced by the properties of the discontinuities, that are fairly constant, while the number of joints (Jv) is probably the dominant parameter for slope failure.

B1-16 Poster Tiranti, Davide

10.1474/Epitome.04.0128.Geoitalia2011

PREDICTING DEBRIS FLOWS OCCURRENCE THROUGH THE RADAR STORM-TRACKING METHODTIRANTI Davide¹, CREMONINI Roberto¹, PISPICO Rocco²

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Key terms: early warning system; nowcasting; GIS technique; Piemonte; North-western Italian Alps

Channelized debris flows affect alpine valleys, causing casualties and monetary losses. A recent classification proposal groups the alpine basins into three main catchment lithology classes: (1) massive and/or crudely stratified/foliated carbonate rocks (i.e., dolostones, limestones, marbles); (2) fine-grained sheared finely-foliated metamorphic rocks (i.e., calc-schists, shales, phyllades); (3) massive or coarse-grained crystalline rocks (i.e., granitoids, gneiss, serpentinites). The basin bedrock nature influences the rheology, the sedimentary processes, the depositional styles and the alluvial fan architecture, the triggering frequency and the triggering seasonality of debris flows that originate in the basins themselves. In particular, this classification includes triggering causes as classifier parameter and distinguishes the rainfall type causing a debris flow in each basin class. The basins of group 2 are more easily triggered by storm of moderate intensity; this behaviour is clearly underlined by the average triggering recurrence of debris flows and increased incidence during the summer, where the storms are much more frequent than the extended and prolonged rainfall events.

Traditional warning systems are usually based on rainfall rate thresholds derived by rain gauges, but ground networks are often inadequate to properly monitor rain field in mountain areas. Operational polarimetric C-band radar can provide reliable real-time rainfall estimation with high spatial and temporal resolution. Recently, it has been implemented an algorithm for storm identification and tracking using TREC (Tracking Radar Echoes by Correlation) technique. In this pattern recognition procedure radar-echo data are stored in arrays, and on each iteration an array is compared to all other arrays of same size for the subsequent time step to determine which array exhibits the highest correlation with previous array. In this way cells are localized, characterized (i.e. maxima echo, storm area, VIL - Vertical Integrated Liquid) and tracked. Considering the overall path of the storm is possible to predict next position of the storm and, consequently, if the storm will involve a basin sensitive to that type of

rainfall.

B1-17 Poster Iovine, Giulio G.R.

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A HYDROLOGICAL MODEL FOR PREDICTING LANDSLIDE MOBILIZATION: EXAMPLES OF APPLICATION FOR EARLY-WARNING PURPOSES

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Key terms: landslide; hydrological model; early warning

Rainfall is the main causal factor of landslide activation in Italy, as in many parts of the world. In this study, a new hydrological model is applied to forecasting landslide activations, provided that a sufficiently long period of observation of rainfalls, and suitable series of dates of landslide mobilizations are available.

Concerning hydrologic models, several valuable methodological proposals can be found in literature, generally focused on thresholds for either single phenomena or specific types of slope movements within a homogeneous geo-environmental setting. Difficulties in modeling landslide activations, both in physical and economic terms, generally increase with dimensions of the considered slope movements.

In this study, the hydrological model SAKe (Self Adaptive Kernel) is applied. The model is based on the assumption of a linear and stationary response of slope stability to rainfall: such response can therefore be expressed in terms of a "mobility function", obtained as integral of convolution between the Kernel and rainfall data. Threshold values of the mobility function can finally be determined by considering past landslide occurrences.

As regards model calibration, different automated tools can be utilized, based on either iterative cluster modification or Genetic Algorithms. As a result, a family of optimal, discretized kernels can be obtained from initial standard analytical functions, whose values represent the probability of landslide activation, given that a critical threshold is overcome. The obtained family of mobilization functions can be constituted by similar individuals in case of high informative content of the considered historical cases of landslide activations.

Model application needs that the geological context, as well as the geomorphic characteristics of the considered phenomena, and their expected evolutive scenarios are properly understood. Effective calibration depends on quality of input information (slope and landslide characterization; dates of past landslide activations; representativeness and completeness of hydrological series).

By employing only a subset of available historical dates of activations for calibration, model validation can be performed against the remaining subset. In case of satisfactory results, the model can finally be adopted to support an early-warning system for civil protection purposes, even more when future rainfalls can be reliably predicted.

Examples of application of the model to case studies of various type and dimension in southern Italy are discussed, together with the first results of sensitivity analyses, and problems in determining the family of kernels.

B1-18 Poster Perna, Massimo

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THE NEW LANDSLIDE INVENTORY AS A TOOL FOR REGIONE TOSCANA: FROM THE SPATIAL-GEOLOGICAL CONTINUUM TO LAND PLANNING

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Key terms: landslides inventory; spatial-geological continuum; object oriented relational database

The Geological Service of Regione Toscana, in collaboration with Consorzio LaMMA (Laboratory for the Meteorology and Environmental Modelling for the Sustainable Development) and CGT (Geo Technologies Centre of Siena University), has started a research program to carrying out a landslides inventory concerning those events occurred in the regional territory and that have been surveyed by many planning tools and through previous regional projects. The Landslides Database comes out from the extraction from the Regional Geological database of all landslide bodies and their associated elements (main scarps, landslide scars), with the main objective to compare these elements with the landslides that have been surveyed by several planning tools such as General Development Plan, IFFI database, Autorità di Bacino Hydrological Plans, and with other maps coming from many other projects focused on the environmental knowledge and on the landslide risk evaluation (AVI, VEL, CARG, SCAI projects and other regional projects).

The landslides inventory is a basic part of the New Geological Database of the Regione Toscana (NBDGRIT) by Corongiu et alii (2004): an object oriented relational database where the 1:10.000 scale geological continuum is archived.

The different object classes are associated to other classes with different shapes (points, lines, polygons) depending on the features that have to be described and inherit their characteristics. This allows to store different objects depending on the more suitable geometry while maintaining the class information describing those specific objects at the conceptual level. Having used the geodatabase data model as a physical format of data storage, all classes of the schema are associated according to ESRI™ rules for object class generalization.

Editing tasks have been accomplished through commercial GIS software (ESRI™) such as ArcGIS/ArcInfo® 9.3, inside the shared architecture of ESRI™ ArcSDE® that allows different desktop client to interface to several enterprise DBMS, including PostgreSQL.

Therefore, the possibility to use proprietary tools/software together with the adoption of an open source DBMS, allows data to be accessible from users (both using open source or proprietary tools) for data visualization, data processing and data publication.

Data quality and interoperability, together with the production of metadata following ISO/TC 19139 - ISO19114 standard, allow the landslides database to be in accordance with the latest European

regulations concerning the production of spatial data, including the 2007 INSPIRE Directive.

Up today the landslides database collects information for 85.448 landslides: 35.780 complex, 12.691 mud flow, 33.593 sliding, 893 falls/topples, 2.491 not determined type of movement. In relation to the state of activity, landslides are classified as dormant: 62.435, active: 11.060, stabilized: 1.900 and with non-assigned status: 10.053. The Landslides Database is a decision tool useful for a responsible preliminary planning and a valid estimate of the susceptibility to slope instability, landslide hazard and geomorphologic risk in Tuscany.

SESSIONE B3

Movimenti di versante a cinematica veloce: meccanismi d'insnesco, modalità di propagazione, cartografia della pericolosità

B3-1 Key Lecture Leroi, Eric

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HAZARD MAPPING OF FAST LANDSLIDES

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Key terms: rock fall; debris flow; hazard

Landslides affect many areas in Europe. They are characterised by a low probability of evolution as a very catastrophic event but may have very large direct and indirect impact on men, infrastructures and environment. This impact is becoming increasingly dangerous due to the rising anthropisation of the territory (continuous construction of new buildings, roads, railways, etc...). Methodologies for the identification and mitigation of risk are therefore a major issue.

B3-2 Orale Ferrero, Anna Maria

10.1474/Epitome.04.0132.Geoitalia2011

APPLICATION OF ADVANCED TECHNIQUES FOR ROCK FALL RISK EVALUATION

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Key terms: Rockfall; Geomechanical Survey; Photogrammetry

Rockfalls are frequent fast moving landslides, which constitute hazards and can damage infrastructures imposing frequent and additional maintenance, crash or bury vehicles and cause injuries or deaths. These type of landslide events are characterised by instantaneous triggering and fast evolution and therefore, even if typically triggered by intense rainfall, they occurs without any clear warning.

The first task to be accomplished is, in these cases, to understand both the intensity and areal distribution of these phenomena; this is normally done using computational instruments able to compute slope hazard and territory vulnerability. As a second task, consolidation works have to be designed and built following a time schedule that takes the risk distribution into account.

The hazard and vulnerability evaluation needs to be based on the knowledge of the surface morphology and on the geometry of the involved rock masses. The data can be inferred by photogrammetrical surveys, either terrestrial and aerial. The data duly treated, can be utilised to analyse both the triggering and the evolution phases for computing block stability and detachment, rock fall paths, energy etc.

This paper reports several application of methodologies that improve the rock fall risk assessment starting from the rock mass survey. These methodologies are described by means of some case histories. In particular an application of terrestrial photogrammetry survey in Chiavenna valley and another of aerial photogrammetry on the Garda lake shores are reported to outline advantages, limits and possible improvements in the applied procedures.

B3-3 Orale Fioraso, Gianfranco

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THE MOUNT CIANTIPLAGNA ROCK AVALANCHE (CHISONE VALLEY, ITALIAN WESTERN ALPS): KINEMATIC EVOLUTION AND IMPACT ON THE VALLEY BOTTOM MORPHOLOGY

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Key terms: rock avalanche; landslide dam; Chisone Valley; Western Alps

In the central Western Alps post-glacial gravitational deformations have given rise to diffuse and impressive slope collapses, leading to the highest concentration of instability phenomena of the Alps: they includes rock slide, rock fall and sackung. The large number of landslides and deep-seated gravitational slope deformations is due to lithological composition of bedrock (mainly composed by ophiolite-bearing calcschists of the Piedmont Zone) and, secondly, to the structural set-up of the area. In many cases (12) landslide dams have been formed with remarkably different age, genesis and morphological characteristics.

In the upper Chisone Valley the most striking landslide dam is located between the villages of Pourrières and Fenestrelle, generated by the collapse of a huge rock avalanche originated at 2605 m a.s.l. on the southern slope of the Mount Ciantiplagna (2849 m), along the Susa-Chisone drainage divide. The landslide involved massive carbonatic calcschists of the Cerogne-Ciantiplagna Unit with subordinate intercalations of serpentinites, prasinites and amphibolites. The blocky accumulation covers an area of 3.56 km² with an estimated volume of 130 Mm³. The rock avalanche travelled a horizontal distance of 4.5 km with a vertical drop of 1.4 km and stopped at an elevation of 1415 m a.s.l. against a transversal moraine ridge situated at the mouth of the Rio del Laux Valley. The travel angle (fahrboschung) is equal to 17.3° with an

excessive travel distance of 2.3 km.

The landslide deposits created a cross-valley barrier with the development of a large fluvio-lacustrine basin extending 4 km upstream and with a maximum estimated depth of 120 m. Detailed fieldwork and deep-seated investigation (drillholes) highlighted that the rock avalanche deposits rests above an earlier rock slide that involved a huge ophiolitic mass (serpentinites with minor metabasites). The original surface accumulation is not preserved because the widespread presence of numerous low-gradient benches suspended 15-120 m above the present river level: these surfaces have been interpreted as a product of erosion by the Chisone river and tributary stream network at the expense of the blocky deposit.

The seismic activity that affects the central sector of the Western Alps, with few strong historical earthquakes up to intensity VIII of the MCS (e.g., the 1808 event), can be regarded as a potential triggering factor of the landslide. The precise age of the rock avalanche is not known; nevertheless i) the overlapping of the distal portion of the landslide over the glacial moraine, ii) the presence of some late Copper Age archaeological sites (Roc del Col and Balm'Chanto) close to the area, and iii) the deep erosion of the blocky accumulation are in agreement with an early post-glacial age of the Mount Ciampagnina rock avalanche.

B3-4 Orale Francioni, Mirko

10.1474/Epitome.04.0134.Geoitalia2011

GEOMATICS AND DISTINCT ELEMENTS NUMERICAL METHODS FOR ANALYZING THE STABILITY OF A ROCK SLOPE IN THE APUAN ALPS MARBLE DISTRICT (ITALY)

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Key terms: Engineering-geological survey; UDEC; Rockfall; Photogrammetry; Laser Scanning

The present paper describes the stability analysis of a quarry front and the simulation of a tunnel excavation carried out through the use of distinct elements numerical methods. The research derives from a project focused on the marble exploitation in the Altissimo Mountain (Apuan Alps, Italy) and carried out thanks to the contribution of the Tuscany Region and the HENRAUX Spa.

The stability analysis of fronts, for rock exploitation planning, bases on the knowledge of both the structural setting and the physical-mechanical properties of intact material and its discontinuities.

Information about the geometrical-structural setting of slopes and joints were achieved in this work by integrating geological, engineering - geological surveys with Digital Terrestrial Photogrammetry and Laser Scanning.

Geological and engineering - geological surveys allowed to get the knowledge of the area structural setting, to characterize the main discontinuities sets and to classify the rock mass as "mediocre" (IV class) according to the Romana (1985) method. Results from these analyses were compared with ones coming from the kinematic stability study in order to find out the most dangerous joints systems.

Afterward, a deterministic study of the fronts stability was performed integrating geological data with geomatics deliverables. Laser Scanning allowed the creation of the digital elevation model of the area from which analysis the joints attitude, persistence and spacing were measured even in inaccessible zones. Moreover, Digital Terrestrial Photogrammetry was used for the photo-interpretation of joints and most dangerous blocks and wedges visible in the fronts and for the processing of topographic profiles in areas characterized by points cloud shadows. In order to achieve the complete stereoscopic viewing of the slopes at any height (up to 200m), the photogrammetric equipment was arranged on an aerostatic balloon and the acquisition of stereo pairs was performed through vertical strips. The integration of data coming from traditional geological and geomatics surveys allowed to carry out the slope stability analysis by distinct elements numerical methods (Itasca UDEC code). This analysis was performed both in static and dynamic conditions considering the historical seismic events occurred in the study area and recorded by local stations. In order to verify the stability even in the case of the proposed tunnel excavation, a further simulation was carried out; starting from previous analyses, several excavation steps were modeled and bolts insertion considered. Mechanical characteristics of bolts and their insertion ways during the expected excavation phase were chosen in agree with the Viareggio ASL 12 PISLL (responsible for the workplace health and safety) and the HENRAUX Spa.

Results from the study highlighted conditions of stability for the whole slope with some exceptions: if the simulation considers a few meters persistence of fractures into the rock mass and consequently, from them, a low attenuation of the seismic wave, the selected seismic event could bring to instability.

With respect to such a result, with the aim to reduce the uncertainty of joints persistence within the rock mass, further investigations by the use of Ground Penetration Radar, drilling and log technologies are in progress. Finally, from the position and volume value of unstable blocks recognized on the slope, possible trajectories of rock falls have been calculated on the DEM. The probabilistic distribution of rock fall end points, together with the kinetic energy along the falling path resulted from this activity. The spatial distribution of trajectories has been analyzed in terms of rock fall transit density and kinetic energy, making possible the creation of the hazard map.

B3-5 Orale Falconi, Luca Maria

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DEBRIS FLOW HAZARD ASSESSMENT IN ANDEAN AREA: TWO CASE STUDIES IN URUBAMBA AND COLCA VALLEYS (CUSCO/AREQUIPA, PERU)

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Key terms: Debris flow; intensity; risk; peru

A practical methodology to landslide risk assessment has been applied in

two Peruvian areas: the village of Aguas Calientes, in the Urubamba valley, close to the historical site of Machu Picchu, and the villages of Maca and Lari, in the Colca valley. Both the areas play an important and strategic role in the Peruvian tourist circuit and in the national economy. The study has been carried out in the framework of a capacity building project (FORGEO), focused on improve quantitative approach in landslide risk assessment.

The Urubamba Valley, or Sacred Valley of the Incas, is a narrow, winding valley, close to the Inca capital of Cusco and below the ancient sacred city of Machu Picchu. Being the heartland of the Inca Empire, it contains numerous archaeological remains and villages. Colca Valley is famous because of its deepness and beauty of the landscape and for historical and cultural traits which hold up recent request to be included in UNESCO World Heritage. High slope energy and specific geological characteristics of these valleys cause the widely presence of different typologies of landslides and, more than other, of several debris flows.

Failure surfaces of these phenomena are developed especially at the contact between soil and bedrock. An inventory focused on identifying predisposing parameters contributes to the quantification of slope susceptibility. Each factor has been mapped and implemented as a layer in a GIS project. Overlay of all layers generates a subdivision of the area into Homogeneous Land Units, which a degree of susceptibility is assigned through a susceptibility function. On the basis of a detailed DEM (5x5m), specially realized from air photos, areas with different potentials to be affected by debris flow run-out were mapped. Run out distance and velocity of potential events triggered in high susceptibility sample areas were estimated using the Johnson & Rondine (1984) method. Exposure maps were developed assigning a relative value index to different structures and infrastructures. GIS overlay of run out susceptibility and exposure maps results in risk maps.

The village of Aguas Calientes is located on an alluvial fan and is regularly hit by floods and debris flows that come from upstream creeks. The southern part of the alluvial fan is characterized by four former drainage lines that have a direct hydraulic or morphological relationship with the Alcamayo creek. Under the centrifugal force effect, water and debris can overflow and overrun old sewer lines. All shallow areas of the alluvial fan show an high hazard level of run-out susceptibility and the railway station is characterized by the highest risk. These critical conditions have been further worsened by the rapid urban growth. Moreover, incipient landslide processes recognized on a ridge close to the Phuyupatamarca historical site, increase the hazard in the Urubamba Valley in the proximity of historical sites of Chachabamba and Choq'susuy. In fact, given the volumes involved, the estimated speed and the distance between potential source area and downstream areas, it seems likely that a landslide could dam the Urubamba river at the mouth of the Santa Rita creek, and potentially damage the hydroelectric plant of Machupicchu and the Aguas Calientes village.

Maca and Lari are two villages, facing each other on opposite banks of the Colca river. The area is affected by large rotational landslides that have repeatedly damaged the main road between Chivay and Cabanaconde. However debris flows developing in loose deposits hanged on the steeper slopes are triggered by the concentrated rainfalls between January and March. An assessment of volumes and velocities of potential events shows that debris flow run out could reach the urban areas of both the villages.

B3-6 Orale Galeandro, Annalisa

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ANALYSIS OF RAINFALL INFILTRATION IN UNSATURATED, FINE TEXTURED AND FRACTURED SOILS AS TRIGGERING FACTOR OF SHALLOW LANDSLIDES

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Key terms: rainfall-induced landslide; infiltration; rainfall threshold; shallow landslides

Rainfall-induced landslides are widely discussed in scientific literature, with particular interest to the evaluation of the rainfall thresholds triggering the slope failure.

The equilibrium of potentially instable masses along a slope is often related to soil suction: in unsaturated soils, rainfall infiltration induces significant changes on pressure heads distribution, causing a decrease of suction and then of shear strength triggering slope instability.

In unsaturated conditions, the presence of fractures at the topsoil accelerates infiltration and can condition pore pressure variation in relation to rainfall intensity and soil properties. Swelling materials cause a progressive closure of cracks and hold water flow. The presence of a permeable layer underlying the top unsaturated soil can create a capillary barrier which could affect infiltration and pore pressure distribution. So the combined effect of cracks, swelling materials and capillary barrier can seriously condition the pressure heads regime and the stability of slopes of unsaturated soil. In spite of their relevance, these features are poorly investigated by the existing models. For this purpose, it has been pointed out an evolving dual-permeability model for the simulation of water flow through fractured swelling soils. The model has been applied to the case of a fractured loamy soil (thickness of 2 m) superimposed to a coarse sand layer, in order to investigate the influence of different rainfall intensities on infiltration process, on pore pressure distribution and then on slope stability.

Results show how, for weak and prolonged rains (2-5 mm/h for 4-10 hours) in the fractured soil matrix it is possible to reach low values of suction close to zero, while in the case of intense and brief precipitations (20-50 mm/h for 0.4-1 hours) there could be small variations of pressure heads. Then, a prolonged weak rain could be more dangerous than an intense one in triggering soil slip in the surficial strata.

Without fractures, the pressure head variation is limited to really surficial strata, while the presence of fractures can facilitate infiltration and diffusion phenomena, leading to fast pressure head variations and consequent fast strength decrease in the whole mass, till the failure. This could mean that slope failure would happen in smaller times in fractured deposits, while without considering cracks the triggering rainfall threshold could be underestimated.

In addition, fractures accelerates the break out of the capillary barrier, which happens in very short times (few minutes for weak rains, seconds for intense precipitation), while for homogeneous soils without cracks the break is delayed.

Finally, cracks closure due to soil swelling holds vertical flow in fractures and stops water diffusion process in matrix. Then, after the closure there is only vertical flow in matrix: the decrease of pressure heads delays and the rainfall amount which triggers the landslide could be greater. The model is a really interesting tool to better understand how rainfall

intensity and duration, fractures and swelling materials condition the infiltration process and the evaluation of rainfall thresholds for soil landslide activation. The implementation of a more specific model can contribute to build up more realistic approach to landslide risk analysis, supporting the identification of more reliable rainfall thresholds for landslide alert.

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B3-7 Orale Pasculli, Antonio

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SPH NUMERICAL MODELING OF FAST LANDSLIDE FLOW

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Key terms: SPH; 2D numerical modelling; landslides in fast motion

The modeling of slopes subject to incipient instability and the eventual onset of fast fluxes, using the same computer code, poses serious numerical problems, particularly with regard to the significant distortions of the numerical grid, as it is usually applied in common practice, due to the soil material desegregation. Both Eulerian and Lagrangian approaches, based on structured or unstructured mesh gridding, show heavy drawbacks. In alternative meshless type approaches have been explored by different authors (i.e. Ha H. Bui et al. 2008, Int. Journal for numerical and analytical methods in Geomechanics). Two of the most common methods of this type are PFEM (Particle Finite Element Method) and SPH (Smoothed Particle Hydrodynamics). The first method, actually, has the advantages of a purely meshless method and the advantages of a method based on finite elements. Nevertheless, for the study of landslides in fast motion, we initiated an exploratory study of the SPH technique, to be followed by a subsequent implementation of PFEM techniques. The SPH method, originally developed during the 70's to solve astrophysical problems, is a particle mesh-free Lagrangian method, well suitable for computing highly transitory free surface flows of complex fluids in complex geometries. Thus it has shown many attractive features that have led many authors to try to use it to solve fluid flows problems. Its free surfaces tracking capabilities and its straightforward implementation of multi-materials interactions make him well suited for complex flows modelling. At this early stage of our research program, a virtual landslide in fast motion has been simulated using a 2D flow of a mixture composed of fluid and solid material. The two set of equations related to fluid and solid phase, has been simplified in only one set of equations, considering just one equivalent material. Both mass and densities have been considered constant. Then the Bingham or "Herschel-Bulkley", non Newtonian constitutive equations, describing a viscoplastic material suitable to simulate the rheological behaviour of mudflows, has been selected. The final mathematical model, a divergence free set of Navier-Stokes equations, has been solved by a numerical approach using a 2D numerical model based on the specificity of the SPH method. Essentially, the following are the SPH discretized equations related to conservation of mass and momentum:

$$\frac{D\rho_j}{Dt} = \sum_{j=1}^n m_j \cdot v_{ij} \cdot \nabla_i W_{ij} \quad \text{mass conservation}$$

$$\frac{Dv_i}{Dt} = f_i - \sum_{j=1}^n m_j \cdot \left(\frac{p_i}{\rho_i} + \frac{p_j}{\rho_j} \right) \cdot \nabla_i W_{ij} + \sum_{j=1}^n m_j \cdot \frac{\delta \eta_{ij}}{\rho_i \rho_j} \cdot \frac{v_i - v_j}{|x_i - x_j|} \cdot \nabla_i W_{ij} \quad \text{momentum conservation}$$

Where: ρ_j is the mass density, f_i is the external force, m_j represents the j th particle mass; $v_{ij} = (v_i - v_j)$ represents the difference between the interacting particles velocity; W_{ij} is a particular influence bell shaped function, characteristic of the SPH method, c is the artificial equation of state from which the pressure of each particle is calculated, where c is the

artificial speed of sound and ρ_0 is the reference density of the fluid at zero pressure, $r_{ij} = r_i - r_j$ represents the difference between the interacting particle position; η_{ij} is a symmetrised dynamic viscosity between

interacting particles, such that $\eta_{ij} = \eta_{ji}$.
Finally a laboratory experimental test has been selected for comparison. Satisfactory results have been achieved. Nevertheless, further parametric analysis will be carried out and further considerations about both constitutive equations and numerical improvements will be employed and discussed in future papers.

B3-8 Orale Revellino, Paola

10.1474/Epitome.04.0138.Geoitalia2011

INITIATION AND PROPAGATION OF THE 2005 DEBRIS AVALANCHE AT NOCERA INFERIORE (SOUTHERN ITALY)

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Key terms: debris avalanche; numerical modelling; Southern Italy

Pyroclastic deposits covering most of the carbonate relief of the Campanian Apennine are prone to develop recurrent high-velocity flow instabilities. The present study investigates the debris avalanche occurred at Nocera Inferiore (Campania Region, Southern Italy) on March 4, 2005, following heavy and intense rainfall, which claimed three casualties. The landslide event is representative of a series of catastrophic failures which taken place in Campania during the last decades and induced loss of human lives and considerable damage to the economy and building

heritage of several sectors of the Region.

Detailed geological-geomorphological surveys, supported by site and laboratory tests and investigations, led us to define the main features of the studied phenomenon and identify the mechanisms and triggering factors. The landslide involved the 1.5 to 2 m thick layered pyroclastic mantle which overlies the carbonate hill slopes. The early stages of the movement consists in a debris slide, then evolving in a debris avalanche on the 45°-dipping open slope. Landslide initiation is linked to the change in the morphological settings due to the building of a carriage path to be used as access for the nearby open quarry.

The debris avalanche has involved a specific slope portion never affected by landslide of the same type of the one occurred. Reconstructions carried out on aerial photographs and photos of different time highlighted that the route construction can be supposed around the 1998, increasing the landslide susceptibility of this section and demonstrating that cut slope is the main cause for the occurrence of the Nocera Inferiore landslide.

Comparison among similar landslide events of the recent past (e.g. Sarno, Quindici, Siano and Bracigliano in 1998 and Cervinara in 1999) shows that such a predisposing cause is a common element in triggering landslide in the pyroclastic mantle of Campania. Road cut and the consequent interruption of the lito-stratigraphical continuity of the pyroclastic layers change the surficial and underground water circulation, modifying the natural equilibrium and inducing pore-pressure increase.

The propagation characteristics of the landslide were modelled by using a 2D and 3D dynamic models (DAN). These analyses are well comparable with those implemented by the same authors on debris avalanches and debris flows happened in different sector of the Campania Region, confirming the similar behaviour and character above mentioned.

B3-9 Invitato Perriello Zampelli, Sebastiano

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A GIS-AIDED METHOD FOR THE ASSESSMENT OF VOLCANICLASTIC SOIL SLIDING SUSCEPTIBILITY ON CARBONATE SLOPES OF A PART OF CAMPANIA (SOUTHERN ITALY)

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Key terms: debris-slide susceptibility; volcaniclastic soil cover; soil cover discontinuities; planform curvature

A significant part of Campania is extensively covered by volcaniclastic soils, deriving from the alteration of airfall-sedimented formations of layered ashes and pumices that were ejected by Campi Flegrei and Mt.Somma-Vesuvius during explosive eruptions. Where such soils cover steep slopes cut in carbonate bedrock, landforms depend essentially on the morpho-evolution of the slopes prior to the deposition of the volcaniclastic soils, because they are generally present only as thin veneers, up to a few meters of total thickness. In this part of Campania, landslides that originate within the volcaniclastic soil veneer "sandwich" lying on carbonate slopes and terminate at their foot or at gully outlets are frequent and often destructive, following critical rainfall events. Such landslides can be classified as complex, occurring initially as debris slides, but rapidly evolving into debris avalanches and/or debris flows. The localization of the initial sliding areas (i.e. "sources") on the slopes depends on both the spatial distribution of characters of the soil cover and the spatial distribution of the triggering rainfall events. It therefore appeared reasonable to separate the two aspects of the problem, and focus on the former one, in order to attempt an assessment of soil sliding susceptibility in the event of landslide-triggering rainfall.

Some results of the application of a method aimed at such an assessment are going to be presented. The method, called S.L.I.D.E. (from SLiding Initiation areas DETection), is based on the assumption that, in case of spatially homogeneous slide-triggering rainfall sequences and volcaniclastic soil cover, different slope gradient threshold values for sliding failure exist, depending on soil cover continuity and planform curvature. Such threshold values are considered as higher on planar slopes than on slopes with discontinuities within the soil cover, as well as on slopes that display upwards concavity in planform (hollows).

The method is indeed geomorphological, but it is also essentially quantitative, as in its workflow only the delineation of soil cover existence, and of discontinuities within it, are subjective. Comparison between past landslides' source areas localization (although available with variable reliability) and S.L.I.D.E. method susceptibility provided encouraging results, especially regarding soil-covered sloping hollows.

Where such a localization was available with adequate accuracy and the number of nearby landslides was large, the method appeared as capable of recognizing most of the actual landslides' source areas. At the same time, the method reasonably overestimated areas considered as susceptible to sliding with respect to actual source areas. Overestimation, however, should be considered as such only with respect to past landslides: areas deemed as susceptible to sliding, but not interested by past landslides, should also be carefully evaluated with respect to the possibility of future landslides.

Developments of the method are being pursued, by analyzing slope areas that fall into more than one susceptibility categories. In practical terms, for instance, opening new slope tracks within volcaniclastic soils covering slope hollows at angles > 30° appears inappropriate with respect to rainfall-triggered potential local instability.

Assessment of soil sliding susceptibility, while only a subset of the related hazard and risk assessments, can certainly be considered worth investigating, as planners and communities could certainly take advantage from knowledge regarding where landslides can originate in case of critical rainfall. This, together with analyses of potential paths and run-out of debris avalanches/flows, could suggest including also the feasibility of slope stabilization work within evaluations of risk-reduction cost-benefit options, as techniques for the stabilization of soil covers on the slopes are nowadays indeed available.

B3-10 Poster Ponte, Maurizio

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DEBRIS-FLOW NEL TRATTO DI COSTA CALABRESE COMPRESO TRA BAGNARA CALABRA E SCILLA (CALABRIA)

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Key terms: Bagnara Calabria; debris flow; Analisi piogge

Il tratto di costa tra Bagnara Calabria e Scilla (provincia di Reggio Calabria, Calabria meridionale), ricadente al piede di versanti molto acclivi in rocce cristalline frantumate ed alterate, costituisce una singolarità morfologica in un lungo tratto di costa alta, sovrastato da ripidi versanti degradanti verso la costa con dislivelli di circa 500m nello spazio di 1km e solcati da numerosi corsi d'acqua a carattere torrentizio altrettanto ripidi.

Esso è soggetto a diffusi fenomeni franosi, ad alluvionamenti ed a debris-flow da parte dei ripidi fossi incombenti sugli abitati e sulle infrastrutture, in particolare sulla ferrovia, a mareggiate per l'esiguità della fascia costiera sede delle espansioni urbanistiche e ad un'elevata sismicità. La presenza di numerosi conii di deiezione alla base dei ripidi versanti dell'area costiera in esame rappresenta la testimonianza geomorfologica di eventi multipli da antichi debris-flow sempre, però, interpretati come fenomeni alluvionali delle fasi di erosione-trasporto-sedimentazione.

Dagli anni '70 nell'area in esame si è verificata una serie di eventi determinati dalle condizioni idrometeorologiche, ma favoriti dall'incuria umana. Nella presente nota vengono presi in esame cinque distinti episodi da debris-flow, innescati da particolari condizioni idro-meteorologiche, verificatisi nell'area in studio nel 1970, 1988, 1989, 2001 e nel 2005, che hanno investito le infrastrutture, provocando, negli ultimi due casi, il deragliamento di treni in transito sulla sottostante linea ferroviaria, che corre alla base del versante costiero, generando una condizione di allarme nella popolazione e richiamando per il loro interesse scientifico l'intervento degli studiosi.

Per tali due casi è stato svolto anche uno studio idrologico finalizzato alla valutazione delle condizioni di innesco.

B3-11 Poster Calligaris, Chiara

10.1474/Epitome.04.0141.Geoitalia2011

A METHODOLOGY TO RE-PROFILE AREAS INVOLVED IN DEBRIS FLOW PHENOMENA.CALLIGARIS Chiara¹, ZINI Luca¹

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Key terms: debris flow; buwal; Friuli Venezia Giulia Region

Rio Velt watershed is located in the municipality of Sauris di Sotto, in the Friuli Venezia Giulia Region and is made by three subwatershed that have their confluence upstream the crossing of provincial road that take to Sauris di Sopra. In Schneider tales during 1800, there were witnesses of possible debris flow phenomena in the area. On this basis and on geomorphologic evidences, an outline of the event has been realized. This perimeter has the ID (Identification Number) 0301070200 inside the landslide Italian inventory called I.F.F.I. (Inventario dei Fenomeni Franosi in Italia) and has been adopted in second instance from the P.A.I. project (Piano di Assetto Idrogeologico). The outlined region represent a wide area in which are located different infrastructures as a camping place, a sport center and part of the province road. The present work would like to highlight the importance of using of objective methodologies to outline the debris flow phenomena and this permit to obtain scenarios of event that reconstruct the verified events or to create new scenario for area that has not yet been involved in alluvial events in which there are not data available for a back analysis process. So, in the studied area many simulations have been realized that allowed to identify with more awareness a possible event in order to modify the actual outline and to make it acceptable for the P.A.I. Project.

B3-12 Poster Budetta, Paolo

10.1474/Epitome.04.0142.Geoitalia2011

ROCK-FALL HAZARD ASSESSMENT AND NUMERICAL PREDICTION OF THE ROCK-MASS BEHAVIOUR FOR A SEA ARCH (THE NATURAL ARCH OF PALINURO, CAMPANIA)BUDETTA Paolo¹, DE LUCA Claudio¹

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Key terms: Sea arch; Rock-fall hazard; Geo-mechanical characterization; FE method

The presence of embayment, caves or arches along the coast, attests a heavy marine erosion developing near structural weaknesses in stiff rocks, such as joints or faults. Even though the strongest wave impacts are episodic, the wave erosion is undoubtedly the most important factor in causing coastal retreat, in more resistant rock-masses. Generally, sea cliffs stand seaward as headlands, or persist offshore as sea arches or stacks, where the waves attack planes of weakness affecting headlands. Over time, caves produced on both sides of a promontory may join, to model a tunnel and, finally, an arch. Successively the supporting roof of the arch may collapse, depending on the rock-mass strength and wave action. Consequently, arches are ephemeral geomorphological structures tending to survive over periods of just few centuries. Therefore, one might ask whether it is worthwhile to protect these structures using adequate, active or passive countermeasures. For purposes of coastal planning and engineering mitigation, these natural "sculptures" must be preserved if they are enclosed in a very attractive landscape or if possible damages, resulting from rockfalls, are intolerable for people and infrastructures. This paper deals with rock-fall hazard and the assessment of stress and displacement distribution affecting the opening of the Natural Arch of Palinuro, developed as a result of "excavation" by wave action. The study area is placed along the Cilento coast (Campania - Southern Italy), and the Arch represents an important geotope inserted in a very attractive landscape. In the last 50 years, this structure has been affected by several rockfalls mainly due to wave erosion as well as gravity. The sea level rise, partially induced by human activities, is the main reason for these phenomena which seriously are threatening the stability of the structure which could completely disappear in a few years. About 15 years ago, in an attempt to protect it, provisional countermeasures were executed consisting in a submerged reef and in a wire netting added to the supporting roof. Nevertheless these works proved to be insufficient, because a new rockfall happened in 2007, affecting the northern facade of the arch.

In order to localize the arch portions which are in urgent need of reinforcements, the rock-mass behavior was studied, by means of a preliminary geo-structural and geo-mechanical characterization. Afterwards, a finite elements approach was implemented using a

two-dimensional elasto-plastic stress analysis program. Stress, strain, and displacements were calculated for an idealized model including four stages. In the first stage, application of the natural in situ stress distribution (gravity loading), in which the vertical stress is assumed to vary linearly with depth, was examined. In the following three stages, simulations of the progressive enlargement of the arch opening, beginning from the last 10,000 years ago (coinciding with the initial post-Glacial sea level rise) were analyzed. This approach was applied by analogy to man-made cavity collapses (such as tunnels, caverns, etc.), bearing in mind a number of problems that are less significant or not considered in man-made excavations. These problems concern: (i) the different excavating modalities distinguishing wave erosion, respect to man-made action; (ii) the shallow rock-mass forming the arch, is subject to concentrated weathering and marine corrosion playing an important role in determining the overall strength and deformation characteristics. In spite of these remarks, the employed 2D approach, assuming a plain-strain behavior largely simplified respect to the in-situ strain pattern, must be considered as a first-order investigation of the arch stability.

B3-13 Poster Calcaterra, Domenico

10.1474/Epitome.04.0143.Geoitalia2011

APPROACHES FOR MAPPING SUSCEPTIBILITY TO SLOPE INSTABILITY IN CARBONATE ROCK-MASSSES: CASE STUDIES FROM THE SORRENTO-AMALFI COAST (SOUTHERN ITALY)APUZZO Donatella¹, DE VITA Pantaleone¹, PALMA Biagio², CALCATERRADomenico³

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Key terms: Rock-slope instability; Hazard assessment; Sorrento-Amalfi coast

The natural predisposition to recession of rocky cliffs represents a typical environmental hazard in densely urbanized coastal areas especially where lifelines and settlements are located along the coast because of orographic and economic factors. Along the coastal sectors of the Campania region (southern Italy) characterized by high rocky slopes, several municipalities, densely populated and highly touristic attractive for the worldwide famous landscapes, are exposed to risk due to rock-slope instability. Particularly, the municipalities belonging to the Sorrento and Amalfi coast, such as Sorrento, Vico Equense and Furore, can be considered among the most representative case-studies being prone to the recurrent instability of rock blocks, which in many cases caused the interruption of roads and railways and their isolation from the other parts of the region.

Rocky cliffs and slopes of Sorrento and Amalfi coast are mainly constituted of sedimentary rock-masses, mostly belonging to Mesozoic carbonates, and subordinately, to Quaternary pyroclastic tuffs. Due to the common location of settlements and roads in the vicinity of carbonate high cliffs and slopes, here a diffuse condition of high risk does exist, which makes difficult to identify priority in addressing financial resources for the construction of suitable mitigation works.

In order to find an appropriate method for assessing and classifying the susceptibility to rock-slope instability as well as to map zones with higher values, the combined application of standard methods was tested, such as the Romana's Slope Mass Rating (SMR) and the Matheson's tests, in two test sites of the Sorrento and Amalfi coast.

Results were respectively balanced and weighted both by means of the number of fundamental instability mechanisms (plane sliding, wedge sliding and toppling), recognized for intervals of slope aspect, and by means of the persistence of each discontinuity set. The implementation of the geometric and mechanical constraints, found out as critical for slope stability, in a GIS environment allowed to map susceptibility to rock-slope instability and to identify conditions of higher susceptibility.

B3-14 Poster Calcaterra, Domenico

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ENGINEERING-GEOLOGICAL AND HYDRAULIC MODELING OF THE SEPTEMBER 9, 2010 COMPLEX EVENT AT ATRANI (SALERNO PROVINCE)TESSITORE Serena¹, DI MARTIRE Diego¹, LOMBARDI Gerardo², MARTINORiccardo¹, MINOTTA Crescenzo², MORETTA Filomena², CALCATERRADomenico¹

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Key terms: Landslides; Hyperconcentrated flow; Runout and propagation assessment

On September 9, 2010 the Amalfi coast has been struck by a rainfall event of short duration and relatively high intensity. The focus of the event coincided with the hydrographic basin of the Dragone torrent, where a variety of instabilities occurred, ranging from linear and areal erosion to debris flows. The downvalley transfer of the debris mobilized from the slopes and eroded along the hydrographic network soon assumed the characters typical of an hyperconcentrated flow, as well shown by some videos. The flow invaded the small town of Atrani, located along the final stretch of the Dragone torrent, causing the loss of a young girl, huge damage and a pronounced progradation of the fan delta.

The Atrani event has been simulated by means of two well-known codes, DAN-W and FLO-2D, with the aim of verifying the overall features of the complex phenomenon, especially as regards its runout and propagation potential. Thanks to the availability of excellent field data, it has been possible to carry out a back-analysis of the event, which, in turn, allowed to assess the reliability of the required parameters, usually adopted under similar conditions. In conclusion, the obtained results have been critically examined, also by their comparison with previous experiences, in light of a wider assessment of the landslide and hydraulic hazard impending upon the study area.

B3-15 Poster De Vita, Pantaleone

10.1474/Epitome.04.0145.Geoitalia2011

FIELD CHARACTERISATIONS OF SHEAR STRENGTH AND TRIGGERING MECHANISMS OF DEBRIS FLOWS IN PYROCLASTIC

SOIL MANTLED SLOPES OF CAMPANIA (SOUTHERN ITALY)

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Key terms: ash-fall pyroclastic soils; shear strength; Borehole Shear Tester; root strength; debris flows initiation

Despite the shallowness, the triggering mechanisms of debris flows involving ash-fall pyroclastic soils mantling mountains that surround volcanic centers of the Campania region (southern Italy) are complex to be modeled. A number of factors have to be taken in account for a correct slope stability modeling, each of them characterized by a high spatial variability and heterogeneity. Among these factors, stratigraphic, hydrogeologic, morphological, pedological and mechanical characteristics of the pyroclastic soil horizons, as well as land use, have to be evaluated. At the detailed scale, debris flows are triggered by initial small landslides, which mainly involve the pedogenised pyroclastic soil horizons partly constituted of pumiceous pyroclasts, with grain size varying from coarse sand to gravel. Consequently, the modeling of the initial slope instability presents a high complexity just for the accurate characterization of the shear strength of pyroclastic soils due to their difficult mechanical testing and to the not negligible contribution of root strength. The first aspect regards the problematic undisturbed sampling of pyroclastic soils due to their high looseness and high porosity as well as the difficult testing of specimens with standard laboratory tests at very low levels of stress, as typical of shallow landslides (1 - 2 m depth), which determine dilatancy effects on coarse granular soils. The second aspect is the contribution to the shear strength given by the dense net of root apparatuses characterizing landuse classes typically occurring in source areas of debris flows that vary from the broad-leaved forest to the sclerophyllous vegetation.

In order to carry out a research focused on these two aspects, we carried out field characterisations of shear strength by means of both the Borehole Shear Tester (BST) and the measurements of root apparatuses in selected test pits of different source areas. The application of the Borehole Shear Tester at various depths in boreholes allowed obtaining a vertical log of the effective friction angle and cohesion. The results for the effective friction angle were determined as ranging from 36° to 38°, instead the effective cohesion was always estimated as lower than 1 kPa. The contribution to shear strength due to the root strength, acting as an apparent cohesion, was estimated by means of density, diameter and tensile strength measurements of root apparatuses and through the application of the Wu's model (1979). The apparent cohesion due to the root strength resulted as very variable along the depth, being highest in the shallower horizon (median value of 22 kPa) and lower in the deeper horizons (median value 9 kPa). The combination of results derived both from the application of the Borehole Shear Tester and from the estimation of apparent cohesion due to the root strength, as well as the results derived from the unsaturated and saturated characterisation of hydraulic properties, allowed formulating a comprehensive mechanical and hydraulic model of the pyroclastic mantle. Starting from this improved characterization, a slope stability modeling was carried out permitting a deeper understanding of the triggering mechanisms.

B3-16 Poster Fiorillo, Francesco

10.1474/Epitome.04.0146.Geoitalia2011

RAINFALL INITIATION OF DEBRIS AVALANCHE-FLOWS IN CAMPANIA (ITALY)

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Key terms: debris flow; rainfall; Campania

Debris flows in Campania begin as soil slides within the pyroclastic mantle that blankets the steep local hill slopes, which are, in turn, composed largely of carbonate bedrock. The historical pattern appears to be that clusters of debris avalanche-flows occur after intense rainstorms that follow an accumulation of a certain amount of pre-storm seasonal rainfall. The physical analysis of the interaction of rainfall with the pyroclastic mantle requires two-phase approach. Phase 1, early in the rainfall season, concerns the accumulation of the capillary and hygroscopic water in the soils, up to field capacity. During this phase, the soil moisture content has been modelled as hydrological balance between precipitation and evapotranspiration, on a daily scale. The amount of rainfall required to reach the field capacity depend on the pyroclastic mantle thickness. After the soil moisture in the pyroclastic mantle reaches field capacity, the second phase of the analysis examines the accumulation of surplus moisture from intense rainfall, leading to the development of positive pore pressures and debris flow initiation.

In this study we analyse hydrological data up to December 2008, providing further 10 years of records respect to previous analyses (Fiorillo & Wilson, 2004), which allow us to verify a previous hypothesis on the soil moisture accumulation into the soil. In particular, we focused the analyses in the Sarno area (P.zzo d'Alvano), where a high-elevation rain-gauge is available since May 1998, which allows also to compare data with low-elevation rain gauges. The topic assumes particular significance in this case, because the storm of May 1998 didn't show exceptional rainfall at any of the rain gauge stations, to justify the high number of debris flows produced.

Finally, the spatial distribution of different values of the soil moisture storage capacity can have a strong control on the location of the landslide initiation, indicating that landslide initiation in Campania is also controlled by the characteristics of the storm and by antecedent hydrological conditions, as well as geomorphological and stratigraphical features of the slopes.

B3-17 Poster Fubelli, Giandomenico

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A GIS-BASED APPROACH TO ESTIMATE DEBRIS FLOW TRIGGERING SUSCEPTIBILITY: A CASE STUDY FROM SORRENTINA PENINSULA (CAMPANIA REGION).

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Key terms: Debris flow; GIS; Volcanic areas

The volcanoclastic flows are among the most recurrent and dangerous natural hazards in volcanic areas characterized by pyroclastic deposits. They can originate not only during or shortly after an eruption (syn-eruptive) but also during a period of volcanic quiescence (inter-eruptive), when heavy and/or persistent rains remobilize loose pyroclastic deposits. Damage and casualties relate to these events are common in the history of recent (AD 1631-1944) activity of Vesuvius, both near the volcanic complex and in the sub-Apeninne basins affected by pyroclastic fallout. Major historic flows occurred (Migale and Milone 1998) in 1954 at Villaggio di Vettica (30 deaths), in 1924 at Amalfi (30 deaths), in 1910 at Regina Major and Catara (60 and 110 deaths, respectively), in 1841 at Molino delle Capre (120 deaths), in 1823 at Salerno-Positano-Siano-Tramonti (120 deaths), in 1764 at Gragnano (43 deaths) and in 1640 at Sarno (40 deaths). In addition, 40 debris flow episodes occurred in the Sarno area in the two centuries prior to 1998 (Migale and Milone 1998). With the aim to mitigate and prevent the volcanoclastic flow hazard, we propose an GIS based application in Peninsula Sorrentina to individuate the drainage basins more prone to triggering debris flows. This application combines several morphometric parameters derived from the analysis of Digital Elevation Model of study area (Bisson, 2010) with information of territory the are considered very useful and necessary for our purpose (i.e occurrence of events in the past, lithology, joint systems, soil and landuse). As result we propose a map that distinguishes and classifies the areas with different degree of susceptibility for triggering debris flow (low, moderate, high).

B3-18 Poster Santo, Antonio

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FLOW-TYPE LANDSLIDES MAGNITUDE ESTIMATION IN CAMPANIA (SOUTHERN ITALY)

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Key terms: Flow-type landslides; Landslide magnitude or intensity; Southern Italy

Flow type landslides represent one of the most severe natural hazards in Campania (Southern Italy) as shown by the large number of victims and the huge economic damage caused in recent years. These mass movements involve thin cohesionless, unsaturated pyroclastic soils widely found over a large area around Somma-Vesuvio and Phlegrean district. Studies on flow-type landslides in pyroclastic deposits have been performed to identify potential source areas and the main depositional mechanisms. Interesting methods for mapping landslide triggering susceptibility and potential invasion have also been proposed. Since the potential volume of flow-type landslides is a measure of event magnitude, hence of considerable use in hazard assessment, we propose to estimate the potential volume at the scale of slope or basin for about 130 municipalities which cover an area of 2,300 square kilometers. A simple method to estimate the potential flow-type landslide volumes use an empirical approach, recently proposed in literature (De Falco et al., 2011), derived from the interpretation of numerous geological and geomorphological data gathered from a vast amount of case histories on landslides in volcanic and carbonatic contexts.

The method is based on determining the thickness of the pyroclastic cover and the width of the detachment and erosion-transport zone. Thickness can be evaluated with a good degree of approximation since, in these landslides, the failure surface is always very superficial (from 0.3 to 2 m) and positioned in pyroclastic covers resting on a generally rigid bedrock (calcareous rocks, lava or tuffs). The area of the detachment and erosion-transport zone (Af) is calculated by a mathematical function (statistical correlation) which link this factor with the difference in height (H) between a point on the slope with the highest susceptibility and a point, the first break at the foot of the slope, where the deposition starts to take place and the landslide loses velocity. Finally, potential volumes are calculated by using Af and a constant thickness of the pyroclastic cover for the whole slope.

The study showed:

- a variability of the volume potentially mobilized ranging from 500 to 200,000 cubic meters;
- a non-random distribution of volumes mobilized that allows to show different macro-areas with several degrees of hazard ;
- a distribution of the volumes mobilized at a municipal scale that allows to identify the most dangerous landslides scenario.

The result could represent a useful tool to define the most critical area in the Civil Protection and to detect the main areas where risk mitigation works are required.

SESSIONE B4

Centri abitati e processi d'instabilità naturale: valutazione, controllo e mitigazione

B4-1 Orale Casillo, Filippo

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HISTORICAL INVESTIGATIONS AS A TOOL FOR A CORRECT LAND-USE PLANNING

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Key terms: Historical investigation; Land-use planning; Geo-hydrological processes; Piedmont

Geo-hydrological risk is one of the most important risks scouring Italy. It is widespread and differs according to the geomorphological characteristics of the territory. Landslides, mud-debris flows and floods are the most frequent geo-hydrological processes. Piedmont region has been violently hit many times in the last 20 years

(September 1993, November 1994, October 1996, October 2000 and May 2008): geo-hydrological processes have caused casualties and damage for millions of euro.

The aim of this research is to evaluate the spatial-temporal distribution of the instability's processes over the past two centuries and to relate it to the urban development occurred since the postwar period.

The study area (1,100km²), located in the north-western part of the Turin's Province, includes the upper part of the Orco Valley, until to the confluence with the Soana stream, and the Stura di Lanzo Valley, upstream the confluence with the Stura di Viù stream.

The methodology has been carried out by the following steps:

- analysis and interpretation of historical documents gathered in the IRPI Archive of Turin;
- drafting of descriptive records into a geodatabase, where are collected all the information about the rainfall event and the consequent natural instability processes;
- localization of the instability processes using Geographical Information System (ArcGIS 9.2);
- evaluation of the urban increase by the comparison between historical maps (1800-1900) and the present situation using the regional technical map (CTR);
- synthesis and data processing.

The documents of 24 municipalities were deeply analyzed and about 800 records were filled and georeferenced. They have permitted to have a more detailed picture of the main instability phenomena which affected the examined area and the relative damage.

This study highlighted how a correct land-use planning for the prevention and mitigation of geo-hydrological risk, cannot ignore a careful historical analysis from which to obtain a wealth of information that, properly developed and compared to the urban growth, can permit to identify the hazard-prone areas that can become risk when it involves urbanized areas.

B4-2 Orale D'Agostino, Vincenzo

10.1474/Epitome.04.0150.Geoitalia2011

THE IMPORTANCE OF RE-READING THE HISTORICAL FLOOD EVENTS: THE DEBRIS FLOW AND THE CONSEQUENT FLOOD EVENT OCCURRED ON THE 9TH AUGUST 1921 IN CHIUSA (RIO TINNE, BOLZANO, ITALY)

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Key terms: debris flow; flooding; historical documentation; event back-analysis; hazard mapping scenarios

Hazard and risk mapping related to debris-flow events is a key step in order to manage urban areas located in mountains regions. Within this mapping activity the assessment of depositional processes is the main task in producing consistent flooding scenarios.

Past events back-analysis allows a direct calibration of numerical models and frequently it offers the almost unique way to assess the flow dynamics at the field scale (e.g. flow rheology and interaction between the debris flow and the surface of the river bed and of the fan).

The study presents the hydrological reconstruction of the historical event occurred in the town of Chiusa (Bolzano, Italy) on 9th August 1921. An intense and composite rainstorm affected the upper part of the Rio Tinne basin and triggered a debris flow which stopped at the confluence with the Isarco river. The natural dam caused - due to a large backwater profile - a lake formation along the Isarco valley stretching as far as the Bressanone city. By the consequence Chiusa was flooded twice: by the Tinne debris flow and by the Isarco river flow.

An hydrological analysis was carried out in order to simulate erosion and transport processes causing the evolution of the historical flash flood into a debris flow. The congruence between sediment volumes which were observed after the event (800.000 cubic meters mobilized and 500.000 cubic meters deposited on the fan and at the junction) and those volumes assessed by a deterministic way using the reconstructed hydro/debris graph was verified. This comparison provided the interpretation of the actual dynamics of an extreme alluvial event, whose return period was estimated about 500 years. The numerical simulation of the event (debris flow propagation and deposition starting from the fan apex) was also conducted by means of a numerical 2-D model. Through the model results hazard maps have been proposed both for the 1921 event and for some possible scenarios related to current catchment disposition. Without the re-reading of the 1921 event the hazard and risk mapping would not be so defensible with respect to local authorities and resident population, thus confirming the key importance of deeply analyzing extreme alluvial events occurred in the past.

B4-3 Orale Ceriani, Massimo

10.1474/Epitome.04.0151.Geoitalia2011

SETTLEMENTS AND INFRASTRUCTURE EXPOSED TO LANDSLIDE RISK IN LOMBARDY - ITALY

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Key terms: LANDSLIDE; RISK; SETTLEMENTS; INFRASTRUCTURE

Studies and analysis of hydrogeological instability (landslides, avalanches, floods) conducted in Lombardia region over the last 10 years, on both local and regional basis, have produced a quite significant framework of knowledge: over one hundred thousand landslides were mapped, more than eight thousand avalanches recorded, 2200 square kilometers of flooded areas identified in plain areas and alpine valleys. Standards of protection were defined and critical areas mapped, also planning choices and major works of prevention and mitigation of risks were made or planned. It would seem we are close to solving every problem and close to avoid any possible risk! Actually, the geomorphologic evolution of mountain areas inevitably implies landslides, even large ones (over 1 million cubic meters) that might cause enormous damage and permanently change the shape of a valley. These extreme events, although rare, have occurred in the past and may recur in the future. The Piuro landslide of September 4, 1618 that destroyed a city (over 1,200 victims) and major roads, the Sernio - Tirano landslide, happened in 1807 (3 victims and temporary lake), the Val Rabbia (Val Camonica) landslide in 1860 with the formation of a temporary lake larger than 2 km, the Gero

and Barcone landslide (Valsassina) in 1762 with the destruction of entire villages (115 victims), are examples of what has happened. Recent events, instead, are the Val Pola rock avalanche (35 victims and settlements destroyed), the debris flows of the Val Tartano (21 victims) and the Torreggio landslides (July 1987), the Bindo Cortenova (LC) landslide and the Brembilla - Camorone (BG) landslide (November 2002), all of which had a great impact on our regional territory and beyond. It is now well known that the evolution of an alpine land as majestic and grand as that of Lombardy, normally happens in a subtle way, but every few centuries, every few decades, the slope instability manifests itself in a devastating way. Works on soil protection, monitoring systems and land use policies may significantly reduce the risk level, especially for people, but real estate cannot be fully protected or relocated: for example the rock falls in Gallivaggio village in Valchiavenna, on Via Mala in Val di Scalve and major roads adjacent to large Alpine lakes, the huge landslides of Ruoin in Valfurva and La Pruna in Valtellina, Val Rabbia and Val Saviore in Valcamonica, Idro Lake in Val Sabbia and large sliding phenomena that could affect some hydroelectric reservoirs in high mountains. If we take into account the phenomena of deep seated gravitational slope deformation (DSGSD), we notice how whole villages like Fuipiano (BG) and Garzeno (CO) are interested by extremely slow continuous movements that usually involve even whole slopes (eg Mount Legnoncino above the lake of Como, Mount Padrio-Varadega, enclosed between Valtellina and Val Camonica). Roads, settlements, infrastructures and major projects related to water use are or may be affected by these extreme landslides (rare... but not so much!). Studies conducted to update the inventory of landslides by Lombardy Region, and summarized in the hundred sheets of the Atlas "Landslides of Lombardy", are meant to focus on events already occurred and on possible events in upland areas, not to scare people living in or crossing these areas, but to make them aware of being exposed to a certain level of risk with which people can and inevitably have to live. For centuries, even millennia, those who venture and settle in piedmont or mountain environments, undertake a certain level of risk, though rewarded by the beauty of the place. In the mountain environment, given the vastness of the areas that humans tend to live on, move and enjoy, a certain degree of risk for landslides will always exist and while it can be reduced, sometimes even predicted, it will never be completely cancelled.

B4-4 Orale Troccoli, Alessandro

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LANDSLIDE HAZARD IN ROMAN URBAN AREA: CRITICAL ANALYSIS OF A FEW CASE STUDIES

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Key terms: landslide; hazard; urban area; risk; dataset

The continuous and fast growth of the Roman urban area suggests to improve existing landslide hazard studies in that territory. Land planning and management has not always been correct in the last years, often owing to an incomplete knowledge of the morphological features of the area or of the slope failures occurred in the past, so the number and the value of the elements at risk increased.

Geomorphological evolution processes are the predisposing factors of instability. Anthropogenic processes act both positively or negatively on hazard, interfering with natural processes. Many historical news about landslides are often available for the Italian cities. They are very useful both to remember "forgotten" landslides and as elements of a statistical dataset to prepare or validate hazard models.

In particular the second issue is very important, because it allows to insert in the right way anthropic features in the model. In this context the Roman urban area is quite interesting both for its extension (geological and geomorphological variability, long and complex urbanization growth) and for the number of case studies.

The Geological Survey of Italy (ISPRA) has recently studied the landslides distribution of the territory of the Municipality of Rome (Amanti et alii, 2008). In this paper the analysis of a few case studies is proposed, to investigate the relationship between natural (geolithological, geomorphological, topographic) and anthropic factors. The aim is to improve the knowledge about landslide susceptibility in urban areas, obtaining as a final result, a support to risk mitigation in the same territory.

B4-5 Orale Petrea, Catalin Costel

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DEBRIS FLOW RISK EVALUATION ON URBANISED AREAS IN THE WESTERN ALPS: VAL VIGEZZO CASE STUDY (VERBANIA, PIEMONTE REGION)

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Key terms: debris flow; alluvial fan; urbanised area; risk; Piedmont Region

Debris flows are amongst the most hazardous geo-hydrological processes that occur in the mountain basins, usually as consequence of short and intense rainfalls, especially in the summer. Such processes take place in a large variety of morphoclimatic environments all over the world. In the European Alps, due to wet climate, lithology and steep slopes, the alpine mud-debris flows are very common and can involve hundreds of villages located on the alluvial fans at the mouths of mountain creeks. For this reason, in the last decades, these kinds of phenomena have attracted the attention of the scientific community and concern of general public due to the death toll and damages to settlements and infrastructures by flooding, erosion, direct impact or sediment deposition. Adopting a well established methodology, frequently used at CNR-IRPI (Turin), the study focuses on: a) reconstruct the frequency and behavior of the flow processes; b) calculate the magnitude of the past events; c) identify the debris-prone areas; d) gather information about the type of damages; and e) evaluate the urban development on the alluvial fan. This methodology can make easier the assessment of hazard and afterwards the debris flow risk evaluation, providing design parameters for risk mitigation. In Piedmont Region, below 2000 m a.s.l., more than 2,900 alluvial fans have been identified with a total area of 1,560 km², which represents 4.8% of regional territory. Must be pointed out that a large heterogeneity exists at geographic and administrative level: e.g. the Verbania province with 18%

of its territory occupied by alluvial fans, has the highest potential hazard linked to debris flow processes in Piedmont. The case study concerns four creeks (Val Vigizzo), which have built up their coalescent alluvial fans onto the nearly level plain of the Vigizzo stream. These alluvial fans, that cover a total area of 8.1 km², were selected by taking into consideration the following criteria: 1) high rate of urbanization; 2) recently-occurred events and potential risk for residential areas located on the alluvial fan; 3) natural events well documented by historical data, aerial/satellite imagery and GIS metadata; 4) long-lasting rainfall records. One of the most important debris flows has occurred on 7-8 August 1978. All four above mentioned creeks have transported huge volumes of coarse-grained sediment that covered the fans with 5.5 km² of debris (with thickness between 0.5 m and up to 6 m). As consequence, several houses and bridges have been totally destroyed and other tens of buildings, road, rail network and many hectares of terrains have suffered considerable damages. In the subsequent years the local authorities have realized sediment control dams and canalization systems in order to mitigate future debris flows. Considering a series of data excerpted from written documents, historical maps and air photographs it was possible to reconstruct the timing and manner of urban development, in the last hundred years. It is comes out that the fastest grow rate occurred between 1950-1970. After the 1978 catastrophic event, urbanization rate has decreased especially within those areas severely affected by debris flow (i.e. apex zone and active channel). The 2006 up-to-date situation shows that alluvial fans represent 4.4% of the study area, but being the most suitable terrain for human settlements, an important percentage of residential areas and infrastructures are located on them. Currently in force, national and regional laws have included the Val Vigizzo debris-flow prone areas into elevate or moderate risk classes. It must be precised that after 1978 event till now no other debris flows have reached the same magnitude, so is hard to evaluate if the retention dams and laws provisions will successfully mitigate the risk for a potential high magnitude flow event with a several decades-long recurrence interval.

B4-6 Orale Falconi, Luca Maria

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GEOMORPHOLOGICAL APPROACH TO INTENSITY AND RUN OUT EVALUATION OF POTENTIAL MUD-DEBRIS FLOW IN THE MESSINA MUNICIPALITY AREA (PELORITANI MOUNTAINS, SICILY)

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Key terms: Debris flow; hazard; peloritani; sicilia

Peloritani Mountains (Messina province, Sicily) are a costal ridge along the Ionian coast, characterized by narrow and steep catchments of small size (5-10 km²) with a high relief energy (up to 1000 meters drop in about 5 km) and a short concentration time (few minutes). The morphology of the Peloritani has been especially influenced by metamorphic lithology, complex geotectonic conditions related to the orogenic tectonics and recent tectonic uplift, active in the area since the late Miocene. All the steep slopes are covered by a few decimetres layer of debris, colluvium and soil.

During the night between 1 and 2 October 2009, this area has been affected by a sudden downpour, accompanied by strong winds and lightning. Sicilian Agrometeorological Informative Service estimated that more than 200 mm of rain fell in seven hours.

Lithological, morphological and hydrological conditions have meant that more than one thousand of mud-debris flows have been produced.

Triggered by heavy rainfall, the flows have reached valley's bottom and alluvial fans in few minutes and with high energy. Urban areas located along the Ionian coast were overrun and affected by heavy damage and casualties. Giampileri Superiore, Briga Superiore and Scaletta Zanclea, small villages 10 kilometres southward from the city of Messina, were the most injured areas.

An empirical geomorphological approach to evaluate run out and energy of potential mud-debris flows that affect the Peloritani Mountains is proposed in this paper.

An inventory map of more than 1000 mud-debris flows was the first task of the study, produced through geomorphological and morphometric survey and aerial photos analysis. The inventory was focused on identifying landslides parameters to obtain a susceptibility map of the area, following Enea-Roma Tre methodology.

Once localized source, transportation and run out areas of past mud-debris flows, velocity and intensity have been assessed. Velocity measurements with Johnson & Rindine (1984) method were realized in different points of occurred phenomena in order to determine the specific deceleration curves of the area. In the same points the kinetic energy released was calculated.

Subsequently source areas, run out, velocity and intensity of potential events have been investigated.

Comparing volume, run out and height difference between triggering areas and the toe of accumulation fan of past events, site specific formulas were obtained in accordance with Rickemann (1999) methodology. Two formulas have been carried out separately for the channelized (L1) and non-channelized (L2) flows due to the different length of run out:

$$L1 = 6,4126(V*He) 0,3078;$$

$$L2 = 3,2666(V*He) 0,3148.$$

Where:

L: length of run out;

V: volume;

He: height difference between triggering area and the toe of accumulation fan.

These results were then applied to some high and very high susceptibility areas in order to determine the expected kinetic energy in each morphological part of potential flows and the impact on the anthropic structures of the Messina municipality area involved by the potential flows. The morphology of Messina territory, the town and villages development above the creek outlet, the transformation of riverbed in street and the abandonment of terracing, contributed to increase geomorphological risk of urban areas.

Complementary to the definition of return times and rainfall thresholds, this study is therefore a necessary basis for an efficient assessment of debris flow's hazard. Moreover, knowledge of potential landslides energy is preparatory for subsequent phases of vulnerability of exposed elements assessment. Ultimately, this study promotes the definition of reliable risk

scenarios for mountain source and transit areas as well as for urban areas prone to deposit of mud debris flows, indispensable basis for predisposing sustainable land planning actions and identify efficient risk mitigation measures.

B4-7 Orale Quaranta, Nicola

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EVALUATION OF HYDRAULIC RISK IN MOUNTAIN BASINS AND ALLUVIAL FAN: THE CASE OF T.BUTHIER, VALPELLINE (AO)

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Key terms: Debris potential; Hydrology hydraulic models; Alluvial fan risk

The basin of T.Buthier di Valpelline is placed in the central Aosta valley, with an extension of about 60 square km, and due to high elevation it includes several glaciers and one small artificial reservoir.

According to standard methodological guidelines edited by Regione Valle d'Aosta, the approach of the study is dedicated to evaluation of current debris-flood risk analysis and design of mitigation solutions at a preliminary stage.

Geological analysis took place from aerial photointerpretation, field survey and data sampling and organization in a pre-defined GIS format. Historical analysis based on archive research has been performed.

Specific care has been dedicated to evaluation of debris potential along minor steep torrents and in the mountain slope, especially in the recent morain loose formations and from landslides, referring to different methods (Agostino, 2006 and Hungr et alii, 1984).

The available volume of debris were distributed referring to a discretization of the main basin in sub-catchments, taking in account the local slope reduction effects allowing intermediate deposition of the solid transport.

Detailed hydrological analysis, considering snowmelt contribution to flood formation, was developed throughout intensive rain analysis and referring to Curve Number (U.S Soil Conservation Service) into HEC-HMS 3.3 environment.

Clark Unit Hydrograph and SCS Unit Hydrograph methods have been applied in order to transform inflow into flows.

Keeping into account the results of Hydrological analysis, the evaluation of the channel functionality in the alluvial fan has been computed with HEC-RAS 4.0, assigning solid transport as a component of the liquid discharge from Smart - Jaeggy formula.

Assessment of risk flood on the alluvial fan considered intrinsic hazard and return-time of the flood as a probability and a parametric attribution of values to the exposed human activities.

Design of mitigation structures along the channel was supported by scenarios simulation with HEC-RAS 4.0, performing the reduction of the risk stage on the alluvial fan.

B4-8 Orale Luino, Fabio

10.1474/Epitome.04.0156.Geoitalia2011

MULTIDISCIPLINARY ANALYSIS TO IDENTIFY FLOOD-PRONE AREAS FOR THE REVISION OF TOWN PLANNING IN THE ITALIAN CENTRAL ALPS

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Key terms: historical investigations; geomorphological analysis; flood-prone areas; town planning; Italian Alps

This study has examined more than 30 municipal areas of three different valley bottoms in Lombardy (Northern Italy). The research was carried out from historical and geomorphological points of view, and was aimed at identifying flood-prone areas. The result has been used to verify the present land-use planning, and to start a review process of the existing urban plans and/or their general changes.

The study was developed in three steps: a) collection of historical flooding data from several public bodies; b) geomorphological analysis by field surveys and aerial photographs; c) analysis of urban planning.

The historical investigation included the identification of the information sources, the collection of the historical report and old maps, and the selection and validation of the data. The aim of this investigation was to map the damaged sites in the past.

The geomorphological analysis was developed with aerial photographs and field surveys, and was aimed at verifying the reliability of the historical data, verifying the planform changes of the river-beds, collecting information from inhabitants and identifying the most critical morphological-hydraulic stretches.

By overlaying the historical and geomorphological maps, maps of flood-prone areas were obtained, and two hazardous strip-like areas along the rivers were identified. The first flood-prone area corresponds to the ordinary flood and the second one to extraordinary flood. The urban planning of 34 municipalities was verified and up-dated by aerophotogrammetric and cadastral maps, mapping of recent buildings by field surveys. The zoning of all urban plans was subdivided into eight main classes: a "risk matrix" was created by combining fluvial hazard and the different urban hazard levels. A final flood hazard map of each valley bottom was obtained by overlaying the flood-prone area map and the urban planning mosaic map, which allowed the most critical hydraulic sites to be highlighted.

B4-9 Orale Campigotto, Laura

10.1474/Epitome.04.0157.Geoitalia2011

A STRATEGY FOR THE LANDSLIDE PREVENTION, THE CHOICE OF ALBA MUNICIPALITY

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Key terms: deep gravitational movements; warning; monitoring

This work shows the prevention strategy in a hydrogeological high-risk

municipality, about deep landslides which can directly involve houses.

INTRODUCTION:

In the municipality of Alba, in which some deep gravitational movements were triggered after the flood in 1994, some inclinometer and piezometer pipes for surveys were installed. These are monitored by ARPA Piedmont which periodically sends the report to Alba municipality. In April 2009 there was a high intensity rainfall event on Piedmont, which made worse a situation already fragile due to rain and snow accumulated in the previous year. The event caused the reactivation of movements, mainly rotational and planar/composite translational.

Although the instrumental registration, during the survey, of a modest increase of the movement, action for public safety were not considered necessary, but the high depth of the potential sliding surfaces and the uncertainty coming from the actual early phase of the breaking mechanism, make the evaluation of the developmental stage unsure, both for displacements and for correlation between rainfall-trigger of the displacement. In other words the aim of the periodical manual monitoring is to verify the general evolution of the phenomenon and not to provide warnings in real time when the alarm thresholds are overcome.

THE CHOICES OF PREVENTION

Alba municipality has been wondering about prevention for the responsibility of the Major, Authority of civil protection to the people of his municipality, and also for the limitations to public expenses introduced in recently in Italy by the specific regulation "Fatto di stabilità". With the aim to intervene for the "Common good" of the city, making choices aimed priority to optimize the expenses obtaining at the same time the best performances, it is clear that investing in prevention means also the determination of instrumental and experimental data allowing an early warning of population, before the event.

Indeed the alarm thresholds defined by the designers of the mitigation works, based on regional data, were not effective for the aim, causing an excessive number of alarms and a lowering of the threshold of perception of risk by the population.

TECHNICAL DATA

For these reasons it was decided to make a system which, thanks to technological evolution developed in the last years, allowed an effective warning to population by the continuous monitoring of the phenomena. Three important sites were chosen: loc. Case Toino, loc. Strada Serre - Villa Fantina e loc. Cascina Villa - Commenda-Salera

A first borehole was made in loc. Case Toino on the upper side of a slope, up to a depth of 30 meters, for the 2D/3D remote monitoring of the landslides.

In the area, placed south of Alba and on the right bank of Cherasca Torrent, there are some houses built in the upper part of the slope (one of these repeatedly evacuated) and a municipal road with some houses in the lower part of the slope, next to the Cherasca torrent.

In particular in April 2009 the municipal road was interrupted by a landslide, which can be correlated to the deep movement mentioned before.

First remote monitoring data (since 20.04.2011) shows already some interesting information, like micro movements at depths of 16 meters and 26 meters in North direction, which are supported by the previous data.

B4-10 Orale Spizzichino, Daniele

10.1474/Epitome.04.0158.Geitalia2011

GEOLOGICAL AND HYDRAULIC RISK ASSESSMENT IN URBAN AREAS: THE ANCONA CASE STUDY

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Key terms: Landslide; Risk; Adaptation

Geological and hydraulic risk in Italy is particularly high since the geological, geomorphological, climatic, seismic and structural settings render Italian territory susceptible to frequent and widespread geological and hydraulic phenomena. Italy is also densely populated and highly urbanized. In terms of landslide hazard, more than 485,000 landslides occurred between A.D. 1116 and 2006 within Italy, with a landslide area of 20,721 km² equal to 6.9% of the national territory. 5,708 municipal districts are affected by landslides (70.5% of the total), of which 2,940 with extremely high levels of criticality due to landslides affecting urban settlements. This data emerges from the IFFI Project (Italian Landslide Inventory) set up by ISPRA - Italian National Institute for Environmental Protection and Research/Geological Survey of Italy and the Regions and self-governing Provinces. With regard to exposure and vulnerability, urban areas in Italy account for 17,929 km², equal to 5.9% of the national territory. In the past 50 years, urban areas in Italy underwent a dramatic increase, whose surface has more than doubled. Often urban sprawl did not benefit from any form of proper land use planning and management or detailed landslide hazard assessment. Scope of the present study is to present a methodology for a preliminary geological and hydraulic risk assessment at municipal scale. The work is being carried out within the framework of the Life Project ACT (Adapting to Climate change in Time) aiming at the development of Local Adaptation Plans and funded by the European Commission. The area chosen for the implementation of the analysis is the municipality of Ancona in the Marche region. The assessment has been implemented within a GIS platform by overlapping landslide data derived by the IFFI Project, hydraulic risk area derived by River Basin Authority, jointly with urban area derived by Land Cover Corine 2006, populations census data and main transportation network at municipal level. The total area of Ancona municipality is equal to 124,4 km² of which 26,9 km² (21,62 %) affected by landslides. The urbanized area is equal to 19,67 km² and the related area affected by landslide is equal to 2,37 square kilometers (1,92 %). For the Ancona municipality area landslides have been classified in two main categories: rapid and slow movements. The rapid phenomena are correlated to the people safety, while the slow one concern mainly losses and usability of goods and infrastructures. Consequently different strategies for planning and emergency management must be adopted and implemented. The people exposed to landslide risk at municipal level and critical points along highways, railways and road network has been also estimated. Related to population, the analysis permitted to estimate the number and age of people exposed to landslide risk in terms of safety of human life and also for social and economic losses. In order to reduce the impact of landslides and hydraulic events within urban areas and along linear infrastructures, different measures should be adopted and implemented by the developing of adaptation plan. In addition to engineering works and delocalization, the instrumental monitoring networks and emergency plans assume a fundamental role for the risk management. The main outcome of the proposed methodology is a rapid and useful tool for land use planning and management at local level in order to reduce and minimize the impact of

geological and hydraulic hazard in urban area.

B4-11 Poster Palomba, Mauro

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DEBRIS FLOWS HAZARD AND RISK IN THE AOSTA VALLEY REGION (NW-ITALY): COMBINING HISTORICAL DATA INTERPRETATION AND GEOMORPHOLOGICAL MAPPING FOR THE IMPROVEMENT OF REGIONAL INVENTORY, LOCAL CONTROL AND MITIGATION MEASURES

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Key terms: debris flows; GIS; geomorphological mapping; hazard assessment

A classical approach to debris flow risk assessment includes: 1) identification of affected area, event's magnitude and return time; 2) estimation of territorial risk and vulnerability; 3) evaluation of social consequences. The three components have been analyzed in the Aosta Valley (NW-Italy), a small alpine Region (area = 3262 km²) where debris flows frequently occur, often interacting with human activities and structures. Results have been addressed to support activities for reducing human and property losses caused by debris flows potential hazard.

For a best debris flow hazard assessment, the joint research team University of Torino-Regione Autonoma Valle d'Aosta realized a debris flows inventory at a regional scale, combining historical data (1900 to present), technical maps and geomorphological analysis. Data collection and analysis have been organized in two different stages. As a first step, aerial photointerpretation and Digital Elevation Models (DEMs) analysis were conducted over the Aosta Valley Region to obtain a complete fans inventory and to identify the most affected sectors by debris flows. As a second step, data on debris flow events occurred in the Region has been collected from different sources, such as bibliographic and historical data, municipality hazard maps for land planning restriction and drainage basin technical studies. For each inventoried debris flow, aerial photointerpretations have been performed to validate geomorphological and historical data, mostly collected during major regional flood events. Finally, the selected debris flow events has been formally organized in a GIS to perform spatial and statistical analysis.

The preliminary analysis of the debris flow selection led to the identification of about 200 single phenomena, thus successfully upgrading a Regional database for management of natural instabilities ("Catasto Dissesti"). Knowledge on natural hazards related to debris flow has been improved at a regional scale by the production of a 1:100.000 geotematic map.

Most vulnerable areas are located where tributary drainage paths intersect major valley bottoms: here debris flows represent a risk for structures and infrastructures located on the slopes or along the valley bottoms, especially on the alluvial fans. Because urbanization on fans has strongly increased in the last decades, the debris flows risk has also been enlarged: these instability phenomena often interfere with man-made structures causing damages to settlements and roads and also, in some cases, people injury and casualties.

Most of the records acquired are connected to the 13th - 16th October 2000 flood event, one of the most severe flood episode of the last century in North western Italy, with 270 different debris flow phenomena occurred on the fans involving a total area of about 4,3 km². Prolonged rainfalls affected large areas of the region, leading to widespread flooding with large-scale sediment transport and several debris flow along the stream network; rainfall-induced phenomena developed both from soil slips and torrential floods, often affecting buildings on alluvial fans at the foot of the steep slopes, causing serious damages to man-made structures in several areas of the middle Aosta valley and also 18 victims in the neighbourhoods of the town of Aosta, almost all killed by a single debris flow event.

Among activities undertaken to reduce human and property losses caused by debris flows, collected data also allowed important improvements to local knowledge on debris flows, through the recognition of multiple occurrences in the same alluvial fan: estimation of their magnitude and temporal occurrence led to more precise hazard and risk assessment, useful for proper land planning. Finally, geological, geomorphological and climate factors have been recognized, responsible for controlling typical activation thresholds and debris flow characteristics in different sectors of the Aosta Valley Region.

B4-12 Poster Turconi, Laura

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HISTORIC ANALYSIS OF NATURAL EVENTS AND URBAN GROWTH, AS A TOOL IN EARLY WARNING STRATEGIES IN RISK-PRONE ALPINE AREAS: THE CASE OF SONDRIO IN THE ADDA VALLEY (CENTRAL ALPS, ITALY)

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Key terms: early warning; historical flood events; risk-alluvial fans; Mallerio stream (Sondrio)

Almost every year and often several times in a year landslides, debris flows and stream floods events are impacting on settled areas and infrastructures, causing deaths, economic and social damages; due to a growing soil occupancy even in high-altitude areas, often accompanied by unsuitable land use practices, the exposure to risk increases, while the events per se should be regarded as usual and cyclical processes in nature. Early warning strategies must take into account the usually very short time span between the initial occurrence of some rapidly-evolving natural processes and the gathering of information in order to cope with risk and organize rescue operations. A purposely-made search and elaboration of historical data concerning natural instability processes and land use evolution is of primary importance in order to draft ready-for-use and up-to-date risk scenarios. The basin of T. Mallerio in the Sondrio

province (Adda Valley) represents a good case-study; it extends for 300 km² and its drainage network accounts for more than 650 km. In such basin landslide and torrential flood processes often occurred in the last five hundred years and the city of Sondrio has once more, dramatically, experienced destructive flood on 18-19 July 1987. A large landslide, which in extreme conditions could act as a dam barrier along the most important tributaries of Mallerio stream, are well-known since Centuries; the last one, involving Quaternary deposits and metamorphic rocks (gneiss, quartzite and marble) accounting for 20-106 m³ of materials, is usually quiescent but could re-set in motion in case of intense and long-lasting rainfall, as did in fact happened several times in the past. A method of analysis is illustrated, based upon research, selection, interpretation and processing of historical data, combined with a comparative analysis of aerial imagery taken at quite regular time intervals, and applied to the Mallerio basin with respect to the urban setup of the city of Sondrio, which has growth untidily when referred to the critical geomorphological conditions characterizing the large alluvial fan where the city is built. The effects of natural events, in case of extraordinarily huge floodwaters, may thus result in damages and danger to inhabitants. Some 170 documents have been used in the study, concerning reports on flood and landslide events as well restoration and protective works realized in the basin, which refer to a lapse of time as long as 500 years, with a fair good continuity over the period dating back to 1800 up to the present. The natural hazard conditions have been thus evidenced, connected to the geographical and geomorphological features of the area with special regard to the built-up alluvial fan. The result goes beyond the procedure usually followed in developing hydraulic models of recurrent floods, because there are not always available useful data inputs at local scale; the method here applied enhances the need for landscape analysis through the use of data objective and sound. The historic datum, appropriately balanced through a careful critical reading, may be regarded as a direct witness handed down through years, often bearing detail and precision required at a small-scale. It must be supported by a methodical investigation through interpretation of the catchment-system as it looks presently; to do it field recognitions are needed, supported by aerial and terrestrial images. In most part of mountain areas the co-existence between natural processes and man life and industry is a mere postulate. That is a good reason by which, independently from structural interventions and protective artifacts, the development inside the small communities of the culture of prevention, is a urgent need. Such knowledge mostly depends upon the historic information which could provide to landscape owners and especially the land planning Bodies the tools to re-act to extraordinary events through suitable rules and in right way

B4-13 Poster Santangelo, Nicoletta

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FLOOD SUSCEPTIBILITY ASSESSMENT IN HIGHLY URBANIZED ALLUVIAL FANS: CASES STUDY FROM CAMPANIA REGION (SOUTHERN ITALY)

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Key terms: alluvial fan; flooding susceptibility; southern Italy

The great urban expansion which has occurred in the foothill areas of southern Italy in recent decades makes the problem of defining flooding susceptibility increasingly urgent. These areas have been prime spots for urban development because were generally considered to be safer than the valley floors. Entire towns (Sala Consilina, S. Maria a Vico, Arienzo, Piedimonte Matese, Volturara Irpina) often dating back to Roman or Medieval times have developed on alluvial fan surfaces. It should be pointed out that due to the relatively long time lags between floods and the consequent loss of historical memory, urban expansion in recent decades has not taken into account the presence of alluvial fans. In many cases the apical areas of the active fans have experienced significant urbanization and the feeder channel has either been completely buried or converted into a road. Extensive observation made during field surveys shows that in many cases hydraulic works are completely lacking and, when present, they are planned for ordinary rains, with small sections that are generally unfit to contain high discharges and/ or high debris loads. The sum of these conditions obviously increases regional vulnerability. In such contexts the difficulty in carrying out investigations and the lack of data or field evidence of past debris flows cause real problems in producing detailed and exhaustive studies. Risk management planning is generally tackled by local and area administrations (such as watershed basin authorities) in an approximate way and at an inadequate scale (1:25,000 or 1:10,000).

In the case of wide and extensively urbanized alluvial fans the real hazard conditions should be checked on a more detailed scale (1:2,000 - 1:1,000), taking into account the hydraulic sections, the topographic and morphological variations of the fan and the interactions between water flows and local infrastructures.

This paper describe some cases study for which the flooding susceptibility zoning was assessed at a very detailed scale (1:2000). The adopted procedure bases on a painstaking field survey both in the watershed basin and in the fan areas, associated with in-depth historical research of past events. Starting from 1581 up to now, we collected evidence of more than 50 alluvial events which often caused severe damage to property and infrastructures, and in many cases also loss of life.

The reconstructed flooding scenarios, showing the fan portions potentially affected by different alluvial processes, may represent a useful tool for subsequent studies aimed at land hazard mapping. In particular, the proposed procedure, allowing precise susceptibility zoning within an urbanized area, may contribute significantly to defining intervention priorities and planning risk mitigation works.

B4-14 Poster Zumaglini, Marco

10.1474/Epitome.04.0162.Geoitalia2011

THE TERRITORIAL DIMENSION OF WATERSHED MANAGEMENT: A SUBURBAN CASE STUDY

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Key terms: land use; watershed; flood; mudflow; forest

Leading to a "territorial dimension" for the environmental policies, in order to more effectively meet the Climate Change adaptation challenges, the incoming EU Common Agricultural Policy will address the ecological connectivity of rural landscape as well as the implementation of the Water Framework Directive. Watershed integrated management is thus supposed to become a crucial matter, focusing on both biodiversity and land use management that are to be improved with a view to flood and landslide risk mitigation.

In order to provide scientifically sound figures and relevant criteria to land planners, the case study of the small Pollena watershed, located in the south-eastern suburbs of Naples but including a small section of Vesuvius National Park, has been analyzed owing to its being well representative of a variety of land use patterns, environmental concerns and human pressures. The research has been carried out by an interdisciplinary team in cooperation with the technical staff of the Napoli-Volla "Consorzio di Bonifica" (Land Reclamation Agency).

With the aim to study the effects of land use in the prevention/mitigation of floods or landslides affecting urban settlements, a computer model (Topkapi by Todini et al.) has been applied to simulate the rainfall-runoff transformation process: a physically-based grid-cell scale modeling of the hydrological processes has allowed detailed understanding of the influence of land cover changes on stream flow.

Alternative land use scenarios have been tested, featuring different land protection practices and/or land use types and patterns, such as the afforestation of buffer areas strategically located either along riparian strips or across the Vesuvius lower slopes.

The contrasting effects have been investigated of urban sprawl and afforestation.

The identified scenarios have served a double purpose: i) Peak flow analysis; the flood hydrographs have been calculated by the model starting from input rainfall of known probability (the two recurrence intervals of 5 and 50 years have been considered adequate); ii) Soil moisture analysis; among the model outputs, soil moisture at grid-cell level is paramount when mudflow hazard is to be assessed: the geology of the area, featuring a volcanic ash layer overlying a volcanic bedrock, makes it dangerously prone to such hazards (the well known Sarno disaster involved quite a similar geology).

The following major issues have then been highlighted:

- Soil moisture prior to precipitation plays an important role in runoff generation (the effects of this parameter have been investigated as well, by applying the same precipitation to two different soil moisture conditions, a "dry" one and a "wet" one);
- Mixed and multi-layered (i.e., close to climax) forests assure high performance in soil protection and stream flow control: they can extend to up to 2m the depth of the underlying topsoil (it corresponds to the plants' root system and is crucial to soil moisture and runoff generation control); when located along watercourses, they prove most effective in mitigating floods featuring low antecedent soil moisture content; conversely, when spread across the lower slopes, they tend to be more effective against high antecedent soil moisture content floods;
- When urban areas sprawl up to 60% of watershed area, parallel watershed afforestation together with revegetation of urban riparian strips allow no substantial changes in major floods, whereas minor floods will noticeably increase in frequency and magnitude;
- Concerning mudflow hazard, climax forests located where mudflows are likely to generate (i.e., spread across Vesuvius's - or rather, mount Somma's - steepest slopes) prove beneficial in keeping soil moisture levels comparatively low, thus counteracting soil liquefaction phenomena; additionally, buffer forests located at the foot of the mountain can contribute to protection of downhill urban areas by damping mudflow destructive energy.

SESSIONE B7

L'idrologia nelle scienze geologiche

B7-1 Orale De Vita, Pantaleone

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COUPLED DECADAL VARIABILITY OF THE NORTH ATLANTIC OSCILLATION, REGIONAL RAINFALLS AND SPRING DISCHARGES IN THE CAMPANIA REGION (SOUTHERN ITALY)

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Key terms: climatic variability; North Atlantic Oscillation; regional rainfall; groundwater recharge; southern Italy

The climate change is one of the issues most debated by the scientific community with a special focus to the combined effects of anthropogenic modifications of the atmosphere and the natural climatic cycles. Various scenarios were been formulated in order to forecast the global atmospheric circulation and consequently the global distribution of air temperature and rainfall. The effects of the climate change were been analysed respect to the risks of desertification, droughts and floods, remaining mainly limited to the atmospheric and surface components of the hydrologic cycle. Consequently the effects of the climate change on the recharge of regional aquifers and on the groundwater circulation is still a challenging topic especially in those areas whose aqueduct systems depend basically by springs or wells, such as the Campania region (southern Italy).

In order to analyse the long-term climatic variability and its influence on groundwater circulation, we analysed decadal patterns of precipitations, air temperature and spring discharges in Campania region (southern Italy), coupled with the North Atlantic Oscillation (NAO).

The time series of precipitations and air temperature were gathered for 90 years, in the period from 1921 to 2010, choosing 18 rain gauges and 9 air temperature gauges among those with the most continuous functioning as well as resulting in a homogeneous spatial distribution. Moreover, for the same period, we gathered the time series of the winter NAO index and of the discharges of the Sanità spring, belonging to a fractured carbonate aquifer (Cervialto Mount) located in the central-eastern area of Campania region. The hydrogeological features of such extended carbonate aquifer, its relevance due to the feeding of an important regional aqueduct system, as well as the unique availability of a long time series of spring discharges, allowed us to consider it as an ideal test site, well representative of the

other carbonate aquifers in the Campania region.

The time series of normalised indexes of mean annual precipitation, mean annual air temperature and mean annual effective precipitations, as well as the time series of the normalised annual discharge index were calculated. Different methods were applied to analyse the time series: trend analysis, trough moving-averages and numerical filters, cross-correlation analyses, Fourier analysis and statistical tests. The analysis of the indexes has highlighted a long-term complex periodicity, strongly correlated with the winter NAO index. Moreover, we also found robust correlations among precipitations indexes and the annual discharge index as well as between the latter and the NAO index itself.

Although the effects of the North Atlantic Oscillation had already been proved on long-term precipitations and stream flows patterns of different European countries and Mediterranean areas, the obtained results appear original because they establish a link between a large-scale atmospheric cycle and the groundwater circulation. Therefore, we demonstrated that the winter NAO index can be considered as an effective indicator to forecast the decadal variability of groundwater circulation in Mediterranean areas and to prospect critical scenarios for the feeding of aqueduct systems.

B7-2 Orale Galeandro, Annalisa

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HYDROLOGICAL ANALYSIS OF THE RAINFALL ANTECEDENT TO THE LARGE LANDSLIDE OF MAIERATO (SOUTHERN ITALY)

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Key terms: rainfall and landslide; hydrological analysis; Maierato landslide

Rainfall-induced landslides is an hot topic in scientific literature, with particular interest to the evaluation of the influence of rainfall on landslide triggering to obtain a pre-alert information on landslide risk.

On the 15 of February 2010 a really large deep seated landslide activate in Maierato Southern Italy after a rainfall period of several months. General characters of the landslide area described in Guerricchio et Al. 2010. These work presents the analysis of the antecedent rainfall events developed using different hydrological technique to show the singularity of the rainfall. The analysis has been developed on the base of the data of Vibo Valentia rain gauge station where daily rainfall data were available since 1920 (ARPA CAL).

The time series analysis showed that both the 2009 and 2010 winters were really rainy, in particular the last three months before the landslide. During this period, there were long and well distributed rain precipitations easy to infiltrate into the soil and denoted by large volumes of water than by high peaks of intensity.

The classic hydrological analysis has developed for cumulative rainfall of 5, 10, 15, 20, 30, 60 for the whole studied period (1920-2010). For each duration, the maximum values of each year were analyzed using the gamma probability distribution to evaluate the return period of the rainfall. The return period of the 20 and 60 day rainfall preceding the landslide is the maximum of the last 20 years, despite being lower than 10 years. This is due to the fact that Maierato area is subject to really severe storms, e.g. in the cases of Vibo Valentia floods (2006 and 1938). These singular events condition the evaluation of rainfall exceptionality, even if they are not particularly important for the activation of deep seated landslide. In fact these events generate intense run-off and poor infiltration.

The analysis has been pursued also according to the approach of Cotecchia & Simeone (1996), who propose to consider a time series of rainfall with a threshold of 25 mm/d. Each daily rainfall value exceeding 25 mm was assumed as 25 mm. So it was obtained a modified rainfall series that considers only the rainfall that can potentially originate a quite high infiltration. The cumulative rainfall analysis has been repeated obtaining really different results. In this kind of analysis the cumulative rainfall to 20 years has a return period of more than 100 years.

In fact, in the 20 days before the landslide there were continuous rainfall, also if the amount of rainfall for each day is not very high. Therefore, a condition favoring deep infiltration occurred, thus implying pore pressure variation at deep levels and triggering deep large landslide.

The study confirmed that hydrological analysis is a really useful tool for estimating the landslide hazard. However, the hydrological exceptionality of single events does not immediately relates to the exceptionality of the landslide hazard pertaining to rainfall.

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B7-3 Orale Baruffini, Mirko

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ANALYSIS OF THE POTENTIAL EFFECTS OF DAM BREAK FLOODING USING A GIS-TOOL FOR RISK ASSESSMENT IN MOUNTAIN REGIONS. AN EXPLORATORY STUDY ON A HYPOTHETICAL EVENT: THE VAL CANARIA FLOOD

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Key terms: risk-assessment; floodplain mapping study; natural debris dams

Several percent of the Canton Ticino (Southern Switzerland) is prone to slope instability. The climate of southern Switzerland favors slope failure. In particular, landslides and accelerated creep are commonly triggered by major storms associated with warm humid air flowing from southwest towards the Alps.

These storms can be particularly severe in the Ticino region. The storms of 1993 and 2000 caused extensive flooding, triggered debris flows and landslides, and induced higher rates of creep in some existing large

landslides.

Some of these landslides are located near Airolo in the upper Leventina valley (Val Canaria). They consist of failed rock masses on both sides of the valley with a total volume of about 80 million m³. The area is historically known for its instability (Seno and Thüning, 2006). In particular, the channel of the Canaria stream at the slope's toe is filled with unvegetated landslide debris. A natural dam could form after a landslide event with a possible subsequent disastrous failure and destructive consequences on the important traffic lines passing in the Leventina valley.

This scenario, although characterized by a very low probability of occurrence, is nevertheless possible and could have effects that would certainly be devastating for a big part of the Swiss economic system. A damaged infrastructure would cause serious material damage that would require extraordinary repairs or restorations. The services inactivity, as a result of a malfunction, would generate important financial losses and problems in essential services supply in the region (Maggi R. et al, 2009). All these elements justify a risk analysis of this region. With a Geographical Information System adapted to run with a tool developed to manage risk analysis, it is possible to survey the data in time and space, obtaining an important system for managing natural risks. The aim is to join and organize the various data currently available to carry out a qualitative and semi-quantitative analysis giving an overview of the risk (BUWAL, 1999).

In this work we present few scenarios of flooding in the upper Leventina valley that are obtained applying two different 2D computational model:

(i) FLO-2D, a hydraulic model distributed by FLO-2D Software Inc and (ii) a numerical GIS embedded model appositely implemented for dam break flooding (Marzocchi & Cannata, 2011).

Evaluation of the models was performed by comparing simulation results against each other and finally a risk analysis is performed using a specific tool appositely developed in a GIS (Baruffini, 2010).

The outcomes can provide an answer to the questions: "what can happen?" and "how achieve maximum safety with a minimum of effort?" or, depending on the desired depth, they can represent also input to start an increasing order of analytical analysis (i.e a cost-benefit analysis or so on).

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B7-4 Orale Mariani, Isadora

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INTERMEDIATE-FIELD HYDROGEOLOGICAL RESPONSE INDUCED BY L'AQUILA EARTHQUAKE: THE ACQUE ALBUE HYDROTHERMAL SYSTEM (CENTRAL ITALY)

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Key terms: Earthquake hydrology; Groundwater level changes; Dynamic stress

Using groundwater level data recorded in seven wells in the Tivoli quarry area and in the Cornicolani Mts (Central Italy), the intermediate-field response to the 6th April 2009 L'Aquila earthquake (Mw 6.3) has been studied. The hydrological setting of the Tivoli area is characterized by two superimposed aquifers, the deep one is in carbonate rocks, the shallow one is in travertine rocks. Has been observed that in five wells located in the travertine quarry area the groundwater level contemporary decreased exactly at the time of the L'Aquila earthquake occurrence, one of this wells reported also a decrease in water temperature at the same time, while there is a slight increase of level in the natural shaft of the Pozzo del Merro karst lake located in the carbonate deep aquifer.

A conceptual model to explain those variations has been proposed, assuming that the variations in groundwater level and in water temperature are given by an enhanced permeability in the shallow travertine aquifer caused by the dynamic stress, from the seismic waves.

B7-5 Poster Guadagno, Francesco Maria

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TREND AND FLUCTUATIONS IN THE LONG KARST SPRING DISCHARGE SERIES

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Key terms: spring discharge; karst; time series; Campania region

The recent tendency of temperature increasing and rainfall decreasing in many region of the world, enclosing the Italian peninsula, favours a reduction of infiltration, and thus the reduction of the spring discharges of many karst aquifers.

Karst springs are very important climate indicator, being controlled directly by the rainfall and temperature regime, and are very sensitive to poor rainfall during drought.

This study analyses long hydrological time series of spring discharge, to find the effect of the climate change on the karst systems analysed. Data refer to the Picentini mountain and Matese massifs, which are the

most important karst systems of Campania region (Southern Italy), characterised by a typical Mediterranean climate. These massifs are constituted by a limestone sequence of Mesozoic, deeply fractured and faulted, and supply the main aqueducts of Southern Italy, providing water for several millions of people.

Analyses have been particularly focused on the drought periods, analysing the effect of poor recharge on the aquifer response. Prolonged periods of poor rainfall can reduce the response of the spring discharge, with spring characterised by a predominant quick flow component showing a diminished frequency and/or peak-values of impulses, and spring characterised by a predominant slow flow component showing a reduced annual maximum value. During intense droughts, spring hydrographs present a continuous decreasing trend, which can occur also for two or more consecutive years (multi-years drought). The effect of the temperature increasing and rainfall drop appear well recorded in the spring discharge series, which show a very similar trend inside a wide area of Southern Italy.

Despite a different hydrological regime can be found for different karst springs, a general similar trend can be ascertained, characterised by a general drop of spring discharge since last two decades.

B7-6 Poster Clemente, Paolo

10.1474/Epitome.04.0168.Geoitalia2011

STUDY ON WATER LOSSES EVALUATION FROM IRRIGATION CANALS

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Key terms: canals; losses; seepage; water

Considering regional scale, several tens of thousands km of irrigation canals are present in Piedmont network.

The loss of water due to seepage from irrigation canals constitutes a substantial part of the usable water. Irrigation canals placed in native soil or lined with earth can have seepage water losses varying from 20 % to more than 50 %. Providing perfect lining can prevent seepage loss from canals, but cracks in lining develop and performance of canal lining deteriorates with time. These losses have economic, hydrogeological and environmental consequences. So quantifying irrigation water losses is required for good water management.

The aim of the research is to find an expeditious, fast and reliable method to identify and evaluate losses.

The seepage loss from canals is governed by hydraulic conductivity of the subsoil, canal geometry, difference between the canal water level and the aquifer one. One way to evaluate water losses is using hydraulic laws for porous medium. But, most of times, numerical models does not reflect real conditions because they do not consider many variables, which depend on the specific context. The purpose is to start from numerical models, for a more detailed assessment, by direct measures.

For the purpose, five sections were selected from five different canals, choosed on the basis of the variability in hydraulic, morphological, geological and hydrogeological contexts.

For every investigated canal, hydrogeological and hydrological characterisation have been leaded, in order to understand the relationship between groundwater and stream water (eg. piezometric and hydrogeochemical survey campaigns). Moreover different soil characterization (eg. size distribution) have been carried out on soil sampled from the bottom of investigated canals. Different infiltration tests have also realized in order to evaluate water losses, both for the canals nearby and for the river bed, in the case of drainage during canal maintenance.

In order to reconstruct the local geological setting different penetrometric tests and electrical tomographies (parallel and transverse to the investigated canals) have been carried out.

In a first phase of the project three different methods have been tested in order to evaluate the stream discharge and its variations, by means of measures along different sections of the selected canals.

The first one, represented by the use of floats, gave us first data about stream flow in the canals, after an appropriate correction of the recorded flow velocity.

Mechanical and digital flow meters have been employed also. This method, even if expeditious and practical, is not totally effective and able to assess the real water loss, because of the high instrumental error (order of magnitude).

Finally lots of tracks (slug and continuous injection) have been realized in order to evaluate the stream discharge in canals. In order to reduce the error of this method, driven by the punctual measurement in the streambed, it has been applied a multistage sampling in different points of the cross section, by means of the contemporary water picking up. The results, obtained with the samples mixing and homogenization, guarantee an error decrease. The multistage sampling, in fact, takes into account the irregular blending of the tracer along the considered cross section. It also guarantees, after water mixing into the pump, a more representative value of the whole section.

Because of some unavoidable lack of accuracy, we are testing the application of more rigorous methods based on quantification of artificial tracers mass loss through exfiltration, by means tracers as well as NaCl, Uranine (Fluorescein) and Rhodamine WT. The first results of such tests seem to be more accurate and in accordance with the aim of the research.

SESSIONE B8

Le tecniche DInSAR nel campo della geologia e della geologia applicata: stato dell'arte e prospettive future - In ricordo del Prof. A. Biasini

B8-1 Key Lecture Zucca, Francesco

10.1474/Epitome.04.0169.Geoitalia2011

MAPPING GEOPROCESS BY MEANS OF PERSISTENT SCATTERERS IN PIEDMONT REGION (NW ITALY): FROM PSINSAR TO SQUEESAR

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Key terms: Advanced InSAR; geological processes; Piemonte

In the last years the use of persistent scatterers (PS) SAR data in the studies of some geological slow processes like subsidence (Herrera et al., 2007), landslides (Colesanti and Wasowski, 2006) tectonics (Bürgmann et al., 2006) or building deformations (Gernhar et al., 2009) has shown a rapid growth.

Many national or local authorities decided to use PS on large scale as one of the instruments of natural hazard mapping. We have studied the from regional to detailed scale the potentiality and limitation of this techniques in Piedmont.

In this work are discussed the results of the interpretation of the Radarsat data (2003- 2010) elaborated with SqueeSAR™ methodology compared with the older ERS data interpretation that we made in the last years. In particular we tested some improvement of the data like the time series quality or the higher density in order to check if the mapping and the description of some geological process are really improved.

The Piedmont region is one of largest areas (25'000 km²) covered by PS data. This wide area, required the development of procedure to manage and to interpret so large amount of data. The "anomalous areas" methodology (Meisina et al., 2008) was set up to solve this problem. The interpretation of ERS (1992-2001) data processed with PSInSAR methodology in Piedmont region produced a database of about 2'300 interpreted "anomalous area".

This work allowed us to describe some advantages and disadvantages of PS techniques:

- The interpretation allowed us to detect a lot of ground displacement related to different geological processes in different geological environments (Alps, Langhe Hills, Apennines,...). For instance with PS data we updated the information of some landslides of IFFI inventory.
- The disadvantages showed by the regional interpretation are also a lot: the data available are good only in descending geometry some many slope in alpine region cannot be investigated; in many areas the lack scatterers related to land use reduced a lot the number of process suitable; the time series are not useful because processed with linear algorithm.

Now on the western sector of Piedmont Region we have the possibility to analyse the data (radarast sensors) processed with the more advanced SqueeSAR™ processing (Novali et al., 2009). This processing allow to obtain ground information displacement information not only from traditional scatterers like rock or buildings but also from the distributed scatterers (DS) represented at ground by sparse vegetation areas. The first results showed that this technique joined with the use of both geometries of acquisition and the RADARSAT sensors with low incidence angle allow an increase in the number of processes mapped. The availability of two geometries allowed us to resolve the velocity in the East-West and vertical components and the time series processed with non-linear algorithm allowed a better analysis of the processes. The classical limitations of PS techniques however still to exist: only slow process can be studied; the time-series even better still have some ambiguity related to phase-unwrapping.

It is possible to describes some interesting case histories representative of different geological processes:

- in the Po Plain we tried to compare the PS Time Series with groundwater level and we find a good correspondence with up-lift and subsidence registered by SAR sensors;

- Over a landslide in the Alps the correlation between PS data, field surveys, and other geomorphological observations has allowed us to well know the kinematic, the state of activity and the geometry of the process.

- In the Langhe hills the time series, in spite of some problems, seems match quite well the inclinometers data.

- Another case is represented by some peri-glacial processes in the Alps. With PS data was possible to detect movement of some geofoms formerly considered as non-active.

B8-2 Orale Rocca, Fabio

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MEASURING SUB - MILLIMETER TERRAIN MOTIONS FROM SPACE WITH PRESENT AND FUTURE RADAR SATELLITES.

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Key terms: DInSAR; PSInSAR; Carbon Dioxide; Oil exploration

Optical leveling campaigns, tiltmeters, GPS and InSAR are geodetic techniques used to detect and monitor surface deformation phenomena. In particular, InSAR data from satellite radar sensors are gaining increasing attention for their cost-effectiveness and unique technical features, making it possible the monitoring of large areas, even revisiting the past. Moreover, more advanced InSAR techniques (PSInSAR, SqueeSAR) developed in the last decade are capable of providing millimeter precision, comparable to optical leveling, and a high spatial density of displacement measurements, over long periods of time without need of installing equipment or otherwise accessing the study area.

Thanks to the high density and quality of the measurements the PSInSAR data can be successfully used in geophysical inversion, to measure the permeability of oil reservoirs and/or to evaluate the possibilities and risks due to seismic faulting in the sequestration of CO₂. In these cases, the precision, the sub weekly frequency of the measurements and the time required for the data to be available are the most important aspects, more relevant than the spatial resolution.

Until recently, the main limitation to the application of InSAR was the relatively long revisiting time (24 or 35 days) and the quite long waiting period for the delivery of the acquired data. The new Sentinel-1 mission, based on a constellation of two satellites, is expected to reduce such limitations guaranteeing a revisit cycle of 6 days over Europe and Canada and providing a high level of service reliability with near-real-time delivery of data within 24 hours, important for risk management applications. Results from ground based radar show that this improved precision is indeed achievable from C to Ku band, provided that an accurate model of the delay due to atmospheric water vapor is available or that precise reference points are close by.

B8-3 Orale Bellotti, Fernando

10.1474/Epitome.04.0171.Geoitalia2011

THE SUPPORT OF PSINSAR™ AND SQUEESAR™ DATA TO GEOLOGY AND ENGINEERING GEOLOGY

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Key terms: satellite geodesy; InSAR; ground deformation monitoring; landslide; oil&gas

Permanent Scatterer SAR Interferometry (PSInSAR™) is today one of the most advanced technologies for surface deformation monitoring capable of overcoming most of the limitations of conventional differential radar interferometry. It exploits long temporal series of satellite radar data, acquired over the same area of interest at different times, to identify "natural radar targets" (i.e. the so-called Permanent Scatterers) where very precise displacement information can be retrieved. Recently, some significant advances have been reported in InSAR data processing that can further increase the quality and the effectiveness of this data source: (a) the availability of new processing algorithms: at the end of last year TRE developed a new algorithm (SqueeSAR™) which allows a significant increase in the spatial density of measurement points by exploiting signal returns from both Permanent and Distributed Scatterers (PS and DS); (b) the availability of an increased number of satellite radar sensors characterized by higher spatial resolution (down to 1 m), as well as higher temporal frequency of acquisition (down to a few days, rather than a monthly update). Thanks to its capability to detect small displacements over long periods and large areas, PSInSAR™ analysis can be considered complementary to conventional geological and geomorphological studies in performing landslides inventories at regional scale and supporting the design of early monitoring systems at local scale. The Italian Ministry of the Environment has recently awarded a contract for the processing of more than 12,000 SAR scenes acquired over Italy aimed at creating the first database of interferometric information on a national level for mapping unstable areas. This is somewhat an evidence of the fact that, in less than ten years from its development, this technology has become a standard monitoring tool. Surface deformation monitoring can provide valuable constraints on the dynamic behavior of a hydrocarbon reservoir enabling the evaluation of volumetric changes in the reservoir through time. Depending on depth and reservoir/overburden rheology, volumetric changes in reservoirs due to fluid extraction and injection can induce either subsidence or uplift which could trigger fault reactivation and threaten well integrity. Examples regarding the use of SqueeSAR™ for monitoring hydrocarbon fields and calibrating reservoir models in case of EOR (Enhanced Oil Recovery), CCS (Carbon Dioxide Capture and Sequestration) and UGS (Underground Gas Storage) will be presented. The availability of surface deformation data can be helpful during site characterization in infrastructure design, as well as during the construction and the operation phase. An overview of applications in the railway field, with particular reference to case studies involving underground works, will be provided.

B8-4 Orale Morelli, Michele

10.1474/Epitome.04.0172.Geoitalia2011

ISO-KINEMATIC MAPS FROM STATISTICAL ANALYSIS OF PS-INSAR DATA OF PIEMONTE, NW ITALY: COMPARISON WITH GEOLOGICAL KINEMATIC TRENDS

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Key terms: Permanent Scatterers; spatial statistic techniques; active tectonics; Piemonte (Italy)

SAR interferometry based on Permanent Scatterers (PS-InSAR™) is used here to study the present crustal mobility of a large area of NW Italy, in the Piemonte region. Thirty-eight satellite scenes (ERS SAR), taken from May 1992 to January 2001, were analysed for detecting more than 2 million PS on the study area. Continuous velocity surface maps (Iso-Kinematic Maps: IKM) were obtained from geo-statistical and spatial cluster techniques (Hot Spot analysis) of PS "short-period" data, to identify relative ground motions and to compare them with "long-period" tectonic mobility trends, i.e. those inferred at regional scale over geological times (some million years). The comparison was made by individuation of homogeneous kinematic areas, represented in the IKM, and characterization of the boundaries between them (Iso-Kinematic Boundaries: IKB). The IKB were used as tools to assess if the PS-InSAR data on present-day crustal mobility could fit with the distribution of real tectonic structures or field geological elements. IKM were drawn for uplifting geological sectors of Piemonte (Maritime Alps, Gran Paradiso, Langhe) where moderate to very low seismicity is recorded, and gravitational instabilities of rock mass on mountain slopes are widespread. The land sectors have been chosen in order to test the suitability of IKM in very different geomorphological conditions. Different types of correspondence between the IKM and the geological kinematic trend were found:
- a first type in which the kinematic trend of short-period (a decade of years, i.e. the PS-InSAR detection time span) is in agreement with a long-period tectonic trend (some million years) and seem to be driven by well known faults subparallel to the IKB. These kinematic trends can be hidden by the slope movement due to gravitational instabilities;
- a second type in which the kinematic trend of short-period does not strictly correspond to the long period trend, but can be considered as minor-order, uplifting-subsidence cycles, even if in contrast with the long-period kinematic trend. Alternatively, the short-period kinematic trends could reflect the action of deep-seated geological forces or structures, not yet known or inferable (at least with the recorded PSInSAR velocities) on the basis of the available geological data and models.

B8-5 Orale Amato, Vincenzo

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AN INTEGRATED MULTIPROXY APPROACH TO EVALUATING THE VERTICAL MOVEMENTS OF THE SELE PLAIN (SOUTHERN ITALY): DIN-SAR AND MORPHO-STRATIGRAPHICAL DATA

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Key terms: Sea level change; DinSAR data; Morpho-stratigraphy; Uplift/Subsidence; Campania

The predicted sea level rise caused by ongoing climatic changes is one of the main problems for the management of the coastal areas, in particular for the low coasts. It's the case of many Italian coastal plain generated by delta and lagoonal-barrier trasgressive/progradational systems during Late Quaternary sea level rise. In the Campania region, the Sele river coastal plain. It is confined seaward by a straight sandy coast formed during the Last Interglacial and the Holocene, and represents the evolution of a barrier-lagoon system shifted alternatively landward and seaward as a result of the eustatic sea level changes. The back-barrier depressions, only recently reclaimed by drainage channels, located an altitude from 0,5 m to 2,5 m a.s.l., could be subject to flood risks by future sea level rise. In order to model possible future scenarios to the sea level rise, it's very important to understand the vertical movements of the coastal area, was interested by local or semi-local vertical ground movements. In order to evaluate subsidence and uplift phenomena with a good approximation in all the sectors of the plain, we compared morpho-stratigraphical data with available ground deformation rates derived by DinSAR data (Settore Difesa Suolo-Regione Campania, 2008).

In this work we present the preliminary results of our integrated approach. The morpho-stratigraphical approach used data by the geological literature and by new boreholes, drilled in different locations of the coastal area. The stratigraphical analysis was integrated by chronological data (14C absolute datings and archeo-tephro-stratigraphical relative datings), by palaeo-ecological data (ostracoda, benthic foraminifera and mollusks assemblage) and by pollen data. This approach also allowed the identification of some palaeo-sea levels of the Upper Pleistocene Age and in particular of the Holocene Age (Amato et al, 2011). Comparing the paleo-sea level data with those of the tectonically stable areas (Antonoli et al, 2008; Lambeck et al, 2004) we can notice some altitudinal discrepancies. In particular, in the SE sector of the coastal plain, near Paestum, the Holocene paleo-sea levels are slightly more high (1-2 m). These values show the area gently uplifting during Holocene times (< 0,5 mm/yr). In the central sector of the plain, near the Sele River, and in the outer NW sector, between the Sele and Tusciano river mouths, the altitude of the Late Quaternary coastal and lagoonal deposits are slightly more low (2-3 m). These values show the area gently subsiding during Holocene times (< 0,7 mm/yr).

On the basis of Din-SAR data, the coastal sector of the Sele plain is characterized by a complex vertical velocity pattern during 1992-2000 time period (Vilardo et al., 2009a). Northward Sele river, a 2 km-wide strip coast-line backward area is clearly characterized by a relative subsidence rate of about 5-7 mm/yr and a relative uplift rate of 1-2 mm/yr occur westward Battipaglia town. The differential vertical rate is of about 6-9 mm/yr along a distance of 6-7 km. A localized area of strong subsidence (up to 8 mm/yr) develops along the river Sele course from 2 to 7 km from the coast in the surroundings of Hera Argiva sanctuary ruins. Southward Sele River, localised subsidence areas are present nearby Capaccio Scalo town only with a relative subsidence rate of about 1-3 mm/yr.

The more recent relative vertical movements derived from Din-SAR data seem to agree with the morpho-stratigraphic data, showing trends of movements that are more durable and will probably cover a consistent part of the Upper Pleistocene and Holocene. As preliminary hypothesis, the vertical movements could be induced by NW-SE and NE-SW trending faults dissecting the plain. In particular the NW sector could be interested by NW-SE fault, lowering the outer part of the plain; the central sector could be interested by two NE-SW faults, lowering the actual Sele river valley, as a like-graben area.

B8-6 Orale Bignami, Christian

10.1474/Epitome.04.0174.Geoitalia2011

THE POSSIBLE CAUSE AND EFFECT RELATION BETWEEN THE SEPTEMBER 2010, DARFIELD EARTHQUAKE, AND THE FEBRUARY 2011, CHRISTCHURCH "AFTERSHOCK"

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Key terms: DinSAR; Coulomb Failure Function; Fault Modelling; New Zealand

On September 2010 a Mw 7.1 earthquake took place along a previously unrecognized east-west fault line, the strike slip Greendale fault, close to Darfield (Canterbury). About five months later, on February 2011, another seismic event of Mw 6.3, hit the city of Christchurch. It was generated by a blind thrust fault, occurred approximately 6 km south-east of city centre. This second event is located at the easternmost limit of the Darfield aftershocks distribution. In the present work we investigated the possible causal relationship between these two earthquakes. For this purpose, two pairs of ALOS PALSAR images acquired along two adjacent tracks have been exploited to retrieve the deformation fields of the two earthquakes. The pre-seismic images have been acquired on August 13, 2010, and January 1, 2011, respectively, while the post-seismic data were on September 28, 2010, and February 25, 2011. The displacement fields from both shocks have been derived by means of Differential SAR Interferometry (DinSAR) technique. In particular, the September 2010 earthquake generated a complex pattern due to the activation of the Greendale fault and other secondary buried thrusts. A linear inversion algorithm has then been applied in order to calculate the fault's features, exploiting the DinSAR results. By evaluating the Coulomb Failure Function, the connection between the first earthquake in promoting the rupture of the second has been analyzed. The outcomes of such analysis, shows that the more shallow part of the Christchurch fault has been unloaded by the Darfield earthquake, whereas, at the same time, the deeper part of the fault has been brought closer to the rupture.

B8-7 Orale Canova, Fabio

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LAND SUBSIDENCE AND ACTIVE TECTONICS OF A FORELAND AREA FROM SBAS-DINARSAR TECHNIQUE (HYBLEAN PLATEAU, CENTRAL MEDITERRANEAN)

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Key terms: SBAS; subsidence; active tectonics; aquifer-system compaction; South-eastern Sicily

Advanced DInSAR technique represents the most innovative geodetic technique developed in the last decade, allowing the analysis of the spatio-temporal progression of typically seasonal or evolving deformations phenomena. The wide spectrum of investigated phenomena includes subsidence induced by fluid extraction, mining, sink-holes, as well as landslides, tectonic, volcanic and urban area deformations. We applied the Small Baseline Subset (SBAS) DInSAR algorithm by Berardino et al. (2001) to a dataset composed of ERS 1-2 SAR data, spanning from 1992 to 2000 and covering part of the Hyblean Foreland, in SE Sicily. The SBAS algorithm, unlike most of the DInSAR techniques, does not rely on point-like targets unaffected by temporal and spatial decorrelation (Persistent or Permanent Scatterers; PS) to calculate displacement time-series. This technique detects even distributed scatterers, maximizing the coherent pixels density. This is obtained using an appropriate combination of SAR image pairs grouped in several independent interferometric Small Baseline Subset (SBAS), linked using the Singular Value Decomposition (SVD) method. We computed 200 and 136 interferograms, from descending and ascending data, and we inverted them retrieving the ascending and descending mean velocity maps. These maps show the deformation along the Line of Sight (LoS) of the satellite (23° with respect to the vertical for ERS 1-2). Displacement time series are available for each of such coherent pixels. The East and Vertical deformation components of the deformation were successively estimated for each pixel common to both the velocity maps.

We compared and validated SAR deformation rates with permanent and campaigns GPS data, morphotectonic and geoarchaeological analyses. The residual values we found fall within the standard deviations (1 mm/a for the Up and 2 mm/a for the East component) reported in literature for East and Up mean deformation velocity maps obtained with the SBAS algorithm and similar ERS dataset.

The tabular morphology of the Hyblean Plateau prevented perspective distortion (shading, foreshortening or layover), resulting in a high coherence all over the area. The scarcity of vegetation, plenty of outcrops and developed sites along the Ionian coast as well favored a striking density of the data.

Using velocity profiles, time series and geostatistical analysis we detected: 1. previously undetected subsidence patterns, in particular the Augusta, Villasmundo, Priolo and Siracusa subsiding areas. Deformation rates reach values up to -18 mm/a, and are mainly attributed to subsidence induced by fluid extraction.

2. a slight uplift (1 mm/a) of the Hyblean Plateau s.s. with respect to the Ionian area, which is quasi-stable, in good agreement with morphotectonic and geoarchaeological data (residuals well below 1 mm/a). In details, morphotectonic rates deriving by paleontological dating and geoarchaeological sites showed the best correlation.

3. the East velocity field points out a major subdivision of the Hyblean foreland in two tectonic domains; the almost stable Hyblean Plateau s.s. and the Ionian area, moving westward. These two domains are separated by a NNW-SSE striking and well constrained deformation belt, showing a deformation gradient much higher than the rest of the study area. We called this feature the Florida-Cassibile Weakness Zone (FCWZ). The FCWZ is parallel to the submerged Malta escarpment and it is located in correspondence of a retreat of this morphological escarpment towards SW; we interpret it as an inherited extensional fault system presently undergoing tectonic inversion. The integrated use of SAR and GPS suggests that the FCWZ works as a left-lateral deformation belt, accompanied by a secondary compressional component, under the current stress field caused by the NW-SE oriented Africa-Eurasia convergence.

B8-8 Orale Moro, Marco

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HIGH RESOLUTION ANALYSIS OF LARGE, SEISMICALLY INDUCED GRAVITATIONAL DEFORMATIONS

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Key terms: Differential SAR Interferometry; Large gravitational deformations; L'Aquila earthquake

We have studied large gravitational deformations triggered by the Mw = 6.3 L'Aquila earthquake, which occurred in the Abruzzi region of central Italy on April 6, 2009. Indeed it is common knowledge that the strong ground motions caused by large earthquakes can induce gravitational collapses. By means of the Differential SAR Interferometry technique and using a couple of high resolution COSMO-SkyMed (Constellation of Small Satellites for the Mediterranean Basin Observation) X-Band synthetic aperture radar (SAR) data acquired on April 4, 2009, and April 12, 2009, respectively, we have obtained an accurate and spatially continuous measure of the co-seismic ground displacement at 5m resolution. Within the classical low frequency fringe pattern belonging to surface co-seismic deformation caused by the normal fault dislocation, we have observed higher spatial frequency fringe patterns suggesting localized deformation not related to the fault displacement field. In particular, we show two examples of subtle (4-5 cm) deformation patterns associated with long-term gravitational mass movements recognized through geological and geomorphological interpretation. We give an interpretation of the deformation mechanisms by integrating geological analysis and simple analytical modeling of the Differential SAR Interferometry (DInSAR) observations.

B8-9 Orale Solaro, Giuseppe

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SURFACE DEFORMATION ANALYSIS IN VOLCANIC AND SEISMOGENIC AREAS VIA THE SBAS-DINSAR APPROACH

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Key terms: DInSAR; Deformation; SBAS

Differential Synthetic Aperture Radar Interferometry (DInSAR) is a remote sensing technique that allows us to produce spatially dense deformation maps with centimeter to millimeter accuracy. An effective way to detect and follow the temporal evolution of deformation is via the generation of time-series; to do this, the information available from each interferometric SAR data pair must be properly related to those included in the other ones, via the generation of an appropriate sequence of DInSAR interferograms. In this context, several approaches have been already proposed. Among these procedures, we consider the one referred to as Small Baseline Subset (SBAS) approach that implements an appropriate combination of DInSAR interferograms generated from SAR images pairs characterized by a small spatial and temporal separation (baseline) between the acquisition orbits.

In this work we perform a full exploitation of SBAS technique to investigate long and short term surface deformation occurring in some selected volcanic and seismogenic areas. To this aim we benefit of the SBAS technique capability to work in multi-frame and multi-sensor scenarios in order to improve the spatial and temporal coverage, as well as to employ new generation SAR sensors to increase the temporal sampling of the retrieved time series. In this work we apply the SBAS algorithm to analyze the temporal evolution of the detected displacements affecting different deformative scenarios by means of deformation time series retrieved through data acquired by European (ERS-1/2, ENVISAT) and Italian (COSMO-SkyMed) satellites. In particular, as a first step we focus on the analysis of the deformation patterns associated with the activity of the North Anatolian (NAF, Turkey) and the Lazufre volcanic area (Chile) retrieved by the ERS-1/2, ENVISAT sensors. Then, as a final issue, we show the benefit that may derive from the shortened revisit time of the new generation SAR sensors if compared to that of the C-band systems. Accordingly, we present the results we achieved by applying the SBAS approach to a set of COSMOSkyMed SAR data over Abruzzo region, Neapolitan volcanic area and Etna volcano; accordingly, we show the strong impact that the new generation sensor data (such as the COSMO-SkyMed ones) may have in seismic and volcano deformation analysis, particularly in terms of spatial coverage and temporal sampling of the retrieved measurements.

B8-10 Poster Ambrosi, Christian

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THE LANDSLIDE INVENTORY OF CANTON TICINO: STATISTICAL ANALYSIS AND COMBINED OBSERVATIONS OF SLOPE MOVEMENTS USING SATELLITE AND GROUND BASED SAR INTERFEROMETRY.

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Key terms: landslide; inventory; SAR; interferometry; photogrammetry

The landslide inventory of the alpine areas of Cantone Ticino (about 1000 km², southern Switzerland) is a large database with more than 2000 phenomena. The inventory is aimed to provide a support tool for landslide hazard assessment.

Inventory was done by means of aerial photo-interpretation. The interpretation of optical images is commonly applied in support of landslide inventories. Based on aerial photography interpretation complemented by field surveys and historical records, landslide inventory maps were produced. The aerial photographs (Swisstopo) are available at 1:20'000 scale and were taken in the last 50 years. Using stereoscopic images landslides were distinguished by typology, depth and activity. The high resolution of aerial digital photographs has also permitted to recognize the geomorphological features associated by mass movements, such as scarps, counterscarps, trenches, debris flows, debris fans and rockfalls. The state of activity was performed by means of available monitoring data, satellite and ground based SAR measurements and morphological features.

A statistical analysis was performed on the landslide dataset and it enhances the relationships between landsliding and several geological and environmental factors. Lithology exerts a strong control on landslide distribution.

B8-11 Poster Bignami, Christian

10.1474/Epitome.04.0179.Geoitalia2011

THE SURFACE DISPLACEMENT FIELD AND SOURCE MODELING OF THE TOHOKU-OKI EARTHQUAKE

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Key terms: DInSAR; Source Modelling; Tohoku-oki; Earthquake

On March 11th, 2011 (at 05:46:23 UTC) a Mw 9.0 earthquake occurred offshore the coast of Honshu island (Japan).

It was generated along the subduction plate boundary between the Pacific and the North America plates and was followed by a destructive tsunami of rare power, which cause wide and heavy damage along the coast of Honshu island. The epicenter was located at about 130 km East of Sendai city at a depth of about 32 km. All the data related to location, geometric parameters, and focal mechanism agree with the occurrence of the seism along the subduction plate boundary.

The mainshock ruptured about 300 km x 150 km along the fault plane, and a maximum slip was estimated up to 30-40 m. Soon after the seism some of the most important Space Agencies, JAXA (Japanese Space Agency), ESA (European Space Agency), DLR (German Space Agency), NASA (National AeroSpace Agency) and CNES (French Space Agency) provided a large number of SAR and Optical data, covering the whole epicentral area.

We applied the Differential SAR Interferometry (DInSAR) technique to a dataset composed of 27 Envisat - C band SAR - IS6 frames along three adjacent tracks and to a set of ALOS PALSAR - L-band SAR - Fine Beam Single polarization (FBS) and Fine Beam Dual polarization (FBD) along ascending and descending paths.

The obtained interferograms have been unwrapped over each track and a maximum displacement of about 2.5 m has been measured along the

Envisat IS6 LOS. Parallely, we applied the same approach to the ALOS PALSAR dataset. Inm order to calculate the displacement along North, East and Up directions, we applied the SISTEM approach that simultaneously integrate DInSAR and GPS vectors. Finally, we used the output from SISTEM for the inversion of seismic moment release. During this cruise event, ESA made available data from the ERS2 satellite, too. ERS2 platform was previously moved on a new three days revisiting time orbit. Precise orbit files, based on Laser Range data, were also delivered with only two days delay. The optimal ERS2 orbital control allowed getting very short baseline values that with the three days revisiting time gave a chance to get an almost continuous monitoring system, allowing a near-real-time data processing. Besides that we had the possibility to extract just the coseismic deformation field with the postseismic deformation filtered out. The choice of the ERS2 processed interferograms, has been done based on the occurrence of some strong aftershocks (April 7th, M7.4 and May 5th, M6.3) after the mainshock of March 11th.

B8-12 Poster Brunori, Carlo Alberto

10.1474/Epitome.04.0180.Geoitalia2011

DINSAR AND OPTICAL REMOTE SENSING TECHNIQUES TO SUPPORT THE GEOLOGICAL ANALYSIS IN VOLCANIC AREAS: THE CERRO BLANCO/ROBLEDO (NORTHWEST ARGENTINA) VOLCANIC COMPLEX CASE STUDY.

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Key terms: geology of volcanoes; DInSAR; remote sensing; ground deformation; geomorphology

Calderas are roughly circular depressions and are distinctive features in volcanic areas. These structures are some of the most studied volcanic features, particularly for their possible implications for hazard assessment and mitigation. In this work we process optical and microwaves remotely sensed data in order to study geological features of Cerro Blanco/Roblede volcanic complex, located in northwest Argentina. Ground deformations associated with the present-day volcanic activity are measured using DInSAR techniques, in particular by means of time series analysis. The Cerro Blanco/Roblede caldera, is unusual among the actively deforming volcanoes because it is subsiding. An ENVISAT-ASAR dataset has been processed on a descending track spanning from 29/04/2004 to 23/01/2007 using StampS/MTI software. In a previous study, the measured rate of subsidence seems to decrease with time from a maximum of more than 2.5 cm/yr in the radar LOS (interferograms spanning 1996/7-1992) to less than 1.8 cm/yr (2000-1996). In this work we obtain a velocity map of the area showing a rate of subsidence of 11 mm/yr in the radar LOS, confirming the deformative trend. Terra-ASTER data will be used in order to depict the surface distribution of erupted products and their evolution with respect to time. The surface classification will be performed by using both the L1B Terra-ASTER data and L1B atmospherically corrected data set. A comparison among the results obtained by means of different atmospheric correction tool will be done. All the results will be compared with the available geo-lithological map also by using DTM understanding the role of the morphology on the recent volcanic evolution.

SESSIONE B9

Analisi e controllo dei rischi connessi con l'instabilità dei pendii in ambiente montano

B9-1 Key Lecture Troisi, Carlo

10.1474/Epitome.04.0181.Geoitalia2011

SOME CONSIDERATIONS ABOUT THE ROLE OF PUBLIC AGENCIES IN COPING WITH THE GEOLOGIC HAZARD

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Key terms: public agencies; geologic hazard; risk perception

If confronted with other types of natural or human-generated hazards, the geologic hazard (s.l.) poses some peculiar types of problems. The geologic hazard is (usually, at least) not human-generated and nobody can therefore be taken as responsible for generating it or for not conforming to given security standards. Geologic hazard and the deriving risk, is almost universally coped by public agencies and, almost universally, a number of such agencies are involved each one with its own mission, hierarchy, political mandate, budget, legal basis, technical and administrative structure. Moreover some of the involved agencies may have conflicting interests, such as the case of a Development Agency and a Geologic Survey posing some kind of restrictions over a new industrial area. The result is that, in many cases, procedures and competences are unclear and many actions may therefore be ineffective. Another point to be considered is the perception of geologic hazard and risk by the populations and by the local representatives (in Italy, at least). Unlike other hazards (such as the car accidents-related hazard) the geologic one is often very poorly understood and it is perceived in a variety of biasing modes, last but not least the diffused belief that "if what should be done was done" no heavy rains (or other natural phenomena) could produce negative effects, giving almost no allowance for any residual risk. This attitude often results in a strong demand, by local councils, for actions which may be of little effectiveness or even be counter-productive.

B9-2 Orale Dal Piaz, Giorgio

10.1474/Epitome.04.0182.Geoitalia2011

LARGE GRAVITATIONAL DEFORMATIONS AND MASS-MOVEMENTS IN THE NORTH-EAST AOSTA VALLEY, WESTERN ALPS.

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Key terms: gravitational deformation; mass movement; DSGSD; Aosta valley; Western Alps

Gravitational slope and ridge deformations extensively developed in the Aosta valley from the retreat of Olocene glaciers. Most of them are active, at least partly, and may be a relevant risk factor. Numerous deep-seated deformations (DSGSD; Terzaghi, 1962; Dramis 1984; Mortara & Sorzana 1987; Bertolo, 1990; Bistacchi & Massironi 2001) have been recognized and mapped by the CARG Project (e.g., sheets Chatillon, 2010, Aosta and Courmayeur, in press). Here we focus on other gravitational deformations along the left side of the Aosta valley, from the Valtournanche (Motta di Pletè, Cime Bianche, Petites Murailles-Bobba, Punta Fontanafredda), Ayas (Piure-Ruine, Tantanè-Portola) and Gressoney (Seehorn-Gabiet) valleys to the Challant-Mt Jovet watershed (Arbaz-Arlaz). They occur within the sheets Monte Cervino, Monte Rosa and Verrès we have mapped in the last decade. These DSGSD are poorly influenced by lithological setting, since they are mainly developed in calcschists and/or ophiolitic units of the Combin zone (Motta di Pletè, Cime Bianche, Punta Fontanafredda, Piure-Ruine, Seehorn), but also in the ophiolitic Zermatt-Saas zone (Arbaz-Arlaz), Dent Blanche nappe (Petites Murailles), Pilonnet-Combin contact (Tantanè-Portola eastern side), and glacial deposits (Valtournanche village). Low-angle thrusts, regional schistosity and lithological bedding are influential factors in the Cime-Bianche case and probably also in the Motta di Pletè, along staircase deformed segments of the Pancherot-Cime Bianche decollement cover unit. Other DSGSD are characterized by high angle out-off-sequence cuts, slow spreading and various amount of lateral displacement. Striking features are crest doubling, open trenches, block rotation along gravitational listric faults with normal displacement and antithetic uphill-facing scarps, boulders or chaotic land-slides in the frontal part. Maximum downslope and lateral displacements are hectometric and kilometric in size, respectively. Bilateral ridge deformations characterize the Piure-Ruine and Seehorn crests, even if the most relevant processes developed in the western slope, favoured by the westward merging regional schistosity and metamorphic bedding. Doubling occurs also in east-west-trending crests (Punta Fontanafredda, between Chamois and Cheneil). The Motta di Pletè DSGSD shows various systems of open trenches that mark the active gravitational stress-field in the mountain range over Cervinia. As a whole, the Motta di Pletè morphostructure may be envisaged as a small-scale natural homologue of continental rifting. Regional brittle tectonics in the study area is dominated by the Aosta-Ranzola line and other Oligocene-Neogene fault systems (Bistacchi et al., 2001), but the main causes of the concerned gravitational processes are post-glacial unloading and high relief-energy of slopes which display a vertical development up to 1.000 m, facilitated by NNE- and N-trending joints. In the Arbaz-Arlaz case, pervasive fracturing and alteration are also related to the emplacement of gold-quartz veins within a ridge of metabasalt and some serpentine slivers, later erased by the Ayas and Aosta glacial confluence. The Petites Murailles sackung (Swiss sheet Matterhorn, 2003) can be better regarded as a huge and fast land-slide, since this basement slice displays a high-angle gliding surface with black cataclasis (Rifugio Bobba prong). The relatively smaller Valtournanche case is equally noticeable because the DSGSD involves the glacial deposits on which the chief town is built up, and their slow flow is induced by fluvial erosion.

B9-3 Orale Pirulli, Marina

10.1474/Epitome.04.0183.Geoitalia2011

RAPID LANDSLIDE RUNOUT SIMULATION: A THOROUGH USE OF NUMERICAL MODELS

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Key terms: rapid landslide; numerical modeling; runout; continuum mechanics

Rapid landslide runout analysis, the prediction of landslide motion and its effect, is an essential component of landslide risk assessment. Numerical simulation can provide a useful tool for investigating the propagation phase of phenomena involving granular material, like debris flows, debris- and rock-avalanches. In the attempt of modeling landslide dynamics, methods based on discontinuum mechanics and continuum mechanics have nowadays emerged as promising approaches. Discontinuum methods model the run out mass as an assembly of particles moving down a surface. Each particle is followed as it moves and interacts with the stationary bedrock and with its neighboring particles. Continuum methods resort to an "equivalent fluid", that is a hypothetical material, whose properties do not correspond to those of any of the slide components but are intended to be able to simulate the bulk behavior of the moving mass. The use of these two approaches have advanced incrementally over the past three decades to the point where, when used in combination with careful engineering and geological judgment, first-order runout prediction appears to be possible. However, there is still considerable room for improvement.

It is here evidenced that whatever the applied numerical model, results of a simulation depend on many aspects that have to be critically considered and not neglected when reliability of both runout results and numerical models are considered.

In this regard, three key aspects for a numerical simulation are discussed in the following:

1) Digital Terrain Model (DTM) resolution; 2) Morphology and substrate influence on rheology; and 3) Entrainment process. The role of each of the above aspects is here analyzed through the application of RASH3D, that is a numerical code based on a continuum mechanics approach and on the St. Venant hypothesis for shallow flows. Similar considerations are valid if a discontinuum model is applied.

The importance of onsite surveys and DTM resolution is here discussed with reference to the 2000 Nora debris flow which had place in the Italian Alps and where the mass split in two branches during the runout process. Comparison of numerical results obtained with the two available pre-event DTMs, which have a 10m and a 5m resolution, respectively, has evidenced that for this case only the high resolution DTM allowed to properly reproduce the runout process. Moving to the second aspect, it can be evidenced how the failure of soil and rock slopes under natural conditions involves a variety of mechanical processes that can produce several kinematically and structurally distinct types of landslide phenomena. As to this, the 2004 Thurwieser rock avalanche (Italian Alps) whose runout path was partially covered by a glacier was analysed with different rheologies.

Whatever the rheology is, it emerges that a correct simulation is possible only if a change in rheological properties is considered in the glacier area. Finally, it is observed that the entrainment of channel path material plays an important role during run-out of many rapid landslides. Such mechanism is able to change significantly the mobility of a flow, through rapid changes of the flow volume and rheology. The case of the 2000 Tsing Shan event (Hong Kong), which was characterized by an important increment of volume during the runout process (from 150 m³ up to 1620 m³) was correctly simulated only if the entrainment was considered in the carried out numerical modeling. In conclusion, the findings of analyses have showed that the selection of an appropriate DTM resolution depends on the type of event to analyze. Furthermore, a detailed knowledge of geological and morphological feature and of the entrainment process, that are fundamental characteristics of the flow dynamics, cannot be neglected when a case is studied.

B9-4 Orale Tiranti, Davide

10.1474/Epitome.04.0184.Geoitalia2011

COMPARISON OF RESULTS FROM A TRANSLATIONAL-SLIDES PREDICTION MODEL WITH DATA RECORDED BY THE REGIONAL LANDSLIDES MONITORING NETWORK OF PIEMONTE (NORTH-WESTERN ITALY)

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Key terms: warning system; antecedent precipitations; Langa hills; South Piemonte; North-western Italy

Several studies were made on landslides of Piemonte (North-western Italy) in order to improve the evaluation of slope instability in this region. In detail, this study outlined the relationship between antecedent precipitations and activation of a particular type of landslide that occur mainly in a southern hilly sector of the Tertiary Piemonte Basin called Langa. The studied landslide type corresponds to a translational rock-block slide involving wide sectors of sedimentary bedrock. The Langa hills are particularly renowned for the cultivation of valuable vines, therefore, constitute a place of important economic and tourist interest. Furthermore, the high density of structures and infrastructure in this area exposes a number of elements to the activity of these large landslides. In order to minimize human and economic losses, it is particularly important to establish a warning system capable of providing sufficient advance announcement for activation of translational rock-block slides. In this direction, the Environmental Protection Agency of Piemonte (Arpa Piemonte) developed a precipitation-thresholds based model, also considering the contribution of snowmelt, according to previous studies and to an extensive collection of historical data on landslides movements since 1926, related to a complete meteorological dataset. The regional meteorological gauges network and the forecasting service of severe weather provide input data to the model. Moreover, the output model results can be tested by the observations from the regional landslides monitoring network consists of inclinometers and piezometers, managed by Arpa Piemonte.

B9-5 Invitato Marchisio, Claudio

10.1474/Epitome.04.0185.Geoitalia2011

GEOLOGICAL DATABASES FOR RISK PREVENTION: NEW PERSPECTIVES

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Key terms: geological databases; geological data production processes; geological staff competence; open source software

Over the past twenty years software used to support the management of geological data has undergone a substantial evolution: in the geological departments of Regione Piemonte and Arpa Piemonte we have evolved from software developed ad hoc, to proprietary software, and from the first databases available on personal computers to relational databases and to complex geographic information systems.

At each step, functional enhancements have been made to meet the growing technical demands of daily use to manage a significant amount of descriptive data, iconographic and geographic information.

But this evolution has changed both the processes of production of databases and the skills of the staff involved. The time in which we can plan to use in a systematic and not just experimental way information technology throughout the process of making of databases, from the measurement to the delivery of the final services is approaching.

Starting from these assumptions Regione Piemonte and Arpa Piemonte have launched initiatives to evolve both the tools and the knowledge of the technicians involved, growing their awareness of knowing how to manage these tools. Both organizations have therefore begun jointly to migrate some data sets used in domestic production processes from outsourced platforms, implemented and managed by external suppliers but not maintained any longer, to platforms managed directly by technicians inside the organizations.

This development is influenced by the dramatic scarcity of resources available to support the software development. In this context open source software combined with the increased staff competence plays a leading role. This particular combination makes it possible to overcome the shortage of resources necessary to purchase new software or to adapt existing ones, while the increased staff competence allows the improvement of the production capacity so that it is not so affected by staff shortages. Moreover reusable software and interchangeable experience make it easier collaboration between public authorities than solutions that use only proprietary software.

Regione Piemonte and Arpa Piemonte have started the process of conversion of both technical geological databases (geotechnics, inclinometers, sources and documentation, SIFRAP, alluvial fans, Damage) and administrative ones, using open source or otherwise free of license costs software.

B9-6 Invitato Lanteri, Luca

10.1474/Epitome.04.0186.Geoitalia2011

THE UPDATE OF ARPA PIEMONTE LANDSLIDE INVENTORY IN THE RISK-NAT PROJECT

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Key terms: landslide inventory; Risknat; SAR; geodatabase

One of the main goals of the strategic Project RISK-NAT, a programme for Italian-France cooperation (Objective 3 ALCOCTRA) is to develop operative tools that can be helpful for land planning and risk management. Especially the B2/C2 working package is aimed to improve the knowledge of the hydrogeological risks in the alpine region and to make available an easy to use and updated framework about natural risks both to common people and administrations.

Starting from the end of '70, the Geological Survey of Regione Piemonte collects information concerning flooding, landslides, geomorphological characteristics of earths and rocks; now the Thematic Department "Geologia e Dissesto" of ARPA Piemonte (Regional Agency for Environmental Protection) is in charge of maintaining this valuable resource and to keep it up to date. From 2000 to 2004 the IFFI project (The Italian landslide Inventory) contributes to the production of a national homogeneous landslide information system: a first level of knowledge, that defines a basic landslide classification (shape, location, state of activity and typology) was reached on the whole region. Now the activity of the RISK-NAT Project is focused to improve the knowledge on the more serious phenomena where detailed examination is needed. Different kind of data are integrated together in order to obtain an effective knowledge of phenomena: detailed morphological analysis, carried out mainly by air-photo interpretation and some aimed field survey, are coupled with the outcome of the monitoring system of Arpa Piemonte. The Agency manage several devices installed all over Piemonte to monitor landslides that occur close to facilities or built-up areas. The network includes about 300 monitored sites, up to now. The monitoring network includes many sites with few, mostly conventional instruments (inclinometers, piezometers, extensometers, and topographic benchmarks).

Another important instrumental data is provided by PSInSARTM analysis technique: indeed, space borne radars are able to increase the potentialities of the monitoring network because it integrates the punctual and accurate information of monitoring system with a superficial but extensive data for the whole region. In 2007, a PSInSARTM analysis was made over the entire region (~25'000 km²) using data sets from ERS-1 and ERS-2 radar satellites. The results identified about 2.5 millions covering the time span from 1992 to 2001. In 2010, thanks to the funding of Risknat project, an alpine area of about 13'000 km² was covered using data sets from Canadian RADARSAT satellite. The survey was made using a newly patented processing algorithm (the SqueasarTM) and identified more than 2 millions PS for the time span from 2002 to 2009.

The results of this integrated approach are particular positive: the comparison of data issued from different monitoring systems has allowed to obtain an important cross-validation, especially for the brand new SqueasarTM technique, where there are few case studied.

All the data are stored in a geographic PostGIS database and they can be accessed by different instruments. Furthermore, some tools was developed in order to allow data analysis and plotting data directly with an open source GIS.

Up to now about more detailed analysis, corresponding to the so called second level of in-depth examination, was made for about 180 landslides and it could be 300 at the end of the project. In order to spread the second level data in a standard format a specific report was made. The reports contain a detailed cartography, some iconographic enclosure, a set of standard information and some textual descriptions. For few landslides, when the knowledge are more detailed, a completely text-form are filled out.

All informations are spreading by a specific webGIS service, available from the website of Arpa Piemonte and now also from the RISK-NAT project geoportal (<http://www.risknat-alcotra.org/>).

B9-7 Orale Cencetti, Corrado

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A CENSUS OF LANDSLIDE DAMS IN A SECTOR OF CENTRAL-NORTHERN APENNINES: SOME CONSIDERATIONS AND ANALYSIS.

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Key terms: northern-central Apennines; landslide dams; threshold for triggering relations

Landslide dams are typical phenomena of hilly and mountainous environments. The aim of this work was make a census of landslide dams of the central-northern Apennines (central Italy), covering the regions of Umbria, Marche, Tuscany and Latium.

In order to manage all collected data, a landslide detection card and a linked database were implemented to record all informations.

The card and the database are splitted in several sections related to different topics (general informations, morphological and geological data, dam typology, predisposing cause, damages, etc.).

A specified graphical user interface was created to upload data into database.

All collected data was used to make some statistical correlations with the most important parameters of each landslide event.

The considered aspects were: spatial-temporal collocation; kind of slided material; landslide typology; natural dam characterization; volume of slided material; width of channel and alluvial plain.

Regarding the spatial-temporal collocation, almost all slides are located in the west side of Apenninic chain and involve sandstones and marls in facies of flysch outcropping.

The most common kind of landslide is sliding (rotational and traslative), while the most frequent type of dam is the type I (using the Costa & Schuster classification, i.e. dam having a width smaller than the width of the floodplain and where the slide does not reach the opposite slope of alluvial plain).

The analysis of all registered landslides shows that for 30% of all cases a dam-lake was not formed or because the stream flow has deviated his path bypassing the obstruction, or because the material was rapidly

removed by the water flow.

For rest 70% cases, the dam-lake evolved in different ways: from the natural drain out up to become a stable lake (5% of cases). Another important observation lies in the fact that alluvial plains wider than 300 m never were dammed by a landslide.

Several statistical correlations have been performed using some considered parameters. Especially it was searched a relation between the two following variables: volume of slid material vs upstream contributing area at the obstruction. Looking the obtained scatter plot it is possible to define the couples of values for which an obstruction of water flow occurred. In practice by the scatter plot we can define a threshold relation which can separate the couples of observed values (in Apenninic area) for which a natural dam was formed, from the couples of observed values where such phenomenon doesn't occurs.

B9-8 Orale Occhiena, Cristina

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APPLICATION OF THE CROSS CORRELATION TECHNIQUE TO MICROSEISMIC DATA ANALYSIS FOR THE IDENTIFICATION OF ROCK WEAKNESS ZONES.

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Key terms: microseismic activity; hypocentral localization; monitoring systems

The formation, growth and propagation of microcracks in rock material, considered as prior factors to a collapse, give rise to elastic waves, that can be detected by a suitable monitoring system. As a consequence, the monitoring of the microseismic activity can be considered a useful investigation tool to measure and analyze the deformation and the potential instabilities of rock slopes.

The correct analysis and interpretation of the recorded signals can provide information about the size, the type and the spatial localization of the source mechanisms. Considering the aims of the present work, the main approaches to the analysis of microseismic data and to their correlation with rock fracturing processes can be classed in three categories, concerning 1) the simple count of the number of events prior to the failure, 2) the localization of the microseismic sources, 3) the whole waveform data analysis.

In the frame of the third type of analysis, it is possible to determine the fault plane solution of the microseismic source events from the first data motion, assessing the direction of the stresses that generated the elastic wave propagation. Another way concerns the grouping of the microseismic events on the base of their waveform similarity. This clustering is referred to as "multiplet" and the grouped events are considered to be related to identical or neighboring source mechanisms. The technique for the multiplet identification is based on the cross correlation theory and the similarity between the analyzed waveforms is quantified by the computation of the coherency for each possible pair of events, recorded by the same microseismic network.

In the present work the application of the above technique to analyze the data recorded by the microseismic monitoring system installed by the CNR-IRPI of Turin (Italy), in the frame of the Interreg Project IIIA Alcotra n.196, "PERMAdatROC", on the Italian side of the Matterhorn peak is described.

The first six months of microseismic recordings have been analyzed and the computation of the coherency for each pair of events has allowed the identification of a class of similar appearing signals, in which nine events are collected. The localization of the nine hypocenters, carried out using the software NonLinLoc (<http://alomax.free.fr/nlloc>), has evidenced the presence of a cloud of source mechanisms aligned along a planar surface. The attitude of this plane is very close to that of a set of discontinuities, measured during a morphostructural survey.

B9-9 Orale Damato, Davide

10.1474/Epitome.04.0189.Geoitalia2011

COMPARISON OF METHODS FOR THE SPEDITIVE ROCKFALL HAZARD ASSESSMENT: ACTIVITY 1 OF THE MASSA (MEDIUM AND SMALL SIZE ROCKFALL HAZARD ASSESSMENT) PROJECT

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Key terms: rockfall; landslide hazard; ALCOTRA project; mountain environment

France, Italy and Switzerland are the countries involved in the project Massa designed to standardize the assessment of the landslide hazard. In particular, the MASSA project (<http://massa.geoazur.eu>), is an operational programme for cross-border cooperation "Italy-France (Alps-ALCOTRA, 2007 - 2013)", it started in 2010 and it will end in 2013, aiming to identify rockfall and landslides hazard assessment along international road in the Alpine area. The project is composed by three actions, that consist of: compare speditive methods for rockfall hazard assessment (Action 1); monitoring (Action 2) and modelling (Action 3) of medium-volume landslides (between 1000 and 100000 m³).

This work describes the Action 1 performed during the first year. The Lombardia (It), Sempione (Ch) and Roya (Fr) valleys were chosen as common test-sites in order to compared different methods:

- Proviapl methods developed by Arpa Piemonte, couple a mechanical probabilistic approach used to define the probability of rock fall, with a specific software (Rotomap software) for the three-dimensional run-out evaluation. The rock falls source areas and the geological and structural data of rock mass were collected by speditive field surveys (Arpa-Cemagref, 2008). In this project, in order to improve the Proviapl method new input data were used:

- * the density of the intersection fractures, derived from multiscale images analysis, was used to refine the evaluation of the probability of rock fall. Landsat ETM and Aster images were used to detect the main regional lineaments whilst the photo aerial were used to detect detailed fractures systems. To derived the density map of fractures intersection the geostatistical analysis of the fractures intersection were applied.

- * the empirical method of shadow angle (Evans and Hungry, 1993), that is used to define a maximum run-out distance zone for block propagation, it was improved in order to consider also the frequency of blocks transit and the maximum and medium height of the block starting points.

- Matterock light methods calculates the probability of rock face failure based on a detailed stability analysis using geomechanical parameters and considering external influences. Trajectories are used to establish the boundaries of the areas subject to rock falls in relation to the speed of the boulders (Rouiller et al., 1998, Crealp et al., 2006).

- BRGM methods allows to hazard assessment resulting to rockfall block trajectory with Bora software starting to field geological data. Bora, born to help hazard cartography allows to assessment downstream areas of detachment, likely invasion landslide (Sedan et al., 2006).

Although these methods are rather complementary, the comparison of the results (susceptibility maps, hazard maps etc.) obtained on common test-sites shows different results mainly due to:

- different set of field geological data collected are strongly related to experience of geologist especially during a speditive field surveys (ex. scales of geological survey, number of discontinuity systems, block sizes and volumes, probabilities of failure of the unstable rock mass, size and geometry of the homogeneous areas, etc.);
- most of the data collect in geologic database can not be used directly in model input;
- different graphical representation of the hazard and susceptibility maps (ex. representation of differing hazard levels, legends, color, symbology, etc.).

In the coming months many efforts being devoted on minimize these differences especially to joint collection of field geological data used as input model.

B9-10 Poster Bacenetti, Marco

10.1474/Epitome.04.0190.Geoitalia2011

UNDERSTANDING GEENVIRONMENTAL DYNAMICS AND RISKS: THE CASSAS LANDSLIDE AND THE LARGE SLOPE INSTABILITIES OF THE MIDDLE SUSA VALLEY

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Key terms: slope instabilities; hazards and risks communication; geological heritage; Piemonte

Mountain regions have geological and geomorphological features that make them attractive for leisure and tourism activities; land occupation and seasonal population in many mountain areas are consequently increasing, together with impacts on the natural environment and geomorphological risks for human activities and infrastructures. This happens also because of enhanced environmental dynamics of mountain areas, due both to climate change, seismotectonics activity and lithostructural conditions.

Sociological surveys have shown that "perceived risk", not "real risk", influences people's behavior towards natural hazards. Proper communication of hazard and risks studies can play an important role in raising awareness of tourists and residents in mountain areas of elevated risk and high geotouristic attraction. Based of this, we aim to: 1) contribute to the awareness-raising communication strategy of the RiskNat project (Interreg Alcotra 2007-2013, Action A.4.3) by synthesizing geoscience knowledge on slope instabilities of the Middle Susa Valley and information on models/prevention measures/warning systems of the Cassas landslide; and 2) achieve a new conceptual and operational discipline in the management of the geological heritage of the Middle Susa valley, by means of the development of techniques for recognizing and managing its rich geodiversity (ProGeoPiemonte Project, submitted to the "Progetti d'Ateneo" selection, operated by Università degli Studi di Torino and Compagnia di San Paolo Bank Foundation).

By analyzing natural risk components in the Middle Susa valley, we outlined an approach to slope instabilities including: (a) natural hazards identification; (b) estimation of risk and vulnerability, and (c) evaluation of social consequences. (a) A review of geoscience literature on geodiversity, climate and landscape evolutionary stages and natural hazards of the area delineated the local and regional components of environmental dynamics. Significant landforms, agents, processes and factors have been described and mapped for reconstructing the evolutionary stages of the mountain environment. The long-term geomorphological changes have been represented through virtual landscapes of the Pleistocene glacial phases, from LGM to cataglacial stages. Relationships between deglaciation and deep-seated gravitational deformation at the Susa-Chisone divide have been explored also by analysis of lichen colonization on rock surfaces. (b) By integration of multispectral satellite images and multitemporal aerial photographs, static and dynamic conditions to Cassas landslide risk and related territorial vulnerability have been outlined. (c) Since vulnerability is a function of population, settlement and infrastructures, images of historical events of instability and documentation of related local damages have been collected. Panoramic view-points have been selected for a didactic trail to show the risk that people face in various circumstances and to present mitigation strategies.

As a result of the systematic review of geoscience and natural hazards information, the Middle Susa valley became one of the 9 strategic geothematic areas have been selected by the ProGEO-Piemonte project to represent the geodiversity of our region, each characterized by high potential for enhancement of public understanding of science, and recreation activities supported by local communities. The visual representations and digital evolutionary models prepared for the RiskNat didactic trail and laboratory will contribute to the popularization of geological history, climate and environmental changes, natural hazards and related risk management practices in the Susa valley. A better recognition of the economic value of geodiversity and a stronger perception of natural risks will reduce local vulnerability to disasters and will support the territorial integrated quality management systems, suitable for tourism and sustainable development.

B9-11 Poster Boccali, Chiara

10.1474/Epitome.04.0191.Geoitalia2011

INFLUENCE OF THE TOPOGRAPHIC SURVEY ON TRAJECTORIES RECONSTRUCTION AND ROCK FALL SIMULATIONS: CASE STUDIES IN THE PROVINCE OF BOLZANO (ITALY)

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Key terms: rock fall; topography; slope geometry; two-dimensional simulations

Rock falls, according to the high speed with which they occur, can lead to catastrophic consequences causing damage to infrastructure and threatening the safety of human lives. For this reason it is important to accurately assess the spatial diffusion of the phenomenon. The slope morphology and the direct surrounding of the potential falling rock are the most important factors determining whether a rock could fall. After the rock has been detached and starts to move, it descends the slope in different modes of motion, that strongly depend on the mean slope gradient.

For these reasons it is important the most likely reconstruction of the slope topography. The aim of this study is to compare different topographic methods, used to outline rock fall paths, and to identify which survey technique is the most suitable for the use of the simulation software RocFall (@RoScience).

The program requires a set of input parameters (geometry and properties of the slope, properties of the simulated rock) and provides, in the form of graphs, results on the location of the end-points, on the bounce heights, kinetic energy and rotational speed of the block.

This study seeks to understand which difference in results are achieved by choosing one or another topographic base, in order to determine which is the best for the purpose of forecasting phenomena of rock fall.

Three sites (Vadena, Vizzate Valley and Sinigo), located in the Autonomous Province of Bolzano (Italy), were chosen given the availability of topographic sections made using GPS, photogrammetry and laser scanner survey. All trajectories, 11 in total, were also reconstructed using the digital terrain model (DTM), with cells 2.5 to 2.5 meters, made available by the Province of Bolzano. A field survey was carried out in the study areas to detect in detail particular morphologies of the slope.

Basing only on the delineation of the topographic sections there is a distinct difference between GPS and photogrammetry, on the one hand, and DTM and laser scan, on the other. The profiles derived from GPS or photogrammetry are simplified and sometimes present morphological features, like stairs, not detected in the field survey. On the contrary, comparing the DTM and the laser scan, the highest density of points detected by laser scan allows a profiling of the rock wall thicker than the DTM and consequently seem that the DTM is missing some morphological characters.

All these morphological differences occur also in charts: in about half of the sections analyzed, comparing the specific topographic method with the DTM, was pointed out a difference of at least 10 meters in the location of the end-points of the boulders.

In all three areas the lack of significant morphological jumps causes, in the DTM profiles, bounce heights significantly lower than other topographic methods. On the contrary most gentle slope, with no evident gradient's changes, means higher angular velocity, linked to a preferential rotational motion, rather than free fall.

High kinetic energies correspond to significant bounce heights, but they cancel out on the impact with the ground. Also high velocities involve high energies, but they are spread over the entire length of the slope where the simulated block rolls.

This study shows that the most accurate method is the laser scan, as the high density of points, that can be detected, provides a good match with the real mountain side. Not to forget, however, are the limitations of this approach, particularly if portions of wooded slope were investigated. In most cases the laser scan data are not available and can be effectively replaced by the digital terrain model, taking care to maintain high resolution.

From these considerations can be infer that a most likely reconstruction of the slope, by topographic survey, combined with direct control on the field and a proper evaluation of land use, are the basis for the definition of rock fall hazard and for the design of mitigation works.

SESSIONE B13

Pericolosità costiera da eventi marini eccezionali

B13-1 Orale Amr, Saleem

10.1474/Epitome.04.0192.Geoitalia2011

GEOMORPHOLOGICAL AND SEDIMENTOLOGICAL IMPRINTS OF HOLOCENE EXTREME EVENTS ON THE NORTH-WEST COAST OF EGYPT

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Key terms: Mediterranean Coast of Egypt; Paleotsunami; Marine Boulders; Holocene

The study deals with geomorphological and sedimentological phenomena which may have been accumulated by the extreme paleoevents. The presence of boulder fields and/or ridges is connected to coastal geomorphological types. Sedimentological phenomenon is equivalent to subsurface sedimentary sequences up to few meters. The term "extreme paleoevents" is used to describe both Holocene paleotsunamis and paleostorms.

The main purpose of the research is to examine some geomorphological and sedimentological findings along representative sites of the North West Coast of Egypt since mid-Holocene, and interpret them in the light of extreme paleoevents against the theory of sea level fluctuations.

Historical data and few sedimentological investigations reveal that many paleotsunamis and or paleostorms events occurred in Alexandria region since late Holocene. The most destructive one have been recorded approximately in (365 AD).

Field investigations of Holocene extreme events along the widespread North-West coast of Egypt are still rare. The precise study of fifteen explored mega boulders fields along the study area (explored by 2010) represents the core of the study. In addition, the study of subsurface sedimentary sequences along selective boreholes will be conducted. The sophisticated laboratory analysis such as geochemical characteristics of

sediments samples and carbon 14 dating are needed to complete the study successfully.

B13-2 Orale Shah-Hosseini, Majid

10.1474/Epitome.04.0193.Geoitalia2011

COASTAL BOULDERS AS EVIDENCE FOR HIGH-ENERGY WAVES ON THE IRANIAN COAST OF MAKRAN

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Key terms: Makran; Coastal boulder; Storm; Tsunami; Hazard

Coastal boulder deposits attesting to large waves are found along the rocky coast of Makran from Chabahar to Lipar. Boulders are either scattered on the rocky coastal platform or accumulated in imbricated clusters. The boulders are mostly rectangular and composed of biogenic calcarenite originated from the present coastal platform. Significant morphologic features observed on the boulders include supratidal karstic pools, sharp broken edges and fractures. Some boulders contain boreholes and shells of marine bivalves suggesting detachment and transportation from the subtidal zone. The dimensions, elevation and distance from the coastline of 60 representative boulders are documented to estimate their volume, weight and inland displacement. The boulders, weighing up to 18 tons, are found up to 6 m above present mean sea level and up to 40 m from the shoreline. We applied hydrologic models to estimate and compare the wave height and inundation distance required to transport the boulders inland. Our results demonstrate that no known or probable storm event on the Makran coast is capable of detaching and transporting the boulders. Conversely, tsunami coastal wave height of 4 m is enough to detach all the boulders from the rocky coast and transport them inland. We conclude that a tsunamigenic origin for boulder deposits is most plausible. These data imply that the western part of the Makran coast has archived evidence of paleotsunami events probably generated by large earthquakes at the Makran subduction zone.

B13-3 Orale Marsico, Antonella

10.1474/Epitome.04.0194.Geoitalia2011

TERRESTRIAL LASER SCANNER TECHNOLOGIES IN THE STUDY OF THE EVIDENCE OF THE IMPACT OF EXTREME WAVES; THE CASE OF THE WEST COAST OF SARDINIA (ITALY)

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Key terms: extreme wave; tsunami; storm; Sardinia; Italy

Recent surveys performer by the team of Prof. Pascucci from Sassari University, highlighted the presence of boulders isolated, or organised in field, sometimes in berms, scattered inland along the western coast of the Sardinia, north to the village of Argentiera. Since the general features of the boulders (shape, size, weight, distribution) they have been considered as evidence of the impact of extreme waves, may be a tsunami. Up to the 2004, studies have been concentrated on boulders accumulation due to past event impact; the tragedy of the Ocean Indian Tsunami, the OIT 2004, evidenced the possibility that tsunamis are effectively able to detach, move and scatter inland several, hundred, boulders of large dimension. In the same time, the capability of exceptional storms to move boulders has been evidenced in several areas of the world.

Recent papers suggested a hydrodynamic approach to study the boulders accumulation. Actually, the scientific debate on the interpretation of past boulders accumulation is very intense; in spite of the numerous bibliography, the question on the methodology useful to discriminate between storm and tsunami boulders accumulation is still open. Generally, Nott's equation, although criticized, are at the base of the most recent hydrodynamic formulas. Some recent model underlined the necessity to perform accurate field surveys to improve the survey's methodology to obtain the correct data (a-, b-, c-axis length, shape and weight) useful to correctly apply the formulas. The use of terrestrial laser scanner methodology in the case of the boulders present along the western coast of Sardinia permitted to quantify these features and to apply the most recent formulas. Jointly to C14 age determination on bio concretions present on the boulders surfaces, the digital analysis and the computer simulation permitted to individuate the event responsible for their accumulation.

B13-4 Orale Monaco, Carmelo

10.1474/Epitome.04.0195.Geoitalia2011

IMPACT OF TSUNAMI AND STORM GENERATED WAVES: DEVELOPMENT OF GEODATABASE AND GIS APPLICATION FOR THE ANALYSIS OF THE VULNERABILITY OF THE SIRACUSA (SOUTHEASTERN SICILY, ITALY) COASTAL AREA.

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Key terms: tsunami; monitoring; southeastern Sicily

The recent tragic event, which occurred in the Indian Ocean on December 26, 2004, and in Japan on March 11, 2011 has drawn the attention of the international community to the natural phenomenon known as tsunami. As these natural events cannot be avoided, the study of the evidence of their destructive effects due to past event can be very useful in drawing up vulnerability maps for coastal area under Tsunami risk. These may help to estimate the recurrence time of future possible events and to calculate the

maximum inland penetration of impacting waves: these factors are very important for establishing evacuation/intervention plans and for locating appropriate shelter locations. South-eastern Sicily is one of the most seismically active areas of the central Mediterranean, marked by a high level of crustal seismicity producing earthquakes with MCS intensities of up to XI-XII and M~7, such as the 1169, 1693 and 1908 events. Several earthquake-generated tsunamis struck the Ionian coast of southeastern Sicily in historical times (AD 1169, 1329, 1693, 1818, 1908, 1990). According to most of published geological data and numerical modelling, the seismogenic source of these events should be located in the Messina Straits and in the Ionian offshore (the Malta Escarpment) between Catania and Siracusa. Geomorphological evidences of extreme waves impact are present all along the coast of southeastern Sicily between the town of Augusta and Capo Passero. Scicchitano et al. (2007) described boulder deposits related to tsunami and storm generated waves between Augusta and Siracusa. Hydrodynamic estimations and radiocarbon age determinations suggested that three distinct tsunami events (1169, 1693, 1908) were responsible for the deposition of the biggest isolated boulders and boulder fields. Scicchitano et al. (2011), using TLS and DGPS techniques, estimated the maximum inland penetration for the tsunami waves responsible for the deposition of the biggest boulders located in Maddalena Peninsula (Southeastern Sicily, Italy) applying the Pignatelli et al. (2009) method. Calculations provided results in good agreement with the morphological evidences of Tsunami impact and they highlighted the necessity to improve the topographical, morphological and infrastructural dataset in order to improve the accuracy of the estimations and to extend them to other area.

The aim of this work is to generate a geo-database for the area of Siracusa (Southeastern Sicily, Italy) including geomorphological evidence of past Tsunami and storm generated waves impact as well as: detailed topographical and morphological data (DEM 2x2, Orthophoto, TLS, DGPS), ondametric wave parameters dataset (RON, RMN), marine geophysical data (SBES, MBES, SSS, SPBP), infrastructural data (industrial areas, road, railway, shelters, etc...) together with the dataset provided from geoportale SITR (Sistema Informativo Territoriale Regionale - <http://www.sitr.regione.sicilia.it/>) to provide through GIS applications maps of vulnerability for the coasts of Southeastern Sicily to Tsunami and storm generated waves impact and to furnish the background of possible monitoring development.

Pignatelli C., Sansò P., Mastronuzzi G. (2009) - Evaluation of tsunami flooding using geomorphologic evidence. *Marine Geology*, 260(1), 6-18.
Scicchitano G., Monaco C., Tortorici L. (2007) - Large boulder deposits by tsunamis along the Ionian coast of south-eastern Sicily (Italy). *Marine Geology* 238, 75-91.
Scicchitano G., Pignatelli C., Spampinato C.R., Piscitelli A., Milella M., Monaco C., Mastronuzzi G. (2011) - Terrestrial Laser Scanner techniques in the assessment of tsunami impact on the Maddalena peninsula (south-eastern Sicily, Italy). Submitted to *Earth Planetary Sciences*.

B13-5 Orale Mastronuzzi, Giuseppe

10.1474/Epitome.04.0196.Geoitalia2011

MITIGATION OF TSUNAMI IMPACT: LESSONS FROM JAPAN 2011 TSUNAMI

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Key terms: Tsunami; mitigation; Japan 2011 tsunami

On March 11, 2011 at 1446 local time (0546 GMT) a terrible earthquake which magnitude has been evaluated from 8.8 to 9.0 struck the bottom of Pacific Ocean about 250 miles northeast of Tokio. This earthquake was the fifth largest in the World since 1900.

The consequent tsunami was detected by the Pacific Tsunami Warning Center; it travelled in the open ocean not particularly large but with a speed evaluated in about 250-400 knots in function of the ocean depth. When these powerful waves approached shallow waters along the coast, their velocity slowed and their energy was dissipated; they consequently grown to a great height before smashing into the shore with a speed ranging from 40 to 80 knots and an incredible residual energy.

Japanese Tsunami hit essentially the coasts of Fukushima, Miyagi and Iwate Prefectures killing thousands of peoples and destroying cities and structures; 12 hour late waves reached the coast of California in USA. All the cited coasts were not unprepared; several tsunami hit these regions in different time. On 869 Jogan tsunami occurred devastating the Sendai coastal plain. A millennium after, on June 15, 1896 the Great Meiji Sanriku tsunami struck the coast of Sanriku few kilometres north to Sendai; the earthquake occurred about 150 km off the coast and waves reached about 38 m above mean sea level; about 22000 peoples were killed. More recently, on 1933 the city of Kamaishi - after to have been damaged by Meiji tsunami - was seriously damaged by the Showa tsunami. In the very recent past 1960, Chilean tsunami hit Matsushima, Kesennuma, Oofunato, Ryori Bay and Kamaishi again. The 2010 a new Chilean tsunami produced limited damages in Kesennuma city.

This long and incomplete list of tsunami that hit the northeast coasts of Japan induced the realisation of extensive operas in junction to early warning systems, evacuation plans and, at last but not least, the education of the population, all together devoted to the mitigation of the impact of tsunami. Breakwaters, seawalls, automatic tidal gates, evacuation areas, escape stairways, network of light, vertical and horizontal signs and acoustic alarms, wave buoys have been widely realised all along the coasts where human lives need to be protected. Notwithstanding the big number of human casualties and the immense economic damages, the effectiveness of the warning centre alarmed the peoples in the about 5 minutes following the earthquake and the identification of the approaching tsunami, saving numerous peoples. In some cases, like that of Arahama village, breakwaters and seawalls didn't produced any protection and the village was destroyed. The biggest lessons from the Japan 2011 tsunami is the necessity to predispose a correct planning in coastal use and urbanisation.

SESSIONE B14

Rischi naturali: nuove ricerche e applicazioni di protezione civile

B14-1/2 Invitato Rosi, Mauro

10.1474/Epitome.04.0197.Geoitalia2011

CRITICAL ISSUES CONTROLLING THE EFFECTIVENESS OF RESPONSE TO VOLCANIC CRISIS

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Key terms: volcanic eruptions; signals monitoring; forecasting

There is a widespread perception that, in contrast to earthquakes, volcanic eruptions can be effectively forecasted (or will be soon successfully forecasted) thanks to the rapid technological advancements and expansion of instrumental networks. However, a revision of the volcanic events of the past four decades demonstrates that unrest volcanic signals are often difficult to separate from actual forecasting signals so that the risk of either false alarm or lack of alarm is still high. Moreover, the perception that expansion of technology represents the only effective way to fulfil eruption forecasting has often pushed geological studies of individual volcanoes to a second order rank of importance. The revision of some recent eruptive crisis actually indicates that solid knowledge of the structure and magmatic/eruptive behaviour of individual volcano provides invaluable elements for the reliable interpretation of pre-eruptive signals and for the definition of the expected scenarios. Perhaps the major challenge of third millennium relies on the capability to combine in a balanced way basic studies on active volcanoes and instrumental monitoring aimed at eruption forecasting also in view of cost/benefit analysis. The effectiveness of response to volcanic crisis finally requires the full integration of the scientific and civil protection functions.

B14-3/4 Invitato Candela, Laura

10.1474/Epitome.04.0198.Geoitalia2011

EARTH OBSERVATION APPLICATIONS FOR CIVIL PROTECTION: THE EXPERIENCE OF ASI PILOT PROJECTS

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Key terms: Earth Observation applications; Multi-mission EO data; Civil Protection; Pilot projects

Earth Observation satellite systems provide key data to generate information that can be very useful to support decisions in all phases of the risk management; the research has already demonstrated technological capabilities and more national and international programs are working to prepare a sustainable and operational use of such innovative tools.

For hydro-geological and geophysical risks management, ASI pilot projects aim at demonstrating the performance improvement of state-of-art system for the civil protection from floods, landslides, seismic and volcanic risks when Earth Observation from space is used in conjunction with ground data.

Such systems covers various phases of the risk management, from the planning and preliminary vulnerability assessment to the prediction, the emergency management and the post-event damage assessment. Using specific data and models and a variety of satellites and sensors, the demonstrations build on the feeding of a large number of EO products and services to support decision, delivered to central and peripheral Functional Centers.

Joining the efforts of the Italian Space Agency in particular with the new COSMO-SkyMed mission and the Italian Civil Protection with the newly up-scaled Network of Functional and Competence Centers, the projects have been designed and implemented in order to produce such a kind of assessments within a three-year implementation and demonstration period.

The presentation illustrates also significant experiences made during real emergencies.

B14-5 Orale Lupiano, Valeria

10.1474/Epitome.04.0199.Geoitalia2011

LAVA HAZARD MAPS AT MOUNT ETNA. APPLICATIONS FOR CIVIL DEFENSE AND LAND USE PLANNING

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Key terms: Lava flows; Hazard; Cellular Automata; Mt. Etna

The use of thematic maps of volcanic hazard is of fundamental relevance to support policy managers and administrators in taking the most correct land use planning and proper actions that are required during an emergency phase. Typically, a volcanic hazard map divides the volcanic area into a certain number of zones that are differently classified on the basis of the probability of being interested by a specific volcanic event in future. Mapping both the physical threat and the exposure and vulnerability of people and material properties to volcanic hazards can help local authorities to guide decisions about where to locate critical infrastructures (e.g. hospitals, power plants, railroads, etc) and human settlements and to devise mitigation measures that might be appropriate. This could be useful for avoiding the development of inhabited areas in high risk areas, thus controlling land use planning decisions.

The methodology for defining high detailed hazard maps here presented is based on the simulation of an elevated number of events, by using the latest release of the SCIARA lava flows computational model. In particular, the methodology requires the analysis of the past behavior of the volcano, for the purpose of classifying the events that historically interested the region. In such a way, a meaningful database of plausible simulated lava flows can be obtained, by characterizing the study area both in terms of areal coverage, and lava flows typologies. Data is subsequently processed

by considering that different events can occur with different probabilities, which should be taken into account in evaluating the actual contribution of performed simulations with respect to the definition of the overall hazard of the study area. In most cases, such probabilities can be properly inferred from the statistical analysis of past eruptions, allowing for the definition of a more refined evaluation criterion. While this methodology permits the definition of general hazard maps, which can *per se* give valuable information to Civil Defense responsible authorities, more specialized applications can be devised by considering that the SCIARA simulation model is integrated in a GIS (Geographic Information System) application that permits, besides other features, to take also into account the effects of "virtual" embankments, channels, barriers, etc. In addition, the fact that a large number of lava flows of different eruption types, magnitudes and locations are stored in the database, a rapid extraction of various scenarios is possible. Civil Defense oriented applications can regard the possibility to identify all source areas of lava flows that are capable of affecting a given area of interest, such as a town or a major infrastructure (e.g., hospitals, power plants, etc.), while other specific category of simulation can regard the assessment of protective measures, such as earth barriers or channel digging, for mitigating lava invasion susceptibility. In this work, we present some applications to inhabited areas of Belpasso, Nicolosi, Zarrerana and Bronte located on Mt. Etna flanks, demonstrating the methodology's full suitability for land use planning and civil defense.

B14-6 Orale Cinelli, Giorgia

10.1474/Epitome.04.0200.Geoitalia2011

EVALUATION OF POTENTIAL RADIOLOGICAL RISK DUE TO NATURAL RADIOACTIVITY IN A RECENTLY ACTIVE VOLCANIC AREA: THE VULSINI VOLCANIC DISTRICT (CENTRAL ITALY)

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Key terms: Vulsini Volcanic Products; Natural Radioactivity; Radiological Risk

The exposure of humans to ionizing radiation from natural sources is a continuing and inescapable feature of life on Earth. There are two main contributors to natural radiation exposure: high-energy cosmic ray particles incident on the Earth's atmosphere and radioactive nuclides present from the origin in the earth crust and ubiquitous in the environment, including the human body itself. Among the natural radionuclides (the so-called primordial radionuclides), only those having half-lives comparable to the age of the Earth, together with their decay products, exist in significant quantities on the planetary scale. Irradiation of the human body occurs both externally and internally. External irradiation is mainly due to gamma radiation from radionuclides in the 238U and 232Th series as well as from 40K, while internal irradiation arises from the intake of terrestrial radionuclides by inhalation and ingestion. Doses by inhalation result from the occurrence in air of dust particles containing radionuclides of the 238U and 232Th decay chains; the dominant component of inhalation exposure are the short-lived decay products of radon.

For most individuals, this exposure exceeds that from all man-made sources combined.

In nature some other terrestrial radionuclides, including those of the 235U-series, 87Rb, 138La, 147Sm, and 176Lu, exist but at such low levels that their contributions to the dose in humans is negligible.

In the quaternary potassic magmatism of the Vulsini Volcanic district, a large volcanic area located between northern Latium and southern Tuscany, processes of magma genesis and evolution produced a significant enrichment of radioactive isotopes, such as U and Th, 1-2 orders of magnitude higher than their average crustal concentration.

Samples from this area were collected and γ -spectrometry measurements of natural radionuclides conducted by means of two Hyper Pure germanium crystal detectors (HPGe).

In the Vulsini area volcanic products, such as lavas and tuffs, have been and still are widely used as building material, the origins of which date back to the Etruscan age. Because of their high concentrations of U, Th and K in this materials (up to 21 ppm, 78 ppm and 8 % respectively) the assessment of doses (both external and internal) is of fundamental importance: this is carried out in agreement with the two recommendations issued by the European Commission, dealing with indoor exposure to members of the public from natural radiation.

In addition to the dose assessment, the goal of this work is also the evaluation of the risk in a standard "house" followed by its comparison with the risk in other situations of average life conditions.

B14-7 Orale Fanucci, Francesco

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MARINE CARTOGRAPHY CONTRIBUTION TO GEOHAZARD ANALYSIS AND NEOGENE-QUATERNARY GEODYNAMICS IN LIGURIAN AND CALABRIAN MARGINS

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Key terms: Geohazards; Neotectonic; Sequence Stratigraphy; Marine geological Cartography

Marine geology data collected within various national and international research projects have been used for geohazard investigation and risk analysis in the Ligurian and Calabrian Margin.

In some areas, detailed 3D reconstructions of surficial and deep-seated morphostructural settings, allowed:

- the identification of the main geo-hazard elements;

- a better reconstruction of their characters;

- a better comprehension of the interaction processes responsible for their quick morphodynamic evolution.

The research has been focused to recent, surficial and deep-seated mass wasting and to their triggering mechanisms such as high sedimentary

input, seismo-tectonic activity and occurrence of gas-charged sediments. Most detailed analyses of some representative cases have confirmed the complexity of the geohazard evaluations and have arisen some, still open, crucial problems.

On the other hand, the geological marine cartography, began with the CARG Project, showed the structure, the recent evolution and the peculiar characters of some sectors of Italian margins.

In Ligurian region the Apennine margin (Sheets La Spezia and Massa), characterised by prevalent disjunctive tectonics, shows a system of thrust faults active in Upper Pliocene and Lower Pleistocene. The sequence stratigraphy of final Pleistocene and Holocene deposits put in evidence three main phases of post-glacial transgression and several testimonial of other eustatic cycles in the Middle and Upper Pleistocene formations. The alpine margin (Sheets Ventimiglia, San Remo and Imperia), very narrow and steep, is affected by a frequent and widespread seismic activity mainly at the base of the slope, where some tectonic lines, originated as transform faults during the opening of the Ligurian Basin, are reactivated as transpressive or thrust faults by a recent tectonic phase. The CARG, MAGIC and MALSAR projects highlighted the structural complexity of the continental slope whose peculiar morphology is determined by tectonics, retrogressive erosion and by several important landslides.

The pleistogeography during the last lowstanding of sea level and during the Younger Dryas has been reconstructed around the Elba Island. This work also clarified the nature of the thrust tectonics that characterizes the recent activity of Pianosa and Capraia Ridges.

B14-8 Orale Ciucci, Mariano

10.1474/Epitome.04.0202.Geoitalia2011

NATURAL HAZARDS AND INDUSTRIAL SAFETY MANAGEMENT

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Key terms: Safety Management; Seismic Hazard; Hydrogeologic Hazard; Industrial Hazard

In the Italian territory about 1/3 of municipalities are located in areas exposed to seismic hazard. At the same time most of the Italian territory is subject to hydrogeologic events (i.e. landslides and floods). The area object of this study, Sulmona Basin and upper Pescara Valley, is characterized by potential exposition to these hazards, with a particular attention to seismic hazard and landslide hazard. Furthermore the area is characterized by the presence of major hazard industrial plants.

For this paper a dedicated GIS database has been built in order to evaluate the interactions between specific natural hazards and industrial hazard and the related vulnerability of territory and population. For this research MIVIS hyperspectral (at a 1500 and 3000 m elevation) images have been used. The obtained images have been georeferenced. From the processing and classification of these images some information layer have been obtained: thematic maps of land-use (industrial areas identification), vegetation conditions, thermal pollution, quality parameters (temperature, organic matter, chlorophyll, sediments) for river waters. Thematic maps obtained from remote sensing have been inserted in a GIS, that means a system to insert, store, integrate, extract, retrieve, manipulate and analyze georeferenced data layers in order to produce interpretable information. Then the data base has been integrated with further information inserted as continuous layers; thematic layers; vector layers; punctual data; attributes. Among inserted layers: location and information regarding industrial plants, seismic classification, local seismic amplification maps, landslides and landsliding hazard maps. Some specific operators (overlying, proximity analysis, recoding, matrix analysis) have been applied that allowed to integrate the information contents and therefore to obtain final thematic maps (hazard maps, vulnerability maps, events scenarios). The innovative technologies proposed facilitate and optimize the management of data and information obtained from different methodologies. Therefore it is useful to develop innovative methodologies in order to support industry and Competent Authorities in safety management and land use planning.

B14-9 Orale Zaccone, Andrea

10.1474/Epitome.04.0203.Geoitalia2011

INSURANCE SOLUTION FOR NATURAL RISKS

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Key terms: natural risks; cover; insurance; reinsurance; regional scale

As a commercial product for the covering of natural risks for private buildings still lacks, RL has developed a project for the exploration of the real chances of insurance solutions for purpose-built houses since 2006. During the first part of the project, RL, has tried to understand the practicality of the project. One of the hypothesis analyzed was the constitution of a Reassurance Company, which would encourage insurance companies to the covering of natural risks. The second part of the project was dedicated to the analysis of risk data necessary for the building of a quantitative basis for the study, which could evaluate the sustainability of natural risks by the insurance system, and, consequently, the convenience of such a policy for subscribers. Concerning this, the results of the analysis conducted with ANIA demonstrate a real possibility to have a sustainable product at a regional scale.

B14-10 Poster Gargano, Francesco

10.1474/Epitome.04.0204.Geoitalia2011

THE GEOGRAPHIC INFORMATION IN THE ASSESSMENT OF GEOHAZARD IN THE MARINE ENVIRONMENT. THE CASE OF THE NORTHERN SICILY CONTINENTAL MARGIN

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Key terms: Northern Sicily continental margin; Geohazard; Morphobathymetry; Submarine landslides; Volcanic activity

Slope instability and erosion, mass transport, volcanic and tectonic activity, fast sediment accumulation, fluid escaping are the main processes responsible for the geohazard in marine environment. A major knowledge about the geological setting of the offshore areas and related processes can be crucial to assess and manage the potential geological risks.

High resolution morphobathymetric surveys, yielded in the frame of the MaGIC project (Marine Geohazards along the Italian Coasts), integrated with previously acquired data, single-channel seismic reflection profiles, backscatter data (sss) and sediments sampling, allow to define the geomorphological, stratigraphic and structural features in the offshore sector located in the north-western Sicilian continental margin and in the Ustica area (Southern Tyrrhenian).

The main goals are: 1) to identify and map the main morphological-structural lineaments of the study area; 2) to correlate the main structural lineaments on- and offshore; 3) to highlight the instability phenomena of the continental slope, being the area seismically active; 4) to draw up risk maps and to individuate the main dangerous sites. Along the continental shelf to slope system we recognized erosional and depositional features, structural elements at regional and local scale, submerged volcanic edifices, structures related to fluid escape as mud volcanoes and pockmarks.

On the basis of the mapping of morphostructural elements, and their integration with seismic data and sampling, we identified the most likely elements of geological hazard. In detail we individuated: 1) in the Gulf of Palermo, canyons making the continental slope very rough, also due to the occurrence of widespread mass wasting; 2) between the Gulf of Castellammare and the offshore of the Palermo Mountains, channels and erosional furrows, slumpings, turbiditic fans, landslides, pockmarks and tectonic lineaments; 3) in the offshore of Ustica island, volcanic structures, some of which aligned parallel to tectonic lineaments as Arso fault.

The quantitative, GIS analysis allowed a better assessment of the real geohazard. Further investigation on the geological processes, ages of paroxysmal phenomena (eruption, landslides and earthquakes) are necessary to define the most appropriate monitoring strategies in order to assess possible risks for the coastal area and its infrastructures.

B14-11 Poster Turconi, Laura

10.1474/Epitome.04.0205.Geoitalia2011

ASSESSING THE FREQUENCY OF STREAM FLOODS AND DEBRIS FLOWS IN THE PIEMONTE REGION (NW ITALY), AS OPERATIONAL BASIS IN CIVIL PROTECTION ACTIVITY

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Key terms: geo-hydrological hazard; historical data; civil protection; chronological map events; Piedmont Region

The study here proposed is based on the historic analysis of landslide, flood and debris flow events which in the past have brought damages and deaths in the Piedmont. We may postulate that everywhere a debris flow or a streamflood process has occurred earlier, it will do the same in the future, possibly with enhanced or catastrophic effects if in the meanwhile buildings or infrastructures have been settled in vicinity; in that case a careful research not only into the present-day conditions of the concerned catchment(s) but also throughout the historic sequence of the events, should be a priority. Here we deal with a method of search based on multi-temporal aerial and terrestrial photographs, historic maps, archival and bibliographic documents. The bulk of the data refers to descriptions and chronicles of torrential flood events since 16th Century and especially concerning the last two centuries. Selected events have been investigated depending on the effects witnessed in the territory. A purposely-made database has been drafted through software ArcGIS® 9.1 (ESRI) at 1:10.000 scale. Selected informations have been ranged according key words in order to make easier to acquire the objects, even through direct access according to the Regional Alert Zones. Information is also available concerning the total number of known events for all torrents in the whole period taken into account (until 2006). Time-series analysis organized in 3 frequency classes allowed to select the streams which came into extreme flood in the last 30, 50 and 70 years. In the Piedmont 1050 flood-prone watercourses have been detected, 80% of which (i.e. 852) have been correctly mapped. Historical data on natural hazards have allowed for the first time in Italy to group different chronological and spatial units in the ambit of several valley systems, of the effects and damages over the territory. Such distribution is moulded through some 3000 case/events recorded over a time span of 400 years. In particular, it is since now possible to evidence, qualitatively, the different combinations or groupings of small basins distributed over the alpine area as a function of different meteo-hydrological events which originated torrential flood phenomena. Depending of the different liability to occur, processes and effects induced by extreme events in a given catchment or locality are thus enhanced, considering that they have occurred according a sum or combination of a set of concurrent physical preparatory causes, much differentiated not only according to the different geological, geographical, morphological and climatic sectors of territory but also according to the geologic-dynamic history. Based on the data base realized it is possible to broadly re-arrange different alert steps in case of incoming, possibly critical meteorological conditions. Results provided by the research above illustrated are to be regarded as a basis for a set of rules issued from Regione Piemonte, in accordance with a National statement (DPCM 27/02/2004): the Ordinance 25/06/2008 No. 14-9023 has established the institution of the so-called 'hydraulic and hydro-geological presidia of civil protection'. They are defined according to technical considerations and classified in three levels. Prevention and operational interventions throughout the whole areas are so ensured, especially concerning: possibly in conflict with flood dynamics; monitoring for avoiding possibly arising hazard; hydraulic survey; logistical supporting; spreading out civil protection actions according to communal plans. Several Bodies and Institutions, as well volunteers by hundreds are involved in operations virtually provided by hydraulic presidia. The presidia are activated by the Provinces in cases when the Functional Regional Center has issued the meteorological alert bulletin, instituted by Resolution 30/07/2007 No. 46-6578; exceptionally, the activation may start on request by Communes, Region and Prefectures

SESSIONE C1

La ricerca speleologica scientifica in Italia

C1-1 Orale Badino, Giovanni

10.1474/Epitome.04.0206.Geoitalia2011

MOIST AIR AND SPELEOGENESIS: THE SUBTERRANEAN CLOUDS

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Key terms: cave atmosphere; condensation in caves; caves energy balance

Many different micrometeorological processes are able to create vapor supersaturation in the cave atmospheres: ascending air parcels, pressure drop behind bottlenecks, mixing of saturated air parcels at different temperatures, water flow fragmentation and Raoult's processes.

The high purity of caves air tends to delay condensation, which is concentrated where airflows are in close contact to the cave walls. It can be shown that the rate of aggressive water condensation on the walls is usually comparable to the external rain deposition, sometimes locally much greater, and then can play a leading role in speleogenesis.

C1-2 Orale Badino, Giovanni

10.1474/Epitome.04.0207.Geoitalia2011

MICROCLIMATE AND MICROMETEOROLOGY OF MT KRONIO CAVE SYSTEM (SICILY): PRELIMINARY RESULTS

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Key terms: air circulation underground; cave atmosphere; Stufe di San Calogero

Mt Kronio is a limestone massif fronting the sea near Sciacca, in the eastern part of Sicily. It is well known and has been cited since classical antiquity due to the presence, at the summit (370 m asl), of many cave entrances (Stufe di San Calogero and 30 other caves) with strong, exiting hot airflow (37°C, RH=100%), which were used for calidaria since the Greek times. In the past centuries, these caves were explored several times, but the hot atmosphere and a shaft allowed very limited visits. We will present a general overview of first microclimatic results obtained in the context of the research project "Progetto Kronio" (CGEB-La Venta). The mountain is crossed by very intense airflows, in part entering in the lowest part (Cucchiara cave) but the first studies with sonic anemometers in coincidence have shown a strong gap between the known entering and exiting airflows.

External and internal thermal and airflow mapping, are showing a complex heat flow structure inside Mt. Kronio. The Cucchiara caves shows an extremely strong thermal air sedimentation, with temperature gradients up to 6.5 °C/m and permanent mixing clouds at the separation layer between different air fluxes.

C1-3 Orale Piccini, Leonardo

10.1474/Epitome.04.0208.Geoitalia2011

THE EFFECTS OF GLACIER DYNAMIC ON THE EVOLUTION OF ENGLACIAL CAVES: THE CASE OF GLACIAR PERITO MORENO - SOUTHERN PATAGONIA, ARGENTINA

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Key terms: englacial drainage; cryokarst; glacier caves; Perito Moreno

In the last decades the glaciers of Southern Patagonian Andes have experienced a very fast and intensive retreat, due to the current strong ablation considered as an effect of the "global warming". The Perito Moreno Glacier is an exception of this "rule". In fact, the most famous characteristic of this glacier is the cyclical advancement of the front which can reach the rocky spur of the Peninsula Magellanes, closing the water passage between the two braces of Lake Argentino. This obstruction causes the lake's level in the branch above it to rise up to 25 meters. With the increased water pressure, infiltrations through the ice fissures also increase, opening a tunnel through the glacial mass, with the consequent collapse of the ice bridge and the return to the lake's equilibrium level. The causes of this peculiar behavior are not completely clear.

Actually, the Perito Moreno hosts several pseudo karst forms due to surface and internal melting and we suspect that this phenomena could have a role in the internal dynamics of the glacier. In its current state, the glacier has three areas having morphological and hydrological conditions suitable for the formation of glacier caves. All three contain well developed superficial drainage networks which feed bedièrre up to over a kilometer long. The ablation area, which is of direct interest in the search for glacial cavities, is a tongue 15 km long and on average 4 km wide.

A comparison of the distribution and morphology of glacier swallow-holes in 1995 and 2010 year,s indicates a fragmentation of the epiglacial drainage probably due to the upstream widening of the distension zone and to the gravitational collapse of the ablation area.

C1-4 Orale Fiorucci, Adriano

10.1474/Epitome.04.0209.Geoitalia2011

COMPARISON OF SOME KARST SYSTEMS BY TRACER TESTS

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Key terms: karst; tracer tests; aquifer

The study of karst systems often requires a multidisciplinary approach

that incorporates different scientific disciplines, including hydrogeology, especially through some of its applications. Among the different hydrogeological applications, those that provide very interesting results are the monitoring of spring water, geochemistry of water and artificial tracer test.

The tracer test, in addition to investigate the borders of a hydrogeological karst system, can provide very useful information about the behavior of the aquifer. In particular, tracer test, can monitor with high detail the arrival of the dye to the source by using automatic data loggers. Through the breakthrough curve and its interpretation (shape of the curve, time of first arrival and peak, maximum concentration) it's possible to identify different types of aquifer (dominant drain network, interconnected drains and dispersive circulation systems). The relationship between the rate of first arrival time and peak time (maximum concentration of dye), provides a coefficient (RVH), which characterizes very well the different karst systems.

This paper compares the results of artificial tracer test performed in several karst systems located in Piedmont (Borello, Vene-Fuse, Bossea), Tuscany (Corchia) and Sardinia (Su Gologone). These karst systems are characterized by different hydrogeological networks. Systems Corchia Borello and Vene-Fuse seem to be set in highly developed karst networks with the presence of large collectors able to drain very quickly the water flow. Systems Su Gologone and Bossea have sections with a significant development in the saturated area with wide and deep siphons. Another test is performed in a portion of the unsaturated zone Bossea system, where the flow is mostly set in the fractured network in the rock.

The results of these tracer test show tracer breakthrough curves very different for the distinct systems examined. The values obtained from the ratio RVH, seem to identify very well the different types of system investigated, too. Tests performed in the same aquifer, but in different hydrodynamic conditions, show breakthrough quite different

C1-5 Orale Grillo, Barbara

10.1474/Epitome.04.0210.Geoitalia2011

THE CONTRIBUTION OF SPELEOLOGY TO THE SCIENTIFIC RESEARCH IN GROTTA GIGANTE (CLASSICAL KARST)

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Key terms: Classical Karst; Grotta Gigante; speleology; diver; hydrogeology

The Grotta Gigante is one of the most interesting and important tourist cave in Italy, open to the public since 1908. It is located in the Classical Karst and it was discovered in 1840 by Antonio Federico Lindner, a mining engineer who in the early XIX century became involved in the research of the underground course of the river Timavo. The cave consists of a large room 165 meters long, 65 meters wide and 107 meters high with a total volume of over 300000 cubic meters. These dimensions have led the cave to gain a place in the 1995 Guinness Book of World Records as the largest tourist cave in the world. The morphology, the central location within the Classical Karst and the possibility to access it with ease, have encouraged, over the years, the use of the cavities as a scientific laboratory and a point of reference in Earth Science studies. Today the cave hosts two horizontal geodetic pendulums, two clinometers, an I.N.O.G.S. seismology station, some stations that measure the intensity of karst leaching and dissolution through TMEM, some continuous sensors for Radon.

Recent explorations have discovered a series of wells which allow the cave to reach an altitude of 18 meters above sea level, for a total depth of 252 meters. Thanks to the efforts of the CGEB - S.A.G. Trieste cavers during several years of excavation, a new frontier of study has opened for Grotta Gigante and all the Classic Karst. The new bottom consists of a wide well intercepting a tunnel (still under excavation) near the base level, along which there are visible signs of rising groundwater. In order to quantify these hydrological signals, at the end of December 2009 the Department of Geosciences of the University of Trieste has installed a Diver - CTD for the continuous measuring of the water level, conductivity and temperature. The records include nine months of data sampling registered every thirty minutes. On two times, the level has shown an increase of more than 30 meters, confirming the hydraulic connection with the Timavo system. This new station complements the extensive karst groundwater monitoring network managed by the Department and it will permit to implement the knowledge of the hydrodynamic Classical Karst.

C1-6 Orale Menichetti, Marco

10.1474/Epitome.04.0211.Geoitalia2011

HYPOGENIC CAVES IN ITALY: GEOLOGY AND SPELEOGENESIS

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Key terms: hypogenic cave; karst; speleogenesis; CO₂

The speleogenesis of carbonate karst system is commonly related to the seepage of the aggressive meteoric water rich of soil derived CO₂. This epigenic process propagates downward from the surface to depth through the drainage network.

Through more than one century of speleological research in Italy, many limestone caves have been explored and mapped. These caves are characterized by a variety of patterns and morphology sizes including three-dimensional maze systems and deep shafts, with both endogenic CO₂ vents and active sulfuric streams. An integrate approach take in account geological, hydrological and geochemical settings in these underground karst systems, permitted to recognize a new important speleogenetic process related to the hypogenic origin. The main cave-forming processes are related to deep-seated hydrogeological recharge where limestone corrosion is driven by endogenic agents with an upward flow. The whole Italian peninsula is rich in volcanic, crustal and mantle-derived CO₂ and H₂S emissions and all the end-members of these karst processes can be found, from solution caves to carbonate travertine deposits. The main hypogenic cave-forming processes are related to the H₂S oxidation to sulfuric acid, by oxygen-rich groundwaters as well as in the atmosphere. Both phreatic and vadose corrosion reactions involve chemotrophic microbial activity, with sulfur-redox bacterial communities that generate sulfuric acid as metabolic product. The bedrock corrosion produce sulfate ions in the phreatic zone and gypsum replacement in the

limestone walls of the vadose sectors of the caves. The caves are characterized by both fossil and active passages in which water rich in H₂S as well as endogenic CO₂ plays a determinant role in speleogenesis. The cave morphologies suggest that the oxidation zone of H₂S is not restricted to the shallow groundwater levels but can be extended to deeper sections of the aquifer to which input of fresh water via a complex regional hydrogeological circuit could occur.

Although sulfuric acid-related speleogenesis typically produces gypsum deposits, in caves where the karstification processes are driven by subterranean CO₂ sources, voids and speleothems are the only final products.

The hypogenic cave are known in different parts of the world, from Central Asia to North and South America, and especially the underground fossil systems in the Guadalupe Mountains in New Mexico and Texas. In Italy, hypogenic caves are distribute along the whole peninsula with a concentration for largest and both fossils and active systems in the Tuscany, Umbria, Marche and Latium regions. These consist of few tens of kilometers of solution passages with galleries and shafts, which are characterized by large rooms, cupola and blind pits, anastomotic passages, bubble trails roof pendants, knife edges, and phreatic passages. In many cases, the caves are developed at several levels related to the evolution of an external hydrographic networks. The smaller karst systems have a ramiform pattern of several large rooms with wide ceilings that end abruptly in narrow passages or fissures. Phreatic passages, often anastomotic, are also spread over large parts of the cave, where they constitute some network zones. Active smaller karst systems are known in Southern Italy related to the geothermal anomaly associated with CO₂ and H₂S degassing in Apulia, Campania and Sicily.

Even though the general speleogenetic reactions are known, the precise geological, hydrogeological and geochemical conditions of their occurrence need to be documented, in particular the role of gases (H₂S, CO₂) and their association with other mineral species. Hydrogeology and, especially, hydrochemistry are key in understanding the space/time evolution of the hypogenetic karst systems.

C1-7 Orale Biolchi, Sara

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COASTAL CAVES ALONG THE NORTHEASTERN ADRIATIC SEA: RELATIONSHIPS BETWEEN SUBAERIAL AND SEAWATER PROCESSES

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Key terms: coastal caves; coastal geomorphology; Istria; Gulf of Trieste

Istrian coast is almost completely carved on limestones, on which many coastal and submerged caves have been surveyed. These caves are well known by divers and fishermen, but no systematic studies have been carried out. Their present position with respect to the sea level suggests the joint contribution of different factors, both marine and subaerial, in the morphological evolution of the studied caves. In particular, we carried out a systematic underwater explorations of 5 coastal caves, along the shoreline of the Gulf of Trieste and Istria. The detailed surveying allowed to identify and evaluate the relationships between subaerial and seawater processes related to their widening and to produce a matrix embodying the genetic factors.

The studied caves are located at Duino, Rovinj, Stoja, Premantura and Brsec. They develop at the sea level and are partly emerged and partly submerged. Moreover, their entrance is always at present sea level. The surveyed caves are not much extended (max 20 m in length) and they are small in size.

The geological surveying of coastal caves in the Gulf of Trieste and in Istria suggested that they are developed mainly following faults, fractures and joints. The bottom of the all caves are covered by rounded cobbles and blocks, mainly in the inner sectors, due to the wave abrasion effects. Even if abrasion interests mainly very exposed coasts while in very sheltered coasts, as the northern Adriatic sea, limestone coastal morphologies are mainly due to bioweathering (De Waele & Furlani, 2010), the pressure effects of entering waves can easily produce abrasion forms. Even the walls that are in contact with these blocks are very smoothed. Potholes, up to 1 meter in size, can be found, sometimes filled by sediments. Even very smoothed rocks can outcrop at the bottom, usually where the bottom of the cave is sloping. Different kinds of speleothemes have been observed in the emerged position, while the submerged part is completely abraded by waves. No tidal notch occur, but sometimes wide submerged abrasion notches have been found. At Premantura this notch is very deep and wide, probably because of the exposition of the coast.

Considering the size of the caves, the results of sea level change studies concerning the tectonic subsidence of the area (Antonoli et al., 2007; Faivre et al., 2011; Furlani et al., 2011), their genesis probably started in a subaerial position, as suggested by the occurrence of speleothemes and scallops. Seawater effects, such as bioweathering, solution and abrasion affected mainly their recent morphological development, when sea level reached the present-day position.

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C1-8 Orale Sanna, Laura

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LONG-TERM EROSION RATE MEASUREMENTS IN CUEVA DEL AGUA GYPSUM CAVE (SORBAS, SE SPAIN)

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Key terms: Micro-Erosion Meter (MEM); gypsum karst; condensation-corrosion; Cueva del Agua (Almería, Sorbas); Spain

The present work deals with the results of long-term micro-erosion measurements in gypsum caves of Sorbas (Almería, SE Spain). It focuses on the Cueva del Agua, a cave with 34 upper entrances developed in gypsum rocks of Messinian age. The 12 km square-large karst massif of Sorbas is characterized by the almost complete lack of surface waters during most of the year and by an important well developed underground and active drainage network. Cueva del Agua is characterised by several small shafts that allow access to a 8.9 km-long series of sub-horizontal passages excavated along fractures, some of them developing vadose canyons. The micro-erosion meter stations are located at different positions and environmental situations along the main passage of the cave. Measurements have been carried out up to four times over a period of 18 years. The observations allow to collect important information on the recharge of the karst aquifer not only by rain water infiltration, but at the present climate conditions also by water condensation of air flow.

C1-9 Orale Vattano, Marco

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GYPSUM KARST SYSTEMS OF SOUTHERN-CENTRAL SICILY (SOUTHERN ITALY) AS POWERFUL MARKERS IN GEOMORPHOLOGICAL STUDIES

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Key terms: Gypsum karst system; geomorphological evolution; erosion base level; Sicily

The importance of the gypsum karst systems in the geomorphological studies has long been recognized by many scholars. Gypsum karst systems are generally characterized by: a) few and large drainage tubes with narrow secondary tributaries; b) main passages accommodated to the highest discharge; c) different storeys of sub-horizontal galleries connected by deep shafts, developed generally in adjustment to the contemporary geomorphological setting; d) impossibility of developing conduits under the water table; e) rapid adjustment to the karst base level fluctuations.

The aim of this paper is to show the results of geomorphological studies carried out in several evaporite karst areas of southern-central Sicily, on the basis of the relationships between surface landforms and forms of underground gypsum karst systems.

The study areas are characterized by surface landforms due to downcutting processes, e.g. fluvio-karst canyons and V-shaped valleys, and to "planation" processes, such as karst planation surfaces, erosion glacia on soft rocks and marine terrace surfaces, developed downward in an arranged succession between 600 m a.s.l. and the actual sea level. Landforms produced by selective erosion and deep-seated gravitational slope deformation phenomena, connected to increased relief energy, have been also surveyed.

The gypsum karst systems consist generally of different storeys of sub-horizontal passages, connected by vertical shafts, and several narrow tributaries frequently filled by alluvial sediments.

The surface "planation" landforms and the underground sub-horizontal galleries have been correlated with stillstand phases of erosion base level, whereas the surfaces forms due to downcutting processes and the underground shafts have been associated with lowering phases of erosion base level.

Dataset analysis and comparison between surface and hypogean karst landforms allowed both to recognize a sequence of events, linked to stillstand or following lowering phases of the regional erosion base level, and to establish a temporal order of events responsible of the geomorphological evolution of these areas of Sicily.

C1-10 Orale Gueguen, Erwan

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MORPHOSTRUCTURAL ANALYSIS OF KARSTIC CAVES IN THE ALBURNI MOUNTAINS (SOUTHERN ITALY)

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Key terms: Morphostructural analysis; Karst; Alburni Mountains; southern Italy

The Alburni Mountains, in the area of the Cilento and Vallo di Diano National Park, represent the most important karstic area of southern Italy with around 500 registered caves and some important touristic sites (Castelcivita and Grotta dell'Angelo caves). The carbonate massif has been the goal of many speleological exploration campaigns since the early '70s. However, its geological and hydrogeological setting, and the karstic evolution, are still poorly known.

Aim of this work is to investigate the relationships between geological structures and cave development using a new geomorphological approach based on cumulative curves of geological and geomorphological data.

The Alburni Mts are mainly built of Mesozoic-to-Cenozoic carbonate rocks of the Alburni-Cervati Units belonging to the Campania-Lucania carbonate platform. They represent a huge 1500 m thick, southward dipping, monoclinical structure, which is locally overlain by Tertiary flysch units trapped in half-graben basins. The massif is limited to the NW by an important normal fault zone, whereas towards the NE it is limited by a complex fault system linking the Alburni Mts to the Monti della Maddalena structure across the Auletta basin and the Vallo di Diano valley.

The entire massif is structured by NW-SE trending transtensional fault systems delimiting the half graben basins, and offset by NE-SW trending faults.

In this paper, we have considered three sets of caves belonging to the different structural sectors identified in the Alburni massif:

1- caves located at the NE boundary;

2- caves located at the central portion of the massif;

3- caves located at the NW boundary.

A geological survey has been conducted within and outside of the caves to collect structural data. A morphological study has been performed on the horizontal maps of the caves in order to identify the main directions of cave development.

The first result of this work is that cumulative curves have shown to be a powerful analysis tool for comparing different types of data. The study has also confirmed the existence of different families of caves in the massif according to their location. Finally, the development of the caves is not only controlled by the main direction of structures at the map scale but also by local structures that in some cases play a major role.

C1-11 Orale Visintin, Luca

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CAVES STUDIES IMPORTANCE IN THE UNDERGROUND INFRASTRUCTURES DESIGN

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Key terms: UNDERGROUND INFRASTRUCTURES; CLASSICAL KARST; STATISTICAL ANALYSIS; KARST; GEOMORPHOLOGY

The caves are the most characteristic landforms of karst rock masses. While the superficial forms often reveal the presence of a network of drainage well developed in depth, on the other hand, the correct location of the voids is extremely important in particular during the design of underground infrastructures. It follows that each new exploration of the underground environments contributes both to the statistical analysis of the karstification of the rock masses in a large scale and to a detailed hypogean feature analysis; it permits, with the interpretation of the recognized forms, to reconstruct and to assume the distribution of karst in the whole rock volume.

The Trieste Classical Karst claims a century-old tradition of caving that led to the discovery of nearly 3000 cavities; these explorations contribute substantially to the definition of karst criticalities in the land-use planning and in the infrastructures design. The analysis of the underground features distribution, their morphology and their genesis, together with a detailed study of the karst surface, allow the creation of thematic maps that represent the true strengths during the dialogue between karstologists and planners or local governments.

Recently, the Classical Karst has been interested by the design of an important high-speed/high capacity railway artery which will link the Western Europe trades and the Eastern Europe ones; the difficulties in the design and in the construction of this infrastructure in an heavily karstified area have already emerged during the feasibility studies. In particular, preferring to advance with underground construction techniques, the statistical studies on the distribution of the cavities in the rock volume has been the determining factor in the most suitable paths choosing; that has been both in an engineering point of view and in a perspective of their impact on groundwater resources and on the overall hypogean environment.

C1-12 Orale Zorzin, Roberto

10.1474/Epitome.04.0217.Geoitalia2011

SCIENTIFIC RESEARCH IN SOUTH CHINA KARST OF THE CIVIC MUSEUM OF NATURAL HISTORY OF VERONA (ITALY)

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Key terms: scientific research; speleological explorations; South China

The results of 13 scientific expeditions organized since 1992 by Civic Museum of Natural History of Verona (Italy) to southern China are described and discussed. One-hundred-twenty-five caves were explored, for a total of more than 60 km in length. All the expeditions were multidisciplinary: they involved Italian speleologists, geologists, biologists, geographers, archaeologists and medical doctors. As a consequence, the results were very interesting and detailed, but the organizers had to face relevant difficulties related to the logistics and coordination of the activities. In fact, even if the research were conducted mostly in caves, the exploration of the surrounding areas took place as well, including study of water quality of superficial water bodies, of soil fauna, geological referencing, Radon measurements, and studies on human geography, water use and land management.

Regarding the more technical-speleological aspect, the large size of the most of the caves allowed for shortened investigation times by easing the exploration, combined with quite high air and water temperatures, allowed the researchers to remain for longer periods in the caves. As a consequence, in several cases, it was possible to collect replicate samples. A total of about 80 Italian (70 speleologists) and 200 Chinese researchers participated to the 13 expeditions. In particular, the 2000, 2001, and 2003 expeditions in Guizhou (Qianxi County - Honglin area) have been relevant for the amount of people and for the consequent amount of collected data.

The karstic area of Honglin has all the features for a turistic evaluation. Nevertheless, it should be noted that the karstic environments in the surroundings of Honglin are characterised by a fragile equilibrium. In fact, the elevated permeability of the rock substrate, the presence of water courses linked in diverse ways with the karstic basins and vice versa, imprint on the territory a remarkable vulnerability, especially in the case of an eventual rapid "turistic development" of the settlement center of Honglin without the realisation of the principal infrastructures needed for a correct management of the territory (adequate sewage system, correct disposal of swine effluent, improvement of the large refuse dump present in one of the caves, etc.). The caves in southern China could be considered a real resource.

From the biospeleological point of view, the Verona Museum research in China caves led to a record in the field of more than 200 taxa. Some of them have not yet been identified at the species level, some were already studied, and some are still in study.

Based on present knowledge, the area of China with the highest number of troglitic species is Guizhou Province. Several biological and paleogeographical factors analysed allow to hypothesize that Guizhou caves acted as refugial during the plio-pleistocene climatic events. The

alternation of numerous warm and cold periods allowed the colonization of the same caves, on different occasions, by species which are now taxonomically very close, but with a different degree of adaptation to life in caves. This hypothesis is supported also by paleogeographical and paleoclimatic studies which show the alternation of cold and warm periods in all China by the means of paleopollen, sedimentary series and fossil fauna distribution.

The elaboration of the data collected, together with the charts produced during the research, provide a useful tool for the protection and evaluation of the hypogean environments and the surface and subterranean water resources and also allow a more correct management of the environmental resources and local economy to be planned. These are, in fact, the basic principles of the concept of "sustainable development".

C1-13 Orale Ruggieri, Rosario

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CYRENAICA KARST MORPHOLOGIES

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Key terms: Libya; Cyrenaica; Karst; Speleology

A campaign of investigations has started in 2007 aiming at studying the karst morphologies of the Jabal Al Akhdar (Green Mountains). Such a campaign is within a research agreement stipulated between the Earth Sciences Department of Garyounis University of Benghazi, Libya and the Hyblean Speleo-hydrogeological Research Centre of Ragusa, Italy. Among the objectives of the project there are: that more general concerning the formulation of a speleogenetic model consistent with the geodynamic evolution and climate changes taken place in the tethyan-mediterranean region from the end of the Cretaceous; those with application fall-outs into the local socioeconomic framework addressing the finding out and protection of new water resources, the mapping of man altered areas, potentially at risk of instability and / or sinking because of the presence of karst voids, and the turistic use of caves with a particular aesthetic interest.

Al Jabal Al Akhdar belt is located in the northeastern part of Libya and it consists of a prominent promontory on the southern edge of the Mediterranean coast. It is 350 km long and 100 km wide. Tectonically, this belt is an inverted basin and has been affected by the Tethyan tectonic activities since its opening during the Jurassic. Lithologic outcrops of Al Jabal Al Akhdar belt involve limited exposures of upper-Cretaceous carbonates that constitute E-W to ENE-WSW structural inliers emerged within extensive exposures of Eocene, Oligocene and, sometimes, Miocene limestones.

The campaign of geospeleological investigations carried out in the 2007, 2008 and 2009 years has concerned the karst area of the coastal belt of Benghazi, Sousa and the plateau of El Marj, Al Bayda and Derna. The study of a series of large collapse dolines, connected with the network of conduits draining the ground water along the coast, was started in the area of Benghazi. Still in the same area, the Lethe karst system with a large underground lake, which was the subject of a tourist fruition during the Italian colonial period, is of particular interest, even historic. In the coastal area of Sousa a significant karst outcrop, surveyed and documented, is the Brag Notta system constituted by a collapse doline and a large neighbouring doline-lake connected hydrologically by a recent tectonic structure draining the brackish ground water now towards the sea now towards the hinterland, depending on the tidal excursions. In the raised areas of El Beida and El Marj plateau it is possible to observe some big dolines and dip shafts, inserted in the context of a typical cockpit relief, while in the plateau of Derna the exploration of a complex labyrinthine cave has allowed also the discovery of paleontological and archaeological finds. Speleological explorations and geological investigations of the above mentioned karst areas are still being carried out.

C1-14 Orale Regattieri, Eleonora

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PENULTIMATE GLACIAL HUMID PHASES AND TERMINATION II DEDUCED FROM SPELEOTHEMS COLLECTED AT TANA CHE URLA CAVE (LUCCA, CENTRAL ITALY)

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Key terms: Penultimate glacial; Last interglacial; Central Italy; Speleothems; Tana che Urla

Relatively few data are available for Central Italy concerning the climate condition during the Penultimate glacial phase (corresponding to marine isotope stage 6, MIS 6) and the transition to the last interglacial (e.g. Follieri et al., 1989; Bard et al., 2002; Drysdale et al., 2009). The Tana che Urla cave is a small cave located at 620 m asl in the inner side of the Apuan Alps (not far from Corchia cave), which preserves an interesting record of this period. Discontinuously monitored since the 2006, several flowstones of the main gallery were drilled in the 2009. In particular, two cores and one stalagmite, chronologically constrained by U/Th dating, have preserved two phases with 18O-depleted calcite at ca170-175 and 150 kyr (that is, during MIS6) interpreted as wetter periods. These two wetter period are in reasonable chronological agreement with similar data coming from the Argentario cave (southern Tuscany, Bard et al., 2002) and Soreq Cave (Israel, Bar-Matthew et al., 2000) records, supporting the notion that wet conditions were present all over the Mediterranean basin. In particular the older period substantially correspond to the phase of deposition of the cold sapropel S6 in eastern Mediterranean sea (Ayalon et al. 2002). Unlike Corchia, which shows a substantial difference between the isotopic records of oxygen and carbon (Drysdale et al., 2009), the transition to the Last Interglacial at Tana che Urla is marked by a substantial decrease of both oxygen and carbon isotopes records. This

difference could be interpreted as a different response to soil development at climatic forcing above the two caves, located at different altitude and with very different conditions of water infiltration and circulation.

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C1-15 Orale Brillì, Mauro

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INVESTIGATION ON THE ISOTOPIC COMPOSITION OF NITROGEN SOURCES IN THE HYGROPETRIC CAVE HABITAT OF THE GROTTA DELLA FOOS (NORTHERN ITALY): IMPLICATIONS ON THE ORIGIN OF THE NEGATIVE NITROGEN ISOTOPE COMPOSITION OF *CANSILIELLA SERVADII*

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Key terms: Nitrogen isotopes; *Cansiliella servadeii*; Hygropetric habitat; Moonmilk

The hygropetric habitat is one of the least studied habitats; it is found where a thin layer of water almost permanently covers a rock surface. In caves, the hygropetric habitat is fairly common. As cave hygropetric habitats provide special conditions for sustaining life, they require special adaptations. Living forms that have adapted to live in such habitats sometimes display unusual modifications: *Cansiliella servadeii* is a specialized troglitic beetle that lives in this habitat at a depth of about 450 m below the surface in the Grotta della Foos (northeastern Italy); this beetle's mouth apparatus has adapted in a peculiar way so as to allow semiaquatic feeding behavior. This species is essentially found browsing for food on calcite moonmilk, which is a thin deposit of calcite crystals, bacteria and water.

The beetle's mouth is not the only peculiarity of the *Cansiliella*. Nitrogen isotope analyses performed on the whole body, the gut and the exoskeleton of *Cansiliella* to examine the foodweb structure in the Grotta della Foos revealed surprising negative results, ranging between -2.5 and -7.8‰ with respect to atmospheric N. It is widely recognized that animals take on the isotopic composition of the food they eat with a small isotopic enrichment. Laboratory and field studies demonstrate increases in δ15N (about 2 to 3 ‰) between consumers and their diet. The troglitic and troglitic generally rely on food derived from non-living organic matter of surface origin transported to the hypogean environment in percolating waters. Nevertheless, the N isotope composition of the OM extracted from some samples of soil collected above the Grotta della Foos, is generally close to that of the atmospheric N.

The organic and inorganic sources of N were isotopically investigated by collecting different types of samples from the hygropetric habitat of the *Cansiliella* to trace the origin of the abnormally negative isotopic composition we detected. The organic N was extracted from the moonmilk that contains, besides calcite crystals, non-living OM and its microbial colonization; it presents an average isotopic composition of +2‰ (vs. AIR), which is even more positive than that of the surface OM. The inorganic N is instead dissolved in the dripwaters and sheetflow on the moist cave-wall surfaces. The most abundant N species in solution is nitrate, whose concentration ranges between 3.0 and 4.5 mg/l; less abundant is the ammonium, whose concentrations are as low as 0.2 - 0.3 mg/l. Nitrate, analyzed for N isotope composition, ranged on average between -10.9 and -5.0‰ (vs. AIR), which was more negative than the beetle. Oxygen isotopes of the nitrates ranged between +7.9 and +9.8 ‰ (vs. SMOW), thereby indicating that the nitrate originates at least partly from the oxidation of ammonium dissolved in meteoric waters. In the area of Grotta della Foos nitrates in meteoric precipitation displayed a similar N isotopic composition but an O isotope composition of +40‰, thereby showing that ammonium makes a marked contribution to the nitrate pool. Isotopes evidently rule out the possibility that OM in the moonmilk is an exclusive source of food for *Cansiliella*. The isotope analysis of the gut (-5‰) of *Cansiliella* also rules out the possibility that the negative isotope composition was due to the chitinous exoskeleton, which has in some insects proved to be strongly depleted in 15N (from -6 to -9‰) if compared with their diet. If we consider that inorganic N in the forms of nitrate and ammonium is much more abundant in this hypogean habitat than organic N, and that the isotopic composition of nitrate is the only value that is more negative than that of *Cansiliella*, the hypothesis that *Cansiliella* may use it as a food source, through microbial uptake, is conceivable. In nutrient-poor habitats, such as that found in the hygropetric cave, this alternative feeding mode may be a particular advantage.

C1-16 Poster Brun, Clarissa

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KARST SPRING "FONTANON DI GORIUDA": CAVE DIVING EXPLORATIONS AND GEOCHEMICAL INVESTIGATIONS TO ATTEMPT THE ANSWERS AT THE HYDROGEOLOGICAL AND GROUNDWATER FLOW PATHS QUESTIONS OF MT. CANIN. (WESTERN JULIAN ALPS).

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Key terms: Mt. Canin; karst hydrogeology; isotopic analysis; cave diving

Recent results obtained from underwater cave explorations of Fontanon di Goriuda karst spring, have inspired new geochemical investigations. These study attempt to improve the hydrogeological knowledge and the groundwater paths considerations. The Canin massif contributes waters to three river basins (Tagliamento, isonzo-Soca, Slizza), and divide Adriatic Sea basin from the Black Sea basin. It is located at the border between Slovenia and Italy which follows the east-west top ridge. The massif is basically formed by Upper Triassic series of Norian dolomite ("Dolomia Principale") at the bottom and several hundred metres of Dachstein Limestone. It is bordered by the Moznica and Koritnica valleys in the northeast and east and by the Soca Valley in the south. On the west it is bordered by the Uccia Valley, the Idria fault zone, and the valley of the Resia River that flows into the Tagliamento River. The Raccolana and Rio del Lago valleys that form the northern boundary of the Canin massif run along the Raccolana fault zone. The geological structure causes springs to occur on its flanks, mainly in the Bovec Basin (Bocic, Boka, Sušec-Mala Boka, Zvika, Vodica, Glijun, Kladenki, Srnica) to the south and Moznica, Goriuda to the north.

In 1999 (Casagrande, Cucchi, Manca 1999) was carried out a monitoring campaign of karst springs in whole Canin massif. The aim of the experiment was monitoring in detail the behaviour of the springs during a strong rainy event. Were considered the following parameters: the discharge, the physical and chemical characteristic and the $\delta^{18}O$ and δD ratio. The springs were: Fontanone M. Sart (Resia), Fontanon di Goriuda, Sella Nevea and Rio del Lago springs, Boka, Glijun and Zvicar. Simultaneously were analyzed the precipitation collected from pluviometers installed in Val Resia (400m a.s.l.), Rifugio Gilberti (1850 a.s.l.) Val Raccolana-Fontanon di Goriuda (750m a.s.l.). Thanks to this first approach, together with other data from tracing tests, it was possible to classify Fontanon di Goriuda as a conduit dominated spring conditioned by rapid flow through larger channels in the system. The Karst springs collect water from different levels and have differing discharge regimes, a multi-level aquifer has developed along the main fissured zones. In 2009, 2010 and 2011, cave divers have sampled the waters of the three siphons inside the cave at different water depth and in different months as also the percolation along the main gallery after the siphons. These waters were analyzed for $\delta^{18}O$ and δD isotope determination. The $\delta^{18}O$ and δD ratio of the stream at the entrance, of the three siphons at the surface and a 6m deep so as the percolation, are depleted with the seasonal precipitation of the area. Instead the water of the II siphon at about 14m deep shows the absolute values of the isotopic data more negative than expected. This could indicate the presence of water infiltrated at highest elevation. This result is in accordance also with the isotope values and with the conductivity variation found at the Sella Nevea spring (Casagrande, Cucchi, Manca 1999). This important results open a new research in the karst spring of Fontanon di Goriuda. The future should be the automatically measuring device recording the water level, temperature and its conductivity.

C1-17 Poster De Waele, Jo

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SPELEOGENESIS OF THE SULPHURIC ACID CAVE OF MONTECCHIO (GROSSETO, TUSCANY) AND GEOMORPHIC IMPLICATIONS

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Key terms: Speleogenic cave speleogenesis; cave minerals; U/Th dating; sulphur isotopes; geomorphic landscape evolution

The Montecchio cave (254 T/GR, close to Saturnia, Grosseto province) opens at 320 m asl, in a small outcrop of Calcare Massiccio, close to the Albegna river. Although known for a long time, there are no speleogenetic studies on this very special cave.

This cave, having over 1700 m of passage, is characterised by the presence of the thermal aquifer at a depth of 100 m below the entrance. The water temperature at this depth exceeds 30°C and the water has high sulphate content. The cave can thus be considered an active hypogenic system.

The cave hosts large gypsum deposits, starting 40 m below the entrance. This gypsum derives from the reaction between sulphuric acid and the carbonate host rock. This process, that occurs in the vadose (oxygen rich) environment, has created a set of typical morphologies such as replacement pockets and bubble trails.

The lower part of the cave hosts calcite cave raft deposits over 1 m thick, evidence of standing, probably thermal, water pools in strongly evaporative areas related to strong air currents. Eleven samples of weathering products have been sampled and analysed at the X-ray diffractometer and investigated using SEM/EDAX. The products of acid weathering are strictly related to the speleogenesis of the cave, having formed by the interaction between the host rock and the sulphuric vapors rising from the thermal aquifer, like those derived from calcite (gypsum) and from clays (alunite, jarosite and caolinite). Sulphur stable isotopes in three gypsum samples have given values ranging between -24.2‰ and -28.3‰, very similar to those obtained from other sulphuric acid caves such as Cueva de Villa Luz (Mexico), Lechuguilla (New Mexico, USA) and Frasassi (Italy).

The speleogenesis and minerogenesis of this cave is surely related to a lowering thermal water level where these processes are occurring at or near the water table, and are likely related to the river incision. Actually, the valley floor of the nearby Albegna river, that flows at a distance of some hundred meters from the cave entrance, is very close to the present level of the thermal water table in the cave. The low nitrate contents and the high temperature of the thermal cave water seems to

exclude a direct recharge from the river to the cave. U/Th dating of gypsum and calcite cave rafts and, possibly, 40Ar/39Ar dating of alunite will hopefully allow us to reconstruct the various phases of cave formation, and make contribution to the reconstruction of the river incision history as well.

C1-18 Poster Parise, Mario

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KARST EVOLUTION OF THE MURGE AREA (SOUTHERN ITALY) RETRIEVED FROM COMBINED SPELEOLOGICAL AND GEOLOGICAL SURVEYS

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Key terms: caves; explorations; structural geology

In karst environments, quarrying is definitely among the human actions causing the worst impacts to the natural setting. Surface and underground quarries may intercept natural caves, and destroy them by producing direct impacts on the caves, or causing severe damage to the karst ecosystem, locally resulting in endangering very rare species. Reaching a balance between the need to carry out quarrying activity and the safeguard of karst environments is not an easy task. Legislation is often absent, or, when present, it remains actually only on paper, whilst the real enforcement of codes and rules is rarely pursued. In this paper, we present a case in which the Apulia regional legislation about underground protection has been effectively applied.

In the Minervino Murge area (Apulia, Southern Italy), a large quarry has been exploited for years leading to severe damage to the karst heritage, including total or partial destruction of caves, until quarrying operations were stopped in 2005 due to an inquiry and a protection procedure. This allowed to explore and survey the numerous karst processes present in the quarry. By chance the large size of the main caves avoided their complete destruction. On the other hand, the quarrying activities also brought to surface many new information on the geological and karst history of the region. Thanks to the protection procedure, it has been thus possible to fully document the high karst values of the studied area, which presents at least six caves of great interest for reconstructing the karst history of this sector of Apulia.

In this work, we describe both the surveyed caves and other karstic phenomenon, with particular regard to the geological setting of the area (local stratigraphy, main structural elements, etc.) and to the morphology and hypogean morphology of surveyed caves. Considerations about speleogenesis are also presented, within the context of a larger sector of Murge, which includes some of the most famous caves in the region (Grave di Faraualla, Grave di Masseria Preveticelli, Grave del Cavone and Grave Grande Campanelli).

C1-19 Poster Sauro, Francesco

10.1474/Epitome.04.0224.Geoitalia2011

LITHOLOGICAL AND STRUCTURAL CONTROL ON SPELEOGENESIS IN SPLUGA DELLA PRETA CAVE, LESSINI MOUNTAINS, VENETO, ITALY.

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Key terms: Karst; Tectonic; Speleogenesis

Spluga della Preta is one of the first caves in Italy to be well studied and described from a geological and morphological point of view. Eighty years after its first exploration a large amount of lithological and structural data were collected in the whole cave complex and detailed surface geological surveys were carried out. The step-like shape of the cave was initially considered as a consequence of the entrenchment of the nearby Adige River. In this work the lithological control of the horizontal passages is demonstrated, considering only the deepest passages to be paleo-phreatic. The main tectonic structures control the oldest and inactive parts of the cave, developed most in low-cohesive fault breccias, while the active streams are now deepened along secondary joints. The morphological analysis allows to infer a hypothesis on the speleogenetic evolution of the cave and on its relationship with an upper suspended aquifer hosted in the cretaceous Maiolica Formation.

C1-20 Poster De Waele, Jo

10.1474/Epitome.04.0225.Geoitalia2011

SPELEOGENESIS OF ALLOGENIC CONTACT CAVES IN CENTRAL EAST SARDINIA

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Key terms: Speleogenesis; Transgressive contact; Erosion; Karst evolution; Mineralogy

Several important cave systems in Central East Sardinia develop, at least partially, along the contact between the granite or phyllite basement rocks and the covering fractured Middle Jurassic sediments. The latter are composed of layers of clays, marls, conglomerates and sands of variable thickness (generally some metres) followed by sandy dolostones, becoming increasingly carbonatic moving upwards in the sequence. These karst systems are fed by allogenic streams with flow rates ranging from a couple to some thousand of L s⁻¹. Parts of these vadose passages are sometimes developed in the insoluble basement rocks for some metres. In

the summer of 2010 cavers of the Centro Speleologico Cagliaritano have discovered a new cave, Gutturù 'e Murgulavò (Baunei), that hosts some passages entirely excavated in granitic rocks.

The typical morphology of all these caves is characterised by very large and rather low chambers, which floor is masked by important underground deposits. Locally the Palaeozoic bedrock is exposed along the underground streams.

Speleogenesis of these cave systems is very much relied upon weathering of the basement rocks and their successive erosion by flood waters, rather than on dissolution of the carbonate rocks. Mineralogical analyses of the weathering products at the contact between Palaeozoic rocks and Mesozoic sediments have revealed the presence of montmorillonite, kaolinite, chlorite and illite, typical weathering products of granitic rocks. Dissolution, however, plays an important role in the first stages of speleogenesis, dissolving the carbonate cement in the basal sandy dolostone beds, thus leaving loose sands that can readily be eroded by running waters. Once a critical dimension in void is reached, cave formation occurs very rapidly, leading to huge chambers in some thousands of years.

SESSIONE C2

Idromorfologia fluviale

C2-1 Orale Bussetti, Martina

10.1474/Epitome.04.0226.Geoitalia2011

AN INTRODUCTIVE OVERVIEW OF FLUVIAL HYDROMORPHOLOGY

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Key terms: hydromorphology; fluvial processes; morphological changes; hydrological alterations

The aim of this presentation is to provide a general overview of a relatively new discipline, hydromorphology, starting from its definition and briefly discussing its applications to river management.

The term "hydromorphology" was introduced by the Water Framework Directive 2000/60/EC (WFD), and includes the consideration of: (a) the extent of modification to the flow regime; (b) the extent to which water flow, sediment transport and the migration of biota are impacted by artificial barriers; (c) the extent to which the morphology of the river channel has been modified, including constraints to the free movement of a river across its floodplain. Following its introduction, many definitions of hydromorphology have been proposed, some of them emphasising physical habitats and related ecological aspects, and some focusing more on the hydrological and geomorphological aspects. However, according to a majority of authors, hydromorphology can be defined as the discipline that, by integrating hydrology and fluvial geomorphology, aims to study fluvial form and processes, their interactions with human impact, and the consequent implications on ecological processes.

Hydromorphology typically includes the following aspects: (a) river morphological changes and hydrological alterations; (b) interactions with ecological processes; (c) applications to river management and restoration.

In the past, and still nowadays, physical habitat assessment or river habitat survey have often been used as synonymous of hydromorphology. River habitat survey consists of a census and representation of the physical habitats existing in a given river reach and related to the morphological channel features. However, we argue that this is a very simplistic and 'form-based' approach, and alone is inadequate for a diagnosis and comprehension of hydrological and morphological problems. More than a representation of physical habitats, a more sound and comprehensive 'process-based' approach is needed to understand any physical alterations. This approach is also needed for an analysis of the influences and impacts when designing restoration actions, as required by the WFD.

C2-2 Invitato Siviglia, Annunziato

10.1474/Epitome.04.0227.Geoitalia2011

ASSESSING HYDROLOGICAL AND THERMAL ALTERATIONS AT MULTIPLE TEMPORAL SCALES: ADIGE AND NOCE RIVER, ITALY

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Key terms: hydrological alterations; thermal alteration; water frame directive; hydromorphology

Under the Water Framework Directive (WFD), member states of the European Union should aim to achieve a "Good Status", comprising Good Chemical Status and Good Ecological Status, in all bodies of surface water and groundwater, and to prevent deterioration in the status of those water bodies. It is now broadly recognized that the hydro-morphological pressure is one of the most relevant cause limiting the achievement of the targets imposed by the WFD.

In this context, the hydroelectric production play a fundamental role because of the alterations of the natural flow and the thermal regime which are imposed at different time scales.

In the present study we analyze hydrological and thermal alterations induced by hydropower plants on both the Adige and Noce River (Trentino region, northeastern Italy).

We analyze an 83 years (1923-2006) streamflow data set collected daily on the Adige River and a 1 year (2007) streamflow and temperature data set collected every 30 minutes on the Noce River. We make use of the well-established range of variability approach (RVA) and wavelet

transform (WT) to identify the most relevant scales of variability and to detect their alteration independently.

Use of the range of variability approach and the wavelet transform analysis allows a better separation between natural and human-induced effects at ecologically relevant scales of variability, thereby identifying changes and trends due to hydropower management.

From the analysis of the Adige River set of data we observe that starting from the 1960s, after the construction of the reservoirs currently in operation, a progressive flattening of the hydrograph, which attenuated the amplitude of seasonal variations.

This negative tendency worsened in the last few years, possibly as an effect of the reduction in winter snowfall. Wavelet analysis shows that hydroelectric production caused the high-frequency components of the signal to increase in amplitude and number, with fairly regular weekly and daily oscillations and sharp transitions. The whole spectrum of low flows is significantly altered.

Analysis of thermal alterations induced by dam operations (hydropeaking) in the Noce River

is performed by applying the Wavelet Transform Analysis which allows to separately investigate the thermal regime alterations at sub-daily, daily and weekly scales. The outcomes of our study confirms that the strongest variability is detected

at the smaller scales, with a strong increase in temperature variability at sub-daily scales. Finally we show that at a seasonal scale, clear alteration can be detected and quantified.

C2-3 Orale Scorio, Vittoria

10.1474/Epitome.04.0228.Geoitalia2011

VALLEY FLOOR MODIFICATIONS AND CHANNEL ADJUSTMENTS OF THE BIFERNO RIVER OVER LAST 150 YEARS.

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Key terms: Biferno river; GIS analysis; Recent channel adjustments; land cover changes; climatic and anthropologic factors

The Biferno river with its length of ca. 90 km and a catchment area of ca. 1300 km² represents the major water course in Molise region (southern Italy) flowing into the Adriatic Sea.

This river has suffered in recent times major channel adjustments including pattern changes, channel and floodplain narrowing and channel lowering, which are thought to be largely induced by human interventions on the catchment and on the river system.

The main purpose of our study is to reconstruct in detail the recent morphological evolution of the Biferno river, and to gain data on the effects on the riparian vegetation and on the possible role played by the Ponteliscione dam which is located ca. 28 km from the river mouth and captures the water supply of ca. 70% of the catchment from the mid-70's. Channel adjustments have been investigated for the time-window 1869-2007 by a multi-temporal analysis performed in ArcGIS using the historical I.G.M. topographic map of 1869 and the large scale topographic map (CTR) edited by Molise region in 1992, medium-scale orthophotographs of 2007 and medium-scale aerial photographs dating to 1954 and 1977, respectively. The investigated valley floor system was subdivided in two sectors which are separated by the Ponteliscione dam. The sector located upstream the dam, very narrow with a current average width of ca. 200 m, has a longitudinal average gradient of 4 degrees. The confining, low to moderate steep valley slopes are deeply affected by mass movements and erosion due to running water which frequently interact with the fluvial dynamics. The valley floor sector located downstream the dam is much more larger (on average 1250 m) and has an average longitudinal gradient of 1 degree.

With the exception of the ca. 10 km long reach preceding the river mouth, showing a meandering pattern which has only slightly evolved in the considered time-window, the Biferno river has registered important pattern changes in both sectors from braided in 1954, to transitional in the late 70's and to sinuous in 1992.

Simultaneously, a progressive narrowing of the channel-floodplain system occurred, less intense in the upstream sector than in the downstream sector. In particular, it could be observed that channel narrowing reached 75% and 85%, while the adjacent floodplain areas even increased about 50% and remained approximately constant, respectively. Channel narrowing and pattern changes were accompanied by intense to very intense channel incision which affected the entire valley bottom system and led to the formation of three orders of terraces (T3-T5) that characterize, together with the first and second-order terraces of pre-1869 age, the current valley floor morphology.

Valley floor terracing occurred simultaneously upstream and downstream the Ponteliscione dam, with terraces T3, T4 and T5 that formed during periods 1869-1954, 1954-1977 and 1977-1992, respectively.

While the terraces T3-T4 can be explained taking into account the climatic amelioration that followed the Little Ice Age and the human interventions on the catchment and on the river system occurred in the first part of the 20th century, the T5 is clearly related to the presence of the dam. The dam in fact has introduced an important modification in the local base level of erosion for the upstream sector, as highlighted by the overall increase of the floodplain areas, while the related alteration of original flow and related sediment regimes provoked the formation of the T5 terrace within the downstream sector.

The observed channel adjustments had major effects on land use and especially on the evolution of the riparian vegetation. In fact, channel adjustments were accompanied by a strong expansion of agricultural areas and broad-leaved forest at the expense of the natural riparian vegetation (especially shrub and/or herbaceous vegetation). The most substantial part of these land cover changes had already occurred in 1977.

C2-4 Orale Giordan, Daniele

10.1474/Epitome.04.0229.Geoitalia2011

MONITORING THE RIVER'S EVOLUTION THROUGH

MULTI-TEMPORAL LIDAR ANALYSIS: AN INTRODUCTION TO THE "ACTIVITY INDEX"GIORDAN Daniele¹, ALLASIA Paolo¹, BALDO Marco¹, LOLLINO Giorgio¹
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Key terms: Morphological river evolution; LIDAR; activity index

The analysis of the recent evolution of rivers implies the use of monitoring techniques that allow accurate evaluations of the volumetric changes occurred. In this context, the comparison of multi-temporal digital terrain models (DTM) represents an effective solution. Indeed, this monitoring technique may allow for quantitative evaluations of the change occurred over large areas with accuracies hardly achievable with other methods. However, the use of such as monitoring techniques requires the definition of algorithms and procedures for a correct interpretation of the results. In this work, we propose a new method to interpret the recent evolution of river beds by considering multi-temporal DTMs generated via airborne LiDAR surveys. The methodology herein presented provides accurate information that evidenced both the occurred volumetric change and the morphological variations of the riverbed. Moreover, we also defined a new quantitative parameter to better interpret our results: the "activity index". The latter is defined as the ratio between areas where important volumetric variations occurred and the total area of the river bankfull. We present several case-studies where our procedure has been successfully applied and the activity index was very helpful in evidencing the predisposition to changes of the river paths. In particular, the methodology has been applied to the Orco River as well as along reaches of the Secchia and the Taro Rivers to test the activity index efficiency on different morphological contexts. Finally, we present the last part of the research project that is related to the comparative analysis between the activity index and the standard discharge evaluations to detect a possible analytical relationship between these two parameters.

C2-5 Orale Barbero, Giuseppe

10.1474/Epitome.04.0230.Geoitalia2011

STOCHASTIC ANALYSIS OF THE WIDTH OF A MOBILE BED ALLUVIAL RIVERBARBERO Giuseppe¹, PELLEGRINI Luisa²1 - DIPARTIMENTO BEST - POLITECNICO DI MILANO
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Key terms: alluvial river width; mobile bed; stochastic process; markov chain; Apennine Po river tributaries

In this paper, the maximum width of a mobile bed alluvial river is represented as a continuous stochastic process. The process is assumed spatially homogeneous and the time is considered a discrete parameter. The considered models are, in principle, non-stationary; however they are referable to an AR(1)-process (autoregressive process of order 1). To define the models the coefficient of variation, the first order autocorrelation coefficient and the skewness must be assigned. The continuous stochastic process is transformed into a Markov chain, in order to estimate the not overcome probability of an assigned of the maximum river width.

The analysis has been applied to the plain reach of three Apennine Po river tributaries: the Scrivia river (Piedmont region) between Cassano Spinola and Castelnuovo Scrivia, the Trebbia river (Emilia-Romagna region), between Mirafiori weir and TO-PC railroad bridge, and the Nure river (Emilia-Romagna region), from Ponte dell'Olio to PC-BO railroad bridge. The width and vertical channel changes of these rivers have been studied and pointed out in several previous works developed within the PRIN project (2005 and 2007) and related to the geomorphological evolution. In particular, the narrowing and widening have been calculated through measure of cross-section of the bankfull, 25m spaced, on aerial images and historical maps, that was scanned and georeferenced. The database of the widths include 15 years for Scrivia River, 12 years for Trebbia and 10 years for Nure, since the end of the 19th century to the 2010.

This paper resumes and processes the results of these analysis to determine the statistical parameter of the considered models.

C2-6 Invitato Mao, Luca

10.1474/Epitome.04.0231.Geoitalia2011

FLUVIAL PROCESSES AND RIPARIAN VEGETATION IN DISTURBED RIVERSMAO Luca¹

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Key terms: Riparian vegetation; Gravel-bed rivers; Human impacts

Riparian vegetation plays a crucial role in determining the morphodynamics and the ecological values of river systems. The significant impact of vegetation growing on bars, islands and floodplains on channel morphology has been increasingly verified in the field, numerically as well as experimentally, demonstrating the remarkable influence of riparian vegetation in stabilizing banks, increasing mean channel depths and significantly reducing the number of channels per river cross section (the braiding index). The geomorphic effect of living plants continues even after their erosion from the banks and transportation within the fluvial network. In fact, dead or living pieces of large wood can exert a tremendous influence on river erosion and sedimentation processes, channel morphology, channel hydraulics, as well as ecological diversity.

The pattern of riparian vegetation in gravel bed rivers depends on the climate, hydrological regime, and the morphological settings of the river. Also, the marked spatial variability of density, height, species diversity, age, and rates of growth reflects the very complex nature of bed colonization, the strong influence of sequences and magnitude of floods, and the feedbacks between morphology, vegetation and hydraulics. Furthermore, a wide array of human impacts acting at either the basin or river network scales can influence substantially the morphodynamics and thus the characteristics, types and distribution of vegetation within the river corridor. A better understanding of how vegetation reacts to natural and anthropogenic impacts is needed in order to increase our ability to predict the response of river systems to flood events, and to assess the human impacts on river dynamics due to different management strategies

of riparian vegetation and river restoration schemes. Moreover, the need for such improved understanding is also enhanced by a requirement to better predict river system and ecological habitat response to environmental change, notably climate and land use alterations. The aim of the contribution is to illustrate the importance of riparian vegetation in determining fluvial shape and processes, and habitat ecology. A special emphasis will be given to describe the vegetation types, structures and distribution patterns in Italian gravel-bed rivers suffering from various degrees of human pressure and disturbances. The case of the Piave river, which suffered intense and multiple human impacts especially due to dam building and in-channel gravel mining, is taken as a reference for discussing the relationship between the vegetation structure and the morphological characteristics in an impacted river. The Piave river shows a complex pattern of vegetation distribution along the cross-sections, with no clear relationship between the elevation and the "maturity" of plant communities as a result of a recent tendency of active channel widening after a long period of channel narrowing. Parallel to the substantial active channel narrowing and incision occurred during most of the twentieth century, the proportion of the fluvial corridor covered by vegetation at the channel margins has experienced a significant increase. These extensive mature riparian areas within the fluvial corridor have beneficial effects on the overall ecological potential of the area, and are in fact sometimes protected. However, these forested areas lie on former active channel portion of the river corridor and their protection could hamper efforts directed at promoting river restoration through channel expansion and aggradation. Furthermore, these areas could represent significant sources of drift wood if eroded and transported downstream during high-magnitude events.

C2-7 Orale Bollati, Irene Maria

10.1474/Epitome.04.0232.Geoitalia2011

THE DENDROGEOMORPHOLOGICAL APPROACH TO INVESTIGATION THE RECENT CHANNEL ADJUSTMENT: THE CASE STUDY OF THE TREBBIA RIVER (EMILIA ROMAGNA, ITALY)BOLLATI Irene Maria¹, PELLEGRINI Luisa², PELFINI Manuela¹, DUCI Gabriele², BAZZI Alessandra¹

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Key terms: Dendrochronology; Fluvial dynamics; Minimum age

The reach of the Trebbia river in the plain shows mobile alluvial channels with braided, wandering and meandering patterns. Evident channel changes have affected this river and recent studies have pointed out the processes of both narrowing, during the twentieth century, and widening, since 2000. In such an active environment, where the modifications can occur in a few years or, sometimes, during severe flood events, it is very interesting to locate and to date, if possible, the stable surfaces.

The proposal approach has the main aim of integrating the evaluation of river-bed erosion and/or deposition, deduced from geomorphological studies, geomorphic indices and their cartography and topography restitution, with the dating of geomorphological surface through dendrochronology.

The selected area for dendrogeomorphological sampling was chosen through aerial photo analysis of the landform modifications of the Trebbia river over time, in order to trace the dynamics of the river influence on the stabilization of bars and alluvial plains. The 93 sampled trees of "Populus nigra" L., whose ring boundaries have been in some cases difficult to locate in the phase of laboratory analysis, were collected from nine sampling clusters in which the changes had been evident between the beginning and the end of the 1980s. These more stable portion of the riverside should be populated by trees whose rings record covers almost the entire time interval. In order to date the geomorphological surface the "ecesi" (time taken by trees to successfully germinate on a bare surface) was considered and, as indicated in the literature, "Populus nigra" L. takes a little time to start settlement on fluvial bars and alluvial plains. In addition, the microscopic analysis of abrupt growth changes in annual tree rings can again provide interesting information to be crossed with the cartographic data.

The geomorphological investigation and the aerial photos analysis through GIS procedure made possible to place the period of maximum narrowing between 1980 and 1990 and the minimum bankfull width in 1990. Starting from 1996 the bankfull began a new phase of widening. The minimum age of vegetation investigated on fluvial bars and islands allows us to limit the interval of minimum bankfull width, indicating that probably it had already been reached in 1985-87 when the areas, that had been part of the active bankfull in 1980, were colonized by vegetation. Here, aerial photo interpretation and tree rings analysis allow better time location of the recent river-bed modification. Once the temporal resolution and the error of dating of the dendrogeomorphology tool have been tested in an area with a good deal of geomorphological data available (aerial photos, topographic maps, etc.), dendrogeomorphology can be used to refine geomorphology investigations and to integrate lacking data in those areas not well provided with other typologies of data.

C2-8 Orale Bertoldi, Walter

10.1474/Epitome.04.0233.Geoitalia2011

USE OF LIDAR DATA TO QUANTIFY THE ROLE OF RIPARIAN TREES IN SHAPING THE MORPHOLOGY OF BRAIDED RIVERSBERTOLDI Walter¹, GURNELL Angela², DRAKE Nick³

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Key terms: braided rivers; riparian vegetation; river bed morphology; LIDAR data

The increased availability and accuracy of remotely sensed data open new possibilities to investigate the relationship between fluvial geomorphology and vegetation development. This paper combines archived remotely sensed data (airborne LiDAR and digital colour air photographs) with non-synchronous ground observations to quantify the impact of colonization of exposed river sediments by riparian trees on channel form. The study site is a 21 km reach of the braided, gravel-bed Tagliamento River, Italy, which is characterized by a wide range of vegetation conditions. Therefore, we have been able to explore the ways in which riparian tree growth moderates the morphological structure of braided river reaches under circumstances where other influential factors such as

peak discharges, slope and grain size remain approximately constant. LiDAR data are analyzed to extract a 2 m resolution DEM and determine riparian vegetation extent, height and structure within the active corridor. Aerial photographs are used to map the topography of the submerged parts of the corridor. These data are divided into 1 km length sub-reaches, which possess strong contrasts in vegetation height and extent. Joint analysis of vegetation and morphological properties of these sub-reaches reveals significant associations between vegetation properties and reach morphology. We analysed the bed elevation frequency distribution, showing that heavily vegetated areas are associated with the appearance of secondary peaks describing island formation. The analysis demonstrated that sub-reaches with an extensive, relatively mature cover of vegetation in the form of patches of varying size up to islands several hundred meters long, exhibit a different morphology from sub-reaches with limited vegetation cover. The skewness and kurtosis of the elevation frequency distribution within each of the sub-reaches are both significantly correlated with vegetation extent, height, median elevation and growth rate, indicating a clear topographic signature of vegetation development along this braided river that reflects sediment accumulation within and around the vegetated patches.

C2-9 Orale Belletti, Barbara

10.1474/Epitome.04.0234.Geoitalia2011

RIPIARIAN VEGETATION AND FLUVIAL GEOMORPHOLOGY: WHICH INTERACTION IN INCISED FLUVIAL SYSTEM? THE CASE OF THE PANARO RIVER (MO)

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Key terms: riparian vegetation; fluvial landform; morphological evolution; channel adjustment; human impact

Several studies have recently focused on the relationship between riparian vegetation and fluvial geomorphology. Anyway few studies have analyzed in detail the relations and feedbacks between channel adjustments and vegetation dynamic in heavily incised alluvial rivers.

This study analyzes: i) the relationship between fluvial landforms and characteristic plant species; ii) the species composition and distribution as indicator of the active channel evolution, iii) the role of the human impacts on the structure and composition of the vegetation in fluvial ecosystems. The study combines the analysis of the morphological changes (aerial photos analysis, longitudinal profiles and field observations) and a detailed phytosociology analysis of the existing vegetation ("Braun-Blanquet" method, 1965).

The study area includes 38 km of the Panaro River (MO), characterized by high incision and general river degradation. The riparian vegetation is at most natural or sub-natural.

Results show clearly relationship between fluvial landforms and types of vegetation, even if we recorded significant deviations from the typical correlation pattern existing between morphology and vegetation. The types of human alterations, their intensity and influence on the relationship between vegetation and fluvial landforms are also discussed. The aim of this study is to provide a useful model to support the understanding of human-modified fluvial systems and to provide tools for environmental and territorial management, for the objectives of the WFD (2000/60/EC).

C2-10 Orale Golfieri, Bruno

10.1474/Epitome.04.0235.Geoitalia2011

ASSESSMENT OF MORPHOLOGICAL AND ECOLOGICAL CONDITIONS OF ITALIAN ALPINE RIVERS USING IQM AND ODONATA

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Key terms: Indice di Qualità Morfologica; dragonflies; hydromorphology; ecological indicators; Alps

The study aims to assess the morphological and ecological conditions of some Italian alpine alluvial rivers, using specific indexes, and to analyze the relationships between these two components of the fluvial environment. Another topic of the research is to test Odonata as ecological indicators over a set of reaches with different channel morphologies (from braided to single-thread) and different human impacts.

The study cases are 7 alpine alluvial rivers, 4 coming from the central-western Alps and 3 from the eastern portion of the Alps. Three reaches will be studied for each river and they'll be located in different physiographic context: one reach in the alpine-prealpine region, and the other two in the High and Low alluvial Plain. The chosen reach should be representative of the whole segment (defined by the intersection of the borders of the physiographic units with the river itself), in terms of morphological and ecological characteristics, human impacts and expected quality.

The recently developed IQM (Indice di Qualità Morfologica - Morphological Quality Index) will be used to evaluate the morphological conditions of the study reaches. The index, which is obtained through remote sensing analysis and field-collected data, is composed by 28 indicators divided in 3 categories: 1) functionality of geomorphological processes; 2) presence of artificial elements; 3) recent channel changes. IQM allows an assessment of the fluvial reach in a five-tiered classification scheme, as required by EU Water Framework Directive (WFD).

Dragonflies (Odonata) will be used as ecological indicators to evaluate the ecological integrity of river-floodplain ecosystems in the study reaches. Previous works have shown that dragonflies are good indicators of ecological quality of land-water ecotones, habitat heterogeneity and hydrological dynamics of water bodies. Dragonflies should allow a more global ecological assessment of the fluvial reach, respect to what is possible with other categories of bioindicators that are generally strictly aquatic organisms (diatoms, aquatic macrophytes, benthic macroinvertebrates and fishes). Within each study reach 4 sites will be selected for dragonflies surveys, that are based on adult observations,

larvae and exuviae sampling. Every site will be visited four times a year, to determine the autochthonous dragonfly community. The sites should be representative of the diversity of habitat that are present in the reach, following, if possible, an ideal transect from the main channel to secondary channels or non-flowing channels, up to isolated ponds - backwaters located in islands or in the floodplain. Dragonflies community data will be used to calculate OHI (Odonate Habitat Index), after having checked the possibility to import this Austrian index in the Italian context, or to develop a new index, based on the theoretical basis of the OHI. In any case, also the ecological index will follow a five-tiered classification scheme, to be easily compared with IQM and the other indexes based on bioindicators used in Italian rivers.

First preliminary results of the research are presented and discussed, analyzing the relationships between the response of the two indexes to common impacts and pressures that are present in the study reaches.

C2-11 Orale Braca, Giovanni

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EVALUATION OF RIVER HYDROLOGICAL REGIME ALTERATION BY MEANS OF A SYNTHETIC INDICATOR: IARI

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Key terms: hydromorphology; hydrological alterations; fluvial processes; hydrology

The hydrological regime of a natural watercourse represents a set of intrinsic characteristics of river flows, in terms of timing, magnitude and frequency..

It is generally admitted that flow regime, together with river morphology, is the main driving element shaping the structure and functionality of river ecosystems.

European Commission Water Framework Directive 2000/60/CE requests evaluation of the hydrological regime alteration in order to assess the high ecological status..

Many procedures, more or less complex, have been developed in Europe and USA to take into account the hydrological regime alteration rate with particular attention to the change due to anthropogenic actions.

In order to implement Water Framework Directive, within the scope of its mission, the Italian Institute for Environmental Protection and Research (ISPRA) has developed a procedure for assessing the river hydrological regime alteration by means of a synthetic indicator named IARI (acronym of Indice di Alterazione del Regime Idrologico).

The definition of this indicator follows the IHA (Indicators of Hydrologic Alteration) procedure implemented by The Nature Conservancy.

The IARI procedure takes into account the availability (usually low) of recent and past hydrological and flow data and recent climate conditions by means the SPI index.

In this paper an illustration of the whole procedure is given and tests on different hydrological regimes are presented.

C2-12 Orale Silvestro, Chiara

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THE STUDY OF RIVERS GEOMORPHOLOGY IN THE MANAGEMENT OF SEDIMENTS THROUGH THE APPLICATION OF GEOMORPHOLOGICAL QUALITY INDEX. PIEDMONT CASE HISTORY.

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Key terms: sediments; directive; geomorphology

In Italy the mining of sediments from river bed is a major business, so some years ago the River Po Authority issued a specific Directive about. The aim of the document is to identify homogeneous methods and procedures to be applied in the river Po basin to manage sediment mining. In the directive, actions on river sediments have to be defined after researches on significant river stretches are done. The scope is to define the river's dynamic equilibrium through the study of three important characteristics: hydraulic, geomorphology and ecology. A multi discipline approach that involves different professional figures.

In 2009, as specified in the Directive, the Region Piedmont began working on the definition of an intervention program for the mining of the sediments in some of the Cuneo province most important rivers: Varaita, Maira, Stura di Demonte and Tanaro (in this case the Asti province territory was also involved). The research also studied the geomorphology of those rivers in details.

As the Po Authority suggested, the Region Piedmont has analyzed geomorphologic aspects through the application of the quality geomorphologic evaluation method, that ISPRA proposes to apply at the Water Framework Directive (2006/60/CE).

The method applied to sediments managements is useful as it also looks into not strictly geomorphologic aspects but still closely related to them. For example it analyses matters as riparian vegetation or hydraulic aspects promoting the integration between different topics: one of the Directive scope.

Applying the ISPRA method on several rivers is also interesting since allows comparisons between the results. For example, it is possible to analyze the same issues at the same scale on different water bodies, or at different scales (river basin, stretch) on the same river; to make hypothesis on the connections between morphological development and natural or human actions;...

In our experience it is not so important the value of the index IQM that the method suggests, but the possibility that the method offers to study several topics, thus make a connection among many aspects and comparing the results.

Sometimes we found difficulties using the ISPRA method to collect informations and elaborate data. Very often we haven't informations on digital support but also we have to go on site to be sure of your data lots of time. The time you need is quite a lot and the hazard is to have a work where the personal interpretation play an important rule.

The application of the method to evaluate the IQM index permitted to describe the actual rivers evolution, their actual situation of equilibrium or of disequilibrium, (as we experimented for Varaita, Stura di Demonte, Tanaro and Maira) and it's a good help to reach one of the aim of the directive.

Our experience says that the IQM evaluation could be a reference method also in different fields, not strictly related to WFD.

C2-13 Orale Cencetti, Corrado

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PRELIMINARY RESULTS OF APPLICATION OF MQI METHOD, BY MEANS OF GIS AUTOMATED PROCEDURE, TO SOME RIVERS IN CENTRAL ITALY.

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Key terms: Fluvial Dynamics; Water Framework Directive; Morphologic Quality Index; GRASS GIS

Recently, ISPRA (Advanced Institute for Environmental Protection and Research, Italy), has acknowledged the indications of the Water Framework Directive 2000/60/CE, and has developed a methodology to survey the hydro-morphologic characters, finalized to the calculation of an index (MQI, Morphologic Quality Index) that can represent the "state of morphologic quality" of the streams, in natural and/or anthropic environment (Rinaldi et alii, 2011).

The method consists of a first phase of subdivision in homogeneous reaches, carried out by means of analysis of aerial images and bibliographical informations, for which the GIS software represents a fundamental tool. The subdivision, in fact, is carried out by determining some morphologic parameters (among these: area of water-drainage, slope, confinement of the stream, sinuosity, tendency to braiding and/or to anastomosing, riverbed width, extension and types of sedimentary bodies etc) that can be calculated by means of simple but frequent measures.

These operations are rather expensive in terms of time and, therefore, they can be favorably automated by GIS.

The note describes 4 codes for the automated calculation of the main parameters, written in python and implemented within GRASS GIS. These need, in input, some morphologic elements in vector format: boundaries of the alluvial plain, of active riverbed and of channel, valley and riverbed axis, banks, bars, islands.

The codes are: Profilo.py, to extract longitudinal profile from a high resolution DTM; Confinamento.py to calculate the Confinement Degree and Index; Sinuosità.py to calculate the Sinuosity Index; Alveo.py to calculate the total width, the real width, Braiding Index, Anastomosing Index.

The method has been experimentally applied to some reaches of Umbrian streams (central Italy), under different morphologic conditions and human impact. The preliminary results are here reported.

C2-14 Orale Ziliani, Luca

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COUPLING NUMERICAL AND CONCEPTUAL MODELS TO ASSESS MORPHOLOGICAL EVOLUTIONARY TRAJECTORIES OF RIVER CHANNELS

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Key terms: evolutionary trajectories; numerical modeling; conceptual model; Tagliamento

Most Italian rivers have undergone notable alterations of their morphological characteristics over the last decades. Such alterations have effects on their ecological condition and it is therefore needed to identify management strategies that can improve morphological condition of rivers. Critical issue for management is assessment of potentials and limits for such morphological improvement, that is definition of possible evolutionary trajectories of river channels in the near future. The aim of this work is to address this issue in the Tagliamento River, a large gravel-bed river in north-eastern Italy, combining conceptual and numerical models. The conceptual model derives from reconstruction of past and present evolutionary trajectories of alluvial rivers in Italy and, more specifically, of gravel-bed rivers in north-eastern Italy. Numerical modeling was carried out using CAESAR, a reduced complexity model which allows application to long reaches over long time scales (i.e. several decades). Future evolution of river channels is assessed according to scenarios that take into different management strategies (specifically concerning sediment management) and changes in hydrological regime. The application was carried out in a 33 km reach characterized by a braided morphology. This reach underwent remarkable narrowing and some incision in the past while, more recently, a moderate recovering (i.e. widening and sedimentation) is taking place. Numerical simulations were carried out to explore channel evolution over the next 80 years. A What-if scenarios strategy was adopted. These scenarios take into account effects of different management strategies which may act both at reach and basin scales. For instance, it was assessed channel response to increase or decrease of bank protections. Besides management, the influence of flood magnitude and frequency on channel evolution was addressed. Results from this application suggest that an integrated modeling approach (conceptual and numerical) may increase our ability to predict future evolutionary trajectories of river channels. Overall there is good agreement between results from the two models. On the other hand the cellular model allows a better appreciation of processes that are simplified or neglected within the conceptual model. For instance numerical simulations show that input of coarse material from lateral erosion, rather than input from upstream, is a driving factors of channel evolution over examined timescales (i.e. tens of years).

C2-15 Orale Rinaldi, Massimo

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IDRAIM: A NEW METHODOLOGICAL FRAMEWORK FOR STREAM HYDROMORPHOLOGICAL ASSESSMENT, ANALYSIS AND MONITORING

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Key terms: hydromorphology; channel dynamics hazard; stream morphological quality; IDRAIM

The EC Water Framework Directive 2000/60/CE requires hydromorphology to be considered as a component of stream quality conditions and the implementation of restoration actions, whereas the EC Flood Directive involves the identification of measures to mitigate floods and related hazards. To achieve the objectives of both directives (river ecological quality and public safety, respectively), there is an increasing need for approaches and methods based on geomorphological processes responsible for river dynamics and related hazards.

In Italy, as in many other European countries, hydromorphological degradation is a major cause of alteration in rivers and, on the other hand, hazards related to fluvial dynamics, each year, determine considerable damages and casualties. Consequently, the Italian National Institute for Environmental Protection and Research (ISPRA) has recently promoted a research program with the objective of developing a comprehensive methodological framework to support the management of river processes, integrating ecological quality and safety objectives according to the two directives 2000/60/EC and 2007/60/EC, respectively. The methodological framework (IDRAIM: system for stream hydromorphological assessment, analysis, and monitoring) stems from existing experiences of geomorphological approaches developed in other countries (e.g. the River Styles Framework), but it accounts for the specific Italian context in terms of channel adjustments and human impact, and also includes the fluvial dynamics hazard component. The general structure includes the following four stages: (1) the general basin setting and its segmentation; (2) the present morphological conditions and past evolution; an assessment of morphological conditions is performed, with particular emphasis on sediment dynamics at the catchment scale, trajectories of channel changes, and implications for fluvial hazards; (3) future geomorphic trends; predictions of likely future channel adjustments and their implications on river morphology and hazard conditions are considered; (4) integrated management: the final step involving the integration of the two objectives, i.e. the improvement of river morphological quality and the mitigation of hazards related to fluvial dynamics.

C2-16 Poster Audisio, Chiara

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MODELLING RIVER EVOLUTION: A COMPARISON BETWEEN REAL AND SIMULATED CELLULAR AUTOMATA DATA ON PELLICE RIVER (NORTH WESTERN ITALY)

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Key terms: river geomorphology; cellular automata model; CAESAR; Pellice River; North western Italy

The past two decades have seen significant improvements of the studies about the rivers morphology, in particular regarding analysis of the processes governing the fluvial evolution resulting from the erosion and transport of the sediments. Important results have been achieved thanks also to the evolution of both instrumental and computational tools. In the first case the new technologies have allowed a more detailed representation of the territory (DTM obtained by LIDAR survey) while in the second case the computational speed of the recent platforms, besides the developing of more advanced mathematical modelling and numerical algorithms, suggest a promising research line in order to simulate or, at least, to estimate the rivers evolution in a more and more suitable and realistic way. In order to model the rivers evolution, essentially two main approaches have been adopted in the literature: CFD and cellular automaton. Within the CFD framework, based on "First Principle Approach", Navier Stokes equations are solved by different numerical techniques: FEM (Finite Element Method), FVM (Finite Volume Method), FDM (Finite Difference Method). The Cellular Automata Model is suitable for analyzing the evolution of landscapes using a grid of interacting cells. Each cell is connected to the small volume around selected points belonging to the system. Then the evolution of a selected phenomenon is studied through the evolution of the "state" related to the mechanical, morphological and so on characteristic of each cell, through their mutual interaction. The interactions among cells (automata) are ruled by simplified versions of the related governing laws of physics. In particular, in within the fluvial geomorphology framework, Cellular Automata physics is based on a simplified or "relaxed" version of the complex flow equations employed in CFD models.

Consequently, it might be interesting to explore how the simplification of the physics adopted by Cellular Automata may affect the adequacy of its numerical response in comparison with experimental data. For this reason, the main target of this paper is to explore the feasibility and suitability of the Cellular Automata technique to simulate, for instance, the evolution of a North Western Italy river (Pellice River), comparing numerical results to experimental measures. Thus, an available Cellular Automata research code (CAESAR) has been selected. CAESAR, Cellular Automaton Evolutionary Slope and River model, is an open source cellular model which can be run in two modes: a "catchment" mode with no external influxes other than rainfall; and a "reach" mode with one or more points through which sediment and water enter to the system. The CAESAR model employs a scanning algorithm that "pushes" water across a grid to the cells in front, along four directions.

The model has been applied to Pellice River, an alpine tributary of Po River in North - Western Italy. It drains 906 km² and its channel is about 53 km long. In the selected reach, 2 km long, the channel is incised in cobble-gravel deposits and shows a single-channel thread. In the past the river channel showed almost everywhere a multi-thread pattern, somewhere braided.

The starting data for the model are a digital terrain model (DTM) obtained by a LiDAR survey dated back on February 2007, water discharge and depth data derived by a hydrometric gauge (ARPA Piemonte), the Corine Land Cover is used for vegetation and some granulometric investigations was made in the selected reach.

Different simulations, covering the period 2007-2010, have been carried out and discussed. In particular, the numerical results have been compared with some GPS cross-sections, related to October 2010. Some important results have been obtained by the comparison: the adopted modelling approach seems to be adequate regarding the depositional processes, even if some problems are still unsolved with the lateral

erosion.

C2-17 Poster Belletti, Barbara

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BRAIDED RIVER PATTERN AND RIVERSCAPE EVOLUTION IN THE FRENCH RHONE BASIN DURING THE LAST CENTURY

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Key terms: braided rivers; river landscape; morphological evolution; aerial photographs; regional pattern

Despite their strong disappearance during the last centuries, several braided reaches remain in French Alpine rivers.

This study is focused on 53 braided reaches in the Rhone basin representing 139 km of the 650 km remaining braided cumulated length. We made a diachronic comparative analysis of the evolution of the river landscape between 1950 and 2000, using aerial photographs from the French National Geographic Institute (IGN).

The objective of this study is to support the understanding of the functioning of braided rivers in terms of dynamic and evolution at the regional scale and in relation to recent human pressure. The morphological evolution of the river planform has been put in relationship with the sedimentary evolution during the last century and with the flood history.

The results show a general narrowing of the active channels due to vegetation encroachment and island development. Some reaches, mainly situated in the Durance basin, show a different behavior. A multi-temporal analysis on a subset of 12 reaches has also been made, with the aim to characterize the river morphology evolution in relation to the biggest floods.

This study enables the identification, amongst braided rivers of the Rhone basin, of the most dynamic braided rivers versus those which are in equilibrium or those which are changing their fluvial pattern. We also proposed and discussed a regional typology.

The evolution of these river systems is studied to define actions of conservation and restoration and to achieve the objectives of the WFD.

C2-18 Poster Maraga, Franca

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COARSE SEDIMENT DYNAMICS IN FIELD INSTRUMENTED STREAMS

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Key terms: research instrumented basin; channel bed changes; sediment transport; alpine environment; Italy

Monitoring experiences of sediment dynamics are presented that regard two small mountain research basins, well equipped to sediment transport measurements of bed load and debris flow in Alpine regions (Italy). Field measurements are tested to investigate the coarse sediment transfer in gravel bed reaches at the outlet of the basins. The small basin Valle della Gallina (1 km² in area; basin outlet elevation 300 m a.s.l.) is selected to represent bed load processes in the region of north western Alps, as a tributary of the upper plain of Po river system (Lozzolo, Vercelli, Piemonte Region), and it is under observation since 1982. The small basin Rio Moscardo (4.1 km² in area; basin outlet elevation 890 m a.s.l.) is selected to represent debris flow processes in the region of eastern Alps as a tributary of the upper valley of the Tagliamento river system (Paluzza, Udine, Friuli Venezia Giulia Region), and it is under observation from 1985 to 2005.

The aim of the experimental small basins is a long term monitoring of the hydro-sedimentary response to explore and compare the changes of coarse sediment transport and channel bottom in changing environment. The experimental basins are promoted and managed by Cnr, Institute for the Geo-hydrological protection (IRPI), branch of Turin.

Bed load experiences (since 1982) - the Valle della Gallina research basin represents a pre-Alpine landscape bordering the Po river plain with a continental-Mediterranean climate. The main stream is equipped with one in-channel natural debris pool regularized into the bottom bedrock, in order to measure the delivered volumes (from 0 m³/year (1985 and 2008) to 73 m³/year (2002)). Average sediment yield from the basin is 32 m³ (1982-2009), grain size distribution ranges from 0.06 to 258 mm.

Furthermore, an instrumented reach is equipped 120 m long upstream the debris pool (slope 1%) in order to measure sediment transfer distances by autochthon pebble tracers. Measurements show an exponential dependence of displacements on the peak flows. The travelled distances show dependence on the pool and riffle sequences as well as on protruding boulders or bedrock, while trapped volumes reveal a dependency on the sediment feeding in the stream.

Seismometers record water and simultaneous sediment transport pointing up the pulse dynamics in sediment transfer.

The total bed load is measured, including the largest sandy fractions moving as bed load. The sediment suspension processes proved to be irrelevant in comparison with the sediment delivering volumes. An explanation for the sediment decrease below the mean after 2000 could be found in the spreading of the coppice vegetation cover up to the head slopes.

Debris flow experience (1985-2005) - Investigation about the coarse sediment evolution also address the issue of the transport produced by debris flows and in 1985 a debris flow prone basin was instrumented (Rio Moscardo) for the purpose.

Researches mainly regarded the monitoring of flow height through ultrasonic sensors, of the vibration induced in the ground through geophones, of surface velocity through fixed videocameras and of the rainfalls through rain gauges.

Measurements of front velocity and peak discharges was also possible and an estimation of transported volumes was performed for the recorded events. These volumes, estimated during a period of almost 20 years, ranged between few hundreds and 60 thousands cubic meters.

A decrease in number of debris flow occurrence was also observed during the years. At the beginning of the monitoring activities a mean of 2/3 events per year was observed, while at the end of the observation period the debris flows reduced to less than one per year.

This decrease was only partially explained by some systematic works that took place at the beginning of the current century.

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C2-19 Poster Teodori, Sauro

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CHANNEL MODIFICATION OF THE FOGLIA RIVER DURING THE LAST 200 YEARS

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Key terms: Fluvial Terraces; Channel adjustments; Historical cartography; Foglia river; Marche region

In the Foglia River basin, as in all the rivers of the Marche region, four orders of polygenic terraces dating back to the Middle/Upper Pleistocene are recognizable. The largest terraced plain, attributable to the last Pleniglacial period (20,000 years ago), is bevelled with minor terraces, probably relating to climatic events occurring in the Holocene.

Unfortunately, these terraces have not been accurately dated. Through a geomorphological analysis, however, at least two levels of terraces may be recognized, the lowest of which is easily distinguishable from confined paleomeanders indicating a high sinuosity channel. The study of differently dated aerial photos together with field surveys reveals significant changes in the lateral and vertical river dynamics over the last 60 years. In particular, we note that these variations are more pronounced in certain sectors of the valley where we recognized a general downcutting trend of the riverbed and a vertical incision. However, a comparison clearly shows a stronger variability in the channels of the middle section of the valley with maximum reduction peaks of over 300 m with riverbed values generally between 50 and 200 m (Tiberi et al. 2009). The presence of detailed historical cartography made available by the State Archive (Gregorian Register, 1835) allows to evaluate the channel evolution over the past 200 year and its latero/vertical modifications. This analysis constitutes a new source of data to verify the persistence of continuous changes along the entire longitudinal section. The Gregorian Register cartography, contained in a GIS format, when compared with the more recent channel changes, will allow to better illustrate the evolutionary trends improving the understanding of the causes of channel adjustments. TIBERI V., DI AGOSTINO V., TROIANI F., NESCI O. & SAVELLI D. (2009) - Bedrock channel reaches morphology: examples from the Northern Marche Region (Italy). GRA vol. 11, EGU2009-A-3432.

C2-20 Poster Turitto, Ornella

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HISTORICAL ANALYSIS AS A TOOL TO IDENTIFY PLANIMETRICAL AND ALTIMETRICAL VARIATIONS IN A RIVER CHANNEL: THE CASE OF THE PO RIVER AT CASALE MONFERRATO (NORTHWESTERN ITALY)

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Key terms: river morphology; channel adjustments; human impact; Po River; Northwestern Italy

Information gleaned from historical maps, published or unpublished documents, and hydrometrical data can provide a valuable support in the analysis of morphological variations in river channels.

This case study describes a 15-km reach of the Po River upstream and downstream from the Casale Monferrato bridge (drainage basin area, 13.940 km²) where a hydrometrical gauging station was installed in 1882. Comparison of historical and recent maps showed a marked reduction (up to 80%) in the total channel width (wet channels with islands and bars) over the last 200 years. The channel width decreased progressively from 1-2 km (early 19th century), to 300-700 m (early 20th century) to 200-500 m (early 21st century). This has been accompanied by morphological changes in the channel pattern from a multi-thread to a single, sinuous channel with small sporadic bars and a gradual disappearance of the islands as they merged with the surrounding floodplain.

From a review of Ministry of Public Works technical reports and plans, we identified the channel regulation works constructed over the past two centuries and the effects they have had on channel dimension and pattern:

- ° since 1808 all peripheral ramifications of the river have been artificially closed off;
- ° in 1840 the old boat bridge at Casale Monferrato was replaced by a new bridge;
- ° over the course of the 19th century continuous embankments where filled in on the left and right sides of the river to control flooding;
- ° mainly after the 1940s bank protections to prevent bank erosion where placed at each fluvial bend or at the embankment foot.

These changes have also resulted in severe channel incision, as inferred from a progressive decrease in the minimal annual water level recorded at the Casale Monferrato gauging station. A clear incision started in 1915 reaching -3.70 m in 1968 (-1 m in 1915; -2 m in 1942; and -3 m in 1955). Between 1950 and 1980, the incision process was additionally exacerbated by excessively deep and widespread gravel and sand mining. Encroachment into the river corridor by agriculture and urban use has opened new areas for development, but also triggered severe and recurrent failures at the bridge, bank protections and embankments.

C2-21 Poster Zizioli, Davide

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QUALITY ASSESSMENT OF PHOTOGRAMMETRICALLY-DERIVED DTM IN THE EVALUATION OF RIVER CHANNELS ADJUSTMENT

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Key terms: PHOTOGRAMMETRY; DTM; CHANNEL CHANGES; TREBBIA RIVER; SCRIVIA RIVER

Developing accurate Digital Terrain Models (DTM) has always been a goal of researchers interested in quantifying land surface topography and processes. In fluvial geomorphology they are a very useful stuff to quantify river morphological changes both width and vertical, comparing multi-temporal and heterogeneous surveys. Prior to the introduction of LIDAR, traditional methods such as photogrammetry and field surveys were conducted to produce DTMs. While these methods can generate DTMs with acceptable levels of accuracy for certain applications, both methods are time and labour intensive. Furthermore, in the presence of steep slopes or high biomass, traditional DTM generation methods are difficult to implement, often leading to reduced levels of accuracy. Researches has demonstrated that LIDAR DTM generation is more efficient and accurate as compared to traditional methods. However the LIDAR datasets are available only since a few years and they are very expensive, while the aerial photographs of the Italian territory are numerous, cheapest, easily affordable and, often, if carried out at low altitude, have a fine ground resolution thus offering the opportunity to do a photo-interpretation finalized to identify objects and vegetated patches. On the other hand, due to the presence of a single return, is more difficult to filter photogrammetrically-derived points clouds to eliminate artefacts in elevation due to the top of the canopy correlation.

This study investigate the accuracy of three methodologies to create a digital terrain model from raw photogrammetrically-derived points clouds in braided bed river. The first one classify ground versus non-ground points using a supervised classification based on NDVI (Normalized Difference Vegetation Index). The second and third are known morphological algorithm frequently used to filter LIDAR dataset relative to forested environments. They are the "MCC, Multiscale Curvature Classification" (Evans and Hudak 2007) from Moscow Forestry Sciences Laboratory and the "BCAL LIDAR Tools" an open-source tools developed by Boise Center Aerospace Laboratory. All methods were tested along stretches of Trebbia (PC) and Scrivia (AL) rivers using aerial images of the years 1980, 2006, 2010 and collecting ground control points using RTK GPS. The accuracy tests were carried out using a raw dataset of GPS points and topographic sections surveyed in 2009 - 2010. Preliminary results show that digital terrain models obtained by filtering the points clouds using morphological filters have greater accuracy with less artefacts, especially along vegetated river banks. The average obtained accuracy, corresponding to about 20 cm, fall in the standards of this photogrammetrically derived DTM. This level of uncertainty is low enough to allow a quantitative comparison of the difference in surface elevations from digital elevation models (DTMs) derived from repeat topographic surveys; however must be taken into account when processing DoD (DEM of Differences) for example using GCD algorithm that provides a suite of tools for quantifying those uncertainties independently in each DEM and propagating them through to the DEM of difference.

C2-22 Poster Bertoldi, Walter

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OBSERVING AND MODELING WOOD TRANSPORT IN BRAIDED RIVERS

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Key terms: Wood transport; Braided rivers; Flume modeling; Tagliamento River

Drift wood is a relevant component of river corridors, strongly affecting fluvial morphology and ecology. Over the last three decades, research has highlighted strong links between driftwood dynamics and river morphology at multiple spatial scales, but few studies have addressed this topic in a braided river context. Little is known about wood recruitment, transport and deposition processes in spatially complex, constantly evolving multi-thread systems. We analyzed coupled examples of riparian trees recruitment from eroded banks and wood deposition on immediately downstream bars combining remotely sensed data and field measurements.

The research has been conducted on the Tagliamento River (Italy) a highly dynamic gravel-bed braided river, with large established islands. A pre-flood LiDAR survey provided information on the vegetation extension and density. Two automatic, fixed digital cameras made possible the monitoring of during-flood process of erosion and deposition of the riparian trees with a high temporal accuracy. We surveyed the position, diameter and length of the deposited trees with the aim to: i) quantify the proportion of trees deposited on the first available bar; ii) explore the relationships between log dimensions, number of trees in each cluster and position on the bar; and iii) assess the temporal dynamics and relate the deposition rate with the hydrological and morphological pattern.

The analysis showed that a large proportion of trees is deposited on the first downstream bar, ranging from 15 to 50% as a function of the flood stage and the position inside the network. The highly variable morphology of braided rivers and the strong variability of the channels width as a function of the water stage causes the distribution of the trees on a wide area, with generally small clusters (on average 2 - 3 logs).

The process of wood transport was reproduced on a large flume model (3x25 m, at the Hydraulic Laboratory, University of Trento). The braided morphology was developed freely with constant water and sediment input and wooden dowels of various sizes were used as surrogate logs.

Preliminary results show that the physical model is able to reproduce the characteristic wood dispersal phenomena observed in real-scale streams. The bar-scale morphological structure appears as a major driver of driftwood dispersal, governing transport distance and deposition pattern, with dowel size playing a secondary role on wood mobility.

C2-23 Poster Luchetti, Lucina

10.1474/Epitome.04.0248.Geoitalia2011

"SALINE AND ALENTO RIVERS" - A SITE OF NATIONAL INTEREST RESULTS OBTAINED FROM THE PROCESSING OF THE DATA DURING THE CHARACTERIZATION PHASE AN APPROACH TO THE STUDY OF FLUVIAL SEDIMENTS

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Key terms: Site of National Interest; fluvial sediments; contaminated sites; chemical and ecotoxicological analysis

The present study reports the very first results of the chemical and ecotoxicological analysis of the final stretch of the Alento river (CH) (about 8,000 metres) involved in the S.I.N. Project "Saline and Alento rivers (Abruzzo).

Aim of the study was to both determine the non-site specific screening levels in common with the CSC for soils and subsoils (D.lgs. 152/06) and the definition of the basic values of contaminants in the water streams' sediments in compliance to the criteria contained in the "A proposal of evaluation system on the qualitative state of the fluvial sediments in the Site of National Interest for the Saline and Alento rivers" drawn up by APAT (April 2007-2009).

The qualitative state of the sediments has been evaluated in those riverbed tracts subjected to a potential contamination through an integrated approach which, starting from the acquisition and evaluation of the historical data, takes into consideration both the chemical components (by definition the chemical levels of reference, CLR) and those ecotoxicological ones.

The characterization survey has been carried out by collecting riverbed sediment samples at 16 different spots (plus an extra natural basic sample), by performing acute toxicity tests on interstitial water obtained by centrifugation of the sediment using as target organism *Vibrio fischeri*, a gram negative bioluminescent bacteria. Furthermore, the research of both inorganic and organic contaminants, paying a special attention to: dibenzo(a,h)anthracene, lead, benzene, selenium, DDE and PCB in the sediment, as sampled.

Toxicological analyses of interstitial water obtained from sediments, point out in the vast majority of them, different levels of biostimulation or hormesis. Just in one sample, inhibition of bacteria luminescence of 52.5% has been observed. This sample can be considered toxic according to the suggestion contained in APAT guide lines (Proposal of technical guide of analysis methods for soil and contaminated sites by using biological and ecotoxicological indicators. RTI CTN_TES 1/2004).

The chemical analyses data show a critical state in a greater number of samples for the following parameters: dibenzo(a,h)anthracene, lead, benzene, selenium, DDE and PCB.

We can assume that the discrepancy between toxicological and chemical results could be related to a different polluting bioavailability between the interstitial water and the sediment as sampled.

C2-24 Poster Rinaldi, Massimo

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APPLICATION OF THE STREAM MORPHOLOGICAL QUALITY INDEX (IQM): A FIRST NATIONAL DATA SET

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Key terms: Morphological Quality Index; IQM; Water Framework Directive; morphological assessment

The stream Morphological Quality Index (IQM) is the procedure for the assessment of river morphological quality which has been formally approved as the standard hydromorphological method to comply with WFD requirements in Italy.

The methodological approach is based on an integration of: (1) field surveys and interpretations; (2) remote sensing and GIS analyses. The evaluation of present morphological conditions is carried out by using a series of forms allowing a guided analysis of the following aspects: (a) longitudinal and lateral continuity; (b) channel pattern; (c) cross-sectional configuration; (d) bed structure and substrate; and (e) vegetation in the riparian corridor. The analysis is carried out with reference to the previous five aspects considering three components: (1) geomorphic functionality; (2) artificiality; (3) channel changes. A scoring system is used to obtain a Morphological Alteration Index (IAM) and a Morphological Quality Index (IQM), thus allowing the classification of the morphological conditions of a stream.

A first data set of applications mainly carried out by the developers of the method is presented in this paper. The data set includes about 100 river reaches, mainly located in Central and Northern Italy. These reaches are sufficiently representative of different morphological conditions (confined, semi-unconfined, meandering, braided, etc.) and of various situations of artificiality (ranging from relatively natural to highly artificial streams).

The overall analysis of this initial data set permits the acquisition of some general information on the morphological status of Italian rivers for the different morphological types. Potentialities of more detailed information that can be obtained through use of the index are also shown. Some study cases are used to investigate downstream changes and causes of morphological quality.

SESSIONE C3

I sinkholes: metodologie d'indagine, ricerca storica, sistemi di monitoraggio e tecniche d'intervento

C3-1 Orale Santo, Antonio

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RELATION BETWEEN GEO-STRUCTURAL CONTEXT AND SINKHOLES IN THE CENTRAL-SOUTHERN APENNINES

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Key terms: Karst; Collapse sinkhole; Geostructural analysis; Southern Apennines

Recent studies about sinkholes on the carbonatic massif of the Central-Southern Apennines have highlighted a strong correlation among

their formation, recent tectonics, presence of mineral springs and hyperkarst processes. Sinkholes are recognized just in areas where the previously mentioned parameters coexist.

In this paper we aim to deepen the relations occurring between geo-structural context and sinkhole at different scale of investigation. At large scale we have tried to understand which is the regional and geodynamic context in which the sinkholes are developed. We observed that most of the sinkholes are located along large cataclastic areas related to the activity of regional Plio-Quaternary faults bordering both the peri-Tyrrhenian graben (Latina and Caserta mounts) and some inner areas of the chain (Aterno valley, areas around Telesse, Solopaca, Contursi villages). Such faults follow an apenninic trend along the Tyrrhenian coast, while they follow in some cases an anti-apenninic trend in the inner areas of the chain. Rarely, the regional faults follow a W-E trend, such as in the case of Contursi.

Thanks to a detailed survey it has been possible to recognize that the grade of fracturing of the rocks inside every single sinkhole is always pretty high, and we have observed that in most of the cases the RMR Beniauskis values characterize rocks of low to very low quality. The work has allowed to observe that sinkholes are developed in areas characterized by regional cataclastic belt. Their perimeter may be important because these areas may be considered susceptible to other collapses and because of the seismic macro- and micro-zonation studies addressed to site amplification. Another important aspect of these studies is related to the paleoseismicity because it is well known that the sinkholes may be a geomorphic evidence of strong earthquakes. Finally, also in the urban planning and in the engineering planning of large works and infrastructures we should consider the presence of large cataclastic belt and high concentration of sinkholes.

C3-2 Orale Spilotro, Giuseppe

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SINKHOLE MITIGATION RISK INTERVENTION IN THE LESINA MARINA AREA (PROVINCE OF FOGGIA, ITALY)

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Key terms: Gypsum karst; suffosion sinkholes; risk mitigation; permeability; grouting

Punta delle Pietre Nere, NW of the Gargano promontory and Lesina lagoon, is considered a particularly interesting geological site, being the only formation of magma rocks on the entire Adriatic coast (the name actually translates as "black rocks"). About 60 million years ago these rocks came to the surface together with a gypsum dome of a diameter of about 1 km. These rocks, normally buried under a layer of several meters of continental and marine sands, emerged in 1930 with the building of a channel which connected the lagoon with the sea, with the mouth right at the head.

Since 1970 the area has been characterized by an intense building program, with the development of a tourist settlement. Since 1990, sinkhole phenomena have been noted on the sides of the canal; their marks on the surface evolve in clusters along well defined directions, ending close to the new building area. Further studies have clarified the context and the causes of this instability phenomenon. It can be associated with the structure of the evaporitic rocks, a widespread presence of discontinuity and voids for violent tectonic shifts and the superimposition of a paleocarsism at different depths, corresponding to the different levels of the sea standing, the reactivation of karst phenomena and of suffosion processes triggered by the movement of groundwater, following the presence of the new channel. More specifically, the groundwater regime is strictly connected to the complex sea-channel-lagoon system, defined by an inland flow towards the channel modulated by the tide with a variable width depending on factors such as the distance from the oscillating border.

The channel has thus determined a new hydraulic regime condition at the core of the area of maximum emersion of gypsum mass, with the complication that such a condition does not correspond to a static level but, according to what was previously stated, to an oscillating level with complex sinusoidal function, to which a variable field of temperature, electrical conductance and flow corresponds. The latter also seems to be able to invert in specific conditions the direction near the channel. Appropriate action in mitigating sinkhole risks in the area must first address the restoration of the hydro-geological regime to its previous state before the digging of the channel.

This, however, cannot be achieved with the simple elimination of the channel, as 80 years of the new hydro-geological regime have seriously modified the permeability and the storage qualities of the evaporitic mass bedrock.

Therefore the contrast of the new karst evolution and of the suffosion phenomena have been taken into account in modifying the permeability and the storage capacity on the left side of the canal with the systematic filling-in of underground voids. As a result, a barrier has been established with a reduced permeability towards the channel.

Along the border of the area affected by sinkholes, close to the built-up zone, the voids have been filled through small diameter drillings to a depth of 28 m and with an average spacing of 6 m. Subsequently, the filling phase of the voids and of the underground hollows was carried out by grouting in two phases with rising pressure of specific mixtures. The filling phase was completed by grouting in a further series of borings arranged in staggered rows with respect to those of the first group.

The effects of the action carried out on the rocks, initially evaluated by numerical models, have been verified through specific surveys in two significant areas; they have highlighted different hydraulic behavior in the aquifer and a notable reduction in underground voids, with a general decrease in gypsum mass permeability.

C3-3 Orale Bianchi, Elio

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SINKHOLE PHENOMENA IN THE PO PLAIN: THE INTERPLAY OF GEOLOGICAL, GEOMORPHOLOGICAL AND GEOTECHNICAL SETTING

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Key terms: Sinkhole; Po Plain; GPS; PSInSAR; Geomorphological

In Italy, natural sinkhole phenomena which are not connected to any type of karst processes are relatively frequent. In the plains of Veneto and Emilia-Romagna, for example, several small sub-circular lakes are described since a long time, whose formation is thought to have been caused by evorsion (erosional processes related to vertical turbulence) and/or piping in alluvial sediments.

This paper deals with particular phenomena and related landforms, recently studied in the Po Plain, clustering in some areas in the provinces of Modena and Bologna. These processes have periodically produced shallow sinks, up to 2 m wide and deep, that disrupted agricultural works and exposed farm operators and equipment to hazard, requiring costly remedial measures. In some cases, the land productivity itself was impaired. On the basis of literature information, as well as available geological, geomorphologic and geotechnical data, the possible triggering factors and the evolution of these phenomena are described.

An inventory carried out some years ago shows that these phenomena tend to develop in different geological settings, from the apex of the alluvial fans down to the lower alluvial plain (i.e., from 64 to 6 m a.s.l.), generally within relatively short distances from streams and artificial channels, independently of the deep geological setting. In most cases, the affected soils have silty-sandy textures, related to alluvial ridges. The latter are composed by sandy channel fills, bounded by levees of mixed sand and silt, which pass outwards to finer silts and clays of interchannel zones. In fact, as sediments accrete, distributary streams shift laterally, forming new channels. Old channels are then gradually buried under interchannel silts and clays. As a result, the silty-clay body of the alluvial plain is laced with intersecting strings of loose sands surrounded by less permeable sediments. These sand strings, recharged by streams and channels, may behave as artesian aquifers at their distal ends.

On the basis of a large number of Cone Penetration Tests (CPTs), some of the affected areas have been characterized with reference to lithology, stratigraphy and relevant geotechnical parameters. The results of the investigations show that under an overconsolidated cohesive unit, with sufficient clay fraction to form and retain shrinkage cracks in the so-called active zone, at a depth in the order of 6 meters, a sandy unit can be typically found, that has shown to be susceptible of liquefaction as a consequence of natural or artificial causes (seismic shaking, water table sudden drawdown, heavy vehicles transit etc.). The liquefaction and subsequent packing of loose sediments leads to the development of proto-chambers, that become sinkholes when their roofs collapse. No particular relations have been observed between gas flux from the soil and sinkhole development.

In the proposed conceptual model, triggering and evolution of these phenomena depend therefore on the grain size of the near-surface sediments, and on specific hydraulic conditions related to the distal sectors of alluvial ridges in a recent alluvial plain.

To test this model, data collection on boundary conditions and a number of further field experiments is ongoing. In particular, the research is focused on two main issues:

- ° the analysis of surface displacements in key areas at a local and regional scale, in terms of horizontal (geodynamic) and vertical displacements (natural and/or artificial subsidence) and their relationships with the development of sinkholes. This will be performed through the exploitation of dedicated PSInSAR multitemporal data and the deployment of a new continuous GPS monitoring network;
- ° geological and geotechnical characterization of soils, in terms of liquefaction susceptibility. This will be accomplished by a number of continuous boreholes, trenches and CPT tests for building cross sections and 3D models of areas prone to sinkhole development.

C3-4 Orale Meloni, Fabio

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THE UNIFIED REGIONAL CATALOG OF LATIUM SINKHOLES AND RISK AREAS

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Key terms: SINKHOLES; LATIUM REGION; CATALOG; RISK AREAS; RULES

Lazio is a land particularly affected by catastrophic collapses. It shows some areas where the sinkholes appear to be sporadic and, on the contrary, other areas that are particularly affected by sinkholes (St. Victorinus and the Pontine Plain).

The event can cause considerable damage when it occurs in a urban areas or in areas with infrastructural networks. In Lazio, the last event of considerable size occurred in 2003, near the town of Marcellina in agricultural area, without causing damage to nearby infrastructure (high-voltage electricity grid and pipeline).

For years, the Lazio Region conducted studies on Sinkholes in order to define and govern the risk areas. The first example of rules in Latium region were those imposed for St. Victorinus plain (RI) and for a small land in the Pontine Plain (Lt). It was subsequently produced the first catalog and the first regional regulation to determine the studies that they have to conduct in risk areas when propose it for the edification (2002). Then it was followed by a new study for a better identification and classification of risk areas (2009, in progress). This studies involved the use of cartographic sources, historical documentation, as well as field trips, and allowed to reach a significant increase in the number of sinkholes.

In order to obtain a more complete mapping of the phenomenon both as number of events either as completeness of the information we made the unification of the catalog of Latium Region and the National ISPRA catalog. In particular ISPRA, which is forefront in the study of the phenomenon, has carried out a consistent catalog for Latium region, based on detailed studies, on historical sources and on old maps.

The effort has been to eliminate some sinkhole duplication and to equip them with more historical information in order to characterize the moment of genesis, or at least a range of time as close as possible to the date of the event (eg with historical evidence of the presence of the sinkhole to a given time or with more maps in a range of time). As well, to characterize the geological and hydrogeological environment, the water type, the surrounding vegetation and degree of urbanization. Correlations were also performed with the tectonic and structural trends.

The ultimate goal is now to understand the sinkhole genesis and frequency of occurrence in each area and to establish a rule for the use of

all these areas, based on the risk level.

C3-5 Orale Buchignani, Vincenzo

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SINKHOLE AFFECTED AREAS SURVEY METHODOLOGY AND MONITORING SYSTEMS: THE EXAMPLE OF CAMAIORE.

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Key terms: Sinkhole; Monitoring; Survey; GBInSAR; Ground Based SAR

In October 1995 a sinkhole of about 35 meters of diameter took place in the urban area of Camaiole municipality and caused the sinking of a 3 floors house and seriously damaged 5 buildings, later demolished. This phenomenon that would have had catastrophic effect on human lives led the Municipality and the Local Authorities to seriously assessing the problem and searching for the best methodology to be used in sinkhole prevention and analysis.

Since then, a series of multidisciplinary studies have been carried out in different phases, allowing the collection of a huge and comprehensive quantity of geological, stratigraphic, hydrogeological, geophysical and geochemical database. Furthermore, the displacements' time series of a few control points spread on the territory have been collected.

After this first series of surveys the water pumping activity running in wells located at about 900m far from the sinkhole area has been discarded as a main triggering factor in case of normal pumping rates, while it is not completely excludable during the summer periods when the average pumping rates can be up to 360 l/sec with peaks of 500 l/sec.

These surveys led to the identification of Camaiole sinkhole triggering factors in the weakness of the carbonatic substrate (affected by paleo-carsism), in the location of the collapsed area that lies inside a tectonically active region having a relevant seismic event registered close to the sinkhole location only 8 days before its collapse, and the presence of big structural lineations intersecting in the sinkhole neighborhoods. A second series of surveys were extended to the whole territory of the Camaiole municipality by means of geophysical prospections (micro-gravimetric, geoelectric and seismic surveys) and geochemical inspections (endogen gas analysis), allowing the elaboration of maps displaying abnormal gravimetric and endogen gas values, as well as the geoelectric tomographical profiles.

A side result of the wide and intensive studies performed on this phenomenon is the detection of other areas affected by the same problems inside the urbanized district.

The integrated analysis of the structural, geognostical, seismic, electrochemical and gravimetric data collected since 1995 shows the presence in the whole area of several clues linked to anomalies at different depths.

The knowledge acquired was recently used to design and to implement an integrated monitoring system including: a) a seismic monitoring network, constantly acquiring data from three different sensors located in strategic points of the Camaiole municipality; b) a periodic monitoring of the water table of the aquifer through water-level tapes or transducers; and c) the implementation of a monitoring system using two different technologies to draw the superficial displacements field of the inspected area and allowing a fully automatic and continuous detection of the premonitory signs ("precursors") of an impending disaster or of those events that are particularly interesting to be analyzed. The technologies involved are GPS and Ground Based SAR interferometry (GBInSAR) measurements, in addition to the seismic control of the underground.

The main component of the monitoring network is the GBInSAR LISALab system implemented by Ellegi srl that constantly updates the values of the multi-temporal displacements field measured in the Camaiole municipality.

The main target of the monitoring network is setting up an effective monitoring methodology to prevent the hazards potentially impending over the urban area of Camaiole.

The Authors would like to present the different survey methodologies implemented in the specific case of the Camaiole sinkhole and the related results that have been used in the design and in the implementation of the monitoring system, as well as the results of the analyses performed over more than 3 years of uninterrupted measurements.

C3-6 Orale Picuti, Maria Romana

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THE STUDY CASE OF BEVAGNA SINKHOLES (PERUGIA DISTRICT)

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Key terms: Bevagna (Perugia District); alluvial plain, springs; SINKHOLES; sacred complex; II sec. B.C. - IV sec. A.D.

Bevagna area (Perugia district) is located at the cross of some rivers: Topino, Timia, Teverone, Clitunno in an alluvial plain rich of numerous springs. Other little lakes and springs (now filled) are represented in ancient maps.

One little sub-circular lake, Aiso lake is located near Bevagna town (ancient town of Mevania); it shows 25 m of diameter and 13 m of depth; at the bottom are presents some springs. Some geochemical analysis are conducted.

It was originated probably in historical age (pre-roman age); some legends refer the origin (perhaps from the 1300) with a quick catastrophic collapse. The water of the Aiso lake runs in an other sub-circular pond (Aisillo Mattoli lake), also originated with a catastrophic subsidence. The analysis of all Bevagna territory have been showed other small lakes and dry cavities (es. Madonna delle Rose cavity, some Aisilli little lakes). These morphologies could be due to deep piping sinkhole phenomena. This hypothesis is supported by geological, hydro-geological and structural setting of the Bevagna plain area. The Bevagna plain area is characterized by alluvial sediments (clay and silt with more than one hundred of meters) at the top of a main syncline, with N-S trend. Some fault systems cross the Topino alluvial plain: the cavities are locates with NS trend. In the Bevagna plain area are present aquifers related to deep hydro-geological circuits (confined aquifers).

In the Aisillo Fanelli area, four campaigns of archaeological excavation (in the 2004, 2005, 2009 2010), are brought to individuate a part of a sacred complex. The sacred complex was frequented between the beginning of the II sec. B.C. and the beginning of the IV sec. A.D., but its sacred title, at the moment, unknown.

The peculiarity of this sacred site is the presence of a spring with a great circular structure in the centre of the monument. The architectonic type send back presumably to a cult of the sanatio. Some analogies of geographic and topographical type indicate a similitude with the temple dedicated to the God Clitumnus, famous from the epistle of Plinio the Young (VIII, 8). The sacred site confirmed, in republican age, the role of Mevania town like a religious center of the Umbrian people and it suggests the sacred role represents by the Aisillo spring

C3-7 Orale Guarino, Paolo Maria

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ANTHROPOGENIC SINKHOLES IN ROME, NAPLES AND CAGLIARI URBAN AREAS

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Key terms: anthropogenic sinkhole; cavity; urban areas

Anthropogenic and natural cavities represent a serious hazard for the built-up environment in many Italian towns and cities. They could propagate upward in urban surface producing the formation of sinkholes. In the last years the number of the sinkholes in urban areas is increasing, due to urban expansion, particularly in the large cities as Rome, Naples and Cagliari.

Underground quarrying was developed in the past in some Italian towns, due to presence in the subsoil of soft rocks (especially volcanic or limestone rocks) suitable to be used for building purposes.

The soft rocks were therefore quarried underground producing an extensive network of galleries.

The underground galleries and caves have been progressively abandoned; somewhere they were used in other ways and finally they were filled or obliterated by urban infrastructures.

Some Italian towns, like Rome, Naples and Cagliari, are nowadays located just above network of cavities and the people loss the memory of the presence of the underground galleries; actually, with the exception of Naples, not exists a detailed cartography of the cavities and their exact localization.

The lost knowledge of the network of cavities produces a potential risk for the human structures and activities with a increment of anthropogenic sinkholes.

In Italy is not present yet a catalog or adjoined database of the sinkholes occurred in urban center provoked by anthropogenic activities.

This paper presents the results of the researches conducted by ISPRA "Sinkholes in urban centres Project". The aims of the study are to census sinkholes in urban centres, to census and map the net of underground cavities, to realize an anthropogenic sinkholes database and to compare sinkhole susceptibility in the three cities above mentioned.

C3-8 Orale Fiore, Antonio

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HISTORY OF SINKHOLE EVENTS IN APULIA, ITALY, WITH PARTICULAR REGARD TO THE INTERACTIONS WITH THE ANTHROPOGENIC ENVIRONMENT

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Key terms: sinkholes; hazard; artificial cavities; collapse; damage

In karst territories, sinkholes represent the most peculiar typology of hazards, being related to the presence of underground voids. These latter may be of natural origin, due to the solutional processes which affect soluble rocks, or caused by man's activities, through excavation of anthropogenic cavities underground. Whether the origin, presence of voids may result in sinkhole formation, causing heavy economic losses, if not casualties to the human society.

In the last years, a worrying increase of sinkhole events, related to both natural and anthropogenic cavities, has been registered in Apulia, southern Italy. Apulia region is actually well known since a long time for the occurrence of such events, as experienced for instance during the crisis that hit the towns of Canosa di Puglia and Andria; therefore, the possibility of occurrence of sinkholes is not unexpected for the area.

However, starting since the first years of the present century, the frequency of events have had a definite increase, which reached a peak during 2009 and 2010. It has to be noted that, in any case, the documented events represent only a small part of what is actually occurring, since many others (likely, the majority) are not registered due to lack of information, or to rapid infilling of sinkholes by the land owners. Our analysis started from historical researches, consisting of the scrutiny of many different sources, including but not limited to scientific publications, newspapers, chronicles, technical reports, and interviews with professionals. Critical analysis of such amount of data resulted in the creation of a database about sinkhole events in Apulia, that was further integrated by direct surveys from the authors in the last years. Overall, the database consists so far in several tens of cases of sinkholes for which a chronological reference (a date, even though generic) was found.

Information on timing of occurrence was considered of great importance in our research. In the analysis of sinkholes, as of any other natural or anthropogenic danger, knowledge of the temporal occurrence of the events is crucial to properly define the hazard. Lack of data about the timing of the events determines the impossibility to actually evaluate the hazard, which forces the analysis to be limited to the susceptibility assessment.

As already experienced in previous researches about other types of

natural hazards (mass movements, floods) in Italy, reliability of the temporal information can be highly variable, depending upon the type of source and the degree and amount of available information. Nevertheless, the sinkhole database we produced represents a valid starting point for examining in greater detail the temporal occurrence of phenomena in Apulia, with particular reference to their relation with different types of triggering factors.

C3-9 Orale La Vigna, Francesco

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A PRELIMINARY SINKHOLE SUCEPTIBILITY MAP OF THE LATIUM REGION

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Key terms: sinkhole hazard evaluation; hydrogeology; probabilistic approach

Several and frequent studies were internationally presented about landslide susceptibility, meanwhile in literature is missing a broad diffusion of studies regarding sinkhole susceptibility. That's why sinkhole recurrence depends on several geological conditions related to specific geological and hydrogeological context (sinkhole prone area) that vary case by case. Notwithstanding this regionalization problem of sinkhole recurrence, in the central Apennine sedimentary basins (Italy) a certain number of geological, geomorphologic and hydrogeological conditions (sinkhole predisposing issues) can be considered in common between the surveyed sinkholes. Eventually this could be compared with similar geological conditions and sinkhole occurrence in the rest of Italy or in other countries.

In this case study is presented a probabilistic approach regarding the Latium Region deriving from the comparison between the regional sinkhole inventory realized during a precedent project and the dataset of the new Hydrogeological Map of Latium Region (scale 1:100,000). Indexed elements, chosen because associated to the majority of sinkhole phenomena, are: outcropping lithologies, slope value, foothills distance of carbonate ridges (in a plain), main faults (even if buried), gas sources, hydrothermal springs, piezometric gradient and land use. These indexed elements were weighted and combined in a matrix which preliminary result is the sinkhole susceptibility map of Latium Region. When definitively validated, this approach could be suitable for local authorities to planning more targeted studies in major hazard areas.

C3-10 Orale Margiotta, Stefano

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INTEGRATION OF MORPHOLOGICAL, STRATIGRAPHICAL AND GEOPHYSICAL DATA FOR SINKHOLE HAZARD ASSESSMENT IN THE CASALABATE AREA (LECCE, ITALY)

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Key terms: SINKHOLES; MORPHOLOGY; STRATIGRAPHY; GEOPHYSICS; SALENTO

In the Apulia region, the low-lying coasts of the Salento peninsula are significantly affected by land subsidence and sinkhole phenomena on both the Adriatic and Ionian coastal territories. Sinkholes are observed at different evolutionary stages, from those occurring at present to other relict features creating peculiar coastal morphologies. The study of sinkholes, specifically addressed to the understanding of their mechanism of formation, is of great importance for the safety of coastal settlements. Long stretches of the Salento coastline were affected by urban expansion in the last decades with residents strongly increasing during the summer season. The construction of new houses, pipelines and roads in areas subjected to subsidence and/or sinkhole phenomena results in great economic losses.

Casalabate, in the province of Lecce, is a small town located along the Adriatic coast that suffered a sequence of eight sinkhole events in the last 20 years. The local stratigraphy is well documented by many borehole data and the area is particularly suited to the investigation of the sinkhole hazard.

The critical analysis of core data integrated by detailed field mapping allowed the recognition of the local bedrock represented by the Pleistocene Gravina calcarenites overlain by Holocene organic-rich marsh deposits and sandy beach and coastal dune deposits. Due to their critical geotechnical properties, the occurrence of organic-rich marsh deposits is of particular importance in the overall stratigraphy. The sites affected by sinkholes in the past 15-20 years were subjected to specific geophysical surveys, consisting of combined georadar (GPR) and electrical resistivity tomographies (ERT). These surveys highlighted the effectiveness of GPR in identifying active sinkholes and lithologic changes and of ERT as an optimal descriptor of the geometry of sinkholes, thus indicating their evolution.

The integration of the geophysical, stratigraphical and morphological studies indicate that the main mechanisms of sinkhole formation are the cover collapse and the cover suffusion, and allowed a preliminary zonation of the sinkhole hazard.

C3-11 Poster Di Filippo, Michele

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DEFINITION OF SINKHOLE PRONE AREAS AND THEIR MONITORING. A CASE STUDY IN LATIUM (PIANURA PONTINA)

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Key terms: sinkholes; gravity survey; risk

In Italy, natural sinkhole phenomena which are not connected to karst

processes are relatively frequent. In the southern plain of Latium (Pontina area) for example, several small subcircular lakes are described, whose formation is thought to have been caused by erosional processes related to vertical turbulence and/or piping in alluvial sediments. At the present it is impossible to think about an estimation attempt for the hazard/risk due to the complete lack of adequate information about the whole plain.

A gravity survey carried out some years ago in whole plain shows several negative gravity anomalies. Later, in the last decade, some negative gravity areas were also studied by microgravity surveys.

Microgravity results show that these phenomena could tend to develop in different geological settings, from the apex of the alluvial fans down to the lower alluvial plain, generally within relatively short distances from streams and artificial channels.

Gravity information set can allow us to select a peculiar areas to be submitted to further intensive monitoring and surveys such as:

- 1) microgravity surveys to detect negative gravity anomalies;
- 2) high-resolution geophysical surveys;
- 3) continuous areal leveling to detect the (negative and positive) vertical motion;
- 4) gas seepage monitoring;
- 5) water seepage monitoring.

In terms of hazards, at the present, it should at least ask whether the sinkholes on the inner side of embankment body could also evolve towards underseepage phenomena, where negative gravity anomalies was detected.

C3-12 Poster Liguori, Vincenzo

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SINKHOLES IN GESSOSO SOLFIFERA FORMATION (CENTRAL SICILY): HISTORICAL RESEARCH

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Key terms: sinkholes; mines; Gessoso Solfifera Formation; evaporite dissolution

The Sicilian sinkhole areas, are diffused on central zone of the island.

Indeed in these areas the sinkholes have a higher probability of occurrence and a greater genetic diversity, because there are the evaporite rocks. This is because evaporites have a higher solubility and, commonly, a lower mechanical strength. The evaporite environment is very sensitive to changes in the local hydrology and hydrogeology, so that human factors such as groundwater extraction, drainage, and irrigation can act as triggering factors to collapse events. The presence of mining-related cavities (workings, shafts and tunnels) or karstic (solution cavities and sinkholes in evaporitic rocks) within the top 100 m in the rock mass restricts land utilisation, and their migration to the surface may damage property or services or cause loss of life.

The Sicilian sinkholes develop in chalks and the salts. In the central-southern Sicily there is a thick formation of evaporitic rocks, deposited during the salinity crisis, happened in the Mediterranean sea in upper Miocene.

The salt in these layers is white coloured and normally has an average grade in NaCl superior to 98%, which is comparable to the best of such layers in the whole world. In some mines KCl salts are extracted. Given the remarkable mining importance of the products of the Gessoso-Solfifera Formation, since the antiquity, different mining centers for the extraction of potassic salts and/or of rock salt have been developed and the greatest of them falls into the provinces of Enna and Caltanissetta. Among the many existing mines in the Sicilian territory at the moment, only two are active. All the others are disused and abandoned, sometimes without any control. These mines, built on more levels than one, had the typical structure of a gallery; chambers and pillars. The infiltration of waters in the subsoil has produced salts dissolution. This process has created a weakening of the hollow vaults of the mining tunnels producing, in extreme cases, sudden and local collapses. This contribution presents examples of sinkhole induced by human activities that cause fresh water to flow through salt formations. The Racalmuto mining basin, classified as one of the greatest in Sicily, is a concrete example of the geomorphologic modifications of the territory linked with the presence of the mines that are now abandoned. The sinkholes, occurring in these areas, are numerous and often situated in correspondence with the meeting points of the mining galleries. They have almost always sub-circular shapes and diameters varying in depth. The dimensions of the greatest sinkhole are approximately of 100 m in width and of 200 m in depth. The sinkholes currently individualized can be found in anthropic areas with road infrastructures and residences, and in sites used by man for cultivation and/or pasture. In many cases they are reasons for damages to houses and the activities that develop in the near areas. Anyway the key measures to prevent sinkholes in mining areas are to control the amount of mine drainage and if present reduce water level fluctuation.

As discussed above the need an accurate evaluation of the risk caused by this phenomenon, and a correct management programme of the territory are born. Before risk assessments for sinkhole damage and indemnification are developed, a data base must be created to predict the occurrence and distribution of sinkholes. Historical data are necessary to develop and calibrate risk-assessment models, and ancient sinks provide an important means of establishing confidence and continuity in the models. With high-quality data, local risk maps and estimates of sinkhole probability can be developed.

C3-13 Poster Meloni, Fabio

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THE VALLECORSIA SINKHOLES (FR, LATIUM) BETWEEN HISTORY AND CURRENT EVENTS

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Key terms: SINKHOLES; CARSISSMO; VALLECORSIA; MONTI AUSONI; LAZIO

Lazio is a land particularly affected by catastrophic collapses. It shows some areas where the sinkholes appear to be sporadic and, on the

contrary, other areas that are particularly affected by sinkholes (St. Victorinus and the Pontine Plain). There are different geological contexts: areas of open plain (Pontine Plain, Acque Albule Basin, Fosso di San Martino Area, etc.) and areas enclosed within mountain reliefs (St Victorinus, Arcinazzo Plateaus, etc.). In some cases the context is of endoreic karst valleys or valleys closed by a very narrow threshold that makes difficult the water runoff. Often these areas are historically occupied by large lakes, then drained by water drainage and reclamation. In a similar context is the Vallecorsa valley (Fr), a very narrow valley into the Ausoni Mountains, in southern Lazio. The valley follows the tectonic lineaments and shows a shape at "Y" upside-down, in agreement with apenninic, anti-apenninic and meridian tectonic trends. The calcareous bedrock is buried under an alluvial and colluvial coverage, about a ten meter thick. In this valley you have two different types of sinkholes: a tract, at the intersection of the three fault systems, where the valley is quite wide, with high frequency of occurrence and small sinkhole shapes (2-3 m large and 3-4 m depth); an other sector, that stretches through the distal end of the valley with a N-S narrow shape, where you experience the most striking sinkhole phenomena (20-50 m large and 6-10 m depth). While the little sinkholes are quickly buried by human activity and have little days of life, the large sinkholes are persistent for several centuries and intersect with the history of the country of Vallecorsa and with the life of its inhabitants. In fact, the large sinkholes were utilized for many years for daily activity of inhabitants and use and protection of them was regulated by severe rules since 14th century. The different sinkhole shapes are probably correlated with the calcareous bedrock and in particular with the mechanism of capture and of removal of floods through the karst caves and tunnels.

C3-14 Poster Nisio, Stefania

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UMBRIAN SINKHOLES PRONE AREAS

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Key terms: Sinkhole; Umbria; Perugia; Lago di Casigliano; Lago di Sugano

Many sub-circular ponds, lakes and dry cavities in Umbrian territory, originated in historical age, should be due to piping sinkhole phenomena. This hypothesis is supported by the geological, morphological and hydro-geological setting of the area interested by the sinkholes. The small lakes have diameters from few to hundreds of meters and depth up to fifteen meters. The names are of dialectical origin and usually they indicate a kind of sinking (es. abyss). Some legends refer the origin of the lakes to a quick catastrophic collapse. Usually these depression are originated by karst erosion (collapsed dolines). Sometimes the genetic process should be related to the presence of artesian, mineralized waters and gas emissions (mainly CO₂ and H₂S) that contribute to the formation of the sinkholes through a mechanical upward erosion (deep piping process; NISIO, 2003).

These cavities are water filled (drown sinkholes) and are located on thin grained impermeable or semi-permeable sediments (silty clay, silt) more than 100 m thick.

The correlation between collapses and piping sinkholes is confirmed by the "drowning" of the cavity soon after the formations creating a ponds or a sub-circular lake, sometimes with underwater springs that feed the small lake.

In some cases are recognized many informations about the date and the modalities of the cave genesis (Aiso lake, Alto lake, Sugano lake etc.). The sinkhole ponds (more than 50 phenomena) are concentrated in Umbrian alluvial plains (Tiber, Topino, Tinia river plains).

In this work are considered some sinkhole prone areas of Perugia and Terni districts.

C3-15 Poster Nisio, Stefania

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SINKHOLES IN THE FROSINONE REGION: FONTANA LIRI AS CASE STUDY

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Key terms: Sinkhole; Fontana Liri; Frosinone; Solfatara; Bucone

The area surrounding the village of Fontana Liri (Frosinone) is characterized by a large flow of mineralised groundwater as evidenced by the presence of several sulphurous and gas-enriched springs. The quaternary, alluvial, lacustrine and slope deposits are affected by a fault system with NW-SE, NS and NE-SW trend. The carbonatic bedrock is overlaid by the sedimentary cover which is 100 metres thick.

In the beginning of the twentieth century, a group of springs named "Le Caldane" was characterized by high temperatures. These springs were initially exploited by a thermal bath that was successively closed due to the temporal instability of the geothermal emissions.

A small lake, "La Solfatara" has a sub-circular shape, and is fed by submerged springs with the presence of gas emissions. Nearby this lake there is another pond smaller in size named "Bucone" that is fed by mineralised spring-waters without the presence of gas. It has a cylindrical shape with very steep shores and lies in the slope deposits.

The chemical-physical characteristics of the lakes suggest its deep origin with a flow through the terrigenous cover. "La Solfatara" shows strong fluctuations in the water level; for some periods, it remains completely dry. However, the numerous other springs in the area are always active. These spring-lakes, as described by Plinius the Elder and known as such since Roman times, have shown chemical and thermal changes throughout the different periods.

We noted a close correlation between the behaviour of the spring-lakes, specially "La Solfatara", and the seismic activity in the area. From 2005 till December 2008 the "La Solfatara" was practically dry. Matching this datum with the local seismic activity, we observed that 2005 was a year without relevant seismic events and with very low local background seismicity. A stronger micro seismicity started in 2006 in the Cassino area (less than 30 kilometres from the lake) with an increasing number of events in 2007. In 2008 seismicity affected mostly the Sora area (less

than 15 kilometres from the lake). By late 2008/early 2009, "La Solfatara" was back in the old location, with an increased flow of the submerged springs and remarkable emissions of gas. On the occurrence of the 6 August 2009 seismic event (MI 3.9), localized few kilometres east of Fontana Liri, the gas emissions inside the lake increased. The surrounding area was also affected by a widespread degassing. Moreover, warm (20-21°) air fluxes were recognized across the travertine banks along the Liri river. In this study we present the first stratigraphic, historical, geological and hydrogeological data that support the theory that the spring-lakes were created by sinking phenomena.

C3-16 Poster Corda, Angelo Salvatore

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SINKHOLES IN THE SARDINIA REGION (ITALY): MINES AND KARST CAVITIES

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Key terms: SINKHOLES; SARDINIA; MINES; SULCIS IGLESIENTE; CAGLIARI

The opening of sinkholes in urban and industrial areas of Sardinia, in relatively recent times, triggered by the presence in the subsol of empty mines and karst cavities, pose serious threats to the protection and safety of the territory, especially in urban centres.

For decades we have witnessed, both in the areas of Sulcis-Iglesiente and in the city of Cagliari, the sudden opening of large sinkholes following the collapse of underground natural and anthropogenic cavities, with major repercussions and reverberations on the surface, in particular when located at a few tens of meters depth from buildings, roads and rail infrastructures, and from industrial areas. We should mention the large soil collapses, attributable to anthropogenic, sinkholes in the city of Cagliari, in the mining town of Carbonia, the villages of Bacu Abis and Cortoghiana, as well as in the metalliferous mining areas of Iglesias-Iglesiente (Acquasera, Nebida, Monteponi, Montevecchio). Over the past 20 years the deterioration of the stability of the mining voids, facilitated mainly by the closure of mines, has resulted in an exponential increase of mining collapses and related surface disturbances. have been recorded, so far, 60 sinkholes distributed in as many sinkhole risk areas, for a total extension of over 10 sq km. In these areas, to testify the past mining activities on the island and the impending risks, it is still present in the subsol a dense network of superimposed tunnels which developed in a straight line of several tens of thousands of km, partly buried by groundwater, including spacious mining rooms not always stabilized by mines fills.

In the same areas, but triggered by other factors, other 50 sinkholes were detected, associated with natural karst phenomena. They are distributed in the inland and coastal flood plains of Sulcis-Iglesiente and are often located in geological settings characterized by prevailing quaternary alluvial deposits with underlying Cambrian karst calcareous rocks. These include the sinkholes opened in the alluvial plain of the rio Cixerri (for a total of 26), along the rail track at km 33+330 of the Villamassargia-Iglesias line, at about 30 meters from the center line of the track (they were already known in the years '50), in the locality of Caput Acquis and in the narrow limestone valley of rio Corongiu, between the town of Iglesias and Villamassargia. Other sinkholes are located in the town of Carbonia (locality of Cannas n.3 and Serbariu n.2), in the plain of Narcao and in the locality of Acquacadda" in the vicinity of Nuxis (n.14), in the narrow limestone valley of Guttururu Saidu (n.5), at the administrative boundary between the village of S. Anna Arresi and Teulada.

This paper presents the results of the research into the sinkholes in the Sardinia Region, which was started in 2010 by the Regional Geological Service of Arpa Sardegna-Regional Geology Department in collaboration with the Province of Carbonia-Iglesias, the Municipality of Iglesias, the Mining Service of the Sardinia Region, and the Italian State Railways (Rete Ferroviaria Italiana S.p.A.).

An initial census of the active disruptions has been drawn up, including in depth bibliographic and historical mining studies, integrated, in their turn, with inspections and detailed geological surveys. At this stage the activities carried out have allowed to reach a preliminary region profile, which outlines the areas of the region at increased sinkholes risk, useful as a method of spatial planning and for safety interventions, monitoring and control of the environment as well as for the inclusion of these areas among those under P.A.I. regulation (Hydrological plan).

C3-17 Poster Pirro, Mario

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LAKE VADIMONE IN THE MIDDLE VALLEY OF TIBER: A POSSIBLE SINKHOLE.

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Key terms: Sinkhole; Cimino Volcano; middle valley of Tevere

In proximity of the right bank of the middle valley of Tiber (Lazio) in the Orte area, it is located a pool, with a circular shape locally known as Lake Vadimone. This small lake is famous in the history because the legend tells that near its sides, in the period around the 7th-6th c. BC, was fought a bloody battle between Romans and Etruscans, following which the latter definitively were defeated.

The floodplain where is homonymous pool is also known with the toponym of Lucignano area which is characterized by a thin travertine deposits (Upper Pleist.-Holocene). Further in Lake Vadimone there is a peculiar mineral spring whose water flows into the Tiber through a canal with a NW-SE direction. The plain of Lucignano is also characterized in the inner and southern sector by other springs with sulphurous nature linked to the quiescent phase of the near Cimino Volcano.

The geological characteristics of the terrains and the quaternary tectonics of the studied area have probably favorite the formation of Lake Vadimone as sinkhole.

The aim of our study is to investigate whether the processes related to the origin of Vadimone Lake are similar to those that generated other sinkholes found in the central Italy e.g., Lake San Giovanni which is located in the Acque Albule Basin (Lazio). In addition, we are interested to investigate the impact of the local seismicity and of the strong

earthquakes occurred in the central Appennine and in the near Tuscia area.

C3-18 Poster Soriano, Asuncion

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DEVELOPMENT AND EVOLUTION OF SINKHOLES IN SOLUBLE ROCKS: A COMPARISON BETWEEN THE MANTLED KARST OF THE EBRO BASIN (SPAIN) AND THE SALENTO PENINSULA (ITALY)

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Key terms: Sinkholes; Evaporites; Carbonates; Human influence; Hazard

Sinkholes of different types and mechanisms occur worldwide in soluble rocks (mainly carbonates and evaporites), and represent one of the most typical features of karst settings. Their analysis may start from several standpoints, depending on age of the sinkhole, involved rocks, hydrogeology, relation with underground caves, connection with voids of anthropogenic origin, and so on. Whether the approach, study of sinkholes has necessarily to begin with a detailed research about the geological setting, in order to identify the most likely conditions leading to sinkhole occurrence.

Comparison of different study areas, therefore, may be extremely useful for a definition of the main factors acting in both the predisposition of terrains to sinkholes, and their trigger as well; such data will be useful for any further work addressed to definition of the sinkhole susceptibility and hazard. With this aim, two areas have been here considered: the Quaternary deposits of the Ebro River in northeastern Spain, and the Salento peninsula of Apulia, in southern Italy. The two areas are characterized by frequent occurrence of sinkholes, of natural and anthropogenic origin, and are being studied since a long time. Involved rock masses are different, being Miocene evaporites in Spain, and Pliocene-Pleistocene calcarenites in Italy.

In particular, the Spanish test site is located in the central Ebro Basin where Quaternary coarse detrital deposits (mainly fluvial in origin) overlie Miocene evaporites (gypsum and more soluble salts). The dissolution of Tertiary beds has caused the generation of cover collapse and suffusion sinkholes being, at present, a very active phenomenon. Since 1970, wide karst areas were urbanized and important damages, with the subsequent economic losses, have been constant in this region. A striking feature in the area is the existence of palaeosinkholes generated during the Pleistocene time indicating that karstification developed by environmental conditions without human influence.

Salento is the terminal portion of Apulia, the heel of the Italian boot, and is an entirely karst land. Recent calcarenites, overlying the local bedrock represented by Cretaceous limestones and Miocene marly carbonates, are affected by a number of sinkhole phenomena, mainly covering the typology of collapse, cover collapse and suffusion sinkholes. In addition, several cases have been recorded in the last years as related to underground quarries, with heavy consequences in terms of economic losses for the society.

Starting from a deep knowledge acquired in the last decades about the geological and morphological setting of the two study areas, we present in this work a first comparison of the sinkhole occurrence, with particular regard to frequency and distribution of sinkholes, morphometric features (size, depth), and relation with the anthropogenic environment. The latter topic is of particular importance, as a matter of fact, being strictly linked to definition of the total risk related to sinkholes. Old and recent sinkholes are analyzed and compared, in order to define likely changes in size of the observed phenomena, possibly linked to climatic changes and/or human interferences.

C3-19 Poster Vattano, Marco

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STUDY OF ANTHROPOGENIC SINKHOLES IN THE MARSALA AREA (WESTERN SICILY) THROUGH NUMERICAL ANALYSES OF INSTABILITY PROCESSES IN UNDERGROUND QUARRIES

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Key terms: anthropogenic sinkhole; underground quarry; Sicily

The territory of Marsala, in western Sicily (southern Italy), is characterized by numerous quarries for extraction of calcarenite rocks to be used as building material. Many of these are underground quarries which were realized at depth ranging from a few meters to about 25 m, on a single or two levels, following the excavation technique of galleries and pillars. With time, the underground quarries have been progressively abandoned because of several reasons, including the decay in the physical and mechanical properties of the calcarenite rock mass, the interaction with the groundwater, the high costs of extraction, the dangers and difficulties encountered in working underground.

Since the 1960's the quarries have been subject to instability processes, through collapse and deformation of vaults and pillars. These phenomena are often propagated upward until the topographic surface with the formation of sinkholes which affected also the built-up area causing extensive damages.

The aim of this paper is to provide a description of the most significant events, in the attempt to understand the factors responsible of the instability processes and the genetic mechanism of anthropogenic sinkholes by means of numerical codes and field surveys, as already performed in other areas of Italy.

C3-20 Poster D'Aniello, Valentino

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THE ENVIRONMENTAL EVOLUTION OF THE HISTORIC CENTRE OF VELLETRI (RM): THE PROBLEM OF THE ANTHROPOGENIC SINKHOLES

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Key terms: VELLETRI; SINKHOLES; GIS; HISTORIC CENTRE

Velletri, a small town of Latium, is populated from thousand years, especially for its location, its fertile soil and a mild climate. In the proximity of Rome, of the current pontina valley and of the southern Latium, Velletri has always been crossroads of peoples, armies and, often, it has been theatre of very harsh conflicts which caused a partial destruction of the city.

Built in the shelter of the Vulcano Laziale, it has been constantly scourged by earthquakes, registered in a particularly high number, which have caused damages to structures in particular, but which rarely brought about casualties.

Then, the history of Velletri is characterized with cyclicity by constructions, destructions and reconstructions, which changed the aspect of the city centre up to 22nd January 1944, when a devastating air raid almost laid waste the town; a new reconstruction, maybe was more devastating than the destruction, overlapped upon its rubble.

Furthermore, Velletri's historic centre suffered, in the last sixty years, a widespread depopulation. From the second half of the last century, while the whole number of the dwellers has went on growing, it has been registered a gradual abandonment of the habitation located in the most ancient part of the city, with the subsequent displacement of dwellers in its more external areas. This had a significant influence upon the loss of the utilization of caves, underground passages and galleries, used in the past both for preserving wine and as an underground system of communication, today almost unknown to people.

In this scenario takes part the analysis made during this work, led up to keep one's mind on a phenomenon that, in the last years, affects Velletri time and time again and, specially, its ancient part; it is built upon a close network of caves by now well-nigh totally forgotten and in which the services as sewers and water system are some centuries-old; it is often affected by episodes of anthropic sinkhole, which, unfortunately, in some cases caused dead persons and injured.

The first stage of this study is based on the use of multifarious sources of information, among the others historical records, newspaper libraries, ancient texts and modern images surveyed by environmental satellites.

In the second stage of the study we proceeded to the creation of a Geographic Information System (GIS), to insert and handle all the recorded data. It has been created a rich database of sinkholes occurred in the district of Velletri from 1967 to nowadays. All the events that have been identified have been georeferenced, can be distinguished the zones of the built-up area most affected by the phenomenon. Afterwards, we proceeded to the subdivision by typology of the sinkholes events.

Furthermore, has been highlighted a mutual relationship between the formation of unexpected swallow-holes and striking showers. A further stage if the study has been the location of the city zones that, in conformity with the recorded data, in theory are exposed to the higher risk of subsidence.

The developed analysis and the creation of the Geographic Information System tend to be the starting point of a program of territorial management for the local government of Velletri and, in particular, of its historic centre, with the purpose to clamp down the phenomenon of sinkholes.

C3-21 Poster Parise, Mario

10.1474/Epitome.04.0270.Geoitalia2011

USING SATELLITE AND SURFACE MONITORING TO MITIGATE THE RISK DERIVING FROM NATURAL AND ANTHROPOGENIC SINKHOLES

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Key terms: sinkholes; interferometry; remote sensing; monitoring; hazard

Sinkholes represent the main hazards in karst areas, characterizing such territories because of the presence of natural and anthropogenic caves.

Dissolution in soluble rocks (carbonates, evaporites), and later evolution of karst caves due to breakdown processes are at the origin of sinkhole events related to underground voids of natural origin. In many regions of Italy, the presence of anthropogenic cavities, excavated underground for different reasons and in different epochs, and generally located at low depth from the ground surface, creates a further hazard, which becomes extremely dangerous in built-up areas. Loss of memory of these underground cavities results, as a matter of fact, in building above voids, which extension and stability conditions are not known. As a consequence, the upward evolution of instabilities phenomena occurring underground may reach the ground surface, thus creating sinkhole events.

In order to mitigate the risk related to such phenomena, the identification of likely premonitory signs preceding the catastrophic phase of collapse may be extremely important. Both remote sensing and surface monitoring can be used at this aim: multi-pass space-borne Differential Synthetic Aperture Radar Interferometry (DInSAR) techniques, for instance, provide a valid support to remotely investigate the sinkhole susceptibility at the regional scale. Especially when integrated by classical topographic surveys at the surface, and by monitoring campaigns underground, significant data can be collected.

In this work, the advanced DInSAR approach referred to as Small Baseline Subset (SBAS) is used and compared to surface data for investigating sinkhole deformation in southern Apulia, with particular reference to some recent events related to underground quarries. Both descending and ascending ENVISAT images spanning the 2003-2010 period have been analysed, allowing to map active areas of surface deformations, and to compare such areas with the real occurrence of sinkholes. Eventually, some considerations about the potentialities of the interferometric approach in the analyses of sinkhole phenomena and in the assessment of the related hazard and risk are presented.

C3-22 Poster Pepe, Pietro

10.1474/Epitome.04.0271.Geoitalia2011

USING GIS TECHNIQUES TO ASSESS THE SINKHOLE SUSCEPTIBILITY

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Key terms: sinkholes; susceptibility; GIS

The town of Altamura, in the Murge plateau of inland Apulia (Bari province) has been affected since 2006 by a number of sinkholes related to the presence of underground quarries of calcarenite, the local rock mostly used for building purposes. Being the calcarenite generally located below a cover of a few to 15 meters of clays, quarries developed underground, and are at present at the origin of several instability problems in the area. This is due to abandonment of the quarries, and progressive weathering of the rock mass, which brought to development of failures from both the walls and vaults of the underground quarries. Eventually, such instabilities may propagate upward until reaching the surface, thus creating sinkholes. Since sinkholes developed within the urban area of Altamura, and/or in areas interested by recent or future constructions, the local Authority established in 2008 a code according to which all the buildings located in territories considered at risk had to perform geological studies aimed at verifying, and eventually removing, the hazardous situations. These studies brought in the last years to collect a wide amount of data from different sources, and of different typologies, which management had necessarily to be performed in a GIS environment.

With this goal, a project has been started by Apogeo and CNR-IRPI, taking advantage of a grant by Apulia Region ("Back to future" call by Apulia Region, POR Puglia F.S.E. 2007/2013, Official Bulletin of Apulia Region, no. 203, 17/12/2009) to implement the structure of a dedicated geo-database to collect, analyze, represent and use all the available information. The database was created by subdividing the information into seven groups (feature datasets), which, in turn, were divided into layers dealing with a peculiar feature of the database: cartography, land use, geomorphology, hydrology, direct and indirect surveys, caving explorations, existing codes. All these data have been collected and analyzed for that portion of the Altamura municipality which is considered to be at risk from a hydro-geological standpoint. Analysis of the available data, including the time and site of occurrence of sinkholes in the last decades, allowed to develop models to produce a sinkhole susceptibility map. Such a map represents a first result deriving from the high level of acquired knowledge on the geological features of the territory, and is, at the same time, a useful tool for mitigating the risk related to anthropogenic sinkholes.

SESSIONE C5

Effetti delle variazioni climatiche oloceniche sui processi di erosione/sedimentazione

C5-1 Key Lecture Giraudi, Carlo

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THE HOLOCENE CLIMATE OF PENINSULAR ITALY AND ALONG A N-S TRANSECT BETWEEN LATITUDES 45° AND 16° N.

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Key terms: Holocene climate; environmental variations; Italy; Mediterranean basin; Sahara desert

Examination of a series of proxy data relating to continental deposits in peninsular Italy has indicated that many environmental variations produced by climatic changes took place in the Holocene. The studied environments (periglacial and glacial high mountain zones, caves, lakes of various origin and size) were influenced in a different manner by these variations. Even though it appears evident that the response to these climatic changes is strongly conditioned by local factors, a basic coherence emerges between the data examined and a number of apparent contradictions may be explained within the context of the overall interpretation of the proxy data taken into consideration.

Apart from the climatic evolution of peninsular Italy, the results will be presented of the studies of the Holocene evolution of sites located along a N-S transect including the island of Lampedusa (35°N, 12°E), the Jebel Gharbi zone in Libya (30-32°N, 10-14°E), the Gobero area, and the Teneré Desert in Niger (16°N, 9-10°E) studied in the course of investigations conducted in the last ten years. In particular the correlations, or the lack of correlations, will be evidenced between humid and arid periods in the southern Sahara affected by the expansion of monsoon rains in the course of part of the Holocene, in the northern Sahara and in the southern and northern Mediterranean area. Particular attention will be paid also to aeolian activity in the desert areas and to the Holocene aeolian deposits present on Lampedusa and in peninsular Italy.

The dating of the environmental variations in the various zones has made it possible to verify that there can be chronological correlations between phases of climate change in the Mediterranean and Saharan area and Ice Rrafted Debris Events in the North Atlantic, mainly during the second half of the Holocene. The variations in air circulation linked to processes that occur at high latitudes in the northern hemisphere could therefore be one of the causes of the climatic variations. However, correlation with events in the North Atlantic appears far less reliable during the early Holocene when insolation, linked with the astronomic position of the Earth, was greater.

C5-2 Orale Chelli, Alessandro

10.1474/Epitome.04.0273.Geoitalia2011

HOLOCENE SLOPE EROSION IN THE NORTHERN APENNINES AS REVEALED BY LANDSLIDE EVENTS

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Key terms: landslide; reactivation; climate variation; Holocene

In the last few decades, globally distributed proxy data demonstrated that Holocene has been characterized by climate variations at different time (from centuries to millennial) scales. Even if the debate on the true significance and pattern of these variations is still open, shifts in temperature and hydrological condition have been frequent in the last 10,000 years.

Around the Mediterranean basin, the occurrence of wet periods is reflected

by data on palaeofloods, erosion processes and slope wasting. Nevertheless, landslides are strictly connected with morphological, geological and hydrological condition of the slopes and, probably, periods of one or more years with long-lasting and/or intense rainfalls episodes determine, even though during relative dry time intervals, the occurrence of debris, earth and mud flows.

In the Northern Apennines, about sixty radiocarbon datings of late Quaternary landslide events, most of them from landslides in the territory between the Secchia and the Taro rivers, have been collected in different datasets. Most of the dated landslide events are reactivations of large earth flows or complex (rotational and/or translational slide-earth flow) landslides. In fact, reactivations of large complex landslides are sensitive to the variation of pore water pressure inside the landslide bodies. Tree remains (roots, pieces of trunks or branches) and organic bulk samples, found inside the landslide bodies, were some of the materials collected and the datings through radiometric and AMS techniques have been performed. Many events are referred to the same landslide body and the stratigraphic setting of the landslide reactivations has been accounted for. During the Holocene, the landslide events cluster round different time periods. In fact, a part from some scattered datings in the late Pleistocene, landslide events are in the time intervals 9,500-8,500 cal yr BP, 6,300-1,800 cal yr BP and 1,000 cal yr BP to present.

The clusters of landslide events found for the western Emilian Apennines are in concordance with landslide datings found in the Alps and in the western and central Europe highlighting phases of enhanced erosion controlled by the hydrologic condition of the slopes in turn due to wet climate periods or to episodes of prolonged and/or intense rainfalls.

C5-3 Orale Piccarreta, Marco

10.1474/Epitome.04.0274.Geoitalia2011

HOLOCENE ALLUVIAL EROSION/DEPOSITION RELATED TO CLIMATIC CHANGE IN BASILICATA, SOUTHERN ITALY

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Key terms: Paleofloods; Gullies; Climatic change; Holocene; Basilicata

Paleofloods and their related geomorphological effects are the result of climate variability and specific environmental conditions and changes in the past. Reconstructing the past hydrological events is one of the main aims of the more recent research in Geomorphology. The natural records of these processes, including fluvial terraces, floodplains, colluvial, paludal and slope deposits and paleosols, can be assessed through geomorphological, sedimentological, pedological and chronostratigraphical methods. Many results on Holocene landscape evolution are available from case studies of river catchments, with data for sediment transport and deposition extracted from colluvial deposits, lake sediments and floodplain sediments. Critical studies about Italian ancient paleofloods both on national and on regional scale are scarce. For the Basilicata region, southern Italy, several studies of both the deposits filling the incisions and those forming the Upper Holocene terraces in the Bradano, Basento and Cavone river basin, dated with radiocarbon techniques, have been conducted in the last three decades (Neboit, 1977; Brückner, 1983; Abbott and Valastro, 1995; Small et al., 1998; Boenzi et al., 2008). All these data can be used to analyze the Holocene paleoflood frequency in Basilicata. The high number of dated samples compared to the extension of the study area allows a very reliable reconstruction. In the last decade, different researchers (Macklin and Lewin, 2003; Gregory et al., 2006; Thorndycraft and Benito, 2006a, 2006b; Zielhofer and Faust, 2008; Hoffmann et al., 2008, 2010) have used the cumulative probability density functions (CPDFs) of 14C-ages obtained on alluvial deposits to reconstruct Holocene phases of increased geomorphic activity in Europe and Northern Africa river basin. The authors focused their attention especially on 'change dates', indicating 14C-ages which coincided with an abrupt modification in alluvial sedimentation structure or rate. The 14C-ages are classified to represent activity, stability and transitional phases based on the depositional environment of the dated sample. The method consists in a probability plot, summed for all the analysed dates, where the y-axis is probability per year and the x-axis is the calibrated radiocarbon age. The plot provides a best estimate for the temporal distribution if the dates entered into the calculation, enabling comparison between the chronologies of the different data set analysed. The same approach has been applied to the Basilicata 14C-database of fluvial 14C-ages. The data recovered from this study have been integrated with those from literature (Neboit, 1977; Brückner, 1983; Abbott and Valastro, 1995; Small et al., 1998; Boenzi et al., 2008). A reliable chronological dataset of 34 radiocarbon dates has been created, which allowed a better reconstruction of the events that occurred in Basilicata during the Holocene. Radiocarbon ages of the Basilicata dataset were calibrated using CALIB 6.0.1 14C age calibration program (Stuiver and Reimer, 1993; Reimer et al., 2004) and plotted as CPDFs. The critical analysis of the 34 radiocarbon dates has identified eight periods of increased fluvial activity in this area, namely: 7200-6800; 4800-4550; 4300-4100; 3400-3100; 2350-1850; 1700-1320; 1050-800 and 300-120 cal years BP. Many of these phases coincide with the main flooding events recorded elsewhere in the Mediterranean. The record is discussed in relation to high-resolution central-southern Italy pollen and lake level records and Alps and Apennine (central Italy) glacier variations to identify relationships between geomorphic activity and Holocene environmental change. The data comparison suggests that aggradational and incisional episodes were primarily climatically driven, whereas flooding coincided with colder and moister phases, while incision (i.e. gully formation) occurred during dry-warm periods due to high magnitude, low frequency alluvial events.

C5-4 Orale Basso, Daniela

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GLOBAL CHANGE, MARINE ACIDIFICATION, AND THE ALGAL CARBONATES

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Key terms: calcareous algae; carbonate production; high-Mg calcite; marine acidification

The global change is producing global warming and ocean acidification. The commonest red calcareous algae on the world's modern shelves are

the Mg-calcite Corallinales and Sporolithales and the aragonitic Peyssonneliales and Nemaliales. They are vulnerable to a lowering pH, because of the mineralogy of their thallus. Among them, coralline algae are ecosystem engineers and major carbonate sediment producers in temperate and cold seas. They are negatively affected by marine acidification and rising temperature, showing decreased net calcification, decreased growth and reproduction, reduced abundance and diversity leading to death and ecological shift to dominant non-calcifying algae. Despite their key ecological and sedimentological role, and because of their vulnerability to marine warming and acidification, we need to improve our knowledge of the distribution of coralline-dominated habitats and the quantification of their carbonate production, in order to allow proper environmental management and confident modelling of global carbon budget.

C5-5 Poster Materazzi, Marco

10.1474/Epitome.04.0276.Geoitalia2011

RECENT AND PRESENT FLUVIAL-COASTAL MORPHODYNAMICS IN THE ADRIATIC CENTRAL ITALY

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Key terms: *Fluvial and coastal morphodynamics; Holocene; Central Italy*

The present work shows the results of many researches carried out from some tenth of years on the fluvial-coastal system of the central Adriatic Italy. The physical landscape, from west to east, is characterized by three territorial units: i) the central Apennine Chain, constituted by calcareous and marly calcareous rocks (late Trias-Oligocene) deformed and cut by folds, thrusts and faults; ii) the wide pedemountain belt, slightly sinclinal, modeled on the Messinian marly-arenaceous turbidites; iii) the monoclinical hilly landscape, verging towards the east and ending on the Adriatic coast, modeled on a Pliocene-Pleistocene sedimentary succession made by though pelitic units with interbedded sandy-conglomeratic levels at different heights. Continental deposits of different genesis and thickness (middle Pleistocene - Holocene), cover the bedrock on wide sectors.

The topographic surface is extremely articulated, because systematically dissected by hydrographic basins, roughly W-E oriented, with outlet along the Adriatic coast. The fluvial axes and the correspondent mouths and beaches show a complex evolution occurred through at times conflicting processes.

The period comprised between the early Holocene and the beginning of the XXth century is characterized, as like as in other areas of the Mediterranean, by an intense phase of deposition both along the river valleys and on the mouths, with consequent strong advance of the shoreline. This evolution is generally congruent with that observed by many authors and concerning the effects on the fluvial dynamics produced by the numerous "cold" and rainy phases of the early Holocene, of the early Middle Age and, mostly, of the Little Ice Age. During this last phase a very important role is played also by the "anthropic resistancy" conditions: the human transformations on the slopes, in fact, favored erosion and transportation processes from the slopes to the hydrographic network.

In the first half of the last century, after a former phase characterized by fluvial erosion and shoreline retreat, the environmental setting is considered almost stable. On the other hand in the second half, said erosive processes (sometimes alternated by depositional ones) occurred with particular strength; about their activation and evolutionary control, the anthropic role (huge quarrying, narrowing of the natural fluvial cross-section etc..) is considered almost exclusive.

C5-6 Poster Lodolo, Emanuele

10.1474/Epitome.04.0277.Geoitalia2011

RECENT SEDIMENTS OF THE EASTERN LAGO FAGNANO (TIERRA DEL FUEGO, ARGENTINA): GEOCHEMISTRY, MINERALOGY AND THEIR IMPLICATION FOR ENVIRONMENTAL STUDIES

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Key terms: *Eastern Lago Fagnano; Holocene sediments; Proxies for environmental studies*

Lago Fagnano is located in a tectonic depression developed along the Magallanes-Fagnano transform fault, a major segment of the South America-Scotia plate boundary. It is 110 km long and its width varies from 2.8 to 9.7 km, and has a maximum water depth of 206 m. The tectonic structure of the Lago Fagnano formed presumably during the Paleogene, and its morphological setting was subsequently modified by glacial erosion, especially during the Late Quaternary.

During a joint Italian-Argentinean acquisition campaign (March 2010) funded by the Italian Ministry of Foreign Affairs, a total of 30 sediment samples were taken from three piston cores collected on the bottom of the easternmost part of Lago Fagnano, in the vicinity of the Rio Turbio inlet. Piston cores CF-1B, CF-3A and CF-F were retrieved at water depths of 20.4 m, 19.8 m and 36 m, respectively, and recovered 80 cm, 92 cm and 90 cm of lacustrine deposits. These sediments have been investigated for their mineralogy (X-ray powder diffraction) and geochemistry (rare earth elements, along with major redox-sensitive elements), with the aim of evaluating the suitability of these proxies for environmental studies. Sedimentological and mineralogical analyses showed that these samples are characterized by a silty-clayey fraction that is mainly constituted by quartz, feldspar and clay minerals. Chondrite-normalised rare-earth elements patterns are similar to those of the lighter upper continental crust, with some depletion of heavy rare earth elements. The analytical results lead to the conclusion that mineralogy and geochemistry provide key clues to the understanding of this depositional environment.

SESSIONE C6

Geomorfologia costiera e variazioni del livello del mare

C6-1 Orale Fubelli, Giandomenico

10.1474/Epitome.04.0278.Geoitalia2011

GIS MODELLING OF THE GELASIAN FARFA RIVER CATCHMENT (CENTRAL ITALY)

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Key terms: *Paleoshoreline; Paleosurface; Uplift*

Air-photo interpretation and GIS analysis can be a valuable key to reconstruct past landscapes and landscape-forming processes, where the investigated area is too wide to be studied with conventional methods. In this perspective we applied a simple GIS based method to model the Farfa River paleo drainage basin.

The present Farfa River, a left tributary of the Tiber River, has a 132 km² wide drainage basin. It flows from the Sabini Mts. (Central Apennine) crossing the "Transitional Sabina Sequence" (Lias to Miocene in age) made of limestone, marls, calcarenites and flysch deposits.

In the upper basin sector the river cuts fluvial conglomerate and sands Gelasian in age. Downstream, on the left side of the Tiber Valley, the facies of the incised sediments shows deltaic to frankly marine characters, that indicate the presence of the Gelasian paleo shoreline. This is also testified by the finding of lithodomus holes in the calcareous bedrock at an elevation of 260-290 m a.s.l. The shape of the Gelasian alluvial plain and delta has been outlined and redrawn by means of GIS techniques. Starting from this, we reconstructed the ancient Farfa River drainage basin whose surface area, more than 1000 km², was much wider than the present one. The reconstruction of the top surface of the old alluvial plain allows to recognize the occurrence of Quaternary faults in the study area. Finally, from the shoreline elevation, an uplift rate of 0.12/0.14 mm/yr has been calculated.

C6-2 Orale Bartole, Roberto

10.1474/Epitome.04.0279.Geoitalia2011

THE SEDIMENTARY BEDFORMS IN THE CHANNELS OF LA MADDALENA ARCHIPELAGO (NW SARDINIA, ITALY): A PRODUCT OF THE HOLOCENE SEA LEVEL RISING.

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Key terms: *La Maddalena Archipelago; upper continental shelf; acoustic facies; bedforms; last eustatic cycle*

The use of a Chirp high-resolution acoustic source made it possible the differentiation of acoustic facies in the recentmost sediments of the channels of the La Maddalena Archipelago and the recognition of large scale bedforms linked to the last eustatic cycle.

The acoustic facies, distinguished on the basis of their reflectivity characters, show a substantial coherence with the distribution of the sedimentary facies described by previous Authors. In the channels of the archipelago flat bottom sediments with medium to poor reflectivity correspond to sands, gravels and muds mainly of bioclastic composition deriving from the high CaCO₃ productivity of the Posidonia Oceanica seagrass that populates the flanks of the channels down to about - 40 m. On the contrary sediments on the flanks, which are mostly non-reflective, are mainly represented by silico-clastic sands resulting from the degradation of the granitic structural highs. Sediments of the most proximal and protected bays are characterized by higher reflectivity and correspond to finer deposits such as silts and sandy silts.

The Chirp survey highlighted the occurrence of large scale, low-H/L-ratio bedforms not evidenced on SSS survey because of their too low relief. In the channels roughly oriented W-E sedimentary bodies up to 3 km long and some meter thick occur in axial position. Two larger and thicker transversal bodies are present in two N-S trending channels, where they act as bathymetric thresholds between the adjacent islands. All these acoustically opaque bedforms, classified as sand ridges or sand banks are younger than the underlying sediments. They are mainly composed of bioclastic sands and gravels and represent the product of the present hydrodynamic regime.

Seafloor undulations of sand wave type occur in the main channel along the Gallura coast down-flow to the headlands with respect to the dominant, eastward directed current. Symmetric forms may be attributed to stormy wave motion, while the asymmetric ones to the seabed current. Sand ridges and sand waves are significant sedimentary bodies in the archipelago depositional system as they witness the importance of the currents in the hydrodynamic regime. These features are overprinted by smaller sedimentary features such as comet marks, small scale sand waves, sand ribbons and ripple mark fields, which indicate the axes and directions of the sedimentary transport.

The large-scale sedimentary bedforms of the channels of La Maddalena archipelago are the result of the hydrodynamic regime set up after the slackening of the sea-level rise, mainly between 6 - 5 ky B.P. This event brought to the stabilization of the sea level and the formation and maintenance of the bedforms.

C6-3 Orale Mastronuzzi, Giuseppe

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GEOMORPHOLOGY OF THE COASTAL LANDSCAPE OF TARANTO (ITALY)

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Key terms: *coastal morphology; suffosion; sapping; Taranto; Italy*

Taranto is located between the Apulian foreland and the Bradanic foredeep on the lowest marine terraces, part of a staircase of flat sub-horizontal surfaces generated during the Middle - Upper Pleistocene. Along the coast,

raised marine bioclastic sandstones overlap in transgression the sandy-clay of the Argille subappennine formation, Plio-Pleistocene in age. Numerous absolute age determination (U/Th) and racemisation analysis performed on the senegalensis faunal assemblage characterising the sediments suggest their correlation to the MIS 5. Although MIS 5.1 has been identified due to the extensive presence of the *Strombus bubonius* specimen, the detection of the MIS 5. 3 and 5.5 sediments is still matter of debate.

In the span of time characterised by the deep glacial regression that culminated about 20 ka in the LGM the entire coastal areas was deeply cut by the water flows nourished by the water deriving from the karstic springs extensively present. During the Olocene transgression, river valleys were filled by the sea generating deep inlets like that who attribute to Taranto the appellation "two seas city". All the coast south of the Ionian city is marked by smaller inlet. Always shaped in the clay/sandstone sequence, they derive by suffusion and sapping processes generated by the fresh water flux at the top of the Argille subappennine formation.

C6-4 Orale Amr, Saleem

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ROCKY LANDFORMS AS INDICATORS OF HIGH SEA LEVEL STAND ALONG THE NORTH-WEST COAST OF EGYPT

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Key terms: Mediterranean Coast of Egypt; Sea level changes; Rocky Coasts; Marine boulders; Elevated platforms

Many evidences reveal that sea level is changing over geological time scale. The rocky coasts are suitable preservation environment of sea level imprints since late Quaternary. Using interdisciplinary approaches and sophisticated laboratory analyses leads to significant improvements of sea level studies all over the world.

On a regional scale there is huge work concerning sea level changes along the Mediterranean Coasts. In spite of this, few studies on the old shorelines and their relation to sea level changes during Quaternary at the Mediterranean coast of Egypt have been made. Previous works in Egypt are concentrated in a limited area surrounding Alexandria region. The present study highlights such issues over the widespread coastal plain westward Alexandria up to the Libyan borders.

The North-West Mediterranean Coast of Egypt is split into three main sectors; the eastern, the central and the western. The eastern and western sectors are characterized by wide plains with a retreating escarpment; the dominant view is an alternation of oolitic Limestone ridges and depressions. In contrast, the central sector is the zone of rocky headlands and coastal ridges which represent ideal sites for sea level changes indicators.

Three exploring field studies have been carried out by 2010 toward the central sector; their findings are the core of the present investigation. The main feedbacks of the field work are:

- I. Studying the coastal ridges (first order ridge) in details
 - II. Positioning the elevated wave cut platforms and parallel marine notches
 - III. Identifying the elevated marine boulders accumulations in 15 sites
- The origin and ages of such relict landforms are highly debatable. Employment of dating techniques such as C14 are critically needed to present strong evidence of higher sea level stand in a finite period.

C6-5 Orale Bini, Monica

10.1474/Epitome.04.0282.Geoitalia2011

SEA LEVEL MARKERS ALONG COASTAL PATAGONIA (ARGENTINA): INSIGHT FOR RELATIVE SEA LEVEL RECONSTRUCTION IN MACROTIDAL AREAS DURING THE HOLOCENE

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Key terms: Sea level markers; Patagonia; Holocene

The Atlantic Patagonia coast preserves unique archives of late Quaternary relative sea level changes useful for testing geophysically based models for an area affected by significant glacioeustatic adjustment (Milne et al., 2005). However, relative sea level reconstructions so far proposed (notably the recent review for the Holocene of Schellmann and Radtke, 2010) are poorly accurate due to the stormy conditions and macrotidal regime characterising this area; many sea level markers employed are rather indicators of surf/storm activity than of mean sea level. Detailed fieldwork on selected sectors of the Atlantic Patagonian coast between ca 44° and 47° S have allowed to identify different typologies of sea level markers so far ignored as research target for the Patagonian area. In particular, we illustrate for the first time how abrasive notches and barnacle levels can be confidently used to reconstruct relative past sea levels. For instance, at Puerto Deseado village (lat 47°45'S, long 65°52'W) detailed description of currently forming abrasive notches allowed to understand that they mark the high tide level, and that this information can be applied for the relict raised counterpart landforms there recognised at different elevations. At Bahía Camarones instead (lat 44°48', long 65°44'), in situ barnacles (*Austromegabalanus psittacus*) levels allow a confident estimation of the Holocene high stand for the area, showing how previous estimation was substantially incorrect, even if a direct dating of these levels is still in progress. The use of accurate sea level markers, providing reliable estimates of age and elevation of former sea levels, is going to enable to propose, in the near future, an update of sea level curves for the area, to be compared and contrasted with geophysical model estimations.

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Schellmann, G. & Radtke, U. (2010). Timing and magnitude of Holocene sea-level changes along the middle and south Patagonian Atlantic coast derived from beach ridge systems, littoral terraces and valleymouth terraces. *Earth-Science Reviews* 103, 1-30.

C6-6 Poster Zecchin, Massimo

10.1474/Epitome.04.0283.Geoitalia2011

STEPPED POST-LGM SEA-LEVEL RISE: EVIDENCE FROM THE NORTHERN ADRIATIC SEA

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Key terms: Northern Adriatic Sea; Post-LGM sea-level rise; Melt-water pulse; Paleoshoreline

The northern Adriatic is an epicontinental sea, up to 20 m deep, developed after the inundation of a Late Pleistocene lowland triggered by the post last glacial maximum (LGM) glacio-eustatic rise. On the basis of oceanic evidence, some authors highlighted that the post-LGM phase was punctuated by faster episodes of sea-level rise called melt-water pulses (MWP), characterized by peaks that reached 60 mm/yr. Evidence of MWPs was recently recognized also along the Ionian margin of Calabria and in the Adriatic Sea, south of the Po delta.

New seismic and core data from the northern Adriatic Sea, off the Tagliamento river delta, allowed the recognition of a partially eroded sand ridge at 12 m water depth, which has been interpreted as a submerged wave-influenced delta, having associated coastal spits. The delta shows local channel fill features, interpreted as the result of the migration of distributary channels and/or inlets connecting the open sea with ancient bays placed adjacent to the delta. The present interpretation resembles the present day setting of the Tagliamento delta.

Taking into account the considerations of previous studies on drowned barrier islands south of the Po delta, it is inferred that the recognized delta developed during a phase of slower glacio-eustatic rise, allowing the rate of sediment supply to outpace the rate of relative sea-level rise and promoting the progradation of a deltaic system and associated shoreline. As the depth of the delta ranges between 18 and 12 m, its development might be linked to a phase of slow glacio-eustatic rise occurred between MWP 1C and MWP 1D, when sea level rose from about 15 to 10 m below present day sea level, between 9 and 8 kyr B.P. New studies are therefore needed to recognize submerged deltas and barrier islands, which may allow the reconstruction of the post-LGM sea-level rise in the Mediterranean and of the position of ancient paleoshorelines.

SESSIONE D1

Ricerca e sviluppo sostenibile nella regione Artica

D1-1/2 Invitato Vitale, Vito

10.1474/Epitome.04.0284.Geoitalia2011

THE SVALBARD INTEGRATED ARCTIC EARTH OBSERVING SYSTEM (SIOS) ESFRI INITIATIVE

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Key terms: ESFRI infrastructure; Svalbard; multidisciplinary observing network; climate change; Earth System Models (ESM)

Environmental and climate changes are currently observed at a global scale and in particular in the Arctic. In order to give better estimates of the future changes, the Arctic has to be monitored and analysed by a multi-disciplinary observation system which is suited to validate and gradually improve Earth System Models. The best chance to achieve significant results within a relatively short time frame is found in regions with a large natural climate gradient, and where processes sensitive to the expected changes are particularly important.

Svalbard and the surrounding ocean areas fulfil above criteria: Svalbard is located in a region with a very large climate gradient, being alternately influenced by cold central Arctic or mild marine climate conditions at time scales of weeks to years. It is also located in the region with the strongest inflow and outflow processes between the Arctic and lower-latitude oceans. In addition, Svalbard is the only region in the world (and has the facilities) where one can study and quantify one of the remaining unknowns in the climate puzzle: the extraterrestrial and especially solar influence on climate. Svalbard is located under the Earth magnetic field's cusp region, an area which is directly exposed to the solar wind, and where one can expect these influences to be most pronounced.

On the base of the above remarks, a proposal to establish an (Arctic) multi-disciplinary Earth System Observing Facility on and around Svalbard were submitted by Norway to the European Strategy Forum on Research Infrastructures (ESFRI), and included at the end of 2008 in the roadmap of this Consortium (including at the end of 2010 44 proposals). The main aim of SIOS is to have an optimised observational infrastructure which can match advanced Earth System models with observational evidence and provide near-real-time information on Arctic change to relevant stakeholders. This will include existing, upgraded and new infrastructure constituting a comprehensive Earth System research infrastructure, organised into a limited number of observation platforms, e.g., space, atmosphere, ocean, land, ice. As the major innovative element, SIOS will have a Knowledge Centre (KC) which will be the "melting pot" where interaction between observation, modelling and process research takes place. SIOS aims to be a pilot study for and future component of the envisaged SAON network as well as the mechanism to develop an internationally coordinated Arctic research hub.

At the moment, preparatory Phase of the Project (PP) is in progress, to establish the formal framework needed to operate a geographically distributed and thematically structured multi-national research infrastructure across Svalbard.

Key elements of SIOS and PP will be presented, together with information on the state of the PP work. Particular attention will be devoted to topics SIOS will intend to address when on place, and opportunities SIOS will offer to the Italian scientific community, taking into account that a fundamental element of SIOS will be to provide access to the Earth System Science research facilities in Svalbard to scientists from all over Europe and beyond. A similar access has been provided, under the coordination of NPI, by the multi-national facilities in Ny-Ålesund since 1996, but SIOS will enlarge the opportunities for such access considerably, since it comprises many more sites and platforms, both ashore and offshore.

D1-3 Orale Romano, Vincenzo

10.1474/Epitome.04.0285.Geoitalia2011

GPS NETWORK FOR IONOSPHERIC PERTURBATION DETECTION OVER ARCTIC

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Key terms: Positioning; GNSS; Ionosphere; Polar network

A specially modified GPS receiver for Ionospheric Scintillation and TEC Monitoring (GISTM) was deployed in September 2003 by Istituto Nazionale di Geofisica e Vulcanologia (INGV) at the Italian Arctic station "Dirigibile Italia" in Ny Alesund (79.9° N, 11.9° E, Svalbard, Norway), in the frame of the ISACCO (Ionospheric Scintillations Arctic Campaign Coordinated Observation) project. The receiver computes and records GPS scintillation indices and Total Electron Content (TEC). Phase and amplitude data, either in raw form or detrended (to remove systematic variations), can also be logged at 50-Hz. Nowadays ISACCO counts on three GISTM receivers at Svalbard (Norway), and three in Antarctica. Post processed and raw data are available in near real-time at INGV site: www.eswua.ingv.it. Visiting this web site is possible to access the INGV database, realized to organize and manage the large amount of information acquired by the INGV instruments measuring the ionospheric plasma parameters.

The importance and the amount of the data collected by INGV has encouraged original investigations on the formation of the ionospheric irregularities causing scintillations and on the dynamics of the high latitude plasma under disturbed conditions. The upcoming solar maximum, which is expected to reach its peak around May 2013, occurs at a time when our reliance on high-precision GNSS (such as GPS, GLONASS and the forthcoming GALILEO) has reached unprecedented proportions. Knowledge and monitoring of scintillations are essential, so that warnings and forecast information can be made available to GNSS end users, global system and local augmentation network administrators in order to guarantee the necessary levels of accuracy, integrity and availability of high precision and/or safety-of-life applications. Especially when faced with severe geospatial perturbations, mitigation tools to minimize destructive effects on satellite signals tracking (loss of lock, degradation of accuracy resulting in poorer satellite availability) are also needed.

This paper gives a general overview on the scintillations and TEC Arctic observatories, on the organization of the data collected, on the international collaborations and projects in which INGV is currently involved and on the scientific investigations aimed to GNSS and Space weather applications.

D1-4 Orale Fiorani, Luca

10.1474/Epitome.04.0286.Geoitalia2011

BIO-OPTICAL CHARACTERIZATION OF THE ARCTIC OCEAN BY LASER-INDUCED FLUORESCENCE AND SATELLITE RADIOMETRY

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Key terms: laser-induced fluorescence; spectrofluorometer; lidar fluorosensor; ocean color; phytoplankton

Global warming is particularly evident in the Arctic Ocean. Ice extent in September decreased from 8 million square kilometers at the end of the sixties to 5 million square kilometers today. If scientific research wants to support sustainable development in the Arctic Region, the biogeochemical cycles taking place in the surrounding ocean has to be clearly understood. This paper report on a research carried out by the Diagnostics and Metrology Laboratory (UTAPRAD-DIM) of the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) in the framework of a collaboration with the Institute of Oceanology of the Polish Academy of Sciences. UTAPRAD-DIM deployed its laser-induced fluorescence sensors CASPER, ELF and POLI on-board the research vessel Oceania during three oceanographic campaigns off the Svalbard Islands in 2006, 2007 and 2008.

CASPER is a laser spectrofluorometer based on double filtration and double excitation and has been applied to detect both dissolved and particulate components of natural waters coming from aquifers, rivers, lakes and seas. It has been patented and has been awarded the "Research and Innovation Prize 2005" by Business Innovation Center Latium.

ELF is a lidar fluorosensor: the main parts of the system are a frequency tripled Nd:YAG and a telescope detecting Raman scattering by water and laser-induced fluorescence by chromophoric dissolved organic matter (CDOM) and algal pigments (chlorophyll-a, phycoerythrin and phycocyanin).

POLI (patented) is the natural evolution of ELF. All the subsystems, i.e. laser source, collecting telescope, detection optics and acquisition electronics (patented) are completely new and allowed the miniaturization of the apparatus now contained in a fly case of 0.7×0.7×0.8 m³.

While CASPER analyzed water samples collected at different depths, ELF and POLI sounded remotely the water surface operating H24. As a result, spectrofluorometer and lidar provided a spatio-temporal picture of CDOM and algal pigments in a wide oceanic region. That information has been used for cal/val of ocean color satellite radiometers in the sea region off the Svalbard Islands.

D1-5 Orale Pisano, Eva

10.1474/Epitome.04.0287.Geoitalia2011

ARCTIC FISH: SNAPSHOTS ON RESEARCH IN A CHANGING ENVIRONMENT

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Key terms: Arctic fish; biology; ecology; biodiversity; marine ice

The unique biological and ecological features, and the evolutionary history of the polar fishes, related to adaptation to an extreme habitat, have been attracting the interest of the scientific community for many years. Nowadays, the attention devoted to this fauna is even higher, being the fish living in polar regions regarded as "sentinels" for climate changes.

Fishes play a key role in the marine food web, acting as predators and/or consumers at the lowest trophic levels, and as preys of the large vertebrates (marine mammals and birds) at the top of the food chain; as such, any effect of the climate change on fish will have implications on the entire marine ecosystem.

At present, the information on the Arctic ichthyofauna is scanty if compared to the large amount of data available on the Antarctic fish fauna counterpart. Such an imbalance is mainly due to different financial and logistic efforts, that, in the last 20 years, favoured researches in Antarctica as opposed to the Arctic. This is paradoxical in the light of the easy accessibility of European countries to Arctic areas. Nevertheless, some Italian teams are participating in Arctic research, mainly in collaboration with Norwegian groups, and relying on various local infrastructures for the field activity. For instance, our group, at the University of Genova, based on experience and technical expertise acquired during similar studies in Antarctica, is contributing, since 2001, to projects dealing with fish biodiversity in Arctic. These studies are included in the TUNU MAFIG (Marine Fishes of North East Greenland - diversity and adaptation) Programme, organized and managed by the University of Tromsø (Norway); despite the lack of specific funding we participated in all the five expeditions on board of RV Jan-Mayen (pre-TUNU and TUNU cruises), also contributing to the IPY international activities. The amount of data collected between Svalbard and Greenland during the TUNU cruises are of huge value as baseline to monitor the biodiversity in a rapidly changing environment. Another Italian group lead by ISPRA (Institute for Environmental Protection and Research, in collaboration with the University of Genova and the University of Tromsø, has recently started a project addressing the relationships between polar fish and marine ice, including a comparison between Arctic and Antarctic species. These issues require urgent attention due to the discovery that the key fish species of the coastal Antarctic ecosystem, the Antarctic silverfish (*Pleuragramma antarcticum*), uses the seasonal pack ice as spawning ground. This recent finding stresses the need to investigate the type and degree of the relationship between the life cycle of polar fish and the ice, in order to assess their vulnerability to the ongoing changes in sea ice dynamics.

With present contribution we intend to provide some snapshots on our ongoing research on Arctic fish, with focus on biodiversity, and vulnerability to climate change. Some major challenges in biological and ecological Arctic research will be also discussed. Effective future research on Arctic fish should be comprehensive and interdisciplinary, integrating biology, ecology, oceanography and glaciology, and will require adequate infrastructures for sampling and operating all year round.

D1-6 Orale Rebesco, Michele

10.1474/Epitome.04.0288.Geoitalia2011

TROUGH-MOUTH FAN DEVELOPMENT AND SUBMARINE LANDSLIDES ON THE NORTH-WESTERN BARENTS SEA CONTINENTAL MARGIN: THE HISTORY OF THE LAST MILLION YEAR FROM HIGH RESOLUTION MULTICHANNEL SEISMIC REFLECTION PROFILES

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Key terms: Barents Sea; Glacimarine Trough Mouth Fan; Glacigenic debris flow deposits; Submarine Landslides; Seismic reflection profiles

The north-western margin of the Barents Sea has been investigated by two companion research cruises carried out within the International Polar Year (IPY). The Spanish SVAIS cruise (BIO Hespérides, summer 2007) and the Italian EGLACOM cruise (R/V OGS-Explora, summer 2008), both contributed to IPY Activity 367 NICE-STREAMS (Neogene ice streams and sedimentary processes on high-latitude continental margins), aiming at understanding erosion and depositional systems associated with ice streams. Data acquisition focused on the Storfjorden and Kveithola Trough Mouth Fans (TMFs) and included collection of multi- and single-channel seismic profiles, swath bathymetry, sub-bottom profiler data and sediment cores.

Sedimentation on the Storfjorden and Kveithola TMFs and on the other northern TMFs surveyed within our data (Kongsfjorden, Isfjorden, Bellsund) has been influenced by the presence of ice during the late Cenozoic and reflects past ice sheet expansions and recessions. Beside the common sedimentary processes operating at low latitudes (as transport and deposition by contour currents, turbidity currents and mass-wasting), these systems are affected by glacial processes, which characterizes the nature and rates of all sedimentary processes. Major periods of margin progradation are associated with relatively short time intervals of ice terminating at the shelf break during glacial maxima. Fleets of icebergs and associated Ice Rafted Debris (IRD), cascades of meltwater and large quantities of suspended sediments (plumes), and unsorted debris, concentrate at the mouths of fast-flowing ice streams occupying cross-shelf troughs. These sediments are efficiently reworked and delivered into the basins by Glacigenic Debris Flows (GDFs) that form the building blocks of the large polar TMFs.

Contrary to low-latitude fans that are fed by rivers through a channel levee complex, glacier-fed TMFs, receive their main sedimentary input from a glacier margin at the shelf break. As a result, high-latitude depocenters are mostly elongated across the upper slope, whereas low-latitude deep-sea fans lie on the middle slope. In contrary, in shallow-bank areas between ice streams, where slower ice reached the shelf break and TMF are not present, the continental slope is characterized by large-scale sediment landslides and canyon systems. Giant paleo-landslide deposits, detected by MCS profiles, are characterized by chaotic acoustic units up to about 250 m thick on the lower continental slope. The thickest, oldest landslide, dated between 1 and 0.8 Ma, took place just after the large-scale intensification of glaciation in the Barents Sea. The apparent spatial coincidence of landslides and channels with the boundary between the two ice-stream generated TMF systems suggests a common controlling climatic process for their development. Most probably the landslides are related to the abundance of basal meltwater beneath the ice sheet, which in addition to determining ice stream motion and

lubrication also influences the behavior of mass wasting processes.

D1-7 Orale Petronio, Lorenzo

10.1474/Epitome.04.0289.Geoitalia2011

JOINT USE OF SEISMIC REFLECTION AND PHYSICAL OCEANOGRAPHIC MEASUREMENTS IN THE ARCTIC AREA: AN EXAMPLE FROM NORTH-WESTERN BARENTS SEA CONTINENTAL MARGIN

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Key terms: Seismic oceanography; Barents sea; reflection; thermohaline structures; ocean circulation

In the frame of the EGLACOM (Evolution of a Glacial Arctic Continental Margin) project a combined offshore reflection seismic and oceanographic cruise was carried out along the north-western Barents Sea continental margin. This cruise was funded by the Italian Istituto Nazionale di Oceanografia e Geofisica Sperimentale (OGS) in the framework of the International Polar Year (IPY). Simultaneous seismic and oceanographic data acquisition were performed to study the thermohaline structures, the ocean current circulation and to evaluate the feasibility of the seismic oceanography approach.

The studied area has a high relevance from the climatic and oceanographic point of view due to the presence of the Arctic front which separates waters of Arctic origin from the warmer and saltier Atlantic Water (AW) flowing northwards, along the western Svalbard margin. Along the Arctic front important heat fluxes take place, which deeply influence the regional climate as well as the overall circulation. Detailed characteristics of the front are still not very well resolved and a combined approach based on high resolution seismic profiles along the water column and conventional oceanographic methods may provide useful information on the vertical distribution of the different masses.

Over 1000 km of multichannel seismic reflection lines were acquired simultaneously with several types of oceanographic data. Seismic data interpretation is supported by 60 XBT (Expendable Bathy-Thermograph) profiles obtained concurrently during the seismic acquisition, 6 additional CTD (Conductivity-Temperature-Depth) casts carried out within 10 days from the XBT launches and by sea-surface temperature and salinity measurements acquired continuously by a thermosalinograph installed on the vessel prow. In addition, Vessel-Mounted Acoustic Doppler Current Profiler (VM-ADCP) data were acquired during navigation to continuously monitor the current velocity distribution in the upper water column (about 400-500 m). The velocity field, together with remote sensing images of the sea-surface temperature acquired from the NOAA-18 satellite were used to depict the dynamic oceanographic background of the area. The results obtained display a strong correlation between seismic reflectors and discontinuities in vertical temperature and salinity gradients and allow to recognise the spatial extension of the water masses of Atlantic and Arctic origin present in the area.

Until now strong efforts have been devoted to define a viable seismic data processing strategy to enhance the imaging of the water column reflections. Future activity will be focusing on the interpretation of the seismic images on the basis of available oceanographic data.

D1-8 Orale Lucchi, Renata Giulia

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POST LGM SEDIMENTARY PROCESSES AND EVOLUTION OF THE STORFJORDEN TROUGH-MOUTH FAN (NW BARENTS SEA)

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Key terms: Storfjorden TMF; sedimentary processes; climatic changes; plumites; last glacial maximum

The continental margin of the Southern Storfjorden trough-mouth fan was investigated within two coordinated Spanish-Italian projects: the SVAIS (BIO Hespérides cruise, August 2007) and EGLACOM (R/V Explora, July-August 2008) projects contributing to IPY Activity N. 367 NICE STREAMS (Neogene ice streams and sedimentary processes on high latitude continental margins). The objectives were to investigate the glacially-dominated late-Neogene-Quaternary sedimentary architecture of the NW Barents Sea continental margin to reconstruct the response to natural climate changes of this sedimentary system. Palaeo-ice streams in Storfjorden had a relatively small catchment area draining ice from southern Spitsbergen and Bear Island. The short distance from the ice source to the calving front produced a short residence time of ice, and therefore a rapid response to climatic changes.

Piston cores recovered the last few thousands years sedimentary sequence representing the Last Glacial Maximum (LGM) and the following deglaciation phase. Inter-core correlation and stratigraphic constraints were based on detailed palaeostratigraphic investigations, down-core logs of magnetic susceptibility, palaeomagnetism, and sedimentary lithofacies with absolute age control from the 26 AMS14C dating. Most cores display at the base Mass Transport Deposits (MTDs), including slumps/debris flows and over-consolidated glacialic diamictites. The latter were deposited during the last glacial stage when the ice sheet was grounded at the shelf edge. MTDs are overlain by an oxidized interval resulting from the massive release and sinking of fresh, cold and oxygenated melt-waters at the inception of the deglaciation phase.

On the upper slope the oxidized interval is overlain by several meters of interlaminated sediments composed of sandy-silt layers cyclically recurring

within finer-grained laminated mud. Textural and compositional analyses suggest preferential deposition by settling from meltwater sediment-laden plumes (plumites) during deglaciation. The laminated sequence is topped by a glaci-marine diamicton consisting of massive or layered IRD-rich sediments which compositional characteristics indicate a renewed strength of the warm North Atlantic Current (NAC). On the mid slope the plumites are only a few cm-thick and are topped by crudely laminated, diatom-bearing sediments overlaid by intensively bioturbated, bioclast-rich silty-clays representing the most recent interglacial sedimentation. The composition of these lithofacies indicates that the NAC progressively had a stronger influence on sedimentation and a fundamental impact on timing of glacial retreat after LGM.

D1-9 Orale Melis, Romana

10.1474/Epitome.04.0291.Geoitalia2011

THE SOUTHERN SVALBARD MARGIN SEDIMENTARY SYSTEM: BIOSTRATIGRAPHIC AND PALEOCEANOGRAPHIC OBSERVATIONS FROM EGLACOM CRUISE 2008

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Key terms: Arctic; ecostratigraphy; paleoceanography; late Quaternary

The Storfjorden sedimentary system (north western Barents Sea continental margin) was investigated during the EGLACOM cruise (R/V OGS-Explora, summer 2008).

EGLACOM (Evolution of a Glacial Arctic Continental Margin: the southern Svalbard ice stream-dominated sedimentary system) project is the Italian contribution to the IPY Activity n°367 - NICE STREAMS in combination with the IPY-Spanish SVAIS project. One objective of this project was the study of the late Quaternary paleoclimatic and paleoceanographic evolution of these glacially-dominated areas.

Four EGLACOM sediment cores were collected from the slope and shelf areas and scanned for radiographs and multi-sensor core logger for physical properties. Samples were collected every 10 cm, and analyzed for textural and compositional characteristics including the biogenic components. Paleomagnetic and rock-magnetic investigations were carried out at high-resolution along the cores length. The studied data sets contributed to develop an high-resolution age model by combining biostratigraphy (using foraminifera, diatoms, nannoplankton and ostracods), AMS 14C dating and paleomagnetic records.

On the upper slope, coarser-grained sediments containing abundant pebbles (IRD-rich facies), overlain a sequence of laminated mud, late Quaternary in age, which is interbedded with silt layers (laminated facies), having scarce, badly preserved and often reworked biogenic fraction. On the middle slope, the uppermost sequence is formed by fine-grained bioturbated sediments with IRD and abundant planktonic and benthic foraminifera reflecting open-ocean conditions similar to present days. The dominance of the benthic foraminifer *Stainforthia wellerstorfi* indicates well oxygenated bottom waters at the base of Holocene, as recorded by the calcareous nannofossil assemblage belonging to *Emiliania huxleyi* Acme Zone. Here, the planktonic foraminifers are mainly represented by *Neoglobobulimina pachyderma* (s) and *Turborotalita quinqueloba*. The bioturbated facies overlay an interval of late Quaternary crudely laminated mud interbedded with silt layers. This laminated facies generally has a scarce, badly preserved and often reworked biogenic fraction including Quaternary, Paleogene and Cretaceous species. It contains a peak of diatoms and sponge spicules corresponding to an increase in planktonic foraminifers content, mainly represented by *T. quinqueloba*. At the base of this siliceous-biogenic interval the pteropod *Limacina helicina* is very common, its presence is probably due to a deepening of the ACD (aragonite compensation level) and/or a rapid burial of the aragonite trests.

The sedimentary sequence recovered from the shelf of the Kveithola trough contains mainly Holocene IRD-rich sediment topped by 10 cm of massive sands including large clasts. The biogenic fraction contains well preserved foraminifers, mollusks, ostracods and sponge spicules. Both Arctic and Arctic-Boreal benthic foraminifers are present with *Cassidulina teretis* and *C. reniforme* (Arctic species) as dominant species, followed by *Melonis barleeanum* and *Islandiella* spp. At the core bottom, the common *C. teretis* indicates the influence of the cold and salty Atlantic Intermediate Water. The uppermost sediments record a climate improvement, for the presence of the boreal, *C. laevigata* and *T. angulosa*, among the foraminifers and the termophylic *Muellerina abyssicola* among the ostracods.

The clay mineral assemblages includes illite, chlorite, kaolinite, and smectite. and they reflect the sediment provenance. Gneisses and amphibolites in southern Spitsbergen can represent the source rocks for illite and chlorite. Smectite derives from alteration of volcanic rocks and can be transported and deposited along the margin by the North Atlantic Current.

D1-10 Orale Sagnotti, Leonardo

10.1474/Epitome.04.0292.Geoitalia2011

PALEOMAGNETISM OF THE SVAIS AND EGLACOM CORES (NORTH-WESTERN BARENTS SEA CONTINENTAL MARGIN): IMPLICATION FOR THE HOLOCENE GEOMAGNETIC PALEOSECULAR VARIATION AND HIGH-RESOLUTION DATING

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Key terms: paleomagnetism; paleosecular variation; Holocene; Svalbard; geomagnetism

A high-resolution paleomagnetic and rock magnetic study has been carried out on 8 cores sampled in the hemipelagic fine-grained (silty-clays) sediments from the continental shelf and slope of the Southern Storfjorden trough-mouth fan, on the north-western Barents Sea. The Storfjorden sedimentary system was investigated during the SVAIS and EGLACOM cruises, when 10 gravity cores, with a variable length from 1.03 m to 6.41 m, have been retrieved. Accelerator mass spectrometry (AMS) 14C analyses on 26 samples (mainly foraminifera, and a few mollusc shells) demonstrate that the cores span a time interval that includes the Holocene, the deglaciation and in some cases the Last Glacial Maximum (LGM). Rock magnetic and paleomagnetic measurements were collected at 1-cm spacing on u-channel samples. The data indicate that the sediments carry a well-defined characteristic remanent magnetization (ChRM) and have a valuable potential to reconstruct the paleosecular variation (PSV) of the geomagnetic field, including changes in ChRM inclination and declination as well as in relative paleointensity (RPI). The paleomagnetic data obtained from the SVAIS and EGLACOM cores allow us to reconstruct dynamics and amplitude of the geomagnetic field variations at high northern latitudes (75°-76° N). These data are important for testing models on the geomagnetic dynamo and the outer core dynamics, since they bring direct experimental constraints on the geomagnetic secular variation within the inner core tangent cylinder, an imaginary cylinder parallel to the Earth's spin axis that circumscribes the equator of the inner core and intersects the surface of the Earth in the polar regions in both hemispheres at a latitude of 69.6°. The Holocene PSV and RPI records appear particularly sound, since they are consistent between cores and they can be correlated to the available regional stacking curves (UK PSV, FENNOSTACK and FENNORPIS) and global geomagnetic models for the last 7 ka (CALS7k.2), matching the obtained 14C dates. We therefore propose a Holocene PSV and RPI stack for the Storfjorden area. Furthermore, the rock magnetic and paleomagnetic data allow a high-resolution correlation of the sampled sedimentary sequences and the development of a refined age model for the cores. These data provide a firm temporal framework for the reconstructed post-LGM sedimentary processes and evolution.

D1-11/12 Invitato Favali, Paolo

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EMSO - EUROPEAN MULTIDISCIPLINARY SEAFLOOR AND WATER COLUMN OBSERVATORY

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Key terms: ESFRI Infrastructure; Permanent European underwater network; Multidisciplinarity

EMSO, an ESFRI large-scale Research Infrastructure (European Strategy Forum on Research Infrastructures Roadmap, <http://cordis.europa.eu/esfri/roadmap.htm>), is the European-scale network of multidisciplinary seafloor and water column observatories from the Arctic to the Black Sea with the scientific objective of long-term real-time monitoring of processes related to geosphere/biosphere/hydrosphere interactions. EMSO will enhance our understanding of processes through long time series appropriate to the scale of the phenomena, constituting the new frontier of studying Earth interior, deep-sea biology and chemistry and ocean processes. EMSO will reply also to the need expressed in the frame of GMES (Global Monitoring for Environment and Security) to develop a marine segment integrated in the in situ and satellite global monitoring system.

EMSO is presently at the stage of Preparatory Phase, funded in the EC FP7. The EMSO status, the perspectives and relations with other existing or incoming sensor networks and data infrastructures are outlined. Also the synergies with other ESFRI projects like SIOS are also discussed.

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D1-13 Orale Tinivella, Umberta

10.1474/Epitome.04.0294.Geoitalia2011

BSR VERSUS CLIMATE CHANGE: EXAMPLE OF PERI-ANTARCTIC REGIONS

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Key terms: BSR; gas hydrate; climate change; slope stability

Submarine slides are global phenomena occurring on slopes that may be considerably less inclined than their terrestrial equivalents due to the presence of excess water; they can displace huge amounts of material over great distances. During the last decades, a debate has been started regarding the relationship among gas hydrate, climate change and slope stability. In fact, gas hydrates represent a significant geo-hazard that is of immediate importance to near and offshore developments. Human activities and installations in regions of gas-hydrate occurrence must take into account the presence of gas hydrate and deal with the consequences of its presence. The hydrate stability zone in marine environments is a function of the water depth, the seafloor temperature and the geothermal gradient. Any temperature and/or pressure changes, both at the surface and in the area adjacent to the hydrate, affect the thickness of the stability zone. Although temperature and pressure are the main controls in the formation of gas hydrates and the thickness of the hydrate stability zone, other factors, such as gas chemistry and gas availability, alter the thickness and location of the hydrate stability zone. Dissociation of

hydrate may trigger the sudden release of large amounts of methane through the ocean into the atmosphere, leading to accelerated climate warming. Hydrate dissociation and gas release in the atmosphere have been proposed as a significant mechanism to explain the rapid and significant climate change during the Paleocene-Eocene Thermal Maximum. This hypothesis has been challenged by different studies, which suggest that methane from dissociating hydrate may never have reached the atmosphere. Alternatively it has been proposed that methane release may follow, rather than lead, climate change. In the last years, several authors have investigated the relationship between the gas hydrate dissociation and the increase of pore fluid pressure below the bottom simulating reflector, which is the seismic indication of the base of the gas hydrate stability zone. In fact, dissociation of gas hydrates at the BSR, in response to a change in the physical environment (i.e., temperature and/or pressure regime), can liberate excess gas and elevate the local pore fluid pressure in the sediment. The increase in pore fluid pressure has the effect of decreasing the effective normal stress on any assumed failure surface, so that less shear stress is required to initiate failure. Whether free gas liberation by gas hydrate dissociation can singularly cause a slide, rather than just being a contributing load or the final trigger, is dependent on various factors. These include rate of dissociation, sediment permeability, depth below sea level, and depth below the seafloor. In this work, we investigate the relationship between climate change and hydrate stability in two peri-antarctic areas: Antarctic Peninsula and South Chile. We consider these areas because the polar and sub-polar areas are the most sensitive about global change. The zone, where the methane can be easily released by hydrate melting, is the shallow water, i.e. in proximity of the intersection between the BSR and the sea bottom. In order to simulate the effect of climate change on hydrate stability, we consider the following seven scenarios for both areas: present environmental condition; sea bottom temperature increase/decrease of 1 °C; water depth increase/decrease of 100 m; sea bottom temperature and water depth increase/decrease of 1 °C and 100 m respectively. On the basis of our result, we can draw the conclusion that the modeling is a useful tool to understand the effect of the climate change on hydrate stability. Moreover, in these areas where the sea bottom temperature is influenced by temperature increase, such as Arctic and Antarctica, slides could be easily triggered by hydrate dissociation.

D1-14 Orale Giglio, Federico

10.1474/Epitome.04.0295.Geoitalia2011

PRELIMINARY RESULTS FROM OCEANOGRAPHIC, BATHYMETRIC AND SEISMO-STRATIGRAPHIC INVESTIGATIONS IN THE KONGSFJORDEN, SVALBARD ISLANDS

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Key terms: climate change; seismic features; Kongsfjorden; Mooring Site

The Kongsfjorden is a narrow fjord of the Svalbard archipelago. It is 20 km long and 4-10 km wide, elongated in SE-NW direction and the exchanges with the Arctic Ocean occur at the northwestern mouth, along the western coast of the Spitsbergen island.

During September 2010, an instrumented oceanographic array was deployed by CNR-ISMAR in the Kongsfjorden with the purpose to monitor the possible impact of the climate change on the interplay between the Atlantic water influx (the northern branch of Gulf stream and the Arctic-type coastal water) and the melting of tidal glaciers (Kongsvegen, Kronebreen, Blomstrandbreen), both being linked to global climate variability.

In order to choose the best site to locate the moored instrumentations, a seismic survey was performed in the inner part of the fjord, which is recently become accessible by the rapid glacier retreating. Over 130 miles of Chirp sub-bottom profiles (4kW Benthos DSP-662 Chirp III with 4 towed transducers) were acquired, with the purpose to describe the morpho-bathymetric features and surficial seismo-stratigraphy. The bottom of the fjord is dominated by a widespread outcrop of bedrock. Several structures were detected, mainly related to relict sub-glacial and ice-scoured topography produced during the glacial re-advances of the Weichselian (20 ky BP) and again during the last major Holocene re-advance of the Little Ice Age. These features are several tens meter high above the sea bottom level, and in the southeastern part emerges as small islands separating the inner fjord into two parts.

The area located at the inner part of the fjord, close to the calving line, is characterized by higher sediment accumulation rates, and a thin (<10m) layer of coarse-grained sediment thickness can be observed, probably due to the interaction of the 3 proximal ice-tongues. The high-resolution seismic data set allowed us to select the optimal site for the mooring deployment. During early September 2011, the mooring will be serviced and short sediment cores will be collected to investigate and discriminate the late Quaternary climatic events recorded in the sedimentary sequence.

D1-15 Poster Giglio, Federico

10.1474/Epitome.04.0296.Geoitalia2011

INTERACTION OF SEAWATER AND GLACIER TONGUES INTO INNER KONGSFJORDEN, SVALBARD ISLANDS

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Key terms: Kongsfjord; seawater-glacier interaction; glacier melting; sea-ice melting

The Arctic glaciers release every year millions of m3 of fresh water from the iced reservoirs to the ocean and the total amount will probably increase in next years following the global warming. The knowledge of the dynamics involved in the Arctic melting zone needs improvements from the physical oceanography point of view in order to better understand the effects produced by ice melting on the hydrological features of the sea and on the transport pathways from the glacier to the open sea by currents. In the inner part of Kongsfjord (Svalbard Islands) close to Ny Alesund Base large ice tongues (from Blomstrandbreen, Kongsbreen, Kronebreen and Kongsvegen glaciers) reaches the sea. Large research vessels study the outer part of the fjord, from the open sea until the moraine, glaciologists study ice tongues until its border but the inner part of the

fjord between the moraine and the marine border of the glaciers has been poorly known. This inner part is very interesting because is the major source of freshwater inputs in the fjord and important chemical-physical and biological processes (i.e. flocculation, algal blooms...) occur in this critical area. Salt water from the fjord enters the basin inside the moraine along the complete water column in the southern passage. It gets colder and fresher mixing with the ice melting water and outflow the basin running toward West through the northern passages. It mainly runs across the passage between Blomstrand Island and Blomstrandbreen glacier that used to be covered by ice in the past but is free from ice now. Sea level records indicate a seiche that is present in the outer part but poorly visible in the inner basin.

The presentation aims to describe some aspects of the physical oceanography of the interface area where glaciers get in touch with the sea in the inner part of Kongsfjord. In particular a description of temperature and salinity and currents of the inner Kongsfjord close to glaciers will be done.

D1-16 Poster Petronio, Lorenzo

10.1474/Epitome.04.0297.Geoitalia2011

SEISMIC IMAGING OF THE POLAR OCEANS: A NEW CONTRIBUTION TO OCEANOGRAPHY?

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Key terms: Seismic oceanography; polar oceans; offshore reflection seismic; Arctic; Antarctic

The existing conveyor belt circulation triggers the global climate, controlling heat and water fluxes with the oceans and the atmosphere from tropical to polar regions, and vice versa. Within this large scale and relatively stable circulation, characterized by having a time scale in the order of thousands years, a key-role is played by the Arctic, as well as Antarctic, regions. However, despite this well-recognized importance in the climate system regulation, data collected in these areas are still rare and sparse.

Moreover, in the last decades there have been rising evidences of deep changes in the Arctic climate, both via direct and remote-sensed observations as well, that appears to be changing faster than many other regions. This is particularly true with respect to the sea ice formation rate and size.

The relatively high contrasts existing between water masses in the polar oceans makes them an ideal target for seismic oceanography (SO), a novel technique to detect boundaries in the water column. SO was primarily designed to image sub-seafloor geologic structures, and recently was shown to be capable of providing clear pictures of water mass interfaces in the ocean, when used in conjunction with classical oceanographic measurements.

Since polar oceans represent a key study area for the global circulation and, ultimately, for the earth climate, we started to reprocess offshore seismic data collected for geological targets focusing on the water column in order to evaluate the capability of SO to support physical oceanography studies.

We present two examples of seismic oceanographic data acquired in Polar Regions.

In the first case we show a reprocessing of seismic data acquired off Wilkes Land (East Antarctica) in the framework of the WEGA project. In this area the deep water formation process is responsible for triggering the Global Thermohaline Circulation. Along the continental slope, a complex reflection pattern in the seawater column was detected. As no contemporary in situ hydrographic data were carried out during the seismic survey, we used CTD data acquired in the same area, but in a different period, to validate the common-mid-point (CDP) stacked section. The synthetic seismic traces were computed starting from velocity and density, derived by means of empirical formula from CTD data. The comparison between real and synthetic data shows a qualitatively good agreement.

The second example derives from the data collected in the frame of the EGLACOM project, a multidisciplinary combined offshore reflection seismic and oceanographic cruise carried out along the southern Svalbard continental margin. First results display a strong correlation between seismic reflectors and discontinuities in vertical temperature and salinity gradients. XBT sections and CTD profiles allow to recognise the spatial extension of the water masses of Atlantic and Arctic origin present in the area, and show the progressive cooling and shallowing of the warm and salty Atlantic Water proceeding northwards.

SESSIONE D2

La geologia ambientale per uno sviluppo sostenibile nei territori di collina in Italia

D2-1 Orale Baima, Lucia

10.1474/Epitome.04.0298.Geoitalia2011

ENVIRONMENTAL-GEOLOGIC PROBLEMS RELATIVE TO SOME LANDFILLS LOCATED IN THE PIEMONTE HIGH TERRACES (NORTH-WESTERN ITALY)

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Key terms: LANDFILLS; HIGH TERRACES; MONITORING WELLS; PROBLEMS

Some environmental geologic problems at two landfills for municipal solid waste are exposed in the present work. The landfills are situated in Piedmont high terraces zone, one in the municipality of Magliano Alpi in the Cuneo district, the other in the municipality of Grosso Canavese in the Turin district.

The plant of Magliano Alpi is located on a high terrace emerging from the eastern part of Cuneo plain the plain of Cuneo, the terrace has formed

consequently to the Pleistocene capture of Tanaro River and the successive remounting erosion of the whole river network. The sedimentary sequence observed from the surface downward shows a Holocene complex around ten meters thick, a low permeable Villafranchian Complex (Plio-Pleistocene) and a marine Pliocene Complex constituted by an alternative permeable sands and unproductive clays.

The landfill of Grosso Canavese is located on the high terrace that remains as a relic of the ancient alluvial fan of the Stura di Lanzo River around 30 km north-west of Turin. It is realized in the Mindel glaciofluvial deposits (Pleistocene), more than 40 meters thick.

For both the sites, a hydrogeological study has been carried out, especially referred to the monitoring wells, in order to characterize the groundwater from both the quantitative and qualitative. Piezometric maps have been realized for visualizing the general direction of the groundwater flow and water samples have been analyzed at the monitoring sessions in order to control the water quality.

During these activities, problems relative to a correct sampling from the monitoring wells have been almost always encountered, as well as inconsistencies in the interpolation of water levels. Sometimes the wells were dry, while, in many cases, the regular purging of the wells before the sampling has caused a too slow recovery of the water level.

The hydrogeologic study has revealed that in both sites the monitoring wells don't tap an aquifer, but a saturated but generally low permeable soil. A local permeability may be related to the presence of lenses of permeable soil (sand, silty sand) in a less permeable matrix, and the different modalities of charging and emptying of these lenses could explain in that way the different levels in the monitoring wells.

In both experiences, the data recorded by the monitoring wells are probably affected by uncertainties attributable to the well monitoring efficacy. Given their importance for proper hydrological and environmental data acquisition, a correct design as well as a special care in all phases of their realization are fundamental for the monitoring wells.

Proposals have been provided for identifying the depth of the underground aquifer below the landfills and properly design the monitoring wells, in order to take samples of water at different depths.

D2-2 Orale Caviglia, Caterina

10.1474/Epitome.04.0299.Geoitalia2011

OCCURRENCE AND MANAGEMENT OF WATER RESOURCES IN THE HILLY TERRITORIES OF CENTRAL PIEMONTE (NORTH-WESTERN ITALY)

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Key terms: Water resources; Hilly territories; Central Piedmont; Aquifer; Water management

About 30% of the Piedmont region (North-Western Italy) is represented by hilly territories.

In the Central Piedmont, the Torino Hill, Langhe and Monferrato constitute the most representative Piedmont hilly territories for both extension and inhabitants. This region is geologically made up by the deposits of Tertiary Piedmont Basin, a marine Oligo-Miocene sequence, structurally separated in five different sedimentary basins, also depending on the geological pertinence of the substrate: Torino hill, Langhe, and Alto Monferrato lie on an Alpine substrate, while Monferrato, and Lemme-Staffora sector appear to be of Apennine pertinence. The Tertiary Piedmont Basin is mainly consisting of conglomeratic, sandy, marly-silty and evaporitic formations, characterized by very low permeability from the hydrogeologic point of view. Above the sedimentary sequence of the Tertiary Piedmont Basin, a covering of marine Pliocene and transitional Plio-Pleistocene sediments complete the lithologic set of the study area.

In the paper, a hydrologic balance of the examined region finalised to the assessment of the water resources has been carried out. Starting from meteorological data of Central Piedmont weather stations, the mean annual isohyetal map has been drawn in order to evaluate the average rainfall in the area. Evapotranspiration has been calculate using different empirical methods, and, by difference, the water resources have been estimated. From the water balance, the examined territories result not too rich in water resources. The subdivision between superficial and underground water resources has finally realized by means of runoff coefficients depending upon the land use, soil type and slope of the watershed.

In the second part of the work, an overview on the water supply of the hills municipalities has been provided. Referring to the local institutions for water management (ATO - Ambiti Territoriali Ottimali n. 3, 4, 5 and 6), the different kinds of water catchments and their peculiar features: wells and springs for groundwater, and aqueduct taps for surface water. Cause of the poorness of the hilly water resources, almost all the water supply comes from sources external to the examined area.

For instance, the Torino Hill, falling in the territory of ATO 3, is supplied by Turin aqueduct (30% from the Po River, 70% from wells tapping the plain aquifers). Similar states have been verified for the hilly territories of Cuneo district (ATO 4) and Alessandria district (ATO 6).

The territory corresponding to ATO 5, entirely included in the hilly studied area and quite superimposable to the territory of Asti district, is partly supplied from a well field located in the Po Plain near the confluence of Dora Baltea River in the Po River (Cascina Giarra - Acquedotto del Monferrato) and, for the remainder, from a well field situated in the Valle Maggiore (Asti district). In this case, the well field is located within the studied area, and the wells tap the Pliocene aquifer occurring in the Sabbie di Asti Formation, but the groundwater recharge come from the western sector of the Piedmont where the Po River enter the Cuneo plain.

D2-3 Orale Chini, Marco

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DEFINITION OF THE EVOLUTION OF THE CORENO AUSONIO (SOUTHERN LATIUM, ITALY) EXTRACTIVE AREA BY MEANS OF REMOTE SENSING DATA

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Key terms: extractive area; remote sensing; automatic detection

A multidisciplinary study, based mainly on interpretation and analysis of remote sensing collected data, has allowed to define status and evolution of the marble quarry area of Coreno Ausonio (Southern Latium, Central Italy). The examined area is part of the Eastern Aurunci mountain chain. The Aurunci range is constituted of massive, mainly Mesozoic carbonate sequences. The lithotype subject to extraction is a sedimentary rock known as "Calcare a Briozoi e Lithothamni", registered under the trade mark Perlatto Royal Coreno © 2004. More specifically, the Calcare a Briozoi e Lithothamni belong to the sedimentary series of the Latium and Abruzzo regions and they constitute the last occurrence of carbonatic deposition before the onset of terrigenous sedimentation. The study has been conducted through multiscale and multitemporal interpretation of the orthophotos taken in 1996, 2000, 2005, 2009. In particular the bidimensional photointerpretation, concerning extractive activities, was calibrated using stereoscopic photographic coverage by the Volo Italia 1988-89 and by the Volo TerraItalia Regione Lazio 2000. All data were implemented on a GIS platform. In addition to the areal estimate of the entire field, as well as of each quarry, at the time of the orthophotographic coverage used, the researchers proceeded with a volumetric estimate obtained through the difference in digital models (TIN- Triangulated Irregular Network) properly gained via the digitalization of contour lines and elevation marking points surveyed in 1954, 1990, 2009. An automatic procedure for the identification of the marble quarry area has been implemented as well, through an unsupervised classification with a multiscale approach. The automatic procedure has been obtained in two steps. First, by means of morphological filters with different window sizes, a morphological profile has been created based on the original multispectral image, accounting for the geometric characteristics of objects. Second, the morphological profile previously extracted, plus the multispectral image, were the input to an unsupervised K-means clustering algorithm. It is worth noticing that the peculiar signature of some objects is not of spectral type but can be associated to specific shapes and size. For this reason, the mathematical morphology is a powerful tool to overcome this kind of problems of classification, i.e. different classes with similar value of radiance, such as building roofs or roads, could have similar radiance value with respect to the quarry class. The automatic approach has been validated by comparison of the obtained map with the one from visual inspection with an overall accuracy of 97%.

D2-4 Orale Destefanis, Enrico

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SOIL LOSS AND LANDSLIDE SUSCEPTIBILITY EVALUATIONS AT THE HILLS OF FREISA VINEYARDS (CENTRAL PIEDMONT, NORTHWESTERN ITALY)

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Key terms: Soil loss; Landslide susceptibility; Piedmont; Hill territories; Terroir of Freisa

In the paper, the potential soil loss and the landslides susceptibility have been evaluated means of empirical models at one of the hilly sites candidate as "Typical Piedmont Vineyard Landscapes: Langhe, Monferrato, Roero" to the World Heritage List of UNESCO. The study area is defined as "Core 1 - Freisa" and its territory is included within the municipalities of Albugnano, Castelnuovo Don Bosco, Moncucco Torinese and Pino d'Asti all in the Asti district.

It is located along the north-western boundary of the Piedmont central hill system, outlined by a wide ridge crown converging towards the Chieri Plain, near the administrative border of the Turin district. The territory possess a historical viticulture tradition, characterized by the culture of the autochthon vines of Freisa and Malvasia. The viticulture is diffused on the sunny slopes, with high quality production and increasing extension; an intricate shrub and wood vegetation grows on the steeper slopes and the lateral watershed. The rich culture mosaic presents parcels of small size also with seminatative cultures, separated by tree fruit rows. The historical settlements are located on the height sites (characteristic is the Albugnano borough), while the rural settlements occurs in isolated or aggregated buildings, disposed on the better exposed slopes. Among the significant historical sites, excels the Vezzolano Abbey, low medieval complex of regional relevance.

The USLE method has been applied in the study for evaluating sheet water erosion. For that scope, the main factors causing erosive processes have been computed from experimental or literature data: rainfall erosivity, soil erodibility, topography of the slopes (length and slope), cropping factor, conservation practice factor. In particular the difference of potential erosion at the vineyard slopes has been evidenced in presence or not of a grass cover among the vine rows.

A simplified method for the assessment of the shallow landslide susceptibility has been applied in the study area. The model takes in account both the rainfall infiltration in the soil and her influence on the slope stability. For the infiltration analysis the model uses the Green-Ampt method that considers the downwards advancement of a saturation front from the ground surface in consequence of a project rainfall. The thickness value of saturated soil is used as input information for the stability analysis according to the infinite slope method. The utilization of the Safety Factor equation permits to relate the project rainfall with the landslides trigger, through the h value, assuming very low values for cohesion and friction angle.

At last, the slope exposure and the layer arrangements (dip direction, dip angle) are elaborated in a simplify model for the evaluation of the susceptibility of the examined territory to the translational landslides.

D2-5 Orale Di Martino, Luca

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THE ROLE OF SATURATION OF SOILS IN RELATION TO THE TRIGGERING OF LANDSLIDES IN THE ASTI PROVINCE IN THE EVENTS OF DECEMBER 2008, APRIL 2009 AND MARCH 2011.

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Key terms: saturation of soils; landslide; flood

From the geological point of view, the Asti Province is part of that domain paleogeographic, usually reported in the literature as the Tertiary Piemonte Basin (TPB). The southern sector is characterized by the presence of a thick marly succession - sandstone (turbidite deposits oligo

- Miocene), while the central-northern area is characterized by a monotonous succession, mainly Pliocene in age, of silty - sandy (sands of Asti) and marly - clay (Argille Azzurre). The northern border of the province is characterized by predominantly siliciclastic lithotypes referable to the Monferrato-Torino Hill domains.

In the geological context outlined, the Province of Asti was characterized in the last four years (November 2008 - March 2011) by three natural disasters that have affected the secondary drainage network of both hills and valley areas.

In particular, each event was marked by hundreds of landslides that have affected both main and secondary roads and also residential areas.

With this memory we will analyze the triggering of landslides in relation to the degree of saturation of the soil and the intensity of rainfall, as each of the three events considered presented mode of initiation, type and extent of the phenomena significantly different.

We will provide a detailed series of rainfall, on a number of reference stations, previous and concomitant to each event. The analysis of the series in relation to effects on the land will lead to some reflections about the factors predisposing the onset of the different types of landslides in the hilly province of Asti.

A first analysis has revealed as the event of November-December 2008 has been greatly influenced by heavy snowfall that led to the saturation of the soil, leading to the development of gravitational movements due to landslides and liquefaction for saturation coverage of the surface layer, without the involvement of the substrate, characterized by rapid linkage.

The event in April 2009 was instead characterized by significant rainfall intensity and duration, that have acted on already heavily saturated soils under conditions of imminent collapse, that in some cases was already occurred.

In a scenario of generalized crisis, widespread landslides and deep involvement with local substrata, even on weak gradients slopes took place.

In March 2011, the Province of Asti was marked by a meteoric event with rainfall of about 100 mm in 24 hours. Despite the modest rain height numerous landslides deep rotational, translational and complex involving large areas and some towns took place.

D2-6 Orale Faccini, Francesco

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ENVIRONMENTAL GEOLOGY AND KARSTIC LANDFORM: SOME EXAMPLE IN THE FINALESE AREA (LIGURIAN ALPS, NW ITALY)

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Key terms: karstic environment; geomorphic hazard; water resource; Finalese; Ligurian Alps

In the framework of the 39 karstic areas spread over all ligurian region the attention has been focused on Finalese area in the Province of Savona, within the catchment of the Sciusa Stream and in particular in the Ponci Valley (about 6 km²), that represents its northeast sector.

The purpose of this study is the environmental-geological description of the karst area so as to identify the main geomorphological hazards and risk scenarios.

Karstic rock masses develop in the San Pietro dei Monti Dolomites, in the Finale Ligure Limestone ("Pietra di Finale") and in the Val Tanarello Limestones. Geomorphological features are associated with the presence of a karstic plateau, divided in some further elements.

Among the surface landforms the sinkholes of Pian della Noce and Pian della Brera, the swallow-holes, the limestone tower of the Rocca del Corno, the canyon of the Sciusa Stream can be observed. In particular the Ponci Valley represents the relic of a palaeovalley that was more extensive than the current surface: it was spread to North past the San Giacomo saddle and was later occupied by the Sciusa and Corealto Streams.

As for beneath landforms, over forty caves have been listed in the Speleological Inventory with a total length of over 2.3 km. The most extensive hydrogeological complex is the Grotta superiore sorgente Priamara (Upper Cave Priamara spring) (almost 1.7 km long), the deepest known is the Grotta Mala (more than 65 m deep).

The hydrogeological features involve a meteoric water absorption either scattered or concentrated: among major aquifers mention can be made of the Pian della Noce-Priamara complex (dolines, swallow-holes, caves and springs) and the Mala-Andrassa-Acquaviva complex (swallow-holes, sub-riverbed cave, springs).

The lithological features, geomorphological evolution and morpho-structural relationships between the outcropping rock masses (biocalcirudites, dolomitic limestones) cause a great infiltration of rainfall and an underground water flow towards the adjacent Sciusa Valley, that is rich in karst springs: the Acquaviva spring supplies the Noli waterworks. Among the geomorphological hazards that can cause risks mention must be made of sinking ground owing to the vaults collapse of caves, ground subsidences as a consequence of deposits settlement after hollows filling, rocks collapse from the scarps due to karstic landforms, floods partly associated with either the obstruction of the swallow holes or heavy rainfall.

Among the assets at risk on this area, in addition to the anthropogenic element that visits the territory partly for tourism purposes, in Ponci Valley there are five bridges of the Roman age - three of them still well-preserved - embankment protection works and some remains of the road "Via Iulia Augusta", a peculiar example of the ancient communication routes of western Liguria. Moreover remnants of an ancient underground mine of bioclastic limestones are left.

In conclusion this is one of the major karstic areas of the Liguria region for the number of peculiarities: it is a prominent archaeological site that, together with its geomorphological and hydrogeological configuration, represents a cultural and landscape asset of great interest for which protection and enhancement measures must be undertaken so as to preserve it.

D2-7 Orale Faccini, Francesco

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GEOMORPHOLOGICAL HAZARD OF A DEEP SEATED GRAVITATIONAL SLOPE DEFORMATION IN THE INTERNAL LIGURIDE OPHIOLITES (PETRONIO VALLEY, LIGURIAN APENNINES)

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Key terms: geohazard; landslide monitoring; deep seated gravitational slope deformation; ophiolites; Ligurian Apennine

This work is a scientific contribution aiming at identifying the Deep Seated Gravitational Slope Deformations, which have been accurately investigated only over the last couple of decades, and to manage them according to their geomorphological hazard.

Camegli hamlet, located in the Ligurian Apennine a few miles from Riviera di Levante, was built over large landslides as well as the majority of settlements in Liguria; these mass movements were probably triggered during lastly Pleistocene following climate changes which fuelled conditions of geomorphological instability.

The area features, as well as covers related to mass movements, serpentinites, basalt and gabbros outcrops belonging to the Bracco-Val Graveglia Unit. The tectonic profile shows a series of faults lineaments, which can be ascribed to the main direction N-S along which the hydrographical network settled and also ascribed to the second direction NO-SE where the valley established.

The work was first carried out through references research regarding both scientific papers and studies related to land planning, secondly through an accurate field survey, supported by photo interpretation analysis of the built-up areas and of a relevant neighbourhood of the landslide bodies, including secondary watershed ridges. Available cartographies of different times, since the end of the XVIII century to date, were compared.

In the area geognostical surveys, by means of piezometers and inclinometers, geophysical prospecting, laboratory tests of the soil and geotechnical tests in situ such as SPT were carried out.

Geotechnical and hydrological monitoring data, based on instruments reading over twenty years, were compared with available targets detected by radar interferometry. The last method aspect involves the inventory of the damaged artefacts of the built-up areas with the purpose of identifying possible correlations between current kinematic mechanisms and implications on buildings.

The settlements of Camegli were built over some landslides which can be ascribed to a deep seated gravitational movement. Going from the ridge toward the valley, various slope failures are observed: they show clear reverse slopes representing the top sector of a series of rock blocks, which locally developed into more recent landslides. Larger trenches were filled up by lacustrine deposits, as indicated by the toponyms Camegli and Case Il Lago. With reference to the landslides classifications this phenomenon appears to be similar to the rock flow type.

Data obtained by inclinometer cases show a good matching with the targets detected on the earth surface carried out by satellites and with the situation derived from the detailed survey of all damage involving man-made structures: relevant deformations are observed in the Case Il Lago slope sector, whereas the deforming sectors do not show important ongoing movements.

The measured total displacements - which are included in a typical kinematic mechanism that can be ascribed to extremely slow movements - goes from a few mm/y to 30 mm/y.

The whole monitored slope features a water table varies 2 to 10 m from ground level: year variations are even lower than 1 m consequently deep source mechanisms can be suggested without a clear correlation with rainfall.

D2-8 Orale Margiotta, Stefano

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INTEGRATED APPROACHES TO DEFINE GUIDELINES FOR BEST PRACTICES IN RELATION TO QUARRIES ACTIVITIES IN APULIA.

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Key terms: QUARRIES; GIS; APULIA

In the Apulia region (S Italy) there are 440 authorized quarries, 68% of which are in activity. The extractive industries make an important contribution to economic development in Apulia. This region has been interested for many centuries in quarrying activities, principally related to limestone, calcarenite and clayey materials. These activities have strongly contributed, with regard to extraction of the main carbonate rocks that were used as ornamental and building stones, to creation of Apulian architectural styles. The uses of clayey materials are various, from that artistic to that in which the clay is used for its impermeable properties, for example in discharge areas. The exploitation of weak rocks, such as calcarenites and second category ones, generally takes place in open quarries. However, underground extraction is not uncommon especially in cases where the calcarenite does not crop out and the removal of surface terrain would be expensive either because of its depth or in order to avoid the resulting loss of the terrain for agricultural production.

Many of the quarries operating today have a history of operation from before the introduction of the Local Government (Planning and Development) Act, 1985, whether permanently or on a seasonal or occasional basis. Quarries which never received planning permission or which received permission many years ago may be operating to older standards of environmental control than modern quarries, other than through voluntary compliance with the industry's codes of practice. However, given their authorised status, it has been difficult to require such quarries to seek consent for any expansion in their activities. Apart from the negative effects directly derived from quarrying, other effects have to be addressed after extraction, when the sites are abandoned without any reclamation work provided, often becoming illegal landfills. Here, we present the results of two projects between "Regione Puglia, Settore Attività Estrattiva" and University of Salento and ARPA Puglia for the study of guidelines to better administrate quarries both in activities (University of Salento) and abandoned (ARPA Puglia). A standard method to geologically map the quarries is proposed. In this project, geographic

information systems (GIS) and relational database technology have been utilized to adapt that reference into a system where spatially arranged collection site features are related to geological data through a series of common fields among tables in a geodatabase. Besides, a methodology to safely quarry related to the destination use has been developed. ARPA Puglia, in the study for the recovery of degraded landscapes from abandoned mining on the region, identifies the variables for the characterization of these landscapes through an analysis of specific indicators. It also defines the criteria for intervention priorities and methods of environmental restoration and landscape, offering private-management models and regulatory instruments applicable to its recovery.

These Guidelines seek to identify those issues and to suggest best practice in dealing with them. However, the operation of quarries can give rise to land use and environmental issues which require to be mitigated and controlled through the planning system.

D2-9 Orale Pastormerlo, Silvia

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INTERFERENCE BETWEEN RAINFALL, MUNICIPAL ROADS AND GEOMORPHOLOGIC STABILITY IN THE TERRITORY OF THE ALTO ASTIGIANO HILLS COMMUNITY (CENTRAL PIEDMONT, ITALY)

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Key terms: slope stability; landslides; Piemonte; Alto Astigiano; hill roads

After the severe rainstorms of December 2008 and April 2009, the situation of slope instability along the hill roads in the territory of the Alto Astigiano Hills Community has become more and more worse. The Italian Government has recognised the natural calamity of national interest for the two events. For such landslide susceptibility, a constant monitoring activity in the Alto Astigiano territory (13 communities of the central Piedmont hills) had to be carried out by the public administration. A research finalized to the production of a guide to the correct land use has been realized with the cooperation of Alto Astigiano Hills Community, Regione Piemonte and Turin University (Dipartimento di Scienze della Terra).

From a geologic point of view, the studied area is located in the Tertiary Piedmont Basin, composed of Upper Eocene to Messinian sediments. In the northern part, the tertiary series forms anticlines more or less accentuated, repeating in a sub parallel way (directed NW-SE). The Eocene and Oligocene terrains result raised in large extent, in some cases sub vertical or strongly troubled. Southward, starting from the Miocene terrains, the slope decreases quite regularly from 40° to around 20°-10°, until, from the Upper Miocene, it reduces to 8°-5° up to vanishing in the Pliocene Deposits. Litologically, the oldest and more resistant terrains, situated in the northern sector, are represented by carbonate sequences of Cretaceous-Eocene and by sandstones formations of Oligocene. Miocene is characterized by alternative marls and sandstones (with lenses of anhydrite and gypsum in the marl formation of Upper Pliocene). In the central and southern part of the study area outcrop the Pliocene terrains, constituted by fine sediments at first (blue clays or Argille di Lugagnano Auct.) and the sands of Sabbie di Asti formation, representing the more widespread lithology outcropping on the territory of the Alto Astigiano Hills Community.

The research activity has been articulated in the following steps:
° enumeration of more than 50 cases of instability reported in the last years by the communities and homogeneously distributed on the territory;
° investigation (technical-geological surveys, measurements, photos, etc.) on every site and finding of data relative to the individuated instability (eventual technical reports, photos just after the occurrence, testimonials, ...);

° drafting of a technical schedule for every case of individuated instability with the identification of the natural, anthropogenic, predisposing, and determining causes of the instability;
° classification of the examined cases in typologies of recurring instabilities for the studied territory;
° for every class of instability typology, individuation of preventive measures and intervention (right land use) for the attenuation of the geomorphologic risk;
° indications for sector laws;
° editing of the guide to the correct land use

The examined cases of instability generally cover landslides both upward and downward the roadways but also flooding of the roads; instabilities occurred almost always because of the faulty drainage of the runoff. Some suggestion for the regular maintenance of the road sides and for the repair of the road bed and surface have been provided in the guide, as well as the temporary and definitive engineering interventions after a road break. But the principal efforts have focused on the importance of an effective runoff disposal for a correct management of the hill territory.

D2-10 Orale Roccati, Anna

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ENVIRONMENTAL GEOLOGY AND SLOPE STABILITY IN REZZOAGLIO VALLEY (AVETO REGIONAL PARK, LIGURIA)

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Key terms: Environmental geology; Permanent Scatterers technique; Deep-seated gravitational slope deformation; Applied geomorphological map; External Ligurides

The work presents the case-study of a large slope instability along the left orographic side of the Gramizza Stream (Upper Aveto Valley). This area represents the best-known and typical part of the Aveto Natural Park for its valuable geodiversity that features it (Mt. Penna and Mt. Aiona area). The interest in this slope is determined both by its geological features - for its lithological and tectonical setting and geomorphological peculiarities - and because of engineering geology aspects, owing to the extensive presence of instability phenomena. These movements frequently involve man-made structures, as shown by the number of damages that can be observed on the buildings in the villages of Magnasco and Cerisola.

The geomorphological interpretation of these areas is not easy and univocal, as shown by the number of detected landforms and processes. Such a complex situation often led to discordant interpretations given by various Authors who studied this area in the past (i.e. the large covers featuring the entire slope that have alternatively been interpreted as either glacial deposits, landforms related to a periglacial environment or gravity-induced deposits). Similarly, the scarps that can be observed on the northern slope of the Mt. Aiona are still commonly interpreted as cirques, despite the scarce scientific evidences supporting the hypothesis of a glacial landform.

This complexity mainly depends on the peculiar geological and tectonic-structural setting: in this sector, indeed, flysch deposits, ophiolitic and ultramafic masses, associated with heterogeneous breccias and olistolithes, detached from their original site (Ottone Tectonic Unit - External Ligurides), crop out.

The field survey shows that the entire sector features landforms, processes and deposits due to gravity, running waters, structural elements and periglacial processes. These originated large-scale landslide, favoured by geomorphological features of the rock masses, highly fractured and jointed, due to the heterogeneous nature and structural characteristics of the External Ligurides geological formations. It is hypothesised that the entire system ridge-slope-valley is characterized by a deep-seated gravitational slope deformation; several geomorphological evidences have been detected (double ridges, counterslopes, trenches, closed depressions, etc.) involving extensive ridge portions, remobilizing and revising deposits of various origin. Some landform might be related to periglacial processes (wetlands, endoreic depressions, block stream, etc.) points out the typical periglacial morphogenesis characterizing this area.

The investigation procedure followed for this study starts from a preliminary bibliographic and maps research, including both engineering geomorphological scientific notes and land-planning tools; bibliographical data have been integrated by an accurate geological and geomorphological field survey. The photo-interpretation of aerial photographs and the development of digital stereoscopic models preceded the survey.

Geophysical surveys have been carried out to evaluate the thickness of the large landslide and to obtain a preliminary engineering geological model. Further indications for the interpretation of the kinematic mechanism and state of activity of the detected gravitative phenomena have been obtained from the analysis of the satellite-monitoring data PSInSAR™ (Permanent Scatterers), radar interferometric technique.

The obtained results have been included in the applied geomorphological map of the slope bounded by the mounts Penna, Aiona, degli Abeti and the Gramizza stream. This geoenvironmental map, of recognized scientific value, currently represents a useful tool for correct land planning and management, and for risk mitigation purposes.

D2-11 Orale Sacchini, Alessandro

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INTRINSIC VULNERABILITY ASSESSMENT OF KARST AQUIFER IN BRIC TAMPA (M.CARMO UNIT, LIGURIAN ALPS)

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Key terms: Ligurian Alps; Karst aquifer; Intrinsic vulnerability; SINTACS method; Bric Tampa

Karst aquifers are an important and strategic water resource. UNESCO data show that in 1975 about 30% of drinking water available on world scale came from carbonatic massif and that in 2005 this value was about 80%.

Water in karst areas is a fundamental resource for the supplying of many Italian town like Trieste, Roma and L'Aquila. In Ligurian area ground water tables contained in alluvial plain, are over-exploited, so the interest in karst springs, many of them are already utilized from local aqueduct, is increasing.

As is known, karst aquifers are vulnerable to possible sources of pollution. The analysis of problems related to karst areas has been poorly developed because of the complexity that this hydrogeological system presents.

Only in recent years, the attention on karst hydrogeological complex has been growing, for the need to develop researches on new water resources and for the simultaneous need to preserve these delicate ecosystems.

The aim of this research is to assess the intrinsic vulnerability of karst aquifer in Bric Tampa (Ligurian Alps), by applying the SINTACS method, proposed in different studies on the vulnerability of the aquifers.

The SINTACS method utilizes the following seven parameters: depth to ground water, effective infiltration, unsaturated zone attenuation capacity, soil attenuation capacity, hydrogeologic aquifer characteristics, hydraulic conductivity range and hydrological role of the topographic surface.

The application of the SINTACS methodology in a Ligurian environment allows comparison with other national case studies, especially performed in karst massifs of the Ligurian Alps and Triestine Carso; in this way it's possible to obtain both the right calibration of the model and the experimental proposal of modifications and integrations, considering the geological and geomorphological Ligurian peculiarity.

Bric Tampa is one of the 39 karst areas in Liguria and covers an area of approximately 3 km and 6 km of underground development detected. Bric Tampa, belonging to M. Carmo Unit, consists of the Dolomie San Pietro dei Monti and Quarziti di Ponte di Nava Formation.

Structural complex is a anticline recumbent fold, overturned toward N, in it turn warped by a series of transverse folds; as a whole it can be described as a complex antiform dome.

The hydrogeological system consists of a complex underground aquifer karst in dolomitic rock masses and of some karst springs tied with effective infiltration, contributing to the formation of congruent groundwater resources.

The hydrodynamics of the system is characterized by a movement in large ducts: the general system is powered by the secondary infiltration, meaningful and focused in the outcrop areal of dolomitic storage. The latter, based both on several geomorphological indications and on geological structure, is also affected by Quaternary tectonic-gravitational phenomena.

To assess quantitatively the hydrogeological characters of the aquifer, hydraulic conductivity and the type of karst network, a multi-parameter probe for continuous monitoring of the Cave Garbo de Cunche has been installed. This cave spring supplies the municipal aqueduct of Giustenice. The results of flow, conductivity and temperature monitoring, in relation with external rainfall, have allowed the definition of the type of

underground drainage network, that is a dominant drainage type. Research has finally allowed the reconstruction of the catchment area, highlighting the contributions of outside water, including the hidden precipitation that are particularly significant in the Ligurian area.

D2-12 Orale Sacchini, Alessandro

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ENVIRONMENTAL IMPACT OF MASS WASTINGS PROCESSES IN LIGURIAN SCRIVIA VALLEY (NORTHERN APENNINE, ITALY)

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Key terms: Ligurian Apennine; Scrivia Valley; Mass wastings; DSGSDs; Environmental Impact

Environmental and applied geomorphological surveys are getting more and more important especially in land planning and risk assessment. The Upper Scrivia valley lies in the Ligurian Apennine, along the Alps-Apennine junction, characterized by a significant geological and geomorphological complexity associated with its evolution and various processes (gravity, running waters, structural elements and periglacial processes) that have - nowadays and in the past - originated its landforms. Cretaceous shales and marly limestone flyschs outcrop in the valley, characterized by both Alpine and Apenninic deformations. Oligocene conglomerates of the BTP (Tertiary Piedmont Basin) outcrops above these Formations linking Alpine and Apenninic Units. These geological and geomorphological characteristics cause susceptibility to mass movements along the slopes, together with a high annual (till over 2000 mm) and daily rainfall (over 700 mm) amounts measured in some Scrivia valley weather stations. The Scrivia Valley is located on the Apenninic slopes of the Po valley only a few kilometers away from the Ligurian Sea and the regional capital and it is characterized by a general moderate steepness near the watershed. These particular conditions has led to its historic vocation of main liaison between the Po plain and Genoa harbour. In the valley there are also important naturalistic areas, biotopes, SIC (Sites of Community Interest) and geosites in the Regional Natural Park of Mt Antola. A significant presence of large landslides, more than national and regional average, has been mapped. In addition many deep-seated gravitational slope deformations (DSGSDs) are located along the slopes. They are mapped with geomorphological forms like scarps, counterscarps, double ridges, trenches, crestal troughs, closed depression, valley bulging, pseudo or para-karst forms. The DSGSDs distribution is particularly related to the geomorphological conditions of geological contacts between the hard rock Oligocene conglomerates and the Cretaceous flyschs, with prevalent weak behaviour. The distribution of these mass movements is also associated with lithological differences in the Cretaceous flysch and local tectonic and neo-tectonic conditions, above all linked to pliocenic and pleistocenec uplift. The mapped landslides are often distributed along DSGSDs which have an extension higher of more than one order of magnitude. In addition data from drillings and monitoring have allowed to analyse some case studies among large landslides surveyed in the valley. Large landslides and DSGSDs have an important impact on land planning and infrastructures but also directly on the population, as people have always settled there owing to favourable conditions of steepness and agriculture.

D2-13 Orale Toja, Maurizio

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FLOOD 15-16 MARCH 2011 - MAJOR LANDSLIDES THAT HAVE AFFECTED COUNTRIES IN PROVINCE OF ASTI

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Key terms: saturation of soils; landslide; flood

This paper aims to be a deepening of our previous memory "The role of saturation of soils in relation to the mode of initiation of landslides in the Province of Asti in the events of December 2008, April 2009 and March 2011" and focuses on the effects on the ground in consequence of the event of 15-16 March 2011.

This event, in the opinion of the authors, presents some peculiarities that lead to distinguish it from recent events registered in December 2008 and April 2009.

The amount of rainfall during the event was of modest importance (about 100 mm in 24 h) and not to justify the initiation of landslide hazards; moreover, in the previous months, no significant rainfall responsible for prior charge of saturation of the soil were registered.

Nevertheless in the event of March 2011 extensive and deep landslides of rotational, translational and complex dynamic took place, involving some settlements dislocated in the whole Asti Province.

Were analyzed five case histories of landslide that affected the municipalities of concentric Aramengo, Casorzo, Mombaruzzo, Montegrosso d'Asti San Marzano Oliveto.

A detailed study of most representative cases is in progress, this study will be focused on triggering and predisposing causes of the phenomena. In particular the following aspects will be analyze:

- Previous rainfall series;
- Previous temperature excursions;
- Saturation index measured in each site;
- Any anthropogenic interference in steady-related discharges water;
- Local factors.

The analysis of all these aspects will contribute to gaining the necessary elements for a better understanding of the event and of its effects on the territory, also in order to make appropriate interventions for both prediction and prevention of landslides.

D2-14 Orale Valente, Alessio

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SUSTAINABILITY OF WASTE MANAGEMENT IN HILLY LANDSCAPE OF THE EASTERN IRPINIA (CAMPANIA)

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Key terms: ENVIRONMENTAL GEOLOGY; WASTE MANAGEMENT; CAMPANIA

Irpinia is a historical region situated in Campania and coincides largely

with the present province of Avellino. Within this region, the eastern sector is characterized mainly by a hilly landscape that stretches for about 1476 sq. km. Insist on it 40 small towns of the 119 total in the province of Avellino, only five of these exceed 5000 inhabitants. Most of these villages spread between 500 and 700 m above sea level.

The geological connotation of the Eastern Irpinia is the presence of an extensive and articulated plateau incised by an immature hydrographic network, which flows into the Ufita River to the north and in the Ofanto River to the south. This plateau is mainly composed of clay and sandy lithologies, attributable to several terrigenous units variously classified in literature as pre- and post-orogenic as well as to a regressive cycle deposited in an epicontinental sea in the Pliocene. On top of these sediments are the degradation products of Quaternary.

The plateau, located between the outermost thrusts of the Apenninic chain, is the result of Plio-Pleistocene tectonic even if paroxysmal seismic events still alive in the memory of places and peoples, like the earthquake of 23 November 1980. In addition, the modeling by means of rain and washout is the direct cause of extensive erosion which affects the slopes of the hills. No less important is the flooding caused by the local rivers, which are mostly characterized by torrential runoff. Obviously these hazards make precarious settlements and human activities in the area.

The Eastern Irpinia has a distinctive rural identity, although the progressive abandonment of the countryside and the depopulation of the settlements are affecting further development. In the landscape other detractors are the widespread areas of extraction, in some cases with a very strong visual impact. In this context, biodiversity and historical-architectural structures must be protected.

However, these aspects, rather than being a barrier to development, can be seen as an opportunity to protect and enhance the landscape in order to define opportunities for development. Such opportunities arise from the potential in the area that, properly planned with a view to a good policy to mitigate risk and danger, making them less vulnerable to anthropogenic and environmental conditions favoring a proper local land-use in compliance with the obligations Act for areas subject to protection in various ways.

In dealing with the Strategic Environmental Assessment of Waste Management Plan of the Province of Avellino has shown that there are potential problems of the actions of the Plan against the geological environment and landscape, especially of Eastern Irpinia. This despite the fact that these actions indicate both a reduction in the use of the storage of waste, which directly affect the geological environment, is a balanced budget plan is proportional to the production of type and amount of waste per inhabitant, which generally results in localized environmental effects and indirect.

Therefore, these problems result in part from the location of treatment plants in areas or placed next to them (for example, from river areas, geological constraints, vulnerabilities inherent hydrological, ecological corridors, etc.) and partly by the intrinsic fragility of the geological territory that changes in appearance due to the fast erosion particularly effective. The latter aspect determines effects not only at the plant, but also on work of man (roads, infrastructures, etc.) necessary for the management of waste. Finally, in this area some specific geomorphological conditions can lead to severe penalties in case of earthquakes.

D2-15 Poster Brandolini, Pierluigi

10.1474/Epitome.04.0312.Geoitalia2011

THE FLOOD EVENT OF OCTOBER 4, 2010 IN GENOA - SESTRI PONENTE (LIGURIA, ITALY)

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Key terms: rainfall; flood; landslide; environmental risk; Genova, Liguria

The paper describes and analyzes the rainfall event that occurred in the west-central portion of the Ligurian coastal zone on October 4, 2010, with particular regard to the district of Sestri Ponente, in the Municipality of Genoa.

Specifically, attention is focused on the basin of the Chiaravagna stream, which was affected by flooding in its final stretch, and on the basin of the Molinassi stream affected, besides its flooding, by a large number of shallow landslides, debris flows, gully erosions, especially in the upper part of the basin.

Meteorological causes that led to exceptional rainfall intensity and subsequent ground effects have been analyzed and described.

In the Genoa - Sestri Ponente area (where the maximum rainfall intensity occurred) the total cumulated precipitation recorded approximately 400mm in six hours, with peaks of over 120mm/h and 18mm/5min.

These rates are similar to those recorded during previous flood events that have repeatedly affected the central area of Liguria, typically occurring in the transition period between late summer and autumn, such as in October 1970, September 1992 and September 1993.

In response to these heavy precipitations, all rivers in the area of Sestri Ponente flooded, in particular along their final stretches, which are heavily constrained because of intense urbanization over the last half century.

The part of the urban area located in the fluvial-coastal plain has been almost completely affected by flooding, for a total surface of 0.7km², with an average water table height of 0.5 m.

A number of erosional and gravitational processes have mobilized a large amount of detrital material along the drainage network, in particular in the upper part of the Molinassi valley, heavily increasing the solid transport and therefore reducing the stream flow capacity and increasing the effects of floodings.

As a consequence of this rainfall event severe damages have occurred both in the urban area located on the level ground affected by flooding and in the slopes rising just above the built up area, where landslides caused widespread disruption of hill roads and evacuations of houses for reasons of public safety.

D2-16 Poster Diligenti, Antonio

10.1474/Epitome.04.0313.Geoitalia2011

AQUIFER VULNERABILITY ASSESSMENT THROUGH RISK ANALYSIS LABORATION. A CASE STUDY IN THE PESCARA RIVER VALLEY (ABRUZZO-ITALY)

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Key terms: risk analysis; vulnerability; aquifer; contaminated sites; waste sites

We consider the Chieti Scalo industrial compound and farmland area, that is located in the right hand side of the medium-lower portion of the Pescara river valley. The topography characterizing this sector consists of hills and top surface that reach altitudes of 15-250 meters a.s.l.. The observed stratigraphy, consisting essentially of alluvial deposits, reflects the typical succession of the fluvial environment. In particular this succession, starts from below with lower Pleistocene marine silty clays (Mutignano Fm) followed by upper Pleistocene terraced alluvial deposits and holocene conglomerates containing silty and clayey beds and lenses. These deposits have been recently referred to the *Sintema di Valle Majelama* (Late Pleistocene p.p) which is subdivided in the *Chieti Scalo* and *Vallemare Subsintema*.

Considering the large site dimension, over 100 drilling points are utilized to assess the geological and hydrogeological characteristics in addition to the source of chemical contamination, with the aim to obtain a solid conceptual model necessary to evaluate the possible mechanism of groundwater and human risk exposure.

Regarding the hydrogeological features, two main aquifers have been surveyed, which are separated by an aquiclude level with thickness ranging from 0 to 7 meters that is located at depth of 8-10 m. Therefore, two groundwater systems are identified within the aforementioned aquifers, which are called, in the following, *superficial* and *deep*, respectively. In several zones the aquifers are connected, due to stratigraphic (the aquiclude level shows pinch-out closures) and anthropic activities reasons. Anthropic activities have profoundly reworked the deposits so locally the original stratigraphy can not be recognized at all. In fact, the intense extraction which activities essentially concentrated along the holocene alluvial plain and mainly related to the iron-steel and tannery industry on the fluvial terraces, determined zones with elevated critical environments.

The alluvial deposits was removed to a depth reaching in some cases 10 m., causing the replacement in the terraces, containing the *superficial* aquifer, with mixed heterogeneous material and urban-special waste often dip in the groundwater. Taking into account the distinctive impact regarding the groundwater, as demonstrated by contamination (heavy metals, metalloids and chlorinate solvents), we consider the aquifer intrinsic vulnerability valuation through usual weights and points methods not appropriate. For this reason we approached the hydrogeologic-hydrodynamic conditions and the contamination of the groundwater, through the deterministic and probabilistic methods of the Risk assessment. As the valuation of the intrinsic vulnerability, the Risk analysis elaboration, combining several geometric properties of the site with others parameters, such as contamination levels and final receptors.

Since the intense human activities radically changed the original site-specific conditions valuation of vulnerability can be assessed directly through the Risk analysis procedure. The collected site-specific data and the results of the risk analysis are processed in a GIS environment geodatabase through geostatistic and deterministic applications, such as kriging and linear triangulation respectively, realizing maps of groundwater direction, contamination plume extension and map of Risk.

In conclusion, the risk assessment of aquifer contaminated sites is the main tool for defining both the site cleanup goal and the response of aquifer to anthropic pressure supporting environmental decisions.

D2-17 Poster Marsico, Antonella

10.1474/Epitome.04.0314.Geoitalia2011

THE FLOOD RISKS ON THE KARSTIC MURGE HILLS (CENTRAL APULIA, SOUTHERN ITALY)

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Key terms: Murge hills; huge rainfall; land use; flood damages

The Murge plateau is the hilly central part of the thick carbonate Mesozoic sequence of the Apulia platform. Cretaceous carbonate platform deposits are known as "Calcarei delle Murge" Group. The carbonate rocks are overlaid by thin transgressive calcareous and marly-calcareous deposits of Tertiary and Lower Pleistocene known as the "Calcareni di Gravina" Formation. The whole area is characterised by developed karst landforms. The "Murge" karstic area exhibits a well developed drainage-network, formed by a dense dendritic pattern in the headwater zone ("Murge Alte") which evolves into regularly spaced, incised valleys moving towards the coastal area ("Murge Basse"). These channels are locally named "lame", and show subvertical rocky flanks and a flat bottom. The drainage channel system develops mainly along N and NE directions.

In the whole area the agriculture is developed and the growing is mainly cultivated where the soil is thick, such as the bottom of both dolines and drainage channels. Moreover, the socio-economic development of the last 60 years caused the enlargement of towns and of industrial districts with no respect for the environment and hydrogeological features. So, houses, commercial and industrial buildings, roads, railroads and service infrastructures as well as vineyards and cultivated fields are located next or in the "lame".

The occurrence of calamitous meteoric events is unusual in the Murge area since the dry climate: the value of the annual mean rainfall is about 600 mm and events of large intensity occur mainly in autumn season. Usually rainwater rapidly infiltrates, feeding a wide, deep karst aquifer. However very intense rainfalls occur causing emergency states and flood damages, involving people as well as socio-economic property because the use of high flood risk areas.

Historical records report that floods occurred in the city of Bari every 10-20 years until 1926 while recent severe floods took place the night between the 22nd and 23rd of October 2005. Other flooding events happened on the south-western Murge side the 8th September 2003 and in the south-eastern part on 29th September 2003, 21st October 2005 and 20th May 2010.

During each of these events, the great amount of rain fallen in few hours caused a huge water flow that carried away soil, growing, road embankments, bridges, walls and other infrastructures, flooding into private houses and industrial buildings. These events also caused the loss of some human lives swept way by water while travelling on roads.

The occurrence of damages clearly shows either that the flood areas were underestimated and, in general, that a bad territory management has been carried out without taking into account the sustainable development. Several studies were carried out in the last years in order to map flood risk areas to define special planning restrictions and providing

contributions to a better management of the area.

D2-18 Poster Masciocco, Luciano

10.1474/Epitome.04.0315.Geoitalia2011

GEOLOGICAL PROCESSES AND THEIR RELATION WITH HUMAN ACTIVITIES, EXEMPLIFIED IN A HILLY VINEYARD AREA OF CENTRAL PIEMONTE (PROGEOPIEMONTE PROJECT - GEOTHEMATIC AREA 4)

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Key terms: Geological heritage; Piemonte; Vineyard; Geosite; Hills territory

The multidisciplinary research project "PROGEOPIEMONTE" aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region by means of the development of techniques for recognizing and managing its rich geodiversity at the local and regional scale. After a systematic review of inventoried geosites, 9 strategic geothematic areas will be investigated to represent the geodiversity of Piemonte, each characterized by high potential for scientific studies, enhancement of public understanding of science, recreation activities and for economic support to local communities. Geological history, climate and environmental changes, natural hazards, soil processes and georesources will be popularized not only with geosites but also with museum collections, evidences of mining activity and quarrying, science exhibits and nature trails. The recognition of the economic value of geodiversity will lead to the production of regional guidelines for Geoconservation integrated quality management system, suitable for tourism and sustainable development strategies. An international advisory board will evaluate yearly project advancements, proposed strategies and products.

The fourth geothematic area of PROGEOPIEMONTE PROJECT is represented by a hilly vineyard area of central Piedmont.

Starting from their evolution in the last period of the geologic history, the hilly territories of Central Piedmont (according to many Authors, the structural limit between the Alpine and Apennine chains) will be analyzed with regards to their geo-resources (soil and climate for vineyards, mineral water springs and mines) and geo-hazards (erosion, shallow and deep landslides).

Five research activities have been developed in the study hilly area.

° In the Torrente Traversola Deformation Zone, the origin and evolution of deformation zone in the western area of the Asti Reliefs have been studied leading to geological mapping and reconstruction of the structural evolution.

° The complex Geosite of Passerano Marmorito, a tectonic cross road in Monferrato recording past methane-rich fluid emissions, has been defined investigating the origin and the reciprocal genetic relationships of different methane-derived rocks such as fossil-rich Lucina limestones, and fossil-free cemented clastic sediments documenting seeping at the sea floor and in the subsurface respectively.

° A cultural and geological heritage of the Monferrato hills like the gypsum quarries and the Upper Pleistocene fossil deposits has been investigated in Moncucco, Castelnuovo Don Bosco and Murisengo sites improving the geological knowledge of the gypsum ore bodies and the valorization of the local traditional activity of the gypsum exploitation.

° The Bardella mineral spring of Castelnuovo Don Bosco has been characterized from both hydrogeological and hydrogeochemical point of view.

° At last, climatic and pedologic analyses, as well as the assessment of geomorphological hazard linked to accelerated erosion and landslides have been realized in the Freisa d'Asti terroir, comprising the territories of Castelnuovo Don Bosco, Pino d'Asti, Moncucco and Albugnano, and representing one of the nine areas proposed for inscription in the list of UNESCO world heritage sites.

Geodiffusion actions contemplate geological routes in the hilly area to show key outcrops equipped with illustrative panels. More detailed information could be available in the tourist centers of the principal villages.

The field itineraries should be of interest not only for a large public interested in improving the geological knowledge but also for specialists wishing to visit key outcrops with comparison purposes.

SESSIONE D3

Metalli pesanti nell'ambiente: sorgenti, rilascio, trasporto, immobilizzazione, trasferimento alla biosfera

D3-1 Key Lecture De Giudici, Giovanni

10.1474/Epitome.04.0316.Geoitalia2011

ZINC BIOMINERALIZATION PROCESSES AT INGURTOSU MINE (SW SARDINIA)

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Key terms: heavy metal; biomineralization; environmnet; mine; tailings

The Ingurtosu Pb-Zn mine (S-W Sardinia) was exploited for about a century until 1968. Huge amounts of tailings were abandoned, resulting in long-term heavy metal dispersion processes in both stream sediments and waters. Zn and Pb concentration in tailings and stream sediments attains values up to thousands of mg per kilogram. The maximum Zn concentration in water attains several hundreds of mg per liter, whereas Cd and Pb concentrations are in the order of thousands of µg per liter. Heavy metal concentration in waters of Rio Naracauli, the main stream of the area, is abated by seasonal biomineralization processes. Precipitation of hydrozincite [Zn₅(CO₃)₂(OH)₆] and of a Zn-rich amorphous phase results in a decrease of Zn concentration down to a few mg per liter. Other metals such as Pb, Cd, Cu, and Ni are coprecipitated with the Zn

phases. TEM analysis of hydrozincite has shown that nanocrystals that are approximately 3 nm long aggregate by an imperfectly oriented aggregation mechanism (De Giudici et al. 2009). This results in the formation of mesocrystals. These are hydrozincite platelets flattened onto the (100) crystal face that were observed by SEM. Hydrozincite globules are made by a further aggregation of these micrometric platelets. SEM images of hydrozincite show that both shape and size of globules are apparently influenced by environmental conditions (namely sunlight, rainfall, runoff, stationary hydraulic conditions; Medas et al. 2011). The cell parameters of Naracauli hydrozincite are all similar, and slightly different with respect to the published structures, possibly suggesting a different stacking order along *ao*.

The nature of binding of Cd and Pb to hydrozincite was investigated by X-ray absorption spectroscopy (XAS). For Cd, the results of extended X-ray absorption fine structure (EXAFS) analysis, backed by anomalous X-ray diffraction, suggest a disordered mode of occurrence, presumably as an amorphous surface precipitate (Lattanzi et al. 2010b), while for Pb a more complex model is suggested (Lattanzi et al. 2010a): this metal is supposed to occur partly as an amorphous surface carbonate, partly either as a substituting ion in the tetrahedral Zn site of the hydrozincite structure, or as an inner-sphere surface complex. Microscopic and spectroscopic investigation on the Naracauli zinc silicate are undergoing. Acknowledgements. This paper was funded by EU grant 226870 UMBRELLA (coordinator Erika Kothe, University of Jena).

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D3-2 Orale Cidu, Rosa

10.1474/Epitome.04.0317.Geoitalia2011

SEASONAL VARIABILITY OF HARMFUL COMPONENTS IN DIFFERENT AQUEOUS FRACTIONS IN NATURAL WATERS

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Key terms: HYDROGEOCHEMISTRY; FILTRATION; NITRATE; SEASONAL VARIABILITY; HARMFUL ELEMENTS

The distribution of aqueous components, including toxic and harmful elements, in different aqueous fractions can be investigated via their determination in non filtered and filtered water samples. Concentrations determined in non filtered samples can be roughly regarded as total amounts. Filtration through 0.45 µm pore-size filters is conventionally used to remove the matter in suspension, thus concentrations determined in the water fraction <0.45 µm might be regarded as 'dissolved amounts'. However, in this fraction the aqueous components may occur either as 'truly dissolved' species or hosted in fine particles of <0.45 µm size, such as clay and colloidal materials.

Results of hydrogeochemical surveys carried out in Sardinia (Italy) showed significant differences in concentrations of specific components when water was sampled under different seasonal conditions, and analyses were carried out in different aqueous fractions (non filtered samples, aliquots filtered through 0.45 µm and 0.15 µm pore-size filters).

Concentrations of nitrate in surface water and groundwater did not significantly change when determined in different aqueous fractions (unfiltered and filtered aliquots), indicating that nitrate occurs as truly dissolved species. However, nitrate concentration in river and stream waters sampled under high flow condition was higher than that in water collected under low flow condition.

Variations in the dissolved amount of trace elements appeared to depend on the composition of rocks drained, and the occurrence of mineral deposits. Concentrations in river and stream waters were also dependent on hydrological conditions, such as runoff, flow and turbulence. Specific trace elements showed distinguished trends.

The elements B, Li, Rb, Sr, Ba, As, Sb, Mo, and U in the studied waters showed small differences in concentrations determined either in non filtered or filtered water samples. Their concentrations were often positively correlated with total dissolved solids (TDS) and/or major ions. Dissolved concentrations in surface waters were higher in summer, when the contribution of rainwater to the rivers was minimum. These elements occurred as truly dissolved species (either as free ions or aqueous complexes), which concentrations appeared related to the intensity of water-rock interaction processes.

The elements Al, Fe, Pb, Zn, Cd, Co, Ni, Cs, Y, REE and Th were not related to TDS and/or major ions; they showed higher concentrations under high flow conditions; marked differences occurred between total and dissolved amounts; concentrations in the water filtered through 0.015

µm were much lower than in the water filtered through 0.4 µm, especially when sampling was carried out after storm events that enhanced the load of solid matter in the water. These observations indicate an aqueous transport of these elements mainly via sorption processes on very fine particles.

Considering that seasonal variability in concentrations of harmful components may affect the water quality, results from this study can be useful to understand the human health and aquatic life risk exposure to potential contaminants.

D3-3 Orale Frau, Franco

10.1474/Epitome.04.0318.Geoitalia2011

DIEL CYCLES OF DISSOLVED ZINC AND ARSENIC IN THE BACCU LOCCI STREAM (SARDINIA, ITALY) AFFECTED BY PAST MINING

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Key terms: Diel cycle; Trace elements; Sorption; Baccu Locci mine; Sardinia

Short-term changes in water chemistry, and especially in dissolved trace element concentrations, associated with diel cycles during base-flow conditions at a specific sampling station in the Bacchu Locci stream draining the homonymous old mine area in Sardinia (Italy) were investigated. Diel fluctuations in pH and alkalinity were correlated with the temperature-dependent CO_2 solubility and the biological-induced CO_2 production, both of which were higher during the night. Adsorption/desorption to/from streambed material, in particular ferrihydrite, is believed to be the main in-stream mechanism causing the observed diel variations in dissolved concentrations of As and Zn. Arsenic was mainly affected by the dual action of temperature and competing carbonate ions, whereas pH seemed less important. Temperature acted in accordance with the exothermic feature of anion sorption onto hydrous metal oxide surfaces; aqueous carbonate species exerted their competitive effect in relation to alkalinity variation. Zinc was primarily affected by temperature, in accordance with the endothermic feature of metal cation sorption onto hydrous metal oxide surfaces, and secondly by pH. Co-precipitation of As and Zn with calcite is another possible mechanism that, to be better investigated, would require a further finalized examination of inorganic and biological materials coating the streambed. All these processes potentially controlling the diel cycles of trace elements should be carefully considered to assess the effectiveness of remediation actions currently in progress at Bacchu Locci.

D3-4 Orale Frau, Franco

10.1474/Epitome.04.0319.Geoitalia2011

GENERATION OF ACID MINE DRAINAGE FROM DISSOLUTION OF SECONDARY METAL SULFATES: THE CASE OF MELANTERITE

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Key terms: Melanterite; Dissolution; Acidity; Modeling

Oxidation of metal sulfides, in particular pyrite, by oxygen or Fe(III) is considered the main process generating AMD (Acid Mine Drainage). However, secondary minerals from sulfide oxidation can significantly contribute to AMD generation. Secondary metal sulfates are common phases in sulfide ore mines and their formation-dissolution cycle is often influenced by climatic conditions. Melanterite, the heptahydrated ferrous sulfate, is one of the most diffuse oxidation products of pyrite. Moreover, its presence has been recently hypothesized in the evaporites on the surface of Mars. Field observations in mine sites show that melanterite is associated with acidic waters and laboratory experiments confirm this finding. However, simple dissolution of melanterite, without oxidation of Fe(II) to Fe(III), cannot generate AMD because the hydrolysis of Fe(II) is not able to significantly lower the water pH. Both commercial and natural melanterites always contain small amounts of Fe(III), probably as a ferric sulfate of some sort. Modeling of laboratory batch experiments with PHREEQC has shown that Fe(III) concentrations in melanterite in the range of 0.16-0.20 wt. % are sufficient to significantly lower the pH of very dilute interacting waters as a consequence of Fe(III) hydrolysis. Since melanterite is very soluble, its rapid acid-generating dissolution can occur without invoking oxidation of Fe(II) to Fe(III) that is slow under acidic conditions, as well as without involving the acidity-generating precipitation of a Fe(III) phase. In the field, the rapid dissolution of Fe(III)-bearing melanterite by rain water may thus generate AMD and also provide a supply of Fe(III) for subsequent sulfide oxidation. These results should be taken into account when evaluating the origin of AMD in mine sites in order to prevent its impact on the environment and plan its treatment.

D3-5 Orale Dinelli, Enrico

10.1474/Epitome.04.0320.Geoitalia2011

ENVIRONMENTAL GEOCHEMISTRY OF AN ACTIVE MINING AREA: THE HUANUNI BASIN (BOLIVIA)

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Key terms: acid mine drainage; sequential extraction; bolivia; water; sediment

Mining activities, concentrated on cassiterite exploitation, developed in the Huanuni basin are operating without any responsibility for the environment and the population living in the catchment. The area, with a population over 50,000 inhabitants approx. is located in the Oruro department, Bolivia. Active mining operations discharge liquid and solid wastes without any treatment directly into various rivers. A detailed study on the geochemistry of water, bedload sediment and suspended material has been carried out in the area to evaluate the degree of pollution in the area, better constrained by the application of a sequential extraction analysis on selected bedload and suspended sediments. Samples were collected around three active mines in the Huanuni basin following the occurrence of Acid Mine Drainage in the area. Electrical Conductivity, temperature, pH, were measured directly in the field, filtered and acidified and unacidified water samples were collected for the analysis of major and trace elements and the anionic composition. The fraction < 63µm of the bedload sediment, directly sieved in the field, and in selected sites the suspended sediment were collected and analysed for total metal content by XRF. Their bulk mineralogical composition has been determined by XRD. To selected samples, a 3-step plus aqua regia sequential extraction procedure has been applied in order to constrain metal distribution within the sediment.

Surface water show strong acidic conditions (pH 2.9-4.5) in several sites, with high SO_4^{2-} concentrations (up to 2400 mg/L), and high metal contents (580 mg/L Fe, 141 mg/L Zn 82 mg/L Al, 6000 µg/L Cd, 5650 µg/L Cu, 2600 µg/L Pb, 1440 µg/L Co, 540 µg/L U, 24 µg/L Ti), generally decreasing downstream from the active mine areas. Their distribution is however different between the mines impacting the catchment and can be used as traces of the source area.

The bedload sediment chemical composition is characterized by high concentrations of Cu, Zn, Pb, but also Sn, As reach high values. Concentrations of Cd, Co, Cu, Cr and Zn are higher in suspended sediments. In general a decrease in sediment concentrations is observed downstream from the active mines, and also for bedload sediments differences can be outlined among the different mines. The results of the

sequential extraction point out differences in metal distribution: in the most polluted sites Cd, Co, Cu and Zn are associated preferentially to an oxidizable fraction and it is important to note that in the suspended sediments the proportion associated to the exchangeable fraction is higher. A completely different distribution is displayed for example by Arsenic or Pb, which are almost completely associated to the residual fraction.

The study shows the hazard of the suspended sediment release in the river system and the possibility to reduce the contamination removing the disposal of the liquid waste. Sequential extraction data suggest that care must be taken for the different geochemical behaviour of critical elements.

D3-6 Orale Rimondi, Valentina

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MERCURY DISTRIBUTION AND TRANSPORT IN THE ECOSYSTEM OF PAGLIA RIVER (MONTE AMIATA, ITALY)

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Key terms: Environmental pollution; Mercury; Methyl-mercury; Monte Amiata; Stream sediment

Mercury (Hg) is a heavy metal of environmental concern as it is highly toxic to living organisms. The most toxic Hg compound is methyl-mercury (MeHg), which is a neurotoxin that biomagnifies in the food chain. Of particular concern around Hg mines is the conversion of inorganic Hg (e.g., cinnabar and elemental Hg) to MeHg, which is primarily by the action of bacteria in the sediment column. Fish accumulate MeHg, thus, representing the dominant pathway of Hg to humans who consume fish. As a result of historical exploitation of Hg deposits worldwide, downstream ecosystems are potentially contaminated by Hg and MeHg, both in abiotic and in biotic compartments. The Monte Amiata Hg district, located in Southern Tuscany, represents one of the world's largest Hg deposits. About 102,000 t of Hg were produced between 1850s-1980s, ranking it as the 4th largest Hg district worldwide. Mine waste calcine deposits, resulting from Hg ore roasting to extract Hg, are located proximal to the abandoned Hg mines, thus, representing the dominant source of Hg to the surrounding environment in this area. The Paglia River drains the east side of Monte Amiata, which hosts the largest Hg mine of the Tuscan district, the Abbadia San Salvatore mine (ASSM). Detailed studies of Hg transport in the Paglia River ecosystem and of Hg speciation are lacking. Therefore, the main objectives of this study are to evaluate: 1) the transport and distribution of Hg in the Paglia River ecosystem, 2) the formation of MeHg in the downstream environment, and 3) Hg concentrations in local freshwater fish.

Samples of stream sediment and water were collected from the Paglia River both upstream and downstream the Hg mines. In addition, calcine samples were collected from mine wastes located in and around ASSM. Regional baseline concentrations of Hg were established by stream sediment and water samples collected distal from the ASSM. Concentrations of Hg in stream sediment samples range from 0.10 to

14 µg/g, whereas Hg in water ranges from 3.2 to 1360 ng/l. Elevated Hg concentrations in stream sediment are found downstream from the ASSM

at a distance of 5 and 20 km (14 and 10 µg/g, respectively). Significantly

lower Hg concentrations (0.35-0.79 µg/g) were found in stream sediment collected 7.5-12 km from the ASSM. A similar trend is shown in stream water, with the highest Hg concentration (1,350 ng/l) found at a distance of 5 km from the ASSM. Mine waste calcine samples contain elevated

concentrations of Hg (up to 1,500 µg/g).

Concentrations of MeHg range from 0.04 to 6.4 ng/g in stream sediment and from 0.10 to 3.0 ng/l in water samples. Concentrations of MeHg as high as 22 ng/g were found in calcine samples. The ratio of MeHg/Hg is higher in stream sediment (0.01-0.44%) as compared to that in calcine (0.00-0.02%), but was found to be highest in stream water (up to 9.1%). Historical mining of the ASSM has affected the surrounding Paglia River ecosystem, where concentrations of Hg and MeHg are elevated above baselines both in stream sediment and stream water. More than 40% of

the stream sediment samples exceed the 1.06 µg/g Probable Effect Concentration (PEC) for Hg, the concentration above which harmful effects are likely in sediment-dwelling organisms. However, only one stream water sample contained a Hg concentration exceeding the 770 ng/l limit established by the USEPA to protect against chronic effects to aquatic wildlife. The presence of significant concentrations of MeHg in sediment and water of the Paglia River ecosystem suggests methylation of Hg in the sediment column, which is then transferred to water and eventually to biota, such as fish. Most important are Hg concentrations in fish muscle as generally greater than 90% of Hg in fish is MeHg. Studies of Hg in fish are in progress to evaluate any adverse effects of Hg to fish as a result of Hg runoff from the ASSM.

D3-7 Orale Lucci, Federico

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LOCAL TECTONIC CONTROL ON HYDROLOGICAL PATTERNS: A KEY TO UNDERSTAND THE AS-SB CONTAMINATION IN THE ABANDONED TAFONE MINE AREA

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Key terms: As-Sb contamination; Tafone mine; Quaternary Tectonic; Hydrography; Environment

Southern Tuscany "Colline Metallifere" are one of the principal epithermal district of Italy: carbonate rocks hosting mineralizations occur at the edges of major epithermal fields as Larderello, Mt. Amiata and Latera district. Mineralizations are typically localized at the contact between carbonate rocks (mainly "Calcare Cavernoso" Fm.) and the overlying flyschoids units ("Ligurides and Sub-Ligurides" AUCT.) or "Macigno" sandstones. Stibnite (Sb carrier) and pyrite (As carrier) are the most common sulfide epithermal minerals: here mining activity is historically

dated back at least to Etruscan times [1]. The "Colline Metallifere" epithermal district is co-genetic to Neogene magmatism (Tuscan and Roman provinces) emplaced during the last phase (late Miocene till now) of the Apennine extensional regime: genesis of NW-SE trending grabens filled by late Miocene-Pliocene sediments lastly faulted by Plio-Pleistocene NW-SE direct and NE-SW strike-slip systems [2]. Tafone mine represents an important area (a NW-SE graben less than 7 km length and up to 2 km large) to evaluate the impact of As and Sb contaminations. The stibnite and pyrite mine is located on the southwestern flank (Monte Maggiore) of the Tafone Graben (TG), near the "Fosso del Tafone" (FdT). The mineralization system outcrops at the intersection of the southern NW-SE extensional system of TG, with one NE-SW trending strike-slip segment. Mineralizations are hosted in Triassic dolostone and in Calcare Cavernoso Fm. overlying the paleozoic metamorphic phyllades and partially overthrust by dark shales and calcarenites (Ligurian units). FdT flows, from NW to SE, on the southwestern flank of the TG along the extensional lineament. Tributaries are, instead, distributed perpendicularly to the FdT, and evolved over NE-SW strike-slip minor tectonic discontinuities. Our focus is the presentation of a comprehensive dataset of As-Sb contaminations in the area along FdT, and their spatial correlation with local tectonic settings i.e. tributaries distribution. It has been observed a strong variability of As-Sb contents in waters (As: 1-20 microgrammi/L; Sb: 0.9-119 microgrammi/L), in stream sediments (As: 23-3060 mg/kg; Sb: 16-1360 mg/kg) and in soils (As: 61-1360 mg/kg; Sb: 23-5140 mg/kg) with maximum concentration of As in stream sediments and Sb in soils [3]. The peculiarity of the study area is represented by a discontinuous distribution of As-Sb along FdT: for example in the mining zone (i.e. the expected most contaminated area), it is possible to observe an anomalous strong downfall of the As-Sb contamination due to the confluence with northern side tributary "Fosso del Molinaccio". We focus on dilution, by a local tectonic controlled hydrographic pattern, of the As-Sb concentrations along the FdT. Accumulation of toxic elements as As and Sb represents a serious hazard for both environment and human health. Considering the wide extension of Tuscan epithermal district and the large population living in the area, the understanding of the geological factors controlling the spreading of toxic elements in the environmental system is highly relevant.

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D3-8 Orale Naitza, Stefano

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ANTIMONY CONTAMINATION FROM MINING AND METALLURGICAL WASTE DEPOSITS IN THE VILLASALTO OLD MINE AREA (SE SARDINIA, ITALY).

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Key terms: Old mine; Waste deposits; Antimony contamination

The historical mine and smelter of Villasalto-Su Suergiu (SE Sardinia) operated from 1882 to 1981, being the largest industrial complex in Italy for antimony ore extraction and metallurgy. The site is characterized by the presence of several mining and metallurgical waste deposits. Environmental surveys and studies performed from 2006 by IGEA S.p.A and DIGITA evidenced, over an area >6km² downstream of the old mine, that soils, stream sediments and waters are affected by serious Sb and As contamination and by the presence of high levels of toxic metals (Zn, Pb, Cu, W). Sb contamination, in particular, attains several orders of magnitude beyond the limits of Italian and EU regulations. The Su Suergiu mine exploited quartz-calcite-sulfide-scheelite veins and lenses, hosted by cataclastic Silurian-Devonian carbonaceous black shales and limestones. The ore included stibnite (main economic mineral), scheelite, arsenopyrite and Zn-Pb-Cu sulfides. The smelter produced metallic Sb and various Sb oxides and sulfides. Mining and metallurgical waste dumps are the most relevant centers of pollution in the area. Three kinds of wastes have been identified: a) mining wastes - 13 heaps of waste rocks (about 130.000 m³ in total); b) metallurgical wastes - 1 large heap of various pyrometallurgical residues (about 50.000 m³); c) mixed wastes - 2 heaps of mixed mining and metallurgical residues (about 70.000 m³). The solid transport downstream has been considerable over the years; about 20000 m³ of waste residuals have been assessed along two watercourses that cross the area. In Su Suergiu area, seepage waters show Sb and As contents up to 32 mg/l and 3,8 mg/l respectively; mine drainage waters show up to 2,6 mg/l Sb and 0,1 mg/l As. The influence of Su Suergiu polluting centers extends well away from the mine; up to 8,8 mg/l Sb have been determined in stream waters at the confluence with the Flumendosa river, 4,5 km far from Su Suergiu. The metallurgical residues show the most relevant contaminating potential. They include 7 different types of slags, casting residuals, metallurgical dusts that have been characterized by ICP-OES, ICP-MS, AAS, XRPD, SEM-EDS; contamination potential has been determined by leaching tests (DLgs 152/06). Vacuolar coarse-grained slags are the most abundant metallurgical residues. They are constituted of gangue and ore minerals remnants in a glassy matrix rich in Ca-Al-silicates, with Fe (Zn, Cu) sulfides and oxides, metallic Sb, Sb oxides. Sb contents are up to 2,7 wt%. Eluates from standard leaching tests evidenced up to 107 mg/l Sb. Metallurgical dusts are prevailing fine-grained materials consisting of quartz, Na-Al hydrated silicates, Na-Sb hydroxides (mopungite, NaSb(OH)₆), Sb oxides (sernamontite, cervantite), Fe hydroxides. XRPD analyses evidenced the presence of amorphous matter. Although not abundant (<10000 m³), dusts have high metalloids and toxic metals contents (6-8 wt% Sb; 0,8-1,3 wt% Zn), associated to soluble Sb phases, like mopungite. Eluates from dust leaching tests show very high Sb contents (120 -150 mg/l Sb), and are distinctly alkaline (pH 10,4 - 10,8). The contaminating potential of metallurgical wastes is therefore related to high Sb availability and is controlled by an alkaline environment that enhance Sb mobility. A new research program on these issues, funded by Sardinia Regional Administration (L.R. 7/07), is currently under way, carried on by a DIGITA and IGAG-CNR work group with the collaboration of IGEA S.p.A. The program includes a further sampling of waste deposits, particle size analyses in order to define the distribution of the contaminants in the different size classes, leaching tests, studies on Sb speciation. Moreover a laboratory investigation will be carried out on mining and metallurgical residues, and on mine and seepage waters, aimed at eliminating or

stabilizing the toxic elements in order to reduce their migration to the surrounding areas, applying different techniques.

D3-9 Orale Petrini, Elisa

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ARSENIC CONTAMINATION IN "CERRO TUZGLE ACTIVE VOLCANIC FIELD" (NORTHERN ANDES, JUJUY PROVINCE, ARGENTINA)

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Key terms: arsenic; cerro Tuzgle volcano; NW Argentina; contamination; environment

Arsenic, a toxic element with metalloidal properties, is almost often present in environmental samples, especially in volcanic area. Its accumulation in environment has been found to be hazardous to both the ecosystem and human health.

Unfortunately arsenic is extremely common in numerous areas from NW Argentina and in particular in volcanic areas of Puna (Jujuy Province). Concha et al. (2006) pointed to the As content in Puna waters ranging

from 140 to 220 µg/L. In particular, in shallow and drinking waters the As concentration ranges from 40-10100 and 10-790 µg/L, respectively,

reaching values up to 12800 µg/L at thermal springs. Clearly this represents a serious hazard for the population, demonstrated by numerous signs of poisoning as: dermal lesions, peripheral vascular disorder and other internal injuries, that could lead to premature death. The focus of this study is to highlight, in a natural laboratory such as an active volcanic field, the links between As contamination and the geological setting.

Cerro Tuzgle (5486 m.a.s.l.) represents an HK-calcalkaline stratovolcano surrounded by small shoshonitic centers, dated back to late Miocene to present as confirmed by numerous active thermal springs. These eruptives are distributed along the eastern edge of Puna Plateau, following a N-S trend similar to regional thrusts [2]. The Tuzgle volcano and minor centres emplaced at intersection of N-S elements with left-lateral segments of transpressive "El Toro" system, thus remarking that volcanism derived from magma uprising, facilitated by the brittle failure of the Puna back-arc crust [2]. N-S distribution of basement superunits (Ordovician sediments and Faja Eruptiva; Tertiary-Quaternary clastics and evaporites) outlines the importance of inherited tectonic lineaments in the area. Tuzgle volcanic field produced an alternation of effusive flows (andesitic and shoshonitic, to dacitic-rhyodacitic) and explosive pyroclastites (rhyolites), as recognized by field and fabric analyses [2]. Hot hydrothermal springs and fumaroles are distributed along local tectonic discontinuities; furthermore also hydrographic pattern seems to be strongly related to the local faults distribution: the two major N-S rivers are Rio de Agua Castilla and Rio de Agua Caliente and along them are settled the three major villages of the area: Puesto Sey, Pastos Chicos and Huanacar. In order to map arsenic concentration and understand its relationship with geological framework, different kinds of samples were collected: rocks, soils, stream sediments and waters. Thin sections and XRD analyses indicate that all samples are mainly constituted by the same mineral assemblage: quartz, micas (Bt+Ms), feldspars (Sa+Pl) and accessories (Di-Aug+Kat-Hbl±Fo±Sp) pointing to genetic link between recent volcanics and soil-sediment system. Thermal analyses show presence of organic matter in lasts. Contamination has been finally measured on volcanic rock, soil, stream sediment and water samples evidencing a very high concentrations of As, in the ranges

2-4150, 28-890, 11-625 mg/kg and 11-12880 µg/L, respectively pointing to maximum values reached in rocks (source?) and water (carrier?). Informations on potential As mobility, have been obtained applying standard sequential extraction BCR procedure on soil and sediment samples. Results demonstrate that As is weakly bounded to matrix host and can easily mobilized becoming environmental-bioavailable. Mineralogical analyses highlight the common origin of sediments and soils from the recent volcanics, and point to water as main carrier of As. If the volcanic system could represent the As-reservoir, the tectonic of the area seem to be the controlling factor on As distribution, since thermal springs and rivers follow the brittle failure pattern of the area.

[1] Concha et al. (2006) - J.Health.Popul.Nutr. 24-3, pp 317-326

[2] Coira and Kay (1993) - Contrib.Min.Pet. 113, pp 40-58

D3-10 Orale Sappa, Giuseppe

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NEW METHODOLOGIES FOR THE DEFINITION OF SOME HEAVY METALS ORIGIN IN SEDIMENTS: A CASE HISTORY COMING FROM AN APPLICATION IN PONTINA PLAIN

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Key terms: Background; geochemical; sediments; As; metals

Metal elements like Cr, V, Pb, Ti, U, As are often present with high concentration in soils and one of the most frequent problem coming out in environmental applied geology is to set up if this concentration is referred to the background of the soils, or it is due to anthropogenic activity, as in many cases it is requested to dig and move the soil in the aim of build a new work. In this framework a correct geochemical characterization of soil outcropping in the work area, is needed to better understand the actual nature of this elements concentration. The natural chemical composition of soils depends on the mineralogical structure of rocks they come from and on the weathering processes these rocks have been subjected in the geological time.

As a matter of fact to establish the real health state of a soil and its potential contamination state it's very important to set up the background values of some heavy metal elements present in it. These background values can be reached by different methodologies, most of them are based on statistical elaboration of data referred to chemical composition of the soil under study. In the last years it has been outlined, on the other hand, the importance of the application of geochemical parameters to

understand the actual origin of these elements in the soils. In the case history under study, referred to a site placed in Pontina Plain, in the South Latium Region, where sedimentary deposit coming from the weathering of volcanic rocks, it has been set up the geological and hydrogeological framework of the area, in the aim of investigating the origin of the natural presence of some elements. Then, it has been made the granulometric analysis to set up their geometric distribution and separate the fraction minor than 2 mm, which has been used in the chemical analysis as it is asked by the Italian law. Chemical analyses have been carried on for the determination of the concentration of Cr, V, Pb, Ti, U, As and the other major elements which are the most important constituents of sediments, outcropping in this area. Geochemical analyses results have been, then, elaborated by statistical methods following the Italian guidelines, released by ISPRA, referring to the definition of groundwater and soil background values definition. The background values output by the statistical elaboration, have been compared by the results come out by the application of geochemical methods for the definition of the health state of the soil. These methods employ two different parameters the Igeo, (Müller, 1979; Förstner & Müller, 1981) which an accumulation index of metals in the soil and the EF, Enrichment Factor (Muller, 1969; Forstner e Muller, 1973). These two parameters, to be calculated, need the values metal concentration of in samples coming from the top-soil (20-30 cm under the topographic level) and from the sub-soil (at least 90-100 cm under the topographic level). The two different depth of sampling the soil are needed in the aim of analyzing also soils which are certainly not affected by anthropogenic activity. The comparison of results, reached by different methods to set up the background values of some metals in the soil, is discussed in this paper, to highlight as the application of geochemical methods can give more effective indications on the actual health state of the soil, and on the possible anthropogenic impact, as they can better represent the real history of the sediments, and the geological, geochemical and pedological processes involved in their composition.

D3-11 Orale Cosenza, Antonio

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THE GEOGENIC NATURE OF SOME HARMFUL ELEMENT ANOMALIES IN THE CENTRAL SECTOR OF THE PELORITANI MOUNTAINS (SICILY, ITALY)

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Key terms: Southern Sector of the Calabria-Peloritani Arc; Peloritani Mountains; Topsoil samples; Geochemical maps; Ratios of lead isotopes

In the Southern Sector of the Calabria-Peloritani Arc, the Peloritani Mountains extend in the NE Sicily. They consist of a stack of nine continental crust tectonic units, involving Pan-African and Variscan crystalline basements, and remnants of Meso-Cenozoic sedimentary covers. Basements and covers are locally affected by an Alpine overprint. Geometrically to the bottom and geographically to the south, the Units are: Aspromonte, Mela, Piraino, Mandanici, Ali, Fondachelli, San Marco d'Alunzio, Longi-Taormina, Capo Sant'Andrea. The Pan-African basement (Aspromonte Unit) derives from a Proterozoic plutonic and metamorphic low crust, the Variscan basements (other units) from Paleozoic sedimentary-volcanic sequences.

Sulphide and sulphosal mineralizations are very widespread in the study area.

Topsoil samples (n=122) have been collected over an area of 300 sqkm in the Central Peloritani Mts., from the Ali to the Bafia Villages, and the concentrations of 53 elements, including potentially harmful metals, have been determined by means of ICP-MS after an aqua regia acidification. Concentration data have been georeferenced and geochemical maps have been produced by means of a GIS aided spatial interpolation process. In accordance with a regional study carried out by De Vivo et al. (1999), on 1198 stream sediments, collected across the Peloritani Mts. area, results obtained by the present study show that higher values of Pb, As, Zn, Cu and Sb are mostly concentrated in a spatially limited area between the Fiumedinisi and Ali Villages.

As a matter of the fact, Pb shows anomalous concentration values in correspondence with both C. Postlioni (Mandanici) (>1600 mg/kg) and Fiumara di Ali (>400 mg/kg). As presents values of concentrations higher than 700 mg/kg between Fiumedinisi area and Ali and Cd is 8 mg/kg in correspondence with the Fiumara di Fiumedinisi. Concentrations of Pb, As and Cd often exceed the trigger and action limits established by the Italian environmental law (D. Lgs. 152/06) for both a residential and an industrial/commercial land use.

To discriminate between an anthropic and a geological origin of harmful elements (mostly metals), in the soils of the central sector of Peloritani Mts. the ratios of ²⁰⁶Pb/²⁰⁷Pb versus ²⁰⁸Pb/²⁰⁷Pb isotopes both in local galena and soil samples have been determined. The isotopic ratios of Pb have been obtained at USGS (United States Geological Survey) in Reston (VA, USA) by means of mass spectrometry after a step-leaching procedure producing a leachate and a residue fraction of each soil sample. Results show that the leached fraction of soil samples with more 1600 mg/kg of Pb (C. Postlioni, Mandanici) has ratio ²⁰⁶Pb/²⁰⁷Pb=1.169539 and ²⁰⁸Pb/²⁰⁷Pb=2.460557 which indicates that contamination of soils collected in the area between the Mandanici area and Ali Village are geogenic and mostly related to the presence of sulphide and sulphosal minerals.

A factor score analysis was also ran on the dataset and results obtained show that the Ag, As, Sb, Pb, Cd, Zn, Hg, Ni can be associated in a unique factor since they clearly marks the areas where old mines were present: San Carlo, Vacco, Magliuso, inside the Fiumedinisi territory, and Tripi, inside the Ali territory.

D3-12 Orale Petruzzelli, Gianniantonio

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BIOAVAILABILITY AT HEAVY METAL CONTAMINATED SITES: FROM CONCEPTUAL MODEL TO REMEDIATION

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Key terms: bioavailability; contaminated sites; conceptual model; remediation

Bioavailability concepts originates from the knowledge that adverse effects in exposed humans and ecological receptors are not caused by total concentration of chemical compounds released into the environment but only by a certain fraction that is biologically available.

From the toxicological point of view, the concept of bioavailability implies that the danger represented by a substance is explained simply in terms of the fraction that can interact with a specific biological site.

In the environmental studies the concept of bioavailability assumes very different meanings that range from the fraction of a substance available for absorption by a living organism, to the amount that can be released from the solid phase of an environmental matrix. Naturally the various aspects of bioavailability are interrelated and in order to understand the complexity of the issue as regards interactions between organism and environment, we tend to refer to processes of bioavailability. By this we mean a combination of reactions that identify not only the different aspects, but also the different temporal stages involving the processes that define bioavailability in a specific situation for a specific organism. Bioavailability is the key to understand the environmental behaviour of heavy metals, the hazards deriving from pollution and to define appropriate strategies of remediation.

Clean up procedures, at heavy metal contaminated sites, are often very laborious and expensive. For a better use of the limited resources available for remediation the use of knowledge of bioavailability processes can be of noteworthy utility. Bioavailability may be a key component of exposure evaluation which has significant implications for the preparation of the conceptual model and the technology selection.

D3-13 Orale Arda, Carla

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UPTAKE OF AS(V) FROM AQUEOUS SOLUTIONS BY ZN-AL SULPHATE LDHS: FIELD EVIDENCES AND LABORATORY STUDIES

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Key terms: Zn-Al-sulphate LDHs; arsenate-sulphate exchange; mine water treatment

Layered double hydroxides (LDHs), a group of compounds with general formula $M^{2+}_xM^{3+}_y(OH)_{3x+2y}(An)_{z-n} \cdot yH_2O$, have a high anionic exchange capacity (AEC), which can widely vary as a function of their composition. The potential use of LDHs for As removal from contaminated mine water is based on the fact that the aqueous speciation of As under natural oxidizing conditions is dominated by oxyanions such as $H_2AsO_4^-$ and HSO_4^- . In this study we investigated the efficacy of natural and synthetic Zn-Al sulphate LDHs in removing As(V) from water solution in batch experiments. This choice ensued from field investigations, which pointed out the capacity of natural Zn-Al sulphate LDHs in attenuation of dissolved As content in NAMD (Net Alkaline Mine Drainage) of the old Bacca Locci mine (southeastern Sardinia, Italy).

Preliminary results showed that Zn-Al sulphate LDHs are effective removers of As(V) from water solutions through anionic exchange with sulphate in the interlayer, while minor amounts of As(V) are likely removed by surface adsorption. The efficiency of As(V) removal increases with Zn/Al ratios in LDH, because of the reduced ionic charge of the metal-hydroxide layers that facilitates the release of sulphate to solution and the entrance of arsenate in the interlayer.

In the laboratory experiments with synthetic LDHs, we used As concentrations of several orders of magnitude higher than found in the field at Bacca Locci. However, experiments with natural LDHs showed a similar capacity in removing As(V) from water solution, indicating that their potential exchange capacity is only partially exploited in the natural system.

The AEC shown by Zn-Al sulphate LDHs encourages further investigation of more complex aqueous systems and different inorganic pollutants.

D3-14 Orale Mignardi, Silvano

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IMMOBILIZATION OF HEAVY METALS IN WATER AND SOIL BY PHOSPHATE TREATMENT

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Key terms: Heavy metals; Immobilization; Phosphate treatment; Mine waste soils

Heavy metals such as Pb, Cd, Cu, Zn, Hg, Cr, and Ni are the main contaminants of surface water, groundwater, and soils. The heavy metals are of great concern because of their extreme toxicity even at low concentration and the tendency to accumulate in the food chain.

Conventional methods for heavy metal removal from water and soil include chemical precipitation, filtration, solvent extraction, electrochemical technique, ion exchange, and adsorption. In particular, chemical immobilization is one of the most used for reducing the bioavailability of heavy metals. The aim is to immobilize the ions trapping them in minerals with low solubility and stable in the environment in a wide range of conditions. Synthetic or natural apatite and phosphate rock have been proved to immobilize divalent heavy metal ions such as Pb, Zn, Cd, Cu, Co, Cr, Ni, and Sb in contaminated waters and soils. The mechanisms of metal removal include ion exchange, surface complexation and dissolution/precipitation.

In this study the removal of Cd, Pb, Zn, and Cu from aqueous solutions by both synthetic hydroxyapatite (HA) and natural phosphate rock (FAP) was investigated in batch conditions at $25 \pm 2^\circ C$. The metals were applied both as single- or multi-metal (Cd + Pb + Zn + Cu) systems with initial concentrations from 0 to 8 mmol L⁻¹. The removal capacity of phosphate amendments generally ranges between 50 and 99%. In the multi-metal systems competitive internal metal sorption reduced the removal capacity by 13-83% compared to the single-metal systems. The sorption of heavy metals by phosphate amendments follows the Langmuir model. Heavy metal immobilization occurs through a two-step mechanism: rapid surface complexation on the $\equiv POH$ sites followed by partial dissolution of phosphates and ion exchange with Ca resulting in the formation of heavy metal-containing phosphates.

The sorption of Cu on HA was further investigated by means of the results of a combined structural simulation and EXAFS analysis. The EXAFS results suggest that the heavy metal is present in the Cu²⁺ form. The structural experimental and theoretical analysis shows that Cu is bonded to about four O atoms at a distance of about 1.95 Å. In all the studied cases the immobilization site of Cu is the same. The fixation of Cu occurs in the surface sites of hydroxyapatite whereas the sorption in the Ca sites in the inner part of the structure is unlikely. The effectiveness of phosphate treatment for Cd, Pb, Zn, and Cu immobilization in mine waste soils from sulfide mine areas (tailing dumps, ore stocking areas, streams, etc.) in Tuscany and Sardinia (Italy) was examined in batch conditions. Application of HA and FAP effectively reduced the heavy metals water solubility generally by about 84 to 99%. Between the two amendments evaluated, HA was slightly more effective with respect to FAP in immobilizing heavy metals. Although the lower effectiveness of phosphate rock, its application to reduce metal solubility in contaminated soils may minimize soil acidification and potential risk of eutrophication associated with the application of highly soluble phosphate sources.

D3-15 Poster Macera, Patrizia

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TESTING OF INNOVATIVE APPROACHES IN GEOCHEMICAL MAPPING: THE EXPERIENCE OF THE "GEOBASI TOSCANA" PROJECT

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Key terms: natural waters; geochemical mapping; stream sediments; spatial analyses; Tuscany

A research agreement was approved in 2009 among the Tuscany Region, the Institute of Geosciences and Earth Resources of CNR based in Pisa and the Tuscan Universities of Florence, Pisa, and Siena, for the implementation of a research and innovation project in the field of environmental geochemistry, named "Geobasi Toscana". The aims of this two-year project are the determination of the natural geochemical baselines for several substances, some of which are potentially harmful, as well as the reorganization and elaboration of all available geochemical data for natural waters (including surface-, ground-, and transition-waters) and active stream sediments.

The "Geobasi Toscana" project continues along the path opened in 2004-2006 by the "Geobasi" project, which was funded by the ministry of the University and Scientific Research of Italy and involved several Italian universities to tackle the complex meaning of elemental compositions in different geo-environmental matrices by means of an integrated multidisciplinary approach. In turn, the roots of the "Geobasi" project are found in the guidelines outlined through a previous APAT-CNR research agreement, whose main outcome is the National Geochemical Archive of Italy (Otonello, 2008).

In this reference framework, it was possible to test innovative approaches in geochemical mapping during the development of the "Geobasi Toscana" project. These methods were then applied to study the behavior of Cd, Hg, Ni, Pb, As, and Cr in the active stream sediments of the Siena area as well as the distribution of other parameters, including U, Cl, SO₄, and Hardness in the fluvial waters of the whole region. Analytical data used to study stream sediments refer to 417 samples collected in the Siena province over a total surface area of 2000 km² approximately, with a density of 1 sample each 5 km². Analytical data of 949 fluvial water samples come from CNEN geochemical surveys carried out in the sixties. They were processed using both deterministic and geo-statistical approaches.

In particular, methods of spatial analysis developed for studying compositional data were applied. In this type of data (percentages, parts per million, molar fractions, etc.), each variable represents a given proportion of a total, which is fixed a priori. From the geometric point of view, compositional data does not occupy the real space, whose dimensions are equal to the number of variables, but are situated in a restricted space, known as simplex (Aitchison, 1986), which is part of the real space. This constrained, non-Euclidean geometry causes several problems if data analysis is approached using the methods of classic statistics. In this research works, new graphical and numerical methods were therefore proposed, respecting the geometric peculiarities of the sample space. Results were discussed in the light of the geochemical behavior of the considered elements and taking into account the geo-lithological characteristics of the investigated areas.

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D3-16 Poster Lucchetti, Gabriella

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MINERALOGICAL AND GEOCHEMICAL CHARACTERIZATION OF OCHREOUS PRECIPITATES FROM THE ROSIA MONTANA GOLD MINE (ROMANIA)

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Key terms: AMD; Rosia Montana; Schwertmannite; Jarosite

The Rosia Montana gold mine (Apuseni Mountains, Romania) is characterized by active and intense Acid Mine Drainage (AMD) processes that cause the widespread circulation of strongly Acid Sulphate Waters (ASW; pH ≤ 3) containing very high levels of ecotoxic elements deriving not only by the sulphide mineralizations but also from host-rock and gangue minerals (such as Cd, As, Cu, Pb, and Zn) [1; 2].

The Rosia Montana hydrothermal ore deposit is hosted in andesites and dacites of Neogene age piercing the prevolcanic sedimentary basement as breccia pipes [3]. The volcanic and subvolcanic rocks show pervasive adularia alteration with a phyllic overprint, as well as local silicification and argillic alteration. They host polymetallic sulphides and Au-Ag-Te mineralizations that are mainly present in epithermal veins, mineralized phreatomagmatic breccias, and stockworks [4]. The ore deposit was mined both in underground and in open pit for more than 2000 years. In the mining area, contaminated waters mainly flow in the watershed of the Rosia and Abrud Rivers, which are indirect tributaries of the Danube River. In order to monitor the mineralogical variations and to evaluate the toxic elements partitioning between contaminated waters and authigenic minerals, twelve samples of ochreous precipitates and the associated mine waters were sampled in July 2010.

The mineralogy of the precipitates was made by XRPD, whereas their bulk chemistry by ICP-MS. T, pH, Eh, and electrical conductivity (EC) were measured *in situ* with portable instruments. The chemical analyses on mine waters were made by ICP-MS, AAS, and chromatography. Two groups of waters were distinguished on the basis of pH, Eh, SO₄, EC, and dissolved metal contents. The first group corresponds to the ASW, characterized by the lowest pH (2.70-3.08) and the highest Eh (460-484 mV), SO₄ (688-4800 mg/kg), EC (1073-5780 μS/cm), and metal contents (Fe, Zn, Mn, and Co). The second group includes either unpolluted and mixed waters, characterized by a general reduction of metal load as well as by significant variations of pH (3.77-6.50), Eh (237-363 mV), SO₄ (326-436 mg/kg), and EC (249-619 μS/cm).

The XRPD analyses evidence that the precipitates are characterized by K-jarosite [K Fe³⁺(SO₄)₂(OH)] and schwertmannite [Fe₈O₈(OH)₂(SO₄)₂] in different proportions. As expected, after the mixing of the ASW with the Rosia and Abrud Rivers, the presence of minerals of detrital origin significantly increases.

The bulk chemistry of the precipitates evidenced significant enrichment in Fe (up to 41.27 wt%) and S (up to 5.01 wt%) and high concentrations of trace metals and As (up to 2930 ppm). Moreover, a positive correlation between Fe and S with As, V, and P have been observed, whereas most of the other elements shows the opposite trend (e.g. Al, Ti, Cu, and Ni). These data suggest a strong control of schwertmannite and jarosite on specific trace elements of environmental concern (particularly As).

Crystallochemical investigations by TEM and spectroscopic techniques will be performed to better understand the interactions of authigenic Fe-oxyhydroxysulphates with metals in the contaminated waters from the Rosia Montana Mine area.

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D3-17 Poster Porro, Silvia

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COMBINATION OF LEACHING AND COLUMN TEST FOR THE ASSESSMENT OF AMD GENERATION FROM THE HOP WASTE-ROCK DUMP (ROSIA MONTANA, ROMANIA)

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Key terms: AMD; kinetic test; heavy metals; arsenic

The production of Acid Mine Drainage (AMD), as a result of the oxidative dissolution of sulphides, and the release of hazardous elements in the environment are main pollution problems affecting natural watercourses in mining areas, with sulphide-rich residues. An important tool for geochemical assessment of abandoned mine areas are kinetic tests, as they provide an insight into the behaviour of the waste-rocks during the interaction with meteoric waters, giving also useful indications of metal mobility and chemical composition of the run-off waters.

In this study two different kinetic tests were applied to assess the generation of AMD from the run-off water of the Hop waste-rock dump, at the Rosia Montana ancient mining area (Apuseni Mountains, Romania). This hydrothermal ore deposit is hosted in andesites and dacites of Neogene age, piercing the prevolcanic sedimentary basement as breccia pipes [1]. They host polymetallic sulphides and Au-Ag-Te mineralizations and the ore deposit was mined both underground and in open pit for more than 2000 years. Intensive alteration due to AMD processes is testified by acid sulphate waters.

The eastern side of the Hop waste dump (2.5 ha area), where the waste has been piled up between 1998 and 2000 from Cetate open-pit, was subdivided in a 30x30 m grid to obtain a final collection of 27 samples. First, the Modified E.P.A. Method 1312 (SPLP) [2] was applied to 20 of them: the < 2 mm grain-size fraction of the solid material was shook for 18 hours in a rotary agitator, together with a slightly acidified de-ionized water, that simulated natural precipitation (water:solid ratio 20:1). The pH value, Electrical Conductivity, sulphate concentration and by ICP-AES total Cu, Zn and As content of the solutions were analyzed.

One sample was then chosen for further investigation: a modified column test [3] was applied to study the different behaviour of the grain-size fraction < 1, 1-2 and > 2 mm. A different weight of each fraction, representing an area of about 100 m², was separated and put in a PET column with 100 mL of tap water. Every week for one month an aliquot of the solution was taken for the same analyses performed with the previous method.

SPLP results showed that eco-toxic elements content in filtered solutions is generally low: Cu ranges from 0 to 98 ppb (mean 14), Zn ranges from 21 to 570 ppb (mean 155) and As ranges from 1 to 7 ppb (mean 2.5). These data are in agreement with the results of bulk waste-rock material chemical composition, whose metal concentrations are in the range of tens of ppm with the exception of As, that shows a content one order of magnitude higher [4]. The pH values vary greatly from 2.9 to 8.9, according to mineralogical and geochemical composition of the waste material. The sulphate content ranges from 13.5 to 475 ppm and exceeds the European limit for drinking waters (250 ppm, [5]) in 6 samples. A significant positive relationship between sulphate content and EC was found.

Modified column test results showed that geochemical features of the solutions tend to stabilize after 3 weeks: pH values grow from 2.5 to 2.7

(mean values) while EC values and sulphate concentration, though highly variables for the three different grain-size samples, clearly decrease. The fraction 2-4 mm is the more reactive one, with a final Cu content of 720 ppb, Zn 880 ppb and As 25 ppb.

The comparison between the two methods allowed to suggest that the first is more useful for materials with fine and homogeneous grain-size, as tailing samples. On the other hand, the column test can be successfully applied on waste rocks, made by heterogeneous grain-size materials.

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D3-18 Poster Lattanzi, Pierfranco

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ZINC ISOTOPIC FRACTIONATION DURING PRECIPITATION OF HYDROZINCITE, RIO NARACAULI, SARDINIA, ITALY

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Key terms: ZINC ISOTOPES; HYDROZINCITE; SARDINIA

In southwestern Sardinia, Italy, the rio Naracauli drains an area of abandoned mines that produced zinc and other metals until 1968. The stream has near-neutral pH, Zn concentrations exceeding several 100's of mg/L, and seasonally high alkalinity (De Giudici et al., 2009). These conditions contribute to the biologically mediated precipitation of hydrozincite {Zn₅(CO₃)₂(OH)₆} (Podda et al., 2000). As the hydrozincite precipitates, the concentrations of Zn and co-precipitated metals (Pb, Cd, etc.) decrease dramatically in the stream water.

Streamwater samples were collected from rio Naracauli from October to December, 2009, using standard sampling methods. At the same time, samples were collected of the hydrozincite that was in contact with the stream water. We also collected several samples of sphalerite from mine dumps in the area to check the isotopic composition of the Zn source. Zinc was separated from all samples using the chromatographic separation methods of Borrok et al. (2007) and Pribil et al. (2010). Purity of separates was checked with conventional ICP-MS analysis, and Zn isotopes were measured on a Nu Instruments high-resolution MC-ICP-MS, using standard-sample bracketing to correct for instrument drift and mass bias. Multiple replicate separations and MC-ICP-MS analyses were used to check the quality of the results. Zinc isotope compositions of the samples are reported as ratios of either ⁶⁶Zn or ⁶⁸Zn relative to ⁶⁴Zn using the standard δ notation, against the isotopic standard JMC 3-0749-L. Precision of the measurements is generally better than $\pm 0.1\text{‰}$.

Values of $\delta^{66}\text{Zn}$ in all samples (solids and water) ranged from -6 to +0.3 ‰; $\delta^{68}\text{Zn}$ ranged from -1.00 to +0.8 ‰ relative to the JMC standard. A plot of $\delta^{66}\text{Zn}$ vs. $\delta^{68}\text{Zn}$ has a slope of 1.98 and $r^2 = 0.97$, indicating that all fractionation of Zn in this sample suite is mass dependent.

Sphalerite had $\delta^{66}\text{Zn}$ values near -0.1 ‰, with almost no variation between samples. In the highest headwater samples, dissolved $\delta^{66}\text{Zn}$ was around -0.2 to -0.3 ‰, with a trend towards slightly lighter values downstream. If sphalerite is the main source of Zn to the stream, then the dissolved $\delta^{66}\text{Zn}$ should be closer to the sphalerite (Fernandez and Borrok, 2009). The fact that dissolved Zn in rio Naracauli headwater samples is 0.1 to 0.2 ‰ lighter either suggests a different Zn source or some in-stream process that modifies the Zn isotope ratio.

The $\delta^{66}\text{Zn}$ values of hydrozincite samples were 0.25 to 0.3 ‰ heavier than the waters with which they were in contact, which would explain the lighter $\delta^{66}\text{Zn}$ values in water samples. Continued precipitation of

hydrozincite also would explain the progressive decrease in $\delta^{66}\text{Zn}$ values for downstream water samples. It is known that the formation of the hydrozincite is biologically driven (De Giudici et al., 2009), but the exact mechanism of Zn fractionation is as yet unknown.

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D3-19 Poster Armiento, Giovanna

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UNUSUALLY HIGH CONCENTRATIONS OF BERYLLIUM BACKGROUND VALUES IN VOLCANIC ROCKS OF LAZIO: GEOCHEMISTRY AND MINERALOGY.

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Key terms: beryllium; baseline levels; site characterization; Roman Comagmatic Province; mobility

Beryllium is widely distributed in soils at low levels (crustal abundance 2-6 mg/kg), but it can also occur naturally in higher concentrations in a variety of materials exploited for many industrial applications. Unfortunately, beryllium is also one of the most toxic natural elements and is known to be a human carcinogen.

We report and analyze a diffuse, unusually high (up to 80 mg/kg, average approximately 18 mg/kg), natural occurrence of beryllium in pyroclastic layers related to the Pleistocene activity of the Vico volcano (northern Latium).

The naturally occurring beryllium content in most of the studied samples is extremely high and even greater than that found in sites contaminated by the accidental release of beryllium into the environment by industrial activities. Only 8 out of the 120 analyzed samples gave values below the Italian limit for potentially unacceptable risk for industrial soil-use (10 mg/kg); in no case values below the limit for residential soil-use (2 mg/kg) were observed.

Additionally, experiments to define Be leachability have been carried out for selected samples, providing evidence of significant mobility in contrast with data presented in the literature that indicate beryllium as an element with low mobility in oxidising surface environmental conditions. This is a crucial point to consider, because a relatively high mobility under certain pH and redox conditions involve a significant risk factor.

The geochemical behavior of the element explains the anomalous Be concentration values because its incompatibility in common rock-forming silicate minerals is concentrated via fractionation during magma crystallization. An additional contribution may be related to the volcanic late-stage fluids permeating through the emplaced rocks.

Combined mineralogical (optical microscopy, SEM-EDAX, EMPA and X-ray diffraction) and geochemical analyses suggests that the higher beryllium concentration in pyroclastics and associated soils are related to the presence of finely dispersed Be-containing minerals, such as gadolinite (Cámara et al., 2008), or hellandite-group minerals (Oberti et al., 2001). However, the possible presence of Be in volcanic glasses is also presently under investigation.

Finally the occurrence of such natural high background concentrations of potentially harmful elements, as it is the case for beryllium studied here, highlights the need for systematic geochemical studies and mapping to produce multi-purpose reference databases for risk assessment and land management.

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D3-20 Poster Costagliola, Pilario

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MINERALOGY, GEOCHEMISTRY AND FLUID INCLUSIONS ON QUATERNARY SEDIMENTS OF THE PECORA AND BRUNA VALLEYS (SOUTHERN TUSCANY, ITALY)

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Key terms: Arsenic; Southern Tuscany; Fluid Inclusion; Quaternary sediments; Hydrothermal systems

Recent studies showed that Quaternary deposits of Pecora Valley (southern Tuscany, Italy) display anomalous As concentrations (up to more than 1000 ppm) (Costagliola et al., 2010 and references therein). Based on these results, the origin of As can be imputed to the dismantling of sulfide mineralization hosted by the pelitic-arenaceous member of Palombini Shales, widely cropping out in the Mt. Arseni and Accesa Lake areas. The Bruna river catchment borders to S-SE the Pecora river catchment, through a watershed that divides them. The two areas, based on paleo-hydrographic reconstructions reported in literature, show a common paleo-hydrological history. This leads to the hypothesis that the As anomaly affecting the Pecora Valley (PV) can also influence the Bruna Valley (BV).

To highlight the geo-environmental evolution of this part of southern Tuscany, the mineralogical and geochemical characteristics of the BV sediments were determined and a study of fluid inclusions found in quartz hosted in BV and PV Quaternary sediments was carried out.

The study included: 1) sampling of sediments, quartz veins and crystals, both in PV and BV Quaternary deposits; 2) study of the mineralogical features of the sediments; 3) determination of the As content of the sediments; 4) microthermometry of fluid inclusions.

The BV Quaternary deposits show mineralogical features and concentrations of As comparable to the Quaternary deposits of the PV, emphasizing the presence of a common source of the metalloid for both areas. They differ only for a different content in trace elements (Zn and Pb), stressing a higher affinity of the BV deposits to base metals mineralization.

Quartz from all the examined areas trapped two-phase (liquid + vapor) aqueous liquid-rich inclusions. Homogenization temperatures of these inclusions are mostly in the 200-275°C range, whereas the computed salinity values are from 0.1 to 13.8 wt% NaCl equiv.. In some cases, such inclusions coexist with vapor-rich inclusions, suggesting boiling processes.

The estimated minimum trapping depth for two-phase inclusions is between 200-600 m, under hydrostatic conditions. Such features indicate an epithermal style of fluid circulation, a quite common occurrence in southern Tuscany. In particular, microthermometric data of two-phase inclusions are similar to those of fluid inclusions hosted in minerals from some pyrite and/or base metals mineralization located close to the examined areas. In one sample (collected near the Accesa Lake)

three-phase fluid inclusions (liquid H₂O + liquid CO₂ + vapor CO₂) were also observed, in addition to two-phase inclusions. The computed salinity of three-phase inclusions is between 0.8 to 12.8 wt% NaCl equiv., and homogenization temperatures fall in the 265-275°C range. Such inclusions probably testify the production of CO₂-rich fluid from decarbonation processes during thermo-metamorphism related to the emplacement of Pliocene-Quaternary intrusions. The estimated trapping depth for such inclusions is at least at 1900 m depth under lithostatic pressure. These data suggest the presence of a complex hydrothermal system located at different depths, that could potentially mineralize several hundred meters of crust. The subsequent dismantling of the mineralized rocks would result in an As anomaly of regional importance, affecting most Quaternary deposits cropping out in southern Tuscany (PV, BV, probably Cornia Valley and the marine sediments off the coast of Piombino up to Elba Island). Thus, the data obtained in this work suggest that PV is only a portion of a larger area affected by As anomaly.

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D3-21 Poster Rimondi, Valentina

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ANOMALOUS ARSENIC CONCENTRATIONS IN SOILS FROM THE VITERBO AREA

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Key terms: Arsenic; Sequential Extraction; Soil; Travertine; Viterbo

The presence of anomalous concentrations of As in the groundwater of the volcanic complex of Monti Cimini (Viterbo, Italy) has been documented in literature by a number of papers (Cremisini et al. 1979; Vivona et al. 2007; Angelone et al. 2009). Specifically, Angelone et al. (2009) ascribed the As enrichment of the aquifer to deep thermal waters belonging to the hydrothermal system active in this area.

Thermal waters in the Viterbo area are known to precipitate calcite, as a consequence of CO₂ degassing, when hydrothermal fluids emerge to the surface. The continuous precipitation of calcite led to the formation of a number of travertine plateaux having variable extensions: one of the largest is located a few kilometres westward of Viterbo, in the so called Bullicame area.

At Bullicame, travertine rocks crop out in close proximity to the present day thermal spring (the Bullicame spring), whereas in the remaining area of the plateau travertines are relatively scarce, and are strongly pedogenised.

Very little attention has been devoted up to now to the presence and availability of arsenic in soils and in the underlying travertines in the Bullicame plateau. The aim of this work is to give a first assessment of the environmental impact of arsenic in this area.

A relatively small area, with respect to the entire plateau, has been studied (approximately two hectares centered around the Bullicame main spring); four soil and ten travertine samples were collected.

For all samples, major and trace elements were determined by XRF, while As was determined by hydride generation flame atomic absorption spectrometry. Furthermore, all soil samples and four travertine samples underwent a sequential extraction procedure (SEP), modified after Wenzel et al. (2000) by introducing a carbonatic extraction step, in order to take into account the mineralogical nature of the Bullicame samples.

Almost all the samples showed As concentrations far above the maximum permissible limit set by Italian law (20 mg/kg for residential areas, and 50 mg/kg for commercial and industrial sites, as stated by D.Lgs. 152/2006), both in soils (As range 81 to 651 mg/kg, with a mean value of 347 mg/kg) and in travertines (from 39 to 279 mg/kg, mean value 136 mg/kg).

SEP results for calcites in travertine showed that arsenic is almost exclusively bound to carbonates (the acetic buffer extracts over 95% of total As) only when Fe concentration is very low (<<1%wt): when Fe exceeded 1wt%, arsenic yields from the acetic buffer step dropped down to 36% of the total. In soil samples As is instead primarily associated with the Fe(Al)-oxyhydroxide fraction (about 80% of the total).

Collected data suggest a widespread presence of As in both soils and travertines of the Bullicame area. Arsenic is mainly associated in the Fe(Al) fractions in soils whereas in the travertine calcite and Fe-oxyhydroxides may behave as traps for the metalloid.

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D3-22 Poster Dughetti, Francesca

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PRELIMINARY REPORT ON HEAVY METALS CONTENTS IN SOILS OF CORNIA, BRUNA AND ALMA COASTAL PLAINS (SOUTHERN TUSCANY)

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Key terms: Arsenic; Heavy metals; Soil; Coastal plain

Southern Tuscany hosts a number of ore deposits which have been actively exploited since the Etruscan period until very recent time. Natural processes of rocks weathering led to the dispersion in the environment of toxic elements.

The Department of Earth Sciences of University of Florence has conducted over the past ten years, numerous studies about the distribution of arsenic and heavy metals in mineralized areas of Tuscany, particularly in the Pecora basin.

The Pecora river drainage-basin is located in the SW part of Colline Metallifere. The area hosts several polymetallic ore bodies and a pyrite ore deposit. The studies have identified several geochemical anomalies (As, Cu, Pb, Zn...) both in the areas which host the ore bodies and in the coastal plain (Scarlino Plain).

The studies suggest that in Scarlino Plain the primary geogenic geochemical anomalies have been overprinted by an anthropogenic input. To increase the knowledge concerning the distribution of As and heavy metals in other Tuscan coastal plains, research is under way in the alluvial plains of the Bruna, Cornia and Alma rivers.

The Bruna Valley is the catchment area adjacent to the Pecora Valley, bordered on the S-SE with the latter through a watershed that divides them. The two areas, based on paleo-reconstructions hydrographic studies, show a relatively recent common history.

The Cornia Valley is the catchment area bordered on the N-NO by the Pecora basin. This basin hosts several polymetallic ore bodies and high-enthalpy geothermal fields, located around the area of Sasso Pisano. Finally, the Alma basin is bordered on the north by the Pecora basin and on the south by the Bruna basin. This small size basin has lithologies common with neighboring basins, but not directly affected by mineralizations. The "Pian d'Alma" coastal plain may represent the geochemical baseline of the Southern Tuscany.

The preliminary analysis have focused on soils and stream sediments, to better understand the correlations between the downstream transport of rivers and the soils. The soil represents together with water (even from a legal point of view) the matrix of most interest to the risk of human exposure to contamination by heavy metals and toxic elements.

We have made physico-chemical analysis, particle size analysis, mineralogical analysis for X-ray powder diffraction, chemical analysis for

the determination of major element (X-ray Fluorescence) and for the

determination of 35 minor elements and traces (AAS and ICP).

The preliminary results show high concentrations of As (21 - 57 mg/kg) in the coastal plain of Piombino (Cornia basin). These values exceed the law limit of 20 mg/kg for Private and Public Land Use and several samples are also over the law limit of 50 mg/kg for Commercial and Industrial Land Use (D. Lgs. 152/06). The samples which present high concentration of As, also have contents in Co over the law limit of 20 mg/kg.

The values in soils sampled indicate that also in the coastal plain of Castiglione della Pescaia (Bruna basin), there are several samples which have concentrations of As (7 - 29 mg/kg), Zn (31 - 163 mg/kg) and of Co (8 - 36 mg/kg) that are over the law limits (20 mg/kg, 150 mg/kg and 20 mg/kg respectively - Private and Public Land Use). Instead, the soils sampled in Pian d'Alma present concentrations below the law limits, with the exception of a sample which shows an anomalous concentration of Pb (612 mg/kg), over the law limit (100 mg/kg - Private and Public Land Use, D.Lgs. 152/06).

Soils and stream sediments of the all three basins of interest are still under investigation.

D3-23 Poster Petruzzelli, Giannantonio

10.1474/Epitome.04.0338.Geoitalia2011

HEAVY METALS IN CONTAMINATED SOIL: "PASSIVE APPROACH" AS A TOOL FOR REMEDIATION

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Key terms: contaminate sites; chemical test; biological test; remediation

Human and ecological risk assessment of metals in contaminated soil is a powerful mean to evaluate environmental quality objectives in the remediation of contaminated sites.

Risk based clean up procedures are carried out by a tiered methodology, which consider sources reactivity and mobility of metals in the soil environment. Among the exposure pathways which link the source of contamination to the potential receptor, the transfer of heavy metals from soil to plant, and by food chain to human beings is greatly influenced by the processes of bioavailability.

Bioavailability is the key to understand the environmental risk derived by metals, since adverse effects only occur when related to biologically available forms of these elements.

Extraction test generally used in soil chemistry were originally developed to predict metal deficiencies, and tend to be fairly aggressive to simulate plant behaviour. The action of plant in the rizosphere is not particularly aggressive, so "passive approach" have been developed. They include the collection and analysis of pore water with different means, (artificial roots, field lysimeter) or the use of passive extraction, water or neutral salts are generally used to mimic plant uptake of metals from soil which occur only via soil solution.

Coupling passive approach with bioassay in which plants growing in the contaminated soils, are used as an extractant, seems to provide a powerful tool to use in the risk assessment procedure. Moreover the results can be utilized to select the best remediation technologies for metal contaminated sites.

D3-24 Poster Petrini, Elisa

10.1474/Epitome.04.0339.Geoitalia2011

FINDING OF A CS-RICH PHARMACOSIDERITE-LIKE MINERAL: PRELIMINARY DATA

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Key terms: cesium; arsenic; cation-exchange; environmental application

During a survey of the As environmental distribution in NW Argentina, we observed a Cs-rich arseniate phase. The mineral occurs in a rhyolitic rock, collected near one hydrothermal spring on the slope of Tuzgle volcano (Puna region, Jujuy Province), as a thin crusts consisting of very small

tetrahedral crystals (average < 2 μm), covering the walls of the rock cavities. Preliminary SEM/EDS and microdiffraction X-ray analysis in thin section, suggested the mineral to be very close to pharmacosiderite KFe₄(AsO₄)₃(OH)4·6-7H₂O, but with anomalously high Cs contents.

Complete WDS-EMP analyses gave a composition compatible with the formula (Cs_{0.47}K_{0.42})Σ0.89Fe_{4.25}(As_{0.96}P_{0.04}O₄)₃(OH)₄·6.43H₂O, thus confirming the similarity of the Cs-bearing phase with pharmacosiderite. The structure of pharmacosiderite [1] consists of FeO₆ octahedra and AsO₄ tetrahedra connected to each other to form a three-dimensional network of channels. The pore has 8-membered ring openings, with alternating arsenic tetrahedra and iron octahedra. Each channel, approximately 3.5 Å in diameter, is occupied by charge neutralizing K⁺ extra-framework cations and H₂O molecules [2]. All the structural sites can be occupied by many other elements: Al, Fe, Ge, Mo, Ti at the octahedral sites, and As, Ge, P, Si at the tetrahedral sites [3].

The extra-framework cations can be Ag, Ba, Cs, H, K, Li, Na, NH₄, Pb, Rb and Tl. This makes possible the existence of many microporous inorganic compounds, isostructural with pharmacosiderite and characterized by remarkable ion-exchange properties. Buerger et al. [1] investigated a synthetic Cs-pharmacosiderite obtained treating natural pharmacosiderite with an aqueous solution of CsOH at room temperature. However, until now the occurrence of a natural Cs-pharmacosiderite was not yet

observed. If confirmed, the observed Cs → K cationic exchange will imply the definition of a new mineral belonging to the pharmacosiderite group. Moreover, the occurrence of a new Cs-bearing natural phase would be relevant to the search for new materials that can be used as selective absorbers for the ¹³⁷Cs isotope from solutions of radioactive wastes and as containers for disposal of radioactive metals [4].

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SESSIONE D5**Inquinamento ambientale da rocce serpentinitiche: analisi del rischio e metodi di bonifica****D5-1 Orale Marini, Paola**

10.1474/Epitome.04.0340.Geoitalia2011

SOIL CONTAINING ASBESTOS: ANALYSIS AND PROBLEMSMARINI Paola¹, ZANETTI Giovanna¹

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Key terms: ASBESTOS; ANALYSIS; threshold value; SOIL; PCOM

The goal of this work is to emphasize the various problems that exist concerning asbestos in nature and how these problems are often difficult to solve. An example of this concept is the analysis of contaminated soil, encountered during the excavation of the foundations of a building in the village of Sommarese, 3 km from Emarese (the Aosta Valley), a site of national interest because of the presence of asbestos.

The soil has been analysed by means of optical microscopy in phase contrast (PCOM), adopting a particular methodology with the aim of obtaining a direct weighing of the asbestos fibres: the sample was divided into granulometric classes, the granular fraction was separated in wet conditions, and the wood fraction, present in a high percentage, was partially or totally burnt in a muffle furnace.

The indirectly weighed asbestos was measured according to Italian regulation on the fibres, adopting SEM counting (Ministerial Decree 06/09/94); then the semi-quantitative grades were obtained taking into account the mineral volumic mass.

The results have shown the presence of asbestos in a quantity that almost reaches the threshold value dictated by Italian regulations concerning ground, (Legislative Decree 471 1999) that is, 1000mg/kg. The ground in the old village of Sommarese is therefore polluted naturally. Some questions therefore arise: should the ground be disposed of in an asbestos dump or it is better to leave it where it is, where all the unexcavated soil has the same level of contamination? And if so, what interventions should be made to make the site safe?

D5-2 Orale Sala, Orietta

10.1474/Epitome.04.0341.Geoitalia2011

PROFESSIONAL EXPOSITION EVALUATION IN THE CULTIVATION OF GREEN STONE QUARRIES IN THE PROVINCE OF PARMASALA Orietta¹, GERBELLI Cinzia², MAGNANI Francesco³, PAGLIAI Paolo³, PECCHINI Giovanni¹, BACCI Tiziana¹

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Key terms: exposure to asbestos fibres; ophiolitic materials; Phase Contrast Microscopy; Scanning Electron Microscopy

The highest concentration of active green stone quarries of Emilia Romagna is located in the province of Parma. Between 2002 and 2004, a regional survey was carried out with the purpose of characterising the extracted materials and defining the exposure to asbestos fibres of workers employed in the mines. In 2009-2010 a further assessment was carried out in order to improve the survey.

The productive sector taken into consideration employs just a few tens of seasonal workers whose number is strongly affected by the market demand for ophiolitic materials. The ophiolitic materials coming from the Apennines are peculiar as the presence of both fibrous and not fibrous serpentine makes the comparison between different microscopic analytical methods interesting.

The 11 mining sites, managed by 8 different companies and employing 30 people as a whole, are homogeneous in terms of kind of activities carried out (with the exception of one quarry only where explosive charges are used): extraction, screening, grinding, loading and transport.

In 4 of these active sites, personal monitoring was carried out on the operators of the typical tasks carried out in the quarry - excavator driver, dumper driver, lorry driver, crusher operator. Despite the limited amount of samples, it is possible to make remarks on the characterisation of the tasks.

The sampling was carried out in accordance with the methodology provided by the UNI EN 589/97 standard. No.13 persona samples (Cp) were taken, corresponding to 7 exposures during a working shift. As specified by the WHO 1997 method, the following instruments were used:

- calibrated portable pumps (Q=2 l/min),
- conductive open face sampling heads with cylindrical extension,
- gridded membrane filters (mixed esters of cellulose).

The filters were analysed both in Phase Contrast Microscopy (PCM) and in Scanning Electron Microscopy (SEM), and compared with the Limit value (LV), concentration in ff/cc and/or ff/litre, in order to compare the two methods and to quantify the presence of asbestos fibres.

The data of the personal exposures have been statistically processed to check the enforceability of UNI EN 689/97 standard. Log-normal distribution, GSD and homogeneity of the group examined were determined and, as a consequence, the exceedance probability of the LV (% Pn) with its confidence interval was calculated using the application software ALTREX.

Regressions were performed so as to make a comparison between the analytical methods and to count the quantity of asbestos fibres and of fibres as a whole.

The results of the survey lead us to consider the extraction process of green stones a situation to be kept under control (ORANGE level as per Annex D of UNI EN 689/97). In particular it is deemed necessary to assess the way the mining activities are performed at the quarry and how the extracted materials are used (coarse pieces rather than powder).

D5-3 Orale Viti, Cecilia

10.1474/Epitome.04.0342.Geoitalia2011

QUALITATIVE AND QUANTITATIVE DETERMINATIONS OF CHRYSOTILE IN MASSIVE SERPENTINITES THROUGH THERMAL ANALYSIS METHODSVITI Cecilia¹, GIACOBBE Carlotta², GUALTIERI Alessandro²

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Key terms: serpentinite; chrysotile; lizardite; thermal analysis; asbestos

One of the main problem in the study of serpentinitic rocks is the accurate determination of serpentine mineralogy, because of the typical coexistence of different serpentine polymorphs in ultrafine, poorly crystalline assemblages, difficult to investigate by conventional methods, such as X-ray diffraction or microanalytical approaches.

In this study, we have collected thermogravimetry (TG), differential thermogravimetry (DTG) and differential thermal analysis (DTA) data for carefully checked serpentine samples, finding that lizardite (lz), antigorite (atg) and chrysotile (ct) have distinctive thermal behaviour, with main differences in the dehydroxylation range (500 - 800 °C). DTG and DTA peak temperatures progressively decrease from antigorite (720 and 715 °C, respectively) to lizardite (708 and 714 °C), polygonal serpentine (685 and 691 °C) and chrysotile (650 and 654 °C). Antigorite has a further diagnostic signal at ~ 740 - 760 °C, always absent in the other serpentinites.

TG, DTG and DTA data have been also collected for lz + ct and atg + ct mixtures, obtained by combining known amounts of the previously investigated reference samples. Deconvolution processing of DTA endothermic signals revealed good linear correlation between peak area ratios (for both ct/lz and ct/atg mixtures) and chrysotile content (with R2 of 0.99 and 0.96, respectively). The DTA correlation curves have been used to estimate the chrysotile content in two unknown samples (massive serpentinites with lz + ct pseudomorphic textures), revealing surprisingly high chrysotile content.

Based on the above results, we suggest that thermal analysis may represent a promising and straightforward method for qualitative and quantitative mineralogical determinations of bulk massive serpentinites, with important petrological and health-related implications.

D5-4 Orale Langone, Antonio

10.1474/Epitome.04.0343.Geoitalia2011

CHROMIUM BEHAVIOR DURING WATER-SERPENTINITES INTERACTION: FIRST RESULTS FROM PETROGRAPHIC AND GEOCHEMICAL STUDY OF SERPENTINITE SOILS AND SERPENTINITES IN A TUSCAN QUARRY (ITALY)LANGONE Antonio¹, BANESCHI Ilaria¹, BOSCHI Chiara¹, AGOSTINI Samuele¹, DALLAI Luigi¹, DINI Andrea¹, GUIDI Massimo¹, TONARINI Sonia¹

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Key terms: Chromium; Serpentinites; Serpentine soils; Weathering; Chromite

Serpentine outcrops, such as the altered ophiolites cropping out in the Tuscany (Western Italy), bear high level of Cr (and Ni) that can be released into ecosystems during weathering. Cr is predominantly contained in spinel-group minerals, such as chromite (Chr), that are highly resistant to weathering causing their accumulation within the soil. The role of chromite as source of Cr in the environmental processes is still under debate. Some authors argued that Cr-spinel is not a significant source of Cr in serpentinite soils, particularly compared to Cr-bearing silicates. Other authors demonstrated that Chr, which may undergo a chemical modification during weathering/pedogenesis, could represent a diffusive minor source of Cr due to its high concentration in soils and its slow weathering with time. Regardless of the composition of the hosting minerals, Cr is generally present in the not bioavailable trivalent state which may be oxidized to the highly toxic hexavalent form (Cr(VI)).

RESPIRA project, financed by EU and Regione Toscana, aims to study processes that promote the leaching of chromium from primary (peridotite) to secondary minerals until to the groundwater, following a multidisciplinary approach.

A serpentinite quarry in the coastal Tuscany was chosen due to the favorable rock exposure, the occurrence of well-developed soils at the top of the quarry, and spring waters at the bottom of the quarry.

XRF analyses of two soil profiles revealed a weak variation in Cr from values comparable with serpentinite bedrock (3100 ppm; deepest horizons) to depleted values into the uppermost horizons (2765 ppm). This variation reflects the mineralogical composition of the soils horizons: Cr-bearing phases occur preferentially in the deepest horizons.

Preliminary FEG-SEM and EMP results revealed that Cr is mainly hosted by spinel-group minerals, such as Mg-Chr. Cr2O3 content of Mg-Chr vary from ~ 23 to 43 wt. %, with the lowest and highest values relative to crystals from soil samples. Mg-Chr is generally replaced by Fe-Chr and magnetite towards the rims and/or near fractures. In several cases, the alteration products of the Mg-Chr may contain variable amounts of SiO2 (5-27 wt. %) inversely correlated with Cr2O3 contents (11-24 wt.%). The SiO2 values apparently give a measure of the extent of Mg-Chr alteration during serpentinization and suggest the presence of fine-grained silicate aggregates. Indeed, locally these alteration products show a microporosity. Appreciable Cr contents (0.5 wt. % < Cr2O3 < 1.5 wt.%) have been obtained from the rare relicts of the minerals of the peridotitic paragenesis (e.g. piroxenes). Generally, the Cr contents of serpentine group minerals is low (< 0.2 wt. %) with the exception of serpentine analysed from bastite pseudomorphic textures and late veins, where Cr2O3 may reach 1.70 wt. %. Garnet and chlorite are secondary phases containing less than 1.0 and 1.3 wt. % of Cr2O3, respectively.

Two springs emerging directly from serpentinites were sampled and preserved for Cr (VI) and Cr (III) analyses. These waters are Mg-bicarbonate and show alkaline pH values (8.1±0.1) as consequence of the interaction with ultramafic rocks. Spring waters collected from the surroundings, and circulating within ophiolites are Mg-bicarbonate with pH values around 7.5 and pCO2 from 3.8E-3 to 7.20E-3 atm. Groundwater circulating in carbonates and marls (sedimentary cover of ophiolites) are Ca-bicarbonate with slightly acid pH (6.8±0.2). Their pCO2 range from 2.3E-2 to 1.0E-1 atm. The total chromium content in groundwater and in the two springs from quarry is about 5 ppb and the prevailing form is Cr (III). They show an enrichment of Mg related to the degree of interaction with the rock.

These preliminary results reveal that integrating geochemistry and petrography should be successful to model the Cr mobility from natural outcrops and quarries. Further investigations will improve our results.

D5-5 Orale Baneschi, Ilaria

10.1474/Epitome.04.0344.Geoitalia2011

CHROMIUM (III) AND CHROMIUM (VI) IN SERPENTINITE-HOSTED SPRING WATERS FROM TUSCANY (ITALY)BANESCHI Ilaria¹, LANGONE Antonio¹, BOSCHI Chiara¹, AGOSTINI Samuele¹, DALL'AI Luigi¹, DINI Andrea¹, GUIDI Massimo¹, TONARINI Sonia¹ - IGG-CNR of Pisa

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Key terms: serpentinites; spring waters; Chromium

Serpentinites and serpentine soils in Tuscan area display high concentrations of Cr, dominantly in the form of Cr (III), as well as other potentially toxic elements including Ni. Geochemical interactions during serpentinite weathering and soil formation may provide oxidative pathways allowing the formation of Cr (VI). In fact, spring waters in serpentinites along coastal Tuscany may have high Cr (VI) contents, indicating a possible remobilization of Cr into groundwaters. Despite the availability of measurements from different systems (rock, soil and water) in Tuscany, the pathway of release of Cr (III) from the serpentinites and its oxidation to Cr (VI) is not assessed. RESPIRA project aims to characterize the Cr-bearing phases within serpentinites and serpentine soils (see Langone et al., FIST 2011) and to assess the processes of release and/or oxidation of Cr from rock to near-surface waters. Our multidisciplinary approach, that combines field, analytical and laboratory studies in solid and water samples, is also necessary to define whether or not serpentinites and serpentine soils are sources of non-anthropogenic Cr (VI).

Springs from serpentinite outcrops and from a serpentinite quarry in the coastal Tuscany were sampled for Cr (III) and Cr (VI) analysis, separating the two forms directly and immediately in the field using cation-exchange cartridges. All the spring waters are fed by Cr-rich ophiolite host rocks, however they exhibit different content in Cr (III) and Cr (VI). The study sites are far away from potentially anthropogenic pollution sources. The springs emerging directly from serpentinite quarry (Santa Luce) are Mg-bicarbonate and show alkaline pH values (8.1±0.1) as a consequence of the interaction with ultramafic rocks. The magnesium content in samples collected during dry season is higher than during rainy season when the discharge of the springs increases, indicating a different degree of interaction with the host rocks. The total chromium content is about 5 ppb and the prevailing form is Cr (III), even if slightly basic pH values indicate that the conditions are potentially favourable for both Cr (VI) and Cr (III) forms. Spring waters collected from the surroundings and circulating within ophiolites are Mg-bicarbonate with pH values around 7.5, while groundwaters circulating in carbonates and marls (sedimentary cover of ophiolites) are Ca-bicarbonate with slightly acid pH (6.8±0.2) and higher pCO₂ (from 2.3E-2 to 1.0E-1 atm). Differently, high Cr concentrations were measured in Querceto spring waters (50 ppb), almost entirely in the Cr (VI) form. As well, a spring in San Dalmazio site has about 15 ppb of Cr (VI). All the spring waters circulating in serpentinites are Mg-bicarbonate with pH values around 8. However Ca/Mg molar ratio in Querceto (0.7) is higher than in Santa Luce (0.03) and in San Dalmazio (0.06). In the same area Cr contents in serpentinite groundwaters are lower (less than 15 ppb), essentially in the form of Cr (III), and TIC content is higher. First results highlight differences in Cr (VI) and Cr (III) contents in spring waters discharging from serpentinites. It has been noticed that in Querceto and San Dalmazio Cu-Fe sulphide ores occur close to the springs. This point out that correlating the geochemistry of the water and the mineralogy of the serpentinites and their alteration products should be essential to evaluate distribution and concentration of Cr in waters. Further analyses of trace elements and organics (e.g. humic and fulvic acid, sulphides, ammonia and nitrate) should be fundamental to better understand oxidation and complexation pathway of Cr.

D5-6 Poster Belluso, Elena

10.1474/Epitome.04.0345.Geoitalia2011

HYDROLOGY, HYDROCHEMISTRY AND WATERBORNE INORGANIC FIBRES AT BALANGERO FORMER MINE AREA, NORTH-WESTERN ITALIAN ALPSPARRERA Selene¹, MASCIOTTO Luciano², BELLUSO Elena³

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Key terms: hydrology; hydrochemistry; waterborne asbestos fibres; Balangero mine; Piemonte - NW Italy

Water resources have been analyzed in terms of quantity and quality at the former mine of Balangero. The mine, set 30 km north-west of Turin, produced chrysotile since the 1920's and in the 1970's became the largest asbestos mine in Europe. In 1990 the mine was closed, although there were still over 18 million tons of asbestos to extract. The mine wasn't reopened because the Law 257/92 banned the extraction, import, export, marketing and production of asbestos, its products and products containing asbestos.

The study area covers a surface of about 7 km² in the nearby of the former mine and its two landfills of serpentinic coarse material, resulting from the rock extraction and processing. The former mine is set in the "Balangero Massif", a geological body mainly consisting of serpentinite. The research has been carried out in accordance with RSA Company, that deals with the rehabilitation and environmental development of the Balangero site, identified as National Interest Site for remediation by the Law 426/98.

A water balance for the years 2006 and 2007 has been calculated for 5 watersheds covering the whole study area. Precipitation and temperature data of seven meteorological stations have been utilized. In the study area, around 65-70% of precipitation is lost by evapotranspiration. The remaining water (water resources) flows principally as surface water rather than groundwater cause of the low permeability of metamorphic rocks. Infiltration is predominant only at the landfills (22% of the study area).

Also a qualitative characterization of some superficial water samples has been carried out in order to assess the influence of the wide landfill of mine rock residues on the water resources. The waters of the five watersheds have been sampled and analysed at the Turin University Laboratories (Dipartimento di Scienze della Terra and Dipartimento di Scienze Mineralogiche e Petrologiche). Water generally shows a magnesium-bicarbonate facies and secondarily a magnesium-sulphate facies. In some cases, the concentrations of sulphate and nickel exceed

the threshold defined by national law. According to literature data, such values are justified by the percolation of rainwater through the serpentinic materials of the landfill, relatively rich in nickel and sulphides. Regard to the suspended matter in water, only the breathable inorganic fibres (length > 5 µm, width < 3 µm, length/width > 3, as indicated by Italian law) have been researched and analyzed by SEM-EDS. Twenty-two mineral species have been found including three classified asbestos: chrysotile, tremolite-actinolite asbestos and anthophyllite asbestos. Cause of the high dispersion due to the reduced size of the fibres, the highest concentrations of asbestos were detected in samples that drain the landfills, while difficulties have been encountered in the other samples where a generalized low concentration of asbestos fibres probably occur. In order to obtain more accurate data for the other samples, analytical determinations by TEM-EDS have been recommended, as practiced in other countries for analysis of microfibrils in water.

D5-7 Poster Marroni, Michele

10.1474/Epitome.04.0346.Geoitalia2011

ASBESTOS MINERALS IN SERPENTINITES: MAPPING AND RISK ASSESSMENT IN THE OPHIOLITIC BODIES OF TUSCANY, ITALYMARRONI Michele¹, BOTTI Flavia¹, BOTTI Laura², DONATIO Deborah¹, FRASSI Chiara¹, GEMELLI Maurizio¹, MENEGHINI Francesca¹, PANDOLFI Luca¹, PARISI Salvatore³, ROCCHI Sergio¹

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Key terms: abbestos; ophiolites; risk assessment; Tuscan region

The six minerals grouped under the name of asbestos are universally recognized as dangerous for human health due to their fibrous shape. The asbestos minerals are generally found as common weathering products in peridotite, gabbro and basalt, typically associated in ophiolitic sequences. The circulation of fluids in these oceanic sequences cause a variably intense and penetrative hydrothermal weathering of pre-existing magmatic minerals such as olivine and pyroxene. No matter their peculiar chemical and physical characteristics, the industrial use of asbestos minerals has been completely eliminated from production and use in many countries. However, the asbestos fibres still represent an ubiquitous pollutant, not simply because of the number of industrial products still present in urban areas, but also because of the tendency, in asbestos-bearing rocks and soils, of fibres to be released naturally (landslides, erosion, weathering) or by human activities (mining, earthworks, excavations, tunnels).

Therefore, the control of the risk of environment contamination in areas where ophiolitic sequences crop out, still represents a relevant societal problem that require a precise estimate of the nature and abundance of fibrous minerals. This assessment can be performed with a multiscale and multidisciplinary geological study that allows a characterization of the asbestos from the mineralogical point of view (different degrees of risk for human health are related to different asbestos minerals).

We show here the main scientific and technical lines of a project of asbestos-related risk assessment developed by the Dipartimento di Scienze della Terra (Pisa University) and the Alitec s.n.c. and PivotConsulting s.p.a. companies, funded by the FSE (Fondo Sociale Europeo) through the Tuscany Region administration. The main goals of the CaMam (Caratterizzazione e Mappature Amianto) project is in fact the mapping and characterization of the asbestos-bearing ophiolitic rocks in the area of the Region of Tuscany.

The main phases of the project comprise a complete lithological and structural characterization of the outcrops with asbestos-bearing lithotypes as well as a qualitative and quantitative assessment of the amounts of these minerals.

All the collected field-based information will be stored and elaborated in a GIS (Geographic Information System) database. This database will contain a directory of areas where asbestos-bearing lithotypes are outcropping and the related qualitative and quantitative information. The database will be constructed starting from that already existing of the geological cartography, recently performed by the Tuscany region administration. The mineralogical characterization of asbestos phases will be performed by various techniques typically used in the context of fibrous minerals, such as XRD analyses, Raman spectroscopy and, where possible, TEM techniques. As much as possible an attempt will be made to check on possible relationships between the type of mineralizing phase and the structural, mineralogical and petrographical features of the lithotypes or fracture systems containing those phases.

In particular, with this project we aim to test a quantitative estimate of fibres by multi-scale image analyses of the outcrops and their mineralized fracture patterns. Thanks to the cooperation with PivotConsulting s.p.a. (c/o the Technology Centre of Navacchio (PI)) and Alitec s.n.c. companies, pilot studies in selected areas will be conducted to test the procedures for a quantitative assessment of content asbestos fibres and establish the background level of fibres resealed into the atmosphere. The companies will provide innovative techniques such as (i) the recognition of images through acquisition by drones (PivotConsulting s.p.a.), and (ii) acquisition of data on the concentration of micro and nano powders dispersed in the air using a portable detector (Alitec s.n.c.).

D5-8 Poster Papapietro, Nunzio Giovanni

10.1474/Epitome.04.0347.Geoitalia2011

EXPOSURE TO ASBESTOS FIBERS IN AGRICULTURE: A CASE OF WORK-RELATED MESOTHELIOMAPAPAPIETRO Nunzio Giovanni¹

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Key terms: mesothelioma; chrysotile; asbestos; fibers; sampling

It's note the correlation between asbestos fibers and pleural mesothelioma which is called the "sentinel event" which highlights a particular exposure to those particular fibers. This case refers to a farmhand who, during his working life, has always worked in the municipality of Viggianello (PZ) Southern Italy - municipal road Cornaleto-Sant'Elena, where there are ophiolitic outcrops (known as green rocks). The woman has contracted a pleural mesothelioma. The survey carried out by means of leaves of particles of respirable fraction, as well as bulk samples of loose soil - the same type of work - and rock samples in place, has revealed the presence of chrysotile asbestos fiber type in soil. This presence appears to be in agreement with literature data. This paper illustrates the methods of

sampling carried out and the analytical results obtained by using optical microscopy (SEM) and phase contrast (PCOM).

D5-9 Poster Sala, Orietta

10.1474/Epitome.04.0348.Geoitalia2011

PROPOSED CLASSIFICATION OF OPHIOLITES DEPOSITS AND USE OF MATERIALS EXTRACTED ACCORDING TO THEIR CONTENT OF ASBESTOS

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Key terms: ophiolites; Classification; DM 14/05/1996

As it is widely known and studied in ophiolites (ultramafic rocks of intrusive magmatic origin, partially altered or metamorphosed) asbestos fibers may be found in the form of slow and small veins (those typical of alpine ophiolites, very rare in Apennines) and distributed within the fractures.

Mining, quarrying and processing could release a number of asbestos fibers into the environment, that needs to implement preventative measures of workers protection and local population.

The methods of control of the extracted materials are carried over from the Ministerial Decree (DM) 14/05/1996, which defines criteria for the classification and the use of "green stone" according to their content of asbestos. The excavation is allowed under a certain danger level as defined by the amount of asbestos released from the rocks, where the value of Release Index must be $Ir < 0.1$.

In addition to this law (exclusive to the ophiolites quarry sector) we can find the provisions of health and safety at work in Legislative Decree n. 81/2009. It stipulates specific analytical measures and controls over all work environments at risk for the presence of asbestos. The law identifies the permissible exposure limit (defined as "VL" Value Limit), beyond which they must take appropriate precautionary measures.

Various objections were raised over the correct application of the Ministerial Decree 5/14/1996, in particular relate to the real meaning of Ir (Release Index). The real ophiolitic danger is related to the chance of rocking crumbler during extraction and subsequent work phases since it is during these activities that rocks can more easily release asbestos fibers. These considerations were already included in the studies carried out by the Emilia-Romagna Region (Il Progetto Regionale Pietre Verdi - 2004). It proposes a new classification of the ophiolites deposits based on a simple but direct measurement of the release index (called AR "asbestos free or releasable") taken before and during the mining activities related to the types of products produced by the quarry.

SESSIONE D6

Stoccaggio geologico e mineralogico della CO₂: stato dell'arte e prospettive future

D6-1 Invitato Boschi, Chiara

10.1474/Epitome.04.0349.Geoitalia2011

IL DECRETO LEGISLATIVO DI RECEPIMENTO DELLA DIRETTIVA 2009/31/EC SULLA CATTURA E STOCCAGGIO GEOLOGICO DEL BISSO DI CARBONIO

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Key terms: prima key word; seconda key word; terza key word

La tematica della cattura e stoccaggio del biossido di carbonio (CCS) rappresenta già da alcuni anni uno degli argomenti di maggiore interesse per il mondo scientifico e la ricerca. Su proposta della Commissione europea, il Parlamento europeo e il Consiglio dell'Unione europea, riconoscendo l'importanza di tali tecnologie, hanno emanato la direttiva 2009/31/EC del 23 aprile 2009. La direttiva considera la cattura e lo stoccaggio del biossido di carbonio come una tecnologia ponte che potrà contribuire a mitigare i cambiamenti climatici.

L'obiettivo indicato nella direttiva è quello di consentire il recepimento da parte di ogni Stato Membro entro il prossimo 25 giugno 2011.

A tale scopo il Ministero delle politiche europee, il Ministero dello sviluppo economico e il Ministero dell'Ambiente hanno costituito un gruppo di lavoro congiunto per la stesura dello schema di recepimento secondo i principi e criteri direttivi stabiliti dalla legge 4 giugno 2010, n.96 (legge "Comunitaria 2009"). Attente riflessioni, confronti, analisi degli aspetti tecnici, amministrativi e giuridici hanno portato nel marzo 2011 alla predisposizione finale dello schema di decreto legislativo, il cui testo è stato dapprima discusso e condiviso con le amministrazioni concorrenti (Ministero degli affari esteri, Ministero della giustizia, Ministero dell'economia e delle finanze) per poi essere sottoposto all'esame del Consiglio dei Ministri, che, in data 23 Marzo 2011, lo ha approvato in via preliminare.

Successivamente, in data 12 maggio 2011, il testo è stato discusso durante la Conferenza Stato-Regioni, dapprima per quanto concerne gli aspetti tecnici, mentre, in data 18 maggio 2011, per quanto concerne gli aspetti politici, riscontrando un parere favorevole, condizionato all'accoglimento di alcuni emendamenti.

Significativo per il raggiungimento di questi traguardi è stato l'apporto continuo e costruttivo delle regioni, degli enti di ricerca nazionali e delle associazioni di categoria degli operatori.

Le attività future, previste nei prossimi giorni, necessarie a concludere l'iter di recepimento riguarderanno la predisposizione del testo finale e l'invio alle varie commissioni parlamentari, chiamate a pronunciarsi in materia.

D6-2 Invitato Boiardi, Bruno

10.1474/Epitome.04.0350.Geoitalia2011

AN ITALIAN EXPERIENCE IN CO₂ CAPTURE AND GEOLOGICAL

SEQUESTRATION

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Key terms: CO₂; Geological Sequestration; Monitoring

Eni is strongly committed to fight climate change by developing a Carbon Management strategy that combines operational and management initiatives with the development of research into innovative technologies aimed at optimizing the energy efficiency as well as promoting the use of renewable.

In the field of Carbon Management, the eni program includes the building of the first integrated pilot project in Italy, exploiting an exhausted gas field at Cortemaggiore (Piacenza) to realize a pilot CO₂ injection test. The project forecast the injection of 24.000 tons of CO₂ during a three years period and consists of different phases: particular evidence will be given to the criteria applied for the choice of the injection site, the preparatory studies and the monitoring plan - covering a long period before the start of the injection in order to acquire a sound baseline - planned to ensure the safety and effectiveness of the pilot. The start of the CO₂ injection is scheduled for mid of 2012.

D6-3 Orale Procesi, Monia

10.1474/Epitome.04.0351.Geoitalia2011

STRATEGIC USE OF UNDERGROUND FOR AN ENERGY MIX PLAN: THE EXAMPLE OF LATIUM REGION (CENTRAL ITALY)

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Key terms: Mix energy plan; synergies in CO₂/natural gas storage; geothermal energy

The world-wide energy demand has been growing so much that there is the need to develop a strategic mix-energy plan to supply low GHG (GreenhouseGas) emissions energy and solve the problem of CO₂ emission increasing.

A study published in 2006 by the European Commission shows that if the existing trends continue, by 2050 anthropogenic CO₂ emissions will be unsustainably high: 900- 1000 parts per million by volume.

A first useful step to solve this problem can be to evaluate the synergies and/or conflicts between reliable technologies that can produce clean energy involving deep geological structures, namely:

1) clean coal combustion, jointed to CCS (Carbon Capture and Storage);
2) CH₄ storage in natural reservoirs;
3) renewable energies as geothermal energy;

These three technologies could coexist in a strategic use of the underground, especially in densely populated country as the Italian territory. In this framework, the preliminary underground screening for a strategic energy use must also consider the presence of potentially suitable areas addressed in the past by dedicated agency for instance to nuclear waste disposal. Selection of these sites is in fact based on more rigid criteria with respect to gas storage or geothermal energy. Therefore, areas selected for nuclear waste disposal represent a peculiar factor that should be taken into account for a correct energy plan evaluation.

CCS is considered one of the main technology able to stabilize and reduce the atmospheric concentration of anthropogenic CO₂. Nowadays CCS market is mainly developed in USA and Canada, but still less accounted in Europe. In Italy there aren't active CCS projects, even if potential areas have been already identified.

Traditionally, CH₄ has been a seasonal fuel. The demand of this gas is usually higher during the winter because used for heat spacing. Storing natural gas is actually strategic for two reasons: to fill the seasonal requirements and to have a strategic energy reserve. Many CH₄ storage sites are located in Northern America, while other are present also in Europe and Italy, but the number of sites is limited despite the huge underground potentiality.

Geothermal Energy is a renewable, clean and sustainable energy which can be used indirectly for power generation and directly for numerous applications such as: space and district heating, water heating aquaculture, horticulture and industrial processes.

In Italy the power generation from geothermal energy is about 5400 GWh/year. It comes exclusively from Tuscany (Larderello-Travale and Mt. Amiata geothermal fields) despite the already evaluated huge potentiality of other regions as Latium, Campania and Sicily. Nowadays, new technologies as EGS (Enhanced Geothermal Systems) and Binary Cycle Plants permit the development of the geothermal energy also in areas considered unproductive in the past, due to low underground temperatures and/or absence of fluids.

Here we present preliminary data concerning this work on the whole the Italian territory, starting from Lazio Region. Results show that in this area the three technologies can coexist despite the general complex geological setting.

Therefore we are developing a self-sustaining Dedicated Geographic Information Systems (D-GIS) necessary to organize and manage a reliable Mix-Energy plan relative to the entire Italian territory. It includes geological strategic data and also environmental and infrastructure information. The development of D-GIS can represent a useful planning tool to evaluate synergies and/or conflicts among different deep underground uses (500-5000 m depth) and correlated technologies. Products of this study can finally represent an useful tool not only for the scientific community but also for the policy makers to improve the guidelines for sites selection.

D6-4 Orale Bencini, Roberto

10.1474/Epitome.04.0352.Geoitalia2011

SUITABILITY OF DEEP SALINE AQUIFERS FOR UNDERGROUND STORAGE OF METHANE AND CARBON DIOXIDE

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Key terms: carbon capture and storage; underground gas storage; deep saline aquifers; naturally fractured carbonates; integrated multidisciplinary evaluation

Storage of Methane (CH₄) and Carbon Dioxide (CO₂) in deep saline

aquifers is a proven technique and a promising strategy to respectively address mitigation of climate change and energy security regarding additional Methane demand during cold weather. These themes are attracting growing interest within both scientific and industrial communities.

According to one of the leading scientific research bodies in geosciences in Italy "Deep saline aquifers offer the largest storage potential of all the geological CO₂ storage options, and are widely distributed throughout the Earth".

Moreover, according to the International Gas Union, "The sciences and technologies that UGS (Underground Gas Storage) operators use for Methane storage, specially for aquifers storage, are a solid basis for CO₂ sequestration projects", highlighting in an authoritative way the strong technical interconnection between these two industrial sectors.

In Italy, several storage projects in deep saline aquifers are underway. A major underground Methane storage site (Rivara Project) is being planned in a fractured carbonate reservoir in Italy's Po Valley. Rivara's working capacity is estimated at approximately 3.2 billion cubic metres (bcm), which would make it one of largest and potentially best performing gas storage facilities in Italy and in Europe.

Additionally, several sites in naturally fractured carbonate aquifers are being evaluated for potential CO₂ storage, among which a site offshore under the continental platform of the Tyrrhenian Sea. Major efforts are in progress to properly characterise these storage sites and to plan their safe operation ahead of the beginning of the construction phase, including reservoir and caprock stratigraphy and structure, geomechanics, reservoir engineering, geochemical and seismological monitoring.

An innovative, multidisciplinary and integrated work flow has been identified to document the suitability of these sites. The work programme is designed to determine the feasibility and the safety of the gas storage project, either CH₄ or CO₂. This includes two main phases, namely an Initial Phase, followed by the Appraisal Phase, which repeats the cycle in more details.

Each phase involves the following integrated sequential stages:

- ° Analysis of pre-existing data (wells, seismics, subsurface data, seismological data);
- ° 3D geologic modelling;
- ° 3D reservoir modelling;
- ° 3D geomechanic modelling.

The Initial Phase involves all the data gathering activities that can be implemented without a specific licence, while during the Appraisal Phase the activities include the acquisition of geophysical data and the drilling of wells, which require specific ministerial authorization and license. The key elements of the Appraisal Phase, in fact, are the acquisition of a new 3D reflection seismic campaign and the drilling of the necessary appraisal wells with the associated specialized activities (cores, logs, reservoir test). Before the beginning of the construction phase, it is also important to implement a multidisciplinary monitoring programme ante-operam, in order to have the basic elements for detecting any change that may occur after the beginning of the site operations.

While underground Methane storage (UGS) activities are fully regulated in Italy, and an aquifer specific European Standard (UNI-EN-1918-1) exists, underground storage of CO₂ is not yet currently regulated. Italy is however about to adopt European Directive 2009/31/CE of 23 April 2009 on the geological storage of carbon dioxide.

Independent Gas Management is a competent specialized operator for the safe development of suitable CH₄ and CO₂ underground storage sites in deep saline aquifers hosted in naturally fractured carbonate rocks.

D6-5 Orale Sciarra, Alessandra

10.1474/Epitome.04.0353.Geoitalia2011

FLUID GEOCHEMISTRY OF SHALLOW AQUIFERS AND SOIL GAS SURVEYS FOR THE ENVIRONMENTAL IMPACT ASSESSMENT OF A POTENTIAL NATURAL GAS STORAGE SITE IN PO PLAIN

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Key terms: soil gas survey; shallow aquifer; flux measurement; natural gas storage; Po Plain

A geochemical survey in soils and shallow aquifers was carried out as part of the feasibility study of a potential natural gas (CH₄) storage site in a deep saline aquifer of Modena Province, Northern Italy.

This paper discusses the areal distribution of CO₂, CH₄ and other geo-gases (Rn, He, H₂, N₂) both in soils and shallow aquifers above the proposed storage reservoir.

Soil and dissolved gas, joined with isotopic analysis, allows to distinguish between shallow and deep origin fluids. This approach is used also to identify the presence of anomalous leakage of deep fluids towards surface, and therefore the presence of tectonic discontinuities by means distribution of pathfinder elements as ²²²Rn, He e H₂.

This methodology is based on the previous experience gathered in other projects aimed to i) water and soil gas surveys in active fault areas; ii) natural gas risk assessment and iii) CO₂ geological storage.

In particular, the goal of this survey is to characterize the composition, distribution and behavior of the geo-gas (CH₄, Rn, He, CO₂, H₂, etc...) in the geological layers closer to the surface, defining their baseline or background values, their origin, pathways and carrier roles.

The geochemical and isotopic characterization of the ground waters circulating in the first 200 meters has been carried out to investigate the origin of the circulating fluids, the gas-water-rock interaction processes, the amount of dissolved gases and/or their saturation status.

In the first 200 m, the presence of reducing waters enriched in CH₄ could be related to organic matter (peat) bearing strata which generate shallow-derived CH₄, as elsewhere in the Po Plain. No hints of thermogenic CH₄ gas leakage from deeper reservoirs have been envisaged.

The acquisition of pre-injection data is very important for the future natural gas storage development project and it is strategic as baseline for future monitoring during the gas injection period. Our study could be considered as a monitoring guideline applicable both to other gas storage sites before, during and after the injection and to natural analogues.

D6-6 Orale Bicocchi, Gabriele

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FLUID GEOCHEMISTRY AND MINERAL CHEMISTRY OF HIGH pCO₂ SYSTEMS: A LESSON FROM THE PSS1 BORE-WELL AT CAPRESE

MICHELANGELO (EASTERN TUSCANY, ITALY)

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Key terms: carbon sequestration; natural analogue; geochemical modeling

Carbon capture and storage (CCS) is considered a valid option for reducing CO₂ concentration in atmosphere without a dramatic impact on the economy. The feasibility of many CCS projects worldwide it is still under evaluation, although others have already started (e.g. Weyburn pilot project in Canada; Cantucci et al., 2009 and reference therein). The injection of CO₂ underground allows to acquire useful experimental data to be used for geochemical modeling purposes as accurate data and chemical-physical constrains on rock and CO₂-rich fluid interactions are needed. Nevertheless understanding if CO₂ can safely be stored at depth for long times (thousands of years) can actually be evaluated only by geochemical modeling. Natural analogues are very useful for identifying key mechanisms and processes relevant to long-term stability and seepage mechanisms associated with CO₂ geological sequestration. Consequently, these systems are presently representing the easiest way to gather experimental data to be compared with those scenarios provided by geochemical models.

A high pCO₂ system was found located in San Cassiano Basin (Tiber Valley, Eastern Tuscany). Here, in correspondence of PSS1 borewell (Anelli et al., 1994), a relevant fraction (92,2% vol) of carbon dioxide is found at the depth of 3,800 m, presumably located at the top of the main fluid reservoir hosted in "andesitic" (?) volcanic rocks interbedded with the evaporitic Formation of Burano, at P-T conditions of nearly 700 bar (70 MPa) and 120 °C respectively, with a density of 860 kg/m³, univocally suggesting the presence of a supercritical fluid (Heinicke et al., 2006).

Fluid chemistry from the bore-well and that discharging at the surface from natural manifestations (bubbling mud pools, springs, stream waters, wells) were studied along with carbon (in CO₂) and helium isotopes.

Moreover extensive surveys on the altered volcanic rocks, likely corresponding to the top of the reservoir, and the hosted minerals were carried out. Qualitative and quantitative analyses were performed by means of SEM-EDS, XRD and EMP techniques. The mineral paragenesis consists of Quartz, Ca-Fe-Mg Carbonates, Na-K Illite, Fe-Mg Chlorite and accessory Apatite and Fe-Ti oxides. Fluid inclusion studies showed the presence of H₂O-rich and CO₂-rich phases. First-type inclusions provide information on the physical-chemical features of fluid responsible for hydrothermal alteration, whilst second-type inclusions indicate changes of CO₂ densities within the reservoir. Experimental runs at LLB (CEA-CNRs, Saclay, France) at SANS (Small Angle Neutron Scattering) diffractometer PAXE were conducted for retrieving data about the microstructure of porosity of the rocks. The mineral chemistry of Ca-Fe-Mg carbonates (Bicocchi et al., 2011) was studied by applying appropriate statistical methods.

The large chemical, physical and mineralogical dataset obtained in the present study will be employed to build up a conceptual model of the fluid-rock interaction processes that affected this geologically complex portion of the central-northern Apennines.

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D6-7 Orale Spagnoli, Federico

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BIOGEOCHEMICAL APPROACH TO THE MONITORING OF BASELINE LEVELS OF CO₂ AT THE SEDIMENT-WATER INTERFACE FOR CCS PURPOSE

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Key terms: Benthic fluxes; Early diagenesis; Benthic chambers; Dissolved inorganic carbon; Carbon sequestration

One of the most promising technological solutions in the CO₂ Capture and Storage (CCS) is the CO₂ injection in the sub-seabed deep saline aquifers. In the sub-seabed CCS a reliable monitoring of possible CO₂ seeps is required in order to assure safety, containment lifetime and biological impacts.

A useful CCS monitoring approach (the experimental biogeochemical approach) is to determine, before the geological storage, natural baseline levels and benthic fluxes of dissolved inorganic carbon species (pCO₂ and DIC) and of other connected parameters (alkalinity, pH and $\delta^{13}C_{DIC}$) in seawater in order to characterize the marine carbonate system from a chemically point of view and regarding its natural or anthropogenic origin. Furthermore, the study of the early diagenesis processes generating the observed benthic fluxes is a useful complementary aspect of the CCS biogeochemical monitoring approach.

The knowledge of the natural baseline levels and benthic fluxes, before the CO₂ injection, will allow the comparison with data obtained after the storage operations so that possible occurrences of unexpected leakages of the CO₂ injected in the geological formations under the sea bottom can be verified.

This approach could also be useful employed as an "early warning" system

in case of possible failure of the CO₂ storage.

The best method to determine dissolved benthic fluxes is the "in situ" measurement by benthic chamber deployments.

The biogeochemical approach is particularly sound in the northern and central Adriatic Sea where numerous previous DIC and other carbonate system connected chemical benthic flux data, various early diagenesis studies and also up to date and appropriate monitoring technologies (automated benthic chamber and on deck laboratory), able to measure "in situ" benthic fluxes, are available and where CO₂ sub-seabed storages can be carried out.

Previous researches allowed the definitions of nine different diagenetic environments in the northern and central Adriatic Sea; each environment is characterized by:

- 1) homogeneous particulate matter and dissolved nutrient continental inputs;
- 2) distances from main sediment sources;
- 3) bottom sediment composition;
- 4) organic matter;
- 5) depths;
- 6) oxygenation of water column.

In each diagenetic environment a natural background value of DIC, alkalinity and pH sediment-water fluxes has been assigned. These background values can be used as natural baseline in the CCS to monitoring possible seeps after the injection of CO₂ in depth. At present, various researches are in progress in the Adriatic Sea for the acquisition of new data of DIC and other dissolved chemical sediment-water fluxes and on early diagenesis studies, in order to increase the background knowledge in areas or seasons not covered by previous researches.

In particular, in fall 2010 and winter 2011 two cruises have been performed to measure benthic fluxes of dissolved inorganic carbon species and to determine the early diagenesis processes that origin the fluxes in the two extreme seasons in the central-western Adriatic Sea.

In these last cruises benthic fluxes have been measured "in situ" by deployments of the ISMAR-CNR and RSE "self-made" benthic chamber and using an on deck laboratory.

Furthermore, a technological development research is now being carried out by ISMAR-CNR and RSE for the set up of a full ocean depth (6000 m depth) Lander equipped with three benthic chambers and one micro-profiler.

D6-8 Orale Mignardi, Silvano

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CARBON DIOXIDE SEQUESTRATION VIA MINERALIZATION: THE STATE OF ART

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Key terms: carbon dioxide; reject brines; carbonation process; nesquehonite

Today a main challenge in environmental management is to consider some contaminants such as carbon dioxide (CO₂) and reject brines, instead of harmful and dangerous by-products, as valuable sources for several compounds to be involved in diverse industrial processes. The geological sequestration of CO₂ currently in vogue is considered the most promising method to trap and store this greenhouse gas. We propose alternatively the long-term sequestration of CO₂ in solid form through its mineral sequestering as hydroxycarbonate of magnesium, nesquehonite [MgCO₃·3H₂O], without any potential risks for the environment as it is stable at Earth surface conditions. Carbonation reactions are common in nature but the idea of developing this process for the disposal of CO₂ based on the chemical fixation of the carbon dioxide in the form of carbonate minerals was only proposed in 90s using calcium in brines, and then by carbonation of magnesium-bearing minerals from ultramafic igneous rocks. There are serious problems with that approach: the reaction kinetics for magnesium silicates tends to be too slow and environmental concerns are associated with mining and processing very large amounts of rocks.

Conversely, we developed an innovative and non-traditional use of CO₂ and brines in a process having a dual beneficial objective to reduce the volume of this greenhouse gas to be discharged and mitigate the negative effects of reject brines.

We recently described a carbonation process involving the reaction of gaseous CO₂ with a magnesium chloride solution producing nesquehonite. In order to evaluate the appropriateness of a reaction of CO₂ with Mg chloride solutions as a process for storing carbon dioxide and wastewater, the thermal behaviour of nesquehonite was investigated *in situ* using real-time parallel-beam X-ray powder diffraction. Nesquehonite appears to be stable up to 373 K suggesting that its storage as "sequestering medium of CO₂ and reject brines" remains stable under the temperature conditions that prevail at the Earth's surface. At temperature above 373 K the process of thermal decomposition of nesquehonite (*via* intermediate hydrated magnesium carbonate phases) ultimately produces magnesite in the range 423-483 K. This sequence involves the formation of carbonate minerals thermodynamically more stable than nesquehonite, assuring the stable storage of these hazardous materials for millions of years.

Our initial work on the carbonation process involved a relatively dilute solution of magnesium chloride, roughly 7 g L⁻¹ of Mg, at room temperature. The reaction rate was found to be rapid, the deposition of nesquehonite being virtually complete in about ten minutes. Nesquehonite removed about 80% of the CO₂ in solution. To test the efficiency of the carbonation process in more concentrated solutions, having salinity more close to that of the reject brines that are industrially available, further experiments have been carried out using solutions with different degree of salinity (16 and 32 g L⁻¹ of Mg). A comparison of the efficiency of the CO₂ mineralization process among sets of experiments at low and high salinity shows that in more concentrated solutions, the efficiency was reduced to about 65%. The results suggest that the goal of CO₂ sequestration and reject brines discharge seems to be realistically obtained also using the more common wastewater.

The sequestration of CO₂ and the disposal of reject brines *via* carbonation produces a solid material that can be utilized directly in many products such as acoustic panels, non structural panels, insulation, or agglomerated in concrete as a man made aggregate. Because nesquehonite growths as fibrous and acicular crystals, it improves the microstructures of manufacturing materials.

D6-9 Orale Boschi, Chiara

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SPONTANEOUS CO₂ MINERALOGICAL SEQUESTRATION IN MINE WASTE MATERIALS: AN EXAMPLE FROM MONTECASTELLI COPPER MINE (TUSCANY)

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Key terms: CO₂ mineralogical sequestration; serpentinite; hydromagnesite; mine tailings; Tuscany

The Montecastelli copper mine, close to Pomarance (Tuscany, Italy), has been exploited since the Etruscan time, but it has been during the 19th century that Cu ores (bornite and calcopirite) were extensively cultivated. Copper minerals are mostly concentrated along a shear zone hosted by serpentinite. During exploitation, barren serpentinites as well as low grade ore material extracted in underground works were disposed in a mine dump in front of the entrance of the tunnels.

Field observations, and mineralogical investigations, indicate that specific layers of the dump were intensively carbonated. Carbonate precipitates are known from serpentinite mine dumps from many other localities (Wilson et al., 2006; and references therein). Such a low temperature alteration is a natural analogue of an induced carbon dioxide mineralogical sequestration, spontaneously developed in a very recent time. RESPIRA project, financed by EU and Tuscan Region, aims to study different type of carbonation processes, that led to natural analogues of CO₂ mineralogical sequestration. Here, we report the preliminary studies of the carbonation in Tuscany mine tailing, in order to give an estimate for the sequestration capacity of ultramafic mine tailings, and to provide a framework for the development of standard protocol of enhanced mineral sequestration at mine sites.

Dumps at Montecastelli mine are composed by a bottom incoherent layer, up to 4m thick, of medium to big size serpentinite clasts (up to 60 cm in diameter), randomly distributed and characterized by the presence of large voids between clasts. The intermediate layer, ranging from 10 cm to 1m in thickness, consists of small- medium-size serpentinite clasts encrusted by a very fine-grained whitish carbonate-rich material. A 15-40 cm of young soil with an initial accumulation of organic matter (litter, three roots, etc), alternating with serpentinite clasts, is on the top. On the distal part of the tailing, the bottom layer disappeared, prevailing a greenish serpentinite- and clay-rich layer very-fine grained and incoherent carbonate-rich layer intercalated to a greenish serpentinite- and clay-rich part.

The carbonate minerals are mainly represented by hydromagnesite, occurring as white coatings and crusts with the typical fibrous-radiating texture, and in veins or fracture fillings. Serpentinites are altered to friable mineral assemblage that consists mainly of clay and carbonates.

Provided that exploitation/exploration of the Cu ores at Montecastelli definitively stopped after the Second World War, spontaneous mineral carbonation of serpentinite clasts disposed in mine dumps has likely occurred during the last 60 years. Mineralogical, geochemical and isotopic (O, C, Sr) investigations will provide insights to the P,T conditions and fluid composition during carbonate precipitation in mine dumps at Montecastelli.

D6-10 Orale Orlando, Andrea

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DISSOLUTION AND CARBONATION OF A SERPENTINITE: INFERENCES FROM EXPERIMENTS UP TO 300 °C AND 30 MPa

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Key terms: mineral carbonation; high P-T experiments; acid attack; dissolution rate; sequestration of CO₂

Mineral trapping is a crucial process in a CO₂ sequestration perspective and it can be simplified as the sum of two consecutive processes: 1) dissolution of primary silicate minerals, such as olivine, serpentine, and pyroxenes, which are mainly found in igneous ultramafic rocks, variably affected by alteration processes, and 2) precipitation of carbonates as a consequence of reaction between solutions and CO₂. Several parameters, such as temperature, pressure, salinity of the solution, control the kinetics of the whole process. Thus, the realization of experimental tests taking into account these parameters is essential in either ex-situ or in situ CO₂ sequestration projects involving mineral trapping. An experimental study was performed within the ZEBU (Zero-Emission Biogas Use) project, aimed at increasing the CH₄ contents of biogas emitted from landfills through CO₂ separation and sequestration by serpentinite carbonation. Experiments in order to determine dissolution rates of a serpentinite sample mainly consisting of lizardite (with subordinate orthopyroxene, magnetite, and chromite) were performed under different P-T conditions (up to 30 MPa and 300 °C) in aqueous solutions at variable salinity. In particular, at 0.1 MPa and 70 °C, serpentinite was reacted with an acid solution (H₂SO₄ 2M) over different times (up to 24h). MgO extraction from the rock turned out to be efficient, varying between 82 to 97%, depending upon the reaction time. Calculated dissolution rates vary from 4.0 x10⁻⁹ to 8.5 x10⁻¹⁰ mole m⁻² s⁻¹. Carbonation tests were subsequently performed rising the pH of the solutions up to 9.5 (through addition of NH₃ solution) under a CO₂ flux, but they failed since Mg- and NH₄- bearing hydrated (or anhydrous) sulphates precipitated causing a considerable Mg depletion of the solutions. In contrast, precipitation of a Mg-hydrated carbonate, nesquehonite, occurred upon mixing a synthetic MgCl₂ solution (which simulates acid attack performed using HCl instead of H₂SO₄) with a solution of (NH₄)₂CO₃ obtained through absorption of CO₂ (from synthetic biogas) in ammonia.

At higher pressures, the serpentinite was reacted with a NaCl-bearing aqueous solution and supercritical CO₂ at 9-30 MPa and 250-300 °C, either in a stirred reactor or in externally heated pressure vessel. CO₂ was supplied from a tank (stirrer reactor) or produced from decomposition of oxalic acid or silver oxalate (pressure vessel). Serpentinite carbonation occurs after 24h at 30 MPa, 300 °C in 100 g L⁻¹ NaCl aqueous solutions. Under these conditions, Fe- and Ca- containing magnesite crystallized; its amount varies from 5 to 10 wt%. As regards the sequestration degree, CO₂ uptake attains a maximum of 16 mol% and possibly can be further enhanced by increasing the salinity of the aqueous solution. Assuming the

rock to be constituted only by pure lizardite, the calculated dissolution rates under these conditions range from 6.3×10^{-11} to 1.3×10^{-10} mole $m^{-2} s^{-1}$, and are roughly comparable to the value obtained through acid attack at 0.1 MPa and 70 °C for similar experimental duration. Overall, the results of the experiments indicate that single-step significant carbonation could be (quickly) attained at high P-T conditions avoiding acid attack. Under atmospheric conditions Mg is extracted very efficiently from serpentinite in acidic environment, but the pH of the obtained solution must be adjusted carefully, to avoid the precipitation of non carbonates Mg-containing solids.

D6-11 Poster Cantucci, Barbara

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GEOCHEMICAL BARRIERS IN CO₂ CAPTURE AND STORAGE: A CASE STUDY

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Key terms: Reactive transport simulation; CO₂ Storage; saline aquifers

The fate of CO₂ once injected into a saline aquifer can be predicted by means of numerical modeling procedures of geochemical processes and fluid flow properties, these theoretical calculations being one of the few approaches for investigating the short-to-long-term consequences of CO₂ storage into a deep reservoir.

In this work the results of a methodological approach for the assessment of the CO₂ injection impact in the reservoir and the cap-rock stability in an offshore reservoir in the Tyrrhenian Sea are shown and discussed. The stratigraphic succession of the investigated area is constrained by a more than 3500 m deep well. It is characterized by: a thick marly-to-clayey cover succession overlying a calcareous fractured succession. The first geological sequence can be considered as an efficient cap-rock, whereas the last unit represents the reservoir of a huge regional deep aquifer. A re-interpretation of available seismic reflection dataset was performed to build a 3D geological model and to calculate its Gross Reservoir Volume.

3D simulations were performed by the TOUGHREACT code at the theoretical CO₂ injection pressure. In order to understand the nuances of this complex system, three different simulations were carried out. The first model is a stratigraphic column with a size of 0.11x0.11x4 km and a metric resolution in the injection/cap-rock area (total of 8,470 elements), with the goal to assess the geochemical evolution of the cap-rock and to ensure the sealing of the system. The second simulation is a horizontal model with a size of 99x11x11 m to study the fate of the displaced water at the plume front and the permeability variations as the injected CO₂ has started to promote geochemical reactions. The third simulation is at full scale (13.5x12.75x4 km) in order to predict the CO₂ path from the injection towards the spill point.

The most important effect evidenced in these runs is a barrier effect due to the flow of the CO₂-rich acidic water into the carbonate reservoir, originating a complex precipitation/dissolution surface that may have an effective impact on CO₂ sequestration due to the reduction of available storage volume reached by the CO₂ plume in 20 years and/or the enhancing of the required injection pressure.

Kinetic modeling suggests a rough dissolution of calcite of about 20% in volume close to the injection well, although precipitation occurs in the reservoir as soon as the effect of the CO₂ plume has disappeared. Basically, as the acidic saline fluid mixes with the alkaline formation waters calcite is precipitating. This implies that at the injection point the permeability increases and a sort of geochemical barrier is produced downstream along the fluid flow path. As a consequence, two key zones can be distinguished: i) inside and ii) outside the CO₂ plume. Calcite behavior may be regarded as "displacement" from the CO₂-rich water front to the downstream fluid path and this is likely the main cause of porosity/permeability reduction. This barrier diminishes the outflow velocity of the CO₂-displaced water, producing a lower CO₂ injectivity. The formation of secondary minerals occurs inside the plume where more acidic conditions are encountered, while the CO₂ plume grows as the injection proceeds up to roughly 1 km of radius after the injection of 30Mt of CO₂ in 20 years.

SESSIONE D9

Energia geotermica per lo sviluppo sostenibile: esplorazione e caratterizzazione delle risorse

D9-1 Orale La Licata, Ivana

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LOW ENTHALPY GEOTHERMAL ENERGY: HEAT EXCHANGE SIMULATION IN AQUIFERS THROUGH MODFLOW AND TRNVDSTP CODES

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Key terms: Modflow; Trnvdstp; borehole heat exchanger; modelation

Simulation models can be applied for a more effective use of the subsol for geothermal purposes. In fact they are useful tools for the design of efficient systems which consider also the need to not create abnormal temperature distributions in soil and aquifers.

Aim of this study is to simulate a borehole heat exchanger through two computer codes: the first one often used in ground source heat pump design (TRNVDSTP, coupled to TRNSYS), the second one suitable for groundwater flow and transport models (MODFLOW/MT3D). The two software have been compared in terms of predicted heat exchange and temperature distribution in the aquifer. A geothermal system, consisting

of a 100 m U-pipe, located into a 200 m saturated sandy aquifer, assumed homogeneous for simplicity, has been implemented in the two programs. Simulations have been performed for a one year period representing winter and summer operation of a ground source heat pump.

Initial attempts with simplified simulations have shown the need to implement in Modflow the typical U-pipe geometry of a real borehole heat exchanger, although this implies strong grid refinement and extensive computational resources. Since TRNVDSTP is considered reliable if only thermal conduction is present, the first runs were performed without a groundwater flow. A good agreement has been observed between the results of the two software, both in relation to exchanged energies and temperature distribution into the model domain. In particular, the difference of exchanged energy, function of the fluid temperature inside the borehole heat exchanger, is less than 6%; also, in two observation points, located at a distance of 0.60 and 2.75 m from the centre of the U-pipe, the observed temperature differences are respectively lower than 1.06°C and 0.25°C. Thus, representing the real U-pipe geometry in Modflow, the program returns reliable results.

The simulated situation, which does not account for a groundwater flow, is not completely representative of the field conditions where groundwater heat exchangers are applied; thus some simulations considering the presence of the groundwater flow, and maintaining the U-pipe geometry, have been performed. In this latter case, the results in terms of exchanged energy differ of about 150%; in the two observation points the simulated temperature difference is less than 1.93°C and 0.78°C, respectively at the distance of 0.60 and 2.75 m. Therefore the two codes seem now to differently simulate the heat transfer between U-pipe and aquifer and then the impact of the geothermal system on groundwater. However Modflow seems suitable for being used also with technical purposes once the causes of the difference in the simulated temperature have been determined. The lack of experimental data and the difficulty in comparing the analyzed situation to the few modelation cases present in literature, have made difficult an exact evaluation of the accuracy of the observed results.

In next step of this research it could be useful to consider the results of some well-known analytic case in order to evaluate which one of the two codes better simulates the thermal exchange.

Anyway it is possible to conclude that the use of computer codes for geothermal systems design provides a positive support, also due to the availability of two reliable computer programs at least.

The comparison between the results obtained using Modflow and TRNVDSTP and those of the analytical solution could identify defects and strong points of the performed simulations; the efforts required to achieve a good match between simulations and analytical solution could also provide useful information for the improvement of the codes features in geothermal system simulations.

D9-2 Orale La Vigna, Francesco

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CHARACTERIZATION AND MONITORING OF AQUIFERS FOR LOW-ENTHALPY GEOTHERMAL ENERGY EXPLOITATION: THE CASE OF ROME

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Key terms: low-enthalpy geothermal energy; monitoring; characterization

The importance of monitoring of hydrogeological parameters in areas of low-enthalpy resource exploitation covers two basic roles: the first one is related to the study of the thermal potential of the aquifers and their seasonal variations, the second concerns the study of physical and chemical changes of groundwater due to the plants in operation.

Two case studies located in the City of Rome are presented: the first relates to an area of the Tiber alluvial Valley, the second concerns the geological sequences of the "paleo-Tiber" the "F.so Crescenza" formation. In the first case, the study focused mainly in the definition of low enthalpy geothermal potential of waters of the two main aquifers of the alluvial Tiber deposits.

The second case focuses primarily on monitoring the chemical-physical and microbiological changes in the groundwater during the pre and post geothermal exchanger installation, and during the operation of the plant.

D9-3 Orale Pasquale, Vincenzo

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TIME-VARYING PROCESSES AFFECTING THE SURFACE HEAT FLOW IN THE WESTERN PO BASIN

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Key terms: Thermal geophysics; Terrestrial heat flow; Sedimentary basin

The thermal history of a sedimentary basin implies the superposition of different heat-transport mechanisms and geodynamic processes which cause changes in the structure and distribution of physical parameters. The thermal field is mirrored by the surface heat flow which is also a fundamental parameter for the evaluation of geothermal resources and their potential. This paper presents heat-flow data of the western Po Basin and surrounding areas, and analyzes the effects on the heat flow due to long-term climate change, radiogenic heat production, sedimentation and thrust faulting.

Thermal and stratigraphic data recovered from petroleum wells were used as basic information. The bottom-hole temperatures were processed for the cooling of the drilling mud and the in-situ vertical thermal conductivity was inferred by taking into account changes due to temperature, burial depth and anisotropy. Temperature data were corrected for the last Pleistocene glaciation, which has lasted over several ten thousand years and still affects the thermal regime to a few thousand meters.

Since the method chosen to determine the heat flow depends on the data quality and the precision required in the results, we utilized a technique based on the thermal resistance. High heat generation results in a decrease in heat flow with depth. Radioactive heat production was determined in the laboratory for a few rock samples. Moreover, as natural gamma-ray logs are available for a number of wells scattered in the basin, an empirical relation was used to convert logs into heat production. Heat

generation is lower in evaporites and carbonates, from low to medium in sandstones, higher in shale and siltstone. Calculations show that heat production should be taken into account in modeling the basin thermal evolution if the sediment layer is thick (>4 km) and if long time spans (>10 m.y.) are considered.

The heat flow is noticeably reduced when the rate and the duration of sedimentation are relatively high. As an initial condition, we assumed a horizontal depositional surface in thermal equilibrium with the underlying stratum of constant thermal properties. On the sea floor, sediment of the same conductivity is accumulated at a uniform rate. It turns out that for normal rates (of order to 0.001-0.01 mm/yr) the effect on the surface heat flow is negligible. With a Plio-Quaternary sedimentation rate as high as 0.1 mm/yr, the disturbance becomes significant in comparison with the measurement error.

Validation of the inferred surface heat flow was made by modeling the thermal state along a geological cross-section spanning from the buried thrusts of the Southern Alps to the Northern Apennines, through the undisturbed foredeep sector of the Po Basin. The model geometry and the petrophysical properties were based on depth-migrated seismic profiles and well information. A finite element approach was used to model the steady-state, purely conductive thermal regime. The measured heat flow is lower than the predicted one in correspondence of the Alps and Apennines buried thrusts. This can be accounted for by a still present transient thermal perturbation, which has been originated by thrusting and folding of the two orogenic belts. For estimating this effect, we use an overthrust model that combines friction heating along the thrust plane with the thermal effect due to relaxation of the thermal gradient. This model is valid if the solid state convection heat transport dominates conductive flow away from the thrust. If the thrust rate is relatively high (1-5 cm/yr) and the thrust sheets thick (>5 km), this process can yield an anomalously low heat flow.

D9-4 Orale Comina, Cesare

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GRAVITY SURVEYS FOR THE IDENTIFICATION OF THERMAL ANOMALIES A CASE HISTORY IN THE ARGENTERA MASSIF.

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Key terms: Geothermal energy; Gravity methods; Geophysical exploration

The Argentera massif in Northern Italy provides an ideal site to investigate the potential of gravity measurements for geothermal resource assessment since the thermal anomalies reveal shallow surface manifestations such as hot springs. The geological and structural setting of the massif is, however, very complex and can be extrapolated to the subsurface only by structural investigations (Baietto, 2006) and geothermal potentiality could be addressed only by appropriate geochemical analysis to understand the circulation system (Guglielmetti, 2010). In this respect gravity data will be a fundamental aid in the comprehension of the geothermal system and in the location of the reservoir.

In this study, we will present the interpretation of a total of 384 gravity measurements collected during summer 2010 on the massif. One of the main goal of the campaign was to investigate the geological structures at depth in order to identify any natural gravity anomaly and figure out if it could be related to the circulation of hot waters or to the presence of a geothermal reservoir at depth.

From the geological point of view, the Argentera Massif, is the southernmost of the external crystalline massifs of the Alps. It is a pop-up structure cropping out owing both to its uplift and to the erosion of the Mesozoic sedimentary succession (Perello, 2001). The studied thermal springs are entirely located within the Malinvern Argentera Complex, which rocks, mainly constituted of quartz, K-feldspar, plagioclase, biotite, are highly milonitized and, as a result, the reservoir rock contains numerous microfractures (Michard, 1989). The structural setting of the Argentera Massif is the result brittle reactivation of pre-Alpine and early-Alpine ductile shear zones. A main NW-SE shear zone, the Valletta Shear Zone, crosscuts the massif dividing the two complexes and runs parallel to the corridor of the Bersezio Fault, a wide zone of fracturing and pervasive cataclases composed by several faults trending 150° and consisting of fractured protholith rocks, fault breccias, cataclases and gouges. In the central part of the massif, the Bersezio Fault connects to the Fremamorta Shear Zone, an E-W oriented milonitic corridor with a reverse sense of shear.

The gravity campaign was planned to cover as much as possible the Italian side of the Argentera Massif. Measures were carried out every 250m and high precision positions were collected using DGPS. Because of the highly mountainous region gravity data were collected both along trails and paved roads following the main valleys. Forward modeling and Inversion methods were applied on geological cross sections extracted from a preliminary 3D geological model. In particular two profiles crossing to the thermal areas locations have been studied. Gravity data inversions along these profiles have shown a very good fit with experimental data and are able to map with depth the faults superficially observed. Moreover the evidence of strong density anomalies near the hot spring locations has been observed.

Further studies are however suggested to collect gravity data also on the French side of the Argentera Massif increasing the density of the measuring stations; gravity results could moreover benefit from magnetotelluric measurements that could be carried out in some selected areas to highlight the resistivity anomalies at depth and compare them to the density distribution variations showed by gravity. A geomechanical study should be carried out to better understand the fracturation conditions of the cataclastic belts and fault zones to come out with more detailed 3D models that could be a useful tool to simulate thermal waters circulation and identify the presence of geothermal reservoirs that could be exploited for heat production and even power generation.

D9-5 Orale Rizzello, Daniele

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INTEGRATED GEOPHYSICAL SURVEY OF A GEOTHERMAL FIELD IN WEST JAVA (INDONESIA)

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Key terms: Geophysical exploration; Magnetotellurics; Gravity; Geothermal field

A major problem in understanding the hydrothermal properties of geothermal reservoirs is to provide images of the subsurface structures, which can host geothermal fluids by means of appropriate geophysical techniques. Electrical resistivity/conductivity is a primary physical property strongly controlled by the hydrothermal processes occurring in geothermal reservoirs. Resistivity can be used to infer open fracture systems and horizons of increased permeability and filled with fluids, as well as high conductivity alteration minerals (clays, etc.) of hydrothermal origin. Aimed at the reconstruction of the subsurface and structural setting together with the identification of horizons, which could host geothermal reservoirs, this paper presents the results of a series of magnetotelluric and time domain electromagnetic soundings has been carried out, together with gravity measurements, in a geothermal area located in West Java (Indonesia).

Geochemical and thermal features at two sites located in this area, show different characters. The north-east site discharges fluids coming from a reservoir typical of volcanic-magmatic association, with temperatures ranging from 180-200 °C. Rainwater feeds the deep aquifer and the recharge area could be in principle situated not too far from the discharge site. The fluids discharged at the south-west zone are hosted in a geothermal reservoir with temperatures ranging from 140 to 160 °C. Rainwater feeds also this reservoir, which should be hosted in granitoid rocks.

Magnetotelluric survey has revealed significant differences in resistivity structure between these two geothermal zones. In the SW area, the conductive layer (clay cap) is rather discontinuous and shallow. The resistivity maintains relatively moderate, with values of 10-50 ohm m, to depth of about 2000 m below the surface. This agrees with a moderate alteration to large depth due to flow of fluid with relatively low temperatures. A possible explanation of this geoelectric setting is groundwater flow through discrete fractures zones scattered within a basement. The thermal manifestations might occur through a major fracture zone. The NE area presents a well discernible and thick (up to 500 m) conductive layer (<10 ohm m), interpretable as a cap rock. This layer is present next to the hot springs area and around it. Beneath the conductive layer, the resistivity increases with depth more rapidly than in the SW area. At depth of 1000-1500 m below the surface, resistivity shows average values larger than 50-100 ohm m. This resistivity pattern supports a hydraulic model through a diffuse flow of thermal groundwater. Sudden lateral changes in resistivity in correspondence of a valley in the NE site, support the presence of a near vertical fault, which might control the groundwater upflow. The Bouguer gravity anomaly is of relatively small magnitude, so that the presence of buried high-density bodies, which could act as heat sources for the hydrothermal systems, has to be excluded. The main positive anomaly, observed at the SW edge of the investigated area, could be related to an intrusive granodioritic body, also encountered by drilling, and the associated volcanic rocks cropping out, and it may reflect the border of an uplifted structure. In the above-mentioned NE site valley, the gravity map puts into evidence the possible presence of a fault roughly NNE/SSW directed.

In synthesis, the different resistivity structure between the two areas argues that the two main geothermal sites belong to geothermal systems which are hydraulically and thermally distinct. Also in relation to the reservoir temperatures estimated with geothermometers, the resistivity pattern appears more promising at and around the NE thermal area.

D9-6 Orale Stocco, Stefano

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SPATIALLY CONSTRAINED INVERSION OF 3D MAGNETO TELLURIC DATA FOR GEOTHERMAL RESOURCE ASSESSMENT: THE TRAVALE CASE HISTORY.

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Key terms: magneto-telluric; geothermal resource; inversion; constraint; 3D model

The use of Magneto Telluric (MT) data for geothermal resource assessment is widely documented in scientific literature (Simpson and Bahr, 2005) because of its versatility, the significant depth of investigation that could be obtained and the potential relationships between the reconstructed electrical resistivity and the thermal properties of the fluids saturating the rock mass. However, MT data inversion approaches are often limited to the reconstruction of 3D structures from one-dimensional inversions of single investigation points or two-dimensional sections along a profile (Aragno et al., 2009; Strack et al., 2008; Azeez and Harinarayana, 2007; Newman et al., 2005).

In this paper, to overcome these limitations, an algorithm for the interpretation of 3D MT data based on a spatially constrained inversion process is proposed. The core of the algorithm consists in a least-squares inversion process in which all the MT sounding points are inverted globally for a complete representation of the investigated area. In this way a unique misfit function is used representing the whole dataset. Each MT sounding is inverted in terms of a one-dimensional resistivity profile but is linked to the closer profiles with appropriate spatial constraints. The structure of the algorithm has been developed on the basis of many similar literature works using analogous approaches for the interpretation of other geophysical data. In particular, the laterally constrained inversion (LCI) algorithm originally presented by Auken and Christiansen (2004) for the interpretation of resistivity data, which was successfully applied to the inversion of surface wave data (Socco et al., 2006). The spatial constraints can be considered as a priori information based on the geological variability of the investigated area: the smaller the expected variation of the model parameters, the more rigid will be the used constraints. In this way it is possible to obtain a subsoil model more or less regularized according to the intensity of the chosen constraints. A priori information on the geology of the site, deriving, for example, by other geophysical surveys or local drillings, could be moreover incorporated in the inversion process allowing for a more reliable model of the area.

An application to a real dataset of the spatially constrained inversion algorithm will be therefore presented to underlining the potentialities of the selected approach. In particular data from an extensive MT survey (a total of 55 soundings) carried out in the geothermal system of Travale

(Tuscany, Italy) will be presented. This last geothermal system is located at the eastern margin of a wide and homogeneous geothermal area, which include the Larderello site, in central Italy. The geological and structural setting of the Travale area involves, below a cover made of neogenic sediments and flysch facies formations, carbonate-anhydrite rocks of the Tuscan Nappe and the Metamorphic Basement. In the lower part of the metamorphic basement, contact metamorphic rocks (Skarn and Hornfels) are often met and represent the contact metamorphic aureole overlying granite intrusions. This aureole exhibits increased permeability due to the presence of fractures and is seismically characterized as a high amplitude seismic reflector (H Marker), that can constitute the potential target for deep wells (Bertini et al., 2006). The main geothermal reservoir is located in metamorphic, thermo-metamorphic and magmatic rocks up to 4000 m depth, characterized by a high degree of heterogeneity and anisotropy. The exploited fluid is superheated steam with temperature ranging up to 350 °C and pressure values around 6-7 MPa at production depth (about 3000 m). The spatially constrained inversion of MT data at this site has shed new light on the possibility of spatially describing the reservoir.

D9-7 Orale Ruggieri, Giovanni

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CONTRIBUTION OF FLUID INCLUSION STUDIES TO GEOTHERMAL RESEARCHES

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Key terms: fluid inclusions; geothermal fields; Larderello (Italy); Berlin (El Salvador); Tendhau (Ethiopia)

Quantitative estimates of the physical-chemical conditions in active geothermal fields and their temporal evolution are of great importance for an optimal exploitation of geothermal resources. Much of the information on geothermal reservoirs characteristics comes from direct in-hole measurements, core samples and geochemical data on the reservoir fluids. Additional, and sometimes unique, information on the reservoir fluids can be obtained from studies of the fluid inclusions trapped within minerals formed during geothermal activity. As fluid inclusions record very local fluid circulation conditions, they represent the fluids present in well-defined zones of the geothermal reservoir. They are, moreover, the only direct evidence of the fluids that have circulated at different times through the reservoir rocks. The study of fluid inclusions, therefore, can provide important information on the local characteristics of the reservoir and on the time-space evolution of its geothermal fluids. The studies carried out on fluid inclusions in the last three decades by researchers of the International Institute for Geothermal Researches of CNR (Institute for Geosciences and Earth Resources (IGG-CNR) from 2002) have yielded important data on the fluids that have circulated in the geothermal fields of Southern Tuscany (Larderello-Travale-Montieri and Mt. Amiata), Ethiopia (Langano and Tendhau) and El Salvador (Berlin, Auachapan, Tortughero). These data provide useful information for both the evaluation of geothermal resources and in the geothermal exploration. For example, concerning the Larderello-Travale geothermal system, data on fluid inclusions trapped in samples from the deepest areas of the system (>2500 m below the ground level) provide information on physical-chemical nature of the fluids (i.e. aqueous-carbonic fluids at supra-hydrostatic pressure) that might be encountered by any drilling reaching the "K" seismic horizon. At Mt. Amiata, fluid inclusions trapped in deep samples of the Bagnore area show that the past geothermal fluids were enriched in CO₂ with respect to present-day fluids and that boiling processes depleted the CO₂ in the fluid. In the case of the Berlin geothermal field (El Salvador) fluid inclusion temperature data indicate a marked cooling process in the southern part of the field and confirm that the recorded temperature inversion in the deepest areas reached by the geothermal wells was not induced by geothermal drillings but it is a natural feature of this part of the system. Finally, studies on fluid inclusions of the Tendhau geothermal field instead showed different thermal histories (cooling, heating or substantial thermal equilibrium) depending on the location of the geothermal wells and on the sample depth.

D9-8 Orale Manzella, Adele

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GEOTHERMAL RESOURCE ASSESSMENT OF SOUTHERN ITALY, THE "VIGOR" AND "ATLANTE GEOTERMICO" CNR PROJECTS

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Key terms: geothermal exploration; geothermal potential; atlas; assessment

A part of the session "D-9 Energia geotermica per lo sviluppo sostenibile: esplorazione e caratterizzazione delle risorse" is dedicated to the discussion of the preliminary results of the VIGOR and "Atlante Geotermico" projects carried out by the CNR. The project "Atlante geotermico", within the framework of the "Progetti Mezzogiorno" of CNR, represents a first level of geothermal data systematization, that will verify and locate conventional as well as unconventional geothermal resources for the regions of Southern Italy. The Southern Italy Geothermal Atlas, with a comparable format to that produced in the USA and prepared in other European countries, aims to provide the updating of the available information related to hydrothermal systems, including also the organization of different kind of information, which are the key point to produce an assessment of the geothermal resource, as well as the identification of the new types of resources, constituting a major opportunity to harness new sources of sustainable energy. At the same time, and starting from the results arisen from the Atlante Geotermico, the evaluation of the geothermal potential of Regions of Convergence -Campania, Puglia, Calabria, Sicilia- will be performed in the frame of the VIGOR Project. The VIGOR project was activated by the operative agreement between the MISE DGENRE (Directorate General for Nuclear Energy, Renewable Energy and Energy Efficiency) and the CNR DTA (National Research Council of Italy, Department of Earth and Environment) under the line of activity 1.4 of POI "Renewable Energy and Energy Conservation 2007-2013". The project marks an important step towards the broader goal of POI "Renewable Energy and Energy Conservation 2007-2013" to "Increase the proportion of energy produced by renewable sources and improving energy efficiency, fostering opportunities for local development".

These CNR Projects aim to provide analytical information useful to engage in exploration and exploitation for both high and low temperature resources, to broaden the knowledge of the natural potential and the real possibility of exploitation of geothermal resources in the Regions of Southern Italy. In these areas, the amount of energy produced from this sources is irrelevant today, despite the interesting perspectives, assessed in relation to new ways of widespread use of geothermal energy, with innovative technologies capable of triggering a thermal cycle even with small temperature differences. A main goal of the projects is also to provide the Ministry of Economic Development - DGENRE with feasibility studies to be used for the formulation of specific calls. This presentation will discuss in detail the characteristics of the projects and give the status of the ongoing activities.

D9-9 Orale Galgaro, Antonio

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GIS-SUPPORTED MAPPING OF SHALLOW GEOTHERMAL POTENTIAL OF SOUTHERN ITALY (VIGOR PROJECT): FIRST RESULTS

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Key terms: GEOEXCHANGE POTENTIAL; GIS MAPPING; GSHP; RENEWABLE ENERGY; SOUTH ITALY

The increasing interest in the direct utilization of shallow geothermal energy comes with the wish for better knowledge about the factors influencing its efficiency.

The project VIGOR (Evaluation of geothermal potential of Convergence Regions) aims to provide useful analytical information to initiate exploration and use of energy from geothermal sources, through the creation of a detailed reconnaissance operations, analysis and case studies to systematize and expand the knowledge of the natural potential and the potential for exploitation of geothermal resources in the territory of Campania, Calabria, Puglia and Sicily (Convergence regions).

The project is voted to extension and systematization of existing knowledge, it will produce all the necessary elements of knowledge (technical and economic feasibility) to carry out executive plans to use geothermal resources in the regions cited even for space conditioning and in other uses in the industrial, power production, agro-tourism and spa. It will also be taken care of the promotion of geothermal resources and its use and disclosure in order to develop an awareness of the population and develop the socio-economic and productive territories.

For this purposes we focused on the subsurface condition's influence on the use of borehole heat exchangers (BHEs) coupled with a heat pump for heating purposes, since this is the most popular heat-extracting technique. We created maps showing the potential for this technique provided by the thermal underground properties. Therefore, we established an underground model for two study areas in south-Italy (Puglia and Calabria) with different geological settings, by using a geographic information system (GIS). The subsurface has been divided into layers with similar thermal properties based on geological, hydrogeological and lithological information, in according to international existing properties database. For depths of 100 m, the weighted mean value of the specific thermal features were calculated and presented within maps. These maps point out how the heat exchange potential differs within and between the study areas and how it depends on local geological assessment.

D9-10 Orale Inversi, Barbara

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CHARACTERIZATION OF MEDIUM ENTHALPY GEOTHERMAL RESOURCES IN THE CAMPANIA REGION (SOUTHERN ITALY): PRELIMINARY RESULTS WITHIN THE FRAMEWORK OF THE VIGOR PROJECT

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Key terms: Geothermics; Campania; 3D Models

Within the framework of the VIGOR project, a characterization of medium enthalpy geothermal resources have been carried out in the Campania region (Southern Italy), with a focus on of "Guardia dei Lombardi" area (province of Avellino).

The VIGOR project has been developed based on an agreement between the Italian Ministry of Economic Development and the National Research Council, for the realization of innovative uses of geothermal sources in the so-called "regions of convergence" (Campania, Calabria, Puglia and Sicilia).

Thanks to the intense hydrocarbon exploration, carried out particularly during the 1956-1996 period, an extensive dataset made up by deep wells and seismic reflection profiles exists in the study area. The previous exploration demonstrated the presence of a fractured carbonate reservoir, mainly belonging to the Cretaceous section of the Apulian shallow water carbonate platform, which is deformed to shape a buried antiformal stack. The culmination of the uppermost thrust unit reaches a depth of about 200 m below sea level (i.e., about 1100 m below the ground level). The reservoir fluids are made up by a CO₂ gas cap, which rests above an accumulation of fresh water in the central and upper part of the culmination (e.g., Monte Forcuso 1 and 2 wells) and on salt water along the flank of the buried anticline (e.g., Bonito 1 Dir, Ciccone 1 wells). Medium enthalpy geothermal resources with a reservoir fluid up to 100°C have been estimated at depth of 2000 m below ground level by ENEL in previous assessments.

However, the presence of thermal springs (e.g. Terme di S. Teodoro) in the area suggest the presence of an active hydraulic circuit and provide further constraints about the geochemical characteristics of the reservoir waters and geothermometers which confirm a reservoir fluid temperature up to about 124 °C.

In this study, the overall reservoir/caprock system structural-stratigraphic setting has been defined based on the integrated interpretation of surface geology, public and available seismic reflection profiles, and composite well logs. In particular, a careful assessment of temperature field at depth has been carried out analyzing well logs through Horner plot construction. Where the data were scarce, a simplified approach has been applied. Moreover, based on well tests, cores and losses/absorptions the reservoir permeability was also re-estimated, confirming quite good permeability value for the fractured carbonate reservoir.

One of the main results of this research is the development of an integrated 3D geological model which provides the base for a detailed assessment of the possible geothermal exploitation of the carbonate reservoir. The preliminary results of our analysis suggest that the "Guardia dei Lombardi" site can be indicated as an interesting area for the geothermal medium enthalpy exploitation, although the presence of the CO₂ gas cap should be carefully evaluated.

D9-11 Poster Bruno, Delia Evelina

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THE DEFINITION OF REGULATIONS AND TRANSPARENT PROCEDURES FOR AUTHORIZATIONS TO PROMOTE THE LOW ENTHALPY GEOTHERMAL: THE VIGOR PROJECT'S CONTRIBUTION

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Key terms: environmental regulations; geological survey; aquifer; map; hydrothermal

Today, in the "Convergence Regions" (Puglia, Campania, Calabria, Sicilia) the amount of energy produced by geothermal resources is still negligible, despite the exciting opportunities to exploit even in the less significant geothermal potential areas, with considerable economy for the air-conditioned and the hot-water production. The "Vigor: evaluation of geothermal potential" project was started as from October 2010 with 24 months of life. The project's objectives are related to examination, identification and dissemination of all scientific and technical informations concerning the evaluation of geothermal potential in the Convergence Regions. Moreover, it aims to promote the optimum conditions in terms of regulations and administrative practices.

In fact, one of its objectives is to support the balanced development of the environmental compartment, preventing deficiencies and asymmetries with particular reference to other renewable resources affected by an initial legislation's delay. Therefore one of the activities is the informations collection of the bureaucratic procedures related to exploration and exploitation of geothermal resources in the four regions. Currently, while the plants for electric energy by renewable resources receive constant attention by the legislature, the geothermal potential exploitation is indirectly treated only. So, this research with connected applications, from the legal point of view, could incur into bureaucratic obstacles avoiding difficulties of interpretation.

Hence, the first step for these activities involved a review of existing regulations, through the drafting of a questionnaire submitted to the Regions offices. The evidences examination for the best regulative practices at national and international levels, with the informations described and discussed in the context analysis, will make certain assumptions of guidelines, protocols and authorizations of regulative instruments. The normatives uniformity will be evaluated and discussed with the scientific support of all researchers involved in VIGOR.

D9-12 Poster Caputo, Maria Clementina

10.1474/Epitome.04.0371.Geoitalia2011

HYDROGEOLOGICAL CHARACTERIZATION OF A COASTAL AREA AIMED AT THE EXPLOITATION OF LOW ENTHALPY GEOTHERMAL RESOURCES

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Key terms: hydrological characterization; geothermal resource; low enthalpy

The interest in low enthalpy geothermal energy is growing in Italy in last years because the geothermal energy represents an important resource among the different kinds of green energies. However the exploitation of the geothermal resources concerns many issues related its environmental sustainability.

Particularly, the matter involves the open loop geothermal systems because of their direct use of groundwater. In the coastal areas, generally characterized by shallow aquifer, the installation of the geothermal systems is considered economically convenient because it doesn't need deep boreholes. Despite this positive aspect there are others negative ones also. Often these areas are affected by seawater intrusion and for this reason; the use of the coastal aquifer is ruled by restrictive laws aimed to protect the groundwater quality and quantity. This is a major problem for geothermal resources development, particularly in regions characterized for most of their territory from coasts. However, as the most of the population, the most important touristic destinations and the larger industrial sites are concentrated along the coast, the exploitation of geothermal resource in these areas is becoming more and more of interest.

This work deals with a hydrogeological characterization by means field tests and experimental measurements carried out in a coastal karst area of Apulia Region, located about 2 km far from the sea. Specifically, the study area extends for about 20 Km² and has been chosen within the VIGOR project as pilot site to study the influence of an open loop geothermal systems, on the sea water intrusion.

In the study area different tests, such as pumping tests, have been carried out in different times in order to determine the aquifer transmissivity; a wells monitoring network has been defined to monitor the depth and the hydraulic gradient of groundwater and its salinity and temperature.

All the data (geological, hydrogeological, geochemical and geophysical) and information collected during the exploration phase, allowed a detailed characterization of the fissured-karst aquifer.

The experimental approach utilized for this study represents a good effort to define a standard methodology, for hydraulic characterization of a coastal site, usefull for a feasibility study of an open loop geothermal system.

D9-13 Poster Petruccione, Emanuela

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A PRELIMINARY GEOTHERMAL EVALUATION OF THE MONDRAGONE AREA (CAMPANIAN PLAIN, SOUTHERN ITALY) IN THE FRAME OF THE VIGOR PROJECT

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Key terms: Campania Region; Geothermal Exploration; Geothermal Resource Assessment

An organic organization and implementation of the available geothermal data in the southern Italian Regions (Campania, Calabria, Puglia and Sicily) useful to improve the exploration and exploitation of geothermal reservoirs, is the aim of the CNR project "Evaluation of Geothermal Potential in Convergence Regions" (VIGOR), financed by the Inter-Regional Operational Programme "Renewable Energy and Energy Conservation" POI 2007-2013.

In the Mondragone area hydrothermal evidences has been known since roman time, and this area has been chosen to further improve geothermal knowledge through new geophysical and geological exploration survey. From the geological point of view, the area is defined by an horst structure (Mt. Massico) elongate in NE-SW direction, characterized by a succession of Triassic-Cretaceous dolomitic limestone and Miocene terrigenous sediments. The Quaternary deposits are widespread in the adjacent plains , where the continental and marine sediments, interbedded with Roccamonfina and Campi Flegrei pyroclastic deposits, filling the Garigliano, to NW, and Volturno, to SE, graben, separated by the Mt. Massico horst through a NE-SW striking normal faults (Bergomi et al., 1969).

Field and seismic data indicate the study area is interested by deep normal NE-SW and N-S striking faults, although ESE-WNW to E-W strike-slip left-lateral faults are also present (Billi et al., 1997; Bruno et al., 2000). Probably these structural pattern plays an important role for the Mt. Massico groundwater circulation, partially confining such structure from the less permeable deposits of plains, and allowing the groundwater to flow primarily to the aquifer of the Garigliano plain (Allocca et al., 2005).

At the southeastern edge of the massif four sulfur hot springs with temperatures between 22°C and 50°C emerge. In particular two hot springs, ("La Calda" and "Della Salute", up to 50°C and 29°C respectively) are located at the foothill of the Miocene terrigenous succession of Mt. Pizzuto, closely to the coast (Bergomi et al., 1969, Corniello, 1988). While the other two ("S. Giuseppe" and "Mt. Petriolo solforosa" up to 22°C and 28°C respectively) are located at the foothill of the Mt. Petriolo carbonatic structure (Trumpy & Manzella, 2009).

According to some authors, the hot springs are fed by groundwater carbonate aquifer, where the water is heated and enriched of endogenous gas (CO₂, H₂S), rising along the extensive and deep tectonic discontinuity present, further testified by the morphological evidenced (sinkholes) found all along the southeastern edge of the Mt. Massico (Del Prete et al., 2004). Moreover the different temperatures and degrees of mineralization of the four springs are interpreted as closely linked to the rising speed and water-rock contact time (Corniello, 1988; Allocca et al., 2005).

A delimited area of 20 km² south-east of Mt. Massico has been chosen to be studied by means of geological and geophysical surveys and deep drilling to provide analytical information useful to develop an hydrogeological 3D model that will allows the application of technologies for direct exploitation of heat from geothermal source.

D9-14 Poster Carlino, Stefano

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THE GEOTHERMAL POTENTIAL OF CAMPANIA VOLCANOES.

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Key terms: Geothermics; Volcanoes; Campi Flegrei; Ischia

Since 1939, many drilling finalized to the exploitation of the geothermal energy, were performed in volcanic district of Campania (Campi Flegrei, Ischia and Vesuvius), by SAFEN Company and subsequently, until 1985, by AGIP-ENEL joint venture. The attention to the geothermal energy exploration in Southern Italy was drawn by either the consolidate energy production of Larderello geothermal field (Tuscany) and by the oil crisis during the mid seventies. The results of the drilling were particularly interesting at Campi Flegrei and Ischia, where the high temperature (> 150°C) recorded at shallow depth (500 to 2000 m) and the occurrence of vigorous hot hydrothermal circulation, highlighted the possibility of geothermal exploitation also in the high enthalpy range. The project was abandoned at the end of 1970, probably due to technical problems related to the extraction of high salinity geothermal fluids, but also because the Italian Government preferred to comply with the oil economy. Nowadays, the advanced technology of geothermal plants (i.e. binary system) allows the solving of problems related to such harsh conditions.

The data obtained by drilling (down to 3 km of depth) and investigation between 1939 and 1985 allowed us to asses, by using the volume method, the geothermal resource for Campi Flegrei and Ischia, which correspond to a potential energy of about 6 and 11 GWy respectively. Such high values, together with the nowadays strong oil cost fluctuation and green energy policies, point out the needs to better define the actual possibility of geothermal exploitation in Campania volcanic district. In recent times, an important project (Campi Flegrei Deep Drilling Project, CFDDP) endorsed by the International Continental Drilling Program, is aimed to the understanding of the Campi Flegrei caldera dynamic and evaluate of the extractable geothermal resource, by two drillings located in the eastern sector of the caldera, the first (pilot hole) 500 m depth and

the second 3.5 km depth. The CFDDP will greatly improve scientific information of the eruptive history of the Campi Flegrei caldera, and knowledge of the related geothermal system. Thus, the project will represent a new starting point for the exploitation of geothermal resource in Southern Italy, where many areas are characterised by the presence of deep to shallow magma bodies, with high geothermal potential.

D9-15 Poster Giambastiani, Beatrice Maria Sole

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GEO.POWER: A PROJECT TO MANAGE THE GROWING DEMAND OF LOW-ENTHALPY GEOTHERMAL EXPLOITATION

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Key terms: Geothermal Energy; Renewable Energy Source; Ground-Coupled Heat Pump; Best Practice; Transferability

The European Union is committed to reducing its own greenhouse gas emissions by at least 20% by 2020 (compared with 1990 levels) by improving the use of renewable energy and decreasing energy consumption. Thus, the Commission in the Renewable Energy Road Map encourages the Member States and their local authorities to implement concrete measures within regional operational programmes in order to improve the yield of energy production and distribution, to facilitate investments in the green sector, and to encourage rational energy consumption behaviour.

Geothermal energy is one of the most environmental-friendly and cost-effective energy resources in use. Recent technological progress, cost variability, and the need to reduce the use of fossil fuels to cut pollution have made the exploitation of geothermal energy, especially low-enthalpy power generation utilizing Ground-Coupled Heat Pumps (GCHP), a feasible alternative. In this context, the GEO.POWER partners developed a project on geothermal energy, under the INTERREG IVC Programme, to fill their legislation gaps and in that way actively contribute to the EU "20-20-20" objective.

The general objective of the 2 year GEO.POWER project ("Geothermal energy to address energy performance strategies in residential and industrial buildings" <http://geopower-i4c.eu/>) is exchange best practices (BPs) related to low enthalpy energy supply and - after a technical and cost/benefit assessment to evaluate the potential of reproducibility - to prepare the ground to the transfer some of the selected best practices within the Mainstreaming Programmes of the regions participating into the project.

The partnership, coordinated by the Province of Ferrara (Italy) is composed by Ministries, Regions, Local Authorities, Universities of 9 Countries (Bulgaria, Hungary, Greece, Italy, Sweden, Estonia, Slovenia, United Kingdom and Belgium).

The project is basically divided in three phases:

° Phase 1 (January-May 2011) regards a review of the BPs achieved within GCHP sector and their possible application for the sustainable heating/cooling technology. Expertises are shared and exchanged within the partners and local deep delegations (composed by energy managers, technicians, stakeholders, urban planners, etc.) through the preparation of benchmarking reports and workshops.

° Phase 2 (July-December 2011) is based on an assessment for the reproducibility of the selected BPs in each recipient region. In this phase all partners go through a local technical analysis to estimate the weakness and potentialities for the application/adaptation of the identified GCHP practises in their own areas. This phase is addressed to design the optimum performance conditions for GCHP systems in terms of technical, economical and environmental point of view.

° Phase 3 (January-June 2012) consists in the elaboration of an action plan for each involved region to support policymakers' commitment. The action plan paves the way towards the transferability of the (adapted) BPs into the Mainstreaming Programmes and energy regulations plans. The main results of the project are the development of one action plan per each involved region, that provides an organized set of legal/regulatory, economical, and technical proposals. These proposals will include the regional operation programmes and address long-term investments strategy for GCHP application at wide scale. The project is still ongoing but preliminary results are now available (<http://geopower-i4c.eu/index.php?page=bpview>) consisting in a selection of best practices. Out of the 31 BPs initially screened, 12 BPs have been selected (4 in the public, 4 in the industry, 3 in private and 1 in the agriculture sector) according to the following criteria: field of application; type of systems; different hydrogeological setting; type of building; efficiency parameters; quality of the monitoring scheme; integration with other RES; benefits and level of supposed transferability.

D9-16 Poster Quarantini, Mattia

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GEOLGY AND HYDROGEOLOGY IN THE GEOTHERMAL HEAT EXCHANGER

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Key terms: Geothermal energy; Geothermal heat exchanger; Hydrogeological properties

The correct design and performance of geothermal heat exchanger coupled with heat pump systems requires knowledge of the thermal properties of the subsurface rocks where the geology and especially the hydrogeology, play an important role. The accurate prediction of transient ground heat transfer is the key to establish the required borehole length and to determine the resulting fluid temperature. Moreover a correct dimensioning of geothermal heat exchanger system is essential for ensuring the sustainability of this technology.

The ground thermal properties can be measured in situ with a thermal response tests (TRT) where a heat transfer fluid flowing in a ground heat exchanger is heated and the resulting temperature perturbation is monitored. This method is largely approved in different countries for to determinate the thermal conductivity and the thermal resistance of the

whole borehole.

The vertical ground thermal property variations inside the borehole during a TRT and the resulting cooling after the test, allows correlating the subsurface thermal conductivity with stratigraphy. The logs of the evolution of the temperature recovery, combined with the hydrogeological data permit to discriminate the thermal exchange of each discrete layers. This methodology permits to obtain a distribute vertical thermal conductivity and thermal resistance of the subsol and provide an useful tool for a correct dimensioning of boreholes number, depth, spacing and geometrical arrays, take in account the entire heating and cooling seasonal cycle of the system.

D9-17 Poster Stringari, Marco

10.1474/Epitome.04.0376.Geoitalia2011

EVALUATION OF THERMAL DISTURBANCE IN SHALLOW AQUIFER INDUCED BY OPEN-LOOP GEOTHERMAL PLANTS

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Key terms: Open-loop geothermal plants; Thermal alteration; Numerical model

Among the various systems of heat exchange with the subsurface it is possible to directly take the heat stored in the groundwater through the use of open-loop geothermal systems. The water is pumped to the surface through one or more wells and then it is generally pumped back into the groundwater (heated or cooled by the plant) through other wells.

The study of the thermal plume generated by the injection of heated or cooled water in the aquifer is very important. The study of propagation of the plume allows to assess the sustainability of the system in terms of heat and it avoids the possible influence / interference with existing plants and the involvement of sensitive areas such as wells for drinking water and rivers.

The thermal characteristics of the aquifer and the re-injection water temperature determine the intensity of the induced thermal disturbance. Hydrogeological characteristics of the area determine the extent of the thermal plume.

An aquifer is composed of a porous media, that is a solid matrix with interstitial spaces and water. The main hydro-geological characteristics that determine the groundwater flow (and the thermal propagation) are the hydraulic conductivity, the specific yield, the hydraulic gradient and the longitudinal dispersivity.

The finite-difference groundwater flow and transport code SEAWAT was used to realize numerical models, representing thermal plumes in typical hydrogeological conditions of Piemonte region. Specifically, the thermal effect caused by the re-injection of hot/cool water in the shallow aquifer was simulated.

SEAWAT is a MODFLOW/MT3DMS-based code designed to simulate three-dimensional variable-density groundwater flow coupled with multi-species solute and heat transport.

The simulations were made varying pumping rates in contexts characterized by different hydrogeological parameters. For each parametric variation was carried out a simulation and the possible propagation of the thermal plume was identified. The range of used hydrogeological parameters are typical of the aquifers of the Po river plain (Pianura Padana) and especially of the Piemonte plain.

The simulations were carried out in permanent regime, assuming either a continuous or intermittent operation of the system, in eating and cooling mode.

The choice of the " ΔT " parameter (the difference between the extraction and re-injection temperature from the groundwater) was based on temperature differences commonly founded in real plants, about 5 °C.

The natural temperatures of shallow aquifer are fairly constant during the year and they generally are between 13 and 16 °C in most of Piemonte plain. Seasonal variations usually oscillate around 1 °C. Since the goal of the survey was not the study of absolute temperature of the thermal plume, but the thermal variations in the aquifer, the undisturbed temperature in the simulations was considered constant and equal to an average value of 14,5 °C.

Comparing the different thermal plumes, it was possible to identify how different hydrogeological characteristics of an aquifer contribute to the expansion of the thermal plume.

For example it resulted that, under the same hydrogeological characteristics, the extent and intensity of the thermal plume increased significantly with increasing pumping rates of re-injection into groundwater. Dividing the same pumping rate between adjacent wells, the extent of the single plume decreases, but the thermal effects of individual wells may be combined with each other.

At constant pumping rates, the temperature changes and lateral extent of the plume are larger the lower the rate of groundwater flow. In the case of intermittent operation of the system, the time required for the disappearance of the plume is also inversely proportional to the groundwater flow.

D9-18 Poster Verdoya, Massimo

10.1474/Epitome.04.0377.Geoitalia2011

PROCESSING OF THERMAL RESPONSE TESTS AND UNDERGROUND TEMPERATURE DATA IN BOREHOLE HEAT EXCHANGERS

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Key terms: Geothermal energy; low enthalpy; thermal conductivity

The use of geothermal heat pumps (GHPs) has been rapidly spreading in many countries, as a clean and efficient system for heating and cooling commercial and residential buildings. A typical GHP system mainly consists of a conventional heat pump unit coupled with a group of drillholes, which act as heat exchangers (BHEs). The thermal power that can be extracted with a BHE is site-specific and depends mainly on the thermal properties of the underground, and in particular, on the thermal conductivity. Laboratory measurements on thermophysical properties can be unfeasible as core samples are often unavailable in commercial holes. Thus, an in situ thermal response test (TRT) is carried out as an alternative investigation to obtain the actual heat-transfer performance between the underground and a BHE, as well as the ground thermal properties.

TRT experiment records the inlet and outlet temperature of a closed loop in a ready-to-operate BHE due to constant heating or cooling by the fluid

circulation. The change of outlet fluid temperature is directly related to thermal properties of the bulk rock surrounding the hole. Compared to lab determinations, the advantage offered by TRTs is that the underground thermal properties are integrated over the entire length of BHE, including groundwater and backfilling material. This provides the so-called "effective" thermal conductivity, which in some cases can be unrealistic for dimensioning purposes, especially in advection-dominated areas. We recently built a new TRT apparatus and performed some tests at selected sites in order to verify its performances under operating conditions. Our TRT apparatus is reversible, thus allowing both heat extraction and injection. Another peculiar feature is the automatic control of power supply. TRT records were performed in combination with conventional thermal logs aimed at the reconstruction of the undisturbed thermal profile prior to TRT and the analysis of the possible presence of groundwater movements.

The thermal test was carried out in "double U" BHEs, with hole diameter of 146 mm, drilled within alternating layers of silty sand and clay to about 100 m depth. The total test time was 72 hours. By processing the recorded temperatures versus time according to the infinite line source theory, an estimation of the effective thermal conductivity in the vicinity of the BHE was obtained.

The thermal properties results can be biased by different sources of errors. A preliminary analysis of the TRT time series showed that data are affected by well visible fluctuations. A first attempt to smooth these fluctuations was made by filtering the recorded signal with an exponential function which fits the temperature data. Then, TRT time series were further processed for their spectral characterization and denoising. A standard Fourier analysis allowed the recognition of a harmonic contribution with period of about twelve hours that can be ascribed to the daily air temperature change. In order to characterize the nature of the harmonic component, the thermal signal was filtered and compared with the data of air temperature change recorded at the test site, by analyzing the cross-correlation function and by estimating the coherency and the phase delay (through the cross-spectrum). The recorded data were then filtered to remove the disturbing spectral components associated to a non-optimal thermostatic behavior of the apparatus.

Finally, in order to investigate the advective heat transfer around the test site we applied some analytical thermal methods for inferring Darcy velocity from temperature-depth logs recorded prior to TRT. The analysis consisted in matching temperature and thermal gradient data with theoretical curves describing horizontal and vertical heat and water flow.

D9-19 Poster Bonetto, Sabrina

10.1474/Epitome.04.0378.Geoitalia2011

GEOLOGICAL-GEOPHYSICAL SURVEYS FOR THE ASSESSMENT OF A GEOEXCHANGE SYSTEM IN NORTH-WESTERN ITALY

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Key terms: geothermal system; energy efficiency; geological survey

The present study focus on ground-side properties definition in an area of 7,000 square meters where a boreholes heat exchanger (BHE) system has to be designed for air conditioning and hot water production in the context of new residential buildings in the city of Tarvisio (Friuli Venezia Giulia, NW Italy). The study has been financed by the SATEA Society. Energy efficiency, environment cleanliness and economy of BHE systems are strictly related to the design and construction quality. In particular a proper knowledge of the local geology is essential for a correct dimensioning of the BHE system. Indeed the geological condition and the consequent plant dimensioning are site-specific, therefore in situ measurement and geological surveys are strictly necessary for its correct design. The larger is the system, the more is to gain on a proper estimation of the ground thermal conductivity and the temperature loss between the heat carrying fluid and the ground. In this context an underestimation of the BHE system will both reduce the efficiency and result in a progressive thermal depauperation of the ground, whereas its overestimation causes excessive and unnecessary costs. In order to optimize the costs and improve the efficiency of the BHE system, an integrated approach has been proposed combining different geological and geophysical investigation methodologies.

The study area is located in the southern side of the Bartolo Valley in front of the Tarvisio town centre at an altitude between 750 and 790 m a.s.l. Due to the limited number of outcrop evidences, a 100 meters investigation borehole has been drilled in order to obtain the local stratigraphy. A geothermal probe was installed in the borehole and a thermal response test was carried out in it. Direct data from the borehole have been integrated by means of different exploration pits, electrical and seismic tomographies and surface wave tests in order to extend the geological knowledge of the subsol to the whole area.

The investigation borehole has shown the presence of a coarse grained glacial deposits overlying the bedrock mainly composed by marly limestone and clayey marls beds. The results of the thermal response test attribute values of thermal conductivity of about 0,4 - 0,5 W/(m K) to the covers and 2 e 2,6 W/(m K) to the bedrock.

According to the observed geological features, glacial deposits and calcareous-marly bedrock both represent potential aquifers. The bedrock should be considered as a fractured aquifer with the presence of open fractures and faults; the glacial cover has a porous permeability due to the variable grain-size distribution depending on the abundance of silty and clay matrix. Local water stagnations have been observed in the glacial cover in presence of thin clay layer, while a significant water flow has been observed in correspondence of the contact with the underlying bedrock.

Geophysical investigations have shown the difference in grain-size, thickening and degree of humidity, between the covers, the altered bedrock and the sound bedrock; in particular they revealed a significantly different depth of the bedrock in the studied area. Contrary to the expectation based on stratigraphical drilling data, the lateral continuity of the surface contact between covers and calcareous bedrock is roughly cut off: in the western sector of the studied areas, bedrock is significantly deeper and the thickness of the covers is higher.

As a consequence, the horizontal equivalent thermal conductivity varies in the area because of the difference in the thickness of deposits which show higher thermal conductivity, in respect to the less conductive bedrock. The geological information obtained by the proposed integrated approach allowed to rectify the value of the thermal conductivity coefficient obtained with the only help of investigation drillings and thermal response tests which are not sufficient to realize the geological areal assessment and their variability

D9-20 Poster Comina, Cesare

10.1474/Epitome.04.0379.Geoitalia2011

GEOPHYSICAL IMAGING OF THERMAL FLOWS IN GEOLOGIC MEDIA: LABORATORY EXPERIMENTS.

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Key terms: Geophysical monitoring; Heat fluxes; Geothermal energy

In low enthalpy geothermal applications most of the studies use numerical models to simulate heat fluxes and temperature variations induced by heat exchangers into the ground. This requires a fundamental understanding of how soil moisture content and grain size affect the soil's thermal behavior. Very few experimental data showing the effects of these variations are however available and the relationships determined are only empirical. This work presents an economic but profitably way of simulating thermal fluxes at laboratory scale by the use of an instrumented thermal box giving also an insight of the potentiality of geophysical controls in imaging transient heat fluxes. Geophysical tests could indeed provide, even if extended from laboratory scale to the site scale, an indirect way of monitoring the variations induced in the soil during the heat production and of determining the relevant heat parameters to be used in the fluxes evaluation.

In this respect a boundary isolated box has been appropriately instrumented. Two electrical resistances, controlled by a thermometer, and a rheostat assure the desired heat flux from one side of the box.

Temperature measurements in different sections of the box are carried out to fathom the time necessary to the heat to propagate within the different types of soils tested until a thermal equilibrium is reached; soil moisture is measured at the same time.

Electrical measurements have been implemented to evaluate the effects of temperature on electrical resistivity and image the heat fluxes. In this respect a series of 16 electrodes have been placed equispaced along the central section of the box and a fast acquiring device (C.I.T. - Iridium-Italy) has been used to:

- ° measure locally (along the singles quadrupoles) the apparent electric resistivity in correspondence of the temperature sensors;
- ° obtain a tomographic reconstruction of the conductivity field inside the box;

In both ways a direct imaging and an indirect monitoring of heat fluxes is possible during tests. Indeed it will be shown, in the presented tests, that the apparent resistivities values confirm their potentialities in monitoring and quantifying the increase in temperature in correspondence of the measuring points by relating it to the electrical resistivity changes.

Moreover to obtain a 2D representation of the monitored phenomena differential tomographic images have been used. In particular: for each time step the difference between the reconstructed resistivity field at that time and the one before the start of heating has been evaluated. In this way it has been possible to obtain a representation of the heating front. Tests presented confirm the potentiality of geophysical tests to monitor heat fluxes and to provide important parameters that could be potentially adopted for a comparison with numerical simulations of the monitored phenomena.

SESSIONE D11

La crosiera come risorsa naturale e bene culturale, indicatore delle variazioni climatiche, archivio d'informazioni paleoambientali

D11-1 Key Lecture Stenni, Barbara

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STABLE ISOTOPE RECORDS FROM TALDICE ICE CORE (EAST ANTARCTICA)

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Key terms: water stable isotopes; Antarctica; ice cores; paleoclimate

Paleotemperature reconstructions from Antarctic ice cores rely mainly on δD

and $\delta^{18}O$ records and the main key factors controlling the observed

distribution of δD and $\delta^{18}O$ in Antarctic surface snow are mainly related to the condensation temperature of the precipitation and the origin of

moisture. The deuterium excess, $d = \delta D - 8 \cdot \delta^{18}O$, contains information about climate conditions prevailing in the source regions of precipitation and can be used as an integrated tracer of past hydrological cycle changes.

In the framework of the TALos Dome Ice CorE (TALDICE) project, a deep ice core (1620 m) has been drilled at Talos Dome, a peripheral dome of East Antarctica facing the Ross Sea, about 550 km north of Taylor Dome and 1100 km East from the EPICA Dome C drilling site. The TALDICE coring site (159°11'E 72°49'S; 2315 m; T -41°C; www.taldice.org) is located near the dome summit and is characterised by an annual snow accumulation rate of 80 mm water equivalent. Backtrajectory analyses suggest that Talos Dome is mainly influenced by air masses arriving both from the Pacific (Ross Sea) and Indian Ocean sectors. A preliminary dating based on an ice flow model and an inverse method suggests for the upper 1580 m an age of about 300,000 years BP.

The full TALDICE $\delta^{18}O$ record obtained from the bag samples as well as δD

and deuterium excess data are presented here. The $\delta^{18}O$ and δD measurements were carried out in Italy and France on a continuous basis of 1 m. These new records will be compared to the ones obtained from the EDC ice core as well as with other East Antarctic ice core records. In particular, we will focus on the whole isotopic profiles and on the last deglaciation. During Termination I the climatic changes at Talos Dome are in phase with the Antarctic plateau suggesting that the bipolar seesaw with Greenland temperature is also valid for this new coastal site facing the Ross Sea sector. At glacial-interglacial scale the full $\delta^{18}O$ record of

TALDICE is in good agreement with other inland deep ice cores but the deuterium excess record of TALDICE shows a larger Last Glacial Maximum - Holocene amplitude than the more inland sites. The $\delta^{18}O$ and deuterium excess records at TALDICE are in phase during deglaciations suggesting parallel variations of moisture source and Antarctic temperatures.

D11-2 Orale Grossi, Giovanna

10.1474/Epitome.04.0381.Geoitalia2011

THE IMPACT OF GLOBAL CLIMATE CHANGE ON THE ADAMELLO GLACIER: RESULTS OF A REGIONAL HYDRO-CLIMATOLOGICAL STUDY

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Key terms: glacier; mass balance; energy balance; climate change

This research aims at the evaluation of the mass balance of the Mandrone glacier, the widest hydrographic unit of the Adamello glacier, in the actual climatic conditions as well as in two climate scenarios foreseen for the 21st century by the IPCC. Since the Adamello glacier is one of the largest alpine glaciers, its representative role within the Great Alpine Region (GAR) is doubtless and the analysis of its response to climate variations can provide precious information regarding the future of other glacial areas. In fact the impact of climate change is expected to be stronger in the GAR with respect to other European areas, as the highest air temperature increase is going to be recorded at high altitude sites. The estimate of the yearly mass balance of the Mandrone glacier in the actual climate conditions was primarily supported by measurements of winter accumulation carried out through a snow water equivalent monitoring network in the areas around the glacier. The mass balance evaluation was also supported by the estimate of the energy balance in the melting season, provided by the run of the physically-based distributed model PDSLIM.

The reliability of this approach depends on the availability of high altitude precipitation measurements, which are seldom recorded nowadays.

Modern Italian meteorological networks mainly consist of gauges located at altitudes lower than 2000 m a.s.l., even in the alpine territory. For the Adamello region the spatial distribution of the annual precipitation cannot be properly described without the information provided by the high altitude precipitation gauges conducted until the 70s.

PDSLIM runs providing the estimate of the energy balance of the Mandrone glaciers were forced by the time series of hourly observations of six meteorological variables: air temperature, humidity and pressure, precipitation, global radiation and wind speed. Meteorological series were recorded between 1995 and 2009 through high altitude measurement gauges, close to the glacier.

Time series of meteorological observations were then modified according to emission scenarios B1 and A1B of the regional climate model COSMO-CLM (developed by Deutscher Wetterdienst) for two twenty-years periods, centered in 2050 and 2090, so that four different future climate scenarios were built and fitted to local climate characteristics. Further PDSLIM runs were performed using as input the modified meteorological series. The expected glacier mass balance for each of the four future scenarios was obtained. Results show intense ice melting, besides according to most pessimistic scenario and for the end of the century: the loss of specific mass of a few meters per year would occur in this scenario, when referred to the actual extension of the glacier. Even if uncertainties in both the climate model and the hydrological model cannot be left aside, a quasi-quantitative analysis of the most vulnerable glacier areas to climate change is attempted, providing a clue to understand the potential evolution of a little, but still fundamental, element of the hydrosphere. A serious concern on the fate of Italian glaciers, as the Adamello one, rises after our analysis.

D11-3 Orale Bocchiola, Daniele

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HYDROLOGICAL SCENARIOS FOR A HIGH ALTITUDE CATCHMENT WITHIN THE ADAMELLO LOMBARDO GROUP (BS).

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Key terms: climate change; Alpine catchments; glaciers

The presence of climate change introduces a quicker dynamics of the glacial and snow fed areas within the Alps. It is therefore necessary to unravel the mechanism of interaction between climate change and the hydrological cycle within the Alpine catchments, strongly depending upon snow and ice feeding. Once the ice and snow accumulation and melt processes have been modelled using physical schemes, it is possible to hypothesize future scenarios of the climate inputs and of the hydrological response of the catchments. Here, we carried out a study based upon this approach for a case study within the Adamello Lombardo (BS) Glacier, the greatest glacierized surface in Italy, covering 18.13 Km² in the Retiche Alps of Italy. First, we build a minimal hydrological model, semi-distributed with altitude belts, able to simulate daily flows within the Pantano catchment (10 km²), including the 2.15 Km² debris covered Venerocolo glacier, a Northern tongue of Adamello. The water from the catchment is exploited by the hydropower company ENEL. The model is validated during 2006-2009, by way of historical data climate and hydro data and field surveys upon the Venerocolo glacier. We then use climate scenarios from an IPCC model (CCSM3, IPCC A2, 2011-2100) to infer hydrological scenarios in the area. Such preliminary scenarios provide a first guess of the future glacier areas and hydrology therein, useful for planning exploitation strategies of water for hydropower, civil and cropping use.

D11-4 Orale Smiraglia, Claudio

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DEBRIS-COVERED GLACIERS, A SPREADING GLACIER TYPOLOGY: DISTRIBUTION OF DEBRIS TEMPERATURE FROM DIRECT AND REMOTE SENSING DATA

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Key terms: current glacier evolution; debris covered glacier; debris thickness and temperature

Debris cover is expanding over large areas in the ablation zone of many Alpine glaciers during the last decades. Then, the energy balance at glacier surface is modified and is impacting ice melt rate. Thermal conductive heat flux through debris is influenced by debris cover properties mainly: albedo, thickness and thermal conductivity. Debris distribution and pattern is driven by periglacial processes (rockfalls), redistribution of supra-glacial (moraines) and in-glacial (melt-out) debris, surface glacier morphology (slope, roughness) and dynamics (surface velocity, crevasse distribution). To study debris cover distribution over debris-covered glaciers, surface temperature from remote sensing and field-based data is the best solution. Also it is the most important parameter to quantify the energy available to melt ice in the surface energy balance. High temporal and spatial resolution measurements of debris temperature were performed at several debris covered glaciers on the Alps (Miage and Lys) and in Karakoram (Baltoro and Hinarche). An analysis of ground surface temperature measurements and Aster surface kinetic temperature data at Miage glacier yields high and significant correlation. Surface temperature distribution from Aster images is mainly influenced by debris thickness and elevation, which are inversely correlated. Longitudinal and cross temperature profiles highlight: crevassed areas, moraine deposits, vegetation areas outside the glacier, shadowed areas, continuous thick debris near the terminus, etc. There is a good correlation between meteorological data (incoming shortwave radiation and air temperature) from automatic weather stations and debris temperature. Surface temperature up to 45°C associated to thick debris and low surface albedo are measured on supra-glacial debris. Aster temperature maps at a pixel resolution of 90x90 m, present average temperature of 30-40 °C at 12:40 am local time. Temporal trends of temperature are analyzed from field-based data and spatial distribution maps are developed. Areas with stable, continuous and thick debris cover are mapped corresponding to positive energy balance and warmer conditions at the glacier surface.

D11-5 Orale Pelfini, Manuela

10.1474/Epitome.04.0384.Geoitalia2011

MIAGE GLACIER INFLUENCE ON THE SHORT-TERM EVOLUTION OF SUPRAGLACIAL AND PROGLACIAL TREE VEGETATION

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Key terms: Miage debris-covered glacier; Italian Alps; supraglacial and proglacial tree vegetation; ice-cliff dynamics; backwasting and downwasting processes

The Miage Glacier (Mont Blanc Massif, Italian Alps) is the most important Italian debris-covered glacier with a well developed tree coverage growing on its debris layer and a continuous interaction also with the surrounding forest in the proglacial area.

Supraglacial debris cover allows vegetation to colonise glacier surface, and whenever it is enough stable and thick, also shrubs and trees can germinate and grow. Supraglacial tree growth and distribution patterns on the glacier are closely connected with the debris-covered glacier dynamics and evolution. The aim of this work was to evaluate tree age and tree spatial distribution on the glacier tongue and the influence of ice-cliff backwasting on tree loss close to glacier terminus. We analysed the fragile and fast changing environment that is present on the lower ablation sector of the Miage Glacier where ice cliffs are present and back and downwasting phenomena occur. Tree features and evolution were analysed with respect to glacier short-term variations (mainly surface displacements and ice ablation) and geometry changes of the two most representative ice cliffs. The supraglacial trees' life time resulted to be mainly controlled by rates and magnitude of ice flow, by glacier surface displacements and by the occurrence of backwasting and downwasting processes, whereas tree germination was associated with fine debris presence. These factors controlling plants' life and growth on the glacier, must be considered for reconstructing past environmental changes occurred on the glacier tongue by means of supraglacial trees. Moreover, we found that a large number of trees die under conditions of dominating backwasting phenomena (condition met especially on the northern glacier lobe), thus reducing the mean age of the whole plant population. Instead, in the case of prevalence of the downwasting phenomenon (as we mainly observed on the southern glacier lobe), trees more easily survive and flow downvalley transported by the glacier flux.

Information about glacial discharge in the proglacial area was obtained using tree rings, dating scars, compression wood and growth releases and reductions. We detected the presence of areas directly affected by glacial discharge and others characterized by boulders falling from the glacier front, highlighting the continuous remobilization of the debris performed by the glacial stream flow.

Therefore the integration of dendrogeomorphological and glaciologica data both from supraglacial and proglacial trees may contribute to better define the complex of biological and physical interactions at Miage Glacier.

D11-6 Orale Baroni, Carlo

10.1474/Epitome.04.0385.Geoitalia2011

THE GLACIOLOGICAL CONTEXT OF THE GREAT WAR SITE OF PUNTA LINKE (ORTLES-CEVEDALE GROUP)

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Key terms: Glaciology; Global change; World War I; Archaeology; Ortles-Cevedale Group

Glaciers are relevant environmental indicators, natural sentinels very sensitive to temperature and precipitation changes. Like huge refrigerators, glaciers retain precious archives of environmental information, preserving a memory within their stratigraphy both of natural events and of the effects induced by human impact.

The recent period of retreat of alpine glaciers is characterized by a marked reduction in the thickness of the glaciers also at higher altitudes, where there are emerging not only large portions of the bedrock, but also trenches and military constructions of the "White War", as is happening in Punta Linke.

After the end of the Great War, the military structures were abandoned and progressively covered by snow and ice, thus preserving climatic-environmental information related to this site from the end of World War I to the present.

During the archaeological excavation campaign conducted in 2010, samples of ice have been collected from different contexts, for analysis at the CryoLab of the University of Milan-Bicocca. In particular, a detailed stratigraphic section of the snow and ice infill has been reconstructed and some thin sections of the sampled ice have been studied.

Particularly significant levels have been sampled to execute analysis aimed at the definition of the time and the modality of archeological structures burial.

The glaciological context of Punta Linke (made by the Italian Glaciological Committee in collaboration with the Provincia di Trento - Soprintendenza per i Beni Librari, Archivistici e Archeologici - Settore Beni Archeologici) includes also the reconstruction of the areal and volumetric variations of the glacial area near the archeological site, starting from the Holocene glacial maximum (Little Ice Age, culminated around the half of the 19th Century).

Moreover, in correspondence with the glaciated saddle between the Punta Linke site and the Mount Vioz, some high resolution geophysical surveys have been performed through a GPR working with 500 MHz and 200 MHz antennas. The GPR data allow us to reach the bedrock and enable us to reconstruct the thickness of the glacier as well as to identify some underlying structures.

D11-7 Orale Maggi, Valter

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TWO MILLENNIA OF ICE ACCUMULATION IN FOCUL VIU ICE CAVE, ROMANIA

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Key terms: ice caves; paleoclimatology; ice cores; Romania

The 8.26 m of ice core drilled in Focul Viu Ice Cave (Apuseni Mountains, Romania) represent one of the longest records from hypogean ice deposits. A sets of 8 radiocarbon dates were done on organic materials found in the ice cores at different depth, and estimate of the age at 6.84 m depth is of 198±66 A.D. (calibrated date). Some large nss-SO₄²⁻ (no-sea-salt sulphates) spikes were preliminary related with historical well known explosive volcanic events, with an improve of age/depth time scale. Using both 14C dates and volcanic spikes, were evaluate the variability of the accumulation rate of ice deposits, that show a mean values for the entire ice core of 34.8 cm/century of ice. Differences in accumulation rate will be related to change in snowfall, and especially the large increase during the Middle Age period (1100 to 1300 AD), probably related to an increase of the snowfall in the area. Interpolating the accumulation rate of for the deeper part of the ice core, were estimate the age of the bottom ice at 8,26 m depth of at around the Vft century A.C..

D11-8 Orale Ribolini, Adriano

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RELIC SAND WEDGES ALONG THE PATAGONIAN COAST BETWEEN CALETA OLIVIA AND PUERTO DESEADO (SANTA CRUZ, ARGENTINA)

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Key terms: sand wedge; permafrost; Last Glacial Maximum; Patagonian coast; Argentina

Conversely to the Terra del Fuego, in the Atlantic Patagonia coast evidence of soil wedging caused by frost cracking is sporadically described, and large sectors seems to be unaffected by this phenomenon. This is surprising because during the Last Glacial Maximum (LGM), we can expect that this coast was affected by permafrost conditions, even if not so intense as in the areas proximal to the LGM glacier margins. During a 3 years long lasting field work aimed at characterizing the coastal deposits in the St Jorge Gulf, several evidence of fossil wedges was individuated and analysed. The grain size of the material composing the fossil wedge, as well as that of the incorporating deposit, along with quartz grain characteristics at SEM analysis, allow to propose an aeolian sand infilling of the frost cracks, that should thus be classified as sand wedges. Some sand wedges intrude a complex soil/colluvial succession covering marine deposits supposed to be MIS5 in age on the base of palaeontological data and of their elevation above sea level, and postdate a pedogenic horizon dated at ca. 25 ka BP. A preliminary OSL age of infilling sand confirms this hypothesis. These chronological constraints individuate the LGM as the cold period of formation of the sand wedges, and allow to ameliorate the

knowledge of the extension of permafrost to the north of the Patagonia during this time. In some cases at least two generations of sand wedges were described, claiming to more than one cold phase during the LGM, separated by a phase of loess deposition and/or soil development (truncated soil with Bk or By horizons). This indicates significant environmental variability during the Last Glacial.

D11-9 Poster Smiraglia, Claudio

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MIAGE GLACIER (MONT BLANC, ITALIAN ALPS): THE CONTRIBUTION OF A DEBRIS COVERED GLACIER TO THE HYDROLOGICAL BALANCE

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Key terms: debris covered glaciers; hydrological balance; glacier ablation; Miage Glacier

Miage Glacier is surely the most intensely studied debris covered glacier of the Italian Alps, also well known to the tourists as "the most Himalayan glacier of the Alps" and because of the presence of the homonymous ice contact lake on the West lateral side. Despite these facts, its hydrological balance has been seldom analyzed. Miage Glacier is located on the South West flank of Mont Blanc; it stretches from 1780 m at its terminus to Mount Blanc summit (4810 m asl) and with a surface area of 10.7 km² ranks as the third largest Italian glacier. The debris covered area is 2.9 km², while the debris free sector covers 7.8 km². Its hydrological basin is c. 24 km² wide and the ratio glacier surface/basin surface is 0.44.

The hydrological balance of Miage basin can be written as:

$$Wd - P - Sm = Ga$$

where:

Wd = volume of water discharged (water flowing through the studied sections + water flowing into the Miage lake + water losses through the bed of the Miage lake)

P = volume of basin precipitations

Sm = volume of snow melted

Ga = glacier ablation

To calculate the summer hydrological balance two different methods were applied: a glaciological approach (by measuring on the field ablation rates and by applying a degree day (DD) model) and a hydrological method founded on river discharge measurements. The DD model permitted to evaluate glacier ablation and meltwater production over the whole glacier area, thus showing the largest ablation (61%) to occur on the bare ice sector. The hydrological approach showed that a large part of the summer basin runoff was due to glacier ablation. The glacier ablation calculated by hydrological approach and the glacier ablation evaluated through DD model resulted in good agreement, the small discrepancies are probably due to the simplifications applied. The data elaborations indicate that the summer Miage basin hydrological balance depends mainly on the glacier ablation (52%) and then on precipitations (29%) and on snow melting (19%).

D11-10 Poster Carturan, Luca

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RECENT GEOPHYSICAL, GEOMORPHOLOGICAL AND GEODETIC SURVEYS OF MONTASIO OCCIDENTALE GLACIER (JULIAN ALPS, ITALY)

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Key terms: glacier; Julian Alps; geomorphology; geodetic survey; geophysical investigations

The glaciers of the European Alps are currently affected by large mass losses, due to unfavorable climatic conditions. Glacier areas and volumes rapidly decrease and the bedrock tends to outcrop, causing morphological changes and fragmentation of most ice bodies. However, different glaciers are reacting in different ways to the same climatic forcing.

Investigations on small ice bodies have a particular significance in this context, since they largely contribute to the total loss of glacier area, due to their large number and rapid shrinkage. In addition, they can provide important insight into processes governing glacier wastage and into snow redistribution by wind and avalanches, since they allow detailed investigations.

In summer 2010 a specific field campaign was carried out on Montasio Occidentale Glacier (W.G.I. number I4L0003005), a 0.07 km² avalanche-fed ice body located in the Italian Julian Alps (Eastern European Alps). The "niche" glacier is exposed to north and its altitude averages 1940 m a.s.l., ranging from 2105 to 1880 m a.s.l.. The purpose was to assess its current status (surface topography, total area and volume, degree of activity and alimentation) and possible peculiarities in the reaction of this glacier to current climatic changes. Indeed, processes and feedbacks governing mass exchanges in this kind of low-altitude, avalanche-fed glaciers are still somewhat unknown. In addition, the Julian Alps are characterized by very high precipitation amounts and differences in climatic sensitivity are very likely to exist with respect to drier areas of the Alps.

The Montasio glacier was completely surveyed by a Terrestrial Laser Scanner in September 2010, obtaining a high resolution Digital Elevation Model (cell size 20 x 20 cm). Additional information like reflectivity and RGB values associated to the TLS survey allowed us to distinguish and map the different substrata (snow, firn, debris) which cover the ice body, and to automatically delineate the glaciated area and the surface features. Geophysical investigations were also performed, to investigate the internal structure of the glacier and its depth. Measurements were carried out along longitudinal and transversal transects using a radar system

equipped with a 75 MHz and a 200 MHz antennas. The EM image of the subsurface highlighted several reflecting surfaces within the glacier body and at the boundary between the ice and the underlying bedrock. Geomorphological investigations were performed in the glacier area and in its foreland, in order to make a detailed geomorphological map. The glacier is bordered by a prominent frontal moraine, cut to the right and left sides by meltwater gullies, almost inactive. Some other outer, minor moraine ridges are present at lower altitude; they formed during stadial phases and are currently covered by a soil. On the glacier, in a middle position, a squeeze moraine outcrops.

The first results of our observations confirm a peculiar behavior of Montasio glacier with respect to the most part of alpine glaciers. In particular, its mass seems to be stationary or slightly increasing in the latest years, in response to recent snowy winters and in spite of current warm summers. This first dataset will constitute the basis for future work. Our intention is to reconstruct the glacier evolution since the Little Ice Age and to continue the monitoring of this ice body to evaluate its behaviour in the coming years.

D11-11 Poster Baroni, Carlo

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OVER A CENTURY OF GLACIAL ENVIRONMENT MAPPING BY THE ITALIAN GLACIOLOGICAL COMMITTEE (CGI)

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Key terms: Glaciology; Historic maps; Global Changes; Geomatics; Italian Alps

Frontal retreat, areal and volume reduction, accompanied by glacier surface lowering are among the fastest geological and geomorphological phenomena. Glacial shrinkage is sometimes so huge and rapid that it can be noticed by inexperienced observers. It is clear, however, that appropriate tools for the quantitative assessment of glacial changes are needed. In general, for an objective understanding of the glacial landscape, photography and, more usefully, the cartography should be used. Already in 19th Century, precursors of scientific studies on glaciers felt the need for accurate base map surveying. This need was emphasized by the Glaciological Commission in 1895 that became the "Italian Glaciological Committee" CGI. In 1914, CGI opened its first Bulletin volume with the publication of the complete Miage Glacier relief map, the first Italian application with "stereoautografo" Zeiss. The tradition of surveying and mapping brought on by the CGI was strengthened particularly between 1955 and 1975; since 1985 CGI produced thematic maps on the glacial geomorphology, of which F. Sacco was a forerunner (in the first half of the century).

Extremely useful maps were produced by terrestrial photogrammetry during the International Geophysical Year (1957-1958), serving as the base for comparison with subsequent surveys and for evaluating changes in recent displacement of some of the most important Italian glaciers. Nowadays geomatics, and in particular aerial and ground laser scanner (coupled with aerial photographs and satellite images) make possible to have very detailed and precise measurements of glacial and periglacial areas in a short time, and at relatively low cost.

The current extraordinary glacial environmental changes linked to global warming, make the cartographic products absolutely necessary to set the spatial and temporal evolution of glaciers and proglacial areas. The modern survey techniques are extremely important in order to provide a better understanding of geodynamic phenomena, environment planning (e.g. availability of water resources) and civil protection in case of glacial risk.

D11-12 Poster Carton, Alberto

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GROUND TEMPERATURE REGIMES OF A DOLOMITIC AREA CHARACTERIZED BY CRYOGENIC LANDFORMS.

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Key terms: periglacial; cryogenic landforms; solifluction; Dolomites

The studied area corresponds to the so-called Basin of Vauz, located between 1840 m and 2250 m of elevation. It lies between the Pordoi Pass (Dolomites) and the village of Arabba (BL). There are several landforms related to frost action and solifluction in this area, such as patterned ground, terracettes and lobes.

This research aims at i) studying the processes involved in the slow movement of the ground and in the development of the landforms of the area, and ii) understanding the role of water circulation inside the slope. Analogous phenomena are present in many areas of the Dolomites, especially on the passes and in several locations where pelitic and volcano-clastic formations crop out (i.e. S. Cassiano Fm. and Wengen Fm.). Indeed, the movements usually develop within the detrital deposits generated from the degradation of the two previously mentioned geological formations. The particle sizes of debris involved in the movements are between coarse sand and fine silt, with a predominance of medium sand and coarse silt (from 4mm to 0,002mm).

Measurements of the thermal state of the soil were recently undertaken in the study area, using thermometric probes (PB-5001-1M5; accuracy $\pm 0.2^\circ\text{C}$) connected to specific data loggers (TGP-4520 TINYTAG PLUS 2). They allow to store hourly minimum, maximum and average temperature. Measurements were collected at 1874 m, 1935 m, 2190 m and 2365 m of altitude, at sites exposed to the south and with an inclination of respectively 23° , 14° , 11° and 36° . In order to analyze the trend of temperature with depth, in one of the monitoring sites (at 1935 m) three thermometers were placed at different depth (5 cm, 25 cm and 50 cm from the ground level). Data on air temperatures and snow thickness are provided by the weather stations of Arabba and Passo Pordoi - Belvedere

(data supplied by the ARPAV Meteorological Centre of Arabba and Meteotrentino). Data series between November 2009 and September 2010 have been already collected, while a second set of data spanning from autumn 2010 to spring 2011 are going to be collected.

The first data show that in autumn 2009, in absence of snow cover, soil temperatures fluctuated in connection the daily air temperature cycles but the ground temperature remained above 0°C .

After the first snowfall, this connection weakened and the ground temperatures developed independently from the air temperature variations. The soil temperatures at the various monitoring sites reached stable values above 0°C during winter, until the snow cover disappeared. Thermometers placed at different depths show an attenuation of the thermal wave with increasing depth. The thermal cycles are visible at a depth of 5 cm, while at 25 cm depth they are more attenuated (only when snow cover is absent, e.g. autumn and late spring). Moreover, higher temperatures were recorded at 50 cm than at 5 cm and at 25 cm in autumn and in winter, the opposite in spring and in summer. During winter, with the presence of snow cover, generally an almost stable value of temperature is reached at every depth without temperature oscillations. The collected temperatures indicate the absence of freeze conditions during the full year at all the monitoring sites. Actually, soil temperatures never fell below 0°C , even if air temperatures reached values well below 0°C (-15° , -18°C). The lowest temperatures are not recorded at the highest monitoring sites, indicating that not only the altitude but also the steepness and the exposure of the slopes exert a strong control on the thermal regime of the soil.

The results obtained so far suggest that the thermal regime of the ground controls in a complicated way the solifluction phenomena affecting the slopes of this area.

D11-13 Poster Seppi, Roberto

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A REGIONAL-SCALE ROCK GLACIER INVENTORY IN TRENTINO (ITALIAN ALPS)

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Key terms: permafrost; rock glacier; inventory; Alps

A number of rock glacier inventories were implemented in the framework of PermaNET (Permafrost long-term monitoring network), a project part of the European Territorial Cooperation and co-funded by the European Regional Development Fund (ERDF) in the scope of the Alpine Space Programme (www.alpine-space.eu). Rock glaciers are regarded as one of the most prominent permafrost-related landforms in the alpine territories. A new statistical model and a permafrost distribution map for the entire Alps are partly based on the rock glacier inventories carried out within the project and, in this framework, a new inventory was completed also in the province of Trento. This region is located in the southern part of the Alps and 20% of its territory lies above an altitude of 2000 m a.s.l. The rock glacier inventory is based on analyses carried out in a GIS using a recent (2006) orthophoto (resolution of 0.5m) and a DEM (grid resolution of 2m). First, the rock glaciers were identified using i) the orthophotos and ii) an hillshade derived from the DEM. Then, the outline of the landforms were digitized in the GIS as polygon shapes.

The characteristics of the rock glaciers were included in an attribute table linked to the shapes. Our database consist of several descriptive parameters, including that of the Permafrost Evidence Database (PED) of the PermaNET project. However, in agreement with other project partner (e.g. ARPA Valle d'Aosta), we used a number of supplementary parameters, in order to achieve a more complete description of the landforms.

The database was partially filled in during the landform digitalization, but most of the information (particularly the morphometric parameters) were obtained from analyses performed in the GIS. In summary, a first group of descriptive parameters of each rock glacier include: location (mountain group and coordinates), altitude (mean and range), slope, length, width, perimeter and area. Other parameters describe additional characteristics, such as: geometry (lobate or tongue shape); general morphology (simple, complex); surface morphology (presence of longitudinal and transverse ridges and furrows and/or hollows and pits); lithology of the feeding area; debris source (talus, till); degree of vegetation coverage, relationships with the local vegetation boundaries and with the glaciers/perennial snowfields located above the rock glacier.

Particular attention was paid to the definition of the activity status of the rock glaciers, that were classified as intact (active and inactive landforms containing frozen material) or relict (landforms without frozen material). The assessment was based on i) several evidences visible in the orthophotos and in the DEM, ii) direct field observations carried out in our previous works and iii) field data (i.e. topographic surveys). We used particularly restrictive criteria for classifying the activity status of the rock glaciers from the orthophotos, and this may have resulted in a slightly lower percentage of intact landforms compared to other inventories. Our inventory includes a total of 705 rock glaciers, 134 (19%) classified as intact, the others as relict. They are located at an average altitude 2280 m a.s.l., with a considerable distinction between relict (average altitude of 2190 m a.s.l.) and intact (average altitude of 2660 m a.s.l.) landforms. 50.3% of the rock glaciers face towards N, NE and NW, while 35.2% face towards S, SE and SW. The landforms density (n of rock glacier/km²) is notably different in the various mountain groups of the province, and this seems to be related to the different lithologies that characterize the region. The average surface of the rock glaciers is about 4.7 hectares (0,047 km²). The total area covered by the rock glaciers (33.3 km²) is 1.2% of the entire area of the province located above 1500 m a.s.l., indicating as these landforms are prominent in the periglacial environment of this region.

D11-14 Poster Colucci, Renato R.

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THE CRYOSPHERE IN THE JULIAN ALPS: THE CASE STUDY OF MONTE CANIN MASSIF

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Key terms: cryosphere; permafrost; ice caves; glaciers; periglacial geomorphology

The massif of Monte Canin, part of the Natural Park of the Julian Alps, represents a particular study case in terms of relationship between climate and environment. The heavy rainfall affecting the area throughout the year and the colder temperature are the main cause for the conditions normally found in much higher elevations in the Alps. The area is characterized by glacial and periglacial environments still less studied from a geomorphological and climatological point of view. Nevertheless general climatic information provided from weather stations located around (but never at altitudes above about 1800 m), and glaciological survey and mapping carried out by various geographers and researchers since the end of the '800 exists.

The glaciological reconstruction of the last 150 years is favored also by the important collection of maps and literature existing in Friuli Venezia Giulia.

Permafrost distribution is completely unknown except for the occurrence of some rock glaciers and protalus rampart where the permafrost presence is not investigated yet. Underground cryosphere is surely represented by the large number of karst caves in which it is reported the presence of snow and ice, often permanent and layered ice. Despite of the gap of knowledge also on the frozen karst caves they could provide a useful key to understand the permafrost distribution and/or the glaciological evolution of the landscape.

SESSIONE E1

La geologia e l'idrogeologia applicata alle grandi opere civili

E1-1 Orale Coli, Massimo

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THE 3D GEOLOGICAL KNOWLEDGE OF THE UNDERGROUND AS A COMPULSORY BASE FOR PLANNING, DESIGN AND EXECUTION OF NEW INFRASTRUCTURES: THE CASE HISTORY OF FIRENZE

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Key terms: GEOLOGY; UNDERGROUND; FIRENZE; UBSU; USCS

Large urban areas are already saturated and the private and collective mobility is affected by the difficulty in finding space for corridors of new infrastructures. Therefore, in order to allow a speedy crossing and connecting of down-town with the outskirts and the main suburban roads and highway it is necessary to develop the new infrastructures underground. The Florence area is currently affected by the planning, design and execution of major infrastructure projects: the urban penetration High-Speed Railway, the northern road bypass, the tramway in the city center. The chance of carrying out these works by minimizing the interference with the urban, social and economic concerns can only occur through a detailed knowledge of the underground 3D geological setting in terms of lithostratigraphy, geotechnics and hydrogeology. For years, the Department of Earth Sciences, University of Firenze and the Municipality of Firenze, Geological Office, have developed a synergistic collaboration that led to the creation of a geodatabase containing lithostratigraphic, geotechnical, hydrological and seismic data of over 2000 logs and wells. The computer aided management of that huge mass of data allowed to develop a 3D reconstruction of the Firenze underground following the of UBSU and USCS criteria, and to characterize the geological units in terms of seismic and geotechnical features, according to the most recent regulations. It was also possible to assign different ranges of permeability to each unit and reconstruct the trends of the groundwater over time. This highly detailed knowledge base can be mounted or the expected path of a work project or executive infrastructure underground in order to be able to conduct feasibility studies, identifying the various issues related to follow in monitoring progress and predict the potential developments in the course of the project. The degree of knowledge gained also allows to identify the bottom structure of the great monuments of Firenze, first of all the Cathedral, with Brunelleschi's Dome and Palazzo Vecchio, with the Tower of Arnolfo, but also the Uffizi, with its priceless collections. The body of these studies allow to public and private appropriate knowledge levels for a safety planning, design and execution of underground infrastructure, both for the environment and the cultural heritage and monuments. But all that must not be a point of arrival but a point of departure for further knowledge the Firenze underground and the protection of its monuments.

E1-2 Orale Dematteis, Antonio

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RECOMMENDATIONS FOR QUANTIFICATION OF THE REFERENCE GEOLOGICAL MODEL RELIABILITY APPLIED TO MAJOR CIVIL WORKS. GIVEN BY THE ITALIAN GROUP OF THE INTERNATIONAL ASSOCIATION FOR ENGINEERING GEOLOGY AND THE ENVIRONMENT

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Key terms: reference geological model; quantification of reliability; major civil works

Geological structures are normally complex and for the major part cannot be directly observed, for these reasons in most cases, a fully reliable prediction of the geological, hydrogeological and geotechnical conditions is not possible. In the other hand, the knowledge of the complexity of subsurface geology is needed in any design and construction of major civil

engineering projects. For this purpose the Reference Geological Model is the particularly decision tool required to design, useful to reduce risk and optimize operational costs.

Reference Geological Model (RGM)

The definition of the RGM is a conceptual reconstruction of a given portion of the subsurface, describing the three-dimensional geometric situation and the evolution in time and space of geological events. It is a model derived from all the objective surface, subsurface and laboratory data available at the time it is formulated. But it is also subjective, as it is also derived from the interpretation given by the technicians concerned. The model is subject to change over time according to new data that is produced after its first formulation. The new data can be integrated in the model without major changes or, sometimes, imposing major revision up to the complete reformulation. The formulation process of the RGM must take into account the following aspects: (i) the area to be investigated should include all regional geological structures (e.g. folds, fault zones) relevant to the project, including all the aquifer recharge areas; (ii) the macro areas with various uncertainty degrees must be clearly highlighted in a dedicated geological chapter of the RGM, explaining the reasons for each causing the uncertainty. The criteria to guide this classification must at least take into account the following aspects: (a) availability and density of direct surveys (e.g. boreholes, etc.), indirect surveys (e.g. geophysics, aerial photo scales, etc.); (b) structural-geology complexity (e.g. deformed metamorphic complex or sedimentary structure not deformed); (c) percentage of outcropping of rock basement (the lower is the outcropping, the lower is the reliability of the geological map interpretation); (iii) finally, the possibility to interpret all the available data into one or more different models (e.g. the presence of different interpretations of the same sector).

All the stages of this process should be recorded in a suitable design report, distinguishing "facts", "interpretations" and "opinions".

Reliability quantification

The quantification of the reliability should be standardized in order to facilitate its correct use in civil works. This should follow into the following steps, listed in chronological order: (i) data collection and organization; (ii) data analysis; (iii) building of the RGM referred to the specific design phase; (iv) reliability quantification.

Generally speaking, the reliability quantification must be undertaken with the cooperation of the geologist, the designer and the customer. The process to be followed by those actors should be traceable and transparent to all those participating in the design (designer, constructor, owner, financiers, control institutions). It is recommended that:

- the reliability of a reference geological model must always be referred to the design phase in which it has been produced;

- to define the reliability it is crucial to use quantitative terms and check their coherence with all project documents;

- the elements that describe the reliability (or uncertainty) of a given geological element are three: existence, location and meaning (or impact on the project);

- the reliability of the Geotechnical Model, or Hydrogeological Model, must be related to the reliability of the Geological Model.

This document summarizes the recommendations written by the technical commission of the IAEG Italian Group, composed by Dematteis (Chairman), Kalamaras, Lombardi, Mandrone, Martinetti, Perello, Piana, Sapigni, Soldo.

E1-3 Orale Serangeli, Stefano

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PLANNING GREAT CONSTRUCTIONS IN DISTINCTIVE GEOLOGICAL AREAS: THE VIADOTTO SAN LEONARDO (SA-RC HIGHWAY).

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Key terms: Great road infrastructures; Salerno - Reggio Calabria highway; lateral variability; pile foundations

During the early phases of the planning of great road infrastructures, a major part is played by the analysis of the influence of geology on the optimal positioning of the road axis in project, in order to minimize the existing urgencies and optimize costs and times of work.

Otherwise, when particular restrictions to the project do not allow to take decision with autonomy it is necessary to widen the work knowledge in order to cohabit with such geological peculiarities.

The Viadotto San Leonardo, on the highway A3 Salerno - Reggio Calabria in Calabria, is located in an area in which a lot of geological realities live together, linked by specific characteristics which offer a wide degree of lateral variability on the soil around them as well as by the tectonics, paleogeography and geomorphology of the area.

The project needs to foresee the adaptation to the ground of the infrastructure, with the resulting demolition and reconstruction of the viaduct over about the same right of way, requires to pay great attention to the solutions to be taken, above all to the piles foundation when dealing with grounds with different characteristics.

The work geological reference model, defined by the geological surface survey, the geotechnical site investigation, the seismic and geoelectric projections, has been further elaborated through several on-site research. At the same time, the geotechnical classification of the soil interested in the work has been improved.

The geological complexity of the area, which made it arduous to plan the foundations of the viaduct, lies in the presence of formations with clearly different geotechnical characteristics: on the one hand there are fine soils (blue-gray clays and clayey silt) and loose coarse soils (conglomerates and sand in yellowish-gray silt-sandy matrix), on the other there are rocks belonging to the carbonate complex (limestone and crystalline dolomitic limestone), which are in tectonic contact through a system of normal faults. This particular structural configuration influences the typological choice of some piles of the viaduct, which are set for a carriageway on the fine soils and the other on the limestone formation.

The total length of the viaduct, which comprehends 8 piles with a maximum height of about 33 meters each, will be 491.6 meters. Bored pile foundations are foreseen, as well as micropiles when altered rock layers are encountered at shallow depth.

E1-4 Orale Capozucca, Flavio

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THE ROLE OF GEOLOGICAL STUDIES IN THE DESIGN OF LARGE CIVIL WORKS: THE CASE OF THE "CALTANISSETTA" TUNNEL

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Key terms: geological model; tunnel; mud diapirism; high pressure fluids

The role of geological studies in the design of Large Civil Works is essential, especially in the Italian region that is locally characterized by a complicated geological framework. The "Caltanissetta" tunnel, which is the most important infrastructure in the Executive Project (EP) for the renovation and adaptation to B category of the SS 640 "di Porto Empedocle", provide an emblematic case regarding critical geological aspects that may condition design and realization decisions. The Palermo-Agrigento stretch is an important route for Sicily traffic and represents not only a penetration road for the internal areas, but also the roadway linking the south-western Sicily with the A19 Palermo-Catania Motorway. Therefore, it is the direct connection between the Agrigento Province and the main bypass of the island. The economically and socially strategic importance of this infrastructure required its inclusion in the "1st Strategic Infrastructure Program" of the "Legge Obiettivo" that requires the externalization to a General Contractor. The design of this 28.2 km long segment, which extends between the 44th km and the connection to the A19 Motorway, is currently at a final executive stage (ED) with a total economic investment of 990 Million Euro. Along this stretch, the "Caltanissetta" crossing is the main infrastructure and for its construction two parallel tunnels (4,052 and 4,044 m long) have been designed. These rods run in the underground beneath the Contrada S. Elia, a region recently affected by the south-westward urban expansion of the Caltanissetta town.

Based on the geological model proposed during the Definitive Design (DD) stage, the excavation of the tunnel was designed by using TBM EPB cutter, that will provide a final coating composed of a ring of seven segments; moreover, the machine should be able to operate soil consolidations during its advancement especially in rocks with poor geomechanical properties.

The choice of using the technology of mechanized excavation by TBM EPB has imposed, during ED stage, the review of the geological and hydrogeological model which will be used for the correct design of the cutter and its various components, as well as for the evaluation of time-advancement. The geological model consists of several stages of study that provide a continuous refinement of the model through the acquisition of new cognitive elements. The review process and the upgrade of the geological model will end only with the stage of building of the infrastructure, when the reliability of the hypothesized model will be checked.

The Reference Geological Model (RGM) for the "Caltanissetta" tunnel was defined through four stages of surveys (DD and ED stages), carried out following increasing quality standards and with the aim of i) validating the proposed model, ii) definition of the critical geological aspects that could interfere with the infrastructure and iii) evaluation of parameters necessary for the design of the TBM. In particular, the geological model of the area is characterized by the association of folds and thrust faults, involving the Messinian deposits of the "Serie gessoso-solfifera" and the lower Pliocene Trubi formation.

The occurrence of huge volumes of brecciate clays was interpreted as the result of mud diapirism related to high pressure fluids at depth. This sequence is unconformably covered by a Pliocene pelitic-sandy-arenaceous succession that is, in turn, deformed by compressive structures, accompanied by further diapirical intrusions of brecciate clays (that cause active mud volcanism) and extensional collapse structures.

The most recent studies are leading to a significant redefinition of the RGM geological model, with potential technical and economic implications that are currently under analysis.

E1-5 Orale Melissa, Paone

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A NON-LINEAR RELATIONSHIP BETWEEN GEOLOGICAL HAZARDS AND DESIGN CONTEXT: THE CASE OF A SMALL GEOLOGICAL BASIN IN THE APENNINES

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Key terms: geological hazard; design phase; Civitavecchia-Terni-Rieti; geological model; subsidence rates

The construction of a road infrastructure, as of any civil work, is closely related to the physical characteristics of the landscape and needs, therefore, an adequate geological characterization. The geological model is so an essential tool for the infrastructure design phase; the assessment of the work feasibility and the identification of geological critical issues would not be possible without a good and reliable geological model.

The model should be developed with a proven method, using from the beginning a multidisciplinary approach for the study of the geological context, e.g. in order to assess the right investigation volumes. Used with awareness, it allows to carefully evaluate the reliability degree, for the right geological risk assessment and a planning of investigations capable to minimize the residual risk.

ANAS has used this approach for the Definitive Design (DD) of the completion of the connection line Civitavecchia-Terni-Rieti, that represents, together with the Roma-L'Aquila-Teramo highway, an important transversal way between the ports of the Tyrrhenian and the Adriatic Sea. Even if the infrastructure has a limited extension, it is included in the Strategic Infrastructure Program because it represents the functional completion of the connection line, waited since the '50s, located between the last stretch in Umbria Region (at its executive phase) and the stretch in Lazio Region, completed during the '80s.

The area interested by the infrastructure, bordered on both sides from the calcareous massifs of Sabini mountains, relies on most of its length on Velino alluvial sediments, except from the sector where the Monte Lungo Maiolica limestones outcrop (Jurassic-Cretacic).

The limited extension of the infrastructure, the occurrence of topographical constraints and of environmental issues (e.g. the Ventina Lake is a SIC area, Site of Community Interest) led to a corridor geometrically forced. In summary, the project includes a main axis consisting of a very high embankment connected to the Umbrian side, a short artificial tunnel and a series of secondary reaches developing in artificial embankments and traffic roundabouts, in connection to the local road network.

The geological study of the Preliminary Design phase led to a basic

geological model that showed important geological hazards, related to the young age of alluvial sediments and to the very active neo-tectonic processes, that also induced high sedimentation rates, with high lateral and vertical heterogeneity. A 14-Carbon radiometric dating assessed sediments ages lower than 5,700 years.

As a consequence, the main construction problems interest essentially all the embankments reaches, particularly the higher ones.

The forecasting of subsidence rates of sediments assessed higher values than those ones measured in the adjacent Umbrian reach, where the 100 cm have been reached. The higher depth of the viaduct foundation elements (more than 50 m) asked for the evaluation of the best foundation solution.

Furthermore, the morpho-structural features of the area suggest an high probability of seismic amplification effects, while the geotechnical properties suggest a significant liquefiability risk of the fluvio-lacustrine sediments of the first 15 m, on which a dynamic characterization will be made by means of cyclic tests.

E1-6 Invitato Marchese, Francesco

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ACHIEVEMENT OF PREDICTIVE MODELS FOR SOIL BEHAVIOUR IN THE DESIGN OF UNDERGROUND WORKS: FROM MOUNTAIN PASS TUNNELS TO HIGH-SPEED RAILWAY LINK LINE TUNNELS

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Key terms: geological model; hydrogeological model; forecasting; tunnel; urban subway

In the arrangement of a reference geological and hydro geological model for the design of an underground work, great importance is given to the context where the work is placed, which can be crossing mountains for tens of kilometres covered by important tectonic structures or running underground high-density urban settlements and infrastructures.

This feature affects the objectives of the modelling, aimed at the identification and resolution during the design phase of possible while working troubles; it affects not only the choice of investigations and the importance of the results that should be attributed to them, but also the detail of the model itself, depending on the expected answers to the questions that the kind of work requires.

It will be shown some examples about important designs of infrastructural works in urban context.

E1-7 Orale Ferrari, Federica

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SPATIAL ASSESSMENT OF GEOMECHANICAL ROCK MASS PROPERTIES BY GEOSTATISTICAL ANALYSES

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Key terms: rock masses; geostatistics; kriging; sequential simulation; San Giacomo Valley (SO)

The forecast of geomechanical rock mass properties can be an important goal in civil and mining engineering planning, especially when a wide area is involved. This work is a contribute in assessing how the geometrical and mechanical properties of the rock masses can be treated as regionalized variables. Indeed the present study deals with the reconstruction of main rock mass characteristics in an extended area, from punctual measurements of the rock mass features, through the use of different geostatistical techniques.

The research site is located in the Italian Central Alps, along the Chiavenna Valley (SO), which is composed by San Giacomo and Bregaglia valleys; it covers an area of about 200 km².

The regional geological setting is related to the Penninic Nappe arrangement, characterized by the emplacement of sub-horizontal gneissic bodies resulting from the Mesoalpine isoclinal folding of crystalline basements ("Tambò" and "Suretta" Units) emplaced through East and separated by metasedimentary cover units.

More than one hundred detailed structural and geomechanical field surveys, mainly located in San Giacomo Valley, unevenly distributed, were carried out in order to characterize the rock masses, in accordance with the I.S.R.M. suggested methods for the quantitative description of discontinuities in rock masses. The investigated lithologies belong to the "Tambò" Unit, to its meta-sedimentary cover and to the "Suretta" Unit. Geomechanical surveys allowed to identify the number of joint sets, their average orientations, spacing, persistence, roughness, aperture, presence and nature of filling, wall strength, weathering and moisture. From the collected data the rock mass quality indexes, such as the Rock Mass Rating and the Geological Strength Index, have been evaluated in each surveyed site.

The geomechanical parameters derived from the measurement stations are local data, therefore in order to know how they are distributed outside the measurement points, in the entire study area, different geostatistical techniques were applied. First of all, the field data of the main rock mass features, such as the intercept of discontinuities, fracture intensity and aperture, were analyzed, and the main statistical parameters were calculated. Then a procedure of Gaussian anamorphosis was performed when necessary. Afterward the correlation structures of the defined rock mass features were investigated, at different scales, by means of a semivariogram analysis, taking into account the occurrence of anisotropic correlations. Both kriging method and conditional simulation techniques were applied to estimate the geomechanical variables. The best results, supported by the validation process, are obtained by conditional simulation method, which respect local extreme values, compared with kriging technique which tends to produce smoothed distributions.

E1-8 Invitato Verzani, Lorenzo Paolo

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GEOLOGICAL AND GEOMECHANICAL STUDIES FOR HYDROELECTRIC POWER PLANTS IN THE ECUADORIAN ANDES - SOUTH AMERICA

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Key terms: geology; geomechanics; investigation; hydroelectric power plants; ecuador

The Ecuador Government started a National Hydroelectric development Program to face both with short-term and long-term country electricity power and energy demand. Coca Codo Sinclair, Minas Union and Villadora Chontal are among the largest planned projects. The engineering geologists team, responsible for the design of the planned works must be able to make reliable predictions for suitable construction methods and how the dam and its foundation, the tunnels, etc. will perform, under every envisaged conditions. The Engineering Geologists supports the design activities from the very beginning phases of planning and interpretation of the investigations, studying and giving solutions for the engineering problems which may arise as the result of the interaction between geology and the planned works as well as to the prediction of and the development of measures for prevention or remediation of geological hazards. The predictions will usually involve both judgement and quantitative analyses, based on data collected by the site investigation team. This data is provided as a Geotechnical Model, which consists of:

- a sufficiently detailed model of the geological situation using the typical approaches of structural geology, geomorphology, hydrogeology and of the other Earth Sciences techniques;
- adopted values of parameters for the model, as required for the analysis.

The design of these large projects faced with Ecuador dramatically active geodynamic context, in terms of kinematics (displacements) and dynamics (forces) acting in the area, and finally with the resultant deformations (joint, faults, folds) at different scales, that, at project scale, means different geotechnical properties. Therefore, before all, a comprehensive geological based approach was used for understand the geotectonic and geomorphological project contexts strictly related with the complex subduction mechanisms and its impact along the arc and back-arc regions, in which the projects are placed.

In such, dramatically active context, the engineering solutions must be capable to work for example under frequent, heavy erosion and sedimentation processes, often catastrophic, sometimes related with active volcanic eruptions.

At the same time, unfortunately, the exceptional vegetation coverage and the thickness of weathering layer heavily mask the geological outcrops, all together with a limited amount of pre-existing data, particularly those regarding the seismic and landslide activities.

In such a context, if the field geological survey, performed by experts familiar with the context in which the work will be built, remains of paramount importance, the Geological Model must be based, more than usual, on remote sensing, boreholes (including some very long and inclined drilling) and geophysics data. Together with these classic investigation techniques the lithological and structural scenario was studied coupling an extensive 2D and 3D magneto-telluric (AMT) survey, giving a regional geological setting, almost continuous along works. The boreholes was scanned using imaging with acoustic and optical televiwers (OPTV, BHTV, Full Wave) that results in continuous and oriented 360° views of the borehole wall from which the character, relation, and orientation of lithological and structural planar features can be defined for hydrogeological and geomechanical studies. Furthermore borehole breakouts was used for the determination of the orientation and module of the natural stress field.

The collected data, was founded well fitting with the regional geodynamic context of the Andean Cordillera. The influence of the main, large scale, tectonic systems, was well detected, with related local scale tectonic structures. On this base it was created the Geotechnical Design Model starting from the geomechanical classes (or groups), then the geotechnical behaviour categories and technical classes of excavation predicted along the underground works and in the dam foundation area.

E1-9 Orale Tallini, Marco

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CONCEPTUAL GEOLOGICAL AND HYDROGEOLOGICAL MODEL FOR "COSTAMEZZA" ROAD (PEDEMONTANA DI FORMIA - S.S. 7 APPIA, SOUTHERN LATIUM)

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5 - Direzione Centrale Progettazione, ANAS spa

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Key terms: tunnel boring project; geological characterization; karst hydrogeology; geophysical investigations; tunnel impact on groundwater

During the last decades the need to improve the long distance road system passing through Formia municipality, located between the coastal line of Southern Latium and the Aurunci Mts. reliefs at the back urgently rose. For this reason the definitive planning stage of the variation of the road SS 7 Appia, which will develop in the Formia municipality, through a natural piedmont tunnel 5 Km long, named "Costamezza" is being planned. The projected tunnel section is "B" category, dual carriageway. The project is commissioned to the grouped enterprises POLITECNICA-SATPI, with the participation of consulting societies and universities.

The Costamezza tunnel crosses the carbonate reliefs of Aurunci Mts., which are here strongly tectonized and karstified. Those reliefs host here an important karst aquifer which feeds the Mazzoccolo spring, located in the Formia municipality close to the eastern entrance of the tunnel, and many other springs located along the coast line. The Mazzoccolo spring (which discharge is around 600 l/s) is fundamental for the water supply of Formia district. For planning the variation, the geological and hydrogeological model has been studied in depth, for supporting the tunnel building and defining possible impacts on the aquifer, and on the spring water quality. The accuracy of the proposed geological-hydrogeological model is based on specific geological-structural and hydrogeological investigations, supported by field geological survey, borings and geophysical investigations (seismic reflection and geoelectrical

surveying for the eastern entrance).

The Costamezza tunnel, located at variable elevation between 30 and 100 m a.s.l., passes through mostly Mesozoic carbonate rocks, except at the entrances. In the western entrance, the tunnel path should cross a detritic complex made by blocks few meters wide, which is characterized by high permeability and instability. In the eastern entrance, the tunnel path should cross a low permeability complex, which is made by messinian clay with gypsum and chaotic flaky clays with rock blocks inside ("Sicilide unit" Aquitanian-Oligocene in age).

The hydrogeological studies evidences, in the internal part of the ridge, two main groundwater flow directions, one directed toward the coastal springs, and the other one toward the Mazzoccolo spring. For the entire Formia spring group, the recharge area is around 50 km², with an average discharge of 1500 l/s. The investigated regional hydrogeological context suggests that the basin feeding the springs is characterized by a wide karst system, allowing a fast and total infiltration of rainfalls which is around 1000 mm/y.

From the piezometric map it can be observed how the Mazzoccolo spring is mostly fed by the Mola Mt. and by the northernmost ridges, while Santa Maria Mt. and Costamezza reliefs feed the piedmont coastal aquifer which directly discharges towards the sea. In the area of Mola Mt., the tunnel elevation ranges between 65 and 75 m a.s.l., which is always above the water table. On the base of these considerations, any interference between the excavation works and the aquifer can be excluded.

For evaluating possible interferences between the gallery building activities, the existing tunnel and the Mazzoccolo spring, a monitoring activity of the aquifers feeding the spring and the springs at the base of the Aurunci Mts. has been performed. The drilling of 4 piezometers in the basal aquifer feeding the Mazzoccolo spring was proposed. The drilling of wells should have the following purposes:

- verify the real position of the piezometric level in many aquifer sectors and directly test the time variability.
- allow the withdrawal of significant water samples.
- allow the installation of measurement divers in the piezometric well, recording chemical and physical parameters
- allow to immediately identify possible polluting events that could rise during the excavation or during the tunnel's operating phase.

E1-10 Invitato Eusebio, Attilio

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HYDROGEOLOGICAL STUDIES FOR DESIGN OF URBAN UNDERGROUND STRUCTURES: THE EXPERIENCE OF TURIN, ITALY

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Key terms: hydrogeology; interference; urban underground works; models; turin

Most of the world largest cities are located in alluvial plain areas. Urban tunnels runs commonly at shallow depth for functional and cost reasons. This gives rise to a series of consequences in terms of geology, sub-surface, and impacts. The sub-surface at shallow depth often consists of loose soils, alluvial deposits, or man made fills. The poor quality of the ground is one of the key factors for the tunnel design and construction control.

The presence of underground waters is one of the important elements that characterise the subsoil. A correct design procedure must carefully take into account the hydrogeological context, either for the construction phases or the entire work life. The study of groundwater is important from both technical and environmental points of view, using quantitative and qualitative approaches.

The technical analysis must include the intrinsic particularities of the permeated soils, that is, a study of the porous aquifer systems is necessary. Therefore the hydrogeological study must be based on a previous stratigraphic and sedimentological model.

After this, for the design scope, the aquifer system can be considered well defined when the relative hydrodynamic parameters (governing the groundwater flow), the geometric characteristics and the flow field are known.

The definition of a hydrostructure, and in particular of the water levels (with its variation during a period comparable with the expected work life, that means tens of years), should be based on historical data series (with more years of measurements) together with the results of the design in investigations.

The site investigations must measure the permeability and other hydrodynamic parameters of the aquifers, all together necessary for the quantitative assessment of the interference of the underground works with the aquifers.

This interference depends, apart from the geological and hydrogeological characteristics, also on the tunnel depth, with its layout and dimensions; it could be negative or positive, eventually permanent (dam effect).

The design should consider the quickly growing up tendency, for the use of the free aquifers for electricity production. The new buildings extensively adopt these power supply systems, sometimes with big plants, pumping and releasing a relevant quantity of underground waters.

Particularly where multiple underground works act together the hydrogeological consequences can be complexes and the importance of a detailed in situ investigation program which data can be analysed with appropriate numerical models, evaluating the interference during construction and life, must not be underestimated.

Some recent projects in Turin, the Linea 1 of Metro, the deep foundations of the skyscraper of Regione Piemonte and the underground relocation of railway lines Torino-Ceres with their potential interference with the free aquifer gave a significant result of experience, both during the design phase and during construction.

E1-11 Invitato Parisi, Maria Elena

10.1474/Epitome.04.0404.Geoitalia2011

ROLE OF HYDROGEOLOGICAL MONITORING FOR THE EVALUATION OF THE NATURAL STATE OF A LONG AND DEEP TUNNEL IN ALPINE CONTEXT

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Key terms: underground civil; water environment; excavation; monitoring; knowledge

The construction of underground civil engineering infrastructure needs specific studies in order to define knowledge on which to base models, to make forecasts to determine the constructive elements, and then to produce a project, to build it and to put it in operation.

In the case of the new Lyon-Turin rail link, the studies involved for "the water environment" are taking on this way. The water component, precious resource, assumes in the conception study of an underground work a fundamental role.

The new Lyon-Turin railway is subdivided in 3 parts : a French part (Lyon - St Jean de Maurienne), an international part (St Jean de Maurienne - Chiusa San Michele) and an Italian part (Chiusa San Michele - Settimo-Torinese). The Lyon Turin Ferroviaria company (LTF) is responsible of the international part and is thus tasked with carrying out the pre-project studies and surveys in order to present the final details (location, costs and conditions for construction) of the engineering works to the French and Italian governments. This international part is running for more than 80 km and includes the major works of the future railway with a border tunnel, the Basis Tunnel, of about 57 km and a secondary tunnel of about 19 km, the Orsiera Tunnel.

The excavation of underground infrastructures may cause interferences on surface with the hydrological resource. In order to estimate the entity of these possible perturbations and to define the measures that allows containing them in acceptable limits, it is necessary evaluating the relationships among the superficial waters and the possible deep water slide intercepted by the tunnel, and then the exhaust flow in tunnel.

As regards the pre-project of the international part of the new Lyon-Turin railway, the studies conducted on the resource water in order to estimate the impacts of the project on the water component have had beginning in the half of 90-ies with the evaluation of the natural state (circulation, alimentation, quality) of the superficial and deep waters both in France and Italy. Monitoring of springs, wells, fountains, rivers have been realized and are still in progress. These monitoring are based on physical and chemical measures in order to have the knowledge of the hydrogeological resource before the beginning of any construction activity.

These monitoring have different aims. Obviously the first one concerns the pre-project of the tunnels with the modeling of the ante-operam natural state (identification of superficial or deep circulations, hot or cold circulations, mineralization, etc...). By crossing the different informations (hydrogeological complexes, structural elements, monitoring data, layout of the project), the potential water inflows in gallery and the potential impacts in surface can be precised. All these studies allow protecting the water component with the mitigation of the possible impact through proposals of adjusted excavation methods and the implementation of safeguard measures in case of really perturbations.

The second aim concerns the contribution of knowledge which is offered to the communes and the public administrations with the diffusion of the data.

E1-12 Orale Piccinini, Leonardo

10.1474/Epitome.04.0405.Geoitalia2011

GROUNDWATER FLOW NUMERICAL MODELING TO FORECAST TUNNEL INFLOWS AND HYDROGEOLOGICAL IMPACTS: THE CASE OF A ROAD TUNNEL IN SOUTHERN ALPS

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Key terms: forecasting; hydrogeological impacts; numerical modeling; tunnel inflows; southern Alps

The project of a road tunnel through a sedimentary rock massif in the Southern Alps at Castion (BL) needed a detailed hydrogeological study in order to forecast the magnitude of water inflows inside the tunnel and the effects on surrounding groundwater flow conditions.

The geological succession crossed by the tunnel is completely represented by "Belluno Flysh", an Eocene turbiditic formation made by biogenic calcarenitic layers, alternated by arenitic and pelitic layers, with occasional inclusions of calcareous breccias. This formation is irregularly covered by fluvial and glacial deposits, that will be also drained by the tunnel.

The main critical issues related to geology are: the possible occurrence of calcarenitic layers interested by karst dissolution phenomena, as evidenced by open and karstified fractures founded in the preliminary geognostic investigations; the different rock mass fracturation degree, related to three main faults that cross the tunnel.

A three-dimensional groundwater flow model have been implemented at the steady state and calibrated using the ante-operam monitoring data on the available boreholes and the main springs in the area.

The numerical model has been used firstly to calculate the groundwater table distribution at the end of tunnel boring (steady state) and the final effects on springs flow at the surface. It also allowed to identify the most critical tunnel sectors in relation to groundwater inflows.

In order to forecast the tunnel effects during tunnel boring, three simulations, at three different time steps of the progressive tunnel advancement, have been set up.

A sensitivity analyses on the hydraulic conductivity of the rock mass has been finally made, in order to assess the effects of parameter uncertainties on the forecasted impacts.

The hydrological monitoring programmed during tunnel advancement will allow a post-audit process on the here presented groundwater model: particularly, groundwater inflows data (as a function of time and tunnel advancement) will allow to refine the calibration process, by means of transient simulations.

E1-13 Invitato Quaranta, Nicola

10.1474/Epitome.04.0406.Geoitalia2011

APPLICATION OF GROUNDWATER FLOW SIMULATION MODELS FOR DESIGN OF DEWATERING SYSTEM IN POROUS AQUIFERS

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Key terms: Drainage system; aquifer modelling; Groundwater interference

The aim of the study is an hydrogeological survey on a stretch of artificial tunnel link, planned in an highway project, through the implementation of groundwater flow simulation models (MODFLOW).

In particular, the purpose of the model is to provide an initial assessment of the effects induced during construction and during operations, in respect of groundwater flow, and therefore optimize dewatering system during construction phase (well-points and deep wells).

The artificial tunnel in question is configured in the redevelopment of a section of SP 103 called "Cassanese", located between the cities of Brescia and Milan, south of the town of Pioltello (Milano district, Italy). The road section is part of the edge of urban areas with widespread presence of road infrastructure, technology networks and services.

The knowledge of the geological and hydrogeological conceptual model was supported both by sub-regional evaluations and boreholes drilled along the artificial tunnel position; geo-stratigraphical tunnel profile was produced as a synthesis of the local investigations, determining scenario's piezometric levels referred to the construction and operative phases.

It has been setup at first a two-dimensional simulation model of groundwater flow along 2 vertical cross sections of the tunnel axis of the gallery, representing the most severe conditions in the two phases of work, in term of lowering of groundwater levels to achieve, and then a three dimensional model in a zone of tunnel at great depth of excavation. The model was first calibrated in steady state, with reference to the current piezometric conditions, reproducing the natural groundwater flow and hydrogeological balance, and then it was extended in order by checking the changes in the flow field.

Estimated piezometric profile (upward-downward gradients) was determined both during the construction phase, appreciating effects due to introduction of piles and jet-grouting, both during the exercise phase, after the inclusion of a waterproof structure in the aquifer.

The interference with the groundwater flow with the construction of artificial tunnel Pioltello are limited, in terms of gradients induced by and planimetric extent of disruptions of the natural groundwater flow field.

Therefore the model was implemented in transient state and it allowed to obtain the following informations:

1. Initial flow rate needed to produce the piezometric depression in the share base of the excavation
2. Time interval after which the depression is achieved.
3. Flow amount that should be removed from the aquifer to maintain the level below excavations.
4. Lowering expected also in the area including the radius of influence characteristic of the aquifer.

E1-14 Invitato Delle Piane, Luca

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ASBESTOS RISK ANALYSIS BASED ON STRUCTURAL GEOLOGY AND APPLIED PETROGRAPHY FOR THE "GRONDA DI PONENTE" TUNNELING PROJECT (ALPS-APPENNINE MARGIN, GENOVA, ITALY): METHODS, ISSUES AND RELIABILITY

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Key terms: asbestos; risk; tunneling; structural geology; petrography

The new highway ring of the city of Genova, the so-called "Gronda di Ponente", aims to reduce road traffic along the existing A10 route, now absorbed by the urban fabric; the plan includes a double-tube main tunnel, by-pass and access tunnels for more than 50 km of underground works, to be excavated by means of both TBM and D&B technique.

In the project area three main Europe-vergent juxtaposed domains crop out, with the association of upper mantle and oceanic crust units (Sestri-Voltaggio Zone auct.), continental margin units (Voltri Group auct.) and Apenninic flysch units. The W to E decreasing metamorphic grade from eclogite facies to diagenesis and the complex tectonic setting testify a multi-phase deformation history.

The ophiolite units are mainly made of basic-ultrabasic rocks, the host rocks for the asbestos minerals typically growing in veins and joints. Thus, the risk related to the occurrence of natural asbestos is a major issue affecting the highway plan, which is expected to cross potentially asbestos-bearing rock units.

Among the minerals considered as "asbestos" by the Italian law, only actinolite, tremolite and chrysotile can be found in the Ligurian hinterland. Antigorite, another mineral of the serpentine group being the main component of metamorphic serpentinites, normally having a lamellar shape, was found to grow in veins with a fibrous habit.

The study was founded on detailed structural field surveys, borehole core analysis and laboratory mineralogical tests, aiming at identifying homogeneous petro-structural facies on the basis of meso- and macroscale structural, lithological and rheological criteria. Homogeneous litho-structural domains were mapped. Consequently a sampling campaign was planned where the choice of sampling criteria resulted as one of the most relevant issues, owing to the need of carrying out an exhaustive sampling as well as of determining the mineralogy and concentration of fibrous minerals for each rock type, vein type and structural context.

The laboratory analytical procedures included MicroRaman Spectrophotometry, X-Ray Diffraction and, especially for fibers concentration < 1%, Scanning Electron Microscope with Energy Dispersion System. The Polarizing Microscope has been also used to study the rocks in powders and in thin sections.

Different petro-structural facies with distinctive asbestos types and contents were defined, i.e.: (a) reaction rocks developed at contacts between different lithotypes, (b) rock volumes with bounded network of asbestos-bearing veins, (c) volumes with pervasive asbestos growth in veins/joints, (d) asbestos lacking rocks. The most critical asbestos-bearing rock types are (i) ductile shear zones with braided tremolite veins at the calc-schist-serpentinite contact and (ii) cataclastic serpentinites within brittle deformation zones. Minor asbestos concentrations were found in (iii) chlorite-tremolite schists at the calc-schist-metabasite contact, (iv) brecciated serpentinites with a stockwork of carbonate veins, (v) massive serpentinites and (vi) blueschist-facies metabasites with acicular amphibole. Fresh to slightly serpentinized peridotites commonly lack asbestos minerals.

Corresponding asbestos risk classes were defined on the basis of the critical 1000 mg/kg threshold as defined by the Italian law in force concerning asbestos concentration in soils. The main open issues concerning the asbestos risk analysis are finally dealt with: sampling representativeness, lack of certified methodological standards, gaps in the law, etc.

The geological reference model was analyzed in terms of global reliability, considering all variables affecting the geological predictions (e.g.: number of available boreholes, complexity of the tectonic setting, etc.). A geological section including a quantitative description of the asbestos-risk was finally drawn, allowing to define safety procedures for both underground works and muck spoil management.

E1-15 Orale Marzocchi, Roberto

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NOBLE GASES AND GEOCHEMICAL DATA AS PROXIES FOR THE ORIGIN OF GROUNDWATER. APPLICATION TO A TUNNEL IN THE SOUTH-ALPINE REGION.

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Key terms: noble gases; groundwater; tunnel hydrogeological interferences; faults; groundwater flow systems

Noble gases (He, Ne, Ar, Kr, Xe) in groundwater are known as useful proxies to study the groundwater flow dynamics in aquifers. [Kipfer et al., 2002]. The atmosphere is the largest noble-gas reservoir on Earth.

Atmospheric noble gases enter the water cycle by gas partitioning at the air/water interface. Therefore, noble-gas concentrations in surface waters are often found at atmospheric equilibrium. In general, deviations from the expected equilibrium concentrations (e.g., due to the accumulation of radiogenic and terrigenous noble-gas isotopes) can be used to understand the transport dynamics within aquatic systems. For instance, the noble-gas concentrations and their isotope ratios have been used in groundwaters to determine residence times, mixing processes, and the origin of water [Mahara & Igarashi, 2003; Althaus et al., 2009]. Tunnel drilling offers a unique opportunity to sample and study deep waters that otherwise are hardly accessible. Understanding of the deep groundwater flow is of primary importance to assess possible negative impacts of tunneling on hydrogeological systems.

We sampled water for noble-gas analysis from tunnel inflows in the Monte Ceneri base tunnel (Canton Ticino, southern Switzerland) which passes through an area mainly characterized by metamorphic rocks (gneiss). Furthermore, we collected water samples from springs located in the same geological environment.

On the basis of the ⁴He, ³He, and ²²²Rn concentrations measured in the water samples, we identified the isotope signature of terrigenous helium for the studied region. The determined isotope composition for each sample allows for the distinction of old groundwaters strongly enriched in helium of crustal origin and more recent waters which are close to atmospheric equilibrium.

In the light of the available tritium measurements and geological logs, we elaborated a hydrogeological conceptual model. According to this model, different flow systems can be distinguished for water circulating through faults, that are generally filled by fine-grained, low permeable, material. One system seems to be separated from the surface and carries groundwater with a strong terrigenous He isotope signature of crustal origin. Other flow systems are a mixture of old and more recent waters close to atmospheric equilibrium. The water collected from more permeable faults shows a ³He enrichment most likely originating from the decay of tritium. Therefore this water seems to contain a fraction of recent recharge. The different types of water allow for the characterization of faults that may be critical for tunnel drilling due to their active hydrogeological role and to their influence on the rock's mechanics.

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E1-16 Poster Soldo, Luca

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GEOLOGICAL AND HYDROGEOLOGICAL MODELS FOR THE DESIGN OF THE SOUTH PORTAL OF BEVERATE RAILWAY TUNNEL

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Key terms: hydrogeology; geomorphology; tunnel excavation; investigation; Beverate

Geological and geotechnical uncertainties and the resulting risks in construction of underground works are well understood. Both the design and construction phases are always characterized with a certain degree of uncertainty, particularly about the nature of the geological and geotechnical characteristics and their spatial variation. The level of knowledge of geological parameters which are the principal sources of the project risks is often not optimum due to geologic complexity, limits imposed on the investigations, etc.

The use of a step-wise investigation approach in reducing these risks has not received the deserved emphasis. In many designed works which met severe problems during construction it was found that often an inadequate model of ground conditions had been used, either because some

geological features had been missed or overlooked during investigation or because its significance had been underestimated.

In the paper a case history of an investigation campaign for the south portal of a railway tunnel focused on the base of a "geological perspective" is described, emphasizing the relevant advantages obtained in the design and construction phases. Site investigations, their follow up and their interpretation are highly specialistic tasks. They are typically following an hermeneutic approach along which the choice of the more adequate site investigation approaches is closely related with the necessary parameters for the design of the different engineering works, different for different geological environments. Also the site investigation phase typically must follow a step by step approach where additional investigations could arise because of the collected evidences.

In this case it is showed as the geotechnical and hydrogeological context was fully understood only on the basis of the contribution of this investigation approach, also supported by a specialistic contribution in sedimentology of glacial deposits.

The anamnesis-diagnosis and the prognosis phases are intimately related and they must be guided and interpreted, with wisdom, by the specialist "medician": does anybody could accept fully persuaded for an eyes disease the diagnosis of a luminary orthopedist?

E1-17 Poster Serangeli, Stefano

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AN EXAMPLE OF GEOLOGICAL AND GEOMECHANICAL CHARACTERIZATION OF ROCK MASS IN THE SOUTH-EAST AREA OF SARDINIA.

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Key terms: Rock mass classification; Roads plan; Sardinia; Ercinic basement

On the occasion of the planning of civil engineering infrastructures, involving rock masses, it's fundamental to collect information about the characteristics of the geomechanical quality, resistance and deformability of the rock mass.

These can be deduced from the usual methods of geomechanics classification of the cluster. Through the collection of field, survey and laboratory data, these methods allow to obtain useful parameters for the geomechanics quality indexes (RMR - Rock Mass Rating; GSI - Geological Strength Index, ecc), also providing geomechanical and geostructural classification of the rock mass under investigation.

During the ultimate planning phase of the first lot of the Tertenia - S. Priamo of new S.S. 125 section, this research methodology was applied. Along the way, the ground of the ercinic basement arises, like the formations of the San Vito Sandstones (ASV) and Monte S. Vittoria (MSV). The first is made up mostly by metarsandstones and quartz-mica metapelites, rarely metasandstones and thin levels of green/gray metaquartzsandstones, with intercalations of metapelites and gray metasiltstones; the second one is represented by metavulcanites, feldspar metarsandstones and metaconglomerates, and it can be divided into two kinds of litofacies: a) metaepiclastites and metarhyolites (MSVa); b) metagraywakes e metandesites (MSVb).

To analyse these formations we have classified the clusters from the proceeds of the data gathered during the geostructural and geomechanical study of rock mass, which was elaborated on linear stations according to ISRM standards. The measurement of each line helped to define the geological characteristics of the site, the classification of the different types of discontinuity and their geometrical and geomechanical features. All these informations have been collected with survey and geostructural synthesis forms and geomechanics classification tables showing the RMR and GSI Index.

The results collected through the field survey have been compared with those obtained by the extrapolation of the geognostic and laboratory data (recording of the RQD inside the borehole, Point Load Test and rock samples uniaxial compression) with the aim of having a more accurate assessment.

According to the performance obtained from the GSI index, the different lithologies have been included in the diagram "Geological Strength Index for Jointed Rocks" (Hoek & Marinos, 2000).

This comparison allowed us to notice a fair correspondence between the two data series and it has lead us to assign the geological parameters on the basis of which we have scaled the project operations.

E1-18 Poster Leta, Mario

10.1474/Epitome.04.0411.Geoitalia2011

TUNNELLING ACTIVITIES IN PALERMO'S URBAN AREA: GEOLOGICAL FEATURES AND INSTRUMENTAL OBSERVATION

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Key terms: public work; travertine; groundwater

Palermo city has been interested up till now by several geological investigations for carrying out a public project: the south east main sewer's finishing.

Preliminary and executive planning stages focused on: geological surveys about boreholes to core sampling, geotechnical laboratory testing and analysis, inspection of excavation face, groundwater management and control, performing of instrumental measures.

The trail of the sewer system crosses the city from the south east to the north west and intersects areas of high geological complexity, where morphology and structural have affected the appear today of the main Palermo plain litho-stratigraphic successions as regards the spatial relationship and the hydrodynamic configuration.

Continuous inspection of excavation face allows to store a detailed geological and litho-technical reconstruction on the spot investigation, improving knowledge about outcropping stratigraphic sequence and distribution of groundwater.

The analysis of stratigraphic data, coming from boreholes, and excavation sections have testified the presence of deposits ascribed to several marine and non marine sedimentary facies, from Pleistocene to Holocene in age. In the middle of Palermo plain near the west borderline of historic centre,

the tunnel excavations have revealed, for the first time, a travertine deposit. The travertine has a high historical meaningfulness in the evolving of depression Papireto and reaches an extension of about 6,000 square meters. Micropaleontology and facies analyses allowed to recognize a silty clays and sandy silt substratum Lower Pleistocene (Sicilian) in age underlying alluvial deposits passing upward to peat level followed by calcareous sand alternating to phytohermal and phytoclastic facies associations.

The areal and vertical development of these deposits, marked by discontinuity surfaces, shows changes in sedimentary environments and breaks the record related to groundwater fluctuations due to climatic/hydrology variations over time. In the early stage an instrumental monitoring started for supporting the public project that allowed us to locate the groundwater in the Calcarenitic deposits at an average depth of about 10 meters. The groundwater have been locally affected by changes correlated to the shape of this deposit. In some areas it was possible to record the presence of sub surface piezometric levels too. These were affected by specific local morphological conditions or due to the presence of deposits Holocene in age very sensitive to underlying aquifer fluctuations. The different instrumental sections have been showing in via Colonna Rotta a sudden recharge related to exceptional rainfall amplified by morphological structure and local stratigraphic sequence.

In November 2008 and February 2009 the exceptional meteoric events caused the flooding of the tunnel up to about 1 meter above the base of the excavation.

In some sections the plots show anomalous piezometric levels related to the public work. These piezometric profiles plotted for a time interval of about 5 years overlap perfectly to the different project phases, exhibiting a meaningful increases level (over 3 meters) on connecting to construction of hydraulic barrier, followed by protracted intervals of stabilization and sudden deflection that place the groundwater to a depth of about 5 meters definitely. On this area piezometric excursions involve a clear interfering between the works and the urban fabric above. This interfering needs continuous monitoring to prevent possible geological phenomena of local instability and protect the functionality of the sewer system.

SESSIONE E2

Paesaggio culturale: un'idea per lo sviluppo sostenibile di un territorio

E2-1 Orale Gregori, Lucilia

10.1474/Epitome.04.0412.Geoitalia2011

THE ART LANDSCAPE: EMOTIONS FROM REAL OR IMAGINED PAST ENVIRONMENTS

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Key terms: landscape; geomorphology; palaeogeography; art; Umbria

In the Umbria region the "landscapes of art" were made by Giotto, Perugino, Pintoricchio, Gozzoli They represent a sort of "widespread museum" on the territory and are unexpected resources and cultural opportunities. The usual vision and capture of the work of art may be increased by an "added value": the assessment of the geological and morphological characteristics of the landscapes, pictured behind the protagonists in the scenes and the comparison with the existing topographic model. The attention to the works background of some local artists, not only on Umbria landscape, offers interesting parallels with the local situations that must be interpreted. As a matter of fact the landscape represented in the painting corresponds to different climatic conditions. Due to this fact is possible to interpret the paleo-environmental characteristics of the area. That scene can be different or not from today, but the interesting challenge allows to recognize the features, compare them and reconstruct the paleo-landscape sometimes still recognizable. The correlation with the actual landscape is a fascinating cultural journey, and absolutely a new way to observe the paintings. (shared with other situations in the Marche region, Nesci, 2008). In Umbria region "Il Perugino" painted the Trasimeno lake landscape through the views through of Città della Pieve (his birthplace) or from Val di Chiana area. He characterizes a particular hydrological condition of the area, in a cross-section view related to the Chiana graben. The fresco paintings of Giotto, in the Upper Church in Assisi are an unusual review of St. Francis' life. They allow to do a "virtual walk" through the landscapes of the area around the Subasio or La Verna mountains. The scenarios, representing the outcropping lithologic complexes, describe the topographic characteristics of the reliefs, where thick sandstone benches influence with the morphology conditions identifying the Tuscan landscape. Also the calcareous bedrock on the Subasio mountain characterizes the landscape of that area. The "landscapes of art" are an addition to the emotions usually related to each painting. They can become an interesting comparison between the actual environment and the landscape observed from the artist.

E2-2 Orale Nesci, Olivia

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THE "RENAISSANCE VIEWS" PROJECT: CULTURAL RESOURCE MANAGEMENT IN THE MONTEFELTRO LANDSCAPE.

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Key terms: Cultural geomorphology; Cultural heritage; Natural resources; Landscape management; Montefeltro region

Cultural geomorphology is a field wherein a geomorphological approach is applied to the study of objects of cultural heritage. This interdisciplinary approach, which has already produced excellent results in the field of

Archaeology, is proving very effective in the study of historical and architectural landscapes and even in the analysis of pictorial representations. The Renaissance Views Project is based on this approach and aims to enhance the natural resources and cultural heritage of Montefeltro through scientific research, towards a cultural resource management of this territory. The idea was born from the discovery of the background landscapes in the works of Piero della Francesca (Nesci & Borchia, 2008, 2009, 2010). First, the landscapes in the diptych of the Duchess and Duke of Urbino by Piero della Francesca were studied utilizing geomorphological, cartographic and historical analysis. Then, other paintings by Piero della Francesca found in Valmarecchia region were studied. These studies increase the cultural value of an area already appreciated for its archaeological sites, historical records, ancient buildings, religious beliefs and practices. Therefore, it is necessary to develop a cultural project aimed at tourists by including parallel events of great prestige and potential visibility, such as courses of study, workshops, and collaborations with academic and cultural associations. BORCHIA R., NESCI O. (2008) - Il paesaggio invisibile. La scoperta dei veri paesaggi di Piero della Francesca. Il Lavoro Editoriale, 134 pp. NESCI O., BORCHIA R. (2009) - Il contributo della geomorfologia alla ricostruzione di alcuni paesaggi in opere pittoriche. Un esempio dai quadri di Piero della Francesca". Atti Convegno Internazionale: I Paesaggi del vino. Cartografia e paesaggi. Boll. Soc. It. Cartografia, 136-137, 203-210 BORCHIA R. & NESCI O. (2010) - Itinerari geomorfologici alla scoperta dei paesaggi di Piero della Francesca. In Peris persi Ed. Territori Emotivi/geografie emozionali. Gente e luoghi: sensi, sentimenti ed emozioni. Dip. di Psicologia e del Territorio. V Convegno Internazionale sui Beni Culturali Territoriali. Fano, 4 -6 settembre 2009. 38-41

E2-3 Orale Badiali, Federica

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THE REPRESENTATION OF THE LANDSCAPE IN RENAISSANCE MINIATURES AND MAPS OF THE ESTE COLLECTIONS IN THE BIBLIOTECA ESTENSE AND IN THE STATE ARCHIVES OF MODENA

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Key terms: Renaissance miniature; Renaissance maps; Anthropical landscape; Iconography

he study of the landscape representations in the miniatures of ancient manuscripts and maps of the Este, now kept at the Biblioteca Estense and at the State Archives of Modena, allows us to capture relevant such as unexpected information to reconstruct the Renaissance anthropic landscape, and to understand the value that contemporaries attributed to it.

In this way can be followed the evolution of relationships between man and environment, in a period when the human influence on the territory was almost exclusively linked to agricultural production and forestry. It presents a selection of some significant iconographic sources that were part of the rich collection of Este, which allow us to understand both the different degrees of adherence to the reality and of intentionality in the representation of landscape.

Often, the iconographic apparatus of these works follows a project of great complexity and elegance, in which there is clearly a choice to give priority each time man's work or elements of the landscape, but always with attention to details, demonstrating the importance of the agricultural landscape and large-scale country planning, topics always at the center of attention of Este dukes.

The ancient images of the landscape always go through the mediation of the will of the author, in turn susceptible to other external influences, which may be cultural, social or imposed by the client. In these images it is evident the strong subjective impression, both artists and the patrons, it emerges with great evidence in the representations of reality, in turn consequence of cultural conditioning that often lead to the adoption of conventional stylistic and symbolic modes, thus representing the landscape with highly variable levels of realism.

What is the motivation of these deviations from the reality? Were taken intentionally or unintentionally arising from the imagination of the artist? Were specifically requested by the commissioner, which wanted to represent their ideal model of landscape? Could be perceived by those who observe the image at that time?

Anyway you answer these questions should always be taken into due consideration the distance between the original idea, in whatever ways born, and the idea originated here and now in the mind of the observer who is immersed in the perception: that distance is simultaneously temporal and psychological.

Fortunately, our advantage in observing the ancient representations of the landscape is, or should be, to have the ability to capture what the observers of the past have not always see, that is the significance of the relationship between elements of fantasy and real issues. Perhaps the most lifelike images are the expression of the achievement of a stable relationship between environmental resources and agricultural production, that is between region's potential and citizens consumption, however, at the same time, alongside these representations of the landscape, we can observe others, in which the imagination produces images that fully belong to the sphere of wonder. Is clear, in these cases, the will of the artist, who consciously decides to use the representation of fantastic landscapes to describe the human soul's emotions.

E2-4 Orale Giardino, Marco

10.1474/Epitome.04.0415.Geoitalia2011

TOOL INTEGRATED MANAGEMENT OF A GEOSITE: APPLICATION OF TIQ (TERRITORIAL INTEGRATED QUALITY) FOR THE PROGEOPiEMONTE PROJECT (INTERDISCIPLINARY RESEARCH TEAM "D").

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Key terms: Integrated Quality Management System; Sustainability; geological heritage; Piemonte

The multidisciplinary research project "PROGEOPiemonte" aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region by means of the development of techniques for recognizing and managing its rich geodiversity at the

local and regional scale. After a systematic review of inventoried geosites, 9 strategic geothematic areas will be investigated to represent the geodiversity of Piemonte, each characterized by high potential for scientific studies, enhancement of public understanding of science, recreation activities and for economic support to local communities. Geological history, climate and environmental changes, natural hazards, soil processes and georesources will be popularized not only with geosites but also with museum collections, evidences of mining activity and quarrying, science exhibits and nature trails. The recognition of the economic value of geodiversity will lead to the production of regional guidelines for Geoconservation integrated quality management system, suitable for tourism and sustainable development strategies. In details, the integration model will be elaborated by the Department of Commodity Sciences, and will be based on the TIQMS (Territorial Integrated Quality Management System), a methodology developed by this Department and tested in a Comunità Montana near Turin. TIQMS allows the user to analyse a region by many points of view, regarding quality, landscape, environmental, occupational health and safety, and social accountability aspects.

All these features are managed on the basis of the European Landscape Convention adopted by Italy and the following international standards: ISO 9001:2008, ISO 14001:2004, OHSAS 18001:2007 and SAS800:2008. The methodology TIQMS was originally developed for the Public Administrations. Its flexible character allows it to be adaptable and for the implementation in new and different territorial contexts.

First of all a phase of research and analysis will take place; it is essential in order to build the next steps, which will mainly develop guides lines for the integrated management of the conversion and use of mining sites for touristic purposes.

It will be necessary to pick out, in agreement with the others agents involved, a number of indicators for quality estimation, environmental quality and landscape, occupational health and safety and social conditions.

For this and other goals, such as the management in real time of the data to calculate the indicators, it will be available a remote sensing system of the variables included in the project; it will be used Scato8TM, an hardware and software open source system elaborated by the Department of Commodity Sciences, able to gather, store and send data regarding the analysis of the natural components of the region, and others data necessary to analyse the landscape units that form the region, which are essential for its knowledge and description.

The implementation of the Scato8TM system has to be seen in an progression way. It is, indeed, able to adopt other noticeable variables, in order to fulfil the needs of the project.

The methodology will follow these steps:

1. Integrated territorial analyses on the region considered as the object of the study. This has the aim of detecting the beginning situation with an accent into the quality, environment, landscape, occupational health and safety, social responsibility aspects, and point out the indicators;
2. Build the plan for the Integrated Management System;
3. Define the procedures and the implementation of the integrated system; a guide for operators training and a documentary system will be arranged to check and improve the variables of the system;
4. Test the system and evaluation of a possible certification;
5. Elaboration of Guide Lines for the implementation of an integrated management system;
6. Elaboration of a Guide for touristic operators training.

E2-5 Orale Valenti, Veronica

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THE GEO-CULTURAL HERITAGE OF THE MONUMENTAL COMPLEXITY OF THE MILAZZO PENINSULA (SE SICILY, ITALY)

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Key terms: Milazzo Peninsula, Southern Italy; Geo-Cultural Heritage; Monumental Complexity; Historic evolution, Technical Construction, architectonic and ornamental materials; model of territorial management

This research aims to contribute to the knowledge and exploitation of the monumental complexity of the Milazzo Peninsula (NE Sicily), one of the most important territories in Southern Italy to be considered as Geo-cultural site.

Specifically, the purpose is to create a guidebook to document and illustrate the historic evolution, technical construction and natural materials used in the most important architectonic structures dating from the Archaic Period of Greek Art to the Rococo Period of Baroque Art. The Milazzo Peninsula leans out towards the Tyrrhenian Sea in a S-N direction, extending for about 7,5 km and reaching an altitude of 135 m (Trinità Mt.). It is characterized by the presence of the homonymous city which expands from the isthmus between the peninsula and the Milazzo-Barcellona Plain to the Milazzo Cape.

The city derived from the expansion of ancient settlements, unified over the course of centuries. It involves three areas: the High City, or the historic centre with its Medieval hamlet, castle and the most important monuments; the Low City, or the present urban centre, which extends from the port area to the archaeological ruins of the Greek Mylai (716 B.C.); the City of the Plain, which is the recent built-up area with several farmed areas.

Due to its strategic geographical position between the Messina Straits and the Aeolian Islands, Milazzo was a centre of important civilizations and the scene of famous historic events, from the Caio Duilio (260 B.C.) to the Corriolo (1860) Battles. The last was one of the most important battles for Garibaldi's Army, fought during the unification of Italy.

Several examples of evidence from the Bronze, Iron, Greek and Roman Ages are still preserved, both in the historical centre of the high city, and in the remaining areas. Under Arab domination the city was fortified with a very important castle (the Castrum) and its commercial and agricultural economy was reinforced. During the Norman, Suevian and Aragonese dominations the castle was enlarged and in the Aragonese and Spanish periods, it was enclosed by two different surrounding walls, transforming this architectonic complex into a Fortified Citadel. Other significant architectonic structures in Renaissance to Baroque Styles characterized Milazzo City.

The present study allowed the following to be analyzed:

- a Hellenistic mosaic of the 2nd century B.C., representing a "Kouros Siceliota" made up of polychrome tesserae, consisting of different types of limestones from Peloritani Mesozoic deposits;
- the Fortified Citadel, constructed by Mastio Federiciano (XI and XII

centuries), the Benedictine Monastery (XV century) and the Aragonese (XV century) and Spanish (XVI century) Surrounding Walls. The architectonic and ornamental materials used in these structures consist of dark Aeolian rhyolitic to basaltic volcanites; Peloritani polychrome metamorphic, plutonic and sedimentary rocks (Aspromonte Unit Pan-African and Variscan metamorphites and Late-Variscan plutonites; San Marco d'Alunzio Unit Mesozoic limestones and dolostones); - the Church of Saint Francis of Paola (XVI century), rebuilt on an old original 1464 structure. Its charming ornamental elements are made up of Sicilian polychrome marbles and limestones;
- the Church of Saint Antony of Padua (XVI-XVIII century), to dig into the rock (Miocene calcarenites), is rich in artistic mosaics made up of polychrome limestones and dolostones from Peloritani Mesozoic deposits (San Marco d'Alunzio and Longi-Taormina Units);
- the D'Amico Palace (XVIII century) is a notable testimony of the Messina Late-Baroque and Rococo Styles. The materials are sandstones and calcarenites from the Oligocene-Burdigalian Capo d'Orlando Flysch and of Burdigalian-Langhian Floresta Calcarenite deposits, respectively. This reconstructed geo-cultural system, which represent a very important heritage for sustainable tourism, is a promoter of innovative territorial conservation and management models.

E2-6 Poster Ajassa, Roberto

10.1474/Epitome.04.0417.Geoitalia2011

NATURAL AND ARTIFICIAL WATERS OF NORTH - EASTERN PIEDMONT (PROGEOPIEMONTE PROJECT - GEOTHEMATIC AREA 5)

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Key terms: Landscape; Geological heritage; Water resources; Piedmont

The multidisciplinary research project "PROGEOPIEMONTE" aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region by means of the development of techniques for recognizing and managing its rich geodiversity at the local and regional scale.

Geodiversity in Piedmont is characterized by high potential for scientific studies, enhancement of public understanding of science, recreation activities and for economic support to local communities. The recognition of the economic value of geodiversity will lead to the production of regional guidelines for Geoconservation integrated quality management system, suitable for tourism and sustainable development strategies. The fifth geothematic area of PROGEOPIEMONTE PROJECT is represented by a sector of fluvial plain of in North - Eastern Piedmont (Po basin). Landforms, agents, processes and factors have been described and mapped for reconstructing the evolution of the fluvial plain. The change of Quaternary landscape and climate in the fluvial plain have been studied by pedological, geomorphological, paleoenvironmental and paleontological data. Waters (natural and artificial waters), are seen as an agent in both landscape evolution and anthropic land use. Geosites and nature trails will show relationships between landscape and anthropic activity.

E2-7 Poster Georgiadis, Teodoro

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SOME CRUCIAL KEY POINTS IN THE URBAN ENVIRONMENT DESIGN: ARE URBANISM AND PHYSICAL ENVIRONMENT DEFINITELY CONFLICTUAL?

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Key terms: microclimate; physical quantities; urban design; wellness

In Italy, from year 1946 which constitute the origin of SVIMEZ (Association for the industry development of the Italian southern regions) a dispute, which is currently open, on the priority of urbanism as a guide and coordination of the urban development still pervades the political action. We saw that the concept of total freedom in managing the land-use and design gave rise to a long and complex series of unsolved problems related to the sustainability of cities as well as the effects on population wellness. Physical relationships between the built environment and microclimate was so poorly considered that the discipline is still not part of the academic cv's of architecture and engineering faculties. Environmental physics demonstrates that it is not quite possible to create a sustainable environment without considering at least elementary principles of human comfort. Thus, the still open question remains: it is possible to conciliate the environmental physical requirements with the urbanistic tools? A positive replay to the question the authors are confident should be possible by putting the human wellness at the centre of this system.

E2-8 Poster Ghiraldi, Luca

10.1474/Epitome.04.0419.Geoitalia2011

CULTURAL GEOLOGY IN VALSesia (N-PIEMONTE, ITALY)

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Key terms: Valsesia; Cultural landscape; geosites

Landscape is a complex dynamic combination of landforms and processes. These elements are memories of the history of the Earth and enable us to understand the evolution of our world.

The paper describes first the conceptual framework and the methodology followed in order to investigate the relationships between landscape's geomorphological features, environmental dynamics and man in Valsesia (Northern sector of Piemonte Region, Italy), and then the suggestions for a program of appraisal and popularization of geoheritage.

Valsesia offers a wide variety of geological and geomorphological elements, and holds stories of different peoples, who founded their independence in the mountains environment by using the available local resources and even suffering the difficulties. There are traces of human activity starting from the Neanderthal man on the Fenera mountain; Waiser settlements in the upper part of the valley and several mines dated

back to period of Savoy. In this perspective, the physical landscape of Valsesia is an available resource for human activity and settlement; local community suffers, models, works, enhances and destroys part of the landscape, giving it a "personality", that can be defined as landscape culture. Culture is not intended only as "activities of human being" but as "the product of the interactions with the environment in which people lives".

In the transition between the physical and cultural landscape there is an increasingly request of information, curiosity and awareness by the observer, where the geomorphological aspects are evident, while the culture is hidden. For these reasons, the research project can be divided into four main parts: data collection, inventory and evaluation of geological heritage, valorisation of the landscape. These activities have been developed analyzing and linking the geological and geomorphological aspects with the cultural and historical ones.

The geological and geomorphological terrain survey and field data collection were performed by using geomatics tools: a pocket PC equipped with mobile-GIS software and GPS, allowing data collection on a dedicated inventory form properly set up for the Valsesia project. For the historical and cultural part, several local institutions were involved. They allowed a large collection of archival and bibliographic documentation.

The selection of 19 sites with the highest interest has been performed taking into account some peculiar features in order to achieve a wide audience: accessibility, potential dangerousness, educational value and scientific interest.

The popularization phase has been carried out through the production of didactic material (field guide), using simple languages, but at the same time scientific rigorously. Illustrations, pictures, and multimedia help the public to facilitate the comprehension of the natural processes.

Essential part of this work has been dedicated to highlighting the active role of humans being in the history of each site, focusing on the landscape's anthropogenic elements. Geosites described may, therefore, be proposed as elements of sustainable tourism, aware of local resources and respectful of local traditions. As different ingredients create a particular dish, so this project joined different and specific interests, in order to develop a valuable drama to tell different stories: glacialism and climate changes, religious sense and the environment, natural and human history of the valley, geological resources and mining activities.

E2-9 Poster Guerra, Cristiano

10.1474/Epitome.04.0420.Geoitalia2011

RECONSTRUCTION OF THE EVOLUTION OF AUSA CREEK BEDRIVER USING HISTORICAL DOCUMENTS IN A GEOGRAPHIC INFORMATION SYSTEM (GIS).

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Key terms: river evolution; historical drawings; Ausa creek

The Ausa creek, in the territory of Republic of San Marino, was strongly affected by human intervention, like artificial levees and flumes, and today it appears as a "urban river".

Seeking and digitizing various historical drawing (cadastral plans, technical and topographic maps) and through other documents it has been reconstructed the evolution of river morphology using a geographic information system.

The evolutionary hypothesis was then calibrated and compared with many geognostic data available in the area.

Finally the changes of the riverbed and channel pattern were reconstructed in the last 150 years, completed by the recognition of the areal extension and age of anthropogenic deposits.

E2-10 Poster Guerra, Cristiano

10.1474/Epitome.04.0421.Geoitalia2011

GEOMORPHOLOGICAL AND GEOLOGICAL STRUCTURAL ANALYSIS SUPPORTING THE ARCHAEOLOGICAL RESEARCH. THE EXAMPLE OF THE TANACCIA ROMAN SANCTUARY IN THE REPUBLIC OF SAN MARINO.

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Key terms: archeology; Mount Titano; nivation

Techniques and methods used in structural geology and geomorphology can offer a substantial contribution to archaeological investigation, especially in sites where the "stratigraphic" approach is difficult, and deposits aren't been in horizontal layers.

The site of "Tanaccia", located close to the cliffs bordering the eastern side of Mount Titano, near to the ridge, looks like "slope" archaeological area, and consists in a rock outcrop with a cave at the base (the Tanaccia). During excavations between 1990 and 1994, the finds of votive bronzes and pottery and coins, confirmed the existence of a medical sanctuary from the V century B.C. to the first century A. D.

The cave is probably a nivation hollow developed inside the rock along some interlayers and joints.

Geomorphological and structural analysis allowed to identify handmade expansions and their timeline.

Detailed survey of debris flow around the site provides insights for future archaeological investigations.

E2-11 Poster Nesci, Olivia

10.1474/Epitome.04.0422.Geoitalia2011

THE EVOLUTION OF THE LACUSTRINE AREA AT MONTELAGO (MARCHE APENNINES): A RECONNAISSANCE STUDY FOR GEO-NATURALISTIC EXPLOITATION OF THE SITE

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Key terms: Landslide-dammed lake; Geosite; Holocene; Montelago; Marche Apennines

Montelago is a hamlet placed approximately at 800 m a.s.l. near Sassoferrato (Ancona, Italy) within the Marche Apennines. Meso-Cenozoic calcareous-cherty-marly formations of the Umbria-Marche succession crop out in the watershed of Fosso del Lago, a NW-SE flowing tributary of Sentino river. The local toponyms "Montelago", "Fosso del Lago", "Il Lago" clearly hint at the presence of a former lake, at present dried out. The first attestation to Montelago appears in historical documents dated to the 13th-14th century, whereas the first cartographic representation accounted to the 19th century Gregorian Cadastre, where some water-ponds are distinctly represented. In this area, the first geological field-based evidence for the presence of an ancient lake was provided in 1960 by detecting blackish, laminated clays cropping out along the present channel of Fosso del Lago stream. In 2008, specifically addressed to a possible restoring and exploitation of the site as a geo-naturalistic attraction, two seismic tomographic profiles have been recorded and a continuous 26.5 m-deep core has been drilled in the area where laminated clays recovering 9 m of lacustrine peaty sediments cropped out. Detailed geomorphological surveys confirmed that the lake was generated by stream damming due to a large landslide failed from the left valley side.

Radiocarbon ages of peats and wood fragments, ranging from 8,180-8,040 cal B.P. (Atlantic) to 3,080-2,880 cal B.P. (Sub-Boreal), demonstrate that the lake persisted for several millennia. However, only a shrank pond survived throughout the entire time-span just in the place where the peaty-clays have been drilled, having been the upstream sector of the lake gradually filled by alluvial gravels. In any case, the youngest ages of the drilled sediments reasonably suggest that the extinction of the lake, by far, antedates the origin of local toponyms. Thus, a major problem arises about the local toponyms, as well as about nature and origin of the ponds represented in the 19th century Gregorian Cadastral maps, which are unlikely to represent relics of an old lake dried out almost three millennia before. Indeed, their very position does not allow regarding them as remnants of the former lake, since they both match the upstream portion of the former lacustrine trough and rest atop the alluvial fan-like bodies filling up this sector of the former landslide-related lake.

The Gregorian maps show a sharp upstream enlargement of the Fosso del Lago stream even to more than fourfold in width, suggesting the occurrence, at that time, of a narrow and elongated water impoundment, also stressed by a nearly horizontal valley-floor profile. This latter is bounded on both sides by 2-3 m-high scarps; a rough parallelism and straightness of the two scarps suggest a human intervention, most likely in enlarging an already entrenched channel to create (and/or to maintain) a small reservoir. Other unusual enlargements shown by Gregorian Cadastral maps on two rather steep (up to 15°-20°) tributaries of the Fosso del Lago stream match former soggy wetlands related to important springs at present dried-out, which evidence are small pot-like holes in the outflow points. It is also worth noticing that several dried-out springs marked by ground depressions and/or dried seepage-channels are apparent throughout the head-valley, thus stressing a recent lowering of the local ground-water level. Finally, long after the former landslide-dammed lake dried up, the Fosso del Lago has been modified by human intervention to create and/or to reshape and maintain a small reservoir supplied by still existing minor streams and by at least three important springs at present drought out. As a predisposing factor to such intervention, re-forming on the Fosso del Lago valley floor of some ponds and/or soggy wetlands because of local abundance in spring water cannot be ruled out.

SESSIONE E3

Geologia delle Aree Urbane: il ruolo delle geoscienze nella pianificazione territoriale e nella protezione civile in aree urbane

E3-1 Orale Martelli, Luca

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GEOLOGICAL INVESTIGATIONS IN URBAN AREAS AND PLAINS: AN INVESTMENT.

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Key terms: urban areas; subsoil investigation; subsoil data base; geological mapping of the plains

Until a few years ago, geological mapping and research projects have focused mainly in mountain areas to the detriment of the urban areas and the plains. This is true also for the new Geological Map of Italy.

Perhaps this choice comes from the need to understand aspects not yet sufficiently clear in dynamics and evolution of complex chains as the Apennines and the difficulty of survey directly geological elements of the subsoil in urban areas and plains.

The increased urbanization, including the dissemination of infrastructure networks (roads, aqueducts, pipelines, etc.), has radically changed the context of the needs of geological knowledge and the role of the geologists in the society.

First, the urbanization of areas with geological hazards increased significantly the exposure to risk, the consumption of soil and the need for exploitation of subsoil resources.

Moreover, the need for research of renewable energy sources, such as geothermal energy, to reduce the emission of polluting gases into the atmosphere, requires geological knowledge especially near urban areas.

In urban areas, both because human works prevent direct observation and because they were developed mainly in valleys, plains and along the coast, it is often necessary to investigate the subsoil with drillings and geophysical surveys.

In situ tests often involves high costs, long time for authorization and execution and logistic difficulties (investigations in the historic centers not permitted, presence of underground utility networks, etc.).

Sparse available survey sites (drillings, seismic lines, etc.) are thus very precious points of observation, perhaps most valuable then outcrops in the chains.

It is therefore extremely important to organize all geological data of urban areas and plains in accessible databases, easy to update. So, geological investigations in urban areas and the related databases raise the meaning of a real investment, useful for urban planning and design of works.

Fortunately, the same data can be used for various purposes. For instance, the study of underground water reserves run in the 90s by the Emilia-Romagna Region and ENI, based on seismic lines and stratigraphic logs from oil wells (ENI data) and stratigraphic bore-holes and water wells (regional data base), integrated with studies on the main bodies of alluvial fan for hydrogeological purposes, have provided very important data also for studies of seismic microzonation and for the exploitation of underground heat, both for the ground coupled heat pumps (open loop and closed loop) and for the research and exploitation of thermal aquifers.

As test sites in the plains and urban areas are spotted, it is necessary to interpolate and correlate data, possibly with an appropriate number of checks distributed according to regular meshes. Moreover, in urban settings is often necessary to use non-invasive techniques. Of course it is also important that additional investigations are fast and low cost.

Measures of ambient vibrations allow quick and low cost checks throughout the territory and, in combination with stratigraphic investigations, allow the recognition of major stratigraphic discontinuities in the subsoil.

The investigation techniques and procedures mentioned above have been successfully tested in geological studies of large urban areas. We will briefly present some interesting results.

Finally, as after the new national seismic classification all Italian municipalities are classified seismic, the new technical standards for construction require detailed geological and geotechnical investigations for design, in particular for the calculation of the seismic force, in some regions the seismic microzonation is required for approval of the urban plans and geological information are used for civil protection plans (damage scenarios, test of strategic buildings, etc.) it is desirable that the official geological mapping will be completed at least in urban areas and in the plains.

E3-2 Orale Mancini, Marco

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DIFFERENT SCALE ANALYTICAL METHODOLOGIES FOR GEOHAZARD ASSESSMENT IN URBAN AREAS: THE URBISIT PROJECT.

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Key terms: Urban geosciences; Geohazard assessment; Rome; Geological mapping; Susceptibility maps

The UrbisIT Project, led by the CNR-IGAG, Istituto di Geologia Ambientale e Geoingegneria, and commissioned by the Dipartimento della Protezione Civile, is aimed at the development of tools and products for geohazard assessment in urban areas, and of geological-technical models for seismic microzonation.

In particular, the project is organized into workpackages, and prefigures the specific procedure explained in the following steps.

- 1) Selection of study areas, in general few km² or tens of km² wide, with related data collection from scientific literature, public administrations and private companies. Data of interest concern the soil and subsoil of urban areas, and are of geological, hydrogeological, geophysical, geotechnical and remote sensing typology, along with related thematic maps.
 - 2) Definition, for each area, of three operational and study levels at different spatial scale, namely the broad, intermediate area, and site specific levels, to reach the detail specifically required for the scopes and expected products of the study.
 - 3) Analysis, selection and classification of collected data to be stored in a GIS supported database, which is projected for the three defined levels, and for different purposes such as, for instance, bi- and tri-dimensional geological reconstruction of urban subsoil, spatial hydrogeological and geotechnical, numerical modeling.
 - 4) Data elaboration and delivery of specific products for each level. At the 1st level, the broad area scale, Synthetic Geological Maps (SGM) (at 1:50.000-1:20.000 scale), and related stratigraphic schemes, are produced, which integrate basic geological cartographic data with the numerous and densely distributed, but not homogeneously detailed, borehole data. Large informal Basic Stratigraphic Units are introduced within the SGM, so as to characterize urban subsoils, and to provide a basic tool for preliminary Susceptibility Maps, related in particular to subsidence and sinkholes. At the 2nd level, the intermediate area scale, detailed Geological Maps (at 1:10.000 or broader scale), Susceptibility and local Geohazard Maps, Seismic Microzonation Maps are produced, along with specific studies on anthropogenic backfill deposits, on their geometrical characterization, and on their relations with the geological substratum. At the 3rd level, the site specific level, more detailed products, at 1:1.000-2.000 scale, such as Local Seismic Response or slope instability studies are expected.
- The city of Rome is one of the selected study areas where the above mentioned procedure and data elaborations have been tested. Synthetic Geological Maps of the entire urban area, and smaller scale Maps of the anthropogenic backfill deposits of the city centre, and Seismic Microzonation studies are here presented and discussed for this wide urban area.

E3-3 Orale Nardi, Giuseppe

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RECONSTRUCTION OF A GEOLOGICAL UNDERGROUND MODEL IN THE CITY CENTER OF TIRANA (ALBANY)

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Key terms: Tirana; Urban Geosciences; Underground model; GIS

The present work is focused on the reconstruction of a "geological underground model" in the center of Tirana. The obstacles in dealing with a geological study in urban areas are the shortage of outcrops and the widespread existence of underground utilities. These difficulties can be largely overcome with a multidisciplinary geological analysis based mostly on data from core surveys but also from new geophysical technologies. Tirana is situated in a flood-plain area actually crossed by the "Tirana" river, flowing in the northern part in his natural riverbed, and by the "Lana" river, flowing in artificial banks in the southern part. The whole plain is surrounded by low gradient hills whose directions reflect a structural control. The stratigraphic bedrock is made by a Tortonian silty mudstone on which can be found the recent alluvial-colluvial deposits. The study has been developed on a data set made by: continuous core surveys, laboratory/field geotechnical tests, digital terrain model, orthophotos, groundwater table levels and historical topographic maps. This data set via a multidisciplinary analysis, using also GIS and CAD software, allowed to develop geological sections (in lithological, depositional and hydrostratigraphic units), a morphological structures map, a 3D groundwater flow model, a chronology of recent events and a three-dimensional litho-stratigraphic arrangement. The digital image analysis together with continuous core wells stratigraphy allowed the recognition of surface and underground forms, the identification of sedimentary bodies and depositional facies and the reconstruction of geological processes that affected the topsoil and subsoil of Tirana. This study confirmed that a Quaternary continental floodplain system is set on a Tortonian marine transitional system. Moreover the present work shows that this continental system has been strongly affected by the fourth-order eustatic changes in Plio-Quaternary but also by tectonic activity linked to the formation of the range of hills skirting the urban area. This tectonic activity is the main cause of the subdivision of the study area in two domains with different fluvial hydrodynamics (erosional, depositional, etc.). Particularly the study of groundwater levels (derived from wells data), related to the subsurface geology, allowed to outline the morphology of the water table and the main groundwater elements. The 3D groundwater flow model developed shows the characteristics of the groundwater system composed by a confined shallow quaternary aquifer whose elements have E-W directions. Finally the GIS analysis allowed to compare the geological model outlined with the hydrostratigraphic one showing a good agreement between the two models. Indeed the morphology and position of the groundwater elements (such as watersheds or drain axes) matches largely the depositional facies defined in the geological model.

E3-4 Orale Vallone, Paola

10.1474/Epitome.04.0426.Geoitalia2011

GEOHERITAGE: A WEBGIS CONCERNING PALERMO URBAN AREA

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Key terms: Palermo urban area; Urban geology; GIS application; Territorial planning

Palermo urban area is characterized by high variability of near surface geology and soil physical-mechanical properties on a very short distance scale, even few meters. So near territory portions can have a totally different hazard exposition.

GeoHeritage is a GIS application developed within Project 7T7, Cluster C 29, funded by MIUR, that manages a Geographic Information System concerning Palermo urban area. It includes: 1) a reliable high density stratigraphic - geotechnical database, assembled by means of a careful data reviewing process; 2) a database of some hundreds of lithotechnical sections, each carried out by using a high density of geotechnical and stratigraphical data; 3) the accelerograms database of the September 2002 seismic sequence, recorded by eight temporary digital seismic stations, located in correspondence of the main geological models recognized in Palermo urban area; 4) a damage census database, performed using the "AeDES" census damage card which codifies the damage suffered by structural elements in few features (damage class, typology and area of the damaged structural elements), set up by Civil Protection Regional Department - Sicily after the 6th September 2002 earthquake; 5) a macroseismic intensity database composed by intensity values estimated in 3000 different sites of the city by means of a macroseismic questionnaire dispensed during the 2002 earthquake; 6) a Palermo cultural heritage database.

GeoHeritage has all GIS functions and tools specifically dedicated to identify the zones interested by the main hazard factors. The possibility to display and simultaneously query the different database managed by GeoHeritage allows to easily highlight the buildings most exposed to hazard factors as soft foundation soils, shallow water table, ecc..., or vulnerability factors, as for example underground cavities. The tools equipped with GeoHeritage and the Geographic Information System elaborated for Palermo urban area can efficiently support territorial planning and management and correctly project interventions to assure safety conditions or in emergency situations.

For these reasons a website (www.ghgis.unipa.it) has been carried out, where GeoHeritage and the GIS concerning Palermo urban area have been implemented, setting up a permanent interface between those studying the territory properties and those preposing to make decisional choices concerning the territory.

Some cases of GeoHeritage utilizations are presented to highlight its reliability in territorial planning and heritage safeguard.

E3-5 Orale Lentini, Fabio

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MULTIDISCIPLINARY GEOLOGICAL APPROACH FOR URBAN AREAS IN SICILY: EXAMPLES OF MESSINA AND CATANIA

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Key terms: Urban geology; Neotectonics; Geomorphology; Geological hazard

In Sicily the geodynamic activity is testified by geomorphological evolution, uplift, volcanic and destructive earthquake events. In recent times the urban geology assumes particular importance, but the field

survey is hampered by roads and edifices and it needs detailed field mapping, integrated by subsurface data for reconstructing the stratigraphy and geometries of the geological bodies. The analysis must be supported by aerial photographs better of different times, and by historical documents.

In Eastern Sicily the Messina and Catania urban areas represent two examples of different geological aspects, but both are affected by geodynamics, which deeply influences the life of people. Messina is located on the western side of the Messina Straits, that shows morphological features strongly related to the structural setting. ENE-WSW oriented morphological escarpments, bordering the coast of the northern sector of the Straits, are clearly controlled by the Scilla System. Single channel seismic lines show faults affecting the sea-floor sediments. This area has been destroyed by the earthquakes of February 6th 1783, located in the offshore of Scilla village, and by the famous earthquake of December 28th 1908. The structure responsible of the last event is still not been recognized: more of ten different hypothesis have been presented in the literature. Recently a project to realize a bridge across the Straits produced a lots of subsurface geological data, that can permit a reconstruction of the geological features in the urban area. Catania is located on the southern flank of the Mount Etna volcano in front of the Ionian Sea. The town has been destroyed by two main earthquakes, occurred in 1169 and 1693. To define the complicate geological and morphological settings below the volcanic cover, as well as the structures responsible of the events, is fundamental the detailed analysis of the pre-volcanic morphology, of the stratigraphy of the volcanic products as well as the stratigraphy of the sedimentary basement. The study must be integrated with geophysical and stratigraphic analysis of the boreholes drilled in the urban area. This kind of study should be extended to a large area of the whole Eastern Sicily to recognize the regional seismogenic structures. The city was damaged by a lapilli fallout originated by a plinian eruption of 122 a.C. In 1381 it was threatened by lava flows originated by an eruptive fissure opened at 400 m a.s.l., and in 1669 the largest effusive eruption destroyed nine villages and reached the town. So that Catania represents another example of a city characterized by both volcanic and seismic high risks, and this should be a fundamental target of an urban geological multidisciplinary analysis.

E3-6 Orale Senatore, Maria Rosaria

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THE GEOLOGY OF THE URBAN AREA OF BENEVENTO. THE PALAEOENVIRONMENTAL RECONSTRUCTION IMPORTANCE IN PREDICTING THE SEISMIC RESPONSE

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Key terms: STRATIGRAPHY; SEDIMENTOLOGY; SEISMIC RESPONSE; SEISMIC VULNERABILITY

Geological studies carried out between 2001 and 2003 in the city of Benevento were performed as part of a multidisciplinary project, coordinated by the National Group for Defense from Earthquakes (GNDDT), called Traiano Project, which was composed by ten research units with eight tasks developed in several stages. The Task 3 - geological characterization - has established the stratigraphic and structural framework to highlight the factors which influence the local amplification of the seismic signal. Since 2003, the data acquired with the Traiano Project have been continuously updated as soon as new boreholes and digs for the construction of building have become available. According to composition, texture, sedimentary structures of the sediments, and the depositional environment and the relative age, several stratigraphic units were recognized. The physical stratigraphy approach made possible to reconstruct with good approximation the spatial distribution of the units with their mutual geometrical relationships as they are not the result of a random geological evolution, but the result of a logical spatial and temporal development of depositional environments, arranged with the tectonic and morphological evolution of the area. Geological survey in the city, in digs for building construction, and in cuts along road was carried out; moreover 16 boreholes carried out for the purpose were analysed and about 400 stratigraphic logs archived and made available by several local public authorities were re-interpreted. The derived geological, stratigraphic and structural model is supported by the experimental geophysical data and has provided the base for the spatial extension of the data useful even to the geostatistic approach. The stratigraphic pattern is defined by: anthropogenic deposit: h, hl, h^o; mixed slope deposits: p-b2 (Late Pleistocene-Holocene), p-b4-7 (Late Pleistocene-Holocene) forming alluvial deposits: b, BN1 (Latest Pleistocene-Holocene), terraced alluvial deposits: BN2 (Late Pleistocene), BN3 (Middle-Late Pleistocene), bn4 (or Cretarossa alluvial deposits CR-bn4; Early Pleistocene); ancient alluvial deposits of Benevento Pacevecchia AABPV (Late Pliocene-Early Pleistocene): facies a silty and gravelly-sandy deposits (AABaPV); facies b: sand silty and gravelly deposits (AABbPV); facies c: silty sand and clayey-silt deposits (AABcPV); syn-orogenic units: Ariano group unit (UGA) (Early Middle Pliocene); pelitic-arenaceous facies (UGAPs); arenaceous pelitic facies (UGASp); Tufo Altavilla unit (UTA) (Late Messinian; Chiocchini & Chiocchini, 1996); pre-orogenic units: calcareous-pelitic Flysch Rosso succession (sfr) (Scandone, 1967; Early Cretaceous Burdigalian. A geological map (1:4.000 scale), demonstrating the validity of the classic geology investigation methods, updated and codified within the CAR.G project. The geological analysis and seismological data (Di Giulio et al., 2008) have made possible to distinguish at least three zones with different seismic response: 1) relatively low amplification (AF 1.1 +/- 0.1) along the Benevento hill, not considering the presence of covers, above AABaPV; 2) amplification of 1.5 +/- 0.2 related to the geological conditions of Rione Mellusi (in particular CR-bn4 above AABaPV or AABbPV), and in the rail station area (b and BN1 or BN2 and p-b2 on AABaPV) producing resonance phenomena with frequencies of 4 Hz; 3) amplification of 2.1 +/- 0.6 related to the geological conditions of the Sabato river plain (Triggio e Rione Libertà). This area was urbanized between 1940 and 1960 with inadequate buildings for seismic actions (Pecce et alii, 2004). The estimate damage for these buildings point out a large proportion of collapses in the case of a strong earthquake (about 40%, Cosenza et al., 2005).

A map of damage at the buildings carried out after an earthquake that struck Benevento in 1688, shows severe collapses in the area of the Triggio.

E3-7 Orale Cammarosano, Antonella

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RECONSTRUCTION OF HYDRO-STRATIGRAPHIC MODEL BASED ON GEOLOGICAL-STRATIGRAPHIC MODEL IN THE BASEMENT OF THE URBAN AREA OF BAGNOLI; VALIDATION ON THE BASIS OF EXISTING IDROGEOLOGICAL DATA.

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Key terms: Urban Geology; Underground Urbanism; Hydrogeology

The Plains of Coroglio and the Terrace of Bagnoli - Fuorigrotta represent a flat area that extends SW-NE direction from the Gulf of Pozzuoli to the central city area and is characterized by the presence of the volcanic edifice of St. Teresa. The basement of this area consists of a sequence of volcano-clastic deposits and transitional resting on a tuff substrate. Hydrogeological characteristics of the area are very unique compared to other areas of the city of Naples. In fact, it is characterized by the presence of an underground watershed that separates it from the rest of the groundwater flow system. It has in fact a drawing of the piezometric surface quite articulate, with a relatively high hydraulic gradient. A qualitative analysis of the trend of the piezometric surface does not identify in a comprehensive manner the geological causes that affect the hydrodynamic morphological elements (Celico et al., 2002). This work identifies these factors and test the existing patterns of the groundwater flow through the creation of hydrostratigraphic sections generated on the basis of a three-dimensional geological model of facies defined by survey data. These sections were made choosing for each depositional facies in the subsurface a particle size fraction, when homogeneous. In case of non-homogeneous particle size an average value has been assigned based on the relationship between thickness and grain sizes. The deposits were classified with respect to the relative permeability using values derived from laboratory data for pyroclastic soils that characterize the Neapolitan area (Cammarosano personal data) and canonical tables for transitional deposits. Taking into account the maximum and minimum value of relative permeability as defined, three classes of hydraulic conductivity were set up: High (K between 10-2 and 10-4 m / sec), medium (K between 10-4 and 10-6 m / sec) and low (K between 6.10 and 8.10 m / sec). Many sections representing the distribution of relative permeability in the subsurface were developed based on these three classes of hydraulic conductivity. Hydrostratigraphic sections, developed from the existing geological model, confirm the hydrogeological pattern established by Celico et al. 2002 (water table levels and watersheds obtained from hydrogeological data) and helped identify the geological causes that affect the hydrodynamic morphological elements.

These results validate the proposed methodology in the construction of hydrostratigraphic sections and lead to use advanced sedimentological analysis of stratigraphic data from wells in urban areas.

E3-8 Orale Urru, Giorgia

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FROM DATA ACQUISITION TO URBAN MANAGEMENT: A GEOLOGICAL APPROACH FOR ADDRESSING GEOHAZARDS PREVENTION ACTIVITIES

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Key terms: Geohazards; G.I.S.; urban environment; Roma

A basic methodology to evaluate geohazards in urban environment is presented in this paper. The proposed methodology is useful for addressing urban planning and risk management before disaster, having a look at spatial data existents, easily consultable, flexible and dynamically connected.

Every day a natural catastrophe at least affects an area of the most populated region of the world where seismic, volcanic, cyclone, landslides, flood hazards are just a part of them. Actually the pervasive urbanization process and the increasing human needs (buildings, infrastructure, transport, energy pipe lines) have strongly modified the environment interacting with surface and underground earth properties, triggering man-made geohazards phenomena (cavities collapse, filling deposits instability, subsidence process). The civil protection authorities are mainly involved in the management of disaster events, but also in the prevention and prediction activities for reducing risks. By now the knowledge integration of environmental characteristics is mandatory to support the planning and the assessment of decision making process.

On this regard a methodological approach is suggested in this paper, based on geological data acquisition, from collecting topographic/thematic cartography to interpreting stratigraphic and geophysical logs, reviewing the pre-existent and new spatial (XYZ) and temporal information available. This semi-quantitative approach is focused on evaluating man-made geohazards, often interlocked to natural ones, giving a spatial tool for planning urban development, so to considerably reduce or mitigate the disaster risk.

The proposal methodology was developed in the city of Rome, a metropolitan area with huge amount of geological and historical information available. Rome is a strategic area for developing the proposed procedure, because of its geological-geodynamical/geomorphological settings and its vulnerability due to its World Heritage resources and its political role. Different geological hazards insist on the city with medium-low degree of impact. The complexity of alluvial deposits (Holocene), the variable thickness of man-made filling, the recent sprawl urban development are the main critical features.

Man-made deposits and seismic properties were principally investigated for Tiber's left bank tributaries. Two presently buried valleys (paleo-valleys), characterized by similar geology, but diachronous urban development, buildings typology, and infrastructure, were analyzed. The conceptual and logical model was implemented in a G.I.S., and the geological, geotechnical, hydrogeological, and stratigraphic data were stored in a RDMS. The comparison of the two valleys shows different seismic velocity profile respect to S-waves at the same depth, according to respective urbanization history and lithotype properties.

Finally, the proposed approach can give a relevant methodology to civil protection authorities, planning managers, and stakeholder for an aware and safe urban management, especially where surface data are rare and anthropic pressure on the local environment is high.

E3-9 Orale Stigliano, Francesco

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THE GEOHAZARD ASSESSMENT IN URBAN AREAS: THE RECONSTRUCTION OF THE ANTHROPIC BACKFILL GEOMETRY IN THE CENTRE OF ROME (URBISIT PROJECT).

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Key terms: anthropic backfill mapping; geostatistics; flooding; geohazard; Rome

The anthropogenic deposits or "anthropic backfill unit" constitute one of the main and problematic geological feature of urban areas. Because of their anthropic origin they could not be referred to the natural processes originating the sedimentary formations; however, they could be considered as a true shallow and heterogeneous "geological body" due to their intrinsic characters, such as geometry, thickness, lithology, texture, and stratigraphic position above the natural geological substratum. Due to their geological/geotechnical characteristics these deposits can be linked to different geological hazards that affect urban areas. The presence of urban service networks and subsurface works excavated in the backfill units may increase the level of hazard. Furthermore, studies about the distribution of earthquake damages show a positive correlation between backfill thickness and seismic amplifications.

The backfill unit commonly hosts an important groundwater circulation fed by rainfall recharge, sewer leakage, buried ditch, and numerous springs localized at foothills. Furthermore, they often hide the original drainage network and could induce flooding phenomena. This study is aimed to reconstruct the bottom surface and the thickness maps of anthropic backfill of the city of Rome by using geostatistical interpolation techniques in order to develop a general tool to rapidly evaluate the flooding susceptibility of urban areas. The backfill elevation discrete values come from about 1400 boreholes located in the center of Rome and stored in the UrbisIT BDGT database (UrbisIT Project, CNR-IGAG-National Civil Protection Department).

As starting hypothesis the maximum thickness of anthropic backfill is thought to occur along the buried streams. An overlay between the map of the anthropic backfill thickness and the original drainage network (published by the Autorità di Bacino del Fiume Tevere) was performed in order to validate the initial hypothesis. The backfill thickness map was used to detect zones where the original drainage network filled by man-made deposits could involve flooding phenomena in case of heavy rainfall. Two variables were considered in the assessment of flooding susceptibility: the distance from the buried valley axes and the backfill thickness. These two variables have been represented as raster dataset and summed by using "map algebra" operation in GIS environment. More variables, like water main network and water table will be further considered in order to refine the risk analysis.

The application of probabilistic algorithm constitutes a reliable technique for the reconstruction of the backfill bottom surface and thickness maps in urban areas starting from stratigraphic boreholes. In particular, the results obtained by integrating the thickness of backfill units and the buried drainage network provides a rapid tool for the elaboration of preliminary maps of flooding susceptibility that can be used for risk evaluation and urban planning by public institutions.

E3-10 Orale Moscatelli, Massimiliano

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GEOHAZARD EVALUATION AND SEISMIC MICROZONATION OF THE CENTRAL ARCHAEOLOGICAL AREA OF ROME

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Key terms: geohazard; seismic microzonation; Palatine hill; Rome

In 2009, after declaring the state of emergency for the central archaeological area of Rome following the adverse weather conditions of November and December 2008, the Commissario delegato (i.e., Government Commissioner, at present Roberto Cecchi, Ministry of Cultural Heritage and Activities) and the Dipartimento della Protezione Civile (i.e., Italian Civil Protection National Service, DPC) assigned the Istituto di Geologia Ambientale e Geingegneria (IGAG) of the Italian National Research Council (CNR) to evaluate the geohazard level affecting Palatine Hill, Roman Forum, and Coliseum. Research activities started up in February 2009 and were concluded in February 2011, with the valued contribution of the Soprintendenza Speciale per i Beni Archeologici di Roma (i.e., the archaeological Superintendence).

The first two phases of the project (between February and December 2009) were carried out mainly using available information from public Institutions and private companies. Three new thematic maps on a 1:1,000 scale were produced at the end of the second phase: (i) a geological and hydrogeological map with seven geological cross-sections, (ii) a susceptibility to instability map, and (iii) a seismic amplification susceptibility map. The third and final phase allowed to perform new field surveys and involved three CNR research Institutes (apart from IGAG, scientific coordinator) and one University department:

- o Istituto per l'Ambiente Marino Costiero (IAMC), CNR;
- o Istituto di Metodologie per l'Analisi Ambientale (IMAA), CNR;
- o Istituto per le Tecnologie Applicate ai Beni Culturali (ITABC), CNR;
- o Dipartimento di Ingegneria Strutturale e Geotecnica (DISG), SAPIENZA University of Rome.

The new surveys were planned to achieve two main goals:

- 1) the characterization of the archaeological layer, in order to (i) map the bottom surface of the anthropic covering, and (ii) typify the archaeological layer in terms of physical and mechanical properties.
- 2) the characterization of the underlying geological bedrock, aimed to (i) map the geological units and typify the recognized lithotypes in terms of

physical and mechanical properties, (ii) detect and monitor the water table position, and (iii) detect conditions potentially susceptible of instability (i.e., landslides, cavity or chamber collapse, seismically induced settlements);

Because almost no direct observation either of the geological bedrock or of the pre-anthropogenic/anthropogenic contact is possible due to the thousand-year-old anthropic covering, an extensive Electrical Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) survey was performed. Integration of the geophysical surveying methodologies with geotechnical boreholes allowed to define a very detailed geological model of the study area, in terms of buried topography, geometries of geological and anthropic bodies, and lithotype distribution. The geological and hydrogeological map, along with the geohazard susceptibility map were updated in the light of the new data. Moreover, geotechnical in situ and laboratory tests, active (Down-Hole, Cross-Hole, and MASW) and passive (noise measurements) geophysical surveys allowed to define a subsoil model aimed at 1D and 2D numerical evaluation of the seismic response of the area. The main results of this study lie in a seismic microzonation map on a 1:2,000 scale and site-specific response spectra to be used for seismic retrofitting of the monuments.

The main goals of the project were achieved at the end of the study. Results demonstrate how valued cooperation among Institution allow to accomplish prevention of risk related to local conditions of instability, both in terms of geological and seismic hazards. Finally, the proposed experience is a good example for managers, in order to develop site-specific guidelines for risk preparedness in heritage sites.

E3-11 Orale Lucchetti, Carlo

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HAZARD ENDOGENOUS GAS EMISSIONS (CO₂, H₂S AND 222Rn) IN THE CAVE DEI SELCI (MARINO-ROME)

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Key terms: Hazard endogenous gas; Soil radon concentration; Radon indoor; CO₂ flux; Alban Hills area

Many areas in the Alban Hills are at risk from endogenous gas emission mainly due to the presence of a quiescent volcano, active since 600000 years ago. The areas of gaseous emissions are located: in correspondence of structural highs of carbonate basement, along extensional faults with directions NW-SE (Cava dei Selci), on bottom of the Albano lake, and in areas where impermeable surface coverage is removed from excavations or perforated by wells. In the area of Cava dei Selci is a site of strong emission of endogenous gases (CO₂, H₂S and 222Rn are main) because anthropogenic excavations removed the surface sediment of low permeability, previously preventing the gas release. Since the year 2000, this area is monitored with flux measurements of CO₂ on a fixed grid. In this area since July 2009, 11 measurements of soil radon at 30 cm depth from ground level were made, having values between 1455 Bq/m³ and 69700 Bq/m³. Mainly the highest concentrations of soil radon were measured in correspondence of sites with higher CO₂ flux from soil (carrier effect). During the winter it was not possible to make measurements of soil radon because the area is covered by seasonal pool of water. Since 2010 concentration measurements of 222Rn and CO₂ in the soil (at 80 cm depth from ground level) were made along with measurements of CO₂ flux, in some home gardens around maximum degassing zone. Also in this case the highest values of soil radon were measured in correspondence of higher CO₂ flux. Since February 2010, radon indoor measurements were performed in some ground or underground rooms, selected for the presence of relevant CO₂ and H₂S air concentrations. In the underground level of some buildings, including three apartments in Maciocco street, at present evacuated, dangerous gas concentrations up to lethal levels (CO₂ 20,6-22 vol.%, H₂S >500 ppm) were observed. In one of these indoor environments, radon continuous measurement from February 26, 2011 to March 02, 2011, indicates 504 Bq/m³ as minimum value, 23500 Bq/m³ as maximum value and 7500 Bq/m³ as total average. During many radon indoor measurements it was possible to check carrier effect of CO₂. The measurements carry out in this area showed a strong release of gases from soils, not only in the main degassing site, but also in various parts of the urbanized area. This implies a widespread situation of danger for indoor concentrations of CO₂, H₂S, and 222Rn in some buildings. At regards these environmental issues, the introduction of constraints for excavation and drilling is recommended to prevent accidents to people and the high cost to restore security conditions.

E3-12 Orale Castelluccio, Mauro

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RADON AND BUILDING: PREVENTIVE ACTION FOR RISK REDUCTION

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Key terms: soil radon concentration; soil intrinsic permeability; building protection; radon hazard mapping; urban planning

The World Health Organization identifies radon as the second cause of lung cancer in the general population, after smoking. Epidemiological studies have provided convincing evidence of an association between indoor radon exposure and lung cancer, even at the relatively low radon levels commonly found in residential buildings.

Radon is a natural gas produced from uranium and thorium decay; soil is generally the main source of radon accumulating in indoor environment. Thus the knowledge of gas potential release from soil is a powerful tool to make new buildings with low level of indoor radon: a preventive action with a specific field survey can be more effective and economic if compared with later mitigation practices.

The knowledge of potential radon emission from soil can have different addresses according to the investigation scale. If applied to large scale survey, it can provide useful data for urban planning and lead to a territory zoning, with location of areas where a significant proportion of homes exceed the reference level (radon-prone areas). In case of small scale investigation (construction site scale), it is possible to collect more detailed information on potential radon release from soil. Here, a protocol

for the evaluation of radon hazard factor is proposed in order to promote a practical approach to exploit in any single construction site. This protocol provides a set of indications whose core is the contemporaneous measurements of soil radon concentration and intrinsic permeability. Using these two parameters, a numerical index is calculated, whose value allows to characterise the site on the basis of hazard classes. Mapping soil radon and radon hazard can be a further investigation tool, useful to define the spatial distribution of parameters. Furthermore, the protocol provides suggestions on the protection degree of a new building, in terms of proper construction techniques to prevent gas transport from the soil to the indoor environment. It also gives indication on the permeability features of the ground surrounding the building with the aim of preventing a focused radon flow towards the building foundations. It is important to keep in mind that different methods can be used to measure the parameters. Consequently, it is useful and necessary to validate the method through intercomparison exercises in test-sites. Caffarella Valley (Rome) represents a well-consolidated reference site to study soil radon variability and intercomparison work took place there. Actually, this kind of events are regularly organised in different European countries with the participation of universities, research centres and private firms.

E3-13 Orale Masi, Umberto

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POTENTIALLY TOXIC ELEMENTS, BIOGEOCHEMICAL AND ISOTOPIC MARKERS AS ENVIRONMENTAL QUALITY INDICATORS IN A COMPLEX LAND SYSTEM (RAVENNA, ITALY)

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Key terms: POTENTIALLY TOXIC ELEMENTS; BIOGEOCHEMICAL INDICATORS; ISOTOPIC INDICATORS; ENVIRONMENTAL QUALITY; RAVENNA, ITALY

The final conclusions of a multidisciplinary study of Earth and Soil Sciences, carried out in the frame of Prin 2007 are presented. The study has dealt with a variety of natural materials, encompassing soils, waters, atmospheric depositions, the vegetation and the bottom sediments of a coastal lagoon, in the territory north of Ravenna, characterized by important agricultural and industrial activities. In particular, by chemical and isotopic methodologies and pedological survey, it has been studied the ecosystem of the San Vitale Pinewood and the Lagoon of Piasassa Baiona, both constituting the southernmost part of the Po river delta Park. The results obtained have shown that the Pinewood is affected by major salinization processes induced by local subsidence and concerning underground water and soils. This jeopardizes the vegetation's health, in particular, the pine trees that are the main characteristic species. Moreover, the proximity of the industrial zone of Ravenna to the Pinewood represents another threat to the environment, as it is a major pollution source by release of particulate matter with stacks. Therefore, potentially toxic elements may fallout onto the soils, waters and vegetation of the Pinewood, arising general concern on the preservation of the forest. The important traffic rolling on the road net contouring the Pinewood-Lagoon ecosystem is a further source of pollution, as indicated by the incoming diffusion of PGE on the topsoils bordering the roads. Lastly, the study of the bottom deposits of the Lagoon at the water-sediment interface has unveiled the diffuse presence of Hg with significant concentrations, derived from industrial wastewaters unloaded in the basin some decades ago. Luckily, Hg occurs in the element form and, thus, its mobility is very reduced, keeping so far the risk factor in the Lagoon low. As a whole, the Pinewood-Lagoon ecosystem is ailing due to incoming salinization processes and, subordinately, moderate pollution proceeding from the industrial zone and the traffic. Therefore, it is recommended to implement a monitoring survey of the study area on the ground of the parameters used in this research. In fact, they have been able to provide the local Administrations with punctual responses to the problem of degradation of the Pinewood-Lagoon ecosystem.

E3-14 Orale Balbi, Pietro

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URBAN GEOLOGY OF GENOVA: AN OVERVIEW

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Key terms: Geology; Geomorphology; Geoarchaeology; Urban; Genova

Several complicated geological and geomorphological features, directly connected to the particular tectonic history of the area, have influenced over the centuries the development and expansion of the Genoese urban area. The city of Genova lies on a transitional zone between the Alps and the Apennines, whose extremely complicated tectonic history has left evident morphological traces. After the Tethys oceanic crust subduction, during the Paleogene, mountain building occurred due to several compressional phases that superimposed very different formations from the lithological, metamorphic and deformational point of view: cretaceous turbidites, jurassic mafic and ultramafic rocks from almost non-metamorphic to eclogites facies, dolomites, cherts, basalts, limestones etc. Some chain scale tectonic lines such as the Sestri-Voltaggio cross Genova and influence the morphology of one of the two important valleys that characterize the shape of the city. The north-east migration of the compressional front after the Oligocene left an extensional regime that caused the formation of the characteristic steep mountain slopes that face the sea along almost all of central and eastern Liguria as well as several graben structures that form the relatively less steep area occupied by the city of Genova. The Messinian-Pliocene sea level oscillations left evidences such as the submarine canyons that continue underwater the course of the two main waterways that cross the city, the Bisagno and Polcevera streams, and, on the other side, the thick marine deposits of overconsolidated shales along

the graben structures (Ortovero shales) as well as several marine terraces structures.

Despite the complicated morphological features, Genova has been populated since pre Roman times because of its position on the Mediterranean sea. The development of the town since its origins has been influenced by the peculiar morphology characterized by a few flat areas squeezed between the sea and the mountains (which can be as high as 800 m like mt Fasce) along an almost E-W direction, with the exception of the two larger valleys Bisagno and Polcevera that run northwards, giving the modern city the approximate aspect of a big upside down T. The morphology of the city has somehow influenced the human activities too, driving the ancient Genoese to sail the seas and develop commerce. The great subsoil lithological variety has allowed the development of several quarries in the urban area. They go from the small Antola marly limestone quarries which used to meet the need of local building material to those of the green opicalcites (Verde Polcevera), still very appreciated as decorative stones and the more recently opened quarries of basalts and dolomites used for the making of concrete, asphalts and steel making processes.

Several geomorphological and hydrogeological problems affect the city of Genova. The fast growth phase that followed World War II, characterized by a lack of proper planning, led to a quite indiscriminate urban sprawl towards the hills and the mountains. Since the 1960ies landslides and floods have periodically affected the city, leaving behind destruction and death as in the case of the landslide which occurred in Via Digione, a new area close to a hill, because of underestimation of geological data, or the 1970, 1992 and 2010 floods that interested various parts of the city. These natural phenomena could have made little or no damage if an appropriate town planning scheme had foreseen the possibility of these events.

Nowadays, in such geological and geomorphological contest lies a city of almost 700000 inhabitants, that tries to implement communication lines through its geologically and morphologically complicated inland to help the trade connected with its harbour grow and, at the same time, to solve its geomorphological and hydrogeological problems, planning a new growth without causing any further damage to its beautiful but difficult environment

E3-15 Poster Liberati, Monica

10.1474/Epitome.04.0437.Geoitalia2011

INTEGRATED METHODOLOGIES WITHIN URBAN GEOLOGY STUDIES: THE EXAMPLE OF THE TOWN OF PAVIA (NORTHERN ITALY)

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Key terms: Urban geology; 3D underground modelling; Groundwater monitoring; Cultural heritage preservation

The town of Pavia is mostly located on the alluvial terrace and the terrace slope of the Ticino river. The ground morphology has been affected over the years by considerable anthropic modifications (ground reprofiling and made land laying). The river terrace is affected by secondary order streams erosion. One of these streams is the Vernavola canal, with its riverbed deepening toward the Ticino river that is the hydrological base level. Since 1985 the Vernavola valley constitutes the urban park of the Vernavola canal functioning as the lungs of the town.

It's worthy of remark that in ancient times, this geomorphological frame, the closeness to the river and the ground water resources supplying, led Roman people to settle in this area.

Nowadays, the town planning is focused on the ground use and does not concern the underground use. On the other hand, it should be necessary to manage the underground space as an urban resource with its limits of exploitation and pointing out that an incorrect use of it can lead implications regarding the environmental and the historical-cultural heritage protection. The urban underground has to be considered as a new usable space, considering the ever-growing utilization of the urban ground.

The authors propose for the town of Pavia an urban geology study dealing with different issues occurring in this area. As far as the urban area hydrogeology is concerned, a perched water table located at a depth of 5-6 m occurs in a first shallow sandy aquifer. This is linked to the occurrence of a likely continuous basal silty-clayey layer with a low hydraulic conductivity and a thickness ranging from 1 to a few meters. The perched water table gets also environmental importance, because it feeds several terrace springs, which are worthy of a touristic-environmental reappraisal. The springs are located along the fluvial terraces of the Ticino river and Vernavola stream. Rainfall inflows recharge the aquifer that consequently shows seasonal metric water table fluctuation according to the seasonal rainfall variation and the rice fields flooding. Since March 2008, the water table of the perched aquifer is already affected by a piezometric level continuous monitoring. In a short time other monitoring stations will be installed in different areas of the town. Indeed the monitoring of the seasonal fluctuations of the water table level is necessary to achieve the effect of the interference between the water table fluctuations and the foundations of the historical building and civil engineering constructions.

Actually, the historical centre of Pavia has a considerable historical and cultural heritage which need to be preserved, avoiding architectural losses as happened in 1989 with the collapse of the Civic Tower. It's worthy of remark that the urban underground still keeps the roman time sewer system. Given that this network overlaps with the layout of the main streets of the town some problems could rise cause of the interference with anthropic structures. Consequently, it appears necessary to carry out a suitable underground exploration survey including both drilling and geophysical not invasive investigation.

The preliminary collected data will concern the monitoring of the perched aquifer water table levels and the reconstruction of a 3D lithological model obtained by the processing of hundreds of wells and boreholes stratigraphies (and cone penetration tests). This modelling is necessary to get a suitable knowledge of the subsoil features, especially for the areas where monuments and historical buildings occur. Shallow geophysical exploration including 2D-3D ERT and GPR surveys will be carried out in the historical centre of the town, in order to reconstruct the map of the Roman sewer system and the different buried ancient canals. Finally, a hydrodynamic flow numerical modelling of the ground water will be carried out.

E3-16 Poster Pennetta, Luigi

10.1474/Epitome.04.0438.Geoitalia2011

FLOODING EVENTS IN THE TOWN OF BARI (APULIA, SOUTHERN ITALY)CALDARA Massimo¹, MARSICO Antonella², PENNETTA Luigi², SIMONE Oronzo³

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Key terms: historical flood events; hydraulic management; Bari (Apulia, south Italy)

The town of Bari developed at the end of a broad fossil drainage network set up on karstic terrains, in a wide depression called "Conca di Bari". During the past centuries, after strong rains that struck the hinterland, almost the whole town underwent to many ruinous floodings. These happened because of the peculiar hydro-geomorphological features of the catchments, widely developed inland up to the more elevated areas on the Murge hills, and the lack of an appropriate land management policy and urbanization plans. The first reported flooding occurred in 1567, when tons of mud struck Bari leaving traces nowadays still clearly evident. Other ruinous inundations occurred in 1827, 1905, 1915, and 1926. The risk of flooding in the "Conca di Bari" area has been reduced after the 1930s, when started interventions made in order to control the water regime of these ephemeral streams. Nowadays, after some tens of years since the last flooding, nothing or little things were done in order to clarify the causes and dynamics of those disastrous events. Therefore, in our research, one among the first contributors dealing with this calamity, we aimed at the understanding and recognizing the meteorological-environmental risk thresholds for the Bari area.

E3-17 Poster Castelluccio, Mauro

10.1474/Epitome.04.0439.Geoitalia2011

SOIL RADON CONCENTRATION SURVEY IN CAFFARELLA VALLEY TEST SITE (ROME)CASTELLUCCIO Mauro¹, TUCCIMEI Paola¹, LUCCHETTI Carlo¹

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Key terms: soil radon concentration; soil radon influence factors; soil radon variability; radon gas transport mechanism

Caffarella Valley, shaped by Almone River, covering approximately 200 ha, is one of the largest natural areas within the city of Rome and is the portion of the Appia Antica Regional Park (SE area of the city) closest to downtown. The valley represents a site particularly interesting for the soil radon survey related to indoor environment risk because of its features: it is a natural area easily accessible, close to urbanized territory and develops on a volcanic-derived background referred to the activity of Colli Albani district (the outcropping products are mainly Quaternary ignimbrites).

Since December 2007, a soil radon concentrations monitoring with simultaneous measurement of many related parameters is in progress, with the purpose of a better understanding of the influence factors that cause the radon spatial and temporal variability.

Investigation showed diffusion as main radon gas transport mechanism in the monitored control stations. Detected radon originates within few tenths of centimeters around the measurement point and its movement in soil is due to the concentration gradient. In this setting, main control parameters on the measured value of soil radon concentration are: geological background type, measurement depth below ground level, soil intrinsic permeability, topsoil conditions, sampling techniques. Specially, water content of the soil, related to rain events temporal distribution, has strong influence. Soil radon concentration shows a characteristic seasonal trend, with maximum values recorded during winter period, due to increased rainfall, and minimum values during July and August. Other geodynamic settings may have a predominant deep origin contribution to soil radon concentration, with transport due to advective fluxes (gas movement in soil caused by pressure gradient). Such settings may occur in volcanic or geothermal areas and generally where geological and structural discontinuities or cavities are present. In these cases, additional influence factors may further complicate the setting: movement dynamics linked to seasonal temperature and pressure gradients, presence of radon carrier gases, interaction with groundwater as a function of water temperature and gas solubility coefficient, etc. An example of a site characterized by predominant advective transport is Ficoncella Spa (Civitavecchia, Rome), a geothermal area with high permeability background (travertine) which promotes radon gas movement.

SESSIONE E4**Le Scienze della Terra per lo sviluppo sostenibile: il caso delle grandi infrastrutture in aree tettonicamente attive****E4-1 Invitato Comerci, Valerio**

10.1474/Epitome.04.0440.Geoitalia2011

HAZARD FROM CAPABLE FAULTS AND THE ITHACA PROJECTCOMERCI Valerio¹, BLUMETTI Anna Maria¹, DI MANNA Pio¹, FIORENZA Domenico¹, GUERRIERI Luca¹, LUCARINI Mauro¹, SERVA Leonello¹, VITTORI Eutizio¹

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Key terms: Seismic hazard; Capable fault; ITHACA database

The importance of capable faults, namely the faults inducing significant deformation and/or dislocation at or near the ground surface, is well-acknowledged in the planning and siting of nuclear power plants and other high risk facilities. Indeed, while other natural hazards might be dealt with, the presence of capable faults is one of the basic exclusion criteria of a potential site for NPP: Where reliable evidence shows that there may be a capable fault ... an alternative site should be considered (IAEA, 2010).

In the Italian territory the presence of capable faults is a well established fact. Surface dislocations, for example, occurred during the 1915

(Avezzano, M 7.0) and the 1980 (Irpina, M 6.9) earthquakes with throw nearing one meter. Many other cases are known in historical times. Also recently, the Paganica fault, responsible of the 2009 L'Aquila earthquake (M 5.9, Mw 6.3) cut the surface with a throw of about 15 cm, severely damaging the water main of the Gran Sasso aqueduct (Vittori et al., 2011, and reference therein). In general, many Quaternary faults are being documented as capable, based on the paleoseismological studies of the last decades (e.g. Galli et al., 2008; McCalpin, 2009).

The ITHaCa (Italian Hazard from Capable faults) database, today available on the Portal of the Geological Survey of Italy

(<http://sg1.isprambiente.it/GeoMapView/index.html>), even if not exhaustive, represents a contribute to the detection and characterization of such tectonic structures on the national territory. The information in the database derives from the critical analysis of available scientific papers, technical reports, field surveys, and dedicated studies by ISPRA. The evidence of capability is: a) coseismic rupture in historical times; b) creep - tectonic deformation (detected by means of ground survey, GPS, remote sensing); c) paleoseismicity (possibly proved by absolute dating) of Holocene-late Pleistocene cut/deformed sediments and/or morphologies; d) cut/deformed sediments and/or morphologies belonging to middle or even lower Pleistocene, where sealing is not clearly proved and further investigation is therefore needed.

Mapping of capable faults is necessary for planning purposes and for building or retrofitting major critical and high-risk facilities, lifelines, etc. Today, apart from the obvious exclusion criterion, there are technological solutions which, if applied together with a targeted geological study, are even able to absorb large surface dislocations and ensure the operability of structures (typical example are the pipelines) after the earthquake. The contribution that geological sciences can offer to modern society in terms of hazard awareness and seismic risk reduction appears so far often underestimated and the need is evident to arise the collective perception that the present scientific knowledge of geological hazards is such that they can be appropriately faced.

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E4-2 Invitato Burrato, Pierfrancesco

10.1474/Epitome.04.0441.Geoitalia2011

FROM SEISMOGENIC SOURCE TO GROUND SHAKING: APPLICATIONS OF THE DISS DATABASEBURRATO Pierfrancesco¹

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Key terms: Seismogenic Sources; Seismic Hazard; DISS

There are three different categories of hazard associated with the activation of a seismogenic source: ground shaking, surface deformation and ground failure, and surface faulting. These three processes are the primary cause for damage to buildings and civil infrastructures, act at different scales, and their mitigation requires different approaches and level of details. Losses from ground shaking and ground failure are the most significant and largely outpace those caused by surface faulting. This is especially true for Italy, where few earthquakes caused unambiguous surface breaks (e.g. the Mw 7.0, 1915 Avezzano and the Mw 6.9, 1980 Irpinia earthquakes), and the associated losses have been negligible with respect to those induced by shaking. Risk mitigation programs at national and regional scale should hence concentrate on assessing the expected ground shaking with the best possible confidence. The construction of a reliable seismogenic source model is a necessary step in this strategy. Most of the emphasis should be placed on identifying a set of seismogenic sources that are: (1) defined in 3D and fully parameterized so as to allow their automatic elaboration, (2) obtained by merging geologic, tectonic and seismological data, spatially complete over the entire study region, and (3) checked for spatial, kinematic and dynamic consistency with the instrumental stress and strain records.

Active faulting data are an integral part in the construction of a reliable seismogenic source model and are the basis for assessing surface faulting hazard (i.e. hazard caused by capable faults). Since surface breaks at various scales represent the surface expression of seismogenic faulting at depth, information on active faulting is not alternative but rather complementary in the construction of a seismogenic source model.

The Database of Individual Seismogenic Sources (DISS, <http://diss.rm.ingv.it/diss/>) is a georeferenced repository of tectonic, fault and paleoseismological information for Italy and bordering countries. Seismogenic sources are fully parameterized for their geometry and kinematics and classified as (1) Individual (ISS), simplified 3D representations of fault planes, often associated with a historical or instrumental earthquake; (2) Composite (CSS), elongated fault systems containing an unspecified number of seismogenic sources that cannot be singled out; and (3) Debated (DSS), active faults that were proposed in the literature as potential seismogenic sources but were not considered reliable enough to be included in the database.

Individual Seismogenic Sources are assumed to exhibit "characteristic" behavior with respect to rupture length/width and expected magnitude, while Composite Seismogenic Sources are not associated with a specific set of earthquakes or earthquake distribution. They comprise two alternative seismic source models to choose from and are tested against independent geophysical data to assess their reliability.

The DISS database is expressly devoted and fully suitable for seismic hazard applications, such as Probabilistic Seismic Hazard Assessment (PSHA), Deterministic (Scenario earthquake) and High-Frequency Maximum Observed Shaking (HF-MOS) studies. We will present case histories and show how the use of basic geological, geophysical and tectonic data can be used for constraining the geometry and kinematics of the potential sources of strong ground shaking and will discuss how they are used as input in the planning of strategic installations and critical facilities. Identifying seismogenic sources is especially challenging in areas of blind or hidden faulting and slow deformation like the Po Plain, where

seismic hazard is relatively low but risk is high due to exposure. Investigating seismogenic sources in this critical part of Italy requires a fully multidisciplinary approach and demonstrates that seismogenic activity is an integral part of the recent local geological and geomorphological evolution.

E4-3 Invitato Sirovich, Livio

10.1474/Epitome.04.0442.Geoitalia2011

CONTRIBUTION TO THE ANALYSIS OF THE SEISMIC HAZARD OF THE SITE OF THE NUCLEAR POWER PLANT IN KRSKO: MECHANISM OF THE LJUBLJANA, 1895 EARTHQUAKE FROM THE INVERSION OF ITS INTENSITIES.

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Key terms: Slovenia; Krsko; Seismotectonics; Ljubljana earthquake 1895; Nuclear Regulatory Commission

Depending on the countries and the construction periods, the nuclear power plants are built to resist earthquakes with a return period of 10.000<T<1.000.000 years (standard for home: T=475 years) with planning parameters not extrapolated only from the historical earthquake catalogues, but also from geologic-palaeoseismological estimates, with accuracy of the assessments in a dramatic decrease to the increase of T. Krsko, in Slovenia, is about 130 km in ENE from Trieste (direction of the dominant winds), planned at the end of the 70's with the "safe shut-down earthquake SSE" of the Regulatory Guide 1.60 of the U.S. Nuclear Regulatory Commission, anchored at PGA 0,30 g on the free field. It has been running since 1983.

The joining of the official hazard maps for T=475 Italian ("the Cornell's way") and Slovenian (with "smoothed seismicity"), considerably different, indicates open questions: belt of 0.275-0.300 g roughly east-west "led by" the Peri-Adriatic overthrust, in Italy; in areas, in Slovenia, with two high hazards apparently centered on Ljubljana, and Zagreb in Croatia. Other accredited "Cornell's way" studies have produced PGA>0,3g in Friuli. On the other side, in Slovenia the concentrations of intensity and hazard surrounding the two capitals could have been a spurious effect (historical sources concentrated in towns and convents); Krsko is found between these two concentrations, but the area is seismically active for the historical (completeness since 1870) and instrumental epicenters (good since 1999). In 1997, on "Nuclear Engineering and Design", Lapajne and Fajfar (Slovenian Geophysical Service; Civil Engineering Ljubljana University) have indicated only PGA(>0,3 g) of a quake with M=3.9 close to the plant.

In Slovenia and Croatia (joint owners of the plant) there are several seismo-tectonic models, but the matter is still in discussion and the palaeo-seismological and neo-tectonic knowledge could be improved. Three different regimes and tectonic schemes of the Krsko area are found in the Literature, all with the regional compression N-S and interaction of the Pannonian Basin. The first, with stronger asserted events produced by faults orthogonal to the geodynamic stress, with the ones considered more dangerous for the plant arranged in inverse/direct pairs [?]. The second has a lowered block (Krsko area) surrounded by 4 raised blocks (mountains) where the N-S compression alternatively would activate faults striking NE-SW and NW-SE. In the third scheme there is an interaction between three "masses at depth" [sic]: Adriatic, Central Alpine and Pannonic, with activation, on a regional scale, of inverse faults in the western sector and direct and transcurent elsewhere, whilst in the central area the maximum compression would be E-W and the minimum N-S, with strong earthquakes in the mid of the faulted areas.

In such articulated context, we show the automated geophysical inversion (KF) of the macroseismic field of the strongest Slovenian earthquake close to the plant, the Ljubljana 1895 one (degree V in Krsko). Achieved parameters: lat. 46.06°, long. 14.45°, strike 103°, rake 90°, dip 54°, depth 20Km (fixed), Vr/Vs=0.71 towards 103°, Vr/Vs=0.50 towards 283°, L=22km of which approx. 7km towards 103°, Mo=4.83·10¹⁸ Nm (Vr=rupture speed; Vs=speed of S waves fixed at 3.5 km/s; L=total length of the fault source; Mo=seismic moment); M=6.4 (from Mo). Note that, with pure dip-slip mechanism, the problem is bimodal and, thus, the plane could strike 103°+180° and dip towards NNE (KF also gives ambiguity of ±180° in the rake).

It would be necessary to gather good macro-seismic data and invert the source also of the event of Zagreb (1180, M~6.3, 60 km from Krsko). Conclusion: the difficult evaluation of the hazard asks for prudence and adequate safety factors. An international consent study is needed.

E4-4 Invitato Lorito, Stefano

10.1474/Epitome.04.0443.Geoitalia2011

Tsunami Hazard (AND RISK) FOR THE COASTS OF SOUTHERN ITALY

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Key terms: tsunamis; hazard; earthquakes

Japan is one of the most advanced countries for seismic and tsunami risk mitigation. Even so, the Fukushima nuclear plant has been seriously damaged by the tsunami following the giant Mw 9.0, 11 March 2011, Tohoku earthquake. This dramatically recalled us that tsunamis are a too often underrated hazard. Mediterranean shorelines have been repeatedly struck by large tsunamis in the past. The current understanding of offshore seismogenic sources in southern Europe is indicative of a potentially destructive tsunami hazard, which is worsened by the concentration of population, infrastructures, and activities along European coastal plains. Nevertheless, for example as regards Italian coasts, official tsunami hazard and/or risk maps do not exist, nor their creation seems to be envisaged. Here, we briefly review some published and ongoing research in this context, with particular attention to a few existing infrastructures at coastal sites in Southern Italy.

E4-5 Invitato Carapezza, Maria Luisa

10.1474/Epitome.04.0444.Geoitalia2011

THE ROLE OF GEOTHERMAL ENERGY IN THE SUSTAINABLE DEVELOPMENT OF ITALY

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Key terms: Geothermal Energy; electric energy production; direct thermal uses

Italy has been the first country in the world to produce electric energy from high enthalpy natural geothermal steam and with its 843 MW of installed capacity is still the first producer in Europe of geothermal electric energy. However, Italy is presently only at the fifth rank in the world, quite distant from the first country (USA, 3093 MW). Because of its geodynamic setting and the presence of many recent or active volcanoes, wide zones of Italy are characterized by high anomalous heat flow and geothermal energy could significantly contribute to the sustainable development of the country. Besides further possible development of high enthalpy resources (T > 150 °C), electric energy could be generated by binary systems using medium enthalpy fluids (90 < T < 150 °C), a widespread resource as yet untapped in Italy. In addition, many volcanic areas of Italy contain at relatively shallow depth low-permeability, very hot rocks (T of 400 °C at 3000 m) that all look economically and technically much more attractive for the development of EGS (enhanced geothermal systems) than the European Soultz-sous-Forêts project (T of only 200 °C at 5000 m depth). Finally still in its infancy is in Italy the development of direct use of low enthalpy geothermal resources (hot waters with T < 90 °C). In particular, space heating and cooling can be conveniently generated using geothermal heat pump in soils or ground waters with only 15-20 °C with significant environmental benefits. Paradoxically we should follow the example of north European countries (e.g. Sweden), although being geologically cold with respect to Italy are much ahead in the utilization of geothermal heat pumps.

SESSIONE E5

La microzonazione sismica: esperienze, criticità e prospettive

E5-1 Orale Piana, Fabrizio

10.1474/Epitome.04.0445.Geoitalia2011

SEISMIC MICROZONING OF SELECTED AREAS IN VALLE D'AOSTA (NW ITALY)

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Key terms: Seismic Microzoning; Alpine environment; Glacial deposits

Seismic microzoning can be defined as:

- the subdivision of a region that has relatively similar exposure to various earthquake related activities or
- the identification of individual areas having different potential for earthquake effects.

The goal of seismic microzoning is the determination of the degree to which seismic activity can affect the infrastructures. The determination takes into account the morphological, lithological and structural setting of particular land sectors in a seismically dangerous region. Such conditions include the physical and dynamic properties of the ground and basement rocks, the thickness of the surface deposits, the presence of permafrost, tectonic features and relief characteristics, and the spectral properties of seismic waves.

The damage pattern due to an earthquake depends largely on the local site condition and the social infrastructures of the region, with the most important condition being the intensity of ground shaking at the time of the earthquakes.

Contrasting seismic response is observed even within a short distance in response to small changes in the geology of the site. This fact is very crucial in the case of microzoning of Alpine environments (i.e narrow valleys with huge and very steep cliffs), where the surface deposits heterogeneities are great due to the presence of mixed alluvial, glacial and sub-aerial slope sediments, very sharp and irregular bedrock topography as well as marked lateral variability in local hydrostratigraphy or water-content of sediments. In these environment the risk definition in a given microzone can also be influenced by danger elements placed outside the microzone, affecting the reliability of the seismic risk evaluation. The "Gi-RES spin-off"

(<http://gdpconsultants.eu/geologia/index.cfm/gi-res-pagina.html>) working group, represented by CNR IGG Torino and GDP Consultants geologists is going to handle these problems in the frame of a seismic microzoning project in selected areas of the Valle d'Aosta Region, commissioned by the local Regional Administration in the frame of the EU Alcotra RiskNat Project (<http://www.risnat-alcotra.org/>).

A preliminary methodology has been defined to allow classification of the different geological and morphological settings of the study areas, that will be presented and discussed with respect to the recommendations and guidelines of the "Seismic Microzoning Working Group" of the Italian "Conferenze delle Regioni".

E5-2 Orale Pergalani, Floriana

10.1474/Epitome.04.0446.Geoitalia2011

SEISMIC MICROZONATION IN A SMALL MUNICIPALITY: THE CASE STUDY OF SANT'AGATA FOSSILI (AL)

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Key terms: microzonation; amplification factors; response spectra; abacus

The earthquake of April 11th 2003 ($M_l = 4.7$), that struck the NW area of Piemonte, caused damages in several municipalities, fortunately without victims.

This event can be considered as representative of the expected seismicity level of the Region and, even if this level can be considered low in comparison to other Regions of Italy, it is necessary to take it into account for an accurate and safety urban planning.

So the government of the Piemonte, in the frame of the European Project RISKNET, decided to perform the seismic microzonation of the Sant'Agata Fossili (AL).

Starting from the recent guidelines "Indirizzi e Criteri per la Microzonazione Sismica (ICMS 2008)", a study regarding the level 1, able to point out the zones that can produce amplification effects, has been performed.

Then an analysis of seismic microzonation of level 3 (ICMS 2008) has been carried out. So a multidisciplinary group has been created, and the fundamental steps of the project have been:

1. geologic and geomorphologic analysis, through survey at scale 1:5,000 on an area about 0.2 Km², that has pointed out the presence of silty clay and marl (Gessoso-Solfifera Formation and Sant'Agata Marl);
2. geophysical characterization of the lithologic units and subsequently construction of the lithologic subsol model: particularly the HVSR survey (15 stations), that pointed out the presence of two sectors characterized by different behavior (the E sector without resonance and the W sector with resonance at 2-5 Hz); 2 Down-Hole (one in each sector); and in a test site different geophysical techniques (MASW, REMI, seismic refraction, passive MASW on 2D array, electrical resistivity tomography), that are necessary to obtain the accurate information for the application of the level 3;
3. geotechnical characterization through 2 geognostic drillings with SPT tests and collection of undisturbed samples to perform the dynamic and static laboratory tests;

4. individuation of the expected seismic inputs in term of accelerograms: particularly the 5 recorded accelerograms were selected from strong motion record databases (ITACA 2006), fixing the constraint of the geologic and seismologic characteristics of studied area, the expected magnitude-distance couple, the soil type of the registration station, the expected maximum horizontal acceleration (through the use of scaling) and the spectrum compatibility with the target spectrum (soil type A, "Norme Tecniche per le Costruzioni", NTC 2008);
5. numerical analysis, using a one-dimensional model, to point out the expected amplifications in term of amplification factors and elastic acceleration response spectra.

The results have been able to understand the geologic and geophysical differences of the municipality and consequently the different local seismic responses, that permit to better define the level of seismic protection of the buildings taking into account the expected amplification effects. In particular, the results in term of acceleration response spectra, in comparison with the corresponding spectra derived by the NTC, show, in some cases, significant differences, consequently the use of the calculated spectra is necessary during the building design project.

To detect, during the urban planning phase, the areas in which the application of the level 3 is necessary, an abacus can be used (level 2 of ICMS 2008). So the results in term of amplification factor, derived by the performed study, have been considered to perform a regional abacus for the silty clay lithology. Such regional abacus allows to have information of the expected amplification, known the average velocity of the shear waves and the correspondent thickness of a lithologic sequence. It permits to have more accurate results than the abacus of the ICMS, due to his regionalization in term of both expected seismic inputs and both geophysical and geotechnical characterization of the considered lithology.

E5-3 Orale De Ferrari, Roberto

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SITE EFFECTS IN THE EASTERN PART OF L'AQUILA (CENTRAL ITALY) FOLLOWING THE 2009 SEISMIC SEQUENCE: ON THE USE OF EXPERIMENTAL AMPLIFICATION FACTORS FOR MICROZONATION STUDIES.

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Key terms: SEISMIC MONITORING; WEAK MOTION; AMPLIFICATION FACTOR

Following the disastrous earthquake ($M_w = 6.2$) occurred on the 6th April 2009 in central Italy, the Dip.Te.Ris - Genoa University carried out several experimental investigation on seismic response of different areas by passive seismic monitoring.

In order to investigate site amplification effects using an empirical approach, seismic temporary networks have been installed in some areas characterized by different geological conditions in the eastern part of L'Aquila.

The seismic networks operated in the period 20 April - 2 July and collected more than 800 weak motions earthquakes, with magnitude ranging between 1.5 and 4.2, at a distance range 5 - 30 km.

The recordings of 31 stations, located in Tempera, Paganica, Bazzano and S. Gregorio areas, were archived and analyzed.

The experimental study of amplification phenomena, has been carried out by using both standard spectral ratio techniques (HVSR and SSR) and different definition of amplification factor (FA) computed through PGA, PGV and Housner spectrum intensity (SI) ratios.

The results show complex and remarkable amplification site effects affecting both the horizontal and vertical component of the ground motion. In particular the Paganica and Tempera area is characterized by significant amplification effects at frequencies between 1.0 to 4.0 Hz and FA values ranging between 1.5 and 4.0. Indeed in some areas surrounding Bazzano village, fundamental frequencies lower than 3.0 Hz were observed. The San Gregorio area is characterized by fundamental frequency values between 2.0 and 3.0 Hz.

The main target of this study is the discussion about the usage of empirical amplification factors (FA) for quantifying seismic amplification phenomena in microzonation studies.

To this aim, a comparison between response spectra obtained from weak motion recordings of our stations and moderate to strong motion recordings of another temporary seismic network installed in Paganica (D'Alema et al., 2009) was carried out. This comparison has allowed us to verify the absence of outstanding variation of the amplification level and fundamental frequencies values with the respect to ground motion levels. Moreover in order to define the best proxy for the estimate of the seismic response of the investigated areas, the variability of the FA values has

been discussed as a function of the criteria adopted for the computation of FA (i.e. PGA, PGV, integration range of SI).

Finally we have compared the experimental amplification factor values with those obtained with numerical analysis carried out by other authors (Compagnoni et al., 2011) for this area. The results of this comparison show a quiet agreement between experimental and numerical amplification factors values and stress the reliability of passive seismic monitoring approach for microzonation studies especially in moderate to high seismicity areas.

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E5-4 Orale Milana, Giuliano

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SEISMIC CHARACTERIZATION OF L'AQUILA HISTORICAL CITY CENTER USING AMBIENT NOISE TECHNIQUES

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Key terms: site effects; ambient noise; seismic array

Following the April 6th 2009, Mw 6.3 event, many studies were addressed to determine the site response in L'Aquila historical city center that suffered severe damage. The historical city is founded on a terrace that slopes down moving in the South-West direction, and raises about 50 meters above the Aterno River bed. The terrace is formed by alluvial Quaternary breccias (BrA) consisting of limestone clasts in a marly matrix. Toward north of the city the terrace is in contact with outcropping limestone, while moving toward South, it is superimposed to lacustrine sediments (LK) consisting mainly of silty and sandy layers and minor gravel beds. The thicknesses of BrA reach values of many tens of meters, while LK layer can be up to 200 meters thick below. Recent drilling data in the main square of L'Aquila report a thickness of 75-80 meters for BrA over more than 200 meters for LK. A deep borehole at the base of terrace along the Aterno River bank was recently drilled on a homogeneous sequence of LK unit with a thickness of about 195 meters overlying the meso-cenozoic limestone bedrock. Due to the high thickness of the sedimentary soft layer, in situ testing (dwn-hole, cross-hole and boreholes) due not allow a reliable characterizations of the deepest sediments. This outcome can be overcome by surface waves analysis based on large seismic arrays. We present the results of several 2D ambient noise arrays testing performed in the L'Aquila old town. The array dimensions and the instruments characteristics allowed us to investigate a wide range of frequencies and large depths. In order to verify the spatial stability of the site response we also performed a dense survey using single station HVNSR measurements. This last wide data set also consents to detect the variability in the soil characteristics of very shallow layers due to the present of local geological heterogeneities.

E5-5 Orale Albarello, Dario

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EXTENSIVE AMBIENT VIBRATION SURVEY SUPPORTING A "LEVEL 2" SEISMIC MICROZONING: THE CASE OF RIMINI

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Key terms: Seismic microzonation; Seismic prospecting; Ambient Vibrations; HVSR; ESAC

Seismic microzonation represents a basic tool for the development of a correct prevention policy devoted to seismic risk reduction. To make this statement effective, three elements are necessary. The first one concerns the implementation of seismic microzonation in urban planning rules. To this purpose, advanced legislative interventions implementing this tool were provided by a number of regional administrations in Italy, that are going to be extended to the whole country also thanks to the "moral suasion" exerted by the national Dept. of Civil Protection. The second element is the definition of codified, up-to-date and scientifically well established experimental protocols and procedures that allows development of comparable microzonation maps. To this purpose, the "Guidelines for Seismic Microzonation" recently published in Italy by the "National Conference of Regional Administrations and Autonomous Provinces" and the Dept. of Civil Protection represented an important step towards and effective standardization of the field activities and map development. The third point, not less important than the previous ones, is the possibility provide cheap procedures that makes seismic microzonation feasible also in the absence of large funding that is in most cases unavailable for local administrations. To this purpose, the above cited guidelines suggests the possibility that three levels of seismic microzonation can be achieved, each characterized by a different level of outcomes (qualitative and exploratory in the first level up to strictly quantitative and very detailed in the third one) and costs. Anyway, in order to allow as many as possible local administrations to achieve at least a first or second level microzonation, the development of cheap experimental tools is mandatory. Ambient vibration measurements, both in the single station (HVSR approach) and array (ESAC approach) configurations may provide such a tool. Despite of the fact that these methodologies are exploratory in character, their extensive application where unevenly distributed complementary data are available (good geologic mapping, drillings, active seismic surveys, etc.) may allow quite reliable and cost effective results. In this view, on behalf of the Emilia-Romagna Regional

Administration and in strict cooperation with Rimini Provincial Administration and Rimini Municipality, an extensive passive seismic survey was developed in the whole Rimini urbanized area. The joint interpretation of ambient vibration measurements, geological reconstructions and borehole data, allowed the development of a "level 2" seismic microzonation map of the Town, where different seismic domains are clearly identified and characterized quantitatively in terms of an integral amplification parameters (FA factor). The most critical aspects of this experience will be discussed along with possible limitations and advantages of the adopted procedures and protocols.

E5-6 Orale Di Filippo, Michele

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GRAVITY CHANGES IN THE AQUILA AREA BEFORE AND AFTER EARTHQUAKE EVENTS.

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Key terms: gravity network; L'Aquila; earthquake april 2009; gravity changes

In 1989 a joint work was developed in co-operation with the University "Sapienza" of Rome and Servizio Geologico d'Italia (SGI) (today ISPRA). A gravity research started in the Aquila area aimed to realize a gravity network for high precise gravity measurements to detect gravity changes due to mass redistribution in the underground inferred by the geodynamic activity.

The gravity network has been designed so as to incorporate 17 stations, settled in 1989 and periodically reoccupied in 1990, 1992, 1995, 2005 and 2011. The local gravity network coincides with some benchmarks of the local leveling networks (L126, L197, L124 and L9) [Giuliani & Mattone, 2010] in order to remove the effect of the vertical ground movements and taking into account the spatial distribution of seismic events. High precision gravity combined with levelling benchmarks offers increasing potentialities for the study of time variations of the earth gravity field and crustal deformations related with geodynamic or tectonic processes. Presently, the network consists of 17 relative stations which are not destroyed during the earthquake. Gravity readings were made using two LaCoste & Romberg D model gravimeters (D-60 and D-138) at the same time. Presently, and similar to previous studies the new gravity data set has been referred to the Absolute gravity station established in 1977 at the Osservatorio Astronomico di Monte Porzio Catone [Cannizzo et al., 1978].

The gravity readings, for both gravimeters, are corrected for tidal effects, atmospheric loading and instrument drift. Later, as regard the gravity survey, the corrected and weighted gravity differences between each pair of stations are organized on joined loops and then adjusted according to the least square method; finally the gravity value at any station is computed relative to the local reference station (Fonte Cerreto-Assergi (4) station) and linked to the absolute gravity station.

During the time period covered by this study, six precise relative gravity surveys were also carried out at all stations of the network. Long-term spatial distribution of gravity changes performed before and repeated after earthquake is represented. Gravity changes have been observed on the whole area, before and after the earthquake period.

The gravity distribution shows different patterns in the eastern, central and western part of the seismic area. The gravity variation field is smoother in the central part of L'Aquila city and it shows a gravity decrease from the stations located in the northern part of the city. Qualitative gravity results are not totally in agreement with vertical changes measured by local leveling networks. It is possible to suppose that the observed gravity changes should indicate a mass variation in the underground, not in the shallow part but in depth.

Moreover, the results obtained from high precision gravity measurements show that, the most significant long-term observed gravity changes on Aquila area, were recorded not in the area corresponding to the seismogenic belt but in a largest zone. However gravity changes were observed in the same magnitude before and after the earthquake. CANNIZZO L., C. CERRUTTI & I. MARSON (1978): Absolute-Gravity measurements in Europe. In : Measurement of Gravity acceleration in Europe, America, Asia: 1976-1981 an example of international scientific cooperation. Istituto di Metrologia "G. Colonnelli". (Ed.) Istituto Poligrafico e Zecca dello Stato, 1C, 1, 79.

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E5-7 Orale Quadrio, Bruno

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EFFECTS OF A VELOCITY INVERSION IN A SOIL PROFILE: PARAMETRIC 1D ANALYSES AND COMPARISON WITH REAL CASES

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Key terms: velocity inversion; local seismic response; NTC 2008; 1D analyses

According to Italian seismic regulations (NTC, 2008) there are two ways to define local seismic response, based on two different methods:
 - "specific analyses" (Local Seismic Response in chapter 7.11.3) that takes into account the specific earthquake that could occur in the site, the specific characterization of a subsoil model in terms of geotechnical and geophysical peculiarity, and the use of targeted calculation codes;
 - "simplified approach" (chapter 3.2.2) to use only in case on non applicability or non practicability of specific analyses, through the choice of a pre-defined class of subsoil (subsoil category), that enable the definition of an elastic spectra for engineering purposes.

Unfortunately, the specification of subsoil categories defined in "simplified approach" of NTC (2008) doesn't take into account a series of subsoil condition commonly found in nature (Vannucchi, 2009). For example there are no cases where softer strata of soil are contained by stiffer strata of

soil (and vice versa).

This subsoil condition is known in geotechnics as "velocity inversion" and is verified when the velocity of shear waves Vs doesn't increase monotonically with depth but soil strata with higher (or lower) velocity in respect of underlying or overlying soil strata are found.

This work, as general purpose, aims to provide ready-to-use information to professionals, about local seismic response of a site where a velocity inversion is present.

In particular we wanted to evaluate through 1D calculation codes and parametric analyses the effect (in terms of an amplification factor) of a stiffer strata between softer and vice versa, varying both seismic inputs applied to each model and every parameter of subsoil taken into account in the analyses (thickness and depth of stiffer/softer strata, depth of seismic bedrock, seismic impedance contrast). In previous works the problem was handled considering only a simpler situation based on a two-strata soil model (softer on a stiffer and vice versa) overlying a seismic bedrock (Aubeny et alii, 1986; Ding et alii, 2008, Sanò et alii, 2010).

Results will be provided through a comparison between amplification factors and, for most topic case, a comparison between elastic spectra will be shown.

Conclusion and comments will be addressed to define suggestions useful for seismic design and will be more specific when the presence of a velocity inversion cause remarkable differences in respect to an "homogeneous case" (where homogeneous means a model with the same thickness of soil overlying bedrock of the "inversion case", but with mean characteristic in terms of stiffness). Therefore, worse case in terms of safety will be highlighted.

Finally, to validate and verify results achieved, case based on models based on real situations extracted from Italian (ITACA) and foreign (KikNet) accelerometric database will be compared.

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E5-8 Orale Fazio, Francesco

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SEISMIC MICROZONATION AND PLANNING. FROM THE EXPERIENCE AFTER THE EARTHQUAKE IN L'AQUILA TO A METHODOLOGY FOR RISK MITIGATION

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Key terms: seismic microzonation; planning; seismic risk

After the 6th April 2010 earthquake in a few Municipalities of L'Aquila Region, seismic microzonation (SM) maps have been produced, following Seismic Microzonation Guidelines (SMG), <http://www.urbit.it/indirizzi-e-criteri-per-la-microzonazione-sismica>.
A specific task group was formed to analyse the impact of SM on planning and to identify a methodology for risk mitigation GIS mapping. SMG, applied for the first time in a real case study, have been issued by Italian Civil Protection Department and Regions and Autonomous Provinces' Conference.

In this context, the application of SMG stands out because of complexity and richness of urban planning conditions.

These conditions concern the urban and environmental structure of L'Aquila Region, composed of a big urban centre included within a network of small and medium size centres, each one with its own morphological and functional characteristics and different accomplishment level of urban planning.

On one hand the research has been supported by a system of standards defined in SMG, included those for cartography and data base. On the other hand there has been several negative elements, such as very short working time, emergency condition given by post-earthquake reconstruction and not much financial and human resources. Firstly, the methodology has provided for a starting analysis of Municipality urban plans, identifying their structure and strategies, their main characteristics and aims, and therefore their different provisions and planning zones.

Secondly, urban plans have been standardized, georeferenced and geocoded. Then MS maps and urban plans have been overlaid and a few quantitative analyses have been processed.

Data comparing has lead to a first, rough description of several case-studies, outlining distinctive characteristics for each locality. A first set of observations and critical issues have been pointed out, tracing back to three, typologies: a) conditions needing further investigations; b) conditions giving operative instructions or rules; c) conditions involving choices in planning and, consequently, different methodological procedures.

This research can be considered the initial step to propose rules and guidelines in planning for the seismic risk mitigation.

E5-9 Orale Dolce, Mauro

10.1474/Epitome.04.0453.Geoitalia2011

SEISMIC MICROZONATION AND SEISMIC VULNERABILITY FOR SEISMIC EMERGENCY PLANNING

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Key terms: seismic microzonation; seismic vulnerability; seismic emergency planning

SIGE is a specific software developed and used by the Italian Civil

Protection Department for processing speedy damage scenarios, related to a given return period T and hence to a seismic intensity. Hazard and seismic vulnerability distribution processed by the software are those provided by a CPD database available at national scale. Results provided by SIGE are relative to the whole territorial "administrative" extent of the Town Council on which the scenario is calculated, and consist in the total amount of losses in terms of collapsed and unusable buildings as far as people involved.

Starting from this operative tool, a new methodology, developed from previous studies by some of the authors (2007), has been developed in order to "distribute" over the urban area the losses resulting from SIGE, through minor information upgrades. The purpose of the method is to provide a geographic distribution of losses on the urban area so as to be more useful for developing or enhancing a seismic emergency plan. Basically, two main steps must be carried out to achieve the purpose: a local seismic hazard analysis and a seismic vulnerability assessment. Data required for the seismic hazard consist of a seismic microzonation sharing the urban territory into different areas featured by homogeneous seismic hazard.

Depending on the different settings and purposes, seismic microzonation can be carried out at different levels of analysis, with increasing complexity and required effort, according to three levels:

Level 1 is a basic knowledge level propaedeutical to the real seismic microzonation studies, as it consists of a collection of pre-existing data which are processed in order to classify the territory into homogenous microzones on a quality level;

Level 2 introduces quantitative information associated to the homogenous zones, by using further specific analyses, and leading to a real seismic microzonation map;

Level 3 develops a seismic microzonation map with detailed analyses on specific areas or subjects.

The methodology under exam uses as basic knowledge standard, the level 2 according to the following 5 tasks:

Task 1: collection, storage and data processing of existing data;

Task 2: definition of the technical-geological model of subsoil and individuation of possible co-seismic phenomena;

Task 3: geotechnical characterization of soils;

Task 4: numerical (amplification factor and susceptibility probabilities) characterization of each microzone;

Task 5: reports and maps elaboration;

The second step in the methodological framework is represented by the seismic vulnerability of the urban territory. This is assessed by outlining the main structural types characterising a given urban area, and then associating to each of them a seismic vulnerability class among those provided by the EMS 98 scale. In turn, the urban layout is divided into zones which can be assumed homogenous under the point of seismic vulnerability, and each of them is associated with the prevalent structural type (or types) and consequently to a given vulnerability class. The resulting product of this information level is a map showing different zones into which the urban area can be shared.

Finally, the intersection, governed by GIS and specific algorithms, between these two information levels (microzonation and vulnerability), provides a third information level consisting of a sub-zones map in which each sub-zone can be assumed homogenous both under the point of hazard and seismic vulnerability.

Seismic scenarios can be then processed and associated losses calculated and associated with each sub-zone. The final product of this process is represented by maps showing for each zone or sub-zones (depending on the purposes) the estimated losses in relation to a given return period of the earthquake.

These maps can be very helpful even for enhancing an existing emergency plan, as for checking the proper location of emergency areas or the accessibility to strategic and public buildings.

E5-10 Poster Caffagni, Enrico

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BASIN INDUCED SURFACE WAVES (RAYLEIGH) PROPAGATION IN A INTRAMOUNTAIN SEDIMENTARY BASIN: THE CASE STUDY OF NORCIA (PERUGIA, ITALY)

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Key terms: Site effects; Polarization; Basin induced Rayleigh waves; Norcia

We present the results of a study on the propagation of edge induced Rayleigh waves in the Norcia basin (Perugia, Umbria, Central Italy). The Norcia plain is a tectonic depression, created by normal and oblique faulting which affects the Apennines during the Quaternary. The seismicity of the area is strictly related to the activity of the normal faults, which induced several earthquakes in the past (very recently in 1997, Mw=6.0). Local site's effects might have occurred in the Norcia plain attributable to the impedance contrast between the bedrock and the lacustrine sediments (mono-dimensional, 1D) and/or to the diffraction of seismic waves at the basin border (2D or 3D dimensional), which generate local surface waves, Rayleigh and Love waves, observed as late arrivals in the seismic signals. In 2009 a seismic monitoring experiment was realized by Istituto Nazionale di Geofisica e Vulcanologia (INGV, Milano and Roma) and the GeoForschungsZentrum (GFZ, Potsdam, Germany), installing a temporary seismic network of 15 stations from January to May. In this work 12 local earthquakes were analyzed, whose epicenters occurred all around the Norcia basin, with MI range 2.0 - 3.8, recorded before the L'Aquila sequence. All seismic signals were windowed (12 sec. before P-wave arrival and 68 sec. after), and denoised using a denoising procedure following Parolai (2009). In order to detect Rayleigh waves, instantaneous polarization attributes, instantaneous reciprocal signed ellipticity (ellipticity) and instantaneous tilt angle from the major axis of polarization, on the three components of each signal are determined using the Renè et al (1986) method, but using the S-Transform (Stockwell, 1996) values of the signals (the S-Transform is a time-frequency representation of the amplitude spectrum). The two horizontal components of the signals were rotated between 0° and 180° (with step by 9°) and the value of the angle (we called it Theta_max) that led to a maximum of the S-Transform for each point in the time-frequency plane was saved. A comparison between energy on the horizontal plane and the vertical directions helped us to identify some Rayleigh arrivals, characterized by an elliptical polarization, (with absolute values of the signed ellipticity greater than 0.125, following Renè (1986)). Finally we reconstructed, for every event, chronology maps of Rayleigh waves

directions (with step by 2 sec), evaluating the most likely values of ellipticity (absolute values) and Theta_max. We found that first Rayleigh arrivals generally in high frequencies, $f > 5$ Hz, and in some cases immediately after the S-wave arrivals, are responsible of 2D or 3D site's effects, in form of wave trains at low values of ellipticity (even < 0.4), but with high energy, while late arrivals, like scattered energy from the edge basin, showed lower energy with higher values of ellipticity (> 0.6).

SESSIONE E6

Processi d'instabilità naturale e copertura assicurativa

E6-1 Orale Martina, Mario Lloyd Virgilio

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PROBABILISTIC RIVER FLOOD MODEL: THE ROLE OF THE SPATIAL CORRELATION

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Key terms: flood; hazard; insurance; spatial correlation; model

The aim of the research is to develop an innovative approach that accounts for the spatial correlation of floods. The methodology proposed is to generate continuous long time series of flows in the different locations from which one can derive a flood event catalogue. The results of this new approach are compared with the ones deriving from the more traditional use of flood data.

The study provides interesting ideas on the benefits that may derive from the setting up of a probabilistic river model which could be used in the feasibility study.

The assessment of the spatio-temporal distribution of flood extremes requires to: (1) extract and reproduce the statistical spatio-temporal distribution of precipitation, (2) model correctly the hydrological processes at point and catchment scales

Therefore the results of the approach is derived by using a cascade of models. The first one is a stochastic rainfall generator, which must be used to increase the size of the historical precipitation and discharge records, while the second one is a distributed hydrological model that converts the rainfall in river flow at a wide number of locations.

It is presented the Po river basin as the case study. The Po river basin (70.000 km²) in Italy is well suited for testing the new methodological approach. Daily precipitation and discharge records are available for research purposes from 1939 for a large number of rain and river gauges. Continuous records of rainfall and discharge are also available for hundreds of gauges over the basin since the beginning of the '90s. Detailed spatial geographical and geomorphological data are also available for the catchment, while the main river network is described by thousands of cross sections.

E6-2 Orale Coviello, Antonio

10.1474/Epitome.04.0456.Geoitalia2011

THE ROLE OF THE INSURANCE INDUSTRY IN THE NATURAL DISASTER EVENTS

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Key terms: Insurance; natural disaster; reimbursement

The purpose of this research is to propose the creation of a national insurance fund which provides for damages in the event of natural disasters and the method of reimbursement in such cases.

More than half the Italian population lives in areas subject to natural disasters such as, floods, volcanic activity and above all, earthquakes. According to official data collected by the Ministry of Environment, 89% of the communities in Umbria are at an elevated risk followed by 87% in Basilicata, 86% in Molise, 71% in Liguria and Valle d'Aosta, 68% in Abruzzo and 44% in Lombardia.

Between 1994 and 2004, the Italian government spent over 20 billion euros, about 2 billion a year to repair damages caused by floods, earthquakes and dangerous landslides to which another billion and a half for less serious damages. On the whole, 50% of the damages to homes were caused by earthquake activity and 6.5% for flood and landslide.

An adequate insurance coverage would instead provide for these types of private damages via a payout via companies in the affected areas. Thus the heaviest expenses would be left to the federal government (and repair costs) to reconstruct public infrastructure. This would create a system which already exists in 21 other countries that provide a public system (and also partially privatized) to help in times of natural calamities. The following are example countries: The United States, The United Kingdom, Australia, France, Germany, Japan, Spain, Mexico, Turkey and Romania. For example "Catastrophe cover" policies could be created which would be supported by an obligatory European pool of insurance which would then take on the role of monitoring the risks by a team of experts.

The cost of the policies would be based on the statistical geographical data of the area in question and also on the probability of a natural disaster. Earthquakes in particular would be taken into consideration given Italy's seismic history.

The purpose of my study is to propose the creation of 4 levels of insurance compensation: the first level concerns small damages in which private citizens would assume responsibility for the damages; in the second level the insurance company would pay based on their role in a particular policy. In the 3rd level we have multinational insurance companies (re-insurance company) which share the risks as a group on an international level. In the 4th and last level, and only in the last level, a government intervention is foreseen in the case of a natural disaster, which would also accept aid coming from international help groups.

E6-3 Orale De Amicis, Mattia Giovanni

10.1474/Epitome.04.0457.Geoitalia2011

FLOOD DAMAGE ASSESSMENT WITH PURPOSES OF INSURANCE: THE CASE STUDY OF ALESSANDRIA (PIEDMONT)

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Key terms: insurance; flood assesment; flood damages

The last census of the Italian Ministry of Environment shows that areas exposed to "highest potential geo-hydrological risk" are 7.1% of the total surface, but relates 5,553 municipalities, representing 68.8% of the total. Annually there are many damages to property in consequence of natural instability processes. For these damages the Italian State annually spends more than 3,000 million of Euros. Periodically, always just after severe geo-hydrological events, the public and the scientific community are debating the possibility to insure damages to environment, structures and infrastructures, but the legislature has never yet defined guidelines. This paper examines the flood event occurred on 5-7 November 1994, which affected the course of the Tanaro River provoking remarkable damages in the city of Alessandria (Piedmont). The aim of this research is to determine a criterion for assessing the damage for insurance purposes. In the first step hundreds of documents collected in the technical office of Alessandria municipality were analyzed. These documents are damage appraisal attached to claims submitted by private citizens. Particular attention has been paid to define the cadastral data of the buildings in order to make a proper georeferencing practices.

With all the information gathered it was created a database containing:
 a) the market value of residential buildings (obtained by the Banca dati delle quotazioni immobiliari, published by the Osservatorio del Mercato Immobiliare dell'Agenzia del Territorio) related to the 1994 and to the second half of 2009.
 b) the building degree of damage related to 1994 and to the second half of 2009, calculated on the basis of "normal value" of buildings. First of all the relationship between the height of floodwaters and the degree of damage has been analysed thanks to the observation of the height water distribution, grouping the buildings by area (eg. Orti district, town center, left bank); thereafter it has also studied the relationship between the distance (Euclidean) from the River Tanaro and the damage. The damage in the town center and in the Orti district have the trend awaited. It is growing in relation to the increase of the waterflood height and it is decreasing when the distance of the building from the river is increasing.

The left bank has another kind of situation. It was affected by particular dynamics of the flood that are associated with the urban characteristics of the territory.

There is a railway embankment that during the flood event played the role of a dam. When it breached the surrounding areas were flooded with violence. On this bank there is also the Cittadella, a sturdy military fortification that protected the buildings located near the bank closer to the river. The presence of this large building diverted waterfloods that bypassed it and then dived back in the Tanaro riverbed.

Sixteen years after the severe event, moreover, the real estate value of the town center has suffered a slight decline: this may be due both to the loss of the area value because of its proximity to the river and to the higher cost of renovations due to the constraints that are normally in force for the buildings in that area. In the Orti district, on the contrary, the trend has proved the opposite: the value has increased probably because it is a growing residential area.

The flood is not just a problem in "terms of water", but especially a problem at "human level". In this sector it would therefore require a holistic approach to identifying problems of urban planning, socio-economic, development and management, in order to prevent and, secondarily, to quantify the hydraulic risk.

E6-4 Invitato Luino, Fabio

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AN INSURANCE MODEL FOR FLOODING RISK AREAS: A CASE STUDY IN LOMBARDY REGION

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Key terms: FLOOD; INSURANCE; RISK; LOMBARDY; ITALY

Floods are very common in Italy. Annually floods occur in different parts of the peninsula and cause severe damage and sometimes result in injuries or fatalities. Researching historical floods gives evidence of the frequency, magnitude, impacts, areas involved and types of damages. In spite of this wealth of information, town-and-country planning rarely takes into account these lessons of the past.

Italy has no single agency with a specific mandate to systematically collect flood data much less to analyze and validate it. There are two agencies that have documentation on the extent of flood-related economic loss: the prefectures and the chambers of commerce. They have collected flood claims filed by public bodies, private citizens and businesses.

In the aftermath of a flood, specifically in the early post-emergency phase, disaster aid and relief is provided by numerous local public and private agencies. Additionally, there is assistance to flood areas provided by other sources. However, data about disaster relief rarely flow into a single database. Consequently, a true estimate of the monetary costs incurred by a particular flood event is nearly impossible to make and all estimates are highly approximate. At best, it is suggested that between 1955 and 2000, the Ministry of Public Works spent between 4500 million euros and 100 million euros annually for flood-related work. Similarly, since their establishment, the regional governments have spent about 700 million euros per year.

This paper presents the use of a model quantifying potential losses suitable for planning and insurance against flood. The model is derived from a methodology for flood damage estimation developed in a small town in Varese province. It simulates event scenarios and evaluates expected economic losses. Potential economic loss assessment implies knowledge of the event, exposed asset values and the degree of damage. Following a widely shared simplifying assumption, flood water level was taken as the only factor indicating event magnitude.

The model incorporates the following steps: a) event description: definition of flood parameters (flooded area and water level), utilizing real-time measurements or data from event simulation with a hydraulic model; b) asset damage and identification of the affected population; c) evaluation of the degree of damage as a function of event magnitude; d) attribution of an economic value to different exposed assets; e)

quantification of economic loss by multiplying economic losses and damage severity.

An insurance bonus has been associated to each building, taking into account the economic loss occurred during the most severe documented event, and the frequency of floods from the Second World War till today. This pilot effort can be useful for land administration bodies and insurance companies in demonstrating the benefit of systematic acquisition and management of flood-related damage data.

E6-5 Invitato Mangano, Luca

10.1474/Epitome.04.0459.Geoitalia2011

NATURAL HAZARDS AND INSURANCE COVERAGE

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Key terms: INSURANCE; REINSURANCE; PAYMENT ACCIDENTS; PREVENTION

Abstract

1. Concept of Natural Hazards and aspects of insurance and reinsurance
2. Italian law Reference
3. European guidelines
4. Pricing, the two tendencies: "Solidarity" or "responsibility"?
5. Comparison of the two schools of thought in relation to the behavior induced in the insurance policy
6. The risk maps: concept and general requirements. Legal aspects of the technical documentation produced
7. Environmental monitoring systems to limit the damage to people, aspect legal and insurance
8. The role of the geologist in the evaluation of the specific vulnerability
9. Conclusions: priorities and needs of an insurance sector in serious delay

SESSIONE F1

Lo sviluppo sostenibile nel territorio attraverso la musealizzazione:

F1-1 Orale Preite, Massimo

10.1474/Epitome.04.0460.Geoitalia2011

THE MASTERPLAN OF THE MINING PARK OF THE COLLINE METALLIFERE

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Key terms: Industrial Heritage; Mining Park; Mining Museums; Mining Landscape; Cultural Landscapes

The strategic objective of the Masterplan of the National Technological and Archeological Park of the Colline Metallifere has very few precedents, insofar as the conceptual project is geared not so much towards the conservation of a few isolated remains, but to the development and promotion of a large-scale area, with a history of mining and metal-working spanning many centuries. Thus, conservation is extended to an assortment of many different objects (extraction and smelting sites, quarries, inhabited sites, transportation and storage facilities, slag heaps etc) which exist in relation to each other, but also with a wider environmental system which supplied the resources needed for them to work. Successfully embracing this complex system of relationships has been the real challenge for the Masterplan. Accordingly, the goal of heritage conservation has been attained on a scale requiring "conservation projects in the landscape": it is landscape which gives meaning and significance to disused machinery and facilities which, otherwise, viewed individually, convey very little ability to explain their function within the wider context of the complex relationship between man and his environment, which arises in each and every occupational process. The landscape dimension unquestionably adds a series of limitations in terms of morphology and the environment; but at the same time proves to be the scale best suited per deducing, from the overall pattern, the margins of transformation on which to base a coherent project to safeguard the heritage, and the margins for ascribing (to that same heritage) an active role in our modern society. From wide-ranging surveys of mining and metallurgical remains in the Colline Metallifere area (survey work which is well covered by this publication), there emerge all the features of originality and innovation of the Technological and Archeological Park, which was set up in 2002. First, its interdisciplinary nature, linked to a multiple supply of attractive elements, ranging from Etruscan and medieval archeology to industrial archeology, the natural and environmental heritage, the historical and architectural heritage (old town centres, castles etc) and the landscape. At the same time, stress should be laid on the twin aim of the Masterplan. It was drawn up as a tool designed to achieve both cultural and economic goals. While heritage protection remains an inalienable objective, the Masterplan does not hesitate to explore the opportunities for development which the Colline Metallifere can benefit from, via innovative enhancement and reuse of the industrial heritage.

F1-2 Invitato Casini, Alessandra

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A THEATRE IN THE PARK. THE TEATRO DELLE ROCCE PROJECT IN THE PARCO NAZIONALE DELLE COLLINE METALLIFERE GROSSETANE

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Key terms: MINING PARK; INDUSTRIAL HERITAGE; THEATRE; CULTURAL PROJECT

The Parco Nazionale delle Colline Metallifere Grossetane is located in northern sector of the Grosseto province in Tuscany, central Italy. The TM Geopark coincides with the territory of the Colline Metallifere

(Metalliferous Hills), the most important mining district in Italy together with some zones of Sardinia.

The area of the park extends on a whole surface of 1087 km² and includes the territories of seven municipalities: Follonica, Gavorrano, Massa Marittima, Monterotondo Marittimo, Montieri, Roccastrada and Scarlino.

The Park area has a relatively low human presence as the resident population is of 53.549 people) with a density of 49.3 people/km² against a level of 198.8 people/km² for the whole Italian territory (ISTAT data of 31 December 2007).

The most densely-populated municipality is Follonica (21.761 inhabitants), while in the others population ranges from 1.221 people (Montieri municipality) to 8.681 people (Gavorrano municipality).

The territory in question is characterized by hilly slopes with frequent outcrops of limestone, and red clayey soils deriving from the action of external agents on the limestone. Of particular note is the presence of various phenomena such as: Karst formations, geothermal phenomena thermal springs; and, finally, the large-scale mining and ore-processing areas of copper, lead, silver, lignite and pyrite.

The areas with the steepest hills, and the more hilly upland country in and around Massa Marittima, Monterotondo Marittimo and Montieri, are rich in mineral, geothermal and thermal resources, the exploitation of which has left a great deal of evidence relating to the various historical periods. This evidence has created a unique and unrepeatable landscape, a distinctive feature of which are the pipelines for steam generated by geothermal activity, and the natural, endogenous manifestations of naturalistic and geological value.

Large-scale morphological and ecological alterations of the landscape (stone quarries) are also a product of the demand for material for use as filler in the mines (Gavorrano), and for stones for ornamental use and for gypsum. However, these are now a characteristic feature of the mining and industrial landscape of the Colline Metallifere, also marked by examples of cultural development (the Teatro delle Rocce theatre, built inside an abandoned quarry connected with the Gavorrano Mine).

Intensive working by mining industry have left significant marks on the landscape in and around Gavorrano.

The Teatro delle Rocce is an open air theatre, it is a part of this project, as the conversion of a quarry which was used by the mine to fill in the underground tunnels. In fact, one of the main aspects of the project is to save the mining factories to give it a new "cultural" function. It was a real process of returning to the community of a lost and abandoned heritage with the closing of mining activities.

The presence of the Teatro delle Rocce has allowed to take an interesting cultural project in the park by organizing a festival of theater and music that in a few years it has become one of the most important events of the Province of Grosseto and allowed to transform a degraded place in a vital center frequented by many visitors, creating quality cultural offer and many reasons for return of visitors.

This allowed to undertake projects with theatre companies in collaboration with the Tuscany Region and the Province of Grosseto, in particular, the company KATZENMACHER of Alfonso Santagata with the project "La Miniera del Teatro" is creating in the park a real permanent workshop about the theatre in the territory.

F1-3 Invitato Sbrilli, Luca

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A CULTURAL ENTERPRISE FOR ARCHEOLOGICAL, MINING AND NATURAL PARKS

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Key terms: Val di Cornia, archaeological-Mineral Park; Mine district; Rocca San Silvestro; Coordinated territorial planning; Management of the cultural and natural heritage

The Parchi Val di Cornia SpA is a public company with a shareholding owned by the municipalities of Piombino, Campiglia M.ma, San Vincenzo, Sasseta and Suvereto, along with the Province of Livorno. It is a cultural enterprise holding some 350 sq.km that has, by statute, the aim of creating an integrated management system for the cultural and historical heritage and the environment of the territory.

Important and original work in coordinated territorial planning between the 5 shareholder towns has, since the '80s, led to the current structure for the protected areas. Important legal battles over ten years against illegal development, degradation and abandonment, permitted the creation of the entire park system.

Parchi Val di Cornia SpA saw the light as a public-private company, using an original tool for the management of the cultural and natural heritage in Italy: the limited company.

Since its establishment in 1993, the company has grown and today includes three museum complexes, an archaeological park, an archaeological-mineral park and 4 natural parks. Now a solid reality, the company has more than 30 full-time employees, a figure which reaches between 70 and 80 during the spring and summer. The work the company has carried out in valorising the historical and environmental heritage has aided the development of sustainable cultural tourism and contributed substantially to an ongoing process that sees tourism as a new force for the local economy, alongside existing industry. It is instructive to consider that in the year 2000 the tourist presence in the Val di Cornia numbered around 1,100,000. In 2009 this figure exceeded 2 million. The development of cultural resources brought about by the company, together with local government, has allowed a new image of the area to arise, one no longer linked to the steel industry.

The company, through the sale of tickets and income from concessions and parking has, in the last five years, been more than 94% self-financing.

The San Silvestro Archaeological-Mineral park is located near Campiglia Marittima and it covers 450 Hectares. This is an old mine district and a very important geological area, in particular for the skarn complex and its mineralization.

This park saw the light in 1996, it was founded in order to valorise a vast mining territory which has always been characterised by the close rapport between man and resources, settlement and extraction activity, archaeology and the landscape. It was the first mining park of Tuscany. San Silvestro Park is an open air history book for the story of mining, from Etruscan times until to the 1970s. The activity of extraction and mine working had left behind a lot of structures and plant that are amongst the most important European examples of industrial archaeology.

These structures are today the museum and hostels for visitors. The park takes its name from the Rocca di San Silvestro, an old and unique medieval mine village. Five years ago, an old mine joining two valleys was

restored, one kilometer used by a mine train transporting visitors.

After 15 years of activity, the results have become important for the culture and economy of the territory. In our country however, there are some legal problems regarding the management of these particular parks, so we hope a new regional law will resolve this. We will work for this objectives together with the all the other Tuscan mine parks. Tuscany has one the richest historical mining and geological heritages in the world.

F1-4 Invitato Mantengoli, Patrizia

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THE ABBADIA SAN SALVATORE MINING DISTRICT (SIENA, CENTRAL ITALY) AND THE MUSEUM MINING PARK

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Key terms: Mercury; cinnabar; Abbadia San Salvatore; Museum Mining Park

The Abbadia San Salvatore mining district (ASSMD) has a long-standing history during which different events have interlaced: a) a small village that in a few years turned to be in an important mining center; b) a company (the Monte Amiata) that became at world level one of the main actors in the mining market and c) a peculiar metal (mercury): the only metal that is liquid at standard PT conditions) whose commercial decline has determined the financial collapse of the producing companies.

Since 1800, the Abbadia San Salvatore mines along with those from Almaden (Spain) and Idrija (Slovenia) have exploited the most important mercury ore deposits worldwide. The mining activity in the ASSMD has lasted for at least one century during which it has suffered ups and downs that can be summarized in four main stages: i) the pioneering exploration when the Hg-bearing mineral (cinnabar) was searched in the Mt. Amiata (the youngest, about 200 ka, and largest volcanic complex in Tuscany, central Italy) area; ii) the build-up of the metallurgical plant with the financial and technological support of foreign companies; iii) the passage of the Hg district from private to public investors; iv) the workers' fights and the closure of the mining activity in the eighties.

Currently, the local museum, hosted in the historical building of Torre dell'Orologio, contains numerous documents, objects, photos and reproductions that allow the visitor to travel back in the past when the mining activity was the heart and the core business of the municipality of Abbadia San Salvatore. In the museum, the technical-scientific instruments are exposed in their original environment in chronological order. Thus, the visitor can appreciate how the mineral was worked for the extraction of mercury and how the technology has implemented since the XIX century. The perception of both the functional structure and the morphological organization of the mining complex is highlighted thanks to a peculiar sequence of the metal that has controlled and determined the fate of Abbadia San Salvatore: the extraction, the metallurgy and the memory. The documentary-exposive organization is in the Study Center and the Archive located in the Torre dell'Orologio, the documentary museum is in the former mechanical workshop that also hosts the machinery museum, temporary exhibitions and conferences and meetings. The museum of Abbadia San Salvatore is included in the network of the Musei Senesi and represents the first step of a larger project aimed to build the Museum Mining Park.

Abbadia San Salvatore is located in the heart of one of the most important districts worldwide by a natural, historical and artistic point of view: the Orcia Valley, Pienza Montepulciano, the thermal resorts of Chianciano, the Bolsena Lake, the Grosseto Maremma, Sovana, Sorano, Pitigliano and so forth. Abbadia is few kilometers away from the important railway and highway nodes of Chiusi from which Mt. Amiata can be reached in about 30 minutes by car or by bus. The Museum Mining Park will thus benefit of exceptionally favorable accessibility conditions from historical centers that have a strong tourist appeal.

F1-5 Invitato Ottelli, Luciano

10.1474/Epitome.04.0464.Geoitalia2011

GEOLOGICAL MINING PARK OF SARDINIA

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Key terms: Geological Mining Park; cultural resources; Charta of Cagliari

The Geological Mining Park of Sardinia is located in the centre of the western basin of the Mediterranean sea. It has been proclaimed the first Geological Mining Park in the world, an emblematic example of the new global network of Geosites-Geoparks established by UNESCO. Therefore, it is identified as a theme Park and it is part of a very special territorial context, namely the island of Sardinia, considered a small, but complete continent, because of its environmental and geological features. The Park includes eight different areas of interest situated all over the regional territory, covering a surface area of 3455 km². Clearly visible within its area there are signs of the material culture and of the settlements built around the mining activities which created new and original forms of landscape and social and cultural environments, able to characterize huge areas with a precise identity of universal value, unique and representative of the whole Mediterranean geological and cultural region.

The Origin Of The Park

The creation of the Geological Mining Park is a result of the realization of ideas, contributions, individual innovations and a united strength of purpose which established themselves during the last decades of the twentieth century in the Sulcis- Iglesiente- Guspinese territory. 1996 was the year of change in the Park's history: the compilation of the dossier to be presented to the UNESCO commission gave full recognition of the international value of historical, geological and environmental peculiarities of the Park. The General Conference of UNESCO in Paris recognised the island's first Park in the network of Geosites and Geoparks. After two years, on September 30th 1998, before the highest authorities of UNESCO and of the Italian Government, the Charta of Cagliari was signed. This is a document containing the working guidelines of the Park. After various difficulties and demonstrations, on October 16th 2001 the Italian government signed the constitutive decree of the Park. From that moment on, the Park became institutionally recognized. In 2007, UNESCO recognition and membership of the Geoparks European network was confirmed.

Mission

The Park was established because of the desire to create an organisation able to enhance its historical and cultural resources, linked to the common

mining tradition, within a context which adds to the preservation of abandoned archaeological industrial and mining sites, the extraordinary naturalistic and landscape resources of the territory. Therefore, the multi-theme peculiarities create an environment able to offer a "Geological Mining Park cultural product" package, linking the coastal areas of the island to the inland areas on a homogeneous sustainable development programme which represents a chance for social and economic rewards, ensuring at the same time a rich offering of topics and interests, made unique by the universal values within the Park territories.

Geology
Sardinia is one of the most geologically complete regions of the European and Mediterranean area. Therefore, its geological history is part of that of Western Europe and strongly differs from that of the Italian peninsula. It has one of the most ancient coastlines in Europe: high sea-cliffs, sandy beaches and impressive dunes. Inside the Geological Mining Park of Sardinia there are many karsts, unique in the whole world, inside of which there are many grottoes, some of them monumental, crossed by underground rivers. Inland and on the coasts we can see the changes of the landscape due to mining activity, carried out since remote ages.

History
The historical course of Sardinia and of its Park is strictly connected to mines. Nuraghes and small bronzes, as well as lead metallurgy are evidence of the exploitation of the mines by Punic, Romans, Pisans and Piedmonteses. The history of its mineral codes and of the whole Sardinian mining district is proof of a close relationship between man and the exploitation of the huge geological resources that both Sardinia and the Geological Mining Park still have. Mining villages and small towns and centuries of mining companies' history, represent, together with miners' struggles and the closure of the mines, a historical continuum which is nowadays guaranteed by the Geological Mining Park and which projects its territories towards a future of reconversion of its resources and memory recovery.

F1-6 Orale Fornaro, Mauro

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THE ENHANCEMENT OF COGNE MINE: A VERY IMPORTANT CHANCE FOR THE VALLE D'AOSTA GEOMINING PARK

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Key terms: Dismissed mining site; Geomining park; Territorial Rehabilitation; Industrial Heritage; Environmental Remediation

The Region of Valle d'Aosta, on the basis of two Regional Laws, foresaw the preservation and valorization of dismissed mining sites (L. 5/2008 Art. 21) and the creation of a Geomining Park (L. 12/2008 - Art. 5) in its territory: it includes different dismissed mining areas.

The increasing interest from local administrations toward "abandoned mining sites" is both motivated by cultural and economic considerations. Several initiatives are related to these two main topics.

Most of them are private and "voluntary", but also public, thanks to "co-financing" and aim to preserve the historical memory and to reintegrate the abandoned structures into the original territory (D.Lgs 42/2004).

The Earth Science Dept. of University of Turin is the coordinator of a group of expertise - Researchers and Consulting Technicians - which carried out a multidisciplinary feasibility study, concerning also the old St. Marcel and Brusson mines. Those mining sites were interested, during the past months, by a public tender for their valorization in a touristic and museum context.

The preparatory study, carried out by Earth Science Dept., was initially based on the works concerning Cogne Magnetite Mine, which was frozen because of administrative difficulties, coming from the same mining claim. For this mine, different studies have helped to identify main points of interest and critical elements, indicating the priorities for intervention in a mining context, perhaps even too "rich" and complex in terms of tourism. The outdoor heritage is composed by the structures, buildings and plants of Colonna Village and the cableway of Costa del Pino that are difficult to preserve or refurbish.

On the other hand, the underground is very well-preserved, equipped with an inclined shaft (skip) and train, that could be easily used.

If the Mine Company would like to renounce to the mining concession, it has to think about the onerous works caused by mine rehabilitation, which are, by law, charged on the last Mine Society.

The preliminary technical investigation of the Department of Earth Sciences has however allowed the priority identification of the interventions of remediation, for the safety and the restoration of some mining structures, that are considered worthy of preservation.

This gave a way to report on the technical results already available, summarizing the operational criteria and giving to the competent Administration some objective elements of evaluation for the planning choices.

In this regard, it should be noted that the recent Italian government approval of the contested law on "Federalismo demaniale (state property federalism)" (D.lgs. 28-05-2010, n. 85) seems to confer the ore deposits to the provincial (or regional) heritage, even if already covered by the existing Mining Law (RD 1443/1927).

The controversial political decision to consider these assets in "availability of the competent authorities (then alienable!) could then put the same Municipality of Cogne in the conditions to acquire - like an historical nemesis - "its" ore-body, as desired in the nineteenth century by the worthy Dr. Grappein! The mine of Cogne has been certainly deserving of all this.

Through the Valle d'Aosta Region, will nevertheless be necessary to make requests for the financing for new Operative Regional Projects (POR), taking advantage of the European Structural Funds (FES).

For the Mining Park of Valle d'Aosta, in addition to the strengthening of the renewed Mining Museum of Cogne and the realization of specific "info points" in other historical mining sites, it may be optimal to identify the well-recovered Bard Fortress facility as the "Gateway Park".

F1-7 Invitato Bergamini, Massimo

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REQUALIFICATION PROJECTS FOR BALANGERO AND CORIO MINING SITE

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Key terms: asbesto mine; requalification; projects; memory preservation; Ecomuseum

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The asbestos mine of Balangero and Corio is "a reclamation intervention site of national interest" as defined by the law n° 426/98 art. 1

The surface area to be reclaimed is a mountain region of about 400 ha situated 30 km far from the north-west of Turin. The area covered by the factories have a surface of about 40.000 sq metres. Inside the asbestos open pit there is a cultivation basin with a volume of about 2 million cubic metres.

The exploitation of asbestos serpentine sediment, consisting most of chrysotile, begun in 1920 and become, by 1970, one of the main international manufacture with a production average between 130.000 to 160.000 ton/year, sending to exportation more than 60% of material. The mining industry, carried out with steps cultivation system, has caused a significant transformation of the rock area involved placed on the borderline between Balangero and Corio.

This activity has caused the heaping of more than 45 million cubic metres of mining tailings, that has re-profiled and completely filled up the valley, as well as the production of 60.000 cubic metres of mud containing asbestos stocked in sedimentation basins all along main streams. Balangero Asbestos Mining Company become insolvent and stopped the activity just before it was issued the Law n° 257/1992, containing regulations about prohibition of asbestos excavation, trade and use. According to art. n° 11 of the Law, it was provided for environmental remediation of the asbestos mine of Balangero and Corio, including execution conditions.

Remediation in progress is carried on with particular care to the environmental setting in order to develop opportunities to recover the site by an economical requalification of territories involved.

Hydro-geological and environmental setting is done by naturalistic engineering techniques in support of environmental restore of the involved territories.

The recovering area take care to ecological sustainable solutions: one of the project, that will be carry out in a short term, is a photovoltaic setting in those territories that will not be any more available to public use because of permanent remediation.

In a long term, when the asbestos mine reclamation will be completed, besides the production of alternative energy sources, the development plan foresees to set up a Mining Park with the purpose of environmental and historical memory preservation and valorization.

By now, R.S.A. Srl has submitted the Ecomuseum Project to the value and approval procedure by the Regional Administration Committee.

Since some years this purpose has already been carried on by a partnership between R.S.A. Srl and the local Government according to the same intention not only to preserve the historical memory of Balangero and Corio Asbestos Mine as an unrepeatable case of industrial archeology, but also for the development of environmental training activities referred to students of territorial different level schools.

Furthermore the future Ecomuseum exhibition area could be used to display on going requalification projects, to organize shared activities with local associations and become, moreover, a study and research centre with the purpose to spur on local business activities.

That is why an European Project Idea Contest, financed by funds of Piedmont Region, has been called in October 2010. Many project professionals have taken part to the competition, this has given us the chance to collect very interesting and peculiar ideas for the mining park. Last 20th of April the Selection Committee has selected the winner between the projects submitted and afterwards, R.S.A. Srl has already scheduled to arrange for exhibition and some events in order to show all projects.

F1-8 Invitato Canavese, Giuliano

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MINERALOGICAL MUSEUMS IN THE MORAINIC AMPHITHEATRE OF IVREA (AMI)

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Key terms: AMI Museum Network; Brossio; Traversella; Zubiena - Bessa; Salussola

As part of its efforts to promote the variety of cultural riches of the Morainic Amphitheatre of Ivrea (Anfiteatro Morenico di Ivrea - AMI), the AMI Ecomuseum has designed and created the AMI Museum Network, with financial support from the 'Compagnia di San Paolo' foundation, the Provinces of Turin and Biella, from the 15 municipalities of the Morainic Amphitheatre of Ivrea and from the Ecomuseum of the Elvo and Serra Valley, as well as by employing its own financial resources.

The AMI Museum Network unites 11 of the 19 museums present and active in Morainic Amphitheatre of Ivrea area. A structure of service and support, managed and controlled by the Ecomuseum of the Morainic Amphitheatre of Ivrea, which aims to:

- o acquaint an audience extending beyond the local area with these museums, through activities directed at informing and promoting, with the support of the Provincial Tourist Agencies and a set of unified and coordinated tools and promotional channels;
- o keep the museums open on an ongoing and certain basis for a significant period of the year, prolonging traditional opening times to the public during village festivals and fairs;
- o provide these museums (which are often managed by volunteers) with human resources that possess university level education and training and that have been properly instructed on how to present each individual museum correctly and how to relate with the public, as well as how to interpret their role as 'museum professionals'.

Museums with different characteristics, but representative, as a whole, of the economic and cultural history of the area of the amphitheatre form the AMI Museum Network.

Among these, two groups of museums dedicated to mining activities prevail, which until the recent past, were of economic importance. In Valchiusella, on the western side of the Morainic Amphitheatre of Ivrea, iron and pyrite mines, as well as stone quarries, were cultivated and exploited, even before the Roman conquest (II Century A.C.) according to historians. During the eighteenth century, Valchiusella was the largest producer of iron in the Savoy state.

The two mineralogical museums devoted to this theme are located in Traversella, where FIAT was the last owner of the mines, and in Brosso, where mining activities were last managed by Montecatini. Both areas concluded their mining activities in the early years after World War II. The eastern side of the Morainic Amphitheatre of Ivrea witnessed gold mining activities even before the Roman conquest. Gold mining probably reached its peak with the Romans, if - as claimed by Plinio - 5,000 men were employed to search for gold in the territory of the Bessa, located in the municipality of Zubiena. Gold hunting activities subsequently declined and are now practised for educational purposes or as a sport or hobby. Both the Gold and Bessa Museum in Zubiena, and the Gold and Stone Laboratory Museum in Salussola exhibit materials, instruments and examples of these mining activities.

F1-9 Orale Castellano, Antonella Maria

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THE MINING INDUSTRIAL HERITAGE OF THE ALPS AND CENTRAL ITALY: AN ANALYSIS OF RECOVERY AND VALORISATION INITIATIVES IN A MINERAL DEPOSITS GEOLOGY KEY

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Key terms: mining industrial heritage; mining sites improvement initiatives; mineral deposits geology; Alps and Central Italy

Nowadays there is a great number of recovery initiatives of abandoned mining sites in a belt that runs from the Eastern Alps through Liguria, Emilia-Romagna up to Tuscany in Italy and in cross-boundary areas. This study involves their census and their characterization focusing on mineral deposits geology aspects.

During the last decade we have seen an increasing interest in these initiatives by the Scientific Community, by the Government (ISPRA) and Territorial Bodies (Tuscany and Lombardy).

In the 1980s and 1990s the closing of the majority of the Italian mines, most of which metalliferous, carried out to a sensible reduction in Italy in the scientific production on the ore deposits geology.

Forty-five improvement initiatives of mining sites (ore and industrial minerals mines and ornamental stone quarries) have been identified. For each site a monographic paper has been produced after direct surveys in situ. A critical comparison between what is offered and what is really accessible by users has also been realized.

The data synthesis yielded a thematic map of the situation of the recovery and improvement initiatives of abandoned mining sites from the Alps to Tuscany updated to 2010.

The recovery initiatives have been divided in three categories which include "Mines and Quarries", "Parks and Museums", "Projects". The first group enables visitors to see the ore deposit with their own eyes, as it proposes to people a visit of underground mining stopes and levels; the second group offers external paths and/or museum exhibitions, sometimes with artificial reconstructions of mining tunnels; at last the third group is made up of the initiatives at a stage of feasibility study. From this study it appears that at present the Italian regions with the largest number of recovery initiatives are Trentino - Alto Adige, Lombardy and Tuscany.

Most of these sites involve ore deposits, mainly base metals sulphides; deposits of industrial minerals, indeed, are incompletely represented by talc, fluorite, salt and sulphur and coal mining sites; a remaining small part is made up of ornamental stones quarries, all underground.

From the Alps to Tuscany today it is possible to have a recovered mining heritage that potentially enables to carry out live observations on mineral deposits geology topics about the following important categories of deposits:

- polymetallic and talc deposits (stratiform and vein-type) in the Crystalline Basements;
- iron, lead - zinc (Ag, Cu) "MVT or carbonate-hosted", coal, salt, and sulphur stratiform deposits in the Mesozoic and Tertiary sedimentary cover;
- polymetallic vein-type pyrite, gold and talc deposits;
- Sed-Ex type copper, pyrite and manganese deposits in the alpine and appenninic ophiolites and meta-ophiolites and in their covers;
- polymetallic skarn type deposits connected to Tertiary plutonism;
- gold-bearing placer deposits in Quaternary fluvio-glacial sediments;
- ornamental stones quarries (marbles) in the Paleozoic (Alps) and in the Mesozoic (Appennines).

All the recovered mining sites are different for types and settings of deposits, mineral substance, geological domain, metallogenic context and age and they are present in a defined geographic neighborhood: from the Alps to Tuscany.

The in situ surveys have pointed out that the mineral deposits geology basic elements of these recovery initiatives are often incomplete or lacking, while great emphasis is given to historic information, together with mining industrial archeology.

This heritage, indeed, covers not only industrial archaeology and/or tourism topics, but also important geological and mineral deposits aspects. The local geology of mineral deposits is indispensable condition for the opening of quarries and mines. Therefore it is also necessary to pass to the wide public this important cultural aspect.

Besides this heritage would be available to the scientific community and to Italian and transalpine universities for didactic and cultural aims.

F1-10 Orale Patane, Agata

10.1474/Epitome.04.0469.Geoitalia2011

THE NATIONAL DAY OF MINES A NETWORK FOR ECO-MUSEUMS MINING IN ITALY

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Key terms: dismissed mining sites; mines, territory; database; mineralogical collections

The National Day of Mines, now in its third edition, is a national initiative that involves many Italian mines aiming to promote the use of geological and mining heritage and create a museum network.

The institutions and associations sponsoring the event are: ISPRA, Italian National Institute for Environmental Protection and Research (<http://www.isprambiente.gov.it/site/it-IT/>); AIPAI, Italian Association for

industrial archaeological heritage (www.patrimoniindustriale.it); ANIM, National Association of mining engineers (www.anim-gallerie.it); Italian Mining Association for mining and oil extraction (www.assomineraria.org); National Association of Geology and Tourism G&T (www.geologiaetourismo.it), sponsoring the G&T day.

The National Day of Mines represents an opportunity to study the dismissed mining sites and their cultural enhancement; the memory of the thousands of workers who were employed in mining, the relationship between rural life and industry, folk tradition and modernization, which is a particular characteristic of the communities associated with mining. The third edition includes the participation of many Italian regions. The calendar of events is available on the ISPRA and AIPAI websites. Initiatives are typically guided tours and geological tourist routes, seminars and conferences.

The comprehensive purpose is to reflect the value of the mining heritage in the Italian countryside, to affirm the historical significance, and to keep the memory alive. In addition, these initiatives are an opportunity to highlight the value of recovering these territories for sustainable development.

The "Italian Directory of Earth Sciences" ISPRA has registered approximately one hundred eco-mining museums, which will be part of the future museum network, supported by the AIPAI Mines Commission. All of these sites are included in a database, which will be available soon on <http://www.museo.isprambiente.it/Regioni.page> site.

ISPRA researches work on the territory concerning the cultural enhancement of the mining sites of geological interest, through the Museum Service Institute, which inherited the Litomineralogical Collections from the former Italian Geological Survey. The Litomineralogical Collections are the result of 150 years of survey activities related to the Geological Map of Italy, mining explorations, and samples acquired by purchase or donation. The whole litomineralogical heritage is currently preserved in a database - GEODOC Project - waiting to receive funding for the purpose of cataloging according to national standards of the Central Institute for Catalogue and Documentation.

The Litomineralogical Collections began with the unification of Italy after the establishment of the Geological Committee, (the new Office and then Geological Survey) under the Royal Corps of Mines, for the purpose of studying soil and subsoil of the Kingdom, of knowing and using of domestic raw materials. The Litomineralogical Collections demonstrate the determination by the rulers of the Kingdom of Italy in order to know its territory in order to plan properly.

The Litomineralogical Collections (currently belonging to ISPRA) were hosted for more than 100 years in a building of great prestige, the "Agricoltura Geological Museum" in largo santa susanna, [built for this purpose in 1875 up to three levels of exhibition space (2700m²), and it was abandoned (because of needed repair work) by the Geological Service in 1995]. Currently the Collections lie mostly in storage rooms (excluding the exhibition space of 270 m² hosted at the ISPRA office in Via Curtatone), it is waiting for public funding that could restore the original and necessary places for the exhibition.

F1-11 Orale Paganoni, Anna

10.1474/Epitome.04.0470.Geoitalia2011

THE GEOLOGY BUILTS THE LANDSCAPE

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Key terms: Museums; Tourism; Geological gardens; Via Geoalpina

Often the subjects of geology are intertwined with those of culture and management of land, its conservation and enhancement. This process is no stranger to transformations taking place, they include the reorganization of the urbanized area, the conversion of raw materials to production areas and the increase in residual areas.

Geologists have a new opportunity to broaden their skills, communicate with other professionals involved in land management, become active participants in defining aspects of cultural value unknown to most speakers. Problem areas, sometimes considered only for material suggestions neglecting the Geological Value reveal important opportunity to achieve users in search of novelty and excitement. Obviously the process does not go through a traditional musealization, aimed at conservation purposes excluding innovative methods and techniques.

Examples of this can be considered in cases of conversion of underground caves of Vicenza stone, temporarily used for cultural events. Massive pillars supporting the ceiling emerge from the water, marks of the blocks draw the walls and the ceiling with their massive size. But also Gavronano mines or quarries in many Italian regions are transformed after the discovery of extraordinary paleontological deposits, all are examples which demonstrate a change in sensitivity to the world of geology and the approach of a new audience. The search for cultural events such as concerts, or art installations leads to the search and discovery of quality sites, and the nature of the materials carried by insights and accomplishments in quality. This method has long pursued by museums for public awareness by involving them in new locations or purposes that are more engaging than the individual paths or guided tours in the exhibition halls.

Today, the inventory of geological heritage, the musealization spread in situ, the recovery of abandoned areas are issues that have assumed a central role in the economic and social debate after years of quiescence in fact, are common examples of its conversion and development of the territory. Abandoned land have become "geological gardens" where large blocks are carefully collected and described to demonstrate unusual geological features. Near the Geological Survey of Regione Emilia Romagna, for example, has been set up this kind of installation, but similar cases are offered in other sites. After a careful selection of geological sequences belonging to a limited geographical area to facilitate the understanding of rocks visible along hiking trails, bicycle paths or recognized in floods. This methodology is particularly suited to convey the basic concepts of geology also at a disadvantage from a public limited mobility.

Is also growing a new type of musealization particularly recommended as it does not alter the environment, it moves along existing routes by offering support guide proposes a context of geological processes and issues in any broader cultural context. Emblematic of this is the experience of Via Geoalpina, symbol project of Planet Earth TYPE, who made trips described in a geological perspective and tourism throughout the Alps. The Italian pathways are described by members of G & T Associazione Italiana di Geologia Turismo. They are available through a dedicated website, free downloadable, computer readable and planned for a user friendly approach to geology.

The process is not without difficulties and contradictions, achievements

banal or difficult to manage, but the excitement that is linked to this type of museum routes documents a new impetus of geological disciplines lowered into a new culture of the landscape.

F1-12 Orale Badiali, Federica

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SUSTAINABLE EXPLOITATION AND UNDERSTANDING OF THE RELATIONSHIPS BETWEEN MAN AND LANDSCAPE IN THE ECOMUSEUM OF HILL AND WINE OF CASTELLO DI SERRAVALLE (BOLOGNA, ITALY)

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Key terms: cultural heritage; tourism; agriculture; sustainable exploitation; involvement

The landscape of the Apennine areas has preserved many important traces of the mutual relationship between man and environment, continuously during the centuries; in this way, a great value heritage has been created, which deserves to be emphasized and protected, and in which we can find also human activities now almost forgotten. For this reason these areas are ideal to a sustainable enhancement, which could be carried out by means of an Ecomuseum, because "don't exist marginal or insignificant areas, on the contrary only places that have not found the correct convergence between potentiality and initiatives yet" (Piacente & Poli, 2003).

An Ecomuseum refers to a new holistic idea of Cultural Heritage, until now mainly related to specific items and objects, performed by traditional Museums; in other words, an Ecomuseum is an "agreement by which a community is committed to taking care of a territory" (Maggi, 2002). In fact, in a traditional Museum it keeps and shows works of art, ancient objects or scientific attestations. On the contrary, an Ecomuseum involves all the land surrounding it and has, as its main task, the increasing in values and the preservation of either the historical and cultural heritage or the natural and environmental one.

Therefore the Ecomuseum doesn't focus its attention just on objects, historical buildings or landscape elements but lets to discover direct the local heritage and the inhabitants activities: the representation of the local community.

It is presented the case of the Ecomuseum of Hill and Wine (Castello di Serravalle, Bologna, Italy), opened in 2004. In this territory, near the border between Modena and Bologna, 325 m sea level, in a hilly zone of wines DOP and DOCG production, the landscape alternates intensive vineyards, cultivated fields and geomorphological elements of great interest, beside charming features such as the fortified medieval village of Serravalle, in whose walls you can see the use of local rocks and re-used Roman bricks. Nowadays, in this area, the most important expression of the interaction between man and landscape is mainly represented by the viticulture; but we shouldn't forget the archaeo-botanical proofs, ensuring the grapevine-growing in the Roman Age and probably even earlier. The Ecomuseum of Hill and Wine, opened in 2004, covers the entire municipality of Castello di Serravalle; the seat is in the medieval Casa del Capitano, here are educational panels and some objects, however the information given by panels are brief and the exposed objects are few, so that the attention of the visitors is not focused inside the Casa del Capitano, but outside, where the real Ecomuseum headquarter is located. All the Ecomuseum routes on the territory are marked with arrows and the points of interest are illustrated by information panels. The Ecomuseum is divided and organized in nine Systems, which represent the main topics in the man-environment relationship: each one has its own colour and is explained inside and outside the seat by didactical panels and meaningful objects.

During the first years of activity, the Ecomuseum of Hill and Wine has created four important educational tools: the map-guide, the interactive totem with touch screen system for the virtual tour, the audio-guide for the visit in the castle and the web-site; particularly, the audio-guide and the totem can be used by persons with disabilities, too. In this way visitors can independently create their own itinerary, based on personal needs and interests.

Ecomuseums can be effective tools both for a sustainable tourist exploitation and for spreading knowledge and awareness of the local cultural patrimony among the residents, although the involvement of the citizens remains a critical issue.

Finally, the archaeo-environmental study, which aims to reconstruct the past landscape, result of a non-destructive environmental use, will be useful as a beginning for next studies about the future landscapes.

F1-13 Orale Bonanno, Rosa

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THE POLITICAL AND SOCIAL ROLE OF FIVE SCIENTIFIC-TERRITORIAL MUSEA OF REGGIO CALABRIA AND MESSINA PROVINCES (SOUTHERN ITALY)

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Key terms: Scientific-Territorial Musea; Research; Conservation; Scientific and Cultural divulgation; Political and Social role

To be able to "read" our Territory, with eyes which understand the significance of each small and large thing, cheering its beauty, proud to know its value and role in the living equilibrium of the Earth's System, is the privilege of a chosen few. But these people, as the chosen few, have a duty to keenly take part in the fight against the indiscriminate use of Nature and its resources. This also means teaching others, not just specialists, the characteristics, peculiarities and wholeness which make this territory important for its environmental aspects and which have to be safeguarded and exploited in the best way possible.

Even today, in spite of natural and anthropic degradation, Sicily and Calabria (Southern Italy), exhibit an high naturalistic-environmental value, testified by the wealth of Natural Reserves and Parks, which constitute a very important system for safeguarding their natural characters, peculiar from place to place and, sometimes, unique. These, according to their geographical positions and geological features, are different from area to area, and responsible for different historical-artistic-anthropological systems. All these elements constitute a

natural-cultural system of high value, and are promoters of innovative territorial management models.

That being so, in the last fifteen years the Petrology and Crystalline Geology team and the Doctorate in Tourism, Territory and Environment of Messina University has organized five scientific-territorial Musea in the Messina and Reggio Calabria Provinces (Southern Italy), under the patronage of Athenaeum and of relevant Municipality. These structures have been set up by researchers prompted by the need to spread capillary scientific-historical-cultural knowledge, so that each visitor can take note of the importance in safeguarding the defined Territory.

With the aim of defining the political and social role of these structures, an examination of them will be carried out in this work, focusing early on their typology and museal itinerary and, subsequently, they will be incorporated into their specific roles.

The structures in object are: the Earth Science Museum - Petrography and Cartography Sections of the Calabria and Sicily Regions (Messina University, Messina); The Natural History Museum of the Messina Straits in the Mediterranean (Villa San Giovanni, Reggio Calabria); the Territorial Museum of Novara di Sicilia (Novara di Sicilia, Messina); the Memory and Emigration Museum of Limina (Limina, Messina); the Historic Museum of Mathematic, Physic and Natural Sciences (Messina University, Messina). The Musea are open to the public and gather up, order, catalogue, conserve and preserve collections and single objects, very important of the scientific and/or technologic and/or cultural point of view. The elements of this heritage, pick up directly in the field if mineral, rock, fossil, and biotic specie, or acquired in different way if thematic map, instrument or historical and anthropological find, originally have not evocative value. For to assume significance of good responsible for a link between the territorial community and its history, the materials have been contextualized through a scientific analysis that allowed them to assume a specific function in the context of scientific and/or historic evolution of the Territory, in addition to the possibility to divulge the significances which they have been loaded.

These Musea have a role of research and popular scientific structures. Its social and political role consist that the displayed natural objects and historical materials testified the evolution of the Territory and of its community. They are the memory of natural and anthropic events which allow to immortalize both community and Territory. This political and social role is the most important function of these Musea, that justified their creation, their status of public institution, and which permit them a continue develop, preventing their destruction.

F1-14 Orale Rapisarda, Carmine

10.1474/Epitome.04.0473.Geoitalia2011

THE VOLCANO ETNA AND THE GRAND TOUR: THE PLANNING OF A NATURAL MUSEUM TO ENHANCE THE AREA

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Key terms: THE VOLCANO ETNA; THE GRAND TOUR; THE PLANNING OF A NATURAL MUSEUM; TO ENHANCE THE AREA

Man was always fascinated by volcano Etna, especially during the eruptive phase, when fear and attraction come together in front of the spectacular natural phenomenon.

In the past, the great mountain has been seen as part of the underworld, where Hephaestus placed his domain. Even in Christianity it was considered as a demonic place, where the fire has been seen as a purifier of souls and in Middle Age the volcano was imagined a gate to communicate with the afterlife; belief that continued in folk traditions until the eighteenth century.

The aim of this work is to consider how the Etna Natural History Museum, to be known for its aspects abiotic, biotic, historical and cultural and for its uniqueness.

This museum will be interactive with a past reconstructed through the memories of the foreign travelers.

Therefore, we have defined routes that lead from the slopes of the volcano to the summit. They relate elements, shapes, colors, sounds and smells of nature to preserve an important area and stimulate a qualified management.

The routes reconstruct, document and illustrate paths that follow in the footsteps of great travelers. The illustrations will make use of documents and maps, a rich iconographic comparing past and present and between the "visible and invisible".

The first scientific approaches to the study of the volcano begin during the humanist period, with Bembo (1493) in particular. But the travelers of the Grand Tour also developed a deep interest in Etna. The first ascents followed a similar route that lasted almost until the 1800's:

After leaving Nicolosi, going through the woods and crossing the desert region they arrived at the only natural refuge, called the "Cave of Capriole". In 1810 Gemmellaro built the first shelter, it was called "The House of the British". The travelers usually setting off around midnight reached the base of the crater, then they walked and reaches the summit at dawn. Obviously, like Houel (1777) and Bartels (1786), not all reached the crater, so instead they saw the show from the ruins of the mysterious "Tower of the Philosopher".

Among the most significant scientific contributions was the work of Déodat de Dolomieu (1781) cataloging materials and making comparative studies with Vesuvius and the Aeolian Islands. His following correspondence with Gioeni makes up a lively and intense debate about the nature of the rocks. The territory of Etna was observed with increasing interest not only from the scientific point of view but also from a social historical perspective: observations of its distributions appear very important in some travel stories, from landing in Sicily the volcano remains the "topos". All travelers aspire to scale it and often follow the classic route, the one made by Fazello (1558) in the sixteenth century, which remain unchanged until the eighteenth century.

From the memoirs of travelers in addition to the varied excursions have been testimonies of some natural lava stone monuments and/or built by human hands, in particular, we include: the cave of goats, the snow cave (grotte à la neige) and the Grotto of Palombe. The first was a stopping place for travelers until 1810, when the first shelter was built by Gemmellaro: "The house of the English", then transformed into an observatory and later destroyed by a lava flow.

Among the monuments of man wanted to mention:

- 1) the aqueduct, interesting for the description and pictures left by Jean Houel, it brings water from a cistern near S. M. di Licodia to Catania.
- 2) castles - would include Paternò was visited by Denon (1778) The materials cataloged and analyzed are the basis for the planning of a natural museum of Etna, designed to promote the territory and its memories: it should be supplemented with historical-cultural and real or

virtual.

The Natural History Museum of Etna was therefore designed to promote the territory and its memories, as a cultural space and as a model for innovative tourism.

SESSIONE F2

Geoparchi, geoturismo e sviluppo sostenibile

F2-1 Invitato Panizza, Mario

10.1474/Epitome.04.0474.Geoitalia2011

DOLOMITES: FROM THE UNESCO WORLD HERITAGE LIST TO A MANAGEMENT STRATEGY

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Key terms: Dolomites; UNESCO World Heritage List; Geomorphology; Management strategy; Geopark

In the collective imagination, the Dolomites are a spectacular area to study and to enjoy. In art, particularly in painting, the shapes of these mountains have inspired many visions, generating emblematic artistic images and also evoking fascinating ideas. Some examples of this will be illustrated.

In order to obtain a geomorphological understanding of these mountains, with reference to their inclusion in the UNESCO World Heritage List, an original interpretation has been introduced, that is, "geomorphodiversity" (Panizza, 2009): "the critical and specific assessment of the geomorphological features of a territory, by comparing them in a way that is both extrinsic (with other territories) and intrinsic (with the territory itself). It takes into account the level of their scientific quality, the scale of investigation and the purpose of the research". Some typical situations are presented concerning the spectacular and attractive landscape and its morphotectodynamics, morphotectostatics, morpholithology, morphoclimatology and mass wasting.

This geomorphological key of interpretation can also be used to define the more general "values" of the Dolomites, referring to "geological" values in a broad sense, subdividing them into extrinsic and intrinsic values.

In the evaluation of the "livableness" of the Dolomites, problems concerning "environmental criticism" must also be taken into account in terms of risk and impact. so as to achieve a correct and sustainable enjoyment of this mountain territory.

As for the appraisal of the Dolomites, particularly regarding Earth Sciences, a conceptual path is illustrated, following the phases of scientific interpretation, communication, knowledge and awareness. The idea is "not planning in order to protect and protecting in order to manage but planning in order to educate, educating to develop awareness and developing awareness in order to appraise and self protect. (Panizza & Piacente, 2003).

Finally, appraisal and enhancement must be linked to a network of all the physical, biological and cultural elements of the territory. A "network" which cannot only be understood as being of "spatial significance" (a network of places, communities etc.), that is a group of sites bounded by territorial limits, but an "open network" system in its cultural significance, which therefore, exists apart from limitations of space, time and concepts.

F2-2 Invitato Graziano, Gian Vito

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CONSERVATION AND VALORIZATION OF GEOLOGICAL HERITAGE: WHICH OPPORTUNITIES FOR GEOLOGISTS?

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Key terms: Geological heritage; alternative job; geotourism activities

Geoparks and geosites directly lead on professional figure of geologists, who usually are not very involved in environmental conservation and valorization politics.

Nevertheless a development of nature conservation systems in geological way must connect with a jobbing outlet for geologists: it's real that census, characterization and interpretation of geological heritage are objectives of recent date, but it's how true that opportunity by the terms of alternative job for geologists must be yet matured.

The occupational outlet is relative to present demand of job for geotourism activities, but it's necessary from now get ready for that will be the future demand, in probably supposition of a strong increment of geoconservation politics in next years.

F2-3 Orale Amato, Vincenzo

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GEOTOURISM IN THE PARKS AND IN THE PROTECTED AREAS OF THE CAMPANIA REGION (SOUTH ITALY).

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Key terms: geodiversity; geological heritage; geosites

The Campania Region is one of the areas with the highest index of geodiversity (landscapes and rock types) of the Italian peninsula. Along the Tyrrhenian margin are present typically coastal landscapes alternating low and high rocky coasts, and, in the Neapolitan areas, typically volcanic landscapes, too. The inner part of the Region is characterized by typically mountain landscapes alternating high and rugged mountains (up to 2000 m a.s.l.) and gentle hills. This part is characterized too by typically fluvial landscapes, alternating broad fluvial-marshy valleys. From the coastal

area to the inner part of the region there are sand and clayey silt alluvial-coastal deposits of Quaternary ages, volcanoclastic (lavas and pyroclasts) deposits of Late Quaternary ages, carbonatic deposits of Meso-Cenozoic ages (Matese, Picentini, Lattari Mountains, ecc.) and terrigenous deposits of Cenozoic ages (Sannio and Cilento Mountains). This geodiversity was generated by the outcropping rock types variability and by their complex deformational and evolutionary history, both ancient and recent.

In very recent times, the environments and the geodiversity of the region are suffering many scratching attacks, sometimes irreversibly devastating, which have heavily depleted the geological and environmental heritage. Nevertheless the geodiversity must not only be presented in the form of risky events but also in the form of resource, often of exceptional natural value. Indeed many of the regional areas covered by this slow process of environmental wasting are subject to protection (2 National Parks, 8 Regional Parks, 6 Protected Marine Areas, 5 National Natural Reserves, 4 Regional Natural Reserves, and 7 Protected Areas, in add to many Local Reserves and protected areas). In these areas the geological heritage presents specific characteristics that can be easily connected to the most natural places that contain them. In fact, here, the Campania Region Offices identified and surveyed the most important geosites. Unfortunately, there are no enterprises to enhance and promote the geological heritage, aimed at a geotourism sustainable use. The efforts to network the sites representative of the geological and geomorphological complexity of the Region are totally lacking, especially regard to geotouristic paths and itineraries, educational materials, etc., with the exception of the Cilento and Vallo di Diano Park, that, recently, became Geopark.

With the aim to promote the geological heritage of the parks and protected areas in the Region, the Italian Association of Geology and Tourism, the Geological Regional Order, the Lerka Minerka Trekking Association, supported by FIST and by some local administration, organized, for the 2011 year, a calendar of geotouristic itineraries and events (see www.geologiaetourismo.it and www.geologi.campania.it). The geotouristic events want to involve mainly the geologists, with the aim of raising awareness the professional responsible for the enhancement of the geological heritage, and, in secondly, the geotourists and trekking sportsman, with the aim of broadcast widely the importance and the value of the geological heritage.

These events may be a proposal and an added value to the tourism, that the Campania region, offers to the visitors of the parks and protected areas, and at the same time, may be represent an opportunity to increase the presence of tourists, attracted not only by natural features but also by geological features that these areas contain. The main geotouristic events interest the territory of the Matese, the Taburno-Camposauro, Lattari M., Picentini M., Roccamonfina regional parks, of the Cilento and Vallo di Diano National Park, of the Elea-Velia, Paestum, Ercolano and Cuma Archaeological Parks, and of the Naples urban and hilly area.

F2-4 Orale Avanzini, Marco

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THE ADAMELLO BRENTA GEOPARK

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Key terms: geopark; landscape; geological heritage; geotourism; sustainable development

The Adamello Brenta Natural Park expand on an area of 620.5 square km between 477 and 3,558 m above sea level. It is the largest protected area in the Trentino region and one of the largest in the Alps. Besides an exceptional wealth of flora and fauna, in which the brown bear is the emblem of an untouched nature, the Adamello-Brenta contains a priceless landscape and geological heritage.

Separated by the Rendena valley, two mountain chains, differing for their geology, characterize the Park. On the eastern side are the Dolomiti di Brenta group; Majestic cathedrals of limestone where the water flows along networks of karst conduits, wells and galleries towards beautiful waterfalls, and springs. On the western side, the Adamello - Presanella massif, is constituted by magmatic rocks and shaped by the action of the water in all its forms, above all, the Adamello glacier: the largest glacier of the Italian Alps.

Thanks to the sustainable development strategy adopted (European Charter for Sustainable Tourism since 2006) and the outreach activities proposed, on the 26th of June, 2008, the Natural Park Adamello Brenta is joined to the European and Global Geopark Network under the auspices of UNESCO.

Exactly one year later, on the 26th of June, 2009, the Brenta Dolomites, with 8 other geographical sectors belonging to 5 different provinces, are inscribed in the list of UNESCO World Heritage Sites because of their beauty and unique landscape and their "scientific importance in geology and geomorphology".

The Adamello Brenta Geopark is characterized by an high geodiversity, and constitute an open-air laboratory where the secrets of the Earth's history can be learned in 61 different Geosites.

In line with the broader and more complex strategy for the conservation and enhancement of natural, historical and cultural heritage, the Adamello Brenta has powered its many initiatives through the development of a new Action Plan.

Besides protecting and promoting the geological heritage, the Plan will ensure an important role in the development of socio-economic fabric of the area for the Geopark. New activities have in particular been turned to Geotourism: from education and communication, to training and route mapping. Special attention has been given to the high altitude mountain refuges, raising residents awareness on scientific research, and on the historical and cultural aspects of the development of productive activities. With Park guides or guidebooks, tourists, residents or alumni can discover the power of the ancient glaciers, explore the old mines of quartz, or walk across the beautiful landscape of the Dolomites, trace the Vallesinella waterfalls to their karst springs or walk on a moraine of the Little Ice Age and directly measure glacier retreat in the last 150 years.

Protecting and promoting geological heritage lead us to improve our understanding of landscape changes over time and space and our responsibility towards nature.

F2-5 Orale Burlando, Maurizio

10.1474/Epitome.04.0478.Geoitalia2011

GEOPARKS IN ITALY: INNOVATIVE TOOLS FOR

GEOCONSERVATION AND LOCAL SUSTAINABLE DEVELOPMENTBURLANDO Maurizio¹

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Key terms: Geoparks; Geoconservation; Sustainable development; Geoheritage

Within the whole international system of Geoparks specifically identified to safeguard and promote the geological heritage of Planet Earth - the European Geoparks Network (EGN) and the Global Geoparks Network (GGN) under the auspices of UNESCO - Italy is well represented by seven territories of particular value.

This is the Madonie Nature Park in Sicily (recognized in 2001), Rocca di Cerere Cultural Park always in Sicily (2001), the Beigua Nature Park in Liguria (2005), the Sardinia Geomining Park (2007), the Adamello Brenta Nature Park in Trentino (2008), the Cilento and Vallo di Diano National Park in Campania (2010) and the Colline Metallifere Geomining Park in Tuscany (2010).

To coordinate and to develop that geoparks system the National Forum of Italian Geoparks was inaugurated on 17th February 2010 in the Adamello Brenta Geopark.

The National Forum of Italian Geoparks consists of:

- one representative from each recognized Geopark (5 at the moment)
 - one representative from the UNESCO Italian National Commission
 - one representative from the National Geological Survey (at ISPRA - Superior Institute for Protection and Environmental Research))
 - one representative from the Italian Federation of Earth Sciences Associations (GeoItalia FIST, which gathers all the scientific associations which deal with Earth Sciences in Italy)
 - one representative from the Italian Federation of Parks and Nature Reserves (Federparchi, which constitutes also the Italian Section of EUROPARC Federation and has also the function of General Secretariat of Italian Committee of IUCN)
 - one representative from the National Council of Professional Geologists.
- The forum could also invite in some circumstances: representatives from National Tourism Organisations and representatives from Universities involved in Geoconservation and Geotourism.
- During the first meeting a proper regulation about the functioning of the National Forum has been approved and the aims of the Forum has been defined:

- to best coordinate the Italian Geoparks' initiatives;
- to promote the development of new Italian Geoparks;
- to promote new projects for the valorisation of the geological heritage at a national level;
- to provide information and popularize the International Network of Geoparks (EGN/GGN) through the various communication tools (website, newsletters, newspapers, etc.);
- to create new opportunity of integration between the many national activities direct to the growing of geological heritage's policy and to the development of geotourism;
- to provide a technical and scientific support to the territories who want to submit to the EGN/GGN;
- to organize an annual workshop in order to exchange best practices and to popularize the various projects and activities of the Geoparks, the geological heritage conservation and the realization of virtuous actions for the sustainable development.

Following the interest from several areas of Italy of Geoparks concept and with the main aims to enhance the geological heritage, to develop geological tourism, to raise public awareness about the Earth Sciences, the National Forum of Italian Geoparks intend to consolidate its first activities working at a large-scale, supporting common projects and initiatives at a national level, serving the European Geoparks Network and the Global Geoparks Network under the auspices of UNESCO in their actions at an international level

F2-6 Orale Casini, Alessandra

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GEOTHERMAL AREA IN THE PARCO NAZIONALE DELLE COLLINE METALLIFERE GROSSETANE. A "SUSTAINABLE" GEOSITE.CASINI Alessandra¹, CINELLI Riccardo¹

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Key terms: GEOSITE; GEOTHERMAL AREA; SUSTAINABLE DEVELOPMENT

Geothermal area of the Tuscan Mining Geopark is a complex landscape where there are a geological heritage of international significance and the remains of the first industrial production of electricity through the heat of the earth. A modern system of geothermal power plants allows the production of energy with low environmental impact and the creation of many agricultural activities that take advantage of this resource.

Geothermal landscape
In this area there are important evidences of recent and present geothermal and hydrothermal activities occur. These evidences have created a unique and unrepeatable landscape, a distinctive feature of which are the pipelines for steam generated by geothermal activity, and the natural, endogenous manifestations of naturalistic and geological value, together with the ancient alum quarries. One of the most interesting is certainly the geological site of Biancane, which has a footpath network with information panels that allow reaching and observing the geological and naturalistic peculiarities of this area.

Industrial Heritage
Geothermal area has also industrial relevance, in fact in this area for the first time in history boric acid was extracted from geothermal fluids. In 1777 Hoeffler, director of the "Farmacie granducali", discovered the presence of boric acid in waters of a thermal pool and carried out some experimentation to extract boric acid. Since 1818 the Count De Lardarel increased the industrial process for the production of boric acid by introducing extraction procedure. At present the signs of this activities for acid boric production are represented by the remains of some decantation pools built in early 19th century. In this area for the first time in the world the geothermal fluids were utilized to produce electrical energy.

The sustainability
At present in the Geopark there are five geothermal power stations which cover 70% of the energy requirements of the Province of Grosseto. Close to the geothermal power station, some cheese factories use geothermal power to produce high quality cheese.

F2-7 Orale Filocamo, Francesca

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A CONCRETE PERSPECTIVE FOR GEOTOURISM IN MOLISE REGION (ITALY): FROM THE INVENTORY TO THE TOURISTIC PROMOTION OF GEOSITESFILOCAMO Francesca¹, BARANELLO Sergio², DI PAOLA Gianluigi¹, GIANNANTONIO Olga², IAROSSEI Mario², MONACO Rossella², RELVINI Maria³, ROSSKOPF Carmen Maria¹

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Key terms: Geosites; Inventory; Molise; Geotourism

The Molise region, albeit of limited extension, is characterized by a high geodiversity. Its geological history, the long-term climatic influences and the geomorphological dynamics that characterize in an unique way its mountainous, hilly and coastal areas, have given rise to numerous sites of geological interest. These sites have been examined, assessed and inventoried in the research project "The Geosites Inventory in Molise region", carried out by the University of Molise in partnership and on behalf of the Molise Region with the main purposes to contribute both to the preservation and valorisation of the regional geological heritage and the implementation of the Italian Geosites Inventory in progress by the National Institute for the Protection and Environmental Research (ISPRA). The inventory we carried out in Molise region has allowed to identify and select over 80 geosites of various scientific interest (geomorphological, stratigraphical, paleontological, etc.). The selected geosites, most of which are of regional interest and of high scientific and didactic value, well represent the geodiversity of Molise region and allow to understand the various steps of its geological evolution. Many of them are located within protected areas (National, Regional and Natural parks, Sites of Community Importance, etc.) which extend over ca. 34% of the regional territory.

In order to enhance and promote the inventoried geosites and to provide a contribution to the development of sustainable tourism within the Molise territory, we have started a series of further activities aimed at the disclosure of the geological heritage to a non-scientific audience. In particular, in addition to the specific catalogue card, a synthetic descriptive card was produced for each geosite which is designed to ease disclosure especially to non-specialist audiences such as excursionists and tourists. This descriptive card, in addition to the data concerning the identification and the assessment of the geosite, contains a section dedicated to the landscape and the territorial context, allowing the reader to deepen the salient features of the physiographic unit in which the geological site is located. The descriptive cards of ca. 20 geosites along with a photo gallery have already been published on the website of the Servizio Turismo, Industria Albergghiera of Molise Region.

Furthermore, the material for a book on the Geosites of the Alto Molise physiographic unit, well-known for its specific geological-geomorphological features and its rich cultural to archaeological heritage, has been produced. This book will contain an introductory section on the Alto Molise physiographic unit, illustrating its geologic-geomorphological, naturalistic, cultural and historical-archaeological aspects, which is followed by a detailed description of the 16 selected geosites, including their descriptive cards, which allows to connect them to the territory. It will also include a map illustrating the location of geosites, protected areas, main streets and main sites of archaeological interest.

What we are currently working on is the development of geo-touristic itineraries aimed to promote both the geosites and the natural and/or cultural heritage of certain areas. In particular, we are working on the illustration of specific geological-naturalistic contexts such as those characterizing for example the "Le Mainarde Itinerary" which interests the Molise portion of the area of the Abruzzo, Lazio e Molise National Park and offers geosites of great scenic impact, and on itineraries combining the visit of geosites with those of historical monuments and/or archaeological sites, as for instance the Geo-archaeological itinerary which links the archaeological site of Sepinum to the surrounding geological heritage. The progress of our research project envisages the realization of an Atlas of the geosites selected in Molise region to further promote the regional geological heritage.

F2-8 Orale Valente, Alessio

10.1474/Epitome.04.0481.Geoitalia2011

THE GEOLOGICAL HERITAGE OF CILENTO AND VALLO DI DIANO GEOPARK: A SOURCE OF SUSTAINABLE DEVELOPMENTVALENTE Alessio¹, GUIDA Domenico², ALOIA Aniello³

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Key terms: Geological heritage; Geopark; Sustainable development; Cilento and Vallo di Diano

The Cilento and Vallo di Diano Geopark extends for more than 1800 km² in the southern Italy. Its great number of geological appearances, with different degree of importance and interest (stratigraphical, geomorphological, hydrogeological, etc.), can be integrated in a variety of ecosystems, already inserted into the "Man and Biosphere" programme of UNESCO, as well as to exceptional and unique archaeological sites as Paestum, Velia and Padula, recognised as World Heritage by UNESCO. However, this territory is considered less economically developed than other surrounding areas, so the geological heritage can be a great opportunity, especially for tourism purposes, in changing this situation.

Moreover, a net difference is observable between the coastal area of the Geopark, which present numerous kind of accommodation and attractions, and the inner one, poorly known and inadequately framed. For instance, in the relieves of Cilento and Vallo di Diano Geopark, belonging to Apennines, are well exposed the successions involved by the former thrust, occurring in the Miocene. The most of these succession, that permit to see, along the inner mountain sides, sedimentary and structural features, uniqueness and scientifically relevant, for different reasons are neglected from tourists, which generally frequent the coastal areas. Besides a more diffusive promotion of the entire geological heritage of the Geopark to the public with publications and events, the improvement of the access of the geological appearances in the inner area. Such improvement require the adjustment of the viability in order to reach trails, also practicable by cycle or by horse. These activity could involve young people in work cooperatives, and provide a system of structures and infrastructure.

The role of water in Cilento and Vallo di Diano Geopark is considerable for the suggestive springs and falls as well as for superficial and underground forms widespread in the territory. About water and its processes a long

term program of education must be realized in the schools of the area. Such program of education can help the young generation to understand the values of the territory in which they live and the necessary actions for the correct maintenance and fruition. The planning of this program foresees moments of popularization in the classrooms integrated by excursions on the territory for the direct knowledge of the natural beauties and particularly of the geodiversity present.

Also along the coast of the Geopark can be focused some geological appearances able to developed tourism activity. In particular, along the more eastern cliffs of the Cilentò, reachable only from the sea, the occurrence of terraces, sea notches and caves, representing traces of paleosealevel, can become the basic elements for a new pathway in the sea. Such pathway, carried out by a fitted boat, could help tourists to discover the changing of sea level in the late Quaternary through these traces. The pathway can be integrated from the evidences of prehistoric settlements, which cover a wide chronological range since 500.000 years ago. This particular cruise, like the first example, promote a particular tourism in which the geological heritage could be represent a way to develop employment and enhance knowledge.

This strategy in geotourism is becoming a reality, as revealed by some institutions that already develop several activity about the geological heritage in accordance with the Geopark authority, such as: the Foundation MIDA (Museums Integrated to the environment), which operate for the exploitation of the environmental resources and the local cultural assets, and manages the famous caves of the Angel of Pertosa (geosite) and the Municipality of Morigerati, which operate in collaboration with the WWF in the Oasis of Morigerati in order to valorise the geologic uniqueness (e.g. karstic cave of the river Bussento) and to safeguard the high biodiversity.

F2-9 Orale Benciolini, Luca

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GEOLOGICAL TRAILS AND SELF-DIRECTED LEARNING: AN EXPERIENCE IN THE SARNTAL ALPS (SOUTH TYROL, ITALY)

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Key terms: self-directed learning; Sarntal Alps; field geology

Since the nineties, both public understanding and teaching activities of Sciences have been progressively shifted from unidirectional communications (books, ex cathedra lessons and so on) toward participatory experiences, as for example them parks, science festivals or didactic curricula based on hands-on laboratory. In spite of this evolution, Earth Sciences represent today a critical subject for science communication. As an example, plate tectonics is a multidisciplinary subject and is very difficult for teaching in scientifically rigorous terms. This is commonly given in didactic curricula postulating a kinematic models more than giving evidences, as an axiom instead of a theory explaining data and phenomena.

On the other hand, geotourism has the task of capture the audience with spectacular geologic phenomena often explained in terms of Plate Tectonics. In this case, because of the knowledge deficit, scientific explanations for the public must be fascinating and surprising more than rigorous. Furthermore, both public understanding and teaching reverse logical connections among data and theories and tell geology to the public in a magical perspective more than as a scientific discipline. Changing this science communication model is possible?

The Sulzspitz area in the Sarntal Alps compounds five metamorphic lithologies, all with a well developed crystalline structure, implying a 200 Ma geological evolution from the Hercynian chain to the opening of the Tethys ocean. Spectacular objects are not available for making such a long and fascinating story attractive for the tourist. A main question is: has this geology filed any interest for geotouristic activities?

A group of tourists has been accompanied in the Sulzspitz area; each tourist was equipped by a field notebook and a geology hammer. The travel guide gave a general stimulation on the geology field work especially on observing, drawing, writing impressions with no any idea on the geological evolution of the area. We infer that: i) these basic field geology activities do not imply a specific knowledge deficit, ii) these activities are possible tools for a free exploration of reality, iii) nature may represents an exhaustive laboratory that does not need a strategic story for communicating emotions. Our approach shifts the public understanding from theories and scientific results to the scientific research. As a strategy, we choose to provide only basic informations as a tool for rocks description, including::

- 1) Rocks are heterogeneous materials
 - 2) Rocks are composed by minerals
 - 3) Any domain homogeneous in colour, form and shine is a single mineral
 - 4) Rocks have to be broken with the hammer in order to evaluate their actual color.
- This activity may provide us the answer to some questions on the public stakeholder:
- Which is the reaction to a self-directed learning proposal ?
 - Which subjects are selected ?
 - Which descriptive strategies are spontaneously chosen ?
- We suggest that this activity may represent in the future a permanent communication channel among researchers and public in order to promote geology as a scientific issue of personal contemplation of Nature.

F2-10 Orale Braga, Roberto

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PEOPLE ENJOY METAMORPHIC ROCKS: CASE HISTORIES FROM TOLLEGNO AND FONTAINEMORE, WESTERN ALPS (ITALY)

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Key terms: Geological Heritage; Geosites; Geotourism; Tollegno; Fontainemore

In this contribution we present two case histories in which basic field and petrographic knowledge coupled with scientific marketing strategies have proven to be successful in promoting the geological heritage of

Fontainemore and Tollegno villages.

The key requirements are: (1) easily accessible outcrops; (2) coarse-grained rocks where minerals can be identified with the unaided eye and (3) readily distinguishable cross-cutting relations among different rock types. In addition, some weathering patterns such as differential erosion can help in recognizing different rock types. Outcrop can be replaced, in favorable circumstances, by an exhibition of meter-sized boulders (the so-called Rock Garden), previously collected from local stream/river and successively located in a portion of public area, e.g. a promenade along the river.

The effort to promote basement rocks requires: (1) to support local communities during the evaluation of the geological heritage potential; (2) the financial and logistic support from local communities; (3) the design and implementation of an Opening Act, generally two-three days culminating into the visit to the outcrops and/or Rock Garden; (4) the organization of activities related to the opening act (e.g. brief seminars, open-air activities organized jointly with local social and educational realities) and, more importantly, (5) to make all the activities go viral on the local media (newspapers, newsletters, informative flyers, postcards) and the internet. All the above practical aspects have been implemented at Tollegno (near Biella, Italy) where high-grade metamorphic rocks and clinopyroxene-bearing calc-silicates cut by andesitic and granitoid dikes occur along the Cervo stream, and Fontainemore (Aosta Valley) where a rock garden of eclogite-facies boulders has been made in a public garden along the Lys stream.

Basement rocks can represent an attraction for people interested in the Natural heritage of their territory.

F2-11 Orale Muntoni, Francesco

10.1474/Epitome.04.0484.Geoitalia2011

THE UPPER CARBONIFEROUS SAN GIORGIO BASIN (SOUTH WESTERN SARDINIA)

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Key terms: Mining; Park; Geosites; Educational; Sardinia

The need to have a better knowledge and preservation of geosites is at present compared to that concerning the flora, fauna and the landscapes diversity; in fact they represents an inestimable natural and cultural heritage testifying the history of Earth. The Upper Carboniferous deposits of the so called "San Giorgio Basin" have been restudied keeping in mind these assumption, especially because of it shows at the same time an elevated scientific value, peculiar in the Sardinian geological context, and, unfortunately, an example of destruction caused by human activities. These outcrops, already known at the end of the Nineteenth Century with an extension of about 3 sqkm, cover at the moment a surface not exceeding 0.3 sqkm.

The Authors propose as protection and exploitation actions, both a project of a thematic itinerary reaching the most interesting outcrops, with educational characteristics.

The geological site is situated in South-Western Sardinia at a few kilometres SW from the down-town of Iglesias and about 50 km from Cagliari within an area characterized by the presence of several important abandoned mines (Campo Pisano, Monteponi, San Giovanni, Genna Luas etc.).

The area containing the Carboniferous sediments, although of little extension, is particularly important from a scientific and teaching point of view. The best exposed outcrops are located in the neighbourhood and partially surrounded by mining dumps originated from the closest mentioned mines since the first half of the Seventies and later for some decades. The geosite is made up of a geological body deposited in a continental environment after the Hercynian Orogeny and assigned to the Upper Carboniferous (Westphalian-Stephanian) after the study of several taxa belonging to macroflora and palynomorphs, of very rare microsaurian trace fossils, arachnoids and blattoids.

F2-12 Orale Gosso, Guido

10.1474/Epitome.04.0485.Geoitalia2011

ABOUT THE INEXPRESSED POTENTIAL OF GOOD LEVEL EARTH SCIENCES OUTREACH IN ITALY

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Key terms: Parco Naturale Alpi Marittime; Parc National du Mercantour; Natural Sciences; scientific outreach

If we digit on the web of Earth Sciences the word Alps, the rewarding number of about 24.000 scientific papers will appear on our screen and this is only an example of what may happen to words as Glacier, Volcano, Apennines or Sea Floor. In Italy, a country sharing a half of the whole Alpine belt with Europe, displaying over 3.000 km of Mediterranean shoreline, disposing of glaciers, volcanoes, forests and plains immersed in the Mediterranean climate, such wealth of knowledge and Nature is all but speculantly flanked by an adequate diffusion of even elementary notions capable of making basics of Earth behavior popular. Information about Science is not a privilege, but a current civil right in many countries; in our case, on Italian TV programs, cooking Italian food is of course at the top! But TV channels are doing good job popularizing basics in Medical Sciences and irradiate a reasonable level of outreach in Zoology, much less in Botany, very little in Astrophysics and Cosmology and modern Biology, although the latter two are recently of great appeal to high school students on the way to choose for their further career. Italian Parks developed a wealth of activities directed to some levels of schools for guided visits, or to tourist groups or solitaires. In the open Nature the level of the offer of commented trips is in many cases adequate, but a higher standard would attract more fascinated visitors. This may be gained if forestry, mineralogy, geology, geomorphology, zoology and botany would be commented during walks in alternance during excursions, following the level of posed questions, and not giving the impression of school-style teaching, but rather that of fulfilling wishes and imagination of participants; there is no pre-cooked package of information that may be displayed by field guides that will not bore even the most curious trekker. Young Ph.D. students may serve as field guides in Italian Parks during summer, periodically; they do have the scientific level requested to follow

a short scientific communication course, and become adequate to explaining in different European languages the beauties of Italian Nature in any season. It is just matter of organization and communication of the offer of well-commented scientific entertainment trips in the Nature. The market for this exists; the offer is not sufficiently diffused! The unexpressed potential is that of young high level Ph.D. science students that would spread enthusiasm for a week or two during summer, or whenever, to the people of Park visitors. Experiments are going on already in many European sites, including Italy and France, and should be diffused into others.

F2-13 Orale Giardino, Marco

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PROGEO-PIEMONTE: A MULTIDISCIPLINARY RESEARCH PROJECT FOR DEVELOPING A PROACTIVE MANAGEMENT OF GEOLOGICAL HERITAGE IN THE PIEMONTE REGION.

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Key terms: geological heritage; Piemonte; geosites; geodiversity management

"Geoheritage" is a generic but descriptive term applied to sites or areas of geologic features with significant scientific, educational, cultural, or aesthetic value. By presenting a project in the framework of the initiative "Progetti di ricerca di Ateneo 2011" (by Università degli Studi di Torino and Compagnia di San Paolo bank foundation), the large, multidisciplinary research team of "ProGEO-Piemonte" (41 senior researchers, 8 fellows and PhD students, 5 technical staff from 5 different departments) aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region by means of the development of techniques for recognizing and managing its rich geodiversity at the local and regional scales.

The ProGEO-Piemonte assumption is that geoheritage sites ("geosites") can serve both the public and private interests. After a systematic review of inventoried geosites by the "Centro di documentazione sulla Geodiversità e la Geoconservazione" (by Università degli Studi di Torino and Museo Regionale di Scienze Naturali, Torino), 9 strategic geothematic areas will be investigated by specialized research teams to represent the geodiversity of Piemonte:

1. The Monviso massif and the Cottian Alps as symbols of the Alpine chain (coord. F. Rolfo)
2. Pages of the Earth history book recorded in the successions of the Marquais area (coord. A. d'Atri)
3. Climate variability and past environmental changes: lessons from the Messinian record of the Tertiary Piedmont Basin (coord. F. Dela Pierre)
4. Interaction of geological processes and human activities in the Monferrato hills (coord. L. Masciocco)
5. Natural and artificial waters of NE Piemonte (coord. R. Ajassa)
6. Glaciation and deglaciation: geomorphic signatures on Morainic Amphitheatres of Ivrea and Belvedere (coord. M.G. Forno)
7. Geomaterials as a resource for mankind development: the Traversella and Brozzo Mining areas (coord. E. Costa)
8. Geoenvironmental dynamics and risks: the Cassas landslides and the large slope instabilities of the Middle Susa valley (coord. M. Giardino)
9. Turin: the foundation stones of geological heritage in the Piemonte Region (coord. A. Borghi)

Since each geothematic area is characterized by high potential for scientific studies, enhancement of public understanding of science, recreational activities and for economic support to local communities, four interdisciplinary research teams (A-D) will cover the aspects of:

- A. It applications for geoheritage data management (coord. L. Ghiraldi);
- B. visual representation of geological processes and evolution (V. Lombardo);
- C. geodiversity action plans for dissemination activities (coord. E. Ferrero);
- D. tool integrated management of geosites by application of TIQ (Territorial Integrated Quality; coord. R. Beltramo)

Scientific concepts will be coupled with geodiffusion interests: geosites within the thematic areas will be accommodated along with elements such as museum collections, evidences of mining activity and quarrying, science exhibits and nature trails. Action plans will be developed with local partners to determine management requirements for the different geodiversity elements.

Outcomes of the project will include didactic tools for educators, schools and public in general, such as real and virtual geological tracks, interactive websites and training courses for geonaturalistic guides. The recognition of the economic value of geodiversity will lead to the production of Geoconservation guidelines for the Regione Piemonte, including planning considerations, and tourism and sustainable development strategies in general.

F2-14 Orale Arena, Libera Paola

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TERRITORIAL DEVELOPMENT THROUGH A SYNERGY OF HISTORICAL, GEOLOGICAL AND ADMINISTRATIVE SKILLS. THE CASE-STUDY OF THE GEO-HISTORICAL TRIP OF CARLO AMORETTI IN THE PREALPS.

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Key terms: geotourism; geological travel; history of geology

Between the 18th and the 19th century, the science of geology, not yet institutionalized, was essentially a practice realized in the field. So, the geological travel became a tool for studying and observing nature. There were many scholars (De Saussure, Dolomieu, Fortis, Arduino, De Luc, von Buch and so on) that made different types of trips (mineralogical, lithological, paleontological) in order to understand the formation of our planet and the stratigraphical shape of the Earth's crust. The main destination of these travels were the Alps and the Prealps that, in those years, were studied in great detail.

The participation to the working group, "Geological travels in the

mountains of Northern Italy. The fieldwork in the stratigraphic locations of historical importance in the 18th century-PRIN 2007" coordinated by Prof. E. Vaccari (Università degli Studi dell'Insubria, Varese, Italy), provided the opportunity to reconstruct and follow in the field a trip made from one of these scholars-travelers, through the study of his letters and diaries. In the summer of 1797, Carlo Amoretti, an eclectic polygraph, explored a wide area from the Piedmont banks of Lago Maggiore to the surrounding mountains observing some aspects of great mineralogical and lithological interest for that historical period: traps, granite, kaolin, fossil fuels and different rock-types.

This cultural heritage of geo-mineralogical knowledge about the practice of travel is a real source to be used today both by geologists for their studies, as a matter of confrontation, and by local authorities, for the territorial enhancement and development of the so-called Geo-tourism. In this context, a geo-historical digital path of the 1797 Amoretti's trip has been planned for the users of the net. Indeed, through the use of Google Earth application, it can be possible to compare the historical maps with the current ones, tracing the path followed by the scientist-traveller, identifying places and points of interest litho-geo-mineralogical and so on. This interactive tour could be enriched by a number of other geological and cultural information. To this end, a collaboration with experts in different fields of geological sciences would be desirable. The final application could provide its users with a complete picture of the necessary information to explore directly on the field the geo-historical routes of interest.

Such use of historical sources has been placed as a key element within a proposal for a recent European project. The "HistGeoAlp" project, presented by Prof. E. Vaccari (University of Insubria), with a network of other 11 partners from Italy, Austria, Slovenia, Germany and Switzerland, has not been activated yet, but if it will meet the interest of the scientific community it will start soon in the future. The main aim of this project is to provide the tool to create a network between different types of existing and new geo-sites and geo-routes (also within geoparks), through multimedia database, a virtual museum on the history of geological travels and information points.

To date some financed projects only partially met the increasing need of territorial improvement, such as the projects concerning the mountain routes (Via Alpina, Via Adventure, Iron Route, Via Geoalpina) and many web-sites concerning the geo-tourism.

The added feature of the "HistGeoAlp" project is the integration of different geo-sites and skills (historical, geological, cartographic, administrative and based on computer science) able to link the net with the territory and promote geo-tourism.

With the cooperation of other historians and geoscientists it will be possible to plan other geo-historical paths and give, in this way, the opportunity to create a network such as the one proposed by the "HistGeoAlp" project.

F2-15 Poster Costa, Emanuele

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GEOMATERIALS AS A RESOURCE FOR MANKIND DEVELOPMENT: THE TRAVERSILLA & BROZZO MINING AREAS IN THE FRAMEWORK OF THE "PROGEO-PIEMONTE" PROJECT (GEO-HERITAGE AREA 7)

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Key terms: Geotourism; Geological Heritage; Historical Mining; Metallurgy Iron Technology; Mineralogical Collection

The multidisciplinary research project PROGEOPIEMONTE (PROactive management of GEOlogical heritage in the PIEMONTE region: innovative methods and functional guidelines for promoting geodiversity knowledge and supporting geoconservation activities (PROGEO-Piemonte - coord. M. Giardino), aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region by means of the development of techniques for recognizing and managing its rich geodiversity at the local and regional scale. After a systematic review of inventoried geosites, 9 strategic geothematic areas will be investigated to represent the geodiversity of Piemonte. Geological history, climate and environmental changes, natural hazards, soil processes and georesources will be popularized not only with geosites but also with museum collections, evidences of mining activity and quarrying, science exhibits and nature trails. The recognition of the economic value of geodiversity will lead to the production of regional guidelines for Geoconservation integrated quality management system, suitable for tourism and sustainable development strategies.

One of the nine chosen geosites is the Brozzo and Traversella mining area. These locations are two of the most important iron mines in the Piemonte area since ancient time. Iron mining activity in Traversella was very important until the end of the second world war, whereas in the Brozzo mine production was focussed on pyrite extraction for sulphuric acid manufacturing until the beginning of '900. Not only these sites are of primary scientific importance, (the Brozzo-Traversella mining district represents the only skarn-type mineralization in the Alps), but also for science passionate, mineralogist and collectors, these two localities are of the highest interest, and outstanding mineralogical samples coming from these two mines are displayed in the most famous museum all over the world.

Among the scientific research actions that our team want to carry out on the site, we will obtain the reconstruction of the mineralogical features of the Traversella and Brozzo mines, by performing mineralogical, petrological and ore deposits studies. We will acquire information from every kind of historical sources. In order to achieve these objectives, we will need to coordinate a study of historical mineralogical samples and of recent findings in these sites. Such a study will be carried on by optical microscopy, SEM-EDS microanalysis, microXRF, XRD, focussing on the field observation and mapping, and the study of historical documentation about mining and metallurgic processes before the XIX century. We will cooperate with the existing organization as well as the Museum of the Mineralogical Group Valchiusella, the Museum of Brozzo Mine, the Comune di Traversella and Comune di Brozzo, the Comunità Montana, the Piemonte Region and the Turin Provincia, and last but not least the Museum of Natural Science of Turin.

With these actions we would like to put on view the extraordinary importance of the Traversella mine from a scientific point of view, but also we want emphasize the role of the site from the point of view of the industrial development in Piemonte Region. We will illustrate the impact

on the surrounding region from a sociological and environmental point of view, investigating the lifestyle of people living and working, during centuries, in this small mining region. As expected results, the team would obtain a new series of books and booklets relative to historical background of mining extraction, metallurgical dressing, mineralogical richness in the area, scientific importance of the samples in various museums in the world, itineraries in the area for a better comprehension of the interaction between mines and geological environment.

F2-16 Poster D'Atri, Anna

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PAGES OF THE EARTH HISTORY BOOK RECORDED IN THE SUCCESSIONS OF THE MARGUAREIS AREA (PROGEO-PIEMONTE PROJECT - GEOTHEMATIC AREA 2)

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Key terms: geotourism; geological heritage; sedimentary environments; Marguareis Massif; Permian-Cenozoic history

The multidisciplinary research project "PROGEO-Piemonte" aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region by means of the development of techniques for recognizing and managing its rich geodiversity at the local and regional scale. Nine strategic geothematic areas will be investigated to represent the geodiversity of Piemonte, each characterized by high potential for scientific studies, enhancement of public understanding of science, recreation activities and for economic support to local communities.

One of these nine geothematic areas concerns the record of deep geological time as stratigraphic successions. In the Piemonte sector of the Alpine chain, sedimentary successions are best exposed in the area comprised between the Marguareis Massif and the Colle di Tenda (Western Ligurian Alps) where altitude and the mainly carbonate rock composition concur to provide superb geological exposures. This sector is particularly complex as it appears as a mosaic of different units, pertaining to the European Mesozoic passive continental margin of the Alpine Tethys, that however consist of sedimentary rocks deposited in different depositional environments and affected by prolonged gaps in sedimentation. These units were juxtaposed and superposed by tectonic processes during Alpine orogenesis. In a relatively restricted area, rocks of very different age (from Permian to Eocene for a total time span of over 200 million years), nature (volcanic and sedimentary), and depositional environment (from carbonate tidal flats to deep sea turbidite basins) are exposed. On the whole, they record the main stages of the geological evolution of the European margin related to the opening and closure of the Alpine Tethys ocean and consequent genesis of the Alpine chain. All these features, moreover, are exposed in a protected mountain area (Parco della Alta Valle Pesio), easily visitable through untarred roads and well indicated trails, that also bears an historical added value related to the presence of military fortresses of the XIX century.

The geological knowledge of these successions and their evolutionary model is quite well established on the basis of both existing scientific literature (Carraro et al., 1970; Gosso et al., 1983; Lanteaume et al., 1990) and original data published by the proponents (Piana et al., 2009; Bertok et al., 2011).

We propose to project a series of itineraries, developed in a GIS environment, aimed to illustrate, in a scientifically correct, but accessible to a large public of non-specialists, way the most significant steps in the geological evolution through time of the rock successions exposed in the area, with particular emphasis on the past environmental factors that have determined the observable lithological changes.

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F2-17 Poster Gianotti, Franco

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GLACIATION AND DEGLACIATION: GEOMORPHIC SIGNATURES ON MORAINIC AMPHITHEATRES OF IVREA AND BELVEDERE

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Key terms: Ivrea Morainic Amphitheatre; Belvedere Glacier; geological heritage; geosites; Piedmont

A study of the Ivrea and Belvedere morainic amphitheatres is included in the Project "Proactive management of geological heritage in the Piedmont Region: innovative methods and functional guidelines for promoting knowledge and supporting geoconservation activities (PROGEO-Piemonte - coord. M. Giardino)" proposed by the Earth Sciences Department of Turin. This multidisciplinary research aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region by means of the development of techniques for recognizing and managing its rich geodiversity at the local and regional scale.

The Ivrea Morainic Amphitheatre (IMA) is the main product of the Aosta

Valley glacialism at the outlet of the Dora Baltea Valley. It is one of the widest (505 km²) amphitheatres of the Italian Alps and the first to be studied (since 1844). The IMA consists of a branched complex of lateral and end moraines and kame terraces, dated from the end of the Early Pleistocene to the end of the Late Pleistocene (900±20 ky BP). This succession is partible into ten stratigraphic units, potentially correlable to the whole sequence of the main Quaternary glaciations registered in the marine oxygen isotope stratigraphy. The IMA shows remarkable evidence of the glacial sedimentation and erosion: above all the Serra d'Ivrea lateral moraine and the Colli d'Ivrea bedrock outcrop area.

The present Belvedere Glacier (9 km²) is the biggest of the Piedmont, placed below the eastern face of the Monte Rosa in the uppermost Anzasca Valley. This debris covered glacier is well-known because of its supraglacial "ephemeral lake", but it is also notable for the Holocene morainic apparatus essentially referable to the Little Ice Age. The following scientific research actions will be developed with the aim to improve the already available data:

- 1) Surveys about sedimentologic, stratigraphical and morphological features of the Serra d'Ivrea moraine.
 - 2) Investigation of the relations between glacial activity and bedrock features responsible for the modelling of the Colli d'Ivrea subglacial landforms.
 - 3) Climatic significance of the Lateglacial-Holocene sequences of the Terre Ballerine and Tomalino peaty records in the Colli d'Ivrea sector.
 - 4) Stratigraphy of the Late Pleistocene sequence of the Andrate glaciolacustrine plain.
 - 5) Reconstruction of the T. Chiussella fluvial deviations related to the IMA right lateral sector edification.
 - 6) Geological study of the gold placers and the ancient mines distributed at the IMA outer edge, including the Bessa Roman auriferodinae.
 - 7) Survey of the IMA erratic blocks, according to the Piedmont regional law about the protection of erratics.
 - 8) Research on the Holocene climatic changes derived from the stratigraphy of the Belvedere morainic complex.
- Research methods will consist of geological survey, photointerpretation and borehole execution, supported by radiocarbon dating, pedological, petrographic and palinological analyses and SEM-EDS gold microanalyses. The IMA geomorphologic exemplarity makes it excellent for scientific education, mainly geologic, geomorphologic and palaeoclimatic. In spite of its remarkable human settlement (93 communes), the IMA preserves wide expanse of country and woody land. The soil protection and the agricultural and natural landscape preservation have to be supported by the diffusion of a scientific knowledge of the territory. Actually a 2% of this valuable land is under the protection of two parks: the Bessa and Barage Regional Park at the eastern edge of the IMA and the Candia Lake Provincial Park into its internal depression. Also the suggestion of further parks and geosites must be documented and well-founded. So an important aim of the project is the popularization of the results by a coordinate output of brochures, posters and geologic itineraries books, as well as lectures, workshop and short courses for teachers and naturalist guides.

F2-18 Poster Rolfo, Franco

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THE MONVISO MASSIF AND THE COTTIAN ALPS AS SYMBOLS OF THE ALPINE CHAIN IN THE FRAMEWORK OF THE "PROGEO-PIEMONTE" PROJECT (GEOTHEMATIC AREA 1)

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Key terms: Monviso Massif; Cottian Alps; Piemonte; geological heritage; geotourism

The multidisciplinary research project "PROGEOPIemonte" (PROactive management of GEOlogical heritage in the PIEMONTE region) aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region. Within the project, 9 strategic geothematic areas will be investigated to represent the geodiversity of Piemonte, each one of them being characterized by high potential for scientific studies, enhancement of public understanding of science, recreation activities and for economic support to local communities (see Giardino & the ProGeo team, 2011, this abstracts volume).

In the framework of the "PROGEOPIemonte", the Monviso Massif (MM) geothematic area may well be considered as one of the most outstanding symbols of the Alps in general, and of the Cottian Alps in particular. Its peculiar shape above the Piedmont basin already impressed the ancient Romans more than 20 centuries ago. Moreover, the Monviso bottom at Pian del Re gives birth to the Po river, the historically most important source of life and welfare in northern Italy.

From the geological point of view, the MM is a very well preserved composite ophiolite nappe, which represents the remnants of a former ocean that disappeared during the powerful orogenic processes due to the Africa-Europe collision, which eventually led to the building of the Alps. This will be a great starting point for a comprehensive study involving the MM area itself together with nearby, geologically related areas. More specifically, a number of different geological topics involving different expertises and some additional non-geological disciplines will be usefully considered:

- 1) A WHOLE OCEAN IN A SMALL PEBBLE: some of the best preserved ophiolites in the Alps at the Monviso and the associated Cu-Fe mineralizations (e.g. Castelli & Lombardo, 2007, Ofioliti, 32, 1-14).
- 2) THE GEOLOGICAL ARCHITECTURE OF THE COTTIAN ALPS: lithostratigraphic units of the Dora-Maira Unit and Piemonte domain from Susa to Varaita Valley (e.g. Borghi, Cadoppi et al., 1984, Boll. Mus. Reg. Sci. Nat. Torino).
- 3) PETROGRAPHY TOGETHER WITH PREHISTORY: the first primary source of jade in the Alps at Punta Rasciassa in the MM, and its importance in

terms of Neolithic to Bronze-age polished stone implements (e.g. Compagnoni, Rolfo *et al.*, 2007, *Period. Mineral.*, 76, 79-89).

4) **TYPE LOCALITIES FOR NEW MINERALS:** the Carlotouranite first found and described at Sampyre, Val Varaita (e.g. Compagnoni, Ferraris, Mellini, 1985, *Amer. Mineral.*, 70, 767-772) and other minerals as for instance the Ellembergerite, Bearthite, Mg-staurolite, Mg-dumortierite in lower Val Varaita (e.g. Compagnoni & Rolfo, 2003, *EMU Notes in Mineralogy*, 5, 13-49).

5) **A GEOMORPHOLOGIC AID TO RECONSTRUCTIVE GEORCHEOLOGY:** the area, now buried under a debris flow, where Hannibal is thought to have regrouped his army while crossing the Alps in the upper Po valley, below Col de la Traversette in the Cottian Alps north of MM (e.g. Mahaney *et al.*, 2010, *Geology Today*, 26/6, 209-215).

6) **THE ROCK-DWELLING ORGANISMS ON THE OPHIOLITIC ROCKS:** the biodiversity of lichens, microfungi and cyanobacteria colonizing the ophiolites, which can give additional value for the environmental assessment and valorization of the MM outcrops (e.g. Favero-Longo *et al.*, 2005, *Int. Biodet. Biodegr.*, 56, 17-27.)

F2-19 Poster Violanti, Donata

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CLIMATE VARIABILITY AND PAST ENVIRONMENTAL CHANGES: LESSONS FROM THE MESSINIAN RECORD OF THE TERTIARY PIEDMONT BASIN. PROGEO PIEMONTE PROJECT, GEOTHEMATIC AREA 3

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Key terms: Piedmont; Geological heritage; Messinian; Climate change; Paleoenvironmental change

The multidisciplinary research project "PROGEOPIEMONTE" (PROactive management of GEOlogical heritage in the PIEMONTE region: innovative methods and functional guidelines for promoting geodiversity knowledge and supporting geoconservation activities) aims to achieve a new conceptual and operational discipline in the management of the geological heritage of Piemonte by means of the development of techniques for recognizing and managing its rich geodiversity at the local and regional scale. After a systematic review of inventoried geosites, 9 strategic geothematic areas will be investigated to represent the geodiversity of Piemonte, each characterized by high potential for scientific studies, enhancement of public understanding of science, recreation activities and for economic support to local communities. The recognition of the economic value of geodiversity will lead to the production of regional guidelines for Geoconservation integrated quality management system, suitable for tourism and sustainable development strategies. In this framework, the climate and environmental change subject will be addressed studying the record of the Messinian time slice, a crucial interval for the geological history of the Piemonte region (Tertiary Piedmont Basin, TPB) and of the Mediterranean basin. During the Messinian the Mediterranean sea became the largest saline basin in the Earth history, with dramatic impact on both marine and terrestrial ecosystems. This event, known as the Messinian salinity crisis (MSC) led to the deposition of sedimentary rocks testifying fluctuating salinity from hypersaline (evaporitic rocks) to hyposaline (continental and lacustrine rocks). Nowadays evaporitic rocks (gypsum, anhydrite and halite) form because of severe evaporation of the sea water under arid climate conditions and in relatively shallow water and silled basins. In this sense, ancient evaporitic successions are useful paleoclimatic and paleobathymetric indicators. In the early '70s the discovery of thick sequences of evaporitic rocks buried under the Mediterranean sea bottom resulted in the formulation of the theory of the desiccation of the Mediterranean, according to which, following the closure of the Gibraltar strait, the communication between the Atlantic ocean and the Mediterranean sea was suddenly interrupted. The negative hydrologic balance and the severe evaporation of the sea water led to a dramatic sea level drop (of the order of 1000 m); as a result, the Mediterranean was completely desiccated and thick sequences of shallow water evaporitic rocks were deposited abruptly on deep water muds and marls. Since then, innovative researches, devoted to the reconstruction of the complex MSC events, were carried out by international teams; but the Messinian succession of the TPB, one of the reference succession for the deep desiccated model, has been overlooked. New researches are now in progress, devoted to the integration of physical stratigraphic, biomagnetostratigraphic and cyclostratigraphic data, and focused to the reconstruction of a reliable chronostratigraphic framework for the paleoenvironmental, paleoclimate and paleohydrologic changes occurred during the MSC and the characterization of the large suite of evaporite gypsum facies that crop out in the TPB. The scientific results of this theme will be disseminated to a non specialist public through the preparation of several itineraries, especially in the Langhe region, showing the most significant steps of the MSC in Piedmont, the paleoenvironmental modifications that occurred and their deep impact on ecosystems. The advancing knowledge on the MSC will greatly help to improve people awareness of environmental modification and past climate variability suffered by the Earth through geological time, and to address the crucial question whether it could happen again in the future.

F2-20 Poster Bollati, Irene Maria

10.1474/Epitome.04.0493.Geoitalia2011

THE CLIMBING SITES AS OPPORTUNITY FOR DIVULGATION OF EARTH SCIENCES AMONG MOUNTAIN HAUNTERS: THE CASES OF MONTESTRUTTO (PIEMONTE, ITALY) AND ARNAD (VALLE D'AOSTA, ITALY) IN THE AUSTRALPINE DOMAIN

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Key terms: geotourism; geosites; climbing sites; scientific value

The climbing sites around the Alps are peculiar geomorphological emergencies. Several are the shapes of climbing cliffs that reflect both

lithotypes and structures and a lot are the examples especially in the Italian side of Alps, where the great geodiversity in lithotypes makes possible to find out a climbing site for different geological and geomorphological situations. In this sense, the scientific and additional values of climbing sites are usually high and they can be considered geosites, ideal situation for divulging Earth Sciences among general public. From the academic point of view, these geomorphological emergencies have been investigated by scientists in virtue of the well exposure of lithologies and structures and so the geological and geomorphological information at disposal are abundant. The potential for use (accessibility, services, actual use of the site) is usually high especially because of the possibility of involving the mountain haunTERS, in particular climbers, in being confident with Earth sciences topics. For this reasons an approach to assessment and valorization of these sites is herein proposed. The project involves specialist of divulgation and geotourism, and researchers expert on geology of the investigated area.

The two selected sites are easily accessible and famous among the climbers communities. They are located in a restricted region along the SS26, about 22 Km straddling the border between Piemonte and Valle D'Aosta, with two different lithological and structural situations. Montestrutto is a geomorphological relief modeled in the Eclogitic Micaschist Complex of the Sesia Lanzo Zone and it derives its name because it constitutes an obstruction along the valley (Mons Obstructus). The Arnad "Gruvieria" sector is an evident cliff constituted by the rocks of the Gneiss Minuti Complex and once again the toponym reflects the alveolar morphology of particular layers, distributed regularly in the cliff. In addition, the selected region is characterized by a lot of cultural elements (Montestrutto Castle, Via Francigena) whose settlement was strictly influenced by the presence of the geomorphological elements. The fieldwork activity has the main aim of reconstructing the geological and geomorphological evolution of the cliffs and it has been specifically addressed to individuation and measurement of structures of the rock (foliations, axial planes, mineral lineation, fractures) highlighting which are the minerals marking which structures. The main aim is to correlate them with the typology of climbing that changes in function of the micro and macro morphologies of the wall. Even in the same climbing site the cliff may assume different geographical orientation, exposing differently the structures. The deriving climbing modalities are singular and reflected in the difficulty grade of the route. This is the topic to play on in order to arouse interests in climber in trying to understand why they climb in a such way and which natural elements can help their vertical progression. In addition, all the obtained information can be useful in order to deepen the investigations about the quality of the rock mass of the cliff to determine the hazardous processes (rock falls mainly) that combined with vulnerability (climbers and tourists in general) may be source of risks. Education of mountaineers to risk and individuation of hazards represent another positive implication of these project. Since the selected sites are easily accessible by other kinds of public, a further step may be the finding of additional viewpoint also for non-climbers in order to make the spectacular geomorphosites and related topics usable by a wider audience. In this sense all the information can be inserted in a whole cultural context including ecologic and historical information in order to provide a complete framework to climbers and general public.

F2-21 Poster Spinello, Francesco

10.1474/Epitome.04.0494.Geoitalia2011

GEOLOGIC AND GEOMORPHOLOGIC STUDY OF GRESSONEY HIGH VALLEY (IN VAL D'AOSTA, NORTHERN ITALY) AIMING TO DISCOVER SITES OF SPECIAL SCIENTIFIC INTEREST AND CREATE A PROTECTED AREA.

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Key terms: Geomorphosites; Gressoney High Valley; Local Communities; Protected areas

Geomorphosites could be defined as locations strategically relevant, often unique, in order to track the signs of landscape evolution across time (Marchetti, 1999). These sites may serve either to increase knowledge for future projects and have a didactic, historical, and cultural value. The decay or damage of these sites by human activities, would mean the loss of a historical and scientific patrimony.

These locations are deeply linked to local communities. Therefore they require some kind of protection in order to preserve and making them accessible to visitors, becoming a destination and an incentive for tourism. Gressoney Valley (or Lys Valley) is located along the Lys river, and constitutes a connection between Lys glacier, belonging to Rosa Mountain chain, and Valle d'Aosta. On its edge the valley resemble a glacial and periglacial environment, extending upward in front of the glacier. In this portion, the typical features of a landscape modeled by a retreating glacier can be found: moraines, sheepbacks, erratic boulders, lakes, peat bogs, solifluxion, and glacial erosion morphologies.

On these bare substrates, which have been recently released by ice, the first type of plant associations begin to appear, modifying the scenery. This environment is extremely sensitive to any climatic change and the typical elements of glacial alpine landscape are quite visible but vulnerable to ongoing changes. In order to analyze and classify the relevant landscape elements of this site of interest we plan to perform a historical and bibliographic survey; a geomorphologic and glaciologic studies by ground and aerial survey, in order to create a geomorphologic map 1:10.000 of Late Quaternary deposits (glacial, fluvial, periglacial, flooding, lake, marsh, of peat bogs and of mountainside). In this way, past and current processes which produced the deposits can be explored.

In a second stage, we will select those elements which can be recognized as sites of interest on the basis of five scientific properties: example of geomorphologic evolution, naturalistic rarity, paleogeomorphologic mark, ecological value (Carton *et al.*, 1994). The score relative to their intrinsic value and their vulnerability will be assigned, finally creating an appropriate informative and geographic support.

This final product will be useful to define the areas and elements which need protection, according what is provided by the Italian law 394/91 (Law on protected areas) and by regional norms of Valle d'Aosta.

The forms of protections provided by the law could be applied to single elements (natural monuments) or broader areas (natural parks); the latter could be administered by the local community, larger community (local park of supra-municipal interest) or regional administration (regional park).

F2-22 Poster Burlando, Maurizio

10.1474/Epitome.04.0495.Geoitalia2011

PROMOTING THE PALEONTOLOGICAL HERITAGE IN BEIGUA GEOPARK (LIGURIA - NORTH WEST ITALY)

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Key terms: Paleontological heritage; Oligocene; Geoparks

Inside the territory of the Beigua Geopark two sites are of particular interest from the point of view of fossil remains: the geosites of Stella S. Giustina and Sassello-Maddalena. The well preserved fossil content of these sites highlights the geological history of the territory, referring in particular to the pre-transgressive and transgressive depositional phases of the Tertiary Piedmont Basin (TPB) on the inner margin of the Ligurian Alps chain before the opening of the modern Ligurian Sea. The S. Giustina silicoclastic deposits records the transition from continental (alluvial plane with flood areas, meanders and small lakes) to brackish (Cerithium facies) environments linked to the pre-transgressive phase of the TPB evolution (30 Mya). In the basal levels, the diversified and well preserved fossil flora is mainly composed of Pteridophytes, Gymnosperms and Angiosperms. This association can be compared to tropical basal and pre-montane altitudinal belts in the today Tropical Western Hemisphere.

The Maddalena succession starts with marine sediments, laying on the metapelites of the Voltri Unit, which testifies the early stage of the Oligocene (28 Mya) transgression of the TPB. This event is here characterized by the development of a small reef of corals and red algae (Corallinales). The reefal build-up is suffocated by coarse to medium grained silicoclastic sediments, that exhibit a rich larger foraminifera assemblage (Nummulites and lepidocyclinids). A new coral and red algae reefal settlement overlies these deposits that are, finally, overlain by mollusk-rich sandstones and pelites, linked to a deepening phase of the basin. The abundant, well preserved, in living position, large coral colonies are the most valuable element of this site. During Miocene the area underwent shallow and deep sea phases until the Messinian (7.2-5.3 Mya), when the deposition of evaporites closed the history of the TPB. Meanwhile, at the beginning of the Miocene the modern Ligurian Sea was opening southward, changing therefore the paleogeography of the entire area.

To promote the high value paleontological heritage the Beigua Geopark authority has set up a dedicated visitor centre in Sassello. The Visitor Center is housed in the wonderful frame of Palazzo Gervino, a historical building in Sassello town center. Through modern multimedia equipment, the Visitor Center provides information both on the features of Beigua Geopark and the Geopark international networks (the European Geopark Network and the Global Geopark Network supported by UNESCO). The Visitor Center - thanks to the collaboration with the Culture Councilorship of the Municipality of Savona - offers the possibility to observe a display of rare fossil finds of Anthracotherium, an Artiodactyl mammal widespread in Europe, Asia and probably Africa between the Eocene and Oligocene periods (50-23 million years ago). It was a big-size animal (about 2 m long and 1.5 m high at the shoulder) living in subtropical climate areas, marshy or lagoon habitats.

Finally some rooms introduce the visitors to the discovery of the Oligocene epoch, a fantastic trip back in the time to investigate the geological environments and species that lived in Beigua territory: the tropical forest in Stella Santa Giustina site with a rich exhibition of fossils about terrestrial higher plants and form of leaves logs; the tropical sea in Sassello with fossil collections found in the area of Ponte Prina - Maddalena.

F2-23 Poster Muntoni, Francesco

10.1474/Epitome.04.0496.Geoitalia2011

THE ROUTE OF THE OLD SILVER MINES IN THE SARRABUS (SE SARDINIA)

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Key terms: Mining; Park; Sardinia

Starting in 1869 with the creation of joint-stock company in Genoa Mining Lanusei, region Sarrabus (SE Sardinia) we began a rational exploitation of large mineral deposits of silver, although the prospecting in this region date back to 1600. In 1860, the noted French engineer Leon Gouin, in its report on mining in Sardinia, presented at the World Fair in Paris, wrote that the mine at Mount Narba, then still being explored, it was of considerable interest for its rich silver, especially the native state in the fluorite scattered visible to the naked eye, the only example of its kind in Sardinia.

In 1870 there were only four active grants (Gibbas, Perd'Arba, Peddie Attu, on Cadillonargiu) more than 24 exploration permits for silver galena. In the following twenty years in the territory of Sarrabus there was a real race to silver as the most legendary gold in America and Australia. In fact, the enhancement of research brought to light the full extent of the reservoir known as the "silver-vein, whose total length is about 30 km roughly in EW direction by up to Burcei Muravera. With these assumptions, the Company was formed in 1869 to Lanusei who commissioned the construction management engineer GB That extended across the highly profitable crops Baccu Arrodas, Giuanni Bonu, and Masaloni Tuviolis. In the same year, realizing westward continuation of the current silver-Leon Gouin Tacconis Sarrabus formed the Society for the exploitation of the mine Tacconis, and the Societe Francaise des Mines du Rio Ollastu for the exploitation of mines Nicola Secchi, Serra S'Illixi and S'Arcilloni.

To connect all these mines and therefore all transactions facilitate transport of the ore was carried out by the same company a road along the tortuous path from the town of Rio Ollastu Burcei who came to the mine director S'Arcilloni connecting to SS 125 'height of Mount Cantoniera Acutzu. Another road, the height of the previous incrociante Fasson, instead linking the mine Masaloni and continued eastward, joining the other mines of Monte Narba, and Giuanni Bonu Baccu Arrodas. The great peculiarity of the mines of Sarrabus it was the richness of native silver and a parade of accessory minerals and gangue beautifully crystallized some of whom discovered for the first time in Italy during his cultivation of these mines. Ullmann, Stefanie, Breithaupt, and antimony pirargirite native was first discovered here in Italy. G.B. Traverso gave

some 170 collections of minerals Sarrabus to Italian and foreign museums. For beauty and elegance of these mineral samples were compared to those found in much more famous and ancient mines of Norway, Saxony and Bohemia. If today we can enjoy this heritage identity fortunately not been lost in manufacturing, we owe exclusively to GB Across one of the greatest figures in the field of view 800 Geomining.

F2-24 Poster Pichezzi, Rita Maria

10.1474/Epitome.04.0497.Geoitalia2011

THE UPPER ANIENE VALLEY BETWEEN GEOLOGY, NATURE, HISTORY AND RELIGION

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Key terms: geology; geomorphology; environmental protection

The upper Aniene River valley, located in central-eastern Lazio region, is an area characterized by peculiar geological and geomorphological aspects, and by a rich historical, artistic and cultural heritage.

The Aniene River originates in Fiumata, in Frosinone province, near the border between Lazio and Abruzzo, in the Regional Natural Park of Simbruini Mountains.

It collects the waters of numerous springs that flow into the massive beech forest located on the southeastern side of Tarino Mount (1959 m). The highest of these springs is Riglioso (or Capo Aniene), located at an altitude of 1203 m, with a water flow lower than the Pertuso Caves spring, between Trevi nel Lazio and Filetino.

Shortly after the Trevi Falls, the Aniene collect the Simbrivio River and, once in Agosta, thanks to the Acqua Claudia spring and later, in the territory of Arsoli and Marano Equo with the contribution of Acqua Marcia springs, the river flow increase significantly.

Continuing its run toward the sea, the Aniene forms the powerful Tivoli Falls, 160 meters high, and reaches the Tiber River at Ponte Salario, after covering 99 km, bringing a quantity of water of 35 m³/s.

With its plenty of water the river has been exploited since ancient times to feed the aqueducts that brought water into the city of Rome; the first of these aqueducts was built in the year 312 BC by the censor Appio Claudio Cieco, and was called Appio aqueduct in his honor. Subsequently, in 272 BC, was realized the second aqueduct, called Anius vetus, by the censors Manio Curio Dentato and Fulvio Flacco. In 52 AD the Emperor Claudio exploited the mid-valley area springs, realizing a new aqueduct, called Anius novus.

The interconnection of the hydrological Aniene circuit with the hydrogeological Simbruini system, fed by abundant rains and snow, combined with the karst environment, create the conditions for a foothills springs system from which up-to-date is taken drinkable water used to supply part of Rome urban area, the Colli Albani area and some municipalities of the Sacco Valley.

The Aniene Valley, originally inhabited by Equi population which, allied to Volsci, long defended their independence from the Romans, had considerable importance during the Roman Empire inducing the Emperor Nerone to build his sumptuous Villa and Termae near Subiaco and the Emperor Traiano in the Highlands of Arcinazzo. During the Middle Age were built castles, hermitages and monasteries; of particular interest are the most important settlements of medieval monasticism, the Sacro Speco di San Benedetto and the Monastery of Santa Scolastica in Subiaco, splendid examples of monastic art and architecture and cradle of the Italian engraving.

The Aniene Valley sums many of the geomorphological features of the Italian territory: the austerity of the high mountain areas with large karstic plateau, dolines, swallow holes and caves, the narrow gorges carved by water, the green hills, and an extensive meandering system in a typical alluvial plain.

The rocks that build up the main ridges are composed mainly of limestones in carbonate platform facies ranging from Triassic to Cretaceous age. Limestones and marly-limestones Miocene deposits crops out on the edge of the ridges and forms the relief of the Ruffi Mountains. After the Subiaco town, the Aniene Valley is developed into Miocene silicoclastic deposits.

The area crossed by the river has a traditional agricultural economy, unfortunately now in steep decline, connected with the livestock activities, small industrial with handcraft activities.

The touristic potential of the area is very important, but little or nothing valued. Beyond the Valley can be visited shrines, ancient villages, castles and museums, a sign of spirituality and rural life.

This territory represents an important example of a high interest geo-archaeological area, therefore suitable to be subjected to environmental protection, thereby contributing to the socio-economic development of the valley.

F2-25 Poster Naitza, Stefano

10.1474/Epitome.04.0498.Geoitalia2011

THE ANCIENT SANDSTONE QUARRIES ALONG THE COASTS OF SARDINIA: STUDIES FOR QUALIFICATION AND CULTURAL VALORIZATION

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Key terms: Geosites; Ancient quarries; Sardinia; Cultural valorization

Mediterranean ancient coastal quarries are geosites of multidisciplinary relevance. As a matter of fact, they may be seen as: 1) historical-archaeological sites, showing evidences of past mining techniques; 2) sources of the original stone materials used for ancient building, potentially employable in cultural heritage conservation/restoration; 3) sites of geological/geomorphological interest, often retaining important stratigraphic sections and frequently associated with significant coastal landforms. These sites are also interesting for paleoclimatological and climate change researches as markers of secular changes in sea level. Our studies are focused on the punic-roman coastal sandstone quarries occurring along the Southern and Western coasts of Sardinia. They exploited Quaternary marine and continental (aeolian) deposits. The former (marine conglomerates and carbonate sandstones) are commonly attributed to the marine sea level highstands of the MIS 5 (late Pleistocene), while the aeolianites (sandstones and sands) have been referred to ages varying from middle Pleistocene to Holocene. Carbonate sandstones were an easy-to cut material, well suitable for shaping stone blocks destined to harbours, military and civil works (city walls,

aqueducts), and for civil and religious buildings. In Sardinia, a general inventory and documentation of the ancient coastal quarries is still lacking, as well as projects of qualification of these sites, often characterized by singular and suggestive landscapes. The ongoing research, also funded by the Geo-mineral, Historical and Environmental Park of Sardinia, is aimed to provide systematic, multidisciplinary studies on the sites, and to establish possible guidelines for their qualification, with the possible inclusion in the network of historical mining sites managed by the Park. The study comprises field surveys and mapping of the quarries, including 1) the geological features of the deposits and the geomorphological aspects of the quarry landscapes, and 2) all the features related to past quarrying activities (layout and structure of the quarries, extraction fronts, spoil heaps, working areas, paths of transport of stone blocks; loading and harbouring facilities, etc.). Study of quarries is coupled with mineralogical and petrographical studies of the stones, essential for further reconstructions of their diffusion at a regional scale. Surveys include systematic observations of the state of conservation of the quarries, and the assessment of site degradation deriving from natural and anthropogenic factors. This large set of heterogeneous data will be organized in a database implemented in a GIS. Until now, 11 main localities and many minor sites have been identified, including several well-preserved quarry landscapes. In some cases the sites may be defined as real quarry complexes, formed by multiple quarries, as in the localities of San Giovanni di Sinis, Piscinnu, and Nora. These latter are of great interest for the intents of this research, since they often preserve important records of extraction activities and quarry organization. In the aims of our research, the systematic documentation of the Sardinian coastal quarries in all their aspects will improve the public understanding of their importance as geohistorical sites of great cultural, historical and scientific relevance. This will allow to delineate appropriate guidelines for their conservation and sustainable management. From this point of view, the Geo-mineral, Historical and Environmental Park of Sardinia, established by UNESCO in 1997 and included in the worldwide geoparks network, is the most considerable resource now present in Sardinia. Sardinian ancient coastal quarries have all the features and values for a future inclusion in the Park, possibly forming a specific thematic area, in order to ensure the protection of sites and, at the same time, promote their fruition within a network of tourist and cultural routes.

F2-26 Poster Rizzo, Roberto

10.1474/Epitome.04.0499.Geoitalia2011

MINING, GEOLOGICAL AND MINERALOGICAL HERITAGE OF THE ABANDONED GREAT MONTEVECCHIO MINE (SW SARDINIA, ITALY)

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Key terms: Sardinia; mining heritage; Montevecchio mine

The great Montevecchio mine is located a few miles NW of Arbus and Guspini villages in SW Sardinia.

All mining works are set into the thick Cambro-Ordovician volcanic and sedimentary formations (Arenarie di San Vito and acid to intermediate metavolcanics). These Paleozoic terranes suffered the intrusion effects of the late Paleozoic Arburese granitic pluton that transformed the wall rock in hornfels for over 300 m from the contact. In addition, the cooling collapse of the pluton has produced in the surrounding area an impressive field of fractures with parallel and perpendicular direction to the pluton axis.

These two fracture systems are place of hydrothermal Pb-Zn-Fe sulphide vein deposits with gangue of quartz and calcite. Based on their relation to the granitic body are recognized peripheral and radial or crossing vein deposits. The former are more tickest, better mineralized and always parallel to the contact granite-metamorphic rocks. Those radials sink into the granite for many km but they stops abruptly against the peripheral veins.

The great Montevecchio mine exploited the richer and very large peripheral mineralized bundle of whole area, that is known for approximately 10 km in length and 600 m in depth, with maximum thicknesses for the individual veins from 1.5 to 7-8 m. The useful mineralization include galena, sphalerite and cerussite, with subordinate acanthite, pyrite, chalcopyrite and arsenopyrite, in gangue of quartz, ankerite and siderite, and more rare calcite and baryte. Secondary minerals are cerussite, anglesite, pyromorphite, smithsonite and brochantite. In particular, the emerald green in colour anglesite is the mine's hallmark mineral. The most important rare metals are cadmium, gallium, germanium, indium, which were recovered at the production of zinc in Porto Marghera, while lead, silver and copper were recovered in the Foundry of San Gavino Monreale.

In 143 years of industrial activity the great Montevecchio mine developed in five mining concessions referred to as Genna Sciria, Piccalinna, Montevecchio I, II Montevecchio, Montevecchio III. According to their geographical position respect to the homonymous village, built to the development of the mining life, an eastern and western zone is distinguished, where the mineralized bundle took the names of S. Antonio, Piccalinna, Sanna, Telle and Casargiu derived from the mines that were prepared for the ore deposit exploitation.

The irregularity of the mineralization, the variability of the tenor of the ore and the instability of wall rock characterized the Montevecchio mine for problems of exploitation. In addition to industrial production, mining has been also experimentation and technological research of high level. The wise management and the technical and scientific experience of managers and technicians has allowed the creation of structures, systems and machines that have revolutionized the mining operation by improving productivity and safety of the workplace.

The exploitation systems, the art of arming the gallery, the continue research have made Montevecchio a school and a training ground. It was culture and technology, and exported worldwide mining technology.

The whole Arburese lode system is of worldwide size, one of the most impressive in Europe, certainly the finest example in Sardinia and Italy of its kind (hydrothermal veins related with plutons). Together with the other neighboring Ingurtosu and Gennamari mines Montevecchio boasted the richest concentration of lead and zinc minerals in Sardinia, having produced over 1,700,000 t of lead metal and about 1,200,000 t of zinc metal as well as silver, bismuth, antimony, copper, cadmium and germanium.

SESSIONE F3

I paesaggi del vino

F3-1 Invitato Graziano, Gian Vito

10.1474/Epitome.04.0500.Geoitalia2011

THE GEOLOGIST BETWEEN NATURE AND CULTURE

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Key terms: Knowledge; social, cultural, economic and territorial contexts; landscape expression of geology

Territorial and environmental problems, ever more delicate and dramatic in our country, require, now more than ever, the constant presence of the geologist in all the social, cultural, economic and territorial contexts. It's necessary to act with greater authority, and involve the society, making the public aware of the real status of the land: how the territory can be both a source of risk or a resource. Knowledge is the key tool: the diffusion of scientific heritage, using topics well known and appreciated, more accessible to the public, may represent one of the new goals for the geologist. Only through the sharing of knowledge, it is possible to reach the common aim of territorial safety and a shared well-being. The wine, well appreciated in our culture, take its roots in the landscape and the landscape is an expression of geology: so it could become a "medium" to communicate the earth sciences to the whole society.

F3-2 Invitato Parotto, Maurizio

10.1474/Epitome.04.0501.Geoitalia2011

LAND AND WINE: A GEOLOGICAL LINK

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Key terms: geology; landscape; wine; education

The study of wine's roots in the territory is closely related to the analysis of landscape and the geology of the wine production areas. The knowledge of the land through one of its most popular products, represent a strategic way for the dissemination of geo-environmental sciences and for the invitation to a responsible consumption, based also on a cognitive and formative process.

F3-3 Orale Gregori, Lucilia

10.1474/Epitome.04.0502.Geoitalia2011

"THE LANDSCAPES OF THE WINE": A BALANCE OF THE EXPERIENCE OF COMMUNICATION AROUND THE "GEOLOGY OF THE WINE"

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Key terms: landscape; wine; geomorphology; palaeogeography; communication

The experience of the "Landscapes of wine" workshop started since 2004 is a new and innovative approach with the aim to put together the wine-oenographic expertise, the knowledge of the wines and their geological reasons. Usually the wine world is enclosed in the tasting experience. On the contrary study of "terroirs" and in particular, their geological and geomorphological context is not still well appreciated. There are still two separated worlds: the first is related to the experts (entrepreneurs, sommeliers, oenologists, etc.). The other grouped the researchers of the wine geology, these two worlds do not still communicate despite of they are both important.

The sedimentary sequences, that represent the vineyards lithological substrate, are the result of different morphogenetic processes. The knowledge of these physical processes is fundamental to comprehend the peculiar characteristics of a wine. After several international conference on this issue now there is an increasing interest around this new approach.

The types of deposits, the mineralogical and petrographic characteristics and the relationships with other disciplines (art, myth, philosophy, geology, etc.) can offer new points of view. Also the review of the "Goethe's Travel in Italy" is another cultural implication. This approach aimed to compare, around a glass of wine, all the interested people. The geology of wine so it is not a "gambling culture" but is a opportunity that opens new perspectives for research and employment.

F3-4 Orale Luger, Francesca Romana

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WINE AND TERRITORY: A GEO-ENVIRONMENTAL PATH

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Key terms: Landscape; Wine; Geomorphology; Environment; Culture

The social-economical scenario of an area is strictly linked to the geological one: even at different scales, the endogenous and exogenous processes, and the rocks, as elements of the landscape, condition the evolution of environment and form the base of spatial-temporal development of a region.

By integrating different information about the geo-morphological arrangement and the land use of a region, it is possible to study the territory and the link between landscapes and wine production areas. Wine production is in fact one of the most important activities in the Italian economy and culture and, at the same time, is an expression of the landscape: in this way it could be a "medium" to communicate the landscape, its origin, its history.

In this work a new approach is purposed, aiming to integrate the complex

aspects of the landscapes, and to share the scientific heritage with the whole society. The goal is to provide a complete knowledge of an area (useful for environmental planning as well as for informative/educational programs and, last but not least, for new purposes of eco-touristic development) highlighting the richness of different landscapes. Wines, as well as other cultural expressions, are strictly linked to the territory: the popularization of the geo-environmental heritage walks on the same paths of tourism. A special attention should be devoted to an original link (already performed in some other countries) between landscapes, eno-tourism and sports: a new field for new actions, in order to promote a sustainable development in Italy, as well as a more sensible culture of responsible wine consumption. The modern technology offers new powerful tools: the GIS are able to synthesize, manage and represent a large amount of data; thanks to GIS it's almost easy to reach an evaluation of the state of the studied landscapes, referring to the dual risk/resource which characterizes our country. A further interesting opportunity is to discover, through this process, agricultural wine areas of special geological, environmental and cultural value, which in some cases can be considered geosites.

F3-5 Orale Bollati, Andrea

10.1474/Epitome.04.0504.Geoitalia2011

VITICULTURE ZONATION AND GEOGRAPHICAL TRACEABILITY OF SUPERIOR QUALITY WINES THROUGH GEOCHEMICAL ANALYSIS: FIRST RESULTS FROM A CASE STUDY IN THE CESANESE WINE PRODUCTION ZONE (LATIUM, CENTRAL ITALY)

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Key terms: Viticulture zonation; Cesanese wine; geographical traceability; isotopic analysis

In this paper we present the first results of an on-going methodological research aiming at the definition of the capability of a territory to wine production, as well as the geographical traceability of typical wines (monocultivar). The main focus is to define an integrated geological-chemical methodology for the characterization of the product, the definition of links between wine composition (and its organoleptic characteristics) and the nature of its substratum, with the aim of valorization of autochthonous vines and the correspondent wines on the grounds of their original environment.

The study area includes two DOC and one DOCG areas, located in the Cesanese wine production zone, in the Frosinone and Rome provinces. The research is being conducted considering the geological, morphological, soil and climate characteristics in wine production aptitude. As for wine zonation, a GIS was used for the implementation of a data base and the realization of thematic layers (lithology, altitude, slope, exposition). First results show that in the study area outcrop mostly volcanic formations (33%) and sandstones (28%); vineyards are more widespread on soils deriving from volcanites and in a lesser percentage on sandy and alluvial soils.

The study vine sites are mostly located on SE, S and SW slopes, secondarily on W and E slopes, pending between 0 and 10%; additionally 92% of vineyard stands at altitudes ranging between 200 and 400 m a.s.l. Temperature, precipitation and humidity data of the study area have been compared to the references for vine-growing and show that the area is climatically suitable for wine production; moreover bio-climate indices are comprised in the typical range for the production of superior quality wine or high alcoholic grade.

In order to verify the geographical traceability of wines, the earth-alkaline metal strontium (Sr) has been considered, and specifically the ⁸⁷Sr/⁸⁶Sr isotopic ratio, whose value depends on the Rb and Sr content of the substratum rock and on the time elapsed since its formation.

For the isotopic analysis we have selected red wines coming from diverse substratum, and from different wine-making farms, chosen on the grounds of wine quality, the reliability of wine provenance from well defined areas, on the mono variety of the cultivar and the wine making process. For each farm, one or more small area with "Cesanese comune" or "Cesanese di Affile" vines variety, on a homogeneous substratum, were selected; the latter is the most widespread in the study area and is one of the few varieties in Latium able to produce superior quality wines. For each vineyard we sampled the rock substratum, soil, grapes, must (with or without yeast) and wine.

First results show that the ⁸⁷Sr/⁸⁶Sr isotopic ratio of the examined must and wines (also of different years) of each farm does not change and that a good correspondence exists between values of different wines and musts when vineyard are placed on soils originated from the same volcanic substratum. On the contrary, there is no correspondence between these values and those of wines and musts coming from farms whose vineyards are placed on substratum of different origin and age. In order to confirm these results samples of musts of 2010 and wine of 2009 are being analyzed, to confirm the repeatability of results in different climate and atmospheric conditions.

F3-6 Orale Aldighieri, Barbara

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WINEGIS: TERROIR OF ITALIAN WINES AND GEOGRAPHICAL INFORMATION SYSTEMS

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Key terms: TERROIR; WINE; LANDSCAPE; WEBGIS; CARTOGRAPHY

Wines and landscapes are deeply linked by a lot of geological elements (soils, rocks, morphological arrangement, climate and so on). This concept is well known, but not so shared as due. All the information about the complex themes about wine are usually summarized in the

French term Terroir, but in these last years new questions need new answers. An original model of web site about wine, GIS based, is able to show to the web surfers all the information about wine, landscapes and territory, following both of scientific and cultural way. One of the most important roles of Internet consists in providing an important source of information and knowledge to a potentially enormous public. Trade journals within the sector were indeed the first to offer blogs and forums on their sites. The vastness and dispersal of the information represents an obstacle to the accessing of this knowledge in particular in Italy. WineGIS, a modern geographic information system based on the internet, aims to make easier the access to information about wine and territory. Through the use of technologically advanced solutions, WineGIS offers, following an integrated approach, scientific and technical instruments able to represent in a unified way, a complex and rich view of Italian wine production areas.

GIS technologies, wide ranges of information, new ways of dialogues: these goals will become the tools for a modern development planning of the wine production areas.

WineGIS can contribute greatly to a richer understanding of the culture of Italian wines and aid to the appreciation of this important "fruit of our earth".

F3-7 Orale Amadio, Vittorio

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THE PRESERVATION OF THE VINEYARD LANDSCAPE AND THE GEO-ENVIRONMENTAL ANALYSIS

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Key terms: Landscape; Ecosystem; Maps; Ecology; gis

The Italian landscape is characterized by a lot of old rural landscapes and abandoned cultivation, particularly in some peri-urban natural areas in the south of Italy. The restoration of a degraded land, in some cases, can be made up performing the re-establishment of those areas traditionally devoted to vineyard cultivation. An integrated study of the territory by the GIS and the related thematic maps, such as Carta della Natura, may allow the identification of the interested areas and the planning for an effective environmental protection. The preservation of the rural historic landscape is a goal of primary importance for the nature and the culture of our country

F3-8 Orale Aviani, Umberto

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CHARACTERIZATION OF PROSECCO VINEYARDS (VENETO REGION, ITALY) USING SR-ISOTOPE DATA FOR THE GEOGRAPHICAL ORIGIN ASSIGNMENT

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Key terms: food safety; stable isotopes; plant-soil interaction

The realization of models of traceability that allow to go back to the origin of a product, protecting food safety, is an issue that has been affecting the wine production sector and the scientific community for a long time. This work aims at defining a reliable and repeatable operating protocol at a regional scale, that allows to confirm the geographic and varietal origin of grape and wine Prosecco CDO (QWPSR) in order to preserve their uniqueness and quality that underlie success recognized by all.

Analysis of stable isotope abundance ratios proved to be quite successful in determining the geographical origin of agricultural products; in particular, the Sr isotopic systematics is increasing applications to verify the authenticity of wines, since every isotopic fractionation occurring during the biological transfer from soil to plant and grapes is in-run corrected during mass-spectrometry data acquisition. The ⁸⁷Sr/⁸⁶Sr ratio in grapes hence reflects the isotopic signature of soils from the different geological environment of growth and can also discriminate wines from different origins, provided that no changes occur during vinification.

In the viticultural areas of Controlled Denomination of Origin, of the provinces of Treviso, Padova, Vicenza, Belluno and Venezia, some zones characterized by homogeneous pedo-climatic environment have been identified: clayey soils and climatic variables comparable with the exception of rainfalls that show a positive gradient of 150 mm, by moving from south to north of the entire area selected.

In each of these areas more vineyards planted with Prosecco were selected, differing by type of conduction and pruning systems adopted, as Guyot, Sylvoz, spur pruned cordon, Geneva Double Curtain (GDC) and pergola, in order to check possible interference of these factors on the dynamics of absorption in addition to the role of soil composition.

To this aim, from each site a representative number of soil samples was collected, 3 depths for each site, interesting a total thickness of 60cm, corresponding to the soil layer more explored by roots; moreover, at the ripening, samples of grape consisting of a significant number of bunches have been taken.

The production activity, recorded over a significant number of vines, and in each vineyard, was assessed through the quantity of grapes per plant, number of bunches per vine and the average bunch weight; on obtained musts, conventional qualitative parameters such as, soluble solids content (° Brix), total titratable acidity and real acidity (pH) were evaluated. Successively, on wines obtained from every vineyard under investigation, the main aromatic precursors will be analyzed.

Samples of vineyard soil were dried in oven and the Sr isotope-ratio was measured on the exchangeable fraction of Sr, the carbonate fraction and by the total soil digestion. The Sr isotopic composition was also measured on crushed and homogenized grape skins, seeds and grape stalks and on carefully extracted grape juice by both nitric acid and hydrogen peroxide and oxidative calcination procedures, to highlight possible experimental bias. Sr was separated from the chemical matrix by ion-exchange and the isotopic composition determined by TIMS. The results indicate Sr-isotopic equilibrium between grape stalk, seeds and juice, supporting the hypothesis that the isotopic signature is not altered during biochemical reactions in the plant. A slightly lower isotopic composition is observed for grape skin, possibly reflecting the effects of an aerosol component.

Grape juices from the different provinces are readily distinguishable on the basis of the different Sr isotopic composition, ranging in the large span between 0.70706 and 0.71215 depending on the lithologic composition of the area. The major correspondence with the juice isotopic signature has been observed for the exchangeable fraction of Sr in soils.

F3-9 Orale Braschi, Eleonora

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TACING THE GEOGRAPHICAL ORIGIN OF WINES USING SR-ISOTOPE AS CRUCIAL GEOCHEMICAL TRACER

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Key terms: Microvinification; Sr-isotope; Terroir; Substratum

The Department of Earth Sciences of the University of Firenze has been involved in the research project ISSUOVINO with the aim to define a geochemical marker suitable to associate the wine to its grape harvest terroir. Following this research guideline, we have determined Sr isotope ratios ($87\text{Sr}/86\text{Sr}$) in a number of microvinifications on single grapevines belonging to the "Azienda Barone Ricasoli S.p.A." at Brolio, and, in order to make a comparison, in other high-quality wines of the Italian territory, namely: other wines of the Chianti Classico Consortium (Tuscany) along with wines of the Cesanese (Latium), Aglianico del Sannio (Campania), and Aglianico del Vulture (Basilicata) Consortia.

The $87\text{Sr}/86\text{Sr}$ measurements on wines have been normalised to the $87\text{Sr}/86\text{Sr}$ of sea-water, resulting in the definition of a parameter called Indice di Provenienza Controllata (IPC). Wines of each farm have distinct IPC values that can be related to the lithologies of the geological substratum underneath each vineyard. The vineyards of the Chianti Classico Consortium are located on geological substrata belonging to both Pliocene marine sediments and Tertiary Carbonate Flysch ($-1.6 < \text{IPC} < -0.2$), and Oligo-Miocene sandstones and pelites of the Tuscan Nappe ($\text{IPC} > 2.0$). The vineyards of the Cesanese, Aglianico del Sannio, and Aglianico del Vulture Consortia are mainly located on Pleistocene volcanic deposits with IPC values from $+0.5$ to -2.0 .

In the context of the microvinifications of the Azienda Barone Ricasoli, we have collected grapes in 11 sampling points, for a total of 62 analyses, during the 2008 and 2009 grape harvest. The results demonstrate an excellent reproducibility of the IPC values of each sampling point in the two harvesting years. This suggests that the Sr uptake process from the grapevine roots to its final product, the wine, is time independent. Another result obtained during the pilot study is related to the small-scale, albeit detectable, variability of IPC values observed among the different sampling points. This variability is due to both the heterogeneity of the geological substratum of the vineyard, and the isotopic change of the leachable Sr fraction, hence bio-available, from the soil. These small-scale IPC value differences can allow to further select the cultivation suitability of single cru apt to yield wines of the best quality.

In conclusion, the results obtained during the research project ISSUOVINO led to the definition of the extremely promising isotope-geochemical tracer called Indice di Provenienza Controllata. Wines inherit their inorganic element inventory from the geological substratum on which each vineyard is embedded, hence the IPC value can safely represent a meaningful parameter in the analysis procedure to guarantee the geographic origin and the production terroir of wines. It is noteworthy that the certificate of guarantee of geographic origin of products of the agricultural food chain has been recently established in the law issued on January 2011 by the Agriculture Committee of the Italian Camera dei Deputati.

F3-10 Orale Castorina, Francesca

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SR ISOTOPES AND ITALIAN WINES : AN ATTEMPT TO CHARACTERIZE TRACEABILITY FOR THE WINE ORIGIN AND MARKETING

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Key terms: Italian wines; Sr isotopes; traceability; origin

The assignment of geographical origin of highly valuable products such as wine, is of considerable importance within the European Union.

Conventional chemical methods of analysis are not always able to evaluate unambiguously the regional provenance of wine. Therefore, stable isotope ratio of bioelements such as C, N, O, S and isotope ratios of heavy elements (Pb and Sr) have been also applied to provide additional information of wine regional origin. The application of Sr isotopes to the characterization of wine dates as back as the '90s (Horns et al., 1993). In these two decades, however, no clear-cut evidence has been achieved on the thoroughly usefulness of Sr isotopes for wine characterization. In fact, isotopic ambiguity has been found for wines from certain areas throughout the world (e.g. Vorster et al., 2010). The first data of Sr-isotope ratios of Italian wines were carried out by Wolff-Bönisch et al. (1998), who reported analyses of wines from the Vesuvius and Etna volcanic districts, finding obvious differences. Recently, Mercurio et al. (2011) have determined the isotopic composition of wines from the Phlegrean Fields area, and Castorina and Masi (2011) have carried out a study of wines from Romagna.

In this work, we present the Sr isotopic composition of several Italian wines aimed at evaluating the potential of this geochemical tracer of provenance. Although a larger database is needed, nevertheless, the results obtained with this study confirm that Sr isotopes can be used as a valuable tool for constraining the geographical origin of wine, at least combined with the application of other isotopic systematics and/or multi-element analysis.

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F3-11 Orale Di Loreto, Eugenio

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WINE AND FOOD TOUR THROUGH THE UNESCO SITES FROM CERVETERI (RM) TO TARQUINIA (VT): A PATH FOR FEELING THE TERRITORY

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Key terms: UNESCO; heritage; geology; archaeology; wine and food

In 2004, the UNESCO has recognized the Etruscan necropolis of Cerveteri and Tarquinia as World Heritage sites. In order to promote and enhance these archaeological sites, a special program for cultural-tourist paths should be developed, aiming to improve both of the cultural and the natural evidences: archaeological monuments, traditional local production of food and wines and, last but not least, the natural features, including the highly specific ones from a geological point of view (geosites). The proposed route offers representative aspects of this area, between the hills stretching inwards from the northern coast of Lazio, between the towns of Cerveteri and Tarquinia. The landscape is differently shaped by the presence of different geological formations: volcanic domes and lava domes of Ceriti reliefs; ignimbrites and pyroclastic flows "Tufo Rosso a scorie nere," referring to the Sabatini Volcanic District and (in part) to the Vicano one; sedimentary deposits as the Tolfa Flysch and Plio-Pleistocene Clays; the so called "Macco" (yellow sandy limestone). The presence of the different rocks characterizes the morphology of the district: lava domes are observed, related to the Cerite acid volcanism, and the gorge landscape, on the main rivers. Thermal and mineral springs with gaseous manifestations testify the volcanic activity in the area. The tour presents further naturalistic features: the "Natural Reserve of Caldara di Manziara", the "Monterano Nature Reserve" and "Suburban Park Marturanum". Well known and famous in all the world for their archaeological value are the Etruscan necropolis of Cerveteri and Tarquinia and Barbarano Romano (VT). Soil fertility also allows a significant agricultural production and livestock farming: these factors give rise to a large and tasty assortment of food and wines (DOC wines of Cerveteri and Tarquinia). The food and wine stops in the presented route, allow to enjoy the local cuisine specialties (Tozzetti Attozzata, Acqua Cotta), as well as indicate the festivals and events of the land.

F3-12 Orale Farabollini, Piero

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THE GIS TECHNOLOGY APPLIED TO THE ANALYSIS OF THE "TERROIR"

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Key terms: GIS; terroir; geomorphology

The term "terroir" reveals more than one meaning. From a geological point of view, it involves many of the landscape's morphological components such as bedrock, soil composition, slope shape, steepness, exposure, weather conditions. An integrated study that would enable the analysis of these factors and their synthesis in a series of meaningful information, is possible thanks to GIS, already successfully used in environmental studies aimed at the exploitation of the territory. The different informative layers for the various components that enable a complete reading of the territory, are integrated into the GIS. These instruments, so flexible and easy to update, are useful in suggesting new strategies and logical processes aimed at solve the environmental contrasts, and in supplying new and complete answers to the various needs of knowledge. In this case, the study of the most important Italian wine's "terroir", can be performed analyzing the territory of production, using the GIS technology: this approach is interesting also in terms of popularization, considering the link between nature and culture symbolized by the wine in the Italian culture.

F3-13 Orale Giannella, Gianluigi

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GEOLOGISTS AND SOMMELIERS: A NEW WAY TO DISCOVER AND COMMUNICATE THE TERRITORY

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Key terms: geologist; sommelier; wine; landforms

In the last years the fields of science and communication became closer, revealing many interesting shared themes, very useful in order to reach and divulge a complete knowledge of a land. The economic and social components that activate the mechanisms of marketing, in the field of food and wine, are investing new energies in this direction, focusing the attention on new image of wine. In this context, however, the territorial contextualization appears not enough exhaustive, referring to the link between the environment in the places of production and the characteristics of each wine: we need something more than the geographical origin or the simple DOC.

The wines are a significant sign of the landscape and the role of the "geologist sommelier" can offer new ways to learn about the wines, studying the natural arrangement of the territory of origin, and the history of production.

The organoleptic analysis may be related to the landscape elements in an integrated approach. In the proposed suggestion, some Italian wines are

analyzed linking their tastes with the landscape settings of the places where the wines are produced.

F3-14 Orale Testa, Bruno

10.1474/Epitome.04.0513.Geoitalia2011

ITALIAN REGIONS: LANDSCAPES AND GREAT WINES. SUGGESTIONS FOR A SUSTAINABLE TOURISM

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Key terms: Wines; landscapes; geology; tourism

The landscapes of Italy are well-known and appreciated around the world: the geological arrangement in our land can be "read" through the landforms.

In the Italian territory, full of different land settings, the geologic and geomorphologic system influences the land use, each region shows its own special association of landforms that corresponds to a characteristic cultural arrangement. The vineyards cultivation and the wine production are very important in many cultures, and play a determinant role in local as well as in global economic development. Particularly, in the Italian culture the wine production represents an activity full of significance; the DOC areas, although identified at the administrative level of municipality, testify the vocation of the corresponding territory. By integrating different information about the environmental components, analyzing the geo-morphological, lithological and biological/vegetational data, we tried to investigate the distribution of the most renowned wine production areas in the different landscape settings. Following this approach it is possible to perform new ways in the local development, combining the social/economical requirements with the environmental planning policies, in terms of sustainable tourism. The Italian wines tell us about the natural and cultural history of their own places of origin, accompanying the passengers in a path of knowledge.

SESSIONE F4

Uomini e ragioni: i 150 anni della geologia dell'Italia unitaria

F4-1 Invitato Laureti, Lamberto

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BEGINNING AND DEVELOPMENT OF THE GEOLOGICAL MAPS OF ITALY BEFORE ITS NATIONAL UNITY

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Key terms: history of geology; italian geology; geological maps

The aim of this paper is to show a review of the geological representations of the Italian territory issued before its political unity. Starting from the half of the XVIII century, the development of the geodetic studies allowed the surveying of topographic maps suitable to include thematic items about the lithological characters of the terrain, the location of ore bodies and fossiliferous sites with other aspects referring to the Earth Sciences. By this regard the paper considers the maps produced both by Italian and foreigner researchers.

As starting point of an evolution developed across a century, a significant event can be represented by the project of a work on the physical aspects of Tuscany (1754) by the Florentine Giovanni Targioni Tozzetti, consisting in a "carta oreografica" with the main tectonic lines, and a "carta icnografica" showing the various lithological formations, each one identified by a specific colour. However technical obstacles and other difficulties compromised the project's development.

One must not forget that the geo-political subdivision of the Italian territory, kept till over the half of the XIX century, if didn't encourage a systematic and wide geological survey, nevertheless didn't prevent detailed observations concerning particularly regions characterized by very impressive natural features (as the volcanic areas of Phlegrean Fields, Vesuvius and Etna). In this regard many observations and drawings were made mainly after the violent volcanic eruption of the Monte Nuovo (1539) near Pozzuoli, or after the Vesuvius one (1631). In the same times among the numerous ones, we can mention the Etna representation by Giuseppe Recupero (1779), with the drawing of the lava flows. Another significant map was drawn by Eliseo della Concezione, after the calamitous earthquake that struck the Calabria region in 1783.

Among the naturalistic representations made in the second half of the XVIII century, a particular attention must be given to the mineralogical maps, generally made on a topographical or geographical basis, by the insertion, nearby the mine sites, of letters or symbols relative to chemical elements (copper, silver, lead, etc.). Typical models are the maps drawn by: Nicolis de Robilant for the Sardinia Kingdom (1784-85); Ermenegildo Pini and Domenico Vandelli for the Lombardy; P. M. Cermelli (1782) and Giuseppe Morozzo (1791) for the Latium.

But only in the first quarter of the XIX century the geological mapping of Italy shows some very interesting realizations as the splendidly coloured Carta fisica del suolo di Roma, drawn by G. B. Brocchi (1820). Also Scipione Breislak (1798-1801), drew other maps relative to the volcanic areas of the Campania region, with yet simple geological colours, while later the botanist Michele Tenore will draw a real geological coloured map of the same region (1827).

Besides the Italian contribution, a very important hand coloured geological map series was realized by foreigner scientists: South Tyrol (1822) and Lombard lakes (1829) by L. von Buch, the lake of Como by H. T. de La Beche (1830), the surroundings of Rome by F. Ch. L. Sickler (1816-21) and G. H. Westphal (1824-28), the Sicily by Ch. Daubeny (1825).

As recently referred by Hugh Torrens (2006) it is necessary to recall a first attempt to draw a geological map of the entire Italian territory by G. Watt in 1804. A real map of the Italian territory was realized later (1844) by H. de Collegno thanks to the numerous local and regional maps meanwhile issued by the same Collegno (Piedmont and Lombardy), Sismonda (Savoy and Piedmont), Da Rio (Euganei Hills), Pasini (Lombard-Venetian

Kingdom), Hoffmann (Sicily), Giuli (Tuscany), Abich (Neapolis Kingdom), Philippi (Calabria), Sartorius (Etna), Gemmellaro (Sicily) and many others.

F4-2 Invitato Vaccari, Ezio

10.1474/Epitome.04.0515.Geoitalia2011

GEOLOGY, CARTOGRAPHY AND KNOWLEDGE OF THE TERRITORY IN THE TRAVELS OF ALBERTO FERRERO DELLA MARMORA (1789-1863)

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Key terms: history of geology; cartography; 19th century; Sardinia

The Piedmontise count Alberto Ferrero Della Marmora, also known as La Marmora (1789-1863), was a military officer and mining inspector who developed a specific expertise on the geological, mineralogical and paleontological features of Sardinia. Between 1819 and 1855 La Marmora spent about 13 years in Sardinia, where he undertook several scientific travels, as shown by his main work, "Voyage en Sardaigne" (1826), later enlarged in a second edition in three volumes: physical and human geography (1839), archaeology (1840), geology and paleontology (1857), the atlas with a geological map.

Indispensable sources for understanding this fieldwork are also the publication "Itinéraire de l'île de la Sardaigne" (1860; Italian edition, 1868), as well as the unpublished notebooks and papers conserved in the Archives Alberti La Marmora of the Centro Studi Generazioni e Luoghi di Biella.

La Marmora also worked for some years on the administration of the Sardinian territory, when he was "Commissario Reale Plenipotenziario" and later, between 1849 and 1851, General Commander of Sardinia for the Savoy Monarchy. His work in the field of the Earth Sciences, both in Sardinia and in North-Western Italy, greatly benefited from the use of travel as an "epistemological tool", allowing to describe and analyze a combination of cultural, social, geographical, anthropological, economical, technical and scientific elements. The purpose of this paper is to reconstruct and evaluate the extent of the impressive scientific contribution of La Marmora, still little known within the context of the Italian geology before and after the unification of Italy, using published and unpublished sources. This work is part of a potential research project, which is currently discussed by Oxford University, Università dell'Insubria, Fondazione Sella and Centro Generazioni e Luoghi - Archivi Alberti La Marmora. It is based on a comparative study of the role of La Marmora and Quintino Sella (1827-1884) in the knowledge of the territory of the united Italy. They put particular attention to the survey for mineral and agricultural resources improving the geological mapping as well as the state-controlled construction and management of infrastructures.

F4-3 Invitato Vai, Gian Battista

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GEOLOGISTS' "OUR ITALY"

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Key terms: pioneers; patriots; geological community; lights and shadows; past and present

Luigi Ferdinando Marsili, the most European and cosmopolitan Italian scientist of the late 17th to early 18th century, making reference to his relations with the Duke of Modena, the Venetian Republic, and the Grand Duke of Tuscany during 1681, in his Autobiografia writes "They promised to give always signs of friendship and esteem to His Highness for his well founded desire, the accomplishment of which would result also profitable to the constitution of Italy". Marsili indeed cared about the concepts of a Bolognese "fatherland", an Italian "nation" whose correlative political unitarian "state" was to be pursued, and a European "theater" in which he was an actor of a sharp conflict between Christianity and the Muslim Empire. The dream of a united nation, rooted in the awareness that modern science and the new arts were born in Italy during the Renaissance, was part of Marsili's legacy.

All Italian naturalist geologists of the late 18th and 19th centuries have profited of Marsili's legacy so much that one can safely state that they unanimously supported the national unity without distinction of party, religion, ideology, institutional link and country of origin. Following Marsili, this case history was punctuated by scientists such as Arduino, Spallanzani, Brocchi, Tondi, Pilla, Della Marmora, Scarabelli, Sella, Sismonda, Omboni, Gastaldi, Scacchi, Palmieri, Pareto, Gemmellaro, Capellini, Stoppani, Taramelli, to quote a little sampling. They contributed greatly to the origin of the new Italian state, obtaining back a quite inadequate recognition. A country like Italy having so many priority needs of protection from geological risks did not exploit the skills of its geologists who succeeded in completing Italy's Geological Map at 1:100,000 only a century after the national unification. This fact shows how the unity was needed, and how much the process was punctuated by shadows and gaps. A celebration is useful if, beyond rhetoric, the past is frankly re-evaluated to understand the present and prepare a better future. In this sense we may look for the reasons why that category of geologists favored so much the Italian unity. Was it depending on the historical evolution of geology or was it linked more or less to the geopolitical setting of Italy at that time?

F4-4 Invitato D'Andrea, Myriam

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THE COLLECTION OF RELIEF-MAPS BY THE GEOLOGICAL SURVEY OF ITALY

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Key terms: cultural heritage; relief maps; Geological Survey of Italy; ISPRA Geological and historic Collections; ICCD "OA" standards

The Italian National Institute for Environmental Protection and Research

(ISPR) preserves the Paleontological and lithomineralogical Collections, inherited from the Geological Survey of Italy. These conspicuous historic-scientific Collections strictly belong to the cultural heritage of Italy and they have indeed a high cultural and economic value. The Collections include more than 100,000 paleontological finds and more than 50,000 mineral and rock samples, as well as relief-maps, busts, portraits and scientific equipment. This unique heritage testifies the geological survey and mapping of the entire territory, since the beginning of the Geological Map of Italy in the last fourth of the XIXth century, up to the 70s of the XXth century.

Among the others, in support of the Geological Map of Italy, the Collection of historic geological relief-maps was commissioned by the Royal Geological Survey, to specialized artists which used various techniques and materials, such as wood, galvanic alloy, gypsum and oil painting. The 17 existing works, realized from 1877 to 1920, are now described in a Catalogue for the first time, directly compared with the contemporary geological maps drawn on the same area. Therefore, one century after their production, it is important to study the connections between politics, economy, science, and art, in the period ranging from the last fourth of the XIXth century (when Italy became a united nation) and the first twenty years of the XXth century (till the World War I).

In fact, the relief-maps witness a new way to represent the geological data considering the whole Italian territory after its unification. It is not possible to approach the history of the geological mapping in Italy without taking account of the great contribution given by these handcrafts, which illustrate many areas of strategic importance for mining industry (Isola d'Elba, Massa Marittima, Alpi Apuane, Montecatini-Val di Cecina), geological risk (Vulcano Laziale, Provincia di Napoli, Campi Flegrei, Monte Vesuvio, Isola d'Ischia, Monte Etna) or for geomorphology in itself (Monte Bianco, Argentario, Monte Soratte).

Who asks himself why such models - so detailed and realistic, but also heavy and cumbersome and expensive - were realized, should think about the use of the relief-maps by architects and planners as well as geologists. There was (and there is still today) the need to immediately identify and understand the strategic sites, in all their multiple and complex aspects, that goes well beyond the mere geological setting. A geological relief, more than a multi-layer cartography, could be suitable to illustrate and to discuss not only geological problems, but also land planning with local and international stakeholders and sponsors.

All the 17 relief-maps have been studied and classified in a Pre-catalogue format as "Objects of Art", following the standards of the Central Institute for Cataloguing and Documentation (ICCD). First of all, this pioneer work aimed at reconstructing the historic, scientific, and technical outline of these real works of art. Furthermore, it has given also the opportunity to test the ICCD standards on this topic, offering in the meantime a service to other institutions, which preserve similar heritage and are interested to improve their cataloguing activity. In fact, the studies led to investigate analogous collections preserved by other institutions (Istituto Geografico Militare, Firenze; Museo Regionale di Scienze Naturali, Torino; Museo Mineralogico e Geologico Estense "Gemma", University of Modena; Museo "G. Capellini", University of Bologna; Museo Storico dell'Architettura Militare - within the Museo dell'Arma del Genio, Roma). Starting from the Collection of historic geological relief-maps of ISPR, the complete census of these handcrafts in Italy will require joint research programs with other institutions dealing with collections and single items localized not only in Italy but also abroad.

F4-5 Orale Procopio, Fabio

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IMPORTANCE OF THE POST-UNITARY GEOLOGIC CARTOGRAPHY IN CALABRIA (1861-1889)

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Key terms: SGI congress; large scale geological map; Catanzaro; Southern Italy

The eighth "Adunanza Generale della Società Geologica Italiana" was opened on September 23, 1889 in the City Hall of Catanzaro, Calabria. At the time, the event was also additionally called "1° Congresso Geologico dell'Italia Meridionale", as to underline the National Geological Unity reached almost thirty years after the political unity of Italy.

It may appear unusual the choice to objectively celebrate this first south Italian geological congress in a region such as Calabria devoid of a university centre, in a small city such as Catanzaro, instead of centers important and known for their geological research such as Naples, Palermo, Catania, Messina and Cagliari.

Although on one hand the choice of Catanzaro was favored in some way by the authoritative president of the SGI Giovanni Capellini (1833-1922) following the withdrawal of Vicenza, on the other hand it was absolutely not casual. Still before 1861, the Liceo Galluppi in Catanzaro, a former Jesuit college, hosted a Gabinetto di Storia Naturale including a rich geological collection. Teachers at the Galluppi school were both Domenico Lovisato (1842-1916) who had produced geological maps of Northern Calabria at 1:250,000 and 1:50,000 scale that were presented at the 1878 Universal Exhibition in Paris, and Antonio Neviani (1857-1946) who was Capellini's student in Bologna and later also became president of the SGI.

An additional Capellini's student, Vincenzo Rambotti (1845-1878), had been intensively active in Calabria. He died prematurely of malaria and his maps were partly published posthumously by Neviani. Moreover, Emilio Cortese (1856-1939) had been active in Calabria for a decade on behalf of the Royal Ufficio Geologico. Neviani and Cortese were asked by Capellini to organize the general assembly of the GSI and prepare two-day field trips on carriages and horse-back to the Tertiary and Recent surroundings of Catanzaro, the Mesozoic of the Tirolo mountains, and the schists and granites of the Gimigliano zone.

Both organizers and participants to the Catanzaro congress were well aware that the geological mapping and researches made in Calabria in the first three decades after the unity of Italy were most important, and the geological anomaly of this area in the national frame had already appeared. To emphasize this point, the opportunity was taken by the Royal Ufficio Geologico to present at the congress members gathering in the Catanzaro City Hall the "Carta Geologica del Catanzarese" at 1:10,000 scale (in 12 sheets); the scale selected and the exceptional level of details for the time showed the possibility of an immediate practical implementation of the map.

It is known that the expectations of the first post-unity geologists were to a large extent unfulfilled. Nevertheless, the quality of the publications and the cartography produced by the geologists operating in Calabria in those

years represented a solid and internationally recognized basis for the geology of the 20th century. The point is best witnessed by the French Maurice Gignoux (1881-1955) and his worldwide famous stratigraphical work on the Calabrian and the Quaternary just starting from the surroundings of Catanzaro, the main place of the 1889 SGI congress.

F4-6 Orale Luongo, Giuseppe

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THE FOUNDERS OF SEISMOLOGY IN ITALY BY THE MID-NINETEENTH CENTURY

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Key terms: Earthquakes and volcanism; Seismic source; Intensity Scale; National Geodynamic Service; Seismograph

The scientific study of earthquakes received a critical stimulus in 1755, when a disastrous earthquake struck Lisbon on November 1. A significant contribution to this evolution comes from Italy, where by the mid-nineteenth century many scientists operated to record, localize and classify the intensity of the earthquakes. During that time two disastrous earthquakes occurred, the Neapolitan earthquake of 1857 and the Ischian earthquake of 1883. Believing that earthquakes were produced from volcanic sources, they drew attention to the nearness of volcanoes to the stricken areas.

The firm foundations of modern seismology were laid by Robert Mallet (1810-1881). The earthquake of December 16, 1857, in Southern Italy (Two Sicily Kingdom) provided Mallet with the opportunity to study seismic effects extensively and to establish much of the basis of observational field seismology. To ascertain the surface position and depth of seismic focus Mallet measured the direction and inclination of fissures in buildings, the direction of the fall of columns and the projection of detached masses of masonry.

To overcome the imperfect record of the features of an earthquake afforded by broken walls, fissured roofs and overturned objects due to a variety of causes, seismologists aimed their activity to construct instruments for registering the complex movements of an earthquake to exclude some errors coming from non homogeneity of structures. Luigi Palmieri (1807-1896) operated in this direction with the invention of his electro-magnetic seismograph in 1855. In the following year, one instrument was placed in the Vesuvius Observatory and a second in a building of the University of Naples. During the eruption at Mt. Vesuvius that began on 8 December, 1861, the first eruption after the Unit of Italy (17 march 1861), two clusters of shocks were recorded by Palmieri's seismograph.

Italian seismology is deeply indebted to Michele Stefano de Rossi (1834-1898) for its advance. He was the founder of the "Bullettino del Vulcanismo Italiano" in 1874, the first journal devoted to the study of volcanoes and earthquakes. His chief object was to encourage the spread of regular observations of endogenous phenomena made at various stations in Italy; it was the de Rossi's journal helped to create in Italy the public interest that made the national seismic service possible. In 1874 de Rossi introduced a scale for comparing intensities of different earthquakes that met with general approval. Moreover he studied the earthquakes which damaged Casamicciola in 1881 and ruined it in 1883. For the last de Rossi proposed an original mechanism for the seismic energy release: the earthquake was caused by sudden slip taking place along a fracture in the upper part of the crust and subsequent vibrations of its opposing faces. Giuseppe Mercalli (1850-1914) investigated several great earthquakes and studied the phenomena of the Italian volcanoes in original way. As an investigator of earthquakes Mercalli soon realized a usefulness scale of intensity which contains the germs of MCS and MM Scales. The violent earthquake that destroyed Casamicciola in 1883 was studied by Mercalli employing the method devised by Mallet. He concluded that this earthquake was a true volcanic earthquake, an unsuccessful attempt to force an eruption.

Henry James Johnston-Lavis (1856-1914) lived in Naples from 1879 to 1894. During his residence in Naples, on 4 March 1881 and 28 July 1883, two destructive earthquakes occurred in the nearby island of Ischia. Johnston-Lavis classified the two ischian earthquakes as events of volcanic origin. On each occasion he was directly inspired by Mallet's investigation of the Neapolitan earthquake.

After the destruction of Casamicciola, the Government established in 1887 a National Geodynamic Service placed under the charge of Pietro Tacchini (1838-1905) and founded the Geodynamic Observatory of Ischia, the director being Giulio Grablovitz (1846-1928).

F4-7 Invitato Magnani, Stefano

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THE STOPPANI AND TARAMELLI'S PROJECT FOR A POST-UNITARIAN GEOLOGICAL CARTOGRAPHY IN THE EASTERN ALPS

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Key terms: Stoppani; Taramelli; Sella; Geology; Cartography

Antonio Stoppani (1824-1891), geologist and paleontologist, author of the scientific bestseller *Il bel Paese* (1876), and his pupil Torquato Taramelli (1845-1922), in his time regarded as a preeminent exponent of the <<new>> geology, having reinstated the Italian Earth Sciences within the European context, had a crucial role in relation in the realization of the geological map of Italy.

In fact, in the aftermath of the unification of Italy, the peninsula was in need of an exhaustive knowledge of the territory under a physical, geographical and geological aspect so to boost its industrial development. Only this kind of knowledge would have allowed an evaluation of the energetic resources that Italy had at its disposal. It was also necessary to have an in-depth study of the geological structure, of the soil's composition and of the morphology of the territory for the execution of drainage works, for the laying of the railroads and of other industrial infrastructures. In this perspective, during those years, the project for the geological map of the peninsula became a priority.

Stoppani, very close friend with one of the main promoters of the project,

Quintino Sella (1827-1884), was strongly committed to this project undertaking it since its beginning in 1861. With Taramelli's support, he upheld the need to assign the direction of the Geological Survey to a national geological institute designed on the German and English models. Within this institute, geologists, paleontologists and academics would have played a prevailing role. In doing so, he opposed those who considered opportune to entrust the project to a special section of the Mine Corps based on a French model, extending a public service centered on the engineer figure, a professional with technical and operative skills, to the whole peninsula.

Although they didn't disregard the practical aims of this undertaking, Stoppani and Taramelli understood that the realization of a geological map based on stratigraphical and paleontological studies, chemical and microscopic analyses, carried out by scholars provided with a deep knowledge of lithology and topography, was crucial. They found a good occasion to put into effect their ideas when Taramelli, thanks to the support of Stoppani and Sella, obtained the Natural Sciences chair at the Istituto Tecnico in Udine (1866-1874). During those years, he dedicated himself to a systematic study of the Eastern Alps. He was especially animated by the will to deepen the knowledge of those territories and to demonstrate their full belonging to the Italian peninsula, not only from the historical and cultural point of view but also from the geographical and geological one. These studies culminated in the realization of the geological map of Friuli, presented at the 2nd International Geological Congress held in Bologna in 1881.

The recent discovery of the diaries regarding the reconnaissances, carried out between 1871 and 1874, provides an extraordinary documentation that allows us to understand Taramelli's approach, showing a different perspective compared with the official publications.

These diaries show the coexistence of two aspects: a <<naturalistic>> consciousness of a geology consistent with the scientific method and, at the same time, a deep humanistic tradition able to perceive the "art" of nature.

Beyond the struggle between geologists and mine engineers that made the work for the geological map difficult until the end of the century, the analysis of the positions held by the two Lombardian geologists and of their sharing views within the Geological Committee (officially constituted in 1867), contributes nowadays to clarify the backstage of one of the founding moments of the modern Italian geology.

F4-8 Invitato Sella, Mattia

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QUINTINO SELLA, BETWEEN SCIENCE, MOUNTAINEERING AND CULTURE. FROM VALENTINO CASTLE TO PALAZZO CORSINI

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Key terms: Quintino Sella; Geology; Corpo Reale delle Miniere; Geological Map of Italy; Geological Society

Quintino Sella, scientist and promoter of science, must be contextualized within the history of Earth Sciences and the evolution of ideas and theories which developed in the nineteenth century when the first geological maps appeared through the work of William Smith, Coquebert de Montbret, d'Ormalus d'Halley, Alberto della Marmora, Giuseppe Scarabelli, Giacinto Ottavio Provana Collegno. But in Italy the real Geological mapping enterprise starts in 1861, thanks to Quintino Sella and Felice Giordano. Sella, born in 1827, graduated in 1847 in Hydraulic Engineering at the University of Turin, right after he was sent by minister Des Ambrois together with Giordano to specialize in Paris at the Ecole des Mines.

Between 1850-52 he traveled around Europe to gain work experience in mining districts. In 1852 he was appointed professor of applied geometry at the University of Turin and from 1854 to 1861 he devoted himself to studies in theoretical and morphological crystallography. In 1856 he was appointed "second class engineer" in the Corpo Reale delle Miniere, the Royal Corp of Mining Engineers, in Turin, and undertook an intense career at this important institution of the Kingdom. In 1860 he was appointed professor of crystallography at the Scuola di Applicazione per Ingegneri, (the Royal Technical School for Engineers founded at the Valentino Castle in 1859, thanks to the commitment of Sella himself). 1860 was a turning point for Sella's life that became a politician. Since that year, he reduces the effort devoted to scientific study but became a promoter of science and culture regarded as key tools for building the new Nation. Sella scientist is best known as crystallographer and mining engineer, but he was also involved in geology. Since 1861 he supported the project of the making of the Geological Map of Italy, and he was one of the makers of the foundation of the Comitato Geologico; during the Congress of Naturalists, in Biella (1864), he presented the "large-scale geological map of the Biellese", made in collaboration with Gastaldi and Berruti; in 1881, together with Capellini, he organized in Bologna the 2nd International Congress of Geology, during which the Italian Geological Society was founded. Sella intended to promote science also through the Italian Alpine Club, born in 1863 at the Valentino Castle. Even the decision to establish this association in the Scuola di Applicazione per gli Ingegneri, which was the technical-scientific and academic seat in Turin, capital of the Kingdom, suggests the aim to promote science in the Italian society. In 1869 the Commission of Inquiry on mining of Sardinia sent Sella to this island and in 1871 he presented to the government the "Relazione sulle condizioni dell'industria mineraria in Sardegna". Sella used La Marmora's geological map to build the "Carta mineraria dell'Isola di Sardegna". In 1870 Rome became the capital of Italy and "the Science must move to Rome", in 1874 Sella, President of the Accademia dei Lincei, organized the reconstruction of this national science institution, in the just bought Palazzo Corsini. He believed that education and training of young people was the prior task for a strong and democratic development of a Nation and became involved in the renovation of Universities, research centers, laboratories and Academies. Sella promoted the establishment of several technical and mining schools. In addition to being a professor of geometry, mathematics and mineralogy, he was a member of the Higher Council of Education, of the Commission for the reorganization of the educational legislation. In 1861 he was appointed Secretary General of the Ministry of Education, ministry who he held ad interim for a few months in 1872. Within the building of the new Nation he also considered the importance of "the mines, the quarrying industry, the construction of underground railways" and he has been also engaged in the construction of rail tunnels (Frejus, San Gottardo).

F4-9 Invitato Dal Piaz, Giorgio

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FELICE GIORDANO AND THE GEOLOGY OF THE MATTERHORN

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Key terms: Felice Giordano; Matterhorn; Geology; Tectonics

The Matterhorn (Monte Cervino, Cervin) is famous in its own right, not only from a climber's point of view. The mysterious spell of this great pyramid, standing out in isolation from its surrounding glaciers, has bewitched numerous generations of naturalists and geologists since the heroic age of Horace B. de Saussure (1740-1799) and other distinguished explorers of the Swiss-Italian Alps in the XIX century (B. Studer, H. Gerlach), who gave the first lithological descriptions of the "inaccessible peak". On behalf of Quintino Sella, in the 1865 Felice Giordano promoted and supported Carrel's Italian team in the unlucky race to the Matterhorn conquest, tragically won by Eduard Whymper. Three years later, Giordano was the first geologist to climb the Matterhorn and to give a direct and accurate description of its lithology and structural setting, shown in two profile profiles across the Western Valais-Monte Rosa area. Discussing protoliths, structure and the age of the Matterhorn metamorphic rocks, Giordano was not far from the mobilist nappe theory, an interpretation which he evaluated in opposition to the fan-mushroom or double-fold fixist models, but which he later rejected, mainly owing to the absence of correct chrono-stratigraphic constraints. The Matterhorn was again at the centre of great geological interest in the early 1900s, and gained its world-wide reputation through the genius of Emile Argand, when the Dent Blanche recumbent fold-nappe, the highest tectonic unit of the Penninic zone in the Western Alps, was revealed, carefully mapped (1908) and described (1909, 1911, 1916).

F4-10 Invitato Praturlo, Antonio

10.1474/Epitome.04.0523.Geoitalia2011

THE "SIXTIES": AN IMPORTANT STAGE OF ITALIAN GEOLOGY

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Key terms: GEOHISTORY; STRATIGRAPHY; TECTONICS; MAGMATISM; MEDITERRANEAN

The "sixties" are an important stage in the history of modern Italy, as an economic and demographic boom is coupled with the search of new development routes.

In 1960 the National Committee for Nuclear Energy (CNEN) is established. In 1961 the first Italian space project ("San Marco") starts. In 1963 Natta receives the Nobel award for Chemistry, for his researches on polymers, parents of the modern plastic materials. In the sixties ENI expands the network of its methane pipelines, and develops its activities even outside Italy.

In 1965 the French-Italian Mont Blanc tunnel is open. In 1968 the works for the Gran Sasso tunnel are started. In the meantime the oil drillings show the complexity of the deep structure of our country.

In the research field, Polvani in 1961 achieves the first important call-up of CNR researchers. Universities receive funds for building, laboratories and libraries. Their staff increases, institutional connections with CNR are set up through a dense network of mixed research structures ("Centri di Studio").

In the Earth Sciences field, we note an intense and lively synergy among University, CNR, Italian Geological Service, AGIP, OGS. Furthermore we assist to a meaningful reorganization of the geological thought, realized through close collaborations among the different sectors, up to now divided by a sort of specialistic drift.

The decade begins with Law. n. 15 of 3 January 1960 (known as "Legge Sullo") for the completion of the Geological Map of Italy at scale 1:100,000. The mentioned law provides for special funding and the direct involvement of Universities and other public and private institutions. The period of maximum field activity and map production is exactly the decade 1960-70s.

Within this new scientific climate, enriched by an intense international cooperation, new important CNR Institutes are established: the Istituto Internazionale per le Ricerche Geotermiche (Pisa, 1965), the Istituto Internazionale di Vulcanologia (Catania, 1967), the Istituto di Geologia Marina (Bologna, 1968), the Istituto per la Geologia Applicata alla Pianificazione Viaria e all'Uso del Sottosuolo (Padua, 1968), the Laboratorio per lo Studio della Dinamica delle Grandi Masse (Venice, 1969), the Istituto per la Geofisica della Litosfera (Milan, 1970), the IRPI of Turin, Perugia and Cosenza (1970).

The pioneer discovery of the synsedimentary extensional tectonics, documented by block faulting, listric faults with their transfer links controlling Mesozoic depositional processes, all occurred during this decade. The huge clastic deposits along the borders of the Italian Alps and inside the Apennines, were correctly interpreted as basinal deep deposits laid down by turbidity currents, as large syntectonic and diachronic bodies emplaced to the more external zones during the gradual motion of the chain toward the foreland. According to the early structural and kinematic reconstructions of the Italian orogenic system, the great structural mosaic including Alps, Apennines, Calabrian arc, Sicily and Magrebe chains was, for the first time, referred to the rotation-translation of great amplitude continental blocks fragments, generating orogenic accretion belts on the front and deep semi-oceanic basins behind.

At the same time it became evident the tectonic control of magmatism during the whole alpine and apenninic orogenesis, for instance the Peri-adriatic plutonism, surely referred to the post-thrust paleogenic intrusive activity, interesting the thrust-fold structure.

When, at the end of the decade, the new theory of Plate Tectonics reaches also Italy, it finds an immense database of information collected during field working, and a considerable number of expert scientists who try immediately to apply it to the Italian tectono-stratigraphic setting. They start from the newly accomplished synthesis of the Structural Model of Italy (scale 1:1,000,000), soon realizing that the Mediterranean geology appears more complex and difficult to understand than the one recognizable in the original oceanic areas. Therefore, starting from the essential theoretical base, an important Italian contribution is given to the development, improving and final reorganization of the new Plate Tectonics theory.

F4-11 Invitato Lettieri, Maria

10.1474/Epitome.04.0524.Geoitalia2011

150 YEARS LATER - THE GEOLOGICAL KNOWLEDGE OF THE NATION THROUGH ITS REPRESENTATION: THE NEW GEOLOGICAL MAP OF ITALY AT 1:50,000 SCALE - CARG PROJECT. □ THE RESULTS OF THE PROJECT AT THE CONCLUSION OF ITS FIRST PHASE OF IMPLEMENTATION - FUTURE PROSPECTS

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Key terms: CARG; Geological Map; Environmental Protection

The realization of the Geological Map of Italy, an essential tool for local knowledge, hasn't had an easy life since its beginning in 1861, immediately after the Italian unification.

It has always been conditioned by the most important events related to the various historical phases of the Country, especially by the exiguity of financial support and the lack of continuity in its delivery. Today, with the planned realization of the new Geological Map of Italy at 1:50,000 scale (CARG Project) the national geological map is experiencing a new phase of renovation, thanks to the latest technical and scientific knowledge, in order to become a practical and useful tool for the environmental analysis and protection.

The CARG Project has enabled the mapping start off and the digitalization of 255 geological maps at 1:50,000 scale, 14 geothematic maps at 1:50,000 scale, 6 maps of marine geology of the Adriatic coastal areas at 1:250,000 scale, 1 morphobathymetric map of the Tyrrhenian basin. Other activities finalized to the realization of the Geological Map of Italy were also carried out.

Of the 255 geological sheets funded until now, 91 have been already printed, 33 are ready for printing, 86 are being prepared for printing, 39 have been completed with regard to the geological survey while only 6 are still under survey.

At this stage the first phase of realization of the CARG Project is almost close to the conclusion.

Today, the coverage of the 1:50,000 scale geological map is approximately 40% of the whole national territory; 374 geological sheets are still missing to complete it.

The same tenacity and conviction of the Fathers of the geological map is still necessary today to bring the mapping process to a fulfillment.

In order to adequately plan the realization of the project in the coming years, it is important to raise awareness in the political and ruling class about the need for funding. It would be also essential to review the procedures before starting a second phase of the CARG Project, thus allowing the realization of the remaining 374 sheets.

F4-12 Orale Pantaloni, Marco

10.1474/Epitome.04.0525.Geoitalia2011

THE GEOLOGICAL MAP OF ITALY 1:1,000,000 SCALE: A MILESTONE ON THE PATH OF GEOLOGICAL KNOWLEDGE

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Key terms: geological map; Italy; history of geology

The need to develop a synthetic geological map of the Italian peninsula emerged even before the unification of the country, at the 1st meeting of Italian Scientists, which was held in Pisa in 1839. The proposal was received with great enthusiasm, but with lack of determination. In fact, in 1841, during the 3rd meeting of Italian Scientists in Florence, this need was again reaffirmed because, despite all efforts, the purpose had been hitherto neglected.

Some projects were developed for personal initiative: Collegno di Provana, in 1844, presented his geological map at 1:2,000,000 scale and Balsamo Crivelli added a small geological sketch of the Peninsula to the book of Omboni "Sullo stato geologico dell'Italia" dated 1856.

Even the intervention of Cocchi, Giordano and Sella in the planning of the national geological mapping project, does not seem to change things. Too strong was the conditioning of the map realized in France by De Beaumont and Dufrenoy: the 1:1,000,000 Geological Map of France had left to local authorities the task to realize the detailed cartography, thus creating the basis for a similar behaviour in Italy.

So just after the start of the project for the Geological Map of Italy at 1:100,000 scale and the publication of some "strategic" maps by the Geological Committee, the work began on the first edition of the Geological Map of Italy 1M scale, which was finally published in 1881 during the 2nd IGC in Bologna. Because of the weaknesses in the geological survey, part of the information was taken from the regional geological maps produced so far. The presence of different criteria and methods in the representation arouse the need for more field work aimed at harmonizing them.

Following these insights, in 1889, a second edition of 1M scale map was printed, and, as stated on the title, "it was compiled based on surveys carried out by the engineers of the Royal Corps of Mines and published works of Italian and foreign geologists".

Forty-two years later, Vittorio Novarese, one of the gifted geologists of that period, engineer at the Royal Geological Survey, oversaw the realization of the 3rd edition of the 1M map: the innovations introduced resulted from the great progresses in the geological knowledge, especially on the mainland, particularly in the differentiation of the Alpine chain.

In 1961 Beneo, Director of the Geological Survey of Italy, realized the 4th edition of the 1M map. It was a review of the 1931 edition, consisting mainly in the division of the units in the legend.

On the occasion of 150 years of the Italian unification, the Geological Survey of Italy published the fifth edition of the Geological Map of Italy 1M scale.

The long period of time since the previous edition, 50 years, makes this map a representative element of the enormous scientific advances in geology. Its realization involved many researchers and was carried out through the analysis and synthesis of the scientific improvement obtained in the national geological mapping project, as well as the huge amount of scientific papers published in recent years.

The purpose of this work is to disseminate in the scientific as well as in the educational field a synthesis of the modern geological knowledge of the country, reaching a wide audience of scholars, teachers and students. The outcome is a substantially different geological map compared to previous versions at similar scale. The final product is a geological map in

which, in addition to "conventional" lithological characterization, was highlighted the geodynamic evolution; in order to provide a valuable support for the understanding of the geological and geodynamic history of the Italian peninsula.

This edition also takes a huge step forward in terms of mapping: the use of GIS and of the digital printing process allows the management of many different colours and the representation of small surfaces, allowing several possible reading keys.

F4-13 Invitato Colantoni, Paolo

10.1474/Epitome.04.0526.Geoitalia2011

THE BEGINNING AND EVOLUTION OF THE MARINE GEOLOGY IN ITALY

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Key terms: Geophysical Survey; Submarine Morphology; Structural setting; Geology of the Italian seas

A brief look at the marine geological investigations in Italy during the recent years is presented. Proper research programs began after the World War Second when technology made it possible to use the acoustic energy to investigate the seafloor and its sub-bottom features. Thanks to A. Segre and C. Morelli we got respectively the first bathymetric maps and an extended geophysical survey. At the end of the Sixties, some CNR Marine Institutes were created. The CNR's Progetti Finalizzati (1975-80), animated by R. Selli, marked the most intense phase of research activity with the use of two oceanographic ships (Vercelli and Bannock). The collected data allowed to attempt the first interpretations of the geology of the seas surrounding Italy.

The Northern Adriatic Sea has been the subject of numerous studies concerning in particular the recent sedimentation and stratigraphy of the last glacial cycle. The Southern Adriatic Sea remains poorly known as well as the Ionian Sea. Although we got to know its complex morphology and depth, the real nature of the crust remains unknown. The Strait of Sicily's features are interpreted as due to tensional stresses in a continental crust, while the Tyrrhenian Sea shows a more complex geological shape. The intricate morphology of its Northern sector seems to be originated by compressing movements and by the origin of the roots of the Apennine chain. On the other hand, the origin of Central and Southern Tyrrhenian Sea, with its deep plain and isolated seamounts, was interpreted as due to vertical movements caused by crustal oceanization processes and later by tangential or shear forces in a back-arc basin. The activities of the ODP (Ocean Drilling Program) Legs allowed to solve some doubts and led to an international debate on the origin of the Messinian evaporites. The underwater observations of many sites using submersibles helped to acquire additional details. After a long period of crisis caused by the lack of a sea policy and the shortage of funds, the worthwhile collaboration between marine and field geologists gained new interest, thanks to the effort for mapping the marine part of the CARG project's new geological sheets. Once more, it is clear the difficulty of combining the two different surveying approaches and also the need for a new generation of scientists trained in Marine Geology and able to use the innovative supporting technologies.

F4-14 Orale D'Angelo, Silvana

10.1474/Epitome.04.0527.Geoitalia2011

THE GEOLOGICAL SURVEY OF ITALY FROM MINING TO ENVIRONMENTAL PROTECTION: THE INVISIBLE TERRITORY

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Key terms: Geological Survey of Italy; marine geology; seafloor

The Geological Survey of Italy (at that time Mining Department of the Ministry of Industry, Trade and Craft) started to investigate sea bottoms at the end of the '60s.

Its task was to implement the geomorphological and geo-mineral knowledge of the seafloor, aimed at the realization of thematic and "special" maps to complete the geological map in the areas of mining interest. The area which served for initial practice was the Elba Island while searching for metalliferous sands.

Between 1979 and 1982 an Operational Unit of the Geological Survey participated in the CNR (National Research Council) Targeted Project "Oceanography and seafloor", sub-project "Placers". The objective was to identify metalliferous sands deposits on the mid-Tyrrhenian continental shelf, in order to determine their thickness and heavy metal content. At the end of the '80s, when the 1:100,000 scale Geological Map of Italy was completed, the new Geological Map at the 1:50,000 scale was financed (CARG Project).

The Geological Survey of Italy was transferred to the Ministry of Environment and the geological cartography started to be addressed mainly at the knowledge of the territory. Particular relevance was given to its vulnerability, which resulted from the economic and technological development. The project aimed at the realization of the geological cartography of marine areas started according to the law n. 183/89 "Soil Defense". The geological survey and cartography was extended to the continental shelf.

The change of the final objectives of the seafloor studies corresponds to a fast evolution of the remote sensing technologies and surveying methodologies, which are shared by many other disciplines concerning marine environments (bio-habitat, archaeology, civil protection, etc.). The contemporary presence within ISPRA of "historical memories" and new disciplines might be favourable to go beyond the use of common means of investigation and increase the knowledge of the relationships among different fields of research.

F4-15 Invitato Pezzotta, Federico

10.1474/Epitome.04.0528.Geoitalia2011

THE MINERAL COLLECTING IN ITALY, FROM THE ORIGIN TO THE PRESENT DAYS

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Key terms: Mineralogical collections; History; Italy

Since the beginning, mineral collecting in Italy has been characterized by a significant historical, cultural and political heterogeneity, and by an extraordinary geo-diversity. This year (2011) Italians celebrate the 150th anniversary of the Unity of Italy; but of course, the roots of mineral collecting date back well before that time, to the courts and noble families belonging to very different countries and dominions that have been in conflict for centuries. In "The History of Mineral Collecting 1530-1799" Wendell Wilson (1994) described the substantial contributions given by Italians to the birth and development of mineral collecting, as we appreciate it today. In particular, in the second half of the 16th century, during the Golden Age of Renaissance, scholars and aristocrats in Italy assembled some of the first great collections of naturalia, including a remarkable number of mineralogical specimens. Throughout the 1600s and up to 1714, under the domination of Spain, the natural collecting history in Italy was influenced by the baroque attitude, as in the rest of Europe. After 1714, the onerous Spanish supremacy ended in Italy, to be replaced by the Austrian presence that fostered the formation of independent states (apart from Lombardy, which was under the direct control of Austria). In the 18th century Europe entered the Period of Enlightenment with a strong scientific impetus. Italy, because of its strong political divisions, did not develop significant industrialization which would have fostered the growth of the middle classes. Therefore, mineral collecting was confined primarily to aristocratic and academic circles. However, from the middle to the end of the 18th century, cultural exchanges with Central European countries were very active, leading to the creation of numerous collections and to the foundation of some historical museums. After the wars and political events associated with the complex Napoleonic episode, beginning in 1815, a veritable political, cultural and scientific ferment took place in Italy, which led to the unification of the country between 1859 and 1861. During this period, universities began to gain a very important role in society, and the development of mineral collecting kept pace with the development of research and scientific knowledge. Collections took on a more systematic and scientific nature. Higher-quality specimens were being collected and new occurrences of varying importance were being discovered. Mineral collecting in Italy during the second half of the 1800s was very extensive and it is interesting to note some examples that at least partially demonstrate how mineral collecting in Italy gradually evolved over the years toward more sophisticated tastes and research of greater quality. This slow but progressive evolution of mineral collecting continued during the 20th century, up to the events that led to the start of the Second World War, which marked the end of an era for mineral collecting in Italy. Mineral collecting began to flourish once again in the country in the second half of the 1960s, but it had inherited little from the pre-war collecting culture.

Through the 1980s, the 1990s and the first decade of the new century, mineral collecting in Italy has undergone a deep transformation, which led to a more demanding form of collecting, involving the refinement of taste and the appreciation of quality as it applies to various specialties. Micromounting, for example, represents a true modern multifaceted experience, strictly tied to the availability of optical and photographic instruments of high quality and ease of use, at an accessible cost.

F4-16 Poster Gallo, Lorenzo Mariano

10.1474/Epitome.04.0529.Geoitalia2011

PIEDMONT'S MINERALOGISTS DURING THE XIX CENTURY

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Key terms: mineralogy; mineralogist; Piedmont

The purpose of the presentation is to describe the contribution to the Italian mineralogy of influential mineralogists operating in Piedmont Region during the XIX century. As highlighted in the paper, the evolution of the mineralogical science in this region is strictly related to the history of the Kingdom of Sardinia (after the French annexion of the Savoy in 1801 and the restoration of 1815) and to the birth of the Italian Kingdom in 1861. From another standpoint, since preeminent mineralogists were professors or assistant professors, there is also a strong connection with the history of two of the most important institutions devoted to the teaching of science and technology: the Royal Turin University and the Technical Institute, which later became the Royal Application School for Engineers and then the Polytechnic School of Turin). Besides it should not be underestimated the influence of the industrial revolution in Piedmont on the mineralogy of the time. In particular, influential mineralogists were involved in the development of the mining sector and in the search of raw materials in Piedmont Region and in the Italian Kingdom, such as Angelo Sismonda (Professor of mineralogy and Director of the Museum of the University of Turin, and author of the first geological map of Savoy, Piedmont and Liguria), Johann Struver (called by Quintino Sella as Assistant at the School for Engineers, whose studies on Traversella mineralogy are still a masterpiece) and Guglielmo Jervis (an English geologist born in Bombay, India, Curator of the Industrial Museum of the Application School in Turin, author of a monumental work about the mineral resources of Italy).

The historical journey suggested by this work starts from one of the earliest mineralogists of the 19th century, Carlo Antonio Napione (1756-1814), artillery officer and author of the first mineralogy textbook written in Italian, and goes on showing the work of several eminent scientists until the end of the century. Along this journey in the history, the reader will meet relevant persons and founders of Museums, Institutions and Collections, such as Carlo Allione (botanic and naturalist, but also collector of mineralogical and geological samples), Etienne Borson (the first Professor of Mineralogy at the University of Turin and author of the First catalogue of the University Museum), Vincenzo Barelli (administrator of the wood and mining collection of the Sardinian Kingdom and publisher of the first catalogue of mineral resources of Piedmont and Sardinia), Angelo Sismonda (pupil of Borson and author of the geological cross section for the realization of the Frejus tunnel), Quintino Sella (expert mineralogist and Geometry Professor before becoming Economist and Minister), Giorgio Spezia (inventor of the hydrothermal method and of the relative device for the growth of synthetic quartz at the beginning of 20th century). Still, the work describes the fervent activity of many other passionate naturalists and mineralogists, who worked not only in Turin but also in the neighboring regions, and contributed to the institution of important museums, through the donation of their precious naturalistic and mineralogical collections to local authorities.

F4-17 Poster Ferraris, Cristiano

10.1474/Epitome.04.0530.Geoitalia2011

THE MINERAL COLLECTION OF THE ISTITUTO TECNICO INDUSTRIALE DI BIELLA; A WINDOW ON THE SCIENTIFIC ACTIVITY OF QUINTINO SELLA

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Key terms: Minerals Collection; Quintino Sella; Samples; Historical Collection

Quintino Sella (QS) collected an impressive number of mineralogical samples through three different paths: personal field sampling, since he started as a student at the Ecole des Mines in Paris, visiting mines in France, Germany and England; donations and trades involving some of the greatest mineralogists of the second half of the XIX century; purchases, often from famous dealers. Following the loss, for war events, of the mineral samples personally donated by scientists to the Politecnico di Torino, the collection kept at the Istituto Tecnico Industriale Quintino Sella (ITIS) of Biella, that was donated in 1909 by the son of QS, Corradino Sella (CS), is likely the only systematic evidence of the mineralogist-collector activity arriving fairly intact to our days, through more than 150 years of vicissitudes. Probably part of this collection was even previously donated by QS, according to a booklet published in 1988 to celebrate the 150th anniversary of the Institute, where the samples are divided as samples from donations of QS and samples and thin sections from donations of CS. After segregation in dusty stores lasted about three decades, as a consequence of the change of educational needs that led to the almost complete abandonment of mineralogy in the Italian high schools, thanks to the interest of the "Opera Pia Sella" of Mosso (Bi) the ITIS's collection is currently undergoing reorganization to be again exhibited in a near future. The collection consists of approximately 4500 samples and its growth during years is witnessed by the original labels that attest exchanges with privates and museums together with acquisitions. An interesting part of the collection concerns the mineralogy of Sarrabus (Sardinia) and was donated by Giovanni Battista Traverso (1881-1909), at that time director of the silver mines of this famous mining district. A manuscript, which lists about 130 samples from the district, is preserved at the "Fondazione Sella" (Bi), but unfortunately a significant number of these samples are now missing for reasons under investigations. Apparently the collection was originally housed at least in 8 cabinets with drawers containing samples arranged according to the classic chemical classification from native elements to silicates, including minerals of organic origin such as amber. Over the time, the collection was definitely altered to be used in part as teaching material. As a consequence, at least for groups of minerals were strongly affected: native elements (many samples disappeared, including diamonds, gold and silver and others such sulphur samples seriously damaged); sulphides and sulphates, now deeply deteriorated by chemical alteration; some halides now severely compromised. Overall, however, the conservation status of the collection is satisfactory. In particular, the original labels - as well as some handwritten notes by QS, CS and their colleagues and friends - are in good conditions. Regardless of their condition, some samples are of great scientific interest because they bear witness of deposits now exhausted or even disappeared, and sometimes they can be considered as rare if not unique items. About 60% of samples come from Italian outcrops. Among these, in addition to the afore-mentioned Sardinian samples, the most important are those from Baveno and Traversella, Val d'Ala, Praborna, Val di Fassa, Tuscany mines including Elba island; The volcanic complexes of Latium and Monte Somma-Vesuvius (including samples collected by Arcangelo Scacchi), Calabria mountains (garnets rarely found in other collections) and rare Sicily localities famous for sulphur, aragonite and celestine are well represented. Among the foreign localities, the collection includes a wide range of species from deposits in Scandinavia, Siberia, Binn and central Europe. Famous American locations (USA; Hidalgo, Mexico, Colombia and Chile) are well represented, while there are only few samples from Asia (Sarawak in Indonesia) and Africa.

F4-18 Poster Grossi, Francesco

10.1474/Epitome.04.0531.Geoitalia2011

CARLO FABRIZIO PARONA (1855-1939): HALF A CENTURY OF GEOLOGY

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Key terms: Carlo Fabrizio Parona; Italy; paleontology; applied geology; scientific popularization

Carlo Fabrizio Parona was born in Melegnano in 1855, and was one of the most influential Italian geologists and paleontologists. He received his degree in Natural Science in the Pavia University (1878), then he was taken by Torquato Taramelli as assistant in Geology in the same university, where he remained, under the guidance of his mentor, until 1890. Afterwards he became professor in geology at the University of Torino in 1889, where he held this role for over forty years. In addition to conducting his research, in this long time he was master of several generations of geologists who constituted, thanks to him, a strong school in geology and paleontology. After several years dedicated to Jurassic geology and fossils of Lombardy, the Cretacic deposits became his next specialization, particularly platform shelf facies. But his interest in Earth Science was wide, as testified by an appreciated book about geology of Italy (Parona, 1903), that had a second edition in 1924. Parona was an all accomplished geologist as they used once: those were years in which analytical specialization allowed a huge leap forward in the geological knowledge, without losing the sight of the ultimate goal, i.e. the integration of the results in order to provide the foundations of the geology of Italy, of its evolution and of possible exploitation of its resources.

In the era of colonialism in Africa, Parona was one of the most important scientists working by means of research and explorations to improve agrarian conditions of Libyan territories, as President of "Geo-agrological Commission for Tripolitania", whilst retaining his geological and paleontological point of view. He dedicated several monographs to Piedmont, his adoptive land: "Caratteri ed aspetti geologici del Piemonte" (1922) and "Il Piemonte e i suoi paesaggi" (1935) are books to be mentioned. Likewise, the link with Turin and with the "Accademia delle Scienze" was so strong: the prestigious scientific academy named him as

national member in 1899 and President in 1928. His multifaceted personality allows Parona also to investigate the applied aspects of geology: hydrogeological studies with the aim to pick up drinking water, reports on thermo-mineral sources, projects for railway communications between Turin and Switzerland, in addition to several agrarian applications: contributions that, like those of other geologists of the past, substantially contributed "to make Italy" during the first decades of '900. Besides the academic tasks, he was well aware of the importance to disclose scientific knowledge to the widest possible audience, showing his usual modesty: "Raised in the Stoppani and Taramelli's school, I wasn't strong enough to reach them, celebrated Master, but I tried to follow them, even from afar, disclosing geological knowledge ex cathedra, mean as useful and effective, although more challenging" (Parona, 1935). Carlo Fabrizio Parona died in 1939 in Busto Arsizio: these are the deeply felt words of Federico Sacco, chosen between a lot of colleagues' memories: "I totally appreciated not only the keen scientific mind of Carlo Fabrizio Parona, but also his nobility, the strong integrity of his character and his heart's kindness. But my pen is unable to write worthily of Him (...). Which the scientist, that the Man: great."

F4-19 Poster De Lucia, Maddalena

10.1474/Epitome.04.0532.Geoitalia2011

120 YEARS OF ITALIAN AND VESUVIUS HISTORY IN THE LAVA MEDALS COLLECTION OF THE OSSERVATORIO VESUVIANO

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Key terms: Museum; Vesuvius; Historical Collection; Malladra; Lava Medals

Lava medals constitute a unique example that links Vesuvian eruptions to history, politics and science. Medals coined in the Vesuvian lava date back to the period in which the state of the volcano was characterized by an open conduit, so that warm lava was still used. This state of activity lasted from 1631 to 1944, a period of time during which effusive or effusive-explosive eruptions frequently occurred, followed by very short periods of rest. The medals were realized through metal molds or punches pinching a small amount of a still molten lava, extracted from lava flows or from the lava lake in the crater, and then dipping it into cold water. This unique industry expanded when volcanic eruptions with significant lava emissions occurred, for the increased availability of material. Furthermore, in periods of intense volcanic activity there was an increasing number of curious and visitors who bought lava medals. Especially for scientific purposes, in the early Nineteenth century collectors and scientists began to gather these unique objects, which were considered as geological specimens, as the medals coined in 1819 and 1820 by Nicola Filomarino duca della Torre, amateur volcanologist. However, he started an intense production of this objects, contributing to make them quite popular at the time.

Over time, lava medals were specifically made by craftsman and used as souvenirs; then, in the first half of the Twentieth century, they assumed a commemorative and in some cases propagandistic value. In addition to medals, vesuvian guides used to make lava objects putting a coin, a medal, a stone or a button in a piece of lava.

The Osservatorio Vesuviano has a unique collection of lava medals coined in Vesuvian lava. It consists of 78 items, dated from 1819 to 1939. Most of them belong to the period between 1920 and 1939, with a peak between 1933 and 1936.

Subjects were extremely varied: emperors, popes, kings, generals, scientists, celebrities, souvenir subjects such as Vesuvius and Italy, mythological, religious and literary characters.

During the Thirties, the purpose for which the medals were made was mostly the celebration of significant events in the history of Italy, as the birth of a king's son, the proclamation of the empire, military conquests and victories and sometimes, the exaltation of dictators like Benito Mussolini or Adolf Hitler. On the back of these medallions the names of the "artists" who had created them were sometimes engraved, such as Giovanni Preti and Salvatore Madonna.

Thirty-eight lava medals of the Osservatorio Vesuviano collection had belonged to Alessandro Malladra, who made a donation of his geological specimens to the institute where he worked for many years. In fact, he was Director at the Osservatorio Vesuviano from 1927 to 1935.

He came from Turin and was a teacher of natural sciences, well-known because he followed the construction of the Sempione tunnel as consultant geologist of the company. The encounter in Milan in 1910 with Giuseppe Mercalli was crucial for the progress of his career and changed his life. In 1911 Malladra left his homeland and followed Mercalli, becoming his assistant at the Osservatorio Vesuviano, where he studied the Vesuvius with the same passion he had for the Alps.

Meticulous and precise, Malladra systematically collected geological samples and minerals produced by Vesuvius, making them available to other scholars. He kept an extensive correspondence with scientists from all over the world and was secretary of several prestigious scientific academies.

He can be regarded as an example of that kind of scientists who have contributed greatly to the geological knowledge of the Italian territory and the dissemination of this knowledge among non-experts.

SESSIONE G1

Geodinamica della regione mediterranea e del Medio Oriente

G1-1 Key Lecture Dal Piaz, Giorgio

10.1474/Epitome.04.0533.Geoitalia2011

THE AUSTRALPINE-PENNINIC COLLISIONAL WEDGE IN THE INTERNAL NORTH-WESTERN ALPS: STRUCTURAL SETTING AND PALEOSTRUCTURAL RECONSTRUCTION.

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Key terms: Western Alps; Austroalpine; Penninic; subduction complex

Most of the Cretaceous-Eocene subduction complex of the collisional wedge which is exhumed in the Aosta valley has been mapped ex novo for the CARG Project. Focusing on the upper part of the wedge, it is a tectonic multilayer of continental (Austroalpine) and oceanic (Piedmont) nappes that, as a whole, override the Penninic Monte Rosa-Gran Paradiso nappes, derived from the distal European continental margin. The Austroalpine includes the external Dent Blanche nappe (s.l.) and the internal Sesia-Lanzo zone. Argand's Dent Blanche is no more a recumbent fold-nappe but a set of independent thrust units, represented by: i) the Dent Blanche (s.s.)-Mt Mary-Pillonet thrust system (upper Austroalpine outliers); ii) a number of eclogitic slices (lower Austroalpine outliers) located north (Chatillon, Etirol-Levaz, Grun-Vollon) and south (Mt Emilius, Glacier-Rafray, Pontay, Santanel-Verres-Tilly, Tour Ponton, Acque Rosse) of the northward-dipping Aosta-Ranzola normal fault, i.e. in the hanging-wall and foot-wall of this tectonic line. Vollon and Tilly are new slices found during the geological survey, whereas the larger Verres slice, previously connected to the frontal part (Gneiss minuti) of the Sesia-Lanzo zone, belongs to the eclogitic outliers and is linked to the Santanel slice. Likewise, the Piedmont zone is structurally composite, including: i) blueschist facies (relics) ophiolitic units and minor continental cover sheets (Pantherot-Cime Bianche), both grouped within the Combin zone; ii) the underlying oceanic units of the Zermatt-Saas zone, marked by a typical eclogitic and ultra-high-P imprint. Contrasting tectono-metamorphic features allow the recognition of two couples of Austroalpine-Piedmont nappes, concerning their structural position, P-T conditions, timing of subduction metamorphism and inferred paleostructural location within Alpine Tethys, as follows: i) the upper group includes the eclogite-free Dent Blanche-Mt Mary-Pillonet thrust system and underlying Combin zone, both displaying a relatively high-P imprint (sodic amphiboles and high-Si white micas), dated as Late Cretaceous (74-73 Ma) in the Pilonet klippe; ii) the eclogitic lower group includes the lower Austroalpine outliers and the underlying or interbedded Zermatt-Saas units: the eclogitic imprint in these continental and oceanic units is dated as Early-Mid Eocene (50-44 Ma), opposite to the Late Cretaceous (80-69 Ma) in the Eclogitic micaschists of the Sesia-Lanzo zone. The underlying Monte Rosa and Gran Paradiso nappes display a syn-collisional eclogitic imprint of Eocene age (44-43 Ma). Ribbon continents, extensional allochthons and ocean-continent transition have been recently proposed instead of classic models of lithospheric microcontinents alternating with oceanic branches. The Dent Blanche-Mt Mary-Pillonet thrust system and Sesia-Lanzo zone are thought to be derived from a set of extensional allochthons probably linked to the Adriatic passive continental margin. The ophiolitic Combin units are coming from the internal edge of the Piedmont ocean and from ongoing subduction were accreted to the Dent Blanche-Mt Mary-Pillonet thrust system. On the contrary, the eclogitic lower Austroalpine outliers probably originated from one or more intra-oceanic allochthons (ocean-continent transition) that, during the Eocene, entered the subduction zone together with the Zermatt-Saas oceanic fragments, 30-25 Ma later than the upper group of nappes. The chronological gap may be filled with the ophiolitic units of the Combin zone (free of continental allochthons) and larger sectors of the Piedmont-Ligurian ocean ultimately lost into the mantle. See presentation for referencing.

G1-2 Orale Malusà, Marco Giovanni

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EXHUMATION OF HIGH-PRESSURE ROCKS WITHOUT EROSION: INSIGHT FROM THE EOCENE WESTERN ALPS

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Key terms: tectonic exhumation; erosional unroofing; high-pressure metamorphism; plate divergence; sedimentary basins

Exhumation of high-pressure rocks has long remained a controversial issue in the Earth sciences. Here, we analyze the tectono-metamorphic, stratigraphic and plate-motion constraints from the Western Alps region, providing new insights on exhumation mechanisms and tectonic evolution during the earliest orogenic stages. Eocene eclogites of the Western Alps form a 20-25 km wide belt on the upper-plate side of the orogen (Eclogite belt), exposed beneath extensional shear zones at the rear of a lower-pressure accretionary wedge. Units of the Eclogite belt show the youngest peak-pressure assemblages within the subduction zone, and experienced superfast tectonic exhumation since 45-40 Ma. The role of erosion was negligible during the whole of this stage. Eocene foreland basins remained starved, and the massive arrival of axial-belt detritus began well after exhumation was completed. Tectonic reconstructions based on fixed-boundaries exhumation models (e.g. channel flow), and/or implying fast erosion at the surface (e.g. slab breakoff), are thus not consistent with geological evidence. In the lack of erosion, exhumation through the overburden requires divergence within the subduction zone. We demonstrate that this was not attained by rollback of the lower plate (Europe), but was instead attained by NNEward motion of the upper plate (Adria) away from the Western Alps trench. Such motion induced localized extension within the weak portion of the upper plate, at the rear of the accretionary wedge, and allowed tectonic emplacement of the Eclogite belt in the upper crust at rates much faster than subduction rates. Tectonic exhumation ceased in the Oligocene, when oblique-divergence along the Western Alps traverse changed into oblique-convergence. The onset of slow erosional unroofing was synchronously recorded by pressure-temperature paths in all major tectonic units of the Western Alps, and by arrival of orogenic detritus in sedimentary basins. This work demonstrates that divergence between upper plate and trench is a viable mechanism to exhume large and coherent eclogite units in continental subduction zones, which may be applied to other eclogite belts showing a similar exhumational record.

G1-3 Orale Beltrando, Marco

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THE BACKBONE OF OROGENS: WHY A REALISTIC PALAEOGEOGRAPHY MATTERS

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Key terms: orogeny; rifting; distal margins; subduction; exhumation

The type of lithosphere reaching subduction zones has profound implications for the evolution of orogenic belts and for mass balance calculations in subduction zones. Numerical and conceptual models of subduction generally distinguish between only two types of lithosphere: (1) oceanic and (2) continental, with the latter consisting of subcontinental mantle and a 20-30 km thick crust, overlain by pre-, syn- and post-rift sediments. However, recent studies of present day rifted margins provided compelling evidence of the existence of a third type of transitional lithosphere between typical 'oceanic' and 'continental' lithosphere. Such domains, which can be up to 200 km wide, comprise the distal continental margins and the so-called Ocean-Continent Transition Zones (OCTZ). The recognition of such transitional domains in (U)HP orogenic belts, such as the Western Alps, has profound implications for understanding the dynamics of orogens and the processes of burial and exhumation of (U)HP rocks.

Here we present two examples from the Zermatt-Saas Zone, which is part of the Eclogitic Piemonte Units, and from the Sesia Zone. The Zermatt-Saas Zone consists of abundant serpentinitized mantle, intruded by Jurassic gabbros and locally overlain by slivers of continental basement rocks and by syn- to post-rift sediments. This lithostratigraphic association has generally been ascribed to complex orogen dynamics. Our study on zircons from Permian plutonic rocks of the Etirol-Levaz continental basement slice shows that a distinctive phase of zircon growth occurred at ca. 170-160 Ma. High U/Th ratios and zoning patterns suggest that zircons grew as a result of melt infiltration related to the intrusion of mafic magmas, also dated at ca. 170-160 Ma, in the underlying serpentinites. Therefore, the continental basement slices and the oceanic basement rocks were already juxtaposed in the Jurassic and they were probably part of an Ocean-Continent Transition Zone (OCTZ). Alpine tectonics resulted only in minor reworking of the Jurassic contacts, generally preserving the original geometry.

In the External Sesia Zone, Palaeozoic continental basement is regionally overlain by a thin layer of Mn-bearing quartzite, which is interpreted as the metamorphic equivalent of early post-rift Mn-rich radiolarian cherts of Middle Jurassic age. A typical gneiss-micaschist layered sequence up to 20 meter thick, lacking any evidence of pre-Alpine metamorphism, is often found between the Palaeozoic continental basement and the Mn-bearing quartzite. A similar lithostratigraphic association, with Palaeozoic continental basement overlain by syn-rift clastic sediments and post-rift Mn-bearing cherts and calc-schists, is typically found in distal thinned margins, such as those preserved in the Err nappe in the Eastern Alps. In those circumstances, continental basement is exposed at the seafloor during rifting at the footwall of low angle detachment faults.

The partial preservation on a regional scale of the rift-related relationships between rock units that underwent subduction to (U)HP conditions indicates that (1) the association of serpentinites and continental basement does not necessarily derive from chaotic counter-flow in a subduction channel, but may also be an inherited feature from the rifting history, (2) the lack of pre-rift sediments at the interface between continental basement and syn- to post-rift sediments is not necessarily a result of orogeny-related tectonic excision and (3) the process of tectonic burial and exhumation is not chaotic but large coherent blocks behave relatively rigidly, while well-defined movement zones accommodate most of the deformation.

G1-4 Orale Buttinelli, Mauro

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NORTHERN LATIUM (CENTRAL ITALY) CRUSTAL SETTING FROM RECEIVER FUNCTIONS ANALYSIS: HINTS FOR THE COMPREHENSION OF TYRRHENIAN POST-COLLISIONAL BACK-ARC EVOLUTION

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Key terms: Receiver Functions (RFs); Tyrrhenian extension; back-arc; Low Velocity Layer; Tolfa Domes Complex

A Receiver Functions (RFs) study has been carried out to unravel the crustal architecture of Northern Latium area (Italy) down to the Moho, a part of eastern Tyrrhenian Sea margin which deep setting have been not univocally addressed by previous studies.

Work was based on the analysis of teleseismic data recorded by a network of temporary and permanent stations deployed in that area.

Crustal structures have been investigated via harmonic analysis performed on computed and observed RFs, yielding the imaging of the 3D Vs characteristics beneath each receiver. This allowed to reveal both dipping interfaces and anisotropic layers.

What we observe is a generally thinned Tyrrhenian crust made of an upper sedimentary cover lying on a very fast anisotropic layer related to a metamorphic complex. Thinning and shallowing of the modeled features is more pronounced in north-western sectors.

Upper crust layers are located on top of a mid-crustal low Vs strongly anisotropic layer. In our model this is a mid-crustal inherited compressional shear zone, reactivated by the Tyrrhenian extension, which caused the decoupling of upper and lower crust.

This regional feature played a major role during the evolution of this portion of Tyrrhenian margin, also promoting and driving the development of the observed shallow extensional structures as syn and post-rift asymmetric basins, low angle normal faults, and the occurrences of early Tyrrhenian magmatism, characterized by volcanic intrusions.

In particular for the Tolfa Domes Complex, located in the study area, intrusions are represented by lower crust partial anatexis materials which slightly interacted with low mantle-derived fluids. We hypothesize that the intrusive volcanism of this southernmost part of the Tuscan Magmatic Province could be linked to the observed complex crustal arrangement and to its tectonic history related to Apennine and Tyrrhenian sea evolution.

G1-5 Orale Pepe, Fabrizio

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HYPER-EXTENDED RIFTED MARGIN IN THE TYRRHENIAN SEA, UPPER PLATE OF THE IONIAN SUBDUCTION ZONE

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Key terms: Southern Tyrrhenian Sea; Marsili Basin; Back-arc basin process; Continent-Ocean Transition Zone; Subduction zone processes

The Tyrrhenian Sea is a Miocene to Present back-arc basin developed in the upper plate of the Ionian subduction zone. Refraction seismic data indicate that the central sector of the Marsili Basin is a zone of thin crust ~7 km thick compatible with its oceanic origin (Steinmetz et al., 1983). Conventional models rather define a Continent-Ocean Transition (COT) with normal oceanic crust (i.e. Finetti et al., 2005). This does not seem to be the case for the whole Tyrrhenian Basin. Serpentinized peridotites, emplaced during Pliocene, have been drilled at ODP Site 651 (Sartori et al. 2004).

The W Calabria segment of the Tyrrhenian continental margin is peculiar as seismic data has excluded the presence of Miocene to Recent significant normal faults (Pepe et al., 2010). There is therefore a major question as to which structures were able to cause thinning and what does the oceanic domain look like. A possible answer is derived from the high-penetration Crop-M27 seismic line acquired along the COT of the W Calabria margin and the Marsili ocean itself.

The most surprising result is the discovery of tilted fault-blocks located within the area Marsili Basin considered as floored by oceanic crust. The blocks are generally 2-4 km wide and are composed of an acoustic basement which corresponds to the top of the Kabilian-Calabrian units and of a sedimentary cover unit that on the basis of their geometry we consider as pre-rift. The overall style of the block is comparable to dominos. The deposits filling the depressions between blocks are partly syn-rift and, more dominant, post-rift. With a very few exceptions, the infill completely smoothes out pre-existing topography and explain the very flat sea floor in the area surrounding the Marsili Basin. Its age was estimated as young as 0.45 Ma (Kastens et al., 1988).

A conceptual model for the evolution of the Marsili Basin was reconstructed along a NW-SE cross-section using seismic data and seafloor morphology (Marani & Gamberi, 2004).

Extensional tectonics during the Early Pliocene was active in the area of the future Vavilov Basin while, towards the SE, tectonics is dominated by contraction with thrust and reverse faulting.

Since ~4.2 Ma, extensional tectonics jump in the area of the future Marsili Basin. Extension tectonics affected a sector of the Kabilian-Calabrian chain and resulting in the formation of normal faults, mostly trending NNE-SSW and dipping to the NNW. The early stage of emplacement of oceanic crust was dated at ~1.8-2 Ma (Kastens et al., 1988). Extensional tectonics persisted until ~0.5 Ma resulting in the formation of ~80 km of oceanic crust and ~30 km of Continent Ocean Transition Zone with a thickness ranging from ~10 to less than ~7 km. Normal faults were active before and after crustal separation. Extensional tectonics ended ~0.5 Ma. However, this was not the end of the overall evolution of the Marsili Basin because from ~0.78 Ma to ~0.3Ma the Marsili seamount formed (i.e. Cocchi et al., 2009). The position of this volcano is not random and is probably controlled by deep transition between continental and oceanic lithosphere.

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G1-6 Orale Corrado, Sveva

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BURIAL AND EXHUMATION HISTORY OF THE APENNINIC-MAGHREBIAN CHAIN IN EASTERN SICILY BY MEANS OF THERMAL MODELLING

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Key terms: VITRINITE REFLECTANCE; CLAY MINERALOGY; APATITE FISSION TRACKS; THERMAL MODELLING; SICILY

The reconstruction of burial and exhumation history of sedimentary successions provides important time-temperature constraints to orogen dynamics, when integrated with the structural and stratigraphic records. The maximum paleo-temperatures and the exhumation rates of sedimentary successions cropping out in Eastern Sicily, obtained by means of paleo-thermal and thermo-chronological datasets and thermal modeling, is the object of this contribution.

In detail, the results concerning four main tectonic domains of the Apenninic-Maghrebian chain in the Eastern Sicily are presented. These domains are: the Peloritani Mts. Units in the internal zone of the chain; the Sicilide Units in the accretionary prism; the tectonic units in which the Numidian Flysch is deformed and the Mt. Judica Unit in the external zone of the chain.

In the Peloritani Mts., the integration of vitrinite reflectance and mixed-layered clay minerals with apatite fission-track and (U-Th)/He ages allows to define the paleo-geothermal gradient of the Stilo-Capo d'Orlando Fm. basin in Oligocene-Miocene times, to constrain its burial evolution and discriminate between areas where it has been affected by sedimentary and/or tectonic load. In the southern area of the basin, organic and inorganic thermal parameters increase as function of depth suggesting that their evolution is only ruled by sedimentary burial. They recorded a decrease in paleo-geothermal gradient values which marked the evolution of the basin from a fore-arc to a thrust-top setting during the convergence-collision process between the Calabria-Peloritani Arc and the African plate. Differently, in the northern edge of the basin, vitrinite reflectance values (ca.0.45-0.6%) indicate that tectonic burial occurred in this area related to a late Langhian-early Serravallian out-of-sequence thrusting.

In double-verging accretionary wedge made up of part of the Sicilide Complex (Mt. Soro, Troina, far-travelled Sicilide Units) and Antisicilide Unit, the integration of thermal indicators allowed us to distinguish portions of the Sicilide-Antisicilide (SA) accretionary wedge with different evolution. We recognised a warmer core -made up of Mt. Soro and Troina Units of the Sicilide Complex- and colder units: - back-thrusted toward the hinterland (Antisicilide Unit) and gravity-mobilised toward the Hyblean Plateau (far-travelled Sicilide Units).

In detail, in the Mt. Soro and Troina Units, apatite fission-track data were partially to totally annealed during wedge accretion and the subsequent exhumation occurred mainly in Burdigalian times. Apatite fission-track data on the Antisicilide Unit confirm low paleo-temperature values. Thus far-travelled Sicilide and Antisicilide Units were probably at higher structural levels in the original accretionary prism and were re-mobilised since late Aquitanian-Burdigalian times. For the Numidian Flysch thrust stack, an increasing level of diagenesis from the uppermost to the lowermost unit has been observed, never exceeding the mature stage of hydrocarbon generation. In the Mt. Judica area, the integration of X-ray diffraction (XRD) data concerning the illite content in mixed layer illite-smectite with data derived from Fourier Transform Infrared spectroscopy (FTIR) on H-rich organic matter allowed to constrain the burial-exhumation path of the Mt. Judica sedimentary succession cropping out in tectonic window in Eastern Sicily. Thermal constraints show that the Mt. Judica succession experienced temperatures between 100-130 °C in late diagenetic conditions with a general depth-dependent thermal maturity signature. As a whole, the Mt. Judica succession experienced maximum tectonic burial (ranging between 2.4 and 3.2 km) during the Middle Miocene as a result of the emplacement of the allochthonous Units atop it. The subsequent breaching phase and erosion during Pliocene times ruled out the Mt. Judica exhumation. This last tectonic phase did not overprint thermal maturity.

G1-7 Orale Maniscalco, Rosanna

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DEFORMATION OF MESSINIAN EVAPORITES AND THE STRUCTURE OF "COBBLESTONE" MORPHOLOGY IN THE CENTRAL MEDITERRANEAN

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Key terms: Messinian evaporites; deformation structures; cobblestone morphology; Ionian Sea; central Sicily

Evaporite formations can exert a strong control on the distribution and geometry of deformation structures in sedimentary basins (e.g. Jackson et al. 1995). In compressional tectonic settings, numerous studies interpret the role of evaporite formation, especially those formed principally of halite, as acting as regional detachment surfaces. In these settings halite (especially wet halite) is assumed to behave as a mechanically weak horizon, in accordance with its measured shear strength at geological strain rates compared to other sedimentary rocks (e.g. Jackson & Vendeville 1994). However, other evaporites show less extreme behaviour. While gypsum-anhydrite can show transient weakening (e.g. Olgaard et al. 1995), due to dehydration, in general it is stronger than poorly lithified sedimentary rocks. As many basins contain spatially-varying evaporitic assemblages natural zones of deformation might be expected to display significant variability in structural geometry and evolution. The purpose of our work is to investigate this proposition with respect to the development of basin-floor tectonic morphology imaged seismically in the Mediterranean Sea. This so-called "cobblestone" morphology is generally correlated with the top of Messinian-age evaporites (e.g. Rossi & Sartori 1981). These in turn show regional variations in composition. However, well-calibration of the seismic data is poor because of the technical challenges of research drilling through evaporite formations. Consequently we use outcrop data of broadly age-equivalent strata on Sicily to inform interpretations of seismic data acquired from the floor of the adjacent Ionian Sea.

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G1-8 Orale Lustrino, Michele

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CENOZOIC IGNEOUS ACTIVITY IN THE CENTRAL-WESTERN MEDITERRANEAN

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Key terms: Petrology; Geodynamics; Tectonics; Mediterranean; Geochemistry

Compared to classic collisional settings, the central-western Mediterranean area shows a range of unusual geological and magmatological features. These include: a) the rapid formation of extensional basins in an overall compressional setting related to Africa-Europe convergence; b) centrifugal wave of both compressive and extensional tectonics starting from a 'pivotal' region around the Gulf of Lyon; c) the development of concomitant Cenozoic subduction zones with different subduction and tectonic transport directions; d) subduction 'inversion' events (e.g., possibly along the present-day Maghrebian coast, in southern France and in northern Sicily, previously at the southern paleo-European margin); e) a repeated temporal pattern whereby subduction-related magmatic activity gives way to magmas of intra-plate geochemical type; f) the late-stage appearance of magmas with collision-related 'exotic' (potassic to ultrapotassic) compositions, generally absent from simple subduction settings; g) the relative scarcity of typical calcalkaline magmas along the

Italian peninsula; h) the absence of igneous activity where it might well be expected (e.g., above the hanging-wall of the Late Cretaceous-Eocene Adria-Europe subduction system in the Alps); i) voluminous production of subduction-related magmas coeval with extensional tectonic regimes (e.g., during Oligo-Miocene Sardinian Trough formation) or in the foreland of the Apennines; j) the overall geochemical and trace element similarities of "anorogenic"-type magmas, despite to the large temporal range of magma production (>70 Ma), the large area and the complex and variable tectonic evolution of the single districts. In such geologically complex areas, much care must be devoted in considering geochemistry of igneous rocks as the smoking gun for or against a given geological process.

G1-9 Orale Poli, Giampiero

10.1474/Epitome.04.0541.Geoitalia2011

PETROLOGY AND GEODYNAMICS: FINDINGS FROM EASTERN MEDITERRANEAN REGIONS

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Key terms: Petrology; Geochemistry; Geodynamics; Eastern Mediterranean

Subduction-related mantle derived melts in Mediterranean regions display large compositional variations. Focusing on mafic Tertiary plutonic and volcanic products cropping out on Eastern Mediterranean (Dinarides, Hellenides and Western Anatolia) and using major and incompatible trace elements as proxy to get insights on metasomatic events, it is shown that mafic melts ranging from calc-alkaline to shoshonitic and ultrapotassic are ubiquitous. This indicates the coeval occurrence of mantle derived melts with strongly different enrichments of incompatible elements and suggest that a heterogeneous mantle, able to generate such a rich compositional variability of melts, existed during Tertiary in the area.

The main question arises as to what processes may generate such an inhomogeneous mantle wedge. Numerical simulations of infiltration of metasomatic fluids into a lithospheric mantle wedge have been performed. We consider a fractured lithospheric mantle wedge in which metasomatic fluids, released by dehydration of the oceanic slab, infiltrate. For sake of simplicity we consider that fluids are constituted by only one "metasomatic agent" (e.g. K₂O). The fracturing of the mantle is assumed to be random. We also assume that fractures are always saturated with the metasomatic fluids and that metasomatism is developed by diffusion of such fluids from fractures to the surrounding mantle. Results show that the efficiency of the process is directly proportional to the density of fractures and this process resulted in coexisting portions of mantle that suffer metasomatism at very variable degrees, leading to a "leopard-skin" like mantle. Partial melting of such a heterogeneous mantle wedge is able to produce mafic melts with highly variable degree of enrichment of incompatible elements.

In the studied area two mantle source compositions can be considered just as two extreme end-members occurring in a mantle wedge able to generate melts spanning all intermediate potassium compositions. The first end-member can be interpreted to be derived by partial melting processes of a strongly metasomatized mantle source where K-rich phases, such as phlogopite, played a key role. The low contents of Al, Na, and Ca, and the high concentrations of compatible elements argue in favour of a restitic peridotitic source. The second mantle end-member shows higher Al, Na, and Ca contents, and lower contents of compatible elements, suggesting a derivation from a fertile metasomatized lherzolitic mantle source. On the basis of these considerations we suggest the presence, during Tertiary, of a metasomatized "leopard-skin" mantle wedge with high variable chemical compositions the partial melting of which may explain the wide compositional spectrum of mafic magmas in Eastern Mediterranean.

Mantle metasomatism and magmatism can be attributed to the complex geodynamic evolution of the area. We suggest that two subduction events metasomatized the same lithospheric mantle wedge from Early Jurassic to Tertiary in the Dinarides and Hellenides areas. In the Hellenides and South parts of the Dinarides, metasomatism was originated by fluids and oceanic sediments, whereas in the Northern part of Dinarides metasomatism was originated also by continental crust. There are systematic differences in the geodynamic evolution of Hellenides and Western Anatolia, probably associated to the presence of an asthenospheric mantle wedge, although metasomatism seems to be again linked to fluids and oceanic sediments. Partial melting of such heterogeneous mantle wedges originated mafic magmas, strongly different in geochemical characteristics, found in the studied areas.

G1-10 Poster Savelli, Carlo

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THE WEST MEDITERRANEAN/TYRRHENIAN SINCE THE OLILOCENE: POST-COLLISION DEVELOPMENT OF CALC-ALKALINE VOLCANISM AND BASIN FORMATION

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Key terms: calc-alkaline magmas; lithosphere extension; seafloor-spreading; subduction; post-collision evolution

Exam of the spatial and temporal features of post-collision calc-alkaline (orogenic) magmatism and episodic sea-floor spreading in the West Mediterranean/Tyrrhenian (WMT) might ascertain whether NW-directed subduction was initiated in the Oligocene or afterwards. Recognizing whether and how the pre-lateMiocene tectono-magmatic situation was different from the late Miocene - Recent might suggest an alternative to the commonly accepted concept of long-lived concomitance of orogenic volcanism and slab roll-back. A deep slab beneath the Tyrrhenian Sea was associated to the spreading events of the late Miocene (ca. 8 to 6 Ma; Vavilov basin) and late Pliocene (ca. 1.9 to 1.6 Ma; Marsili basin) which were characterized by absence or scarcity of peri-basinal volcanism. Post 1.2 Ma calc-alkaline and K-rich volcanics extending from the Aeolian islands and Vesuvius to the "Roman Province" and southern Tuscany (i.e. the Tyrrhenian active margin above the deep slab) showed small across-strike extent (ca. 100 km like that of volcanic arcs). By contrast, large across-strike extent (ca. 700 km, like the continental wide-rifts)

characterized the peak of silicic and tholeiitic volcanism and the continental lithosphere extension which occurred in Burdigalian (ca. 20 to 16 Ma) time along with sea-floor spreading of the Sardinian-Provençal (Hercynian European Plate) and north Algerian basins (western portion of Mediterranean Alpine Lithosphere - MAL). Such spreading and extension caused most likely the Burdigalian start of NW subduction, the inversion from upper to lower plate setting of the "north African" plate system and shift of the shortening mode from the MAL back-thrusting to the front-thrusting of the nascent Apennines-Maghreb belt. This tectonic inversion occurred after the Oligocene to Aquitanian (ca. 33/32 to 20 Ma) magmatism of silicic character associated with continental lithosphere thinning and back-thrust shortening (MAL). Also the Alps (s.s.) saw the Oligocene stop of shortening of the front thrusts. Generation of calc-alkaline magmas and lithosphere thinning of the Oligocene Alps were supplanted by early Miocene resumption of thrust shortening and SE subduction in the absence of magmatism. In the WMT post-Burdigalian to pre-late Miocene (ca. 16 to 8 Ma) orogenic volcanism was associated to shallow NW subduction. That pre-late Miocene calc-alkaline magmas were generated presumably by "lost" volcanoes of the eastern portion of MAL (the future Tyrrhenian Sea) is suggested by the large occurrence of pre-late Miocene allochthonous volcanoclastics in the Apennines. These rocks of calc-alkaline affinity are here studied jointly with the in-situ magmatics for the first time. This is in line with some authors' suggestions that the rocks and their "lost" emission centres were originally located in the Tyrrhenian segment of MAL. The source location of these rocks lacking of the corresponding emission bodies is a much debated dilemma. However, a solution of the source problem is linked to the identification of the major event of tectonic inversion that caused presumably the down-thrusting and burial of the emission centres as the corresponding volcanoclastics (past topographic "lows") were uplifted and preserved in the Apennine thrusts. The appropriate event of tectonic inversion might be the shift from upper to lower plate setting of the "north African" plate system which occurred in the Burdigalian. The peri-basinal abundance vs absence/scarcity of calc-alkaline magmas during sea-floor spreading, and the broad vs narrow across-strike extent of such magmas reflect significant changes of subducted lithosphere development in Burdigalian and late Miocene time which modify the concept of uniform slab-pull and concomitance of calc-alkaline volcanism and subduction. Eastward flow of uprising asthenosphere was probably linked to the WMT tectono-magmatic evolution.

G1-11 Poster Caricchi, Chiara

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PRELIMINARY RESULTS ON THE RECONSTRUCTION OF THE CENOZOIC THERMAL AND KINEMATIC EVOLUTION OF THE EXTERNAL PORTION TUSCAN NAPPE (NORTHERN APENNINES)

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Key terms: NORTHERN APENNINES; TUSCAN NAPPE; VITRINITE REFLECTANCE; PALEOMAGNETISM

Paleogeothermal and paleomagnetic analyses have been performed on the sedimentary sequences of the external area of the Tuscan Nappe (Northern Apennines), in order to give new constraints on the burial and tectonic history of this portion of the chain. In particular, this study can provide pieces of information on both the structural style and the timing of the emplacement of the Tuscan Nappe (Tuscan domain) onto the internal portion of the Marnoso Arenacea foredeep basin (in the more external Umbrian domain).

The Tuscan Nappe is made of the Scaglia Toscana (Eocene) and the Macigno (Oligocene-Lower Miocene) formations. The former consists of mudstones and wackestones of continental platform ramp; the latter consists of siliciclastic turbidites, deposited into foredeep basin during the chain building.

Paleogeothermal analyses have been focused on the Macigno Formation to derive values of maximum tectonic and/or sedimentary burial and to reconstruct the geometry of the foredeep basin and its tectonic evolution. Organic matter optical analysis dispersed on sediments (vitrinite reflectance, Ro%) displays indigenous vitrinite with reflectance values between 0.6 and 0.8% in the mature stage of hydrocarbon generation. These data suggest that sedimentary succession underwent tectono-sedimentary loads in the order of a few kilometers.

Paleomagnetism has been used to investigate both the Scaglia Toscana and the Macigno Formations in order to better define the deformational pattern and to reconstruct the rotational history of this sector of the chain. The Anisotropy of Magnetic Susceptibility (AMS) shows a primary sedimentary magnetic fabric, partially overprinted by a tectonic fabric. The magnetic fabric and in particular the NW-SE oriented magnetic lineation suggests a SW-NE regional compression. Paleomagnetic data indicate a counterclockwise rotation, according to regional trend of the Northern Apennines. Tectonic rotations may reach 120° (in the Scaglia Toscana Formation), values recorded for the first time in sediments of this age. Data from this study can be used as robust constraints for the understanding of the Northern Apennines evolution in the framework of the Western Mediterranean area.

G1-12 Poster Buttinelli, Mauro

10.1474/Epitome.04.0544.Geoitalia2011

TRACKING THE TYRRHENIAN EXTENSIONAL REGIME STEP-EASTWARD MIGRATION IN NORTHERN LATIUM OFF-SHORE AREA (ITALY): NEW INSIGHTS FROM SEISMIC DATA STRUCTURAL INTERPRETATION

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Key terms: Tyrrhenian extensional regime; stepward migration; Northern Latium; seismic data; structural interpretation

A revision of the available seismic reflection survey in the off-shore part of the northern Latium (central Italy) has been accomplished to better

understand the shallow structural architecture of the area.

The general stratigraphy is well constrained by an off-shore deep well, a discrete amount of deep wells in the on-shore part and by a voluminous bibliography. The stratigraphic succession of the area could be divided in four main groups of units, from top to bottom: Plio-Pleistocene post-orogenic marine deposits, Cretaceous-Oligocene sub-Liguride flyschoid units, Jurassic Tuscan Nappe mainly calcareous deposits (which also comprehends Triassic evaporitic formation) and a deep basement probably belonging to metamorphic units.

Seismic reflection data analysis show that this area was affected by at least two deformational phases. After the deposition of the Tuscan Nappe sedimentary units, the area underwent: i) an initial compressional phase associated to the early Apennine chain build up, with formation of compressional features as regional thrusts, back-thrusts and fold structures (within a compressive wedge and foredeep system development). These structures are clearly visible in the deep Tuscan Nappe and sub-Liguride units setting; ii) an extensional phase related to the spreading of the Tyrrhenian Sea, probably started in the late Miocene times. This caused the formation of several small and narrow graben and asymmetric half-graben basins, with NW-SE and NE-SW direction of elongation, which bases are defined by a regional unconformity surface on top of the pre-deformed basement. The sedimentation in there is characterized by the trasgressive deposition of late Miocene and Plio-Pleistocene conglomeratic-to-clayey units, separated each other by several unconformity surfaces. This architecture is similar to that already observed in the on-shore grabens and half-grabens basins, closer to this area.

The reconstruction of the horizons related to the passage between the post-orogenic sedimentary units, focusing on the progressive activation and de-activation of normal faults which affected this layers, make us able to track the stepward migration of Tyrrhenian extensional regime from western to eastern sector. Normal faults activity can be clearly followed from late Miocene when this interested the central part of the study area, while during Plio-Pleistocene it moved stepwise toward eastern sector until late Pliocene, when the area became almost stable and the extension migrated in the present on-shore areas. This process occurred in association with the formation of Tyrrhenian ocean, characterized by a first development of syn-rift basins in a general low stretching rate regime, and followed by post-rift sequences in a general high subsidence rate regime, especially for south-western sectors.

G1-13 Poster Albanese, Cinzia

10.1474/Epitome.04.0545.Geoitalia2011

THE DEEP STRUCTURAL SETTING OF CENTRAL SICILY BASED ON SEISMIC REFLECTION DATA. PRELIMINARY RESULTS.

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Key terms: central Sicily; seismic reflection profiles; Sicilian fold-and-thrust belt; structural style

Deep seismic reflection profiles covering the northern sector of central Sicily have been interpreted to shed light on a segment of the Sicilian-Maghrebian fold-and-thrust belt. The study area connects the widely studied central-western Sicily, characterized by a well exposed carbonate to terrigenous meso-cenozoic collisional complex (Catalano et al., 2000) with the eastern Sicily, where the meso-cenozoic tectonic pile is buried under a thick sequence of Neogene terrigenous covers overlying a late Cretaceous-Early Miocene pelagic succession (Bello et al., 2000).

The interpreted seismic lines cross the eastern sector of the Madonie Mt., from the northern Sicily coast to the northern edge of the Caltanissetta through. This sector is well constrained by several exploration wells: more than 10 wells were used to calibrate the seismic units, while field data have been used to correlate outcropping and buried bodies. At depth, the recently acquired SiRiPro (Sismica a Riflessione Profonda) profile, located in the western adjacencies, give insight about characteristics, extent and geometries of the deepest structural layers as well as their relationships with the related crustal segment (Accaino et al., 2010).

Results arisen from this integrated analysis have revealed the occurrence of the following structural layers:

° A strongly deformed uppermost layer, identified throughout the study area as a package of medium to high frequency reflectors reaching, locally, a thickness of about 1.8 s TWT. Field and well data ascribed this body to the Numidian Flysch (Oligo-Miocene) alternated and/or replaced by Varicoloured clays (Eocene?);

° A 1.3-1.5 s TWT thick body of medium to high amplitude reflectors bounded on top by a high amplitude, almost continuous horizon. The body, correlated by well data to the Meso-Cenozoic deep-water carbonate units (Imerese-Sicanian) is frequently faulted, doubled and/or arranged in stacked thrust sheets;

° A lower layer, identified at the top by a discontinuous and high amplitude horizon, locally recognized at a depth of about 4.0/4.5 sTWT. The bottom of this body, correlated for its seismic attributes to the Meso-Cenozoic carbonate platform units (Trapanese-Saccense) outcropping and/or calibrated by well data in adjacent sectors, is not always well defined.

The structural setting of these seismic bodies, well identified on the N-S trending transects, reveals the occurrence of N-verging high angle reverse faults interesting both the uppermost and the intermediate elements, reaching, at times, the lowermost one. S-verging reverse faults have been recognized, as well, in the same tectonic layers. The interaction with the two differently verging faults generated, locally, large dome-shaped structures while, in the NW sector of the study area, N-verging thin-stacked tectonic sheets, pertaining to the uppermost and the intermediate elements, are predominant. That suggest that backthrusts are the dominant features in the analyzed sector, pointing out a common structural styles connecting central-western and eastern Sicily. The new insights arisen substantiate the hypothesis that the development of backthrusts, recognized in the adjacent sectors (Albanese, 2008), do not only have a local implication.

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G1-14 Poster Balbi, Pietro

10.1474/Epitome.04.0546.Geoitalia2011

TECTONIC AND SEDIMENTARY RELATIONSHIPS BETWEEN TWO CRETACEOUS TURBIDITIC FORMATIONS IN THE ALPINE/APPENININE JUNCTION CONTEXT

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Key terms: Antola; Gottero; thrust; sedimentary

Within the complex, unclear and frequently discussed junction between the Alps and the Apennines, two cretaceous turbiditic, partially superimposed Tectonic Units outcrop: M. Antola and M. Gottero. The studied area is located in Oriental Liguria (Northern Italy) between the cities of Genova and Chiavari, where the Monte Antola Unit (Upper Campanian - Paleocene), the shallowest tectonic unit of the Ligurian stack, overlies the Internal Ligurian Units, particularly the Monte Gottero Unit (Valanginian - Paleocene). These two units are made up of Late Cretaceous Flysch, both calcareous and siliceous, and they show an intense pre-Oligocene brittle-ductile deformation followed by a mainly fragile deformation.

The recent bibliography shows an about N100° thrust that superimposes the Antola Unit on the Gottero Unit with a north-east bound movement, but an accurate and detailed field survey doesn't completely confirm this interpretation. Evidences of stratigraphic contacts between the Calcarei del M. Antola Formation and the hemipelagic rocks underneath seem to point to a slightly northward shift of the position of the thrust surface and, above all, to draw a new and deeper lithostratigraphy of the Unit that can help in reconstructing its Cretaceous paleogeography.

The above-mentioned hemipelagic rocks lie at the base of the Antola Unit and, for the time being can be informally named "Sanguinetto Member" and "Argillosisti di Maxena Formation". These rocks shows interesting lithological and temporal analogies with some basal formations of the Gottero Unit and respectively with the "Scisti Ardesiaci di M. Verzi Formation" and the "Scisti Manganiferi Formation".

Within this new scenery, the Gottero and Antola Units have an approximately coeval and partially common sedimentary history, followed by a similar succession of deformational events (mainly compressional, known as the "Ligurian Deformational Phases") during which the Antola Unit overthrusts the Gottero Unit. During these events, because of the thrust surface, the Antola Unit got folded into an antiformal shape while the Gottero Unit got its slight metamorphism (epizone) by being folded into a synform shape. It is actually possible to ascribe this deformation to the second brittle-ductile event which, in the Antola Unit, is followed by a third pre-oligocene event, as demonstrated by Corsi et al. (2001).

To a chain scale, these new data allow interpretation of the deformational history of these two Units, as it turns out to be mainly Alpine at least until the thrusting event, and it doesn't fit a complex tectonic and metamorphic path. The two mentioned Units probably formed at the same time and roughly the same area, Antola at a greater depth and Gottero closer to the continental margin, then they followed a similar geodynamical path except for the thrusting of the Antola Unit over the Gottero Unit. With the north-east bound migration of the Apennines compressional front, these Units were affected by a post-Oligocene extensional regime, that finally faded out into gravitative deformation.

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G1-15 Poster Scafidi, Davide

10.1474/Epitome.04.0547.Geoitalia2011

THE OCTOBER-NOVEMBER 2010 SEISMIC SWARM IN THE SAMPEYRE AREA (PIEDMONT, ITALY)

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Key terms: seismic swarm; Sampeyre; seismic network; waveform similarity analysis; strain rate

Last October, the area surrounding Sampeyre (Piedmont, Italy) was affected by an intense seismic activity, which evolved into an earthquake swarm. The word "swarm" is used here since no single earthquake in the sequence can be defined as the main shock. The whole seismic crisis lasted approximately one month, from October 13 to November 12, 2010. During this period, approximately 550 earthquakes were recorded and localized by the Regional Seismic network of Northwestern Italy - RSNI (<http://www.diptervis.unige.it/geofisica/>) in the study area. Among these events, 179 exceeded a local magnitude (M_l) of 1.0 but only two exceeded M_l 3.0 (the major event has a magnitude of 3.2). It is noteworthy that these two earthquakes occurred close to each other on two consecutive days, precisely on October 23 and 24.

The Sampeyre area is located in the inner part of the Dora Maira crystalline massif, which corresponds to the northern Tethyan margin (part of the stretched European continental crust) exhumed during the collision of the Eurasia and Africa plates. The Dora Maira massif consists of three main geological units of high-grade metamorphic rocks (gneiss, schists, eclogites): the Sanfront-Pinerolo unit, the Vanesca unit, and the Dronero-Sampeyre unit. The earthquake swarm took place in this area, more likely in continental crust (bulk crust) at a depth comprised between 5 km and 20 km. The analysis of various seismic sections, however, clearly indicates that higher magnitude events were confined between 10 km and 15 km.

The temporal evolution of the Sampeyre swarm reveals that most of the earthquakes occurred during the first 15 days since the beginning of the crisis. This period of intense activity was followed by an evident decay in the occurrence rate. A subsequent peak of activity was then recorded on November 11, when more than 40 events were generated in the area. In order to find possible correlations or similarity with previous earthquake activity, we analyzed the seismic history of the last 30 years. It reveals that the investigated area never experienced events comparable to that under study. Only in 1989, an intense aftershock sequence, but of shorter duration, took place in the Sampeyre area (approximately a tenth of events were recorded in two days). The strongest instrumental earthquakes, which occurred in January 1994 (Melle earthquake) and April 1998 (Oncino Earthquake) with magnitude 4.3 and 4.1, were neither preceded nor followed by intense activity. Also concerning the historical

seismicity, the area shows a generally infrequent activity characterized by low-magnitude events. The major shocks felt in Sampeyre were the 1905 Alta Savoia (I₀ = VIII-VIII MCS) and the 1914 Tavernetta (I₀ = VIII MCS) earthquakes but they did not produce any damage. Following a general description of the swarm evolution and the performances of the RSNI network, the study will present the results of a waveform similarity analysis, aimed to identify families of earthquakes belonging to common genetic sources. Results of a strain rate analysis will be also discussed, focusing on the release of seismic energy with time.

SESSIONE G2

Strutture geologiche e tettonica attiva in Pianura Padana e avanosso adriatica

G2-1 Key Lecture Valensise, Gianluca

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MAKING OUT THE INVISIBLE: THE CHALLENGE OF IDENTIFYING ACTIVE FAULTS IN THE PO PLAIN

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Key terms: Po Plain; Active tectonics; Blind faulting

When I was a young student in Earth Sciences I somehow got accustomed to the idea that the real Geology is only that seen in mountainous terrains, and that flatlands are by definition non-active portions of the Earth. It did not take very long to realize that I was completely wrong. The publication of "Hidden earthquakes" by Stein and Yeats disclosed to me a new set of scientific questions that could hardly be faced with traditional structural geology tools and approaches. When I started seeing alluvial plains simply as the result of the progressive submergence of a mountain chain by intervening sedimentary deposits, my entire perspective of active tectonics changed. The Po Plain is one of such drowned mountain chains - perhaps one of the most mysterious yet interesting ones.

The problem of understanding if and how the Po Plain may be underlain by large active and potentially seismogenic faults became a national issue in the 1970s, when the Italian government planned the construction of several nuclear power plants near the Po River or by its delta, along the Adriatic coast. The Po Plain has been the locus of significant and well known earthquakes of certain local origin, such as the 1570 Ferrara, 1624 Argenta and 1802 Soncino events, all having a magnitude close to 6.0, but its instrumental seismicity is rather limited. Extensive geophysical surveys carried out by the oil industry since the 1940s first revealed the subsurface structure of the Po Plain; still they returned little or no clues as to if and where modern tectonic activity is concentrated. Similarly, very little information on ongoing deformation could be obtained from conventional geological mapping.

The "living nature" of the Po Plain is indeed testified also by its recent evolution, and in particular by the recurrent modifications of its drainage network. This evolution is largely controlled by a combination of sedimentary and climatic processes but is then "modulated" by subtle differential elevation changes caused by the activity of some of the buried compressional structures imaged by exploration geophysics (commonly referred to as "blind faults").

Today we know that the faults and anticlines buried beneath the Po Plain hold a sizable seismogenic potential. We also know that through the ages they have controlled or triggered some of the most significant changes in the historical river patterns, such as the progressive northward migration of the Po near Correggio and Suzzara, the "Rotta di Ficarolo" of the 12th century, the abandonment of the city of Ferrara. Perhaps nowhere in Italy has tectonic activity had such a profound and lasting influence on trade, agriculture, population patterns and even languages. And the Po Plain preserves one of the most complete records of unambiguous albeit slow-paced active tectonic shortening and a unique example of converging orogens. So much for a region that traditional geologists would have considered inactive, uninteresting, and perhaps downright boring.

G2-2 Orale Maesano, Francesco Emanuele

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SLIP-RATES OF THE BURIED NORTHERN APENNINES THRUST FRONTS FROM 3D MODELING OF KEY GEOPHYSICAL HORIZONS (PO PLAIN, NORTHERN ITALY)

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Key terms: slip rates; po plain; Northern Apennines thrust fronts; 3D modeling; active tectonics

The Northern Apennines (NA) are a folded mountain chain with NNE convexity and vergence including a frontal and outermost structural belt buried under the alluvial sediments of the Po Plain, and an outcropping chain. The former is deformed by blind thrusts and folds that controlled the deposition of the syntectonic sedimentary wedges, with the Plio-Quaternary sequence locally up to 7-8 km thick. The fast sedimentation hid the growing structures, and, as a consequence, today there are few direct surface evidences of the possible ongoing activity of the thrusts. The buried thrust front of the Northern Apennines shows three main folded arcs: the Monferrato arc in the western part of the Po Plain, that underwent the minor amount of shortening; the Emilia arc in the central part, partly deformed during Messinian time and with its maximum activity during Middle-Upper Pliocene; the Ferrara arc located in the eastern part of the Po Plain, active from Late Pliocene to Pleistocene times.

Present-day activity of the buried frontal thrusts of the NA is testified by historical and instrumental seismicity, the latter characterized by contractional focal mechanisms, by the influence on the drainage network and faulting and folding of recent sediments. The historical and instrumental Italian seismic catalogues show that the southern Po Plain is affected by low to moderate seismicity, with M_{max} up to 5.8. The

borehole breakouts and the focal mechanisms both show Shmax oriented perpendicularly to the trend of the buried thrust fronts.

In this study we present 3D reconstructions of different sectors of the NA thrust front, referred to the Emilia and Ferrara arcs, supporting the evaluation of the late Tertiary and Quaternary slip rates of the NA thrusts. The subsurface data we collected and analyzed come from published cross sections, seismic lines, subsurface maps and borehole data. We used them to build well constrained and geometrically consistent 3D models where all data have been analyzed as a whole.

The models were built to obtain a reliable estimate of the decompaction history applied to a 3D cylindrical volume. For our analysis we chose sections located in the central part of each thrust, in order to prevent the effects of curvature and reorientation common along the fault tips. For each section some structural culminations were analyzed in order to restore the observed deformations and to calculate the relative slip rates. To restore the displacement along the analyzed structures and to calculate the slip on the fault planes, we used different methods: for faulted horizons we used the fault parallel flow algorithm; for fault propagation folds, we used the trishear algorithm; and for the shallower and unfaulted horizons we used an elastic half-space dislocation model of surface deformation.

The horizons we analyzed include the Messinian top horizons, the Zanclean, the Piacenzian and the Gelasian tops and, where possible, the Pleistocene intervals of the Quaternary Marino Supersynthem (Costamezzana Synthem, 0.9 My) and of the Emiliano-Romagnolo Supersynthem (Emiliano-Romagnolo inferiore Synthem 0.65 My, Emiliano-Romagnolo superiore Synthem 0.45-0.35 My).

GPS studies show that convergence between the African and European plates at the Italian latitude is going on with rates ranging between 3 and 8 mm/y, while velocity field solutions across the NA fronts show a compression of about 1 mm/y, increasing from west to east and related to the rotation of the Adria indenter around a pole located in western Alps. Our results indicate an increase of the slip rates toward the easternmost sections, in agreement with the GPS convergence data.

Moreover, the reconstruction of the evolutive history of the structural culminations both in the Emilia and the Ferrara arcs, highlights that the total deformation is partitioned between different tectonic structures that are active alternatively during different time intervals.

G2-3 Orale Scafidi, Davide

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GEOTHERMAL SIGNATURE OF TECTONOTHERMAL CRUSTAL PROCESSES: THE CENTRAL PO PLAIN CASE STUDY (ITALY)

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Key terms: Temperature measurements; Deep boreholes; Geotherm; Rheology; Po plain

The present structural setting of the Po plain (Italy) is the result of a polyphase tectonic deformation history beginning in the Late Cretaceous, which involved both the Alpine and the Apennine orogenies. Here we present a thermo-rheological study of the crust of the central Po Plain (approximately 44.5-45.7° N lat, 9.4-11.2° E long), which records the convergence of the Alpine and Apennine external fronts.

The present thermal regime of the crust is based on geological and geophysical data from oil exploration (Eni Exploration & Production). A set of temperature data from 37 deep boreholes (bottom hole, drill stem, and production test temperatures) is used to estimate undisturbed formation temperatures down to 6-7 km of depth. Best quality data are used to estimate linear geotherms, which are grouped taking into considerations the following factors: i) presence/absence of relevant fluid circulation (thermal convection), ii) conductive thermal refraction, iii) recent sedimentation, and iv) other disturbing tectonothermal processes (e.g., recent tectonics). The groups are dominated by thermal conduction only (Group 1, Pede-Alpine; Group 2, Pede-Apennine), thermal conduction + recent sedimentation effects (Group 3, Apennine foredeep), and thermal convection + other disturbing effects (Group 4, Anomalous zones).

Assuming reasonable corrections for Group 3 data, and not considering Group 4 data which cannot be used to infer undisturbed deep temperatures, the other geothermal data fall within the same range and provide a homogeneous thermal signal.

Temperature measurements in the upper ~7 km are used to constrain a 1D thermal model at the crustal scale, assuming averaged 1D geometries as a first approximation. The crustal section is simplified into four layers: molasse sediments, carbonate series, upper crystalline crust, and lower crust. The best fitting modelled geotherm gives an estimated Moho temperature of 620±80 °C. Using the estimated crustal structure and composition and the best-fitting geotherm, a representative strength envelope is obtained. Frictional sliding, high-pressure failure and power-law creep are considered as deformation mechanisms. The 1D strength envelope is compared with a depth profile of the hypocentral frequency (database period 1900-2010; International Seismological Centre). For hydrostatic and supra-hydrostatic pore pressures, the calculated total crustal strength of this sector of the Adria plate (not including the upper mantle contribution) is in the 1.8-2.5 TN m⁻¹ range. Considering also the lithospheric mantle contribution for hydrostatic pore pressures, the total lithospheric strength is estimated to be between 23 (wet peridotite) and 39 (dry peridotite) TN m⁻¹.

G2-4 Orale Ricciato, Angelo

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EVOLUTION OF THE ALPINE VENETIAN FOREDEEP ALONG THE SCHIO-VICENZA FAULT SYSTEM BY SEISMIC SECTIONS ANALYSIS

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Key terms: South Alpine; Schio-Vicenza fault system; Veneto foredeep; flexure

The aim of this work is to show how and when the NW-trending Schio-Vicenza fault system (SVFS) acted during the South-Alpine

deformation in the Veneto plain. The SVFS is an inherited Mesozoic to Paleogene extensional feature currently bordering to the west the Venetian foredeep. During the Neogene development of the foredeep, the SVFS was reactivated with sinistral transtensional kinematics, which vertical component of the offset should increase moving towards the chain.

The ENI database (2D seismic sections and wells) was used to map the SVFS. About 1000 km of seismic lines were interpreted and more than 10 wells were used to calibrate the seismic interpretation. Some selected seismic sections, sub-orthogonal to the main faults, were chosen to obtain geological cross-sections through depth conversion process. This phase involved the tracking and interpretation of the most important spotlights that previously have been recognized in the sections. Moreover, more sections were used to map the hanging wall cut-off of the faults related to the Messinian unconformity.

The collected data display a complex buried fault system that extends southward with a NNW trend until the Po delta. In the cross sections the faults (most of them NE dipping) show a vertical component with down-throw in its eastern side (hanging wall block). The fault system cumulative displacement decreases from the northwest (Schio area, where the fault crops out) to the southeast (Po delta). The main displacement occurred from Early to Middle Pliocene. The results confirm that the SVFS acted as a kinematic transfer of the Neogene shortening between the South Alpine front and the innermost Giudicarie front. In this context, the SVFS tract corresponding to the western border of the Venetian foredeep accommodated the subsidence induced by the foreland flexure with a prominent throw gradient increasing moving northwards.

G2-5 Orale Anselmi, Mario

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CRUSTAL AND UPPER-MANTLE STRUCTURES IN VENETIAN ALPS (NE-ITALY): INSIGHTS FROM LOCAL EARTHQUAKE TOMOGRAPHY (L.E.T.) AND RECEIVER FUNCTION ANALYSIS

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Key terms: Venetian Alps; Tomography; Receiver Functions; Seismicity; Subduction

In the past decades several studies were carried out regarding the geometrical and kinematic characteristics of the active faults in Italy. To this end, different areas where future large earthquakes are expected were identified. These areas were monitored with local seismic networks, in order to detect background seismicity.

In this work we present the results obtained by an integrated approach using both the local and teleseismic data acquired during a passive seismic experiment located in Venetian Alps (NE-Italy).

In this study we focus on 1) the definition of the three-dimensional Vp and Vp/Vs crustal structures using the local earthquake tomography (L.E.T.); 2) the characterization of the geometrical setting of the Adriatic-Europe plates margin at lower crust and upper mantle depths through the application of the Receiver Function technique.

In the period between June 2004 and May 2005 a dataset of 310 local and almost 600 teleseismic earthquakes have been recorded.

A subset of 130 local earthquakes has been selected to calculate a well-constrained 1-D velocity model of the area. From this 1-D velocity model we have performed a 3-D local earthquake tomography, using 1960 P and 560 S- phases of high quality arrival times.

Almost 350 teleseismic earthquakes have been selected to perform the Receiver Function's analysis. The data-set is displayed as back-azimuthal sweeps of RFs binned over 20 degrees of back-azimuth angle and 40 degrees of epicentral distance, centered at 90 degrees of epicentral distance, with a 50% of overlapping area between adjacent bins. A detailed image of the seismic signal pulses on both the radial and transverse components is obtained. The RF method is very suitable to identify positive and negative velocity jumps under the seismic stations, and dipping structures and anisotropic characters could be discerned too. Venetian Alps are an interesting training zone to be investigated by this point of view since they have been shaped by the geodynamic evolution of the doubly vergent subduction/collisional system, which is still poorly investigated.

Here we show that the upper crust is characterized by abrupt Vp and Vp/Vs variations, both vertical and lateral, due to the complexity of the geological structures. In particular, high Vp bodies characterizes the shallower 15 km depth, yielding the definition of the thrust system.

Seismicity is located in correspondence with the high Vp values close to the southern thrust structures verging toward to the Po Plain. Moreover the presence of two different Mohos belonging to the Adriatic and European plates, their relative geometry and position give new details about the deep structure of this sector of the Alps.

G2-6 Orale Busetti, Martina

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NEOTECTONIC ACTIVITY IN THE GULF OF TRIESTE (NORTHERN ADRIATIC)

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Key terms: neotectonic; Dinaric structures; northern Adriatic Sea

The setting of the Dinaric fault system and its neotectonic activity has been recently outlined in the Gulf of Trieste (Northern Adriatic), using 525 km of multichannel seismic profiles acquired in 2005 and 2009 by R/V OGS Explora.

The Gulf of Trieste area belongs to the northernmost part of the NW-SE oriented External Dinaric foreland. In particular, the gulf corresponds to the foredeep constituted by the flexured Mesozoic - Paleogene carbonate of the Friuli Platform, filled by the Eocene turbidites of the "Flysch", both outcropping onland. The Flysch has been intensively eroded from Late Miocene (Messinian) to the Pliocene, and is overlaid by Quaternary marine and continental sediment.

The presence of a Dinaric fault system in the Gulf of Trieste, which is linked to onshore structures, have been identified: it is represented by the following evidences: a) at the eastern coastal area, the Karst frontal ramp (Trieste Fault), presents a deformation zone of about 2-3 km wide and

with more than 1500 m of vertical displacement of the carbonates buried below the gulf and outcropping onland: b) across the gulf, the occurrence of Dinaric compressive/transpressive aligned features. In both structures, some fault strands affect the Messinian-Pliocene erosion surface with throws up to 30 m, and the Quaternary sediment.

The offshore occurrence of neotectonic activity provides new and unique information in the area, so far been considered tectonically quite inactive or poorly active, mainly because of the absence of evidence onland induced by the lack of data. Moreover, despite being surrounded by seismogenic zones (Dinaric faults in Slovenia and Croatia and also Alpine faults in the Friuli area), the Gulf of Trieste has long been considered to have low seismicity, as only low magnitude and shallow events have been reported by the historical and instrumental seismicity catalogues.

However, the occurrence of neotectonic deformation of the Dinaric thrusts, provides new insights into possible seismogenic activity. This is a key point in the re-evaluation of geological risks, as the area has recently been proposed as site for strategic facilities, such as nuclear power station and LNG (Liquefied Natural Gas) regasification terminal.

G2-7 Orale Donda, Federica

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STRATIGRAPHIC AND STRUCTURAL SETTING OF THE NORTHERN ADRIATIC SEA: A POTENTIAL LOCATION FOR CO₂ GEOLOGICAL STORAGE?

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Key terms: Northern Adriatic Sea; Multichannel seismic profiles; CO₂ geological storage

The Northern Adriatic Sea has been deeply investigated in the framework of several studies performed by various research institutions, mainly finalized to the reconstruction of the Quaternary stratigraphic evolution of this area. A comprehensive study of the sedimentary and tectonic evolution of the Northern Adriatic sea has been also performed by Eni, based on the integrated analysis of boreholes and 2D and 3D seismic data (Ghielmi et al., 2010; Fantoni et al., 2010).

In 2009, OGS has performed a geophysical survey ("Stratigraphic and tectonic Evolution of North Adriatic in the Plio-Quaternary"-STENAP 09) in the northernmost sector of the Northern Adriatic Sea with R/V OGS Explora. About 800 km of 2D multichannel seismic and Chirp profiles have been acquired, together with Multibeam data in selected areas, aimed at the reconstruction of the Plio-Quaternary evolution of this area.

Recently, the Northern Adriatic Sea has been also investigated as one of the possible sites for CO₂ geological storage. This is one of the major OGS research activities, thanks to its involvement in several European and National projects concerning the Carbon Capture and Storage (CCS). The STENAP 09 seismic profiles, together with the data of the available boreholes drilled in the area, have been then analysed also from the possible CO₂ storage perspective, since previous, basin-scale studies already highlighted the occurrence of suitable areas offshore the Northern Adriatic sea (Donda et al., 2011). Here, several hundred meter-thick turbiditic successions, mainly represented by the so called "Porto Corsini" and "Porto Garibaldi" formations, deposited during the Pliocene and Pleistocene and commonly host natural gas fields. They also contain deep saline aquifers that would have suitable characteristics for the application of the CCS techniques.

G2-8 Orale Menichetti, Marco

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THE ADRIATIC FOREDEEP STRUCTURES IN THE PESARO AREA

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Key terms: Adriatic sea; structural geology; seismotectonics; foredeep; Pesaro

The external portion of the Neogene foreland thrust belt of the umbro-marchean-romagna Apennines is buried by a thick clastic sequence pertaining to the Adriatic foredeep. The Pesaro area and related Adriatic offshore is characterized by an arcuate system of NE verging thrust sheets with at least two foredeep basins. Since Upper Oligocene, the nappes-troughs system of the Northern Apennines migrated discontinuously from West to East. During the Pliocene this system reached the Adriatic area and originated, and differentiated, several deeper major foredeep basins. These basins were progressively filled by siliciclastic sequences mainly supplied from NW, with a maximum subsidence deeper than 6000 m in the Pliocene time. The main shear zones are buried and their surface evidence is often faint because of the combination of fast sedimentation rate and low deformation rate. The geological interpretations of the structures in the Pesaro area are quite controversial with different views of geomorphological and geological structures. The deep structures described in the seismic reflection profiles mainly differ from thin-skinned to thick-skinned style of the deformation. The recent-to-current tectonic activity and the seismogenic potential of the area have been inferred from regional morphological analysis of drainage anomalies and from the altimetric evolution of the coastal terraces. Several A. consider an active compressional NE-SW stress field, computed from breakouts and focal mechanism and related to the thrust faults; others inferred an WSW-ESE oriented extensional or inactive stress field from geological data.

The geometrical and kinematic data derived from field survey are summarized in a new structural map of the Pesaro area. The stratigraphic analysis of syndepositional compressional structures related to the growing buried anticlines is combined with the geometry of the thrust sheets obtained combining seismic reflection lines with deep well logs. Several seriate cross sections permitted to discriminate the deformation rate of the thrusts sheets and the partitioning among them. The integration of all data allowed designing a new picture of the tectonic evolution of the area and recognizing the tectonically active structures. The M. S. Bartolo anticline between Pesaro and Gabcice is an arcuate complex structure with the axial direction oriented NW-SE, stretched in the southern part by N-S subvertical strike-slip faults. The anticline is asymmetric with a reverse NE limb, detaches over a sole thrust rooted in the Triassic evaporites. Several backlimb back-thrusts splay from the

Upper Miocene marls, in the SW part of the anticline forming a crestal syncline. The main thrusts and strike-slip faults are characterized by an offset of many hundreds of meters with cataclastic shear zones few decimeter thick. The kinematic analysis of these structures indicated a NNE-SSW oriented shortening direction. In the Pesaro off-shore a large syncline along the Plio-Pleistocene foredeep is affected by wrench and compressional structures related to the regional detachment. Few km towards NE, low-angle backlimb superficial thrusts seem to reach the upper part of the Upper Pliocene and the Quaternary stratigraphic sequence. The activity of this structure can be related to the evolution of the deepest part of the North Apennine front in the foredeep, where also the fluid pressure play an important role.

G2-9 Orale Conti, Alessia

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3D RECONSTRUCTION OF THE CENTRAL PERIADRIATIC BASIN (MARCHE-ABRUZZI ONSHORE SECTOR)

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Key terms: fold-and-thrust-belt; anticlines; 3D modeling; seismic lines

In the Central Periadriatic Basin (CPB) the more external anticlines of the Apennine thrust belt system are buried under a syn and post orogenic, Plio-Pleistocene, siliciclastic marine sequence; this sequence records the last tectonic phases associated with the E-migration of the Apennine chain [1] and it is partially deposited on wedge top position and partially in foredeep position [2].

In this study we proposed a 3D reconstruction of the main geological structures and surfaces recognized in the CPB basin through the interpretation of 2D seismic lines, constrained with well logs and surface geology.

The structural setting pointed out is characterized by two main N-S buried tectonic trends: the Nereto-Bellante trend (NBT), located in the western portion of the basin, close to the outcropping front of the chain, constituted by the Teramo thrust [3]. A lower thrust, the Villadegna-Costiera trend (VCT), constitutes the footwall and the lower ramp of the Struttura Costiera Anticline (SCA) [4], located along the present coast line. They are characterized by deeper ramps in the carbonate sequence, long flats developed at their top, and shallower ramps and related anticlines involving the Plio-Pleistocene siliciclastic sequence.

The 3D reconstruction allowed us to correlate these main trends along strike, revealing a variation in the geometric relationships, in the displacement and in the chronology of deformation.

The NBT reaches the maximum displacement and structural elevation in the northern sector, whereas the VCT shows a regional northward axial plunging and progressively becomes the main trend moving to S, where maximum displacement is observed. The activity of thrusts results diachronic along strike: the frontal thrust of the NBT shows a main activity from the G. punctulata Zone until the G. inflata Zone, older in the southern sector. The VCT was active during the G. margaritae - G. punctulata Zones, and continued to propagate forward forming the SCA in the foreland, during the Lower-Middle Pliocene; this latter structure shows a deformation younger toward the N, where the Upper Pliocene deposits are folded at the top of the anticline, suggesting that the final activity postponed until the Late Pliocene.

A W-E cross section crossing the described structures was depth converted. Forward restoration of the SCA shows a progressive reduction from Middle Pliocene up to now of strain rate and uplift rate of this fault-related anticline. The restoration of the complete geological section led to a total shortening of about 13% corresponding to 6 km on a section of 52 Km of length.

On the same cross section hypocenters and trace of the seismogenic sources provided by DISS database [5] were projected, in order to attempt a correlation between the main trends and the seismicity distribution detected in the area. A pretty good correlation between the lower ramp of the VCT and the trace of the seismogenic source ITC5020, and between the upper ramp of the same trend and the ITC5054 seismogenic source, is observed.

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SESSIONE G3

Il ruolo della morfotettonica nello studio della tettonica attiva

G3-1 Key Lecture Faccenna, Claudio

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TOPOGRAPHY OF THE CALABRIA SUBDUCTION ZONE (SOUTHERN ITALY): CLUES FOR THE ORIGIN OF MT. ETNA

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Key terms: Subduction; Calabria; uplift

Calabria represents an ideal site to analyze the topography of a subduction zone as it is located on top of a narrow active Wadati-Benioff zone and shows evidence of rapid uplift. We analyzed pattern of surface deformation using elevation data with different filters and showing the existence of long wavelength (>100 km) relatively positive topographic signal at the slab edges. The elevation of MIS 5.5 stage marine terraces supports this pattern, although the record is incomplete and partly masked by the variable denudation rate. We performed structural analyses along the major active or recently reactivated normal faults showing that the extensional direction varies along the Calabrian Arc and laterally switches from arc-normal, within the active portion of the slab, to arc-oblique or even arc-parallel, along the northern and southern slab edges. This surface deformation pattern was compared with a recent high resolution P-wave tomographic model showing that the high seismic velocity anomaly is continuous only within the active Wadati-Benioff zone, whereas the northern and south-western sides are marked by low velocity anomalies, suggesting that large-scale topographic bulges, volcanism, and uplift could have been produced by mantle upwelling. We present numerical simulations to visualize the 3D mantle circulation around a narrow retreating slab ideally similar to the one presently subducting beneath Calabria. We emphasize that mantle upwelling and surface deformation are expected at the edges of the slab, where return flows may eventually drive decompression melting and the Mount Etna volcanism.

G3-2 Orale Furlani, Stefano

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LATE HOLOCENE EVOLUTION OF THE KARTALINI BASIN (GEORGIA)

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Key terms: Geoarchaeology; Tectonic evolution; Georgia

Archaeological and geomorphological data are useful in studying Holocene rivers because of the close relations between the presence of water and human settlement. In addition, the presence of active tectonics could have heavily conditioned both the geomorphological evolution and the development of human settlements.

In this study we aim to outline the late Holocene evolution of the Aradeti Orgora site, through the analysis of archaeological and morphological data. The site is located in the Transcaucasian basin, historically characterized by active tectonics.

The study area is located in the Shida Kartli Region, a hundred kilometres westwards from Tbilisi. The Kura River crossed the area following a NNW-SSE direction, while the Liakhvi River represents an important tributary, whose junction with the Kura is located near the town of Gori. The site of Aradeti Orgora-Dedopoli Gora is located at the junction of a system of rivers (Kura, Western Prone, Eastern Prone). In particular, Aradeti Orgora lies on an isolated portion of the fluvial terrace (660 m a.s.l.), about 20 meters above the recent Kura floodplain.

The site hosted an important settlement Roman/Medieval in age, which was excavated by Georgian archaeologists under the direction of prof. Julon Gagoshidze. The archaeological horizons are underlain by a long sequence of earlier levels, which date back at least to the late 4th millennium BC, and are still virtually unexplored.

The stratigraphic analysis was carried out on an exposed section on the southern sector of the terrace slope, where the archaeological levels are superimposed to an alluvial stratigraphy related to the Kura River and its tributaries. Three main archaeological horizons have been identified:

- 1) An Early Bronze Age level characterized by a sequence of layers with abundant pottery and ceramics fragments of the Kura-Araxes and Bedeni periods (late 4th-mid 3rd millennium BC) in a muddy matrix. Radiocarbon dating of a wood fragment from the base of the sequence yielded the age of the layer ($\pm 1\sigma$ 3025-2920 BC.). The level had been buried by a coarse alluvial event characterized by 1,5 m thick gravel body;
- 2) a Late Bronze Age layer characterized by muddy matrix with abundant pottery fragments;
- 3) a Roman Age and later layer at the topmost part of the site, characterized by abundant pottery and brick fragments.

The presence of coarse alluvial deposits between the two Bronze Age levels indicates a channel fluvial activity on the terrace after 4300 BP.

We suggest two possible hypothesis about the drainage evolution:

- a) The gravel layer covering the Early Bronze Age could represent the last phase of aggradation of the Liakhvi alluvial fan and its progradation toward south. Subsequently the deepening of the Kura riverbed and its northward migration triggered the small incisions of the trenches surrounding the site. The Roman Age site was probably chosen for the isolated position derived from the geomorphological evolution of the terrace. According to the present difference in elevation between the Liakhvi alluvial surface and the present Kura riverbed, the estimated total erosion is about 5 mm/year, that is the result of a joined effect between river incision and active uplift of the area.
- b) The gravel layer may be ascribed to a palaeo-Kura running waters. After about 4000 BP, the Kura was forced to migrate toward south because of an active uplift of the Transcaucasian region. In this case, most of the 20 metres in the elevation difference between palaeo and present Kura should be related to tectonic activity.

The importance of tectonic activity in the area is furthermore supported by the high seismicity of the Transcaucasian Basin and the low fluvial erosion expected in a time span in which no great climatic changes occurred. Local uplift within the basin possibly related to a contractional step-over along the Borjomi-Kazbegi fault zone or the southern propagation of the Greater Caucasus belt.

G3-3 Orale Volpi, Valentina

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MORPHOLOGICAL FEATURES OF THE APENNINES FORELAND/ACCRETIONARY - WEDGE BOUNDARY IN THE SALENTO OFFSHORE, FROM RECENTLY ACQUIRED GEOPHYSICAL DATA.

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Key terms: multibeam; seismics; Apulian foreland; Calabrian Arc

The investigated area is located in the Ionian offshore of Puglia (southern Italy). Recently acquired multibeam and seismic data provide new information regarding the morphological and structural processes that involved the Apulian foreland and the Calabrian arc from Mesozoic to Present. Multibeam bathymetric data were acquired by the R/V OGS Explora in three successive campaigns, November 2003, August 2005 and the latest on October 2010 where five regional multichannel seismic profiles were also collected.

Based on the integrated analysis of the available data, we produced a geo-morphological map of the deep Ionian basin.

The tectonic domains in this area are the Calabrian accretionary wedge and the Apulian foreland. The contact between the two domains, oriented NW-SE, morphologically coincides with a NW-SE trending sea-bottom erosional channel (Taranto canyon) characterized on both sides by mass movements induced by slope instability.

The accretionary wedge/Apulian foreland boundary presents a different morphology from NW towards SE (o direttamente from NW to SE), which is controlled by the different structural setting induced by the relationships between the accretionary wedge and the foreland as interpreted on seismic profiles. Moreover, the canyon pattern appears to follow the changes of the slope morphology, with an erosional activity increasing going from NW to SE.

New processed seismic data highlighted the presence of fluid migration paths, sometimes up to the seafloor, suggesting the presence of gas. The geological-structural setting of the area, characterized by evaporites and transtensional features, is particularly favourable to the accumulation of gas. In fact, Messinian evaporites are generally considered to play a major role in controlling mud volcanism. The fluid flow occurs through the vertical conduits, represented by the distensive faults, which is highly possible in this tectonic regime characterized by thrusting and backthrusting of the Calabrian accretionary wedge.

G3-4 Orale Santoro, Enrico

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DETECTING AND MODELING ACTIVE STRUCTURES IN NORTHERN CALABRIA: NEW INSIGHTS FROM DRAINAGE NETWORK MORPHOMETRIC ANALYSIS.

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Key terms: morphometric analysis; knickpoints; active transpression; North-eastern Calabria

The longitudinal profile of bedrock channels may yield valuable information about the landscape vertical deformation processes. In this study, inspired by previous results obtained through the mapping of the marine terraces and the reconstruction of the relative paleo-shorelines, we have performed a detailed morphometric analysis of the drainage network on the eastern side of the Pollino mountain range, Calabria, Southern Apennines frontal area. The uniform coastal lithology and climate allow us to isolate the tectonic signal from the fluvial morphometric analysis.

Along the Pollino coastal range, marine terrace paleo-shorelines show the superposition of two small-wavelength and amplitude undulations superposed to the regional uplift. These local undulations were interpreted as fault-propagation folds by performing fault numeric models of blind thrusts.

The morphometric analysis was carried out to test and improve the above mentioned deformation model. Linear regressions of the logarithms of channel gradient and drainage area data across the bedrock channel region were used to find knickpoints (kps) and to determine, the concavity

index (Θ) and the steepness index (ks).

Because of DEM (10x10 m) elevation errors, the rivers longitudinal profiles were corrected averaging the elevation through a mobile 200 m window. In order to compare channels characterized by different drainage areas, a

fixed reference concavity ($\Theta = 0.45$) was used in order to calculate a normalized steepness index (ksn). The ksn values increase regularly toward the anticlines; in other words, the rivers flowing through the areas that are affected by the higher uplift rates tend to establish a steeper longitudinal profile in order to have the energy sufficient to erode the uplifting tectonic barrier.

Several kps were detected along the longitudinal profiles of the trunk streams. Being the analyzed rivers adjusted to the sea level, it is reasonable to hypothesize that some of the kps are related to the Quaternary eustatic cycles. To test this idea, for each knickpoint (kp) the reconstruction of the interglacial profile was performed through the ks and

the Θ values calculated for the respective river. An eustatic origin was considered valid if: 1. the paleo-longitudinal profile crosses a marine terrace; 2. at least three kps are related to the same marine terrace (same eustatic regression); 3. the kps correlated to the same eustatic cycle are characterized by migration rates and positions that are in direct relationship with the landward drainage area. Besides, for some of the kps the eustatic origin is confirmed by the presence of fluvial terraces aligned with the relative paleo-longitudinal profiles. The fluvial terraces are, reasonably, the consequence of the erosive wave triggered by the eustatic regression and progressively transmitted to the entire drainage basin through the kp landward migration. Generally, the elevation of an eustatic kp is influenced by the drainage area (migration rate) and the trunk stream longitudinal gradient. As a consequence, holding constant the drainage area the kp elevation can be influenced by gradient changes determined by differential uplift rates. In the study area this theoretical prediction is perfectly confirmed: all the kps related to the same marine terrace are always characterized by an increase of the elevations toward the modelled anticlines. Finally, based on the migration rates, it was possible to determine the

drainage network response time considered to be the time necessary for a k_p to migrate through the entire drainage basin. All the analyzed rivers show a low response time (~ 10 ka) that highlights the youthfulness of the detected tectonic deformation.

The longitudinal profile analysis have permitted to confirm the results independently reached with the marine terraces and the fault modelling, evidencing that compressional regime is still active in this sector of the Southern Apennines.

G3-5 Orale Olivetti, Valerio

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COSMOGENIC EROSION RATES AND RIVER PROFILES APPLIED TO DECIPHERING QUATERNARY LANDSCAPE EVOLUTION OF THE SILA MASSIF, CALABRIAN ARC, SOUTH ITALY

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Key terms: cosmogenic erosion rate; river profile; uplift; Calabrian Arc

The topography of orogenic belt results from the competition between tectonic and surface processes. This competition is mostly controlled by fluvial erosion through lowering of valley bottoms, which in turn controls hillslope processes and maximum mountain peak elevation. The sensitivity of the river system to climatic and particularly to tectonic perturbation makes the fluvial network a potential source of information about tectonic forcing on landscape.

The Sila Massif in the Calabrian Arc (southern Italy) is a key site to study the response of hydrography to rock uplift. Herean uplift of around 1 mm/yr imparted a deep imprint on the Sila landscape recorded by a high standing low-relief surface on top of the massif, deeply incised fluvial valleys along its flanks, and flights of marine terraces in the coastal belt. In this framework, we combined the longitudinal river profile analysis with the hillslope erosion rates calculated by ^{10}Be content in modern fluvial sediments to reconstruct the long-term uplift history of the massif. The analyzed river profiles exhibit a wide range of shapes diverging from the commonly accepted equilibrium concave-up form. Generally, the study river profiles show two or, more frequently, three concave-up segments bounded by knickpoints and characterized by different values of concavity and steepness indices. Cosmogenic data show a large variation in erosion rates, marking two main domains. The samples collected in the high standing low relief surface atop Sila provided low erosion rates (from 0.09 ± 0.01 to 0.13 ± 0.01 mm/yr). Conversely, high values of erosion rate (up to 0.92 ± 0.08 mm/yr) characterized the incised fluvial valleys on the massif flanks. This wide variation in cosmogenic erosion rates and the non-equilibrated river profiles suggest the Sila landscape is in a transient state of disequilibrium in response to a strong and unsteady uplift not yet counterbalanced by erosion.

G3-6 Orale Tansi, Carlo

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STRIKE-SLIP ACTIVE TECTONICS AND SOIL GAS RADON CONCENTRATION AT THE NE BORDER OF THE CALABRIAN ARC (SOUTHERN ITALY)

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Key terms: strike-slip tectonics; seismotectonics; Calabrian Arc; radon concentrations

A regional NW-SE left-lateral strike-slip with strong reverse components fault system deeply conditioned the post-Tortonian evolution of northern Calabria during the last stages of post-collisional processes which involved the Apulian block and the Calabrian Arc (Tansi et al., 2007). This system dissects and contributes to the raise an Oligocene-Early Miocene orogenic belt made of Alpine nappes overthrust over the Apennine Chain. The above mentioned system locally inverted the former geometric relationships between the units of the orogenic belt.

In this paper, superficial effects - in terms of morphology, geometry and kinematics of the structures - linked to the above mentioned regional fault system, were defined in detail through interpretations of aerial photographs and field surveys. Measurements of structural data comprise orientations of more than 500 fault planes with slickensides, gathered from 54 measure stations located along the main faults, within the cataclastic belts. Such data allowed the determination of the associated stress field (according to Angelier, 1979, method), and the in situ validation of the regional deformational model.

As atmospheric and near-surface gas concentrations are considered as background values, while concentrations conducted by faults and fractures are considered as anomalous, analyses of gas emanations is a useful way of detecting faults and of identifying possible earthquake precursors (Ciotoli et al., 1993; Klusman, 1993; King et al., 1996; Torgersen and O'Donnell, 1991). Radon gas, the isotope of which (^{222}Rn) is used in this paper, is especially useful in such work because it is inert. The movement distance of radon through the subsurface depends on diffusion rate, permeability, and the half-life of ^{222}Rn (3.824 days).

Finally, the obtained structural scheme were compared with macroseismic fields of the main earthquakes, instrumental seismicity and focal mechanism, and the soil gas radon concentrations, to infer some information about the present activity of the faults.

According to seismological, structural and morphological data, described in the present paper, an extension of the activity of the left-lateral strike-slip system up to Present seems reasonable. Moreover, when taking into consideration the regional extent and the hierarchical order of the system, together with its kinematic characteristics, it can be stated that, in NE sector area of the Calabria, sectors exposed to the highest seismic risk are those affected by the NW-SE shear zone.

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G3-7 Orale Gennaro, Carmelo

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DETECTION OF PLIO-QUATERNARY FAULTS IN MADONIE MOUNTAINS (SICILY) BY USING QUANTITATIVE GEOMORPHIC AND STRUCTURAL GEOLOGY ANALYSES

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Key terms: QUATERNARY TECTONICS; STRUCTURAL ANALYSES; QUANTITATIVE GEOMORPHIC ANALYSES; NORTHERN-CENTRAL SICILY

The Northern Madonie Mountains (Northern-Central Sicily), sector of the Sicilian Maghrebic chain, consist of a tectonic thrust system developed through two subsequent main contractional events: 1) a shallow-seated compressional event developed during the Middle-Upper Miocene; 2) a deep-seated transpressional event occurring since the Late Miocene. Lower Pliocene (Trubi) to Quaternary clastic deposits unconformably lie on the tectonic units and are partially involved by deformation.

In the selected area, syntectonic sedimentary basins characters are able to define the timing of deformation only until the Lower Pliocene; to resolve this gap of information application of quantitative geomorphic techniques, based on relationships between tectonics and hydrographic network development could contribute to recognize and characterize Quaternary structures in areas where clayey/marly deposits, widely outcropping, are not marked by pervasive tectonic deformations.

In order to define the geological setting of the study area and to detect Quaternary tectonic structures, geological, structural and geomorphological analyses have been carried out.

Geological and structural analyses have shown:

1) characters and style of deformation of fold structures: two main systems of folds have been recognized - the early system NW-SE-trending is refolded by a later system (trends in the E-W to NE-SW range); 2) orientation and kinematics of faults related to superimposed compressional events: an early thrust system characterized by SW-ward tectonic transport; a later transpressive system consistent with a maximum compression oriented N-S $\pm 20^\circ$, and nearly horizontal. Although the occurrence of two compressional deformation events, interplaying in the construction of the Sicilian chain, is well-known, the field data, here collected, help to better characterize the relationship between shallow-seated and deep-seated structures.

Due to rare and thin Quaternary deposits, quantitative geomorphic analysis has been performed on the hydrographic network of the study area, because the river drainage of Sicily is believed to have developed during the Quaternary age. In particular, have been carried out:

1) azimuthal distribution analysis, by cumulative length, of stream channels related to different orders, taking into account structurally and lithologically homogeneous areas to evaluate the influence of Quaternary tectonics on the geometry of drainage patterns; NNW-SSE, NNE-SSW, E-W and N-S domains have been evidenced in lower orders of channels; 2) "azimuthal transect method", performed along 16 suitable segments crossing previously inferred fault zones, able to detect possible Quaternary strike-slip kinematics. Progressive apparent rotations of stream channels have been found, documenting the occurrence along the main rivers of Quaternary faults and suggesting both right-lateral (NNW-SSE oriented) and left-lateral (NE-SW oriented) kinematic components.

The multidisciplinary approach used suggests the geological/geomorphological setting of the study area is influenced by Quaternary faults with strike-slip component, highlighting a general congruency between hydrography and tectonics.

G3-8 Orale Ristuccia, Gloria Maria

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OSL DATING OF QUATERNARY TERRACES BETWEEN MT. ETNA AND THE CATANIA PLAIN

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Key terms: Anticline; Mt. Etna; OSL dating; Pleistocene; Terraces

In the hills of Terreforti, located between the Catania Plain and the southern slope of the Mt. Etna, the Quaternary sedimentary substratum of volcano, composed of a Lower-Middle Pleistocene foredeep succession, crops out.

The basement is folded in a E-W trending anticline, which has been interpreted as a fault propagation fold at the front of the Maghrebic thrust system.

This sequence consists of about 600 m of marly clays followed by a few tens of meters of coastal sands and fluvio-deltaic conglomerates. These last are assigned to the Mindel-Riss interglacial stage, which rest unconformably on the terraced fluvial-coastal deposits.

In this area, there are evidence of the Etnean submarine to subaerial fissural early activity, represented by products of tholeiitic-transitional affinity (pre-Etnean volcanism). This phase is coeval or next to the deposition of the Etna substratum sediments. Potassium - argon (K/Ar) method have allowed to date (320-250 ka) the lava flows outcropping at the top of the oldest terrace (T1).

This work has consented, through structural survey and aerial

photographs at a 1:33000 scale, to identify seven orders of terraces between Mt Etna and the Catania Plain. In particular, the terraced deposits of the two higher orders, were deformed with the foredeep sediments. The present results are related to the chronology of the terraces obtained by the Optically Stimulated Luminescence (OSL) technique. From the intensity of luminescence emitted by quartz and feldspar crystals content in the sediment, the OSL is used to determine the total dose absorbed since the last optical bleaching in terms of Equivalent Dose (ED). The accumulation rate of total dose is assessed measuring the natural radioelements present of the sample in order to calculate the Annual Dose (AD). The relationship between ED and AD can be traced to the bleaching event that, in the case of sedimentary layers, corresponds with the age of formation.

The outer layers of each sample have been used in the laboratory for radioactivity measurements and water content determination; while the ED values were determined using the single aliquot regeneration protocol (SAR) coupled with coarse grain sample following the PH3DRA laboratory standard methodology.

OSL ages have allowed the correlation of coastal alluvial terraces with different isotopic stages corresponding to high-stands of the eustatic curve of reference. The results agree with data reported in the literature, based on the attribution of volcanic clasts contained in the terraced deposits to different Etnean volcano-stratigraphic units. This work has permitted the reconstruction of the tectonic evolution of the area of interest during the Middle-Upper Pleistocene, constraining in time the structures which deform the deposits.

G3-9 Orale Pace, Bruno

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CONSTRAINING THE SLIP RATE OF ACTIVE FAULTS ON MT. ETNA USING COSMOGENIC HE EXPOSURE DATING OF LAVA FLOWS

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Key terms: Mt. Etna; Cosmogenic Helium; Pernicana fault; surface exposure dating; seismic hazard

Mount Etna, Sicily, is located in a complex geodynamic position. It is situated at the intersection of the outer front of the Quaternary S-verging Apennine Maghrebian thrust, and N-S oriented extensional structures formed in response to a possible reactivation of Malta Escarpment. Extension mainly affects the eastern side of the volcano where the flank is sliding eastward. The Pernicana fault system (PFS) is one of the most important active structures of the eastern side of Etna and represents the northern boundary of the unstable flank of the edifice. It is a W-E left transverse fault that is down-thrown to the south. It has been active since late Pleistocene-Holocene time, it cuts basaltic lavas over a length of about 18 km, with a maximum throw of about 30 m. The system is a complex of dextral en echelon segments with an overall direction of N°110 E. The western and central sectors of the fault are characterized mainly by stick-slip behaviour with occurrence of several recent earthquakes over magnitude 4.0 (e.g. 2/04/2010, M = 4.2). The eastern part of the system is characterized by stable-sliding motion with aseismic creep phenomena. Slip rate data are mainly based on geodetic levelling (~20 years of measurement) and anthropic displacement measurements (from ~1920 A.D. to present) on the central part of the fault with a values range between 5 and 35 mm/yr. In the western sector, slip rates between 5 and 20 mm/yr have been determined from the displacement of historical lavas (from 1614 A.D. to present). In order to accurately determine the vertical displacement rates of Pernicana fault we have initiated a program of dating lava flows that are cut by the fault using in situ cosmogenic ³He (³HeC) exposure ages. Effort has been concentrated on the western sector of Pernicana fault where the normal component of fault movement dominates. The first site chosen is in a basalt flow near Mongibello that is cut by a 13 m fault scarp. Pyroxene phenocrysts were extracted from 3 samples of uneroded lava flow tops taken from the hanging wall of fault scarp. Helium isotope ratios in the melt step are between 7.5 and 22.5 Ra indicating that ³HeC is present in all the samples. Exposure ages range from 0.9 to 1.2 kyr (n = 6), yielding an average age of 1,088 ± 96 years (that includes uncertainty in ³HeC production rate). This suggests that the western sector of the PFS has had an average vertical slip rate of 11-12 mm/year over the last 1,000 years. The measured slip rate is consistent with previous values, but more dating work is underway to calculate the slip rate in an enlarged temporal window (few thousand years) with the aim of understanding the fault behaviour in the past and improving predictions of earthquake occurrence, i.e. reducing the uncertainties on the expected mean recurrence times.

G3-10 Poster Ferranti, Luigi

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Holocene Coastal Uplift at Capo Vaticano, Calabria: Implications for Differential Deformation Rates

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Key terms: Holocene uplift; paleo-earthquakes; Capo Vaticano

Capo Vaticano promontory is located along the Tyrrhenian coast of central Calabria, and, as part of the Calabrian arc, experienced sustained Quaternary uplift, reflected by flights of coastal terraces (Bianca et al., 2011, and references therein). In addition, the area is affected by active extensional faulting and strong historical earthquakes (Cucci and Tertulliani, 2006). Although long-term uplift has been studied since long, data on Holocene coastal deformation, which could provide vital information to assess active tectonic processes, are sparse (Antonoli et al., 2009). Previous studies identified a NE tilt of the promontory as reflected by a NE-decreasing elevation of marine terraces. On the SW side of Capo Vaticano, the tilt pattern is interrupted and terraces margin are offset by an extensional faults system, made of two branches (Coccorino and Nicotera faults). On the SW and NW side of the promontory, we mapped markers of raised

Holocene shorelines (terraced deposits, wave-cut platforms, barnacle and algal rims, and locally notches). Based on the elevation of the markers and on field relations between them, we recognized two different Holocene shorelines. On the SW side of the promontory, the higher (PS2) and lower shoreline (PS1) attain elevation of ~2 and ~1.4 m a.s.l., respectively. Morphologic relations indicates that relative displacement of the two shorelines above the sea level was abrupt, possibly related to earthquake uplift. We obtained calibrated radiocarbon ages of ~5.5-5.7 and ~4-2 ka for the upper and lower shoreline, respectively. This findings constrains two episodes of co-seismic uplifts between 5.5-4 ka (~0.60 m displacement) and after 2 ka (up to ~1.4 m), respectively. These abrupt displacements are superposed on a regional uplift that in the area, is occurring at rates approaching 1 mm/yr.

On the NW side, however, two shorelines appears to attain a lower elevation of ~1 m and ~40 cm a.s.l., respectively. Radiocarbon age constrains are yet preliminary to establish whether they coincide with PS1 and PS2, or are, at least partly, of different age. A yet upper shoreline has been mapped, but age constraints are not conclusive. Nonetheless, we suspect that three shorelines are present here.

Available data from the NE side of the promontory (Anzidei et al., 2006) indicate that a post-roman shoreline (PS0) exists, but is uplifted at lower rates (0.6 mm/yr). This observation, combined with the raised shorelines on the other sides of Capo Vaticano, suggests that Holocene uplift was asymmetric, with greater magnitudes to the NW and SW, likely related to co-seismic events which are not registered in the NE. This finding places a major constrain on the location of the 1905 seismogenic source, which should be west or south of the head, but not on the north. Significantly, on the SW side of the promontory, we have comparable uplift rates at sites located across the Coccorino strand of the border fault, suggesting the fault is locked or inactive. Instead, the Nicotera strand (and its offshore extension) may be active, in agreement with seismicity data (Cucci and Tertulliani, 2006).

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G3-11 Poster Monaco, Carmelo

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THE USE OF HOLOCENE GEOLOGICAL AND ARCHAEOLOGICAL MARKERS TO DETERMINE COSEISMIC DEFORMATION: NEW OBSERVATIONS FROM THE TAORMINA COASTAL AREA (NORTHEASTERN SICILY)

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Key terms: eastern Sicily; coseismic deformation; Holocene

Detailed mapping of geological and archaeological markers around the Capo Schiso volcanic headland, a few kilometers south of Taormina, north-eastern Sicily, has documented the occurrence of three Holocene paleoshorelines raised at different altitudes. The uppermost shoreline (PS1) is represented by a fossiliferous beach deposit which is heavily eroded and only few small sections, at elevation ranging between ~3 and ~5 m above the present sea-level, are visible. The middle shoreline (PS2) was found at a maximum altitude of ~3 m and is represented by algal rims, remnants of barnacle bands and vermetid concretions, and by a fossiliferous beach deposit. The lowermost shoreline (PS3) includes remnants of algal rims, vermetid concretions, fossil barnacle bands and a beachrock, and reaches an elevation of 1.60 - 1.80 m. New radiocarbon dating results, integrated with published data nearby, provides an average uplift rate of 1.7-1.8 mm/yr in the last 5 ka, and constrains the occurrence of three co-seismic uplift events at 4.4-3.9 ka, 2.1-1.8 ka and <1.0 ka ago. These estimates are consistent to velocities obtained by the ancient Greek slipways of Naxos: in fact, comparing elevation and age of the considered archaeological marker with the curve of the predicted sea level rise, an uplift rate of ~1.72 mm/yr for the last 2.4 Ka can be estimated.

Abrupt displacements are tentatively attributed to footwall uplift along an offshore normal fault, but further investigations are needed to better constrain the causative source of past earthquakes. Notwithstanding, based on coastal tectonic analysis, this paper provides a new assessment of age and recurrence time of Holocene earthquakes in a historically seismogenic, and densely populated area.

G3-12 Poster Cartoian, Elena

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THE ROLE OF TECTONICS IN THE TAMMARO RIVER BASIN: A GEOMORPHOLOGICAL APPROACH

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Key terms: Geomorphology; Tectonics; Southern Italy

The tectonic control on the setting of the Tammaro River basin was investigated by applying several different methodologies: analysis of surface drainage network by calculating morphometric parameters; reconstruction of longitudinal profiles and hypsometric curves, in order to seek significant changes in shape indicating particular lithological conditions and/or tectonic control; and, finally, analysis and comparison of preferential directions of fault families and streams by means of statistical analysis of the azimuthal orientations.

The Tammaro River basin, located between the Molise and Campania regions and about 670 km²-wide, is characterized by a bedrock mainly consisting of sandstone and/or clay alternated with marl and limestone, belonging to the Sannio and Fortore Tectonic Units. Fault families mainly strike NE-SW, NW-SE and E-W.

As a first step of this study, a "Map of the Hydrographic Network" of the basin was created through the digitization, in GIS environment, of both the stream courses and preferential drainage pathways on 1:25,000 topographic maps produced by IGMI (Italian Geographic Military Institute). This allowed to calculate the morphometric parameters of the hydrographic network. Then, the Tammaro River basin was subdivided into the 40 partial basins of the direct tributaries of the main stream, each of which was considered as a single geomorphological unit and studied separately. Examining the values of the morphometric parameters of each partial basin, it was found that the lower values of hierarchical anomaly density (ga) and hierarchical anomaly index (Δa), generally indicating a better organization of the hydrographic network, affected those partial basins characterized by minor areal extension.

According to several Authors, the Δa trend seems to be more influenced by the type and trends of the bedrock fractures than by erosional

processes. In the studied area, the Δa values range between 0.1 and 2.3; however, most values were close to or higher than 1, which indicates an elevated disorganization of the drainage network.

The analysis of the hypsometric curves allowed to identify 3 families of curves, on the basis of the integral hypsometric values. The most frequently occurring values ranged between 0 and 0.45 and between 0.45 and 0.55. In general terms, low values are typical of well-developed streams, along which linear erosional processes are negligible, while areal erosion strongly prevails on the surrounding slopes. Conversely, intermediate values are typical of basins affected by complex dynamics, in which the areal erosion and the linear erosion intensity are the same. Using a semi-automatic methodology, the river courses were rectified and the orientations of the stretches were determined. These data were classified into classes of 10° azimuth intervals and circular histograms were plotted. The main orientation domains of the watercourses were NW-SE, NE-SW and E-W, which are coherent with the strikes of the regional tectonic features that control the evolution of the local drainage network. Furthermore, N-S, NNE-SSW, NNW-SSE and ENE-WSW orientations were identified for some partial basins; they mainly affect the first and second order streams and this was interpreted as evidence of a more recent tectonic activity.

In conclusion, the results showed a discrepancy between the data deduced from the quantitative geomorphic analysis, that indicates a disorganized pattern, and those deriving from the hypsometric analysis, which provided values typical of well-developed basins. The statistic azimuthal analysis confirmed the control by recent tectonics on the setting of the hydrographic network; these effects are not yet evident on the morphology of the river basin. Thus, the study confirmed that the tectonic effects appear more slowly on the river basins, which tend to retain longer their planimetric configuration, than on the drainage network.

G3-13 Poster Sgambato, Claudia

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LATE NEOGENE EVOLUTION OF THE FORMIA PLAIN (SOUTHERN LATIUM)

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Key terms: TECTONIC EVOLUTION; GEOMORPHOLOGY; FORMIA

This work aims at the reconstruction of the Neogene geological evolution of Formia area. The study area is located in southern Latium including the westernmost portion of Aurunci Mts.; this area is bounded by Liri - Garigliano Rivers to north, the Ausente Torrent valley to east and by Ausoni Mountains to west. The Formia Plain represent the southernmost portion of this area.

The superposition of extensional and compressional tectonics is the result of the complex relationships between the central and southern Apennines that connect in this area.

A shallow water carbonate succession (Late Triassic-Cretaceous) forms the structure of the Aurunci Mts.. Chaotic dark gray mudstones, embedding blocks of different ages, locally crop out. Turbidite deposits (Tortonian) widely crop out in the eastern sector followed by clays, sandy clays and mudstones with lenses of gypsum (Messinian). A polygenic conglomerate succession (Pliocene) rests in angular unconformity on Messinian deposits and widely crops out in the area (Scauri, Incrociatura Mt., Campese Mt., Mola Mt.). Fluvial and alluvial deposits (Pleistocene-Holocene), closely related to recent tectonics, crop in the entire Formia plain. Dunes (Late Pleistocene-Holocene) can be somewhere found along the coast.

Tectonic and morphological features have been examined through the use of aerial photographs and satellite-derived DEMs. Remote studies, conducted in pair with a geological survey at scale 1:25,000, helped to clarify the spatial distribution of main tectonic structures in the Formia area and determining the relative chronology of faulting events.

We propose a new tectonic history of the area beginning with an early compressive phase determining the east-verging transport of carbonate tectonic units (Tortonian-Messinian); this phase results in the development of NW-SE trending thrust faults (e.g.: Spigno Vecchia) and N-S trending side ramps.

A Late Messinian NW-SE extensive phase is responsible for the new-formation of NE-SW trending dip-slip normal faults and reactivation of NW-SE faults with strike-slip kinematics.

Since the Late Pliocene a second extensive phase, determine the lowering of the Aurunci Mts. carbonate structure towards the Tyrrhenian Sea, through a series of E-W trending normal faults. The severe erosion of carbonate relieves, followed to this last extensional phase, led to the formation of powerful alluvial fans.

An almost Early Pleistocene E-W trending fault system affects Pliocene conglomerates at southern slope of Campese and Incrociatura Mts.. The deviation of some river courses of the Formia Plain can be a clue of late Pleistocene-Holocene tectonics in the study area.

G3-14 Poster Tavarnelli, Enrico

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MULTI-DISCIPLINARY APPROACH TO THE STUDY OF THE PERNICANA FAULT SYSTEM, MT. ETNA, SICILY: INTEGRATION OF STRUCTURAL, GEODETIC AND SEISMOLOGICAL DATA

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Key terms: Pernicana Fault System; Mt. Etna; structural geology; geodesy; seismology

This contribution investigates the Pernicana Fault System (PFS), a seismogenic structure that dissects Mt. Etna (Sicily). The study was carried out through a multidisciplinary approach based on integration of structural, geodetic and seismological data, with the aim to produce a consistent model for this complex sector of the volcano edifice.

The PFS is a W-E trending fault array, organized into segments arranged en-échelon, and displays a dominantly left lateral component of strike-slip. From West to East it joins the NE-Rift (1900 m a.s.l.), crossing Piano Provenzana and Piano Pernicana, and reaches Rocca Pignatello (1050 m a.s.l.) and Rocca Campana (900 m a.s.l.) where the fault branches out SE-wards into two fault segments. The former shows a roughly N105°E orientation from Rocca Pignatello to Rocca Campana, where the fault rotates to N090°E and terminates without morphological evidence; the latter propagates downhill from Rocca Campana with a roughly N120°E orientation. During the 2002-03 Mt. Etna eruption, an intense ground-fracturing phenomenon affected the entire NE flank, allowing to identify the development of the N120°E fault segment and to trace it down to the Ionian coast.

The work has been carried out with different approaches: structural analysis, to identify the kinematics and geometry of the fault system through the study of well-recognized structural markers; seismology, based on the analysis of focal mechanisms in order to unravel the dynamics of the system, and space geodesy, in order to infer the recent ground motions due to slip along the PFS.

Three main segments are recognised within the PFS: a western, a central and an eastern segment. The western and eastern segments indicate dominantly transtensional kinematics, with both important normal and strike-slip displacements, whereas the central segment best illustrates the effects of the strike-slip component. This segment was monitored with local networks based on GPS techniques since early 1997. GPS data indicate daily displacement vectors up to 50 cm as recorded during the first days of the 2002-03 eruptive event of the Mt. Etna volcano. These data collectively indicate a sliding towards SE of the southern block identified by the PFS.

The analysis of focal mechanisms is in general agreement with data inferred from structural analysis and GPS techniques, indicating a good kinematic and dynamic consistency. The eastern segment of the PFS is characterised by a low seismic activity and by the lack of recent earthquakes, therefore outlining that this part of the PFS is dominated by aseismic creep.

SESSIONE G4

Analisi Strutturale multiscala per la ricostruzione di traiettorie tettoniche lungo i margini attivi

G4-1 Key Lecture Green, Harry W. II

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ULTRAHIGH-PRESSURE MINERALS FROM BOTH DOWNWELLING AND UPWELLING ENVIRONMENTS: SNAPSHOTS OF MANTLE CONVECTION ON A GRAND SCALE

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Key terms: UHPM; Mantle Convection; Subduction; Ophiolite; High Pressure

The concept of Ultra-High-Pressure Metamorphism (UHPM) grew out of the discovery that blueschist minerals in metasediments required simultaneous high pressure and low temperatures that, in turn, required rapid travel to several 10s of km to grow the minerals in the first place, and similarly rapid return to the surface to avoid their reaction to greenschist facies. Both the trip down and the trip back had to occur faster than any known mechanism. The birth of plate tectonics resolved this conundrum. Subsequent discovery of coesite and diamond in shallow protoliths extended the depth of implied subduction to > 150 km but the context remained transport of surface rocks to conditions with a high ratio of P/T. Indeed, the presence of coesite or implication of its former presence became the working definition of UHPM. However, mantle rocks caught up in UHPM terranes also can carry very deep signals. Prior to that discovery, metamorphic petrology implicitly assumed that travels of rocks begin at the surface; solid-state transport of dense rock from significant depth was implicitly thought to be impossible. Peridotite is the fluid by which the mantle of Earth convects, with the unavoidable implication that large volumes of such rock have "seen" the deep upper mantle and some must have circulated deep into the lower mantle. We now understand that they can carry memories of these travels in their microstructures. A simple example of this is the ubiquitous presence of pyroxene-spinel symplectites in spinel peridotites of ophiolites and mantle xenoliths, recording the former presence of garnet. A more complex example is exsolution of pigeonite at very high angles to (001) in diopside, recording depths of ~400 km in the Alpe Arami peridotite in the Swiss Alps. UHPM terranes now have yielded "memory" in continental lithologies of almost that deep. I'll provide case studies demonstrating these facts. Even more surprising, minerals recording comparable depths are now known from an ophiolite and the presence of diamonds in another demonstrates that this deep environment is not unique. The evidence that ophiolites form at Earth's surface is overwhelming. Nevertheless, chromites within them show unambiguous evidence of a highly-reduced environment of great depth and high temperature. One of them contains coesite-after-stishovite and TiO₂ (II), as well as titanium and boron nitrides, with no evidence of down-pressure reaction. Lastly, we now know that some diamonds contain inclusions from the mantle transition zone and the lower mantle. Indeed, I will show one such an inclusion for which the simplest interpretation of its microstructures is that it comes from the core-mantle boundary, as absurd as that sounds.

What more can these rocks tell us? Beyond identification of the relevant minerals, pretty much the only evidence marshaled so far has been from microstructures. Careful use of microfabrics is now also proving useful. But these rocks should not be of interest only to mineralogists and

structural geologists. UHPM rocks from continental collision terranes are the most abundant of these rocks and their geological context clearly tells us that they went down in a subduction zone and came back up along essentially the same pathway. Thus, it would seem inescapable that these rocks must have passed through a depth interval in which fluids from dehydration reactions in the downgoing slab have passed through them on their way to fluxing arc volcanism. They must contain evidence of those fluids, potentially inclusions of the fluid itself. For example, the "white rocks" of UHPM terranes that enclose the peridotites and eclogites have clearly been exhumed along with the denser rocks (they have coesite and (rare) diamonds included in zircons) but they have otherwise completely recrystallized back to the low-pressure assemblage. They surely must have included inclusions of the hydrous fluid passing through them as they returned to the surface.

G4-2 Orale Scambelluri, Marco

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MANTLE WEDGE PERIDOTITES: DECODERS OF DEEP SUBDUCTION ZONE PROCESSES.

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Key terms: Subduction; Fluids; Mantle peridotites; Metasomatism; Relicts

The physical and chemical changes at convergent plate margins affect the subducting slabs and the overlying mantle wedges. Flux melting of supra-subduction mantle regions is caused by fluid phases released by the subducting plates. The distribution of fluids and deformation in such settings affects the extent of mineralogical and structural transformation of rocks and, hence, the survival of relict minerals and structures of previous events. So far, much research has been focussed on the slabs and still few are the observations of rocks at the slab-mantle interface. For this purpose, information can be achieved from orogenic garnet peridotites. In several occurrences these are mantle slices tectonically sampled by the subducted continental plates and disclosing the characteristics of the mantle in a 100-200 km depth range. Such tectonic 'xenoliths' can retain old events, pre-dating their engagement in the subducting crust and enabling to design the long-term dynamics of the deep mantle. These processes are yet readable as meso to micro-scale structures, the geologic significance of which is unravelled through integrated structural, petrological and geochemical studies. Two case-histories of garnet peridotites hosted in subducted continental basements are presented here. The mantle rocks record different physical pathways prior to their engagement in the crust and correspond to: (i) shallow lithospheric mantle wedge dragged to depth (Ulten Zone garnet peridotites, Eastern Alps, Italy); (ii) transition-zone mantle upwelled and accreted to cratonic roots (UHP garnet peridotites of the Western Gneiss Region, Norway). Both mantle occurrences were flushed and metasomatized by incompatible element-rich fluids sourced from the continental crust. Fluid infiltration in the two systems took place at variable depths: < 3 GPa in Ulten and about 7 GPa in Bardane, with formation of new subduction-related majoritic garnet in veins. Interaction with the subduction fluids is crucial to rock recrystallization and to the preservation of the earlier structures.

Comparable geochemical fingerprints observed in HP and UHP Ulten and Bardane mantle rocks call for concomitant subduction of the continental crust, providing the incompatible element-enriched fluids. For Bardane this implies crustal subduction to 200 km depth. The two examples show that mantle refertilization by crust-derived COH subduction fluids operates over a large depth range. The textural features of Bardane and Ulten Zone mantle rocks indicate that outside the channelways for fluid infiltration the rocks preserve pre-subduction, long-lasting stories and pristine geochemical characteristics. The available data show that crustal slabs subducted to variable depths entrain mantle wedge peridotites, the relict structures of which emphasize the stories and fate of the subcontinental mantle through time. Comparably with uprising magmas, the subducted continental crust appears to be a very efficient carrier to the surface of ultra-deep mantle tectonic 'xenoliths' that represent major observatories of diverse metamorphic and geodynamic histories recorded by the Earth's mantle at variable depths.

G4-3 Orale Zanoni, Davide

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DEFORMATION - METAMORPHISM RELATIONSHIPS IN THE RODINGITES OF THE ZERMATT-SAAS ZONE

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Key terms: Rodingite; structural and metamorphic evolution; Western Alps

The Zermatt-Saas Zone is a remnant of the Piedmont-Ligurian oceanic lithosphere, within the suture zone of the Western Alps.

The investigated rodingites are hosted in serpentinites with minor eclogitic metagabbros and chlorite-schists and record three groups of superposed syn-metamorphic ductile structures. Both D1 and D2 are associated with the development of high-pressure parageneses. Mineral and textural relics predating these stages developed during the serpentinization and rodingitization processes ascribed to oceanic metamorphism.

S1 is a relic foliation preserved only in rodingite dykes and lenses, in the millimetre thick microlithons of D2 crenulation cleavage and as internal foliation of garnet porphyroblasts; it is marked by pyroxene and amphibole or vesuvianite, chlorite and pyroxene SPO.

S2 is the dominant fabric in rodingites and metagabbros; in rodingites it is evidenced by alternating chlorite- and amphibole-layers and trails of small garnet and vesuvianite.

In metagabbros pre-D3 relics are garnet, omphacite, rutile and glaucophane + phengite and, successively, barroisitic amphibole, zoisite, Mg-chlorite, phengite and ilmenite.

D3 structures are the most pervasive in serpentinites and metagabbros; they consist of a crenulation cleavage type foliation associated with open metric folds and are correlated to post-P peak greenschist facies retrogression. S3 in rodingites is marked by Fe-chlorite, replacing zoisite. Both S2 and S3 affect the reaction rim underlying the serpentine and rodingite boundaries, which consists of chloritic schist.

HP fabrics between metagabbros and rodingites have been correlated on

the base of structural analysis, allowing the identification of the HP assemblages in S1 and S2 fabrics in eclogitized rodingites: S1 - garnetI, Mg-chloriteI, epidote-clinozoisiteI, clinopyroxeneI, vesuvianite, titanite + amphiboleI; S2 - Mg-chloriteII, vesuvianiteII, clinopyroxeneII, epidote-clinozoisiteII, garnetII (in veins), titaniteII, + amphiboleII; locally clinopyroxene forms porphyroblasts either predating S1 or S2; S3 / post-D2 - amphibole, Fe-chlorite, epidote. These results highlight that vesuvianite is coeval to chlorite, epidote, garnet, clinopyroxene HP assemblages.

G4-4 Orale Malatesta, Cristina

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NUMERICAL SIMULATION OF AN INTRAOCEANIC/INTERCONTINENTAL SUBDUCTION: THE CASE OF THE OPHIOLITIC VOLTRI MASSIF (WESTERN ALPS).

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Key terms: intraoceanic subduction; numerical models; serpentinite channel; Voltri Massif; exhumation

We run 2D numerical models in order to highlight the processes occurring during subduction/exhumation at intraoceanic subduction settings. We reproduced a relatively narrow oceanic basin (about 600 km-wide) surrounded by continental crust; an "heterogeneous" oceanic lithosphere, as the one produced at present slow/ultra-slow spreading ridges, floors the oceanic basin. Gabbros are discrete bodies inside the serpentinized mantle; the latter forms highs on the ocean floor that are spaced out by a discontinuous basaltic layer; a homogeneous sedimentary cover overlies them. Subduction starts at a weak zone in the mantle and the process is free to evolve. During subduction the fluids released from the slab migrate upward hydrating the overlying mantle-wedge and thus producing a serpentinite channel.

The relevance of several parameters on subduction/exhumation dynamics has been tested. In particular, serpentinite rheology, initial slab dip, structure and age of the oceanic lithosphere are the most important parameters controlling the geometry of the channel. Convergence rate and distance of the subduction zone from the continental margins have a minor role. If serpentinite is controlled by a power-law rheology, planar or wedge channels form; a Newtonian deformation style produces planar or "hourglass" channels that widen with increasing depths. Serpentinite rheology strongly controls also the mixing and exhumation mechanisms inside the channel. If we consider a Newtonian rheology of serpentinite, slab slices, sediments and mantle-wedge serpentinite are mixed together inside the channel. Slab serpentinite and mantle-wedge serpentinite can be therefore closely associated. Conversely, a continuous accretion and underthrusting of slab slices at the base of the channel occurs if serpentinite is controlled by a power-law rheology; in this case a shallow circulation inside the serpentinite wedge, enhanced by high convergence rate, prevails. Considering a serpentinite controlled by a Newtonian rheology, a stronger flux inside the serpentinite channel occurs; a mélange made of slab slices, sediment or mantle wedge serpentinite is finally exhumed even from depths exceeding 70 km. The rise of the mélange occurs after continental crust subduction and at the onset of collision. The main force driving exhumation is buoyancy, related to the presence of low density serpentinite, matched with a slight slab rollback. One of these models fits well some peculiarities that were observed in a serpentinite massif outcropping in the Ligurian Western Alps (Voltri Massif); the Voltri Massif includes ophiolitic rocks that record metamorphic peak conditions varying from the blueschist- to the eclogite-facies.

The comparison between P-T paths recorded by some metagabbro bodies of the Voltri Massif and P-T trajectories of selected gabbro lenses in the 2D simulations showed several similarities: they are clockwise, reach comparable metamorphic peak conditions and the exhumation paths are almost isothermal. Moreover, the modeled exhumed mélange and the Voltri Massif are characterized by similar exhumation velocities (mm/a) and comparable areal relationships between the forming lithologies. Finally, the analysis of the selected numerical simulation allowed us to define a hypothetical evolutionary model for the Voltri Massif. Few real outcrops were located in their paleogeographic position comparing natural and simulated P-T peaks: ophiolite outcrops recording eclogitic metamorphic conditions probably pertained either to the slab or to the upper plate, since in the model they both can reach high depths; mafic lenses recording lower metamorphic conditions (blueschist facies) can be tentatively related to portions of the oceanic lithosphere scraped from the overriding plate and dragged inside the serpentinite channel. As observed in the simulation, the final stage predicts the exhumation of the Voltri Massif rocks in relation to the presence of buoyant serpentinite.

G4-5 Orale Martin, Silvana

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EVIDENCE FOR ALPINE ECLOGITE-FACIES OVERPRINT IN THE MONTE ROSA MASSIF (ALPS)

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Key terms: Distinct metamorphic stages; Eclogite metamorphism; Monte Rosa nappe; Western Alps

On the northern side of the Aosta valley (Italy), the Alpine collisional wedge is characterized, from bottom to top, by: (i) the Monte Rosa nappe, (ii) the eclogite/blueschist-facies Zermatt-Saas and Combin meta-ophiolites, and (iii) the capping upper Austroalpine units (i.e. Sesia-Lanzo, and the Dent Blanche klippe). These 3 complexes have been classically attributed to the pre-Alpine European continental margin (Monte Rosa), Piedmont ocean (Zermatt-Saas and Combin), and Adria continental margin (Austroalpine), respectively (e.g. Dal Piaz et al., 2001). The Monte Rosa nappe may be in turn subdivided into three main units: (i) Variscan high-grade gneisses; (ii) Upper Carboniferous and/or Lower Permian granite-granodiorite plutons; (iii) remnants of Permian-Mesozoic sedimentary cover and the composite Furgg zone (Beath, 1956). The pre-granitic basement is composed of paragneiss, micaschists, and migmatite (see Dal Piaz, 2001), which have undergone high-T low-P metamorphic conditions during the Variscan orogeny (e.g. Engi et al., 2001). They were sharply intruded by Upper Carboniferous granodiorites

and Permian granites (Hunziker, 1970; Liati et al., 2001; Scherrer et al., 2001). The whole Variscan basement was deformed and metamorphosed during Alpine orogeny. On the southern side of the Monte Rosa Massif (e.g. Rifugio Città di Mantova, Pian di Verra, Brusson), the migmatitic paragneisses, as well as the orthogneisses that derived from the Variscan granodiorites and granites, show petrological evidence for two distinct metamorphic stages. An early paragenesis, typical of high-T low-P conditions and coincident with migmatitisation in the paragneiss, consists of biotite + quartz + plagioclase + garnet ± cordierite ± K-feldspar + ilmenite. During a second stage, the rocks underwent a high-P metamorphism that is indicated by several metamorphic reactions:
 Biotite + plagioclase = garnet + phengite + quartz + rutile [micro-coronas];
 Biotite + K-feldspar = phengite + quartz + rutile [micro-coronas];
 Biotite = garnet + phengite + rutile [pseudomorphs];
 Ilmenite + plagioclase = garnet + rutile + quartz [coronas around ilmenite];
 Cordierite = garnet + micas + kyanite ± quartz [pseudomorphs];
 Plagioclase = albite [possibly after jadeite] (+ minor phengite + zoisite + kyanite) [pseudomorphs];
 Monazite + plagioclase = apatite + allanite [micro-coronas].
 These reactions, which produced garnet, rutile, and phengite at the expense of biotite, ilmenite, K-feldspar and plagioclase, are typical of a high-P eclogite-facies metamorphism.
 These two stages belong to the Variscan orogeny (migmatitisation and granitic intrusions) and the Alpine orogeny (eclogite-facies coronas and pseudomorphs). Their P-T conditions have been estimated to be T = 700°C and P = 6 kbar, and T = 600-700°C and P > 20 kbar, respectively. This metamorphic history seems characteristic of the whole Monte Rosa basement, since evidence for eclogite-facies metamorphism has also been mentioned elsewhere in the Massif (Chopin & Monié, 1984; Dal Piaz & Lombardo, 1986; Le Bayon et al., 2001). Very similar rocks are also well known at Monte Mucrone (Alps, Sesia-Lanzo) and have been observed in the Variscides (see Godard, 2009).
 The Monte Rosa nappe would represent a slice of the Variscan European continental crust that underwent subduction and subsequent eclogite-facies metamorphism during Alpine convergence. In this part of the Alps, not only the meta-ophiolites and the upper Austroalpine nappes show an eclogite-facies metamorphic imprint, but the Monte Rosa basement as well, suggesting that most of the Alpine collisional wedge entered in subduction at an early stage of the Alpine orogeny.
 Note: See <http://virtualexplorer.com.au/journal/2004/16/martin/> and Godard, 2009, Eur. J. Mineral. 21, 1173-1190, for the references.

G4-6 Orale Delleani, Francesco

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MULTISCALE STRUCTURAL ANALYSIS IN SUBDUCTED CONTINENTAL CRUST OF WESTERN ALPS: THE MONTE MUCRONE EXAMPLE (SEZIA-LANZO ZONE).

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Key terms: subduction-related deformation; HP metamorphism; Sesia-Lanzo Zone

The Mt. Mucrone metagranitoid is one of the extensively explored Permian intrusives belonging to the Eclogitic Micaschists Complex (EMC) of Sesia-Lanzo Zone (SLZ) within the high-pressure (HP), metamorphic belt of Western Alps (e.g. Compagnoni et al. 1977). An integrated structural and petrological study has been focused on the still poorly-analysed southern slope of Mt. Mucrone, in order to integrate the available data and to relate them with the structural and metamorphic history inferred in the Mombaron-Mt. Mars area (Zucali et al., 2002).
 EMC comprises micaschists, paragneisses, metagranitoids, eclogites and impure marbles (Compagnoni et al., 1977).
 All these lithotypes are eclogitized and typically show a foliated fabric marked by Qtz, Pg, Phe, Grt, Gln, Jd (or Omp), Rt and Zo. This HP fabric is the axial plane foliation (S1) of the oldest recognized fold system (D1). Minor volumes of eclogite, metagranitoid and paragneiss only display coronitic reaction textures. The D1 deformation is highly heterogeneous in metagranitoids where domains fully preserving the igneous texture (grey-type metagranite) are juxtaposed to foliated domains (green-type metagranite). Isoclinal folding D2 is associated to coronitic reactions producing Qtz, Phe, Pg, Omp, Aeg, Gln, Grt, Czo and Rt; a foliated S2 fabric locally develops in some metapelites. D3 meter-thick mylonitic shear bands localize a S3 foliation marked by Qtz, Phe, Pg, Rit, Brs, Win, Grt, Na-Agt, Mg-Chl, Czo and Ttn.
 The last groups of structures are associated with the growth of Ab, Qtz, Phe, Pg, Act, Ep, Chl and Bt, and consist of either open to gentle folds (D4 and D6) or centimeter-thick shear zones (D5).
 During D1, metamorphic reactions in the grey-type metagranite occurred without the development of a new planar or linear fabric: pseudomorphic replacement of the igneous Pl by fine-grained Jd, Zo and Qtz, partial replacement of Bt by Phe + Grt; development of fine-grained Phe after igneous Kfs. During D2 widespread relics of primary Bt are preserved and the whitish pseudomorphic aggregates of Jd, Zo and Qtz are only partially replaced by Aeg and/or Omp. In the green-type metagranite, the combined effect of deformation/recrystallization and fluid migration during D1 allowed the complete replacement of the igneous Bt and Pl by coarse-grained Phe and greenish Jd.
 Deformation-metamorphism relationships evolution point to the development of D1 and D2 under Qtz-eclogite facies conditions, of D3 under blueschist-facies conditions, and of D4 to D6 under greenschist-facies conditions.
 During D1, the effects of strain gradients on reaction progress influences the compositional zoning of Grt in the mylonitic metagranitoids (green-type) with respect to those observed in Grt from the poorly deformed ones (grey-type).
 As proposed for the metagranitoids of the eastern slope of Mt. Mucrone (Castelli et al., 1994), the distinction between the two types of metagranitoids, is consequent to a fabric and re-equilibration gradient during the D1, eclogite-facies transformations.
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G4-7 Orale Zucali, Michele

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A NEW SUBDUCTION-RELATED TECTONIC TRAJECTORY IN THE SOUTHERN SESIA-LANZO ZONE: INSIGHTS FROM MULTI-SCALE STRUCTURAL ANALYSIS.

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Key terms: subduction; tectonic trajectory; multiscale analysis; P-T-t-d path

Pre-Alpine continental crust of western Alps is widely affected by subduction-related high-pressure low-temperature (HP-LT) metamorphism and the Sesia-Lanzo Zone (SLZ) represents the widest crustal slice re-equilibrated under HP conditions during Late-Cretaceous (early-Alpine) times. Its Alpine tectonic evolution is compatible with an uplift during active oceanic lithosphere subduction (e.g. Spalla et al., 1996; Meda et al., 2010; Zucali & Spalla, 2011). The SLZ consists of three main lithological complexes (e.g. Compagnoni et al., 1977): i) Gneiss Minuti complex (GMC); ii) Eclogitic Micaschists complex (EMC); iii) II Dioritic-Kinzigitic Zone (IIDK). IIDK consists of kilometric lenses of pelitic and mafic granulites escaping the eclogitic re-equilibration. EMC and GMC, both pervasively eclogitized, strongly differ in the volume percentage of greenschist re-equilibration (Stuenitz, 1989; Spalla et al., 1991). In the southern SLZ the metamorphic complex of Rocca Canavese thrust sheets (RCT; Pognante, 1989 a; Pognante, 1989b) has been recognised, on the ground of its strongly contrasted Alpine metamorphic evolution, characterized by a P-climax recorded under very LT conditions. A multi-scale structural analysis has been performed to support the acquisition of new highly detailed petrologic data, useful to refine, and better constrain, the tectonic trajectory of such a peculiar crustal slice. The result of structural analysis field-work is the reconstruction of a superposed grid of metamorphic foliations allowing the regional scale correlation of structural and metamorphic stages. The micro-structural investigation identified mineral assemblages marking successive fabrics in each rock type. In this way, by means of micro-structural analysis of the successive foliations, details on relative chronology of structural imprints and metamorphic environments in which they developed have been acquired. Chemical data on mineral phases were collected discriminating the micro-structural sites, with the goal of an accurate reconstruction of a Pressure-Temperature-relative time of deformation path: a fundamental tool to infer tectonic trajectories of metamorphic units, involved in a subduction system dynamics.

G4-8 Orale Remitti, Francesca

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THERMAL AND GEOLOGICAL CONSTRAINTS FOR THE TIMING OF THE ACTIVITY OF THE FRONTAL PART OF AN ANCIENT SUBDUCTION CHANNEL, NORTHERN APENNINES OF ITALY

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Key terms: Northern Apennines; subduction channel; Sestola-Vidiciatico tectonic unit; Subligurian Unit

During the Miocene, the no-longer active oceanic accretionary prism -the Ligurian Units- and its wedge-top sediments - the Epiligurian Succession- gradually overthrust the Adria plate and its sedimentary cover - the Tuscan and Umbrian Succession- as deduced from the progressive younger age of the foredeep deposits. During this overthrusting at least a second major décollement was activated, allowing the underthrusting of the different components of the Sestola-Vidiciatico tectonic unit in the southeastern part and of the Subligurian Units in the northwestern part of the Emilia Apennines to the Ligurian Units. The components of both the Sestola-Vidiciatico tectonic unit and Subligurian Units - are: a) Cretaceous to middle Eocene deep-water sediments deposited on oceanic, transitional and/or thinned continental crust (the Ligurian Units and the pre-middle Eocene Subligurian Units) originally composing the Ligurian-Subligurian accretionary prism; b) slope apron and thrust-top basin deposits (Modino succession, Porretta succession and epi-Subligurian Units) sedimented on the frontal part of the Ligurian-Subligurian prism starting from the middle Eocene. Therefore all the components sandwiched between the Ligurian prism and the Tuscan-Umbrian Units derive from the underthrusting of the toe of the overriding plate and its slope deposits which occurred during the contemporaneous underthrusting of the foredeep deposits. This evidence point to the formation of a subduction channel composed of material moving both with respect to the upper and the lower plate and bounded by two main décollements (at the top of the Tuscan and Umbrian Succession, and at the bottom of the Ligurian prism). The channel was fed mainly by a process of tectonic erosion which affected the frontal part of the upper plate. The age of the youngest block in each considered section of the subduction channel of the Emilia Apennines constrains the time of the underthrusting. The detailed reconstruction of the spatial distribution of the slope deposits of different ages shows that the time of underthrusting varies from the inner sector - at ~100 km from the Ligurian prism front- to the external sector - at ~10 km from the Ligurian prism front - and ranges from at least the early Miocene (Aquitainian) to the middle Miocene (Serravallian). During the overthrusting the upper plate remained mainly undeformed, as suggested by the subduction channel model (Shreve and Cloos, 1986).

This is testified by the Epiligurian Succession - the prism sedimentary cover- that do not show evidence of major deformation structures. From the regional thermochronological study of Thomson et al. (2010), it is known that most part of the material inside the channel underthrust from the Aquitanian (early Miocene) to the Langhian (middle Miocene), reached temperatures sufficient to reset the apatite fission-track system (>120°C) and was exhumed at a time younger than 10 Ma after the end of the incorporation of new material in the subduction channel (younger blocks are Serravallian in age) and the deactivation of the channel. New fission track data, integrated with geological data, allow to determine that part of the material was exhumed during the activity of the subduction channel (i.e., during the Aquitanian). A possible mechanism controlling this early exhumation is the deactivation of -part?- of the frontal section of the upper décollement at the bottom of the Ligurian Units and the activation of another deeper main décollement inside the subduction channel material.

G4-9 Poster Spalla, Maria Iole

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PRE-CORDILLERAN HISTORY OF MANTLE ROCKS FROM THE MONASHEE COMPLEX, INFERRED BY MULTISCALE STRUCTURAL ANALYSIS

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Key terms: Subduction; Collision; Canadian Cordillera

In the Northern portion of the Thor-Odin dome, boudins and lenses of ultramafic rocks (JOHNSTON, 1998) occur along the Thor-Odin high strain zone (e.g. JOHNSTON et al., 2000, KRUSE & WILLIAMS 2007), at the transition between the "Selkirk allochthon" and the Monashee complex. The Selkirk allochthon has been interpreted as a sheet thrust over the Monashee complex (e.g. READ & BROWN 1981; BROWN et al. 1986), or more recently, as an upper level of an infrastructure zone (that includes both the Selkirk allochthon above, and the Monashee complex below) down-dropped by a normal shear zone, during crustal extension (KRUSE & WILLIAMS 2007). The occurrence of peridotite boudins in a regional scale shear zone makes their structural and petrologic investigation crucial to infer the tectonic context in which they were coupled with the surrounding rocks of the continental crust. The ultramafics are embodied in Bt-Sil-bearing gneisses, with minor metabasics, and are intersected by pegmatite dykes. Detailed structural mapping indicates that the peridotites are boudins aligned in the regional scale high-grade foliation and that locally they contain an internal foliation (STI) that is at a high angle to the country rock foliation. The latter, is part of a regional transposition fabric, marked by SPO of microboudinaged Sil and red brown Ti-rich Bt, wrapping garnet porphyroblasts. In the peridotites, two textural types are recognizable at the microscale: granoblastic (polygonal texture with medium grain size) or poikiloblastic (with pyroxene poikiloblasts, partially replaced by amphibole). The granoblastic type, which occurs where the ultramafics show a foliated texture (STI), contains Ol, Opx, Spl, minor Amp and Phl and opaque minerals. The poikiloblastic type is not foliated and comprises Ol, Amp, Opx, Spl, Phl, opaque and rare Cpx. Amp and Phl occur as porphyroblasts or in veins. This texture characterizes undeformed domains preserved in rocks of the granoblastic type (STI). Two kinds of Amp and Phl have been detected: (1) brown Amp, which replaces Px and is partially replaced by a thin symplectite of green Amp and Spl and (2) green Amp, which occurs where brown Amp recrystallizes, showing a foam texture. Microstructural investigations at the electron microscope scale reveal the occurrence of relics, aligned parallel to a discordant internal foliation of Ol polygonal grains defining STI. This is diagnostic for inferring the earlier metamorphic evolution of the ultramafics. Whole rock chemical composition data indicate that these rocks are metasomatized mantle peridotites. Variations in mineral chemistry associated with superposed fabrics in peridotites and country rocks allow their metamorphic and microstructural evolution to be inferred and help to unravel the emplacement history of mantle peridotites in the high-grade continental crust of the Thor-Odin dome.

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G4-10 Poster Zanoni, Davide

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RECONSTRUCTION OF PTD PATHS IN THE SHUSWAP COMPLEX, CANADIAN CORDILLERA: AN EXAMPLE FROM JOSS MOUNTAIN

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Key terms: Tectono-metamorphic memory; Transposition; Monashee complex

Joss Mountain is located in the south-eastern Canadian Cordillera and is

part of the Shuswap complex of the Omineca belt (SE British Columbia), which is one of the five belts of the Canadian Cordillera. This belt consists of reworked intrusive and metamorphic rocks of the Precambrian North American craton, exhumed during the accretion of terranes to the North American (Laurentia) margin during Middle-Late Jurassic and Cretaceous. The study area is in the hanging wall of a high-strain-shear zone that bounds the Thor-Odin dome of the Monashee complex, one of the deeper metamorphic core complexes of the cordilleran orogen. Rocks in the Joss Mountain area mainly comprise marbles, calcisilicates and layers of metagranitoid. Layers of metapelite and quartzite, within both calcisilicate and metagranitoid, are less common. All these rocks display a penetrative sub-horizontal transposition foliation (ST) at micro to regional scale. There are at least two generations of W- SW-trending intrafolial folds (F1 and F2) coeval with ST. The latter is overprinted by, up to km-scale SW-vergent F3 folds that lack an axial plane foliation, and an upright NW-trending regional-synform (F4). Minor F4 folds are upright, open, and plunge gently north. Felsic and younger mafic dykes crosscut all the ductile structures.

Wm-bearing metapelites and Bt-bearing schists have been analyzed at the micro-scale.

In Wm-bearing metapelites ST is defined by shape and lattice preferred orientation of WmII and BtII. Coarse-grained WmI and BtI mark intrafolial folds between ST films; also WmI forms coarse-grained porphyroclasts wrapped by ST. Coarse-grained Grt shows rare inclusion trails oblique to ST, which are straight in the core and bent at the rim of porphyroblasts, and locally are continuous with ST in the matrix, suggesting that Grt porphyroblasts grew during progressive ST development. Grt encloses BtI, Qtz, rare PII, WmI and opaques. Fine-grained Grt shows rational grain boundaries with BtII. Post-ST micro-shear zones are marked by BtIII ±Sil, and locally replaced by WmIII and Chl. Sil also rims or overgrows WmI and II.

In Bt-bearing schists ST is defined by lattice and shape preferred orientation of BtII laths and PIII and Qtz layers with very rare KfsII. Relicts of BtI, KfsI, and PII are locally deformed and wrapped by ST. Grt porphyroclasts appear pre- to syn-ST, indicated by inclusion trails at a high angle to ST, in the core and progressively asymptotic to ST in the outer part of the porphyroclasts. PIII and minor Qtz form a corona around Grt. BtIII marks shear bands at a low angle to ST. Rare Chl grew at the expense of Bt; Chl-filled fractures intersect Grt and are sub-orthogonal to the inclusion trails.

The slight variation in Ti in the different Bt generations is consistent with temperature varying between 640° and 700°C. The Ti-content in BtIII, associated with Sil, is consistent with a decompression below 0.6 GPa. Grt and Pl composition is consistent with a pressure of 0.7 - 0.6 GPa during ST development.

Pressure and temperature estimates for ST development at Joss Mountain are slightly lower than those estimated for the P-T climax during ST development in the western part of the Thor-Odin dome. This result suggests that Joss Mountain rocks were at a shallower structural level than rocks of the Thor-Odin dome during ST. This is consistent with Joss Mountain rocks being down-dropped relative to Thor-Odin rocks.

G4-11 Poster Grande, Antonietta

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COEXISTENCE OF PSEUDOTACHYLITE VEINS AND MYLONITIC ZONES AT THE BASE OF THE DEEP CRUST: AN EXAMPLE FROM THE CALABRIA (SOUTHERN ITALY)

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Key terms: pseudotachylite; mylonite; ultramylonite; felsic granulite; deep crust

Natural examples indicate that pseudotachylites coexist in the same outcrop with mylonites and ultramylonites. Pseudotachylites intimately associated with mylonites and ultramylonites can develop in high strain zone close to the brittle-ductile transition (e.g. Passchier, 1982) or entirely within the ductile regime as result of plastic instabilities (e.g. Hobbs et al., 1986; Handy & Brun, 2004).

This study reports microstructural investigations on two pseudotachylite veins found within the felsic granulites at the base of the ~20-25 km thick Variscan crustal section outcropping in the Serre Massif (southern Calabria). Felsic granulites consist of quartz, plagioclase, K-feldspar, biotite, garnet, sillimanite and accessory minerals. Stretched minerals and S-C composite foliations are detected in zones crystal-plastic deformation. In places, felsic granulites exhibit an alternance of mylonitic and ultramylonitic bands (a few millimeters thick). Pseudotachylite fault-veins develop along planes, which have a parallel orientation to the mylonitic and/or ultramylonitic foliation. Locally, pseudotachylite fault-veins occur along the S-C composite foliations of the felsic granulite. On the other hand, the pseudotachylite injection-veins cross cut the mylonitic and/or ultramylonitic bands.

Microstructural observations indicate that the felsic granulite exhibits a strong grain-size reduction along the S-C composite foliations and near the contact with the pseudotachylite veins. Back scattered electron (BSE) images, obtained by scanning electron microscopy (SEM) and Field-Emission Gun SEM, show that in proximity of the contact with the pseudotachylite the garnet of the felsic granulite is fractured and shows rims characterized by a new crystallization of very small euhedral garnet

(3-4 μm). On the other hand, the ultramylonitic bands display a very fine-grained matrix and have a dark appearance. However, the BSE images reveal a strong penetrative foliation, which is defined by the alignment of biotite and by the shape preferred orientation of quartz, plagioclase and garnet. Moreover, the ultramylonitic bands are characterized by a new crystallization of very small crystals (a few microns in length) of sillimanite and K-feldspar, aligned along the foliation planes. Matrix of the pseudotachylites is microcrystalline and contains abundant clasts (>50%) made up of quartz, plagioclase, K-feldspar, garnet and rare biotite. Clasts in the matrix are aligned with a parallel orientation to oblique foliation of the mylonitic granulite. At the margin of the vein, garnet of the pseudotachylite may occur in two habits: 1) garnet

microlites with very small sizes (3-4 μm) and an idiomorph habit, which formed by direct crystallization from the frictional melt, and 2) garnet

clasts (a few ten micrometres in size), with rims characterized by a new crystallization of very small garnets (<2µm) and with a similar aspect to the garnet rims of the host rock. In the vein centre, the matrix is mainly composed of skeletal plagioclase and biotite (a few microns in length). Plagioclase and biotite microclots often nucleated on rounded clasts of quartz or plagioclase. Garnet microclots are absent in the vein centre. These data, combined with the indications for the formation depth of the pseudotachylytes (21-23 km) obtained by Altenberger et al. (2010), indicate that during propagation of the seismic rupture the shear deformation was highly heterogeneous and took place through the development of alternating pseudotachylyte and ultramylonite, as result of plastic instabilities.

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G4-12 Poster Tartarotti, Paola

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FROM OCEAN TO SUBDUCTION: POLYPHASE METAMORPHIC EVOLUTION OF THE FRIDO UNIT OPHIOLITE (SOUTHERN APENNINE, ITALY) AS INFERRED FROM MICROSTRUCTURAL RECORDS IN METADOLERITE

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Key terms: Southern Apennine; ophiolite; blue-schist facies; oceanic alteration; amphibole

The Southern Apennines (SA) chain is a fold-and-thrust belt derived from the collision between the African and European plates starting in Upper Oligocene. The oceanic lithosphere of the Jurassic Tethys interposed between the paleo-Africa and paleo-Europe now occurs as ophiolitic slices enclosed within the Liguride accretionary wedge, which is part of the SA chain. Ophiolites consist of dominant serpentinites and minor mafic rocks exposed in the north-eastern slope of the Pollino Ridge (Calabria-Lucania border zone). Here, serpentinitized peridotites are cut by metadolerite intrusions showing different types of structure, ranging from magmatic intersertal/intergranular through cataclastic to mylonitic. Bulk-rock chemistry suggests that the protolith of mafic rocks has a N-MORB affinity. Based on mineral assemblage and texture, three different metadolerite types were recognized: plagioclase, clinopyroxene-bearing metadolerite; plagioclase, clinopyroxene, brown amphibole-bearing metadolerite, and plagioclase, clinopyroxene, brown amphibole, blue-amphibole metadolerite. Relict primary microstructural domains were selected for deciphering the tectonic and metamorphic evolution of metadolerites and hosting serpentinites. Such domains are characterized by metamorphic mineral pseudomorphs related to oceanic alteration in the Jurassic Tethys, in turn replaced by orogenic metamorphic minerals under static recrystallization. Namely, primary clinopyroxene (augite) is first replaced by pseudomorph brown amphibole rimmed by colourless, pale green, or blue-green amphibole, although in some samples green amphibole is pseudomorphous on clinopyroxene; all these amphiboles are interpreted as being of oceanic origin. Brown amphibole shows Mg-hastingsite, edenite, pargasite, Fe-hastingsite, Mg-hornblende compositions, whereas colourless, pale green, green, and blue-green amphibole show Mg-hastingsite, hastingsite, edenite, actinolite, tschermakite and Fe-tschermakite compositions. Blue amphibole then grows at the rim of brown or green amphibole, and is interpreted as being crystallized during the early stage of orogenic metamorphism. Within some structural domains, relict clinopyroxene is replaced by pseudomorphs with a zoned distribution from rim to core, with brown amphibole being at the external rim, blue amphibole at the internal rim, and chlorite+epidote at the core. Blue amphibole has glaucophane, Mg-riebeckite, and winchite compositions. The orogenic mineral assemblage in metadolerites includes glaucophane, Mg-riebeckite, lawsonite, phengite, pumpellyite and aegerin-augite which are typical minerals of LT-blueschist facies conditions. Textural and mineralogical observations suggest that the metadolerites of the Frido Unit have been affected by early ocean-floor metamorphism in the amphibolite to greenschist facies and subsequent orogenic metamorphism under relatively HP/LT conditions. Such polyphase metamorphic evolution is well preserved in the metadolerites probably in response to deformation partitioning within the Apennine accretionary wedge.

G4-13 Poster Zucali, Michele

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MULTI-SCALE APPROACH TO THE PERMIAN TECTONOMETAMORPHIC EVOLUTION OF THE DENT-BLANCHE UNIT (AUSTRALPINE DOMAIN, WESTERN ITALIAN ALPS)

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Key terms: multi-scale; tectonometamorphic; permian; geochronology; western alps

The Dent-Blanche Unit (Austroalpine domain, Western Italian Alps) is constituted by Valpelline and Arolla units, respectively composed by high-grade pre-Alpine basement rocks and Permian intrusive with high-grade pre-Permian xenoliths. The main structural imprint of the high-grade rocks is characterized by amphibolite to granulite facies conditions, commonly associated with large melt-bearing parageneses. During this melt-producing stage the meso- and microstructural evolution is polyphase and produce decametric isoclinal locally rootless folds. The multilayer is defined by alternate garnet-clinopyroxene bearing amphibolite, marble and melt-bearing gneisses (i.e. migmatites). Locally metre-scale orthopyroxene-clinopyroxene basic granulite boudins are

enclosed in migmatites. Melt-bearing associations differs with respect to bulk chemical compositions, leading to cordierite + melt, orthopyroxene + melt and garnet + melt associations. Absolute geochronological data for the pre-Alpine history of the Valpelline unit, until now reported as pre-Permian, show that the main metamorphic and structural imprint of the Valpelline unit is Permian, corresponding to the main granulite imprint, characterized by pegmatite bodies and by the partial melting of metapelites.

These results highlight the occurrence of an important tectonometamorphic Permian event in this portion of Austroalpine basement, likely reflecting a lithospheric scale thermal perturbation in the whole African continental lithosphere (SPALLA AND MAROTTA, 2007; PERESSINI et al., 2007).

G4-14 Poster Malatesta, Cristina

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THE VOLTRI MASSIF (LIGURIAN ALPS): A TECTONIC SERPENTINITIC MÉLANGE? INSIGHT FROM STRUCTURAL AND PETROLOGIC EVIDENCES.

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Key terms: tectonic mélange; subduction channel; Voltri Massif; high-pressure rocks

A 100 m-scale tectonic mélange located in the Voltri Massif (Ligurian-Piedmontese Units of central Liguria) was considered as an example of "fossil" subduction channel (Federico et al., 2007). This exhumation mechanism considers the presence of a low-viscosity serpentinite channel between the subducting- and the overriding-plate and has been invoked to explain the exhumation of ophiolitic massifs in other sectors of the Western Alps (e.g. Monviso Massif; Guillot et al., 2004).

Could the subduction channel mechanism be applied at a larger scale in the Ligurian-Piedmontese Units and be responsible for the exhumation of the whole pluri km-scale high-pressure Voltri Massif?

We tried to answer this question studying the eastern sector of the Voltri Massif: in this area lenses of metagabbro, metabasite, slices of sub-continental mantle and sediments of continental margin origin are wrapped by severely sheared serpentinite and metasediment, that are the prevalent lithologies.

We focused on metagabbro lenses since they best preserve metamorphic peak conditions. The most evident feature in these bodies is the strong strain partitioning acting between core and rims. The cores still preserve magmatic textures statically overgrown by the high-pressure assemblages, whereas rims display tectonite and mylonite structures.

The petrographic study of metagabbro samples was coupled with garnet-omphacite geothermometry estimates and P-T pseudosections; pseudosections were used to avoid any influence of chemical composition on P-T estimates. The results gave peak conditions of 10-15 kbar and 450-500°C for the blueschist body; the eclogitic lenses reached peak metamorphic conditions in the lawsonite eclogite stability field, ranging from about 21 kbar and 450-490°C to 22-28 kbar and 460-500°C. P-T paths are clockwise with almost isothermal, slightly cooling decompression trajectory.

These results can be compared with literature data for the studied area: the metamorphic peak conditions are scattered; temperature reach values up to 650°C and the pressures range from 18 to 25 Kbars. The different metamorphic peaks show that the selected rocks reached variable depths during the subduction process.

The heterogeneous metamorphic peak conditions recorded by the Voltri Massif rocks and the pervasive strain partitioning between the highly deformed matrix (serpentinite and metasediments) and the more competent boudins of different size (e.g. metagabbro and metaperidotite) fit the characteristics of a tectonic mélange.

This study thus indicates that the eastern sector of the Voltri Massif could be considered as a serpentinitic tectonic mélange developed in a serpentinitic subduction channel where a forced-return flow acted.

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SESSIONE G6

Le zone di sutura trassico-cretacee del Mediterraneo Orientale dalla Serbia all'Iran

G6-1 Key Lecture Goncuoglu, M.cemal

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EVOLUTION OF THE NEOTETHYAN OCEANIC BRANCHES IN TURKEY

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Key terms: Neotethys; suture belts; petrology; ages; Turkey

The alpine orogeny in Turkey is the result of the end Mesozoic- Early Tertiary closure of three main Neotethyan oceanic seaways. Remnants of their oceanic lithosphere are found as tectonic slices within the subduction-accretion complexes along the E-W trending suture belts or as olistoliths within the flysch complexes of the peripheral foreland-basins. Hence, a detailed study on the petrology of the oceanic lithologies combined with paleontological and geochronological data may help to reconstruct the paleotectonic evolution of these oceanic branches.

The previous data from the northernmost and least known branch, the IntraPontide Ocean between the Istanbul-Zonguldak and Sakarya continental microplates suggests a ridge-spreading from middle Middle Jurassic to middle Upper Cretaceous. Our new data however, indicates the

presence of late Middle Triassic oceanic sediments.

In the Izmir-Ankara-Erzincan Suture belt between the Sakarya and Tauride-Anatolide continental plates, the tectonic discrimination of volcanic rocks in the mélanges indicates four distinct groups: MORB, OIB, IAT and CAB, the first two types dominating over others. Moreover, the REE patterns very clearly demonstrate the presence of subtypes such as N-MORB and E-MORB types within the spreading ridge of IAO; calcalkaline, alkaline and tholeiitic types within the arc-related volcanics and two distinctly separate subtypes of OIB basalts that differ in the level of enrichment. Back-arc-type basaltic lavas are as old as Late Ladinian-Early Carnian. OIB-type basalts with Bajocian, Callovian-Tithonian and Valanginian-Barremian ages are typical. The youngest OIB age is Early Aptian. Oldest MORB-type basalts are Aelian in age. The MORB ages range between Carnian and Cenomanian. The supra-subduction-type basalts overall have age ranges between Aptian - Cenomanian ages. These ages are in accordance with radiometric ages from the sub-ophiolitic metamorphics. The recent data reveal that the Neotethyan Izmir-Ankara Ocean in NW Turkey opened already at early Late Triassic. The sea-floor spreading and the formation of OIB-type intra-plate seamounts within it started already in late Bathonian and persisted until early Aptian. The formation of the intra-oceanic subduction and the generation of supra-subduction-type volcanism have commenced until early Santonian and the spreading-ridge of the Izmir-Ankara oceanic plate has not been subducted until Cenomanian.

In regard to the southernmost oceanic branch of Neotethys, ophiolitic assemblages occur between the Tauride-Anatolide, the Bitlis-Pütürge-Alanya and the Arabian continental fragments respectively. Hence, the number and locations of the related suture belts are disputed. In the former case, the ophiolitic rocks are dominated by supra-subduction-type volcanic rocks and their ages are scattered around middle Late Cretaceous. The ophiolitic rocks between the Bitlis-Pütürge-Alanya terrane and the Arabian plate, on the other hand, are dominated by OIB and E-MORB type basalts of largely Triassic age with a distinct decline towards Jurassic. The oceanic branches of Neotethys well match-up with those in the east but there are critical discrepancies on the locations, ages and subduction directions towards west across the Aegean Sea.

G6-2 Orale Pandolfi, Luca

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A REGIONAL CROSS SECTION ACROSS THE INTERNAL DINARIDES IN THE CENTRAL-WESTERN SERBIA, ZLATIBOR-MALJEN AREA

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Key terms: ophiolites; tectonics; Dinarides; Serbia; Zlatibor

Two regional cross sections across the Internal Dinarides in the Central-Western Serbia are presented. The study area is located 100-150 km south of Belgrade in a sector between the Maljen Massif, the Zlatibor Massif and Prijepolje along a ca. 40km long NE-SW transect. Three main groups of tectonic units belonging to different zones can be distinguished: Vardar Zone. Three main tectonic units have been distinguished: the Maljen Ophiolitic Unit thrust by the Brus Unit and the underlying Sub-ophiolitic Mélange Unit. The Maljen Ophiolitic Unit is mainly composed by huge slices of serpentinites and serpentinized peridotites often characterized by remnants of a metamorphic sole. The succession of the overriding Brus Unit is composed by siliciclastic Upper Cretaceous turbidites (Lijg Flysch, cfr. Brus Flysch of the Kopaonik area). Below the Maljen Ophiolitic Unit a sub-ophiolitic mélange has been recognized (Sub-ophiolitic Mélange Unit).

Dinaric Ophiolitic Belt Zone. Two main tectonic units have been distinguished: the Zlatibor Ophiolitic Unit and the underlying Sub-ophiolitic Mélange Unit.

The Zlatibor Ophiolitic Unit is characterized by an assemblage of thrust slices ranging in thickness from 200 up to 1000 m. The reconstructed stratigraphy includes, from bottom to top: the metamorphic sole (amphibolites and garnet-bearing amphibolites), serpentinized peridotites and mafic-ultramafic cumulates (cropping out in Bosnia).

The Sub-ophiolitic Mélange Unit consists of an assemblage of thrust slices derived from both continental and oceanic domains set in a shaly or serpentinitic matrix. The slices of continental origin generally consist of Triassic to Lower Jurassic? carbonate successions made up of Triassic cherty limestones and platform carbonates and Early Jurassic pelagic cherty-limestones. In addition, slices consisting of pillow-lavas and massive basalts volcanics rocks covered by cherts have also been recognized.

Adria-derived Units zone. Two main tectonic units have been recognized: the Drina-Ivanjica Unit and the Durmitor Unit. Both these units are overthrust by the Sub-ophiolitic Mélange Units or directly by the ophiolitic (Zlatibor and Maljen) Units. The Drina-Ivanjica Unit consists of a Paleozoic metamorphic succession covered by an unmetamorphic Permo(?)–Triassic sequence. The metamorphic succession is made of phyllites, micaschists, metaconglomerates and limestones with a complex structural setting, due to the superposition of different tectono-metamorphic phases, related to the Carboniferous–(?)Permian metamorphic events. The unmetamorphic succession, that lies unconformably on the top of this latter, is represented by (?)Upper Permian sandstones and continental quartzitic conglomerates followed by Middle-Upper Triassic carbonatic platform deposits. The Durmitor Unit crops out west of the Zlatibor Ophiolitic Unit in the Prijepolje area and it is represented by low-grade schists, metasediments and metaconglomerates of Carboniferous age, followed by Permo-Triassic sandstones and quartz-rich conglomerates, interlayered with acidic volcanics and subvolcanics rocks. Follow a Triassic carbonatic sequence, made up of well-stratified limestones and marly-limestones, interlayered with subordinate cherts and cherty-siltstones.

The deformed Ophiolitic units of Maljen and Zlatibor and the Sub-ophiolitic Mélange Unit are unconformably covered, starting from Early Cretaceous (?Barremian), by thick calcareous sediments known as the "Cretaceous transgressive deposits". These deposits start with continental, transitional and shallow marine coarse clastic sediments followed by marine fine clastic and carbonate sediments. Different authors describe an unconformity between the Upper Cretaceous clastic deposits and the eastern part of the Drina-Ivanjica Zone, but the real nature of this contact

is still matter of debate.

G6-3 Orale Bortolotti, Valerio

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THE OPHIOLITES OF ALBANIA: GEODYNAMIC HISTORY

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Key terms: Ophiolite Nappe; Geodynamics; Dinaric-Hellenic belt; Triassic-Jurassic; Albania

The Triassic-Jurassic ophiolites of Albania are the remnants of a thick and complex nappe originated from the obduction on the continent of a portion of oceanic lithospheric sequences.

Several main questions are still matter of debate. They concern: the original location of the parent ocean; the ages of its birth and consumption; the recognition and interpretation of its continental margins; the reconstruction of the mechanism and direction of the ophiolite thrusting.

The data collected by our team permitted us to hypothesize a model for the tectono-stratigraphic evolution of this nappe in the frame of the Dinaric-Hellenic orogenic chain.

In Albania the Ophiolite Nappe, laying on top of the Adria continent successions, includes six tectonic units. From bottom upwards they are: 1- The Rubik Complex, a tectono-sedimentary subophiolitic mélange; 2- the Porava Unit, basalts, with intercalations or covers of Middle - Late Triassic red cherts; 3- the Metamorphic soles, deriving from a protolith with OIB affinity, typical of oceanic seamounts, metamorphosed between 174.0±2.5 and 162.1±2.4 Ma, and with a top-to-the-west sense of shear; 4- the Western Ophiolite belt, massifs of Iherzolites covered by MOR magmatic sequences grading upwards to SSZ volcanic sequences and dykes, covered by Jurassic cherts; 5- the Eastern Ophiolite belt, a very thick sequence with harzburgites and only SSZ magmatic sequences, covered by Jurassic cherts coeval to those of the Western Ophiolite belt; 6- the sedimentary-type Simoni Mélange, which unconformably lies at the top of both the Western and Eastern ophiolitic sequences and grades upwards to the late Tithonian Firza Flysch.

The easternmost ophiolite massifs lie on the Pelagonian, which lies, in turn, on the Ionian units, and the metamorphic sole structure indicates, all along the Mirdita ophiolites, a clear westward movement. So, the ophiolite nappe has to come from east of Pelagonian, i.e. from the Vardar Ocean, sited between the Pelagonian (representing the eastern margin of Adria) and the the Serbo-Macedonian Massif (representing the western margin of Europe).

The early phases of the oceanization can be restored to the Middle Triassic, and the spreading was continuous up to the Late Jurassic, for about 40 my. The subduction-related sequences are Middle Jurassic, so the beginning of subduction can be considered as Early Jurassic. The coexistence of MOR and SSZ ophiolites in the Western Ophiolite belt testifies for an intra-oceanic subduction, where a trapped MOR crust was subsequently covered by SSZ magmatism.

Thus, in the Early to Late Jurassic times, the oceanic area between Adria and Eurasia continental margins was characterized by an east-dipping subduction zone.

The ocean was closed in the latest Middle Jurassic and the continental collision occurred between the uppermost Late Jurassic and the earlier Cretaceous times. Subsequently, the compression-related deformation migrated into the Adria continental margin.

G6-4 Orale Fazzuoli, Milvio

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TRIASSIC AND JURASSIC CONTINENTAL MARGIN MEGA-BLOCKS IN THE MIRDITA OPHIOLITIC MÉLANGE (ALBANIA): EVIDENCES OF TRANSITION FROM EXTENSIONAL TO COMPRESSIONAL TECTONICS

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Key terms: TRIASSIC; JURASSIC; MEGABLOCKS; ALBANIA

The Mirdita Zone in Albania is characterized by MOR- and SSZ-type ophiolites and ophiolitic tectono-sedimentary mélanges including megablocks of continental margin carbonates, up to kilometre thick and up to some tens of kilometres large. Their stratigraphic succession consists of Middle Triassic-Early Jurassic carbonate platform carbonates, Early-Middle Jurassic pelagic condensed limestones and Middle-Late Jurassic radiolarites. Several stratigraphic sections have been studied both in the Triassic and in the Jurassic units from different blocks: four examples are here presented. The "Nunziatura" Late Triassic section near Rubik consists of m-thick beds of peritidal limestones and dolomites, cyclically arranged: subtidal Megalodon-bearing beds are interlayered with intertidal stromatolitic and fenestral beds and with supratidal breccias, and rare tepee structures. All these features strongly recall the "Hauptdolomit" sequence of the Northern Calcareous Alps. The section of Shkopet, near the Mati River, consists, from bottom upwards, of Rhaetian-Hettangian subtidal beds overlain by a metres-thick condensed section, made up of Sinemurian crinoid packstones with Agerina (Vidalina) martana, an hardground, Toarcian packstone with embryonic ammonites, a second hardground, dm- to m- thick beds of pink nodular wackestone, with Protoglobigerina and abundant cm-large Mn nodules, of early Bajocian. The section of Baiwash consists of Hettangian-Sinemurian, lagoonal, massive wackestone/packstone with Lithiotis banks at the top, an hardground, about ten meter of metre-thick beds of pink nodular wackestone / packstone with crinoids and Protoglobigerina of early Bajocian, a second hardground, green and red radiolarites of Middle Jurassic age. At Leshnja (Vithkuqi), the Jurassic succession consists of Hettangian-Sinemurian, lagoonal massive wackestone/packstone, with Lithiotis banks at the top, cross-cut by pink neptunian dykes, with a coquina of thin-shelled bivalves filling, and overlain by some metres of

mudstone/wackestone with Orbitopsella of Pliensbachian age. This succession is topped by a syn-sedimentary detachment surface and overlain by slumped beds of cherty limestones, of possible Middle Jurassic age, indicating the tectonic drowning of the carbonate platform. The sequence is topped by a 20 m thick, matrix-supported debris-flow deposit, made up of a siliceous-clayey matrix and metric chunks of beds of grey cherty limestones, green cherts and Middle Jurassic red radiolarites. In general the sedimentary evolution of the studied sequences indicates a progressive foundering of a continental margin by extension until the Middle Jurassic, then followed by an important seismotectonic activity (Middle-Late Jurassic), heralding the obduction of the ophiolitic nappe, and finally the offscraping of large blocks of the continental margin and their involvement in the ophiolitic melange at the base of the obducted oceanic crust (Late Jurassic).

G6-5 Orale Chiari, Marco

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BIO-CHRONOLOGICAL AND PETROLOGICAL CHARACTERIZATION OF THE OPHIOLITIC MÉLANGE IN THE CENTRAL VARDAR ZONE OF NORTHERN GREECE

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Key terms: Ophiolitic mélangé; Basalt; Jurassic radiolarites; Almopias; Greece

The Vardar zone consists of an assemblage of continental and oceanic units and, in Greece has classically been subdivided into three distinct sub-zones, which are (from west to east): the Almopias, Paikon and Guevgueli sub-zones. While the Guevgueli has been intensively investigated and is interpreted as a Late Jurassic ensialic marginal basin, the Paikon and Almopias are relatively poorly known. Few works on the Paikon suggest that it represents an "Andean-type" volcanic arc developed during the Mid-Late Jurassic. The Almopias sub-zone consists of several tectonic units, mainly including ophiolitic rocks, obducted westwards onto the Pelagonian zone. They have been subdivided into three main groups: the Western (WA), Central (CA), and Eastern (EA) Almopias ophiolites. The CA and WA mainly consist of mantle harzburgites and an underlying metamorphic sole tectonically emplaced over a basal mélangé, which incorporates volcanic rocks and dykes with calc-alkaline (CAB), alkaline within-plate (WPB), normal (N-) and enriched (E-) mid-ocean ridge (MORB), island arc tholeiitic (IAT), and boninitic affinities. Few, old works on the EA report the occurrence of a number of different ophiolitic units (e.g. Ano Garefi, Mavrolakkos, Kranea, Vrissi, Nea Zoi, Liki units); though, all these units consist of ophiolitic mélangé sequences. In some of them, the scattered occurrence of MORB and WPB pillow lavas and dykes, and Late Jurassic radiolarites has been recognized.

This work is focused on the bio-chronological and petrological characterization of the EA ophiolites in order to provide new solid constraints for the tectonic evolution of the Vardar Ocean. For this reason, paired volcanic-radiolaritic sequences have been investigated in the Kranea, Vrissi and Nea Zoi units.

The Kranea Unit includes a thick sequence of CAB basalts, basaltic andesites, andesites and rhyolites. At the top of this sequence, a basaltic dolerite showing MORB affinity has been found. The radiolarian chert sampled close to the top of this basalt contains radiolarians not well preserved.

The Vrissi Unit consists of basalts with MORB affinity overlain by low-K tholeiitic (LK-T) pillow lavas and crosscut by LK-T dykes. Radiolarian cherts associated with the basalts indicated a Middle-Late Jurassic age. The Nea Zoi Unit includes basalts and rhyolites with LK-T affinity. The samples of radiolarian cherts collected near the contact with the basalts yielded radiolarians with a low preservation.

The LK-T and CAB rocks clearly pertain to the Paikon Arc, whereas MORB rocks may have formed in either a mid-ocean ridge or backarc settings.

G6-6 Orale Fazzuoli, Milvio

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CONTINENTAL AND SHALLOW-MARINE DEPOSITS OF THE CRETACEOUS TRANSGRESSION SEALING OPHIOLITE OBDUCTION AND CONTINENTAL BASEMENT EXHUMATION: EXAMPLES FROM NORTHERN GREECE AND SOUTHERN ALBANIA

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Key terms: CRETACEOUS; TRANSGRESSION; OPHIOLITE; PELAGONIAN; GREECE

The ophiolitic nappes of the Dinaric-Hellenic orogenic system underwent complex deformations related to subduction, accretion and obduction onto the eastern Adria continental margin during Middle to Late Jurassic; these deformed units were later on unconformably overlain by the so-called "deposits of the Cretaceous transgression".

In western Macedonia (Northern Greece), two main tectonic units are present: the metamorphic Pelagonian Unit, consisting mostly of Triassic-Jurassic marbles, and the overlying Ophiolitic Nappe+Subophiolitic Mélangé, thrust during Late Jurassic. Moreover, in the Rhodiana area (Vourinos Massif), the ophiolites are tectonically overlain by limestones of Middle-Late Jurassic age (Zyghosti carbonate platform). At Tsimodia (Vourinos Massif), the top of the Zyghosti carbonates includes a thick Fe-Ni lateritic lens and it is overlain by limestone containing Salpingoporella urladanasi Conrad, Peybernes & Radoicic, of Barremian/Aptian age, and, on its turn, by a Cenomanian Orbitolina limestone. At Kteni (Vourinos Massif), a laterite horizon on the top of weathered serpentinite is covered by coarse- to fine-grained limestones with S. urladanasi and by a coarse-grained detrital limestone with Orbitolinidae. At Koumaria (Vermion Massif), the serpentinite is unconformably overlain by laterite pockets, by m-thick beds of

conglomerates with pebbles of marbles and ophiolites passing laterally to limestone with S. urladanasi and, upwards, by Late Cretaceous limestone with Orbitolinidae and Rudist fragments.

In southeastern Albania the Cretaceous sediments that unconformably overlie the ophiolites and the Subophiolitic Mélangé are mainly coarse clastics in the lower part, passing upwards to shallow marine limestones. At Germej, near the town of Leskovik, weathered basalts included in the Subophiolitic Mélangé are overlain by a m-thick cover of siliceous duricrust with lateritic clasts, by m-thick bodies of conglomerate with basalt pebbles scattered within reddish lateritic, sandy-clayey matrix. At Lubonja, not far from the town of Korçë, above the Subophiolitic Mélangé, a 60 m-thick succession of conglomerate crops out; the medium- to well-rounded, cm- to dm-sized pebbles are made up mostly of marble, grey to black chert, locally abundant limonitised laterite and rather rare ophiolitic rocks; the fine-grained matrix, more or less abundant, is laterite-rich. Calcarenite of Late Cretaceous age caps the succession.

All these features allow to hypothesize that during Late Jurassic/earliest Cretaceous obducted ophiolites underwent emersion, prolonged subaerial weathering and erosion, that gave origin to widespread lateritic deposits, both "autochthonous" and "allochthonous". Starting from the late Early Cretaceous, a marine transgression spread above the ophiolites (and locally on the Zyghosti Jurassic platform limestone); the flooding was heterochronous, possibly due to an uneven erosion surface. The marine flooding was connected with high-angle extensional tectonics, at turn possibly driven by low-angle extensional tectonics. The transgression, beginning from Barremian/Albian, locally developed firstly under restricted, brackish lagoonal conditions, marked by the occurrence of the dasycladacean alga S. urladanasi, and then followed by normal salinity conditions, starting from Albian. In other areas, a more severe tectonic phase gave origin to horst- and graben structures with consequent development of ophiolite-originated coarse-grained deposits in usually dark red, argillaceous-lateritic matrix. Where the exhumation involved also the Pelagonian metamorphic units underlying the ophiolitic nappes, the erosion gave origin to coarse-grained deposits with marble clasts, together with an abundant laterite derived-matrix. The frankly marine sedimentation generally started since Cenomanian.

G6-7 Orale Nirta, Giuseppe

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THE TIMING OF EMPLACEMENT OF THE OPHIOLITIC NAPPE IN THE EXTERNAL HELLENIDES: STRUCTURAL AND STRATIGRAPHIC EVIDENCES FROM THE CRETACEOUS AND TERTIARY FLYSCH SEQUENCES OF THE PINDOS MOUNTAINS (EPIRUS, GREECE)

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Key terms: OPHIOLITE; OBDUCTION; GREECE

A thick nappe consisting of ophiolites derived from the Vardar Ocean along with a composite tectono-sedimentary mélangé at the base (Sub-ophiolitic Mélangé) was thrust above the eastern continental margin of Adria starting from the Middle Jurassic. After a long westward travel lasted about 140 Ma across the Adria continental units, nowadays the westernmost tips of the Ophiolitic Nappe+Subophiolitic Mélangé thrust front are emplaced onto a Paleocene-Eocene foreland turbidite sequence. In the northern Pindos Mountains the study of the stratigraphy and tectonic history of the Cretaceous to Tertiary turbidite sequences lying below the Ophiolitic Nappe allowed to add new data on the mechanisms of emplacement of the Ophiolitic Nappe on the continental crust. The studied sequences pertain to the late Paleocene-Eocene Pindos Flysch and to an assemblage of tectonic slices of Early Cretaceous continental margin sequences known as Beotian Unit, the latter overthrusting the former. The younger deposits of the Beotian Unit, considered the westward continuation of the Pelagonian platform (easternmost portion of the Adria continental margin), are characterized by the occurrence of ophiolite-bearing mass flow deposits, known as Beotian Flysch. From a regional point of view the ophiolite-bearing detritus within the Pelagonian sequences show a younging direction from the Maliac-Othrys area to the Beotia area suggesting a westward emplacement of the Ophiolitic Nappe. The Paleocene - Late Eocene Pindos Flysch is regarded as a foreland basin deposit, which was progressively overthrust westwards by the Sub-ophiolitic Mélangé + Ophiolitic Nappe. This event is recorded in the turbiditic sediments by diffuse syn-sedimentary deformations and catastrophic events of mass deposition (mega-debris flows and slide blocks) with provenance from both continental margin units and ophiolitic units.

The structural and stratigraphic analyses in the Pindos Flysch and in the Beotian Unit sequences and their integration with first order geological constraints of the Hellenic Chain allowed to discriminate between different emplacement mechanism of the Ophiolites onto the continental margin sequences: (a) obduction and (b) passive advancing through activation of main thrust in the continental crust.

Obduction mechanism started with an oceanic stage during the Middle Jurassic with development of metamorphic sole at the base of the Ophiolitic Nappe and mélangé formation. The obduction continental stage started with the overthrusting of the Pelagonian platform. During this stage the advancing Ophiolite Nappe shed with ophiolitic debris the facing continental margin basins (e.g. Beotian Flysch) and, contemporaneously, chunks from the Pelagonian platform were progressively included in the Subophiolitic Mélangé. During the Early Cretaceous, obduction ceased and was followed by emersion of the Ophiolitic Nappe and later exhumation of the underlying Pelagonian sequences followed by transgression with deposition of continental to shallow marine sediments starting from the Barremian.

During the Cretaceous-Paleocene transition the continental collision between the Serbo-Macedonian and Rhodopian Massifs (Eurasia) and the Pelagonian margin (Adria) took place. This event rejuvenated the westward thrusting of the continental units followed by crustal thickening and enucleation of a foreland basin to the west since the Paleocene (i.e. the Pindos Flysch basin). During this phase the activation of a main west-directed thrust at the base of the Pelagonian Unit carried on passively the ophiolites and mélangé to overthrust the Pindos flysch since late Eocene. The westward movement of the Ophiolites onto the Pindos Flysch ended only during the latest Eocene-early Oligocene, when a climax of compressional deformation caused eastward verging reverse faults connected with strike slip movements, that cut the Ophiolitic Nappe + Sub-ophiolitic Mélangé basal thrust.

G6-8 Orale Principi, Gianfranco

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THE OPHIOLITES OF GREECE AND THEIR TRIASSIC TO TERTIARY GEODYNAMIC-TECTONIC HISTORYPRINCIPI Gianfranco¹, BORTOLOTTI Valerio¹, CHIARI Marco², FAZZUOLI Milvio¹, MARCUCCI Marta¹, MARRONI Michele³, MENNA Francesco¹, NIRTA Giuseppe¹, PANDOLFI Luca³, PHOTIADES Adonis⁴, SACCANI Emilio⁵, et al.

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Key terms: Ophiolitic Nappe; Geodynamic; Hellenides; Greece

The Hellenides consist of several NW-SE-trending, parallel tectono-sedimentary belts (the 'Isopic Zones' of Aubouin). From west to east they are: the Ionian, Gavrovo, Pindos, Parnassos, Subpelagonian-Pelagonian and Vardar Zones. Macedonian Zone and Rhodope pertain to the deformed westernmost European margin. The first five zones are made of continental margin successions. An Ophiolitic Nappe with an underlying tectonic mélange overthrust the Pelagonian, Subpelagonian and, partially, Pindos Zones, and now is represented by the N-S trending Western (Pindos-Mirdita) and Eastern (Vardar Zone) Ophiolitic belts.

The Pelagonian Zone (including the Subpelagonian) consists of a Palaeozoic metamorphic basement, covered by a Permian to Jurassic succession with volcanics and sediments. According to some previous works, the Pelagonian was considered a microcontinent between a western (Pindos-Mirdita) and an eastern (Vardar-Axios) oceanic branches of the Neothethyan Ocean. The others continental zones were considered as parts of the Adriatic microplate.

Late Jurassic to Late Cretaceous calcareous successions and, in places, a Tertiary flysch overlap these mélanges and shed debris in them. Along the sub-ophiolitic mélange of the Western Ophiolitic Belt, cherts with Triassic radiolarian associations stratigraphically linked to basalts with MOR and OIB characteristics, as well as to continental rift volcanics are present. Also Middle-Late Jurassic oceanic (MOR) and supra-subduction (IAT) basalt-chert associations are widely found.

The obducted Ophiolitic Nappe (e.g., Pindos, Vourinos, Othrys) is made essentially by ultramafics, mainly hartzburgites, with minor ultramafic-mafic cumulates of IAT signature. Where present, the volcano-sedimentary covers are of Middle-Late Jurassic and the basalt have a IAT signature. At the contact between the overriding ultramafic bodies and the subophiolitic mélange, thin HT-LP metamorphic (amphibolitic) soles can be observed almost everywhere. Their ages range from 174.0±2.5 and 162.1±2.4 Ma. In the central-northern Greece, the Pelagonian suffered an Alpine metamorphic phase (green schists). Except for the metamorphic soles, the overriding ophiolites are not metamorphic. Probably, the last tectonic contact is the consequence of a low angle normal faulting, perhaps divergent, operating during the Cretaceous-Tertiary exhumation of the Pelagonian metamorphic basement.

Our data and field observations, together with many literature data, permit to establish that:

- 1- The western ophiolitic belt derive from the Vardar zone.
- 2- The Pelagonian was the easternmost part of the Adria Plate.
- 3- The ocean MORB basin originated in the Middle Triassic (latest Anisian-early Ladinian) and persisted up to the Middle-Late Jurassic.
- 4- The IAT magmatism started in the Middle Jurassic.
- 5- The westward obduction, as testified by the metamorphic, soles begun in the same age.
- 6- The Pelagonian suffered an orogenic metamorphism probably in the earliest Cretaceous or slightly older in the easternmost realm of the Pelagonian.
- 7- At the same time, the collision between the Adriatic and Rhodopian continental lithospheres took place.
- 8- Immediately after, probably during the early Cretaceous, the Pelagonian was exhumed.
- 9- From the same time, up to the Tertiary, carbonate and clastics sediments unconformably covered both ophiolitic and Pelagonian units. Finally, during the Mesozoic only one ophiolitic basin existed between Adria and Rhodope and this ocean started in the Middle Triassic (latest Anisian-early Ladinian), immediately after the beginning of the rifting stage that, starting from the Anisian, affected the Adriatic continental margin.

G6-9 Orale Tortorici, Luigi

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THE CRETAN OPHIOLITE-BEARING MÉLANGE (GREECE): A REMNANT OF ALPINE ACCRETIONARY WEDGETORTORICI Luigi¹, CATALANO Stefano¹, CIRRINCIONE Rosolino¹

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Key terms: ophiolites; accretionary wedge; Palaeogene; Crete; Greece

New geological, structural and petrographic data collected in central Crete on the ophiolite-bearing terranes of the Cretan mélange, result in a better understanding of the role and tectonic significance of these units in the construction of this segment of the external Hellenides. The Cretan mélange is composed of three main tectonic units that, characterized by different metamorphic facies conditions, are represented by a un-metamorphosed to weakly metamorphosed lower unit, a greenschist to HP greenschist-facies intermediate unit and a blueschist-facies upper unit. These chaotic rock-complexes include blocks of oceanic and continental deriving rocks and can be considered as a remnant of an accretionary complex. In this context the lower unit represents the toe of the wedge whereas the intermediate and upper units are referred to the innermost and deeper subducted portions of the wedge exhumed and superimposed one on each others during the early stages of continent-continent collision. The structural evolution of the accretionary wedge was controlled by two main contractional deformation events that, including distinct groups of structures developed at different crustal levels, were driven by a SSE and a SSW directions of tectonic transport, respectively. Geological and structural data strongly suggest that the ophiolite-bearing allochthonous tectonic wedge was accreted during the Paleogene subduction of a Late Jurassic-Cretaceous oceanic realm beneath the continental margin of the Pelagonian domain and was successively involved in the continental collision with the Adria (Cretan) Block. The greenschist to blueschist facies metamorphism and the subsequent

exhumation and emplacement of the intermediate and upper units above the frontal portion of the wedge may be mainly due to deep duplexing marking the onset of the continental collision. We thus suggest that the ophiolite-bearing units of Crete represent a single suture zone related to the closure of a unique oceanic domain (Pindos-Cycladic Ocean) subducted beneath the Internal Hellenides Platform continental domains thus assuming the significance of a southern oceanic seaway of the largest eastern Neothethys developed since the Triassic between the Eurasia and Africa continental masses.

G6-10 Orale Marroni, Michele

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PALEOTHEYS AND NEOTHEYS SUTURE ZONES IN NORTHERN TURKEY: EVIDENCES FROM DADAY-ARAC-KURSUUNLU GEOTRAVERSEELLERO Alessandro¹, GONCUOGLU M.cemal², MARRONI Michele³, PANDOLFI Luca³, SAYIT Kaan²

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Key terms: OPHIOLITES; CIMMERIAN OROGENY; INTRAPONTIDE SUTURE; SUTURE ZONE; NORTHERN TURKEY

The present-day tectonic setting of the alpine belt in Turkey consists of several amalgamated continental microplates separated by suture zones, where ophiolites occur. The study of these ophiolites is able to provide valuable insights for the reconstruction of the long-lived geodynamic history responsible of this complicate setting.

A key-area for this aim is represented by the Daday-Arac-Kursunlu geotransverse in northern Turkey where two different ophiolite-bearing suture zones can be recognized, hereafter reported as IntraPontide (IP) suture zone and Karakaya Complex.

The IP suture zone is represented by an ophiolite-bearing mélange, reported in the literature as Arkotdag Mélange, topped by a mantle slice. This suture zone is sandwiched between the Istanbul - Zonguldak Terrane at the top and the Sakarya Terrane at the bottom. The Istanbul - Zonguldak Terrane includes Late Neoproterozoic basement unconformably covered by a continuous, well-developed sedimentary succession ranging in age from Paleozoic to Cretaceous, topped by Late Cretaceous-Paleocene turbidite deposits where andesitic volcanic rocks have been found. The Arkotdag Mélange consists of huge blocks of oceanic rocks, generally bounded by shear surfaces, interlayered with ophiolite-bearing deposits. This mélange is topped by a mantle slice represented by serpentinites showing at its base a metamorphic sole. The preliminary observations on the Arkotdag Mélange suggest its formation in Late Jurassic to Late Cretaceous time span during the closure by obduction of an oceanic basin originated in Middle to Late Jurassic time span between the Eurasian plate and Sakarya microplate. The structural setting of the IP suture zone is quite complicated, as recognized along the Daday-Arac-Kursunlu geotransverse, where a new, puzzling metamorphic unit has been identified in the field. This unit, that consists of a strongly deformed succession of micaschists, para-gneisses and metabasites, is sandwiched between the ophiolite nappe at the bottom and the Istanbul - Zonguldak Terrane at the top.

The Arkotdag Mélange is thrust over the Sakarya Terrane, represented in the studied geotransverse by the Karakaya Complex and its Jurassic-Cretaceous cover. The Karakaya Complex represents remnants of Triassic accretionary wedge, where a lower sequence, consisting of E-MORB to OIB metabasic rocks folded with metacarbonates and schists, was strongly deformed under a high-pressure metamorphism ranging from blueschists to eclogite facies. Radiometric dating points out to a latest Triassic age of the metamorphism. The deformation and metamorphism recognized in the Karakaya Complex is the result of the Cimmerian Orogeny, resulting from the subduction of the PaleoTethys oceanic lithosphere below the Laurasian continental margin. The tectonic structures related to the Cimmerian Orogeny are unconformably sealed by the continental to marine Early Jurassic-Cretaceous, mainly carbonate succession, showing a transition to turbidite deposits ranging in age from Late Cretaceous to Paleocene. These deposits are characterized in their uppermost levels by carbonate and ophiolite blocks, the latter ones derived from IP suture zone.

On whole, the data collected along the studied geotransverse indicate that in the northern Turkey an old suture zone is preserved in the Karakaya Complex connected with the PaleoTethyan oceanic basin closure in the Late Triassic. The unconformably sedimentary cover indicates that deformation and metamorphism related to Cimmerian Orogeny terminated in the Early Jurassic.

A younger suture zone is represented by the ophiolites from the IP suture zone. This suture, that is still poorly known, is today marked by an ophiolitic mélange (Arkotdag Mélange) topped by a mantle slice, both emplaced southward onto the continental margin today represented by the Sakarya Terrane. The closure of this NeoTethyan basin is referred to Late Cretaceous, whereas its opening is still matter of debate.

G6-11 Orale Sacani, Emilio

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THE KERMANSHAH OPHIOLITIC COMPLEX (ZAGROS BELT, IRAN): A KEY AREA FOR UNDERSTANDING THE GEODYNAMIC EVOLUTION OF THE NEO-TETHYS IN THE MIDDLE EAST. PART 2: STEADY-STATE OCEANIC SPREADING AND OCEANIC CONSUMPTIONSACCANI Emilio¹, ALLAHYARI Khalil², BECCALUVA Luigi¹, POURMOAFI Mohamad², MASOUDI Fariborz²

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Key terms: Ophiolite; Mantle Peridotite; supra-subduction zone; Zagros; Iran

The Kermanshah ophiolitic complex consists of a mélange formation, which includes dismembered ophiolitic sequences. These ophiolites are located along the Main Zagros Thrust (MZT), which marks the suture zone between the Zagros belt and the Sanandaj-Sirjan zone. They represent the Tethyan oceanic lithosphere, which originally existed between the continental margins of Arabia (to the south) and Eurasia (to the north). These ophiolites were emplaced onto platform carbonate rocks, which

represent the northeastern Arabian margin.

The Kermanshah ophiolitic complex is composed of various partial sequences, which are represented by: 1) a dynamo-metamorphic sequence of mantle lherzolite and gabbro intruded by basaltic dykes; 2) mantle tectonites consisting of depleted lherzolites and both cpx-rich and cpx-free harzburgites; 3) a troctolite-cumulate gabbro-isotropic gabbro sequence mainly showing pegmatoid texture; 4) a wehrlite-cumulate gabbro-isotropic gabbro sequence showing foliated texture; 5) pillow basalts. Mantle tectonites are volumetrically predominant and, in places, tectonically overlay the gabbroic sequences. The Foliated Gabbros are characterized by very low contents of TiO₂, P₂O₅, Zr, Y and variable amounts of Al₂O₃, CaO, MgO, which correlates with the variability of the modal composition. They display a flat N-MORB normalized incompatible element pattern and chondrite-normalized REE composition with slight LREE/HREE enrichment coupled with a slight LREE/MREE depletion. Mineral chemistry, REE composition and many incompatible element ratios (e.g. Ta/Yb, Th/Yb, Ce/Y, Zr/Nb) indicate that these gabbros are geochemically similar to gabbros generated in a mid-ocean ridge setting from a depleted MORB mantle (DMM). In terms of major elements, lherzolites and harzburgites can be distinguished on the basis of TiO₂, Al₂O₃ and CaO contents. In general, both these peridotite-types show depletion in incompatible element concentrations with respect to the DMM. Lherzolites have MREE and HREE contents higher than those of harzburgites, but show a marked LREE/MREE depletion (CeN/SmN=0.05-0.86), though one sample displays a relative enrichment in La and Ce. Cr-spinels in lherzolites show relatively low Cr# and Fe#, which are comparable to those of abyssal peridotites. REE modelling shows that they may represent a residual mantle after 15-20% removal of N-MORB melts. Both cpx-rich and cpx-free harzburgites are characterized by marked U-shaped chondrite-normalized patterns with LaN/SmN=3.69-6.02 and SmN/YbN=0.07-0.50. The (La/Sm)N ratio correlates well with the degree of depletion (Al₂O₃/SiO₂), showing that the more depleted samples have the higher relative enrichment in LREE. Cr-spinels from all harzburgitic-types show Cr# and Fe# similar to those of Cr-spinels from SSZ peridotites. REE modelling shows that they may represent a residual mantle after 25-30% removal of SSZ-type melts. The marked LREE/MREE enrichment suggest that this mantle was enriched in LREE by fluids released from the subducting slab. The rocks studied in this work record the two distinct phases of the geodynamic evolution of the Tethys in the Iran sector. The foliated gabbroic sequence and the depleted lherzolites represent the conjugate magmatic rocks-mantle residua formed in a mid-ocean ridge setting during the steady-state spreading phase, which persisted from Late Triassic to Late Jurassic. The moderate LREE/MREE enrichment observed in some depleted lherzolites suggests that the residual MORB mantle was subsequently trapped in a SSZ and enriched in LREE by subduction-derived fluids. Harzburgites represent the residual mantle formed in a SSZ setting and thus can be related to the existence of an intra-oceanic arc that is associated in turn with the convergence phase and consumption of the Tethys through a NE-dipping subduction beneath the Sanandaj-Sirjan continental margin, which started in the Late Jurassic.

G6-12 Orale Saccani, Emilio

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THE KERMANSHAH OPHIOLITIC COMPLEX (ZAGROS BELT, IRAN): A KEY AREA FOR UNDERSTANDING THE GEODYNAMIC EVOLUTION OF THE NEO-TETHYS IN THE MIDDLE EAST. PART 1: FROM THE CONTINENTAL RIFTING TO THE EARLY OCEANIC SPREADING

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Key terms: *Ophiolite; Oceanic spreading; MORB; alkaline basalt; Iran*
 Ophiolites extensively crop out along the Main Zagros Thrust (MZT) and record the geodynamic evolution of the Tethys branch between the Arabian shield and a composite puzzle of continental blocks bordering Eurasia. Many geological aspects of the Zagros have previously been examined, but the MZT ophiolites are still poorly constrained. Nonetheless, any regional reconstruction must take account of the tectono-magmatic characteristics of the ophiolitic sequences. The Kermanshah ophiolites represent a key area of the MZT, as they record the evolution of the Tethys ocean developed between Arabia and the Sanandaj-Sirjan block and are believed to represent the conjugate oceanic sector of the Oman ophiolites. These ophiolites include several distinct rock-associations that can be related to distinct phases of the oceanic evolution. In particular, these ophiolites consist of an ophiolitic mélange, which include: 1) a dynamo-metamorphic sequence of mantle lherzolite and gabbro, which is intruded by basaltic dykes (hereafter referred as metalherzolite, metagabbro and metadyke); 2) mantle peridotites affected by ocean-floor metamorphism; 3) foliated gabbroic sequences; 4) pegmatoid gabbroic sequences; 5) pillow lavas. Metalherzolites show a very little depletion in HFSE and REE concentrations with respect to the depleted MORB mantle (DMM). They show both mineral and whole rock chemistry, which is very similar to that of lherzolites from the External Ligurides of Northern Apennine. Metagabbros and metadykes have relatively high contents of TiO₂, Zr, Y and show an overall geochemistry, which resembles that of basalts generated at mid-ocean ridge. REE patterns of metagabbros and some metadykes show a marked MREE/HREE enrichment (SmN/YbN = 1.67 - 2.47), while other metadykes show no MREE/HREE enrichment. The chemistry and Sr-Nd isotopic composition of these rocks is comparable to that of gabbros and basalts from the External Ligurides and Corsica. Three chemically distinct groups of volcanic rocks can be identified. Group 1 displays a clear alkaline nature and show HFSE, REE and Sr-Nd isotopic composition, which is similar to that of alkaline within-plate basalts from oceanic island (OIB). They show LREE/HREE strongly enriched patterns and high Th/Yb, Ta/Yb and Zr/Nb ratios. Group 2 shows a sub-alkaline nature and significantly enriched incompatible and LREE patterns, as well as relatively high Th/Yb, Ta/Yb and Zr/Nb ratios. Mineral and whole rock chemistry and Sr-Nd isotopic compositions are similar to those of typical plume-type MORB (P-MORB). Group 3 have LILE/HFSE and LREE/HREE smoothly enriched patterns and Th/Yb, Ta/Yb and Zr/Nb ratios lower than those of Group 2. The overall geochemical features of these rocks resemble those of typical E-MORB. Likewise, the Pegmatoid gabbros also display E-MORB signature. REE modelling show the following results: 1) N-MORB metagabbros and metadykes with high Sm/Yb ratios are generated by 15% partial melting

of a DMM source bearing garnet-pyroxenite relics; 2) N-MORB metadykes are generated by 15% partial melting of a DMM source in the spinel-facies; 3) alkaline basalts are generated from an enriched OIB (plume-type) source by 5% partial melting that starts in the garnet-facies and continues in the spinel-facies; 4) P- and E-MORBs are generated by <7-8% partial melting of a DMM source variably enriched in LILE and LREE by a plume-type component. The rocks studied in this work record the early phases of the geodynamic evolution of the Iranian Tethys, as summarized as follows.

- 1) The Late Triassic continental break-up resulted from an asymmetric extension, which allowed the exhumation of the subcontinental mantle and the preservation of garnet-pyroxenite relics in the MORB mantle source.
- 2) The early oceanic evolution is characterized by rifting with volcanism associated with "plume" effects (i.e. OIB, E-, P-MORB), which occurred at the continent-ocean transition zone or in off-axis oceanic settings.

G6-13 Orale Zanchi, Andrea

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THE PERMO-TRIASSIC EVOLUTION OF THE PALAEO-TETHYS SUTURE IN NE IRAN

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Key terms: *Cimmerian orogeny; Suture zone; Ophiolites; Geodynamics; accretionary complex*

The region of NE Iran is a key-area for the Cimmerian orogeny, which is related to the Late Triassic collision of Iran with Eurasia as a consequence of the closure of the Palaeotethys. In spite of recent studies carried out on the Cimmerian Orogeny in the Alborz, and in the Binalud mountains south of Mashaad, where these processes were firstly recognized 40 years ago, few information is available to the NE within the large area extending between the city of Mashaad and the Afghan border. Due to the importance of this area for the understanding of the Cimmerian event, a research project, which has been sponsored by the DARIUS PROGRAMME and MIUR, focused on the area extending east of Mashaad between Fariman and Torbat Jam. Here, the occurrence of a thick succession of Permian andesitic to basaltic submarine lava flows interfingering with carbonate platform limestones and siliciclastics poses several questions on the geodynamic significance of this peculiar rock association, previously interpreted as a Palaeotethys-related accretionary wedge. The same is true for the Permian "ophiolites" of Darreh Anjir, which were interpreted as remnants of the Palaeotethys oceanic crust. Detailed structural, stratigraphic and petrological study of this Permian succession allowed us to substantially modify previous interpretations. According to our data, the Permian units were deposited in a marine basin close to a volcanic area with complex features, where a large volume of lava flows was emplaced in submarine conditions. In addition, tectonic deformation is not compatible with an accretionary wedge as neither disruption of the stratigraphy, nor penetrative shear zones and high pressure metamorphism have been identified. Preliminary geochemical data from the Darreh Anjir and Fariman units clearly suggest an arc-related setting developed on a continental crust. We thus interpret these units as remnants of a supra-subduction arc-related complex, developed during the Permian along the active Southern Eurasian margin above a N-dipping subduction zone related to the consumption of Palaeotethys. To the north of these units, the arc-related basin of Aghdarband records the Triassic history of the collision zone. The Triassic successions show a well preserved N- to NNE-verging Cimmerian imbricate thrust fan developed in a retro-wedge position, with respect to the main N-dipping collision zone located south of Mashaad. The thrust fan interacts with an important ESE-WSW left-lateral fault zone, accommodating an important component of oblique collision of Iran through a mechanism of strain partitioning. All these structures are sealed by the Bajocian Kashaf Rud Fm., demonstrating that the main deformation, affecting also the Upper Triassic Miankuhi Fm. can be related to the Cimmerian events. This suggests that the deformation of the Aghdarband area lasted longer than in the Alborz, possibly post-dating the main collision of the Iran microplate with Eurasia.

G6-14 Orale Principi, Gianfranco

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THE INFRA-WILSONIAN CYCLICITY OF TETHYAN OCEANS AND THE ACCRETION OF GONDWANA SLICES TO THE EURASIAN MARGIN. IS IT TO A LONG-LIVED LITHOSPHERE-MANTLE GEODYNAMIC MEMORY?

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Key terms: *intrapangean oceans; geodynamic cyclicality; Earth memory*

Considering life and location of past intrapangean oceans we note three interesting characteristics: the different duration of their lives, their cyclicality and parallelism. Regarding their lives, we can observe three main types: a) the long-lived oceans, like the present day Atlantic Ocean (in the past time the Japetus Ocean), which has a life corresponding to a Wilsonian cycle; b) The short-lived oceans, the Rheic Ocean, Paleotethys and Neotethys, which had lives corresponding to a portion of a Wilsonian cycle (infra-Wilsonian); c) the fossilized oceans, like the Gulf of Mexico or, in the past, the Western Tethys during the Early Cretaceous. Regarding the cyclicality, the long-lived intrapangean oceans (e.g., the Atlantic) reopened several times, more or less in the same places or nearby, in relation to successive Pangean break-ups and reassemblies. The formation of short-lived oceans (e.g., Paleotethys, eastern Tethys, Neotethys), the argument of this talk, seems to be linked to a continuous process, active from Paleozoic to now, which moves terrains from the passive Gondwana margin to the Eurasian active margin. The processes that took place during the Paleozoic, regarding the Rheic and Paleotethian oceans, outlived with respect to those during the Mesozoic, regarding

Vardar-Meliata, and Neotethys, but all caused a continuous cutting of Gondwana slices, which were accreted to the paleoeurasian margin. The process, active up to now in the Red Sea-East Africa rift system: This process operated and operates as if all the Gondwanian slices migrate northeastward with a not easily defined Eulerian pole located to the west. Does some type of memory exist in the interior of the Earth, responsible for these cyclic phenomena? We propose some reflections on the location and mechanisms of the supposed Earth memory.

G6-15 Poster Nirta, Giuseppe

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SEDIMENTS OF THE CRETACEOUS TRANSGRESSION IN THE MOKRA GORA SECTION, WESTERN SERBIA, DINARIC OROGEN

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Key terms: CRETACEOUS; TRANSGRESSION; WESTERN SERBIA; OPHIOLITE

In the internal (eastern) part of the Dinaric-Hellenic orogenic system the ophiolitic units, accreted and obducted during the earlier tectonic phases (Middle-Late Jurassic), show evidences to have been broadly emerged during the earliest Cretaceous compressional phases, forming rather high relieves which underwent erosion and pedogenesis. In several places, the ophiolites are unconformably overlain by the so-called "deposits of the Cretaceous transgression". A detailed lithostratigraphic and sedimentological study was performed at Mokra Gora and Vardiste sections (Zlatibor ophiolitic massif, Western Serbia), in the lower part of the Cretaceous succession that unconformably overlies the ophiolites, to evidence the onset and the development of the "transgression". The lithological and sedimentological features of the succession reflect two main deepening-shallowing cycles, informally named Unit A and Unit B. The substratum consists of serpentinite and weathered serpentinite, locally covered by lateritic deposits and siliceous duricrusts. The Unit A (?Barremian) has been subdivided in four subunits. Subunit A1 consists of conglomerate and sandstones with ophiolitic clasts, deposited by braided streams. Subunit A2 consists of ophiolite-derived sandstone and siltstone, deposited by meandering streams. Above a sharp flooding surface, subunit A3 is represented by fossiliferous limestone, marl and siltstone deposited in lagoonal and marine subtidal environment. Subunit A4 consists, in the lower part, of alternating marl and limestone of marine mid/inner ramp environment passing upwards to calcareous and litharenitic sandstone of inner ramp environment. The overlying Unit B (Aptian-Cenomanian) is very thick and has been subdivided in five subunits. The sharp surface between Unit A and B represents an unconformity surface, possibly due to emersion, and marks the onset of a younger cycle of deposition. Subunit B1 consists, in the lower part, of reddish mixed carbonate-ophiolitic sandstone and siltstone of coastal plain environment passing upwards to reddish siltstone including silcrete bodies and caliche beds, owing to evidences of pedogenesis occurred in an ephemeral lagoon-coastal lake environment. Subunit B2 is made up by nodular limestone and marl with subordinate litharenitic sandstone, of partially restricted lagoon with terrigenous inflow. The surface between B2 and B3 subunits represents the flooding surface of the second cycle. The subunit B3, that constitutes the large part of the B Unit, mostly consists of fossiliferous marl and subordinate limestone with frequent bioclastic storm beds, indicating an inner- to mid-ramp environment. A dark grey marly horizon with abundant organic matter is intercalated within the subunit B3 and represents an anoxic episode and possibly the maximum flooding surface. The subunit B4 consists of alternating limestone and subordinate marl and indicates the return to the subtidal inner ramp environment. The overlying Unit C, not studied (Turonian-Senonian), is represented by massive to thick bedded bioclastic redstone to boundstone, and evidences the onsets of widespread reefal bioconstructions.

The geodynamic framework in which these deposits had developed is presumably that of a widespread tectonic collapse, involving the Ophiolitic Nappe after the Eohellenic compressional phase (?Late Jurassic - Early Cretaceous), followed by the marine flooding of the previously formed depressions, possibly in connection with eustatic rises (Aptian-Cenomanian).

G6-16 Poster Bortolotti, Valerio

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INFLUENCE OF TECTONICS IN THE EMERSION AND COLLAPSE OF THE ZYGHOSTI CARBONATE PLATFORM, JURASSIC-CRETACEOUS, NORTHERN GREECE

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Key terms: Carbonate platform; Jurassic-Cretaceous; Zyghosti; Greece

Periods of emersion and karstification with occurrences of pockets of laterites and bauxites are well known during the evolution of the "persisting" or long-lived (up to Tertiary) carbonate platform in Southern Apennines and Greece. These phenomena are very rare, if any, in the precociously drowned (during Early-Middle Jurassic) carbonate platforms of Alps, Apennines and Greece. The Zyghosti carbonate platform, present only in small tectonic chunks in the Northern Greece over the Ophiolitic Unit, presents all these features. In the Middle-Late Jurassic, mostly lagoonal facies were developed; later on, the platform suffered two emersion episodes: in the latest Middle Jurassic and in the Early Cretaceous. During the first and shorter episode, karst sinkholes developed, later on filled by Tithonian marine deposits; during the latter one, lasted about 27 m.y., a widespread karst took place and laterite levels accumulated in the depressions of the subaerial surface. Over this surface a marine transgression occurred since early Albian up to late Albian; during the early Cenomanian a large-scale tectonic collapse occurred and fine-grained pelagic sediments were interlayered by turbidites, coarse-grained mass-flow deposits and slumped beds, up to the Maastrichtian.

The long-lasting emersion cannot be explained only by eustatic

variations, but tectonic causes must also be invoked: possibly a peripheral bulge in front of the advancing ophiolitic nappes and/or the overthrusting of the carbonate body onto the obducting ophiolites during the "paleo-hellenic" tectogenetic phases. The later abrupt platform collapse was instead connected with the westward migration of the compressional tectogenesis and the consequent extensional tectonics.

G6-17 Poster Chiari, Marco

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THE OPHIOLITES OF THE KOZIAKAS MASSIF (GREECE): PALEONTOLOGICAL AND GEOCHEMICAL FINAL DATA

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Key terms: Ophiolites; basalts; Radiolarian cherts; Koziakas; Greece

In the Koziakas Massif (Thessaly), an Ophiolitic Nappe crops out at the top of the Western Thessaly Units, which represents the transition between the Pindos Basin and the Pelagonian Platform (i.e. the eastern margin of Adria). These units are thrust onto the Pindos Basin (i.e. the intra-continental rift located between the Gavrovo and Pelagonian platforms).

This nappe pile is unconformably covered by Oligocene-Miocene molasses pertaining to the Mesohellenic trough and consists of:

- 1- The Late Paleocene-Eocene Pindos Flysch, which includes fragments of serpentinites, basalts and cherts. Paleocurrent data indicate a provenance from NE, where the Pindos and Koziakas ophiolites were located.
- 2- The Western Thessaly Units which consist of two tectonic units (Thymaïma and Koziakas) whose latest Jurassic - Early Cretaceous sediments contain ophiolite-derived turbidites and/or olistostromes.
- 3- The Ophiolitic Nappe, which consists of four tectonic units:
 - a) The ophiolite-bearing Koziakas Mélange, consisting of small and scattered outcrops.
 - b) The Fourka Unit, consisting of thrust sheets and blocks of pillow lavas locally covered by radiolarian cherts.
 - c) A metamorphic sole consisting of scattered and thin levels of amphibolites derived from N-MORB-type protoliths and showing a clear syn-metamorphic fabric. Two K-Ar radiometric data indicate 161 and 174 Ma for the amphibolitization.
 - d) An "Ophiolite Unit", consisting of sheared serpentinites, with some dunite bodies, plagiogranite and boninite dykes.

The volcanic rocks of the "Fourka Unit" consist of basaltic rocks. Six samples display a clear alkaline affinity and are characterized by incompatible element and REE composition resembling that of typical alkaline within-oceanic plate basalts (OIB). REE modelling indicates that they are compatible with <6% of partial melting of a theoretical plume-type source and therefore, are interpreted to have generated in a seamount setting.

Two samples are characterized by incompatible element and REE patterns strongly resembling those of E-MORBs. REE modelling shows that they are compatible with 8-15% partial melting of a theoretical mixed N-MORB/OIB mantle source. These rocks are interpreted as formed from a N-MORB type mantle source enriched by an OIB-type component during the early stage of oceanic spreading or in an off-axis oceanic setting.

In the Fourka Unit, the cherts at the top of the basalts have well preserved radiolarian assemblages, which indicate Triassic ages: latest Anisian (associated with OIB) (as the trachyandesites present in the continental rifts to the west), early Carnian-middle Norian and late Carnian-early Norian (associated with OIB), early Norian (associated with E-MORB); in the Koziakas Mélange early-middle Bathonian (associated with OIB).

As regards the geodynamic evolution of the Koziakas ophiolites we can hypothesize this succession of events: a- The Vardar Ocean opening during Middle Triassic, contemporaneously with the sinking of the continental basins located to the west (e.g., Pindos Basin, etc.); b- The ocean spreading, persisted till the Late Jurassic and from the beginning of Middle Jurassic was accompanied by an intraoceanic obduction which caused a doubling of the ocean crust with formation of the metamorphic soles; c- The narrowing and closure of the ocean during Late Jurassic-Early Cretaceous times, and the overthrusting of the Ophiolitic Nappe onto the Adria continental margin (Pelagonian); d- The westward thrust of the nappe underlined by the presence of an ophiolitic detritus in the Western Thessaly Units during latest Jurassic-Early Cretaceous times, and then, more to the west, in the Paleocene-Eocene Pindos flysch.

G6-18 Poster Goncuoglu, M.cemal

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THE KARAKAYA COMPLEX: A PALAEOETHYAN SUBDUCTION/ACCRETION COMPLEX FROM N TURKEY

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Key terms: Paleotethys; mélange; Anatolia; L. Triassic; accretion

The northern margin of Turkey is of particular importance as it retains the relicts of the gigantic collisional orogen that led to the consumption of the Palaeotethys. The relicts of this orogenic event, known as the Cimmerian orogeny (Sengör et al. 1984), are preserved within the Karakaya subduction/accretion complex that covers the northern part of Turkey as an E-W trending belt for over 1000 km. The Karakaya Complex lies within the pre-Liassic basement of the Sakarya Composite Terrane (Göncüoğlu et al. 1996), including a number of mélange units made up of variably deformed and metamorphosed rock assemblages. These mélange units of distinct characteristics comprise metabasic rock lithologies of oceanic origin (the Nilüfer Unit), metaclastics (the Eymir Unit), back-arc-type ophiolite assemblages (the Kure Unit), and some lithologies probably of continental rift-origin.

Of these mélange units, the Nilüfer Unit crops out widely within the central and the western portion of the Karakaya Complex, and characterized by metabasic rock assemblages primarily alternating with recrystallized limestone, mudstone and chert. The metabasic rocks have mainly experienced greenschist-facies conditions, though high-pressure varieties,

such as blueschists and eclogites, can also be found throughout the complex. The metabasic rocks are dominantly of alkaline character, and reflect OIB- and E-MORB-type geochemical signatures with no continental input. These mafic lithologies represent oceanic islands/seamounts that formed on the Palaeotethyan oceanic crust in association of a mantle plume during the Early?-Late Triassic. The latest Triassic was the time when the oceanic island/seamount system (the Nilüfer Unit) was incorporated into the accretionary prism, and chaotically mixed with the distinct rock assemblages derived from the other tectonic settings (forearc, continental-rift, intra-oceanic back-arc), forming the Karakaya Complex. The deeply subducted portions were metamorphosed in HP/LT conditions at the end of Triassic. This accretionary prism material was thrust on a Late Triassic peripheral foreland basin topping the Permian platform on the S margin of Palaeotethys. The oldest overstep sequence on top of this melange-foreland basin complex is Liassic in age.

SESSIONE G7

Faglie attive nel quadro dell'evoluzione tettonica quaternaria in Appennino: trent'anni di progressi dall'Irpinia 1980 a l'Aquila 2009

G7-1 Invitato Argnani, Andrea

10.1474/Epitome.04.0603.Geoitalia2011

ACTIVE TECTONICS IN THE SEAS OF SOUTHERN ITALY: EVIDENCE AND OPEN QUESTIONS

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Key terms: active tectonics; southern Italy; seismogenic structures

The maps of macroseismic felt intensity and of instrumental seismicity show that southern Italy is a seismically active region, and also indicate that seismic sources located at sea substantially contributed to the seismic release. The sea surrounding the Gargano Promontory, the Messina Straits, the slope of south-eastern Sicily, and the southern Tyrrhenian region are the main areas where tectonic structures appear to be seismically active. In many instances, earthquakes are large enough to allow reliable focal mechanisms to be obtained, also showing that sometimes contrasting tectonic regimes coexist within short distance. Attempts to characterize the tectonic structures that may be responsible for the recorded marine seismicity have been made using different approaches. However, in most of these regions a general consensus on the nature of the deformation has not been achieved.

In the Gargano region hints of active deformation are broadly diffuse within and around the promontory. Multichannel seismic data in the peri-Gargano marine area show evidence that deformation is more intense on the NE side of the promontory. Large emphasis has been given in the literature to the offshore extent of the Mattinata fault, mostly due to the civil consequences of the San Giuliano 2002 earthquake, although both earthquakes and observed deformations are mostly marginal to the Mattinata Fault. It might be worth noting that the area to the north of Gargano is the only potential source for the 1627 tsunami, as landslides with suitable age and location are not present in the submarine slope to the SW of the promontory.

The Messina Straits is one of the most seismically active regions in Italy, and uplifted marine terraces and Quaternary faults crop out extensively onshore. Onshore faults, however, are considered inactive, and are poorly consistent with the seismic and geodetic data recorded during the large (M 7.2) 1908 earthquake, which has been located within the straits. On the other hand, evidence for the occurrence of large active faults are scarce also offshore, possibly supporting the interpretation of a seismogenic blind fault, although growth strata are not found in seismic profiles. Moreover, the tsunami associated to the 1908 earthquake can hardly be explained by a blind fault, leaving room for landslides or other faults to play a role. South-eastern Sicily has a long record of historical seismicity, including the largest event in the parametric catalogue of Italian earthquakes (M 7.1, January 1693). Often tsunamis are related to the earthquakes, indicating near-field events. The search for the 1693 seismogenic source is still ongoing, particularly onshore, where a clear fault has not been found. As onshore faults cannot explain the tsunami, a concomitant submarine landslide is required. On the other hand, offshore active faults have been well documented, together with large-scale landslides associated to footwall collapse. The offshore fault are considered too small to reproduce the estimated magnitude, although it cannot be excluded that the close time proximity of two earthquakes (9th and 11th February 1693) possibly contributed to confuse the macroseismic pattern.

The southern Tyrrhenian margin, located north of Sicily, has long been considered a classic passive margin, before it became recently evident that it is characterized by a belt of compressional earthquakes. Since then, the area has quickly been interpreted as an incipient, south-dipping subduction zone, and several papers have been devoted to explore this geodynamic issue; regrettably, very little data have been presented to back up these interpretations. Although the belt of earthquakes trends roughly east-west, the best documented seismic sequence, September 2002 offshore NW Sicily, has a marked NE-SW trend, and extensional faults that appear to be active have been reported from detailed bathymetry, further to the east.

G7-2 Orale Saroli, Michele

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TECTONICS, HYDROGEOLOGY AND KARSTIC MORPHOGENESIS: A NEW MULTIDISCIPLINARY APPROACH TO INVESTIGATE ACTIVE FAULTS? FROM THE EXAMPLE OF THE 1980 IRPINIA EARTHQUAKE TO THE WESTERN MARSICA CASE STUDY (SOUTHERN LATIUM REGION)

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Key terms: active faulting; hydrogeology; karstic systems; Posta Fibreno fault; central Apennines

After the November 23, 1980 Irpinia earthquake (Mw 6.9), several seismically induced effects at surface have been identified. Among these, a strong variation of the Sanità spring flow rate (from 4.5 m³/sec, in the days preceding the quake, to 7.5 m³/sec, in December 1980) occurred. Such observation can be considered as an important starting point to investigate - in hydro-structural settings comparable to the Sanità spring one - possible variations of permeability thresholds of springs following episodes of activation of seismogenic tectonic structures. The present study is utilises a multidisciplinary approach aiming at the identification of sectors of the central Apennines where carbonate reliefs (carbonate hydrostructures), affected by active normal faults, are characterised by springs related to permeability thresholds and by karst systems. In particular, we investigate the southern sector of the carbonate ridge that bounds the Marsica region to the West, where the Posta Fibreno springs (10 m³/sec) are located, acting as the present base level for karstic erosion. This sector is affected by a portion of the regional tectonic structure known in the literature as "Val Roveto-Atina Line", here represented by the Posta Fibreno fault, which places in contact the cretaceous-miocenic carbonate sequences with the miocenic flysch and with quaternary continental sequences hosted by the Posta Fibreno depression. Several epigeous and hypogeous karstic landforms (dolines, abandoned valleys and karstic conduits) developed in this area along tectonic features NW-SE trending; the not well developed hydrographic network is characterised by abandoned valley which originate from the rims of the main dolines (i.e. Fossa Maiura, Pozzo la Pescara). These landforms show evidence of different stationary phases of the karstic erosion probably due to hydrological base level of the Posta Fibreno springs. From a chronological viewpoint, the onset of the karstic phenomena probably took place at the end of the Lower Pleistocene - after the deposition of the first sedimentary cycle "Conglomerato di Campoli Appennino" sequence - when the groundwater level was next to the surface. Then, during the uplift of the carbonate ridge - which was probably structurally separated by the Posta Fibreno depression by the activity of the normal fault - the karstic springs evolved in doline-springs and, subsequently, in sink dolines owing to the progressive lowering of the permeability threshold of the Fibreno springs. The above described tectonic, hydro-structural and geomorphic setting is comparable to present one, with doline-springs located both below the lake level and at the base of the relief slopes in the Posta Fibreno area. Then, within this light, the difference in elevation between the present Posta Fibreno springs and the uppermost paleo-springs (represented by the systems dolines-abandoned valleys) above described can provide useful information to estimate the amount of regional uplift and probably testifies to the activity of the Posta Fibreno normal fault to which might be associated the 1654 Sora earthquake. Lastly, the ongoing analysis of the historical data indicates that the "La Prece" doline assumed its present shape after about 1600 AD. Indeed, an high-relief attributed to this age (located in Villa Mazzenga) which depicts the Posta Fibreno village, shows a very mild depression in the "La Prece" area while a large doline is clearly visible at present.

G7-3 Orale Gori, Stefano

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NEW PALEOSEISMOLOGICAL DATA FROM THE FUCINO NORMAL FAULT SYSTEM (CENTRAL ITALY)

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Key terms: Paleoseismological investigations; Fucino fault system; 1915 Avezzano earthquake; Central Italy

New paleoseismological investigations have permitted to improve the knowledge about the recent kinematics behaviour of the Fucino fault system, in the central Apennines, the activation of which determined the 1915 Avezzano earthquake (Mw 7) (Galadini and Galli, 1999). The analyses of two quarry walls located at the base of the reliefs that border the eastern flank of the Fucino basin, where the surficial expression of one of the segments of the fault system - namely the S. Benedetto-Gioia branch - is located, have allowed to individuate at least three events of displacement. Two of these are referable to a chronological context comprised between 15000 BP and 3000-1500 B.C. (Saroli et al., 2008). The most recent event(s) occurred after 1466-1372 cal. B.C. (Saroli et al., 2008). Probably, the oldest and the intermediate events may represent two of three Holocene episode of activation of the Fucino fault system identified by Galadini and Galli (1999) and occurred between 5 and 10 ka BP. The most recent event(s), besides the 1915 rupture, may be associated to the event dated at 1500-1300 B.C. and/or at the Late Antiquity/early Middle Ages (Galadini and Galli 1999), likely occurred in 484/508 AD (Galadini et al., 2010).

Further paleoseismological data have been obtained from the investigations carried out in the area localised NW of the Pescara village. In particular, three excavations performed along the fault segment known as "of S. S. Marsicana" of the Fucino fault system, showed evidence of at least two displacement events subsequent to the deposition of a colluvial deposit containing fragments of pottery attributed to the beginning of the Bronze Age. Considering that the most recent event displaced the whole stratigraphic sequence, comprised the ploughed soil, we may associate it to the 1915 rupture.

On the whole, the achieved paleoseismologic data confirm that, as hypothesized by Galadini and Galli (1999), the S.S. Marsicana fault segment activated during the 1915 earthquake and allow to improve the dataset of paleo-events available for the Fucino plain.

G7-4 Orale Galli, Paolo

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THE DISQUIETING SEISMOGENETIC BEHAVIOUR OF THE 1980 EARTHQUAKE FAULT (IRPINIA, SOUTHERN APENNINE). NEW INSIGHTS FROM GEOELECTRICAL, GEOMORPHOLOGICAL AND PALEOSEISMOLOGICAL DATA

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Key terms: ACTIVE TECTONICS; PALEOSEISMOLOGY; GEOELECTRICAL ANALYSES; SOUTHERN APENNINE; EARTHQUAKES

The deep seismogenetic source that generated one of the most catastrophic European earthquake in the past century (1980, Mw 6.9, ca 3000 fatalities) still shows its impressive surficial expression across the backbone of the Picentini Mountains in the Irpinia region, between the San Gregorio Magno plain at the southeastern tip, up to the northern slopes of the Mt. Cervialto, at northwest (Irpinia, southern Apennines). Here, a complex array of N270°-N350° normal faults (N315° average strike), arranged into a dozen of dextral en-echelon main strands can be followed for a total length of ca. 38 km, forming the Mount Marzano fault system. At the end of the 80s, two of these segments have been carefully investigated at two sites by Pantosti et al. (1993) and D'Addezio et al. (1991), who dug four paleoseismological trenches, founding many unknown 1980-like events during the Holocene. However, it must be stressed that the historical seismicity of this sector of the southern Apenninic chain is more complex and much more abundant than what showed today by the available Italian seismic catalogues, with several poorly known strong events clustered in a narrowed area. Most of them have a mesoseismic distribution similar to the 1980 one (as the 1466 and 1694 events; Mw 6.4 and 6.9, respectively), whereas many others known and unknown, Mw₆ earthquakes had their epicentre within the hangingwall area of the Mount Marzano fault system (e.g., 1517, 1561, 1680, 1692, 1853, 1910; see Galli et al., 2010). Nevertheless, none of these have been geologically associated to any known seismogenic structure, although the Mount Marzano fault system would seem the most reasonable candidate.

Considering the new information coming from studies concerning the seismic history of this region and in order to characterize in terms of seismogenic behaviour the entire fault system, we performed 45 high-resolution topographic profile across the 1980 surface faulting trace and/or across the surveyed fault scarp. Then we carried out several Electrical Resistivity Tomographies (ERT) across some segments of the fault system and we made further paleoseismological analyses in other trenches and pits.

Our results, besides confirming the complex pattern of surficial rupture of the Mount Marzano fault system during the 1980 event, from the Pantano Grande of San Gregorio Magno to Caposele (ca. 33 km), provide some indication concerning the post Last Glacial Maximum slip-rates and suggest robustly this structure to be responsible also for some other strong events described by the historical sources, such as the 1694 earthquake, and others previous ones.

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G7-5 Orale Galli, Paolo

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QUATERNARY TECTONIC AND SEDIMENTARY EVOLUTION OF THE L'AQUILA 2009 MEOSEISMIC REGION (CENTRAL APENNINE): STRATIGRAPHIC, PALEOMAGNETIC AND 40Ar/39Ar CONSTRAINTS

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Key terms: quaternary tectonics; sedimentation; paleomagnetism; central Italy; earthquakes

The epicentral area of the L'Aquila 2009 earthquake roughly matches with a Quaternary intermountain basin including, from NW to SE, the areas of Paganica, San Gregorio, Poggio Picenze, Barisciano and San Demetrio ne Vestini.

Morphological and stratigraphic investigations, integrated with paleomagnetic and teprostratigraphic studies and 40Ar/39Ar measurements, allowed us to recognise three main depositional cycles, here labelled as Lower (Early Pleistocene), Upper (ca. 550-350 ka) and Late (Upper Pleistocene) cycles, and to outline the basin evolution history. At its early stage (Lower Pleistocene) the whole basin, from Paganica to Civitavecchia and Campana, hosted a lake characterised by whitish carbonate silts and muds sedimentation (ca. 100 m thick; San Nicandro Fm.) indicating a very low energy sedimentation. Later in the Lower Pleistocene, the sedimentary processes changed, becoming highly energetic. At this stage the basin hosted a powerful fluvial-lacustrine system, which was characterised by pebbly braided river that, originating from the southern Gran Sasso slopes through the Paganica area (paleo-Raiale river), discharged into a vast intermountain lake. Here, it supplied a deltaic gravel-sand complex (ca. 100 m thick) which, prograding south-eastward, determined the progressive diminution of the lake size and the consequent growing of the braided river. At same time, along the north-east margin of the basin (e.g. Barisciano and S. Pio delle Camere areas), a large alluvial-fan developed (Valle Valiano Fm.), in association with slope graves (Fonte Vedice Fm.) that discharged into lake.

Before 780 ka, this fluvial-lacustrine system disappeared, and the whole area was subjected to erosional or pedogenetic processes. These processes were active up to ca. 550 ka, when in the area developed the fluvio-lacustrine system of the Upper depositional cycle, made up mainly

by volcanic-rich silty-sands, and subordinately gravels (San Mauro Fm.). This paleogeographic domain was considerably lesser than the early one being completely carved in the former and restricted to a narrow stripe around the present course of the Aterno river.

This depositional cycle ended around 350 ka when the area was again subjected to prevailing erosional/pedogenetic processes. Finally, during the Upper Pleistocene, the Raiale river and other minor torrents generated a series of alluvial fans that are geomorphologically carved in the deposits of the older depositional cycles (i.e., Paganica and Caporciano alluvial fan), being almost in equilibrium with the present hydrographic network. Some units of these three depositional cycles are associated to well-preserved, terraced, depositional top surfaces that in turn are displaced by a normal fault system composed by at least three, up to ca. 18 km-long, sub-parallel WNW-ESE trending segments (Paganica-San Demetrio fault system). The westernmost one fits with the surface breaks observed in the 2009 earthquake. This circumstance allowed us to evaluate the temporal-spatial evolution and the style of the tectonic deformation for different time windows.

On the whole, independently from the considered time windows (~1 Ma vs. 500 ka), our investigations indicate that the total slip rate across this fault system was consistently evaluable at ca. 0.6-0.5 mm/yr. Moreover, during the past 1 Myr the tectonic deformation of the paleogeographic domains was not uniform in time, space and style. Whilst the northern (Paganica) and southern (San Demetrio) sectors of the basin were preferentially downthrown by normal faulting, the central part of the basin (Poggio Picenze) experienced a gentle warping, without appreciable faulting.

As far as the timing is concerned, the easternmost fault segments started the Quaternary deposits offset early, at least ca. 1 Ma, progressively transferring the throw to the central and westernmost splay, where the most recent faulting traces, including those of 2009 earthquake, occurred.

G7-6 Orale Voltattorni, Nunzia

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GEOLOGICAL AND GEOCHEMICAL ANALYSIS FOR THE INDIVIDUATION OF REGIONAL DISCONTINUITIES: THE COMINO VALLEY (SOUTHERN LATIUM, CENTRAL ITALY).

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Key terms: Val Roveto-Atina-Caserta fault; Moho step; soil gas geochemistry; radon anomalies

A multidisciplinary study based mainly on aerophotogeological interpretation and geochemical prospectings were performed in the Comino valley area which extends between Vicalvi and San Donato Val di Comino villages. The studied area covers 70 km² of a considered key-area in the geological-seismic framework of the Central Apennines. The Comino valley is located in the SW sector of the Central Apennine (Southern Latium) where the "Val Roveto-Atina-Caserta" regional fault has been studied since many years. Indeed, according with some authors, this fault can be interpreted as a crustal discontinuity probably corresponding to a deep step of the Moho. The studied area is also characterized by the presence of secondary tectonic lineaments (e.g. San Donato-Val Comino fault) having a typical Apenninic orientation (NW-SE).

The Comino valley is affected by high seismic activity: last destructive earthquake was in May 7, 1984 (ML 5.9) while during 2009 many seismic events (ML < 4) have occurred for several months suggesting a new micro-seismic activity.

The spatial soil-gas distributions have been compared with the location and orientation of brittle deformations described in the literature and/or recognized by new field surveys, as well as with morphotectonic features obtained by photogeological analysis. Soil gas results show a pervasive character of the radon, helium and methane values. Soil gas prospecting together with geological survey has provided an inedited and detailed mapping of the structural setting of the studied area and in particular new data about the Comino valley have been acquired. The identified structural lineaments by geological survey as well as the He, CH₄ and Rn anomalies in soil gas in correspondence of lineament crossing, suggest that such faults may be considered as the surface expression of a deep structure network (probably down to the Moho) playing a role of important avenue for a vertical and rapid migration of endogenous gases. In particular, the high Rn median value (51.80 Bq/L) in an area without shallow possible radon sources, suggests a deep origin for this gas and therefore a vertical migration through fractured media, i.e. faults and fractures. The elongated gas anomalies show that the area is characterized by tectonic discontinuities oriented mainly NNW-SSE in accordance with and linked to the regional Val Roveto-Atina-Caserta fault and WSW-ENE that suggest transversal fractured zones.

The investigated area is also interested by mineralized springs with a high gaseous component: CO₂ is the dominant gas (concentrations > 95 %, v/v) but also discrete amounts of CH₄ have been measured (max value: 4200 ppm). The spatial distribution of thermal springs, cold CO₂-rich springs and localized gas emissions suggests that the structural framework of the studied area, i.e. the bordering faults of buried structural highs of the carbonate basement, exerts a strong control on the uprising patterns of fluids.

G7-7 Orale Ercoli, Maurizio

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A GEOPHYSICAL APPROACH TO THE PALEOSEISMOLOGY USING 3D GROUND PENETRATING RADAR (GPR) DATA.

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Key terms: 3D GPR; Paleoseismology; Normal fault; Mt. Vettore; Central Apennines

The faults responsible of strong earthquakes are usually studied with

quantitative geomorphologic and paleoseismological techniques investigating shallow Quaternary sediments with trenches to find geological evidences of ancient seismic events.

Recently, the improvements of applied geophysical techniques as the 3D Ground Penetrating Radar (GPR), have been successfully applied on studies in different geological environments. Some 3D-GPR application on paleoseismological studies are available in literature, showing unambiguous geophysical evidences of shallow faulting compared to 2D data.

The Mt. Vettore fault (Italy, Central Apennines) has been extensively investigated by various paleoseismological studies. This structure shows both geomorphological and trench-derived evidences of Late-Quaternary activity and a recent new seismic catalogue includes events possible related with the activity of this fault.

In our study, we employed a high-resolution 3D-GPR survey across a branch of the Mt. Vettore fault tied to trench-derived stratigraphy data in order to cross validate the two independent data. We used a 300 MHz GPR system above a small scarp rising on a Late Pleistocene-Holocene alluvial fan, recording, at first, some 2D profiles using Common Offset configuration to precisely locate the fault zone. After detecting the fault signature on 2D profiles, a 20 x 20 m high-resolution 3D-GPR grid was acquired across the fault.

The processed 3D GPR volume shows a clear imaging of the fault zone and faulted units due to the simultaneous display of profiles and time-slices. We used an open source geophysical interpretation software to interactively manage the entire 3D dataset and to detect and interpolate interesting horizons that allowed to build a detailed geometrical model of the subsurface up to 4m below the topographic surface.

Our experience demonstrates that GPR constitutes a geophysical technique particularly useful to paleoseismology, not only to optimize the possible sites for trench digging but also to obtain data along and across the strike. Moreover, the promising results make the GPR an interesting alternative to other studies in sites where topographical evidences or geological contest are poorly defined.

The study here presented provides qualitative and quantitative geological information in a completely non-invasive way, essential especially in nature reserves like the Sibillini Mountain's National Park.

G7-8 Orale Giorgianni, Alessandra

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NEW GEOLOGICAL-STRUCTURAL CONSTRAINTS FOR A SEISMOTECTONIC MODEL OF THE HINGE ZONE BETWEEN SOUTHERN TYRRHENIAN AND NORTHERN SICILY.

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Key terms: *Seismotectonic; Maghrebian chain; Southern Tyrrhenian; Sicily*

The Northern Sicily and its Tyrrhenian off-shore are part of the Maghrebian chain, whose the architecture is the result of a multiple-phase tectonic history from Late Oligocene-Early Miocene to Present. Since Early Pliocene, the regional tectonic activity of the area is associated with a complex structural grid related to a wider W-E trending right-lateral regional shear zone, extending for about 300 km from Ustica-Eolie alignment to the "Pantelleria rift". The main structural features, occurring from regional to outcrop scale, are represented by NW-SE to W-E striking right-lateral faults and by N-S to NE-SW striking left-lateral faults, both responsible of uplift and lowering respectively of restraining or releasing zones. The latter, filled by Plio-Pleistocene clastic sediments, are characterized by extensional faults showing listric geometry producing block accommodation and rotation along the hinge zone between the Southern Tyrrhenian margin, characterized by crustal thinning, and the emerged northern Sicilian orogen, with a moderate thickened crust. Within the hinge zone, seismicity is mainly located between 10 and 20 km of depth and clustered around high-angle dipping planes well fitting the orientation of the outcropping fault systems. The focal mechanisms showing transpressional, compressional, transtensional and extensional kinematics, are the results of the mechanical heterogeneity of the rock volumes related to the polyphasic tectonic evolution of the area.

With the aim to better define the seismotectonic model of this area, we carried out an integrated research, by means structural, geophysical and statistical analyses, in two key zones: (i) onshore, in the southern sector of the Palermo Mts. (Kumeta Mt.), where the brittle strain partitioning related to a right-lateral simple shear zone has been reconstructed, and (ii) offshore, north to Palermo, where the structural setting has been inferred from morpho-bathymetric and geological maps of the Southern Tyrrhenian basin.

Moreover, in this latter zone, a new seismological study has been carried out on a part of 2002 seismic sequence, using a database obtained by the integration of data recorded by the stations of the National Seismic Network with those recorded, in four months, from 7 three - components stations of a temporary network installed by INGV. In particular, 40 seismic events, recorded by more than 40 seismic stations, occurred between September and December 2002 have been relocated using a procedure based on the HYPODD program, and an eight layers velocity model optimized relocating some thousands events of the southern Tyrrhenian. The focal mechanisms of such events have been determined using FPFIT code.

The Coulomb stress changes related to the main events of the sequence have been also calculated in order to recognize the seismogenic volume, whose geometric characters fit well with a simple shear deformational style compatible with that one reconstructed on the study zone located onshore.

G7-9 Orale Maffione, Marco

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DEFORMATION PATTERN AT THE HANGING-WALL OF AN ACTIVE LOW-ANGLE NORMAL FAULT (ALTOTIBERINA FAULT, NORTHERN APENNINES) INFERRED FROM ANISOTROPY OF MAGNETIC SUSCEPTIBILITY (AMS) ANALYSIS.

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Key terms: *Anisotropy of magnetic susceptibility; Altotiberina Fault; Low-angle normal fault; extensional tectonics; northern Apennines*

Anisotropy of magnetic susceptibility (AMS) represents a valuable proxy able to detect subtle strain effects in very weakly deformed sediments. Commonly, in compressive tectonic settings the magnetic lineation is parallel to fold axes, thrust faults and local bedding strike, while in extensional regimes it is perpendicular to normal faults and, thus, parallel to bedding dip directions. The Altotiberina Fault (ATF) in the northern Apennines (Italy), is a Plio-Quaternary low-angle normal fault characterized at its hanging-wall by the presence of a 1200-m-deep basin (Tiber basin) filled with a syn-tectonic, sandy-clayey continental succession. We collected 129 oriented cores at 12 sites within this formation, and measured the AMS with a Multi-Function Kappabridge. The shape of the AMS ellipsoid (oblate to prolate), together with the anisotropy parameters, suggests that a primary sedimentary fabric has been overprinted by an incipient tectonic fabric. The magnetic lineation is well-developed at all sites with directions ranging from NE-SW (western sector of the basin) to N-S and NW-SE (central and eastern sectors). Locally, magnetic lineations sub-parallel and sub-perpendicular to relative bedding strike are observed, revealing the effect of a compressional and extensional tectonics, respectively. The presence of compressional structures at the hanging-wall of the ATF can be explained by the presence of gently, ~N-S-trending local folds (hardly visible in the field) formed either by passive accommodation above an undulated fault plane, or by simple roll-over anticline formation close to the fault planes. Accordingly, the long-lasting debate on the extensional vs. compressional Plio-Quaternary tectonics of the Apennines orogenic belt should now be revised evaluating the importance of compressional structures resulting by local effects.

G7-10 Orale Pastori, Marina

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IMAGING THE ACTIVE STRESS FIELD OF THREE SEISMOGENIC AREAS ALONG THE APENNINES AS REVEALED BY CRUSTAL ANISOTROPY

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Key terms: *crustal seismic anisotropy; fracturing and stress field;*

Apennine crust; automatic analysis code

During the last decades, the study of seismic anisotropy has provided useful information for the interpretation and evaluation of the stress field and active crustal deformation. Seismic anisotropy can yield valuable information on upper crustal structure, fracture field, and presence of fluid-saturated rocks crossed by shear waves. Several studies worldwide demonstrate that seismic anisotropy is related to stress-aligned, filled-fluid micro-cracks (EDA model).

An automatic analysis code, "Anisomat+", was developed, tested and improved to calculate the anisotropic parameters: fast polarization

direction (Φ) and delay time (Δt). Anisomat+ has been compared to other two automatic analysis codes (SPY and SHEBA) and tested on three zones of the Apennines (Val d'Agri, Tiber Valley and L'Aquila surroundings).

The anisotropic parameters, resulting from the automatic computation, have been interpreted to determine the fracture field geometries; for each area, we defined the dominant fast direction and the intensity of the anisotropy, interpreting these results in the light of the geological and structural setting and of two anisotropic interpretative models, proposed in the literature. In the first one, proposed by Zinke and Zoback, the local stress field and cracks are aligned by tectonics phases and are not necessarily related to the presently active stress field. Therefore the anisotropic parameters variations are only space-dependent.

In the second, EDA model, and its development in the APE model fluid-filled micro-cracks are aligned or "opened" by the active stress field and the variation of the stress field might be related to the evolution of the pore pressure in time; therefore in this case the variation of the anisotropic parameters are both space- and time- dependent.

We recognized that the average of fast directions, in the three selected areas, are oriented NW-SE, in agreement with the orientation of the active stress field, as suggested by the EDA model, but also, by the proposed by Zinke and Zoback model; in fact, NW-SE direction corresponds also to the strike of the main fault structures in the three study regions. The mean values of the magnitude of the normalized delay time range from 0.005 s/km to 0.007 s/km and to 0.009 s/km, respectively for the L'Aquila (AQU) area, the High Tiber Valley (ATF) and the Val d'Agri (VA), suggesting a 3-4% of crustal anisotropy.

In each area are also examined the spatial and temporal distribution of anisotropic parameters, which lead to some innovative observations, listed below.

1) The higher values of normalized delay times have been observed in those zones where most of the seismic events occur. This aspect was further investigated, by evaluating the average seismic rate, in a time period, between years 2005 and 2010, longer than the lapse of time, analyzed in the anisotropic studies. This comparison has highlighted that the value of the normalised delay time is larger where the seismicity rate is higher.

2) In the Alto Tiberina Fault area the higher values of normalised delay time are not only related to the presence of a high seismicity rate but also to the presence of a tectonically doubled carbonate succession. Therefore, also the lithology, plays a important role in hosting and preserving the micro-fracture network responsible for the anisotropic field.

3) The observed temporal variations of anisotropic parameters, have been observed and related to the fluctuation of pore fluid pressure at depth possibly induced by different mechanisms in the different regions, for instance, changes in the water table level in Val D'Agri, occurrence of the April 6th Mw=6.1 earthquake in L'Aquila.

Since these variations have been recognized, it is possible to affirm that the models that better fit the results, both in term of fast directions and of delay times, seems to be EDA and APE models.

SESSIONE G9**Tettonica trasversale nelle catene orogeniche****G9-1 Orale Piana, Fabrizio**

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THE FORELAND FOLD-AND-THRUST BELT OF THE WESTERN LIGURIAN ALPS AND THE TRANSFER KINEMATIC AT THE BOUNDARY WITH THE MARITIME ALPS.PIANA Fabrizio¹, BERTOK Carlo², D'ATRI Anna², MARTIRE Luca², VARRONE Dario¹, BARALE Luca²
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Key terms: Ligurian Briançonnais; Penninic Front; transpressive tectonics; paleofaults; paleoescarpments

The External Ligurian Briançonnais (ELB) has been recently interpreted (Piana et al., 2009) as the inner part of the SW-Alps foreland fold-and-thrust belt (Provencal-Dauphinoise region). ELB is characterized by a Triassic-Eocene stratigraphic succession largely detached from its volcanoclastic Permian basement and deformed, coherently with the internal part of the Provencal-Dauphinoise Domain (PDD), by multistage flexural folds and ductile-brittle shear zones. Although a gradual decrease in the intensity of deformation from the Internal Ligurian Briançonnais to ELB is observed, the ELB boundary with the adjoining Provencal-Dauphinoise Domain (PDD) does not correspond to major changes in metamorphic grade, but to several Km-long transpressive shear zones (such as the Limone-Viozene Zone, Piana et al., 2009) that merge with the basal detachment level or displace it. Deformation developed mainly in anchi-metamorphic conditions in the sedimentary successions of both ELB and PDD (Battaglia et al., 2011), with T ranging from 150° to 280°C.

The Alpine structural evolution of ELB and PDD was strongly controlled by primary sedimentary features such as palaeofaults and palaeoescarpments and/or major thickness and facies variations that allowed partitioning of deformation into different-order sub-units showing different structural associations and different intensity of deformation.

The preservation of such km-scale continuous syn-sedimentary features (Bertok, 2007; Bertok et al., 2011) demonstrates that ELB and PDD did not suffer significant internal reorganization, neither diffused transposition phenomena. This is also confirmed, at most stratigraphic levels, by ubiquitous preservation of depositional or diagenetic features such as bedding and laminations, mineralized hard grounds, neptunian dykes and sills, bioturbations, macro- and microfossils etc..

The role of the primary features on the kinematic evolution of ELB/PDD thrust belt is here discussed. Pre-Alpine faults acted as lateral transfer during the Alpine contractional evolution, separating different-order tectonic and tectono-stratigraphic subunits, characterized in some cases only by minor detachments along the weakest stratigraphic layers, or by development of superposed fold systems, or by shear zones where closely spaced dissolution cleavages are prevalent.

The transpressive zones developed along the ELB/PDD boundary pertain to the regional transfer fault systems developed at the joining zone of the Maritime and Ligurian Alps, namely the Argentera Massif boundary transpressive faults and the "Stura fault" or "Stura couloir" system, that determined the sharp southern termination of the Western Alps arc.

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Piana et al (2009) It. Jour. Geosci.

G9-2 Orale Vigano', Alfio

10.1474/Epitome.04.0614.Geoitalia2011

CRUSTAL STRUCTURE OF THE GIUDICARIE (SOUTHERN ALPS, ITALY) FROM LOCAL SEISMIC TOMOGRAPHYVIGANO' Alfio¹, SCAFIDI Davide², COCCO Saverio³, FRANCESCHINI Andrea³, GROAZ Oscar³, FRONER Luca³, SPALLAROSSA Daniele², MARTIN Silvana⁴
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Key terms: Seismic tomography; Crustal structure; Giudicarie

The Giudicarie belt (Southern Alps, Italy), that acted as a principal deformation zone since the Early Alpine age, is a crucial zone in the geodynamic context of the Alps. The Giudicarie belt has a direction (NNE-SSW) approximately perpendicular to the main Alpine chain and it is today characterized by a diffuse seismic activity of low-to-moderate

magnitude ($M_w \leq 5.0$). The most important instrumentally recorded earthquakes are the Salò event (24th Nov 2004, M_w 5.0) in the Southern Giudicarie, and the Merano event (17th July 2001, M_w 4.8) in the Northern Giudicarie.

Here we present a local seismic tomography of the Giudicarie area, in order to estimate average seismic velocities (V_p and V_s) and to characterize the principal structures of the crust.

The work is based on a set of selected earthquakes (database period 1994-2007), chosen considering event magnitude, number and quality of phases, and areal event distribution in the study area to obtain an optimal seismic ray coverage. All phases were accurately re-picked on original recordings from different networks: i) Provincia Autonoma di Trento, ii) Istituto Nazionale di Oceanografia e Geofisica Sperimentale, iii) Istituto Nazionale di Geofisica e Vulcanologia, iv) other networks available via the European Integrated Data Archive (EIDA). Phase readings, also checked through the Wadati diagram, are used to initially relocate input earthquakes. For the relocation, different 1D velocity models are computed by the code VELEST within homogeneous domains, assuming a layered crust and considering initial V_p/V_s ratios estimated from the Wadati diagrams. Geographic coordinates of the seismic stations used in the relocations were carefully checked.

The inverse problem for both V_p and V_p/V_s ratio is approached via the code SIMULPS, with the implementation of an accurate shooting ray-tracer algorithm. Taking into account the available data and their quality, the

study volume is discretized in order to have an approximate homogeneous spatial resolution of 5 km (horizontally and in depth). The reliability and accuracy of inversion results are estimated by analyzing the Resolution Diagonal Elements (RDE) of the resolution matrix and by making checkerboard resolution tests. Only areas passing a minimum quality threshold are interpreted and shown in the tomographic cross-sections. The results are discussed taking into consideration available crustal sections (Deep Seismic Soundings), the distribution of significant lithological domains (e.g., Adamello batholith, thick carbonate covers), and regional tectonic lineaments (Giudicarie and Schio-Vicenza fault systems). The main different geological domains of the area are highlighted in the resulting 3D velocity model, both for P wave velocities and for V_p/V_s ratios. In particular, the significant difference between the Giudicarie domain and the others in terms of V_p/V_s ratios is pointed out. This study also represents the necessary base both to enable better quality local seismic event (re)locations (e.g., seismic bulletin), and to perform applied hazard investigations at the local scale (e.g., seismic microzonation).

G9-3 Orale Elter, Franco Marco

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AN ALTERNATIVE MODEL FOR THE RECENT EVOLUTION OF THE NORTHERN-CENTRAL APENNINES (ITALY)ELTER Franco Marco¹, ELTER Piero², EVA Claudio³, EVA Elena³, KRAUS Rita Katharina³, PADOVANO Matteo¹, SOLARINO Stefano¹

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Key terms: Northern Apennines; Strike-slip; Focal mechanisms; releasing bend; restraining bend

The aim of this presentation is to propose an alternative model for the Plio-Quaternary to present evolution of the Northern-Central Apennines by combining geometrical requirements (Riedel system) with existing structural and geological geometries (fault systems and their tectonic associations).

We define three sectors characterized by different seismological, geodetic, geothermal and geological signatures: the North-Western Sector (NWS), the Western Central Sector (WCS) and the Eastern Central Sector (ECS). They result from the fragmentation of the northern-central Italian peninsula as a consequence of the NW-SE push of the African plate. According to GPS data the three blocks move independently. In particular, the NWS is bound between the Central Apennines and the Alps; this constraint leads to a stress accumulation responsible for a fragmentation into further several blocks, which move either to the NE or SW. The WCS is relatively stable; the ECS moves towards NE and is characterised by the presence of numerous releasing and restraining bends, which can be related to the action of a main NNW-SSE left-lateral shear zone. The role assumed by the strike-slip kinematics, in the Plio-Quaternary evolution of the Northern-Central Apennines, allows us to define the chain as a "transcurrent orogen".

G9-4 Orale Turtù, Antonio

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PALEOMAGNETIC ANALYSIS ALONG THE OLEVANO-ANTRODOCO-SIBILLINI FAULT ZONE (NORTHERN APENNINES, ITALY)TURTÙ Antonio¹, SATOLLI Sara², MANISCALCO Rosanna³, SPERANZA Fabio⁴, CALAMITA Fernando¹

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Key terms: Olevano-Antrodoco fault zone; tectonic rotations; paleomagnetism

The Olevano-Antrodoco-Sibillini (OAS) thrust represents the outer front of the Northern Apennines. It played an important paleogeographic role during Jurassic, as it separated carbonate platform and pelagic domain. At present, its southern sector is characterized by the alternance of NE-SW and N-S oriented segments. Its kinematic evolution has been interpreted in the literature as dextral strike-slip fault, dextral transpressive fault, or frontal and oblique ramp complex linked to the reactivation of pre-existing Jurassic faults (e.g., CALAMITA et al., 2011).

This study integrates new biostratigraphical and structural data with detailed paleomagnetic analysis, in order to constrain the OAS thrust kinematics. We sampled 52 sites predominantly in pelagic limestones, collecting on average 13 samples from each site. Cores were drilled using a petrol-powered portable drill and oriented in-situ with a magnetic compass, correcting their magnetic orientation to take into account the magnetic declination.

All samples were stepwise demagnetised by thermal heating in 15 steps (up to 620°C) and measured with a 2G DC-SQUID cryogenic magnetometer at the Istituto Nazionale di Geofisica e Vulcanologia of Rome.

The samples display three magnetization components: 1. Normal-polarity low-blocking temperature removed before 180°C, lying close to the geocentric axial dipole field; 2. Intermediate-temperature component isolated between 220°C and 320°C-460°C; 3. Characteristic remanent magnetization (ChRMs) till 580°C - 620°C, well defined in 536 over the 704 demagnetized samples.

Both the in-situ and tilt-corrected paleomagnetic directions are far from the local geocentric axial dipole field direction, suggesting the absence of both pre- and post-folding magnetic overprints. Furthermore, the intermediate-temperature component, acquired during diagenesis, is antipodal to the ChRMs, suggesting a primary nature of the ChRMs. As a summary, a primary nature for the ChRMs may be reasonably inferred. The tilt-corrected directions were compared to the coeval directions expected for the Adriatic-African foreland (BESSE & COURTILLOT, 2002) in order to calculate the rotations due to the orogenesis.

Thanks to 44 retained sites, this study documents a peculiar pattern of tectonic rotations along the OAS thrust. The thrust footwall is characterized by a homogeneous domain with counterclockwise (CCW) rotations (~-31°) linked to the Latium-Abruzzi thrust system and a null

rotated domain observed in the Laga Fm. Four clockwise (CW) rotated domains have been identified in the hanging wall: 1. strongly rotated close to the NE-SW thrust orientated segment, probably related to strike-slip faulting or transpression; less CW rotated ($\sim 35^\circ$) domain at a greater distance (0.5 - 1.2 km); slightly rotated ($\sim 16^\circ$) domain close to the N-S thrust orientated segment; 4. weakly rotated ($\sim 14^\circ$) domain 8-to-15 km far from the thrust front, most probably related to the Northern Apennine oroclinal (SPERANZA et al., 1997). Rotations are stronger along NE-SW lateral ramps and close to the thrust plane, and become smaller moving away from the thrust plane. Such pattern could be interpreted as due to the development of NE-SW lateral (or strongly oblique) and N-S frontal ramps along the OAS thrust. BESSE J. & COURTILOTT V. (2002) - Apparent and true polar wander and the geometry of the geomagnetic field over the last 200 Myr. *J. Geophys. Res.*, 107 (B11), 2300. doi:10.1029/2000JB000050. CALAMITA F., SATOLLI S., SCISCIANI V., ESESTIME P. & PACE P. (2011) - Contrasting styles of fault reactivation in curved orogenic belts: Examples from the Central Apennines (Italy). *Geological Society of America Bulletin*, 123, 1097-1111. SPERANZA F., SAGNOTTI L. & MATTEI M. (1997) - Tectonics of the Umbria-Marche-Romagna Arc (central northern Apennines, Italy): New paleomagnetic constraints. *J. Geophys. Res.*, 102 (B2), 3153-3166, doi:10.1029/96JB03116.

G9-5 Orale Tavarnelli, Enrico

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OBLIQUE DEFORMATIONS IN THE ALPS-APPENNINES OROGENIC SYSTEM: KINEMATIC CONSTRAINTS

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Key terms: strain partitioning; transpressional regime; structural inheritance; oroclinal bends; kinematic constraints

In the study of curved orogenic belts deformations are often complex, with structural associations that may appear as kinematically non consistent: for instance, in these environments contractional structures, such as folds and related thrusts, are often compartmentalized by strike-slip fault systems. A wide literature ascribes this inferred thrust/strike-slip fault relationship to distinct, superposed episodes or phases of deformation; however, recent advances in the field of transpressional tectonics illustrate that coexisting thrusts and strike-slip faults may result from effective kinematic partitioning of oblique movements into components of both contractional and lateral deformation. Similarly, in the analysis of the post-orogenic evolution of mountain belts, coexisting extensional and strike-slip faults, often ascribed to distinct, superposed tectonic phases or episodes, is more reasonably explained in terms of transtensional deformation models. With this contribution we aim at investigating the association of strike-slip and boundary-normal (i.e. contractional or extensional) deformations, that are widely present in the outer and inner zones of the Alps-Appennines orogenic system. The analysis makes it possible to test the hypothesis, hitherto only proposed on the basis of merely theoretical considerations, of an oblique, i.e. transpressional and/or transtensional, origin for these complex structural associations. The arcuate shape of the Alps-Appennines orogenic system seems to provide a clue for investigating at oblique deformation processes. Indeed, the boundary-normal (i.e. contractional and extensional) structures of the central part of the system tend to be increasingly oblique with respect to the generally persistent orogenic transport direction moving towards the lateral terminations. Three key-areas, where contractional structures and extensional structures coexist with strike-slip deformations, have been investigated in detail, through compilation of original field surveys, accompanied by extensive structural data collection. It appears that pre-orogenic structures played a critical role in controlling the onset of strain-partitioning paths. The results are synthesized in a model of oblique deformation for the evolution of the Alps-Appennines system, with transpressional components in the outer zones and transtensional components in the inner zones of these paired curved orogenic belts.

G9-6 Poster Di Domenica, Alessandra

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RELATIONSHIPS BETWEEN THRUSTS AND NORMAL FAULTS ALONG THE OLEVANO-ANTRODOCIO-SIBILLINI TRANSVERSAL THRUST: NEW INSIGHT IN THE GROWTH OF THE NW-SE QUATERNARY NORMAL FAULTS

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Key terms: Central-Northern Apennines; inversion tectonics; pre-orogenic/Quaternary normal faults; Olevano-Antrodocio-Sibillini transversal thrust

The Apennines are a curved fold-and-thrust belt that originated during the Neogene-Quaternary time and are strongly influenced by the architecture of the Mesozoic Adria paleomargin. The NNE-SSW-trending Olevano-Antrodocio-Sibillini transversal thrust (OAS) juxtaposes the Northern Apennines on the Central Apennines.

The arcuate OAS thrust is characterized by NW-SE- and NNE-SSW-trending arms to the north and south of the Mt. Vettore apical zone, respectively. Along this thrust plane, the Triassic-Miocene pelagic Umbro-Marchean carbonate succession is overriden on the Scaglia Cinerea (Oligocene), Marne con Cerrognana (Miocene) and Messinian siliciclastic Laga Fm.

The timing of thrusts and normal faults has been analyzed along the NNE-SSW-trending OAS transversal thrust that intersects the NW-SE-trending normal fault systems of Mt. Vettore-Mt. Bove, Norcia-Mt. Fema and Mt. Boragine, using their crosscutting relationships. These normal fault systems are confined in the hanging wall block of the OAS transversal thrust and, in proximity of the thrust trace, show cumulative downthrows that reach 1000-1100 m involving the carbonate succession up to the Marne con Cerrognana Fm. Normal faults with the same trend are also present in the footwall of the OAS thrust. These crosscutting relationships indicate that the NNE-SSW-trending OAS transversal thrust displaces the NW-SE-trending normal faults outcropping

in both hanging wall and footwall blocks, thereby showing a down-section trajectory corresponding to these normal faults. Consequently, the NW-SE-trending normal faults can be interpreted as pre-thrusting discontinuities that were active until the Miocene and were then passively carried in the hanging wall of the thrust during the Neogene compressional deformation stage. The restored template of geological cross sections allowed us to interpret the OAS transversal thrust as the reactivation of the NNE-SSW pre-thrusting Ancona-Anzio fault that played the role of a transfer of the NW-SE-trending pre-thrusting normal faults during the Messinian extensional deformation event.

Moreover, the NW-SE-trending normal fault systems of Mt. Vettore-Mt. Bove and Norcia-Mt. Fema show Quaternary activity starting from 2-5 km to the intersection with the OAS transversal thrust and are responsible of the development of wide Quaternary intramontane basins at a distance of 4-8 km from the OAS trace. Consequently, two inversion tectonic events can be recognized. During the Neogene positive inversion event, the NNE-SSW-trending pre-existing normal faults were reactivated as oblique thrust ramps (i.e., the pre-orogenic Ancona-Anzio fault reactivated by the OAS transversal thrust) while the NW-SE-oriented normal faults were displaced by NW-SE frontal thrusts with a shortcut trajectory. Successively, NW-SE-trending pre-thrusting normal faults were reactivated during the Quaternary negative inversion tectonic event. The distribution of the NW-SE Quaternary normal faults and the related seismicity have been controlled and compartmentalized by the NNE-SSW-trending transversal thrusts of the chain.

G9-7 Poster Pace, Paolo

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TRANSVERSAL TECTONIC LINEAMENTS IN THE CENTRAL-SOUTHERN APENNINES AND IN THE ADRIATIC FORELAND (MID-ADRIATIC RIDGE)

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Key terms: Transversal lineament; Sangro-Volturno transversal thrust; inversion tectonics; Central-Southern Apennines; Adriatic Foreland

Commonly, fold-and-thrust belts are characterized by axial culminations and depressions corresponding to salient and recess shapes leading to crop out different tectono-stratigraphic units within duplex or imbricate fan tectonic styles. Within this context, the along-strike changing of the cropping out tectono-stratigraphic units usually occur throughout transversal lineaments as regards to the major trending of the chain.

In order to ensure the role of the transversal structures in the Central-Southern Apennines and in the Adriatic foreland, an integrated structural study of surface geological data and seismic line interpretation has been proposed in this work.

The Apennines are a fold-and-thrust belt compounded by two major arcs: the Northern Apennines arc and the Southern one, joined by the Central Apennines. The NW-SE trending northern and southern arcs merge toward the Central Apennines through two transversal tectonic lineaments trending approximately N-S. They are represented by the Olevano-Antrodocio-Sibillini and the Sangro-Volturno (S-V) transversal thrusts, respectively.

The NNE-SSW trending S-V transversal thrust juxtaposes the Central Apennines onto the Southern Apennines. In the Central Apennines, NW-SE trending thrusts, affecting the carbonate succession referred to the Apulian and Lazio-Abruzzi platforms with their relative slope-to-basin transitions, merge toward south in the S-V oblique thrust ramp. In the Southern Apennines, the Apulian carbonate succession is involved in NW-SE and N-S trending thrust-related folds, buried underneath the Molise-Lagonegro allochthonous units.

Along the S-V transversal thrust, seismic line interpretation revealed both hanging-wall and footwall ramp relationships with respect to the buried Mt. Maiella and Mt. Porrara thrusts, consistent with a shortening value up to 4 km. In both the hanging-wall and the footwall of the Sangro-Volturno transversal thrust, N-S and NNW-SSE trending structures (e.g., Rocchette Mts., Setteporte, Mt. Taburno, Mt. Marrone structures) show push-up or high angle thrust-related folds geometries, suggesting the reactivation of pre-existing normal faults within transpressive deformation. Otherwise, the NW-SE thrusts present short-cut relationships with respect to the NW-SE trending hinterland-dipping normal faults affecting the backlimbs of the anticlines (e.g., Mt. Arazzecca structure).

In the Central Adriatic, compressive-transpressive deformation developed a NW-SE trending tectonic lineament that transects the entire foreland (i.e., Mid-Adriatic Ridge). The Mid-Adriatic ridge is either considered a compressive foreland deformation zone or connected to the frontal thrusts of the NE-verging Apennine chain. Deep seismic profiles interpretation lead to identify high angle crustal thrusts-related folds. The E-dipping high angle thrust-related anticline (i.e., Corinna structure), interpreted on the CROP M-17C seismic line between Alessandra 1 and Corinna 1 wells, shows a growth comprised between the Paleogene-Lower Pliocene time as indicated by thinning of these intervals in the fold crest. In addition, the eastward thickening of the Early Triassic-Middle Jurassic sequence in the hanging-wall of the anticline suggests a reverse reactivation of a Mesozoic normal fault. On map view, this pre-existing normal fault represent the southern termination of a major N-S trending discontinuity within the NW-SE trending Mid-Adriatic ridge.

In conclusion, N-S and NNE-SSW trending pre-thrusting normal faults were reactivated in a transpressive deformation as push-up features (e.g., Rocchette Mts., Setteporte, Mt. Taburno structures) or high angle thrusts (e.g., Mt. Marrone, Corinna structures) in both the Central-Southern Apennines and in the Mid-Adriatic ridge. Moreover, NW-SE trending pre-thrusting normal faults were truncated according to a short-cut trajectory by the frontal thrust ramps of the Apennine chain (e.g., Mt. Arazzecca structure).

G9-8 Poster Satolli, Sara

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SC VS. S TECTONITES IN THE NORTHERN APENNINES (ITALY) THRUST SHEAR ZONE: IMPLICATION FOR MODE AND TIMING OF DEFORMATION

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Key terms: tectonites; shear zone; Northern Apennines

SC tectonites are fault rocks characterized by the association of two foliations related to simple shear asymmetric and rotational deformations context: S surfaces are related to the accumulation of finite strain and C surfaces are related to localized shear strain. The angle between C and S is 45° at the initial stage of deformation and decrease to 0° with progressive shear (S tectonites). Conjugate extensional shear planes (extensional crenulation cleavage) in tectonites can be the result of deformation within domains of shear zones characterized by flow that moved away from the progressive simple shear.

We analyzed the ductile-brittle shear zone associated to the Olevano-Antrdoco-Sibillini (OAS) thrust, which offers spectacular outcrops within the Tertiary marls and shales lithotypes. The Pliocene OAS thrust of the Northern Apennine has a curved shape defined by NW-SE frontal ramp and NNE-SSW oblique ramp to the north and south of Vettore Mt., respectively. In the southern sector, NNW-SSE-trending anticlines involve both the footwall and the thrust plane of the NNE-SSW arm of the Olevano-Antrdoco-Sibillini thrust, suggesting an in sequence deformation.

In the NW-SE trending sector, the shear zone is characterized by SC tectonites compatible with a simple shear deformation, where the S fabric is oriented at 45° to the shear plane C, with a top to N50-60° direction of tectonic transport. Whereas, along the NNE-SSW-trending sector of the OAS thrust, the fabric is characterized by S tectonites crenulated by conjugated extensional planes.

The compatible strains in shear zones of the S tectonites are: 1. Progressive simple shear that realizes the rotation of the S fabric until its parallelization to the wall of the shear zone; 2. Simple shear associated to negative dilatation perpendicular to the shear zone walls; 3. Sub-simple shear (combination of simple shear and pure shear). A progressive simple shear should be testified by the presence of synthetic reidel shears and rotated extension fissures that characterize strong deformed SC tectonites, eventually evolved in S tectonites. None of these features is detected in the analyzed area. In this area, S tectonites can be possibly due to sub-simple shear, whereas the extensional crenulation cleavage also involving the OAS thrust plane can be related to the pure shear strain, post-OAS thrusting. They are most probably related to the OAS thrusting contemporaneous to the footwall anticlines growing (sub-simple shear strain in the thrust shear zone) and to the definitive growth of footwall anticlines after the OAS thrusting (pure shear strain involving the thrust plane and its hanging-wall and footwall blocks, related to the fold outer arc extensional deformation).

As consequence, S tectonites cannot be related univocally to the amount of shear strain deformation (proportional to the amount of thrust shortening) that is due to the same amount of shortening along the OAS thrust sectors analyzed in this work. S tectonites are strongly affected by the sub-simple shear related to the contemporaneous development of the NNE-SSW-trending OAS oblique thrust plane and of the NNW-SSE-trending anticlines involving its footwall block and of pure shear strains during the definitive footwall anticline growth. This hypothesis is in agreement with the in-sequence development of the thrust and related folding toward the Adriatic foreland.

The analysis and comparison of SC and S tectonites along an oblique regional-scale thrust ramp allowed us to reconstruct the in-sequence deformation mechanism of the Central-Northern Apennines, which is in agreement with an inversion tectonic context characterized by the reactivation of NNE-SSW pre-thrusting normal faults as transversal thrusts. We propose the detailed analysis of thrust shear zones as a useful tool not only to define the kinematic and deformation mechanism, but also to constrain the mode and timing of thrusts and related folds development

SESSIONE H1

Anatessi CROstale: evidenze Naturali, Esperimenti e Modelli

H1-1 Orale Cesare, Bernardo

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CONSTRAINING THE P-T CONDITIONS OF MELTING IN STROMATIC MIGMATITES FROM RONDA (S SPAIN)

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Key terms: anatexis; migmatite; thermodynamic modelling; thermobarometry; nanogranite

We have studied fine-grained stromatic metatexites occurring c. 400 m below the contact with the Ronda peridotite (Ojén unit, Betic Cordillera, SE Spain). These rocks contain Qtz + Pl + Kfs + Bt + Fib + Grt + Ms + Ap + Gr ± Ilm and have a main foliation defined by alternating layers of biotite and fibrolite and thin (~ 0.5 cm) leucosomes. Garnet occurs in very low modal amount (<1%). Muscovite is an armored inclusion or texturally retrograde.

Microstructural evidence of melting in the migmatites includes pseudomorphs after melt films, euhedral feldspars, and nanogranite inclusions in garnet. Remelted nanogranites show granitic compositions. The latter microstructure demonstrates that garnet crystallized in the presence of melt.

We have constructed two pseudosections: one for the bulk rock in the MnNCKFMASH system, and the other for the composition of the remelted nanogranite inclusions in the NCKFMASH system. Calculated isopleths for chemical parameters of garnet (X_{Mg} , X_{Ca}), biotite (X_{Mg} , X_{Fe}) and plagioclase (An content) in the Qtz-Pl-Kfs-Bt-Grt-Sil-melt field match the actual values in the rock. The P-T conditions of equilibration were estimated at 4.5-4.8 kbar, 680-700 °C. These P-T conditions overlap with the low-T tip of the melt field in the pseudosection for the nanogranite composition. They are also consistent with the complete experimental remelting of nanogranites at 700°C.

These results indicate that nanogranites represent the anatectic melt generated at, or soon after, muscovite melting, and that garnet is able to trap melt inclusions also at temperatures lower than those of biotite breakdown melting.

H1-2 Orale Bartoli, Omar

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MELT PRODUCED DURING ANATEXIS OF THE CONTINENTAL CRUST: COMPOSITIONAL CONSTRAINTS FROM EXPERIMENTAL HOMOGENIZATION OF MELT INCLUSIONS IN PERITECTIC GARNETS OF MIGMATITES

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Key terms: anatexis; migmatite; garnet; melt inclusions; nanogranite

Recently, Cesare et al. (2009 and 2011) showed that peritectic minerals in migmatites and granulites can trap droplets of anatectic melt that were formed by incongruent melting reactions during high-temperature metamorphism and granite formation. Detailed geochemical studies on these melt inclusions (MI) have shown that they can represent a window of information into the prograde history of partially melted rocks (Acosta-Vigil et al. 2010). However, the recovery of these information is not straightforward as remelting and homogenization of MI at ambient pressure with the routine technique in igneous petrology produced inclusion decrepitation, interaction with host mineral and volatile loss (Cesare et al. 2011).

To avoid these problems, we performed the experimental remelting of MI using a piston cylinder apparatus. MI are located within peritectic garnets, hosted in the metasedimentary migmatites from Ronda (Betic Cordillera, SE Spain). These garnets contain primary 2-10 µm MI that range from totally glassy to fully crystallized (nanogranite, Cesare et al. 2009). Partially crystallized MI are very common and generally contain quartz, biotite, muscovite and, more rarely, plagioclase, along with variable proportions of glass. Raman spectroscopy has documented the presence of liquid H₂O-filled micropores in nanogranites, in agreement with the presence of a micro- to nano-porosity observed by SEM investigation. Piston cylinder remelting experiments led to the complete rehomogenization of crystalline MI at conditions (700 °C, 500 MPa) close to those inferred for anatexis. Remelted MI have a peraluminous, granitic composition with high (up to 7.5 wt%) H₂O content; they overlap the composition of glassy MI, but differ from the composition of leucosomes in the host rock. Some CO₂ bubbles are present after remelting experiments, suggesting fluid present, a_{H₂O} < 1 conditions, in agreement with graphite being present in the protolith.

Our study shows that partially crystallized and nanogranite inclusions in peritectic minerals from migmatites can be successfully remelted and analyzed, and that this experimental approach may become an ordinary procedure for future studies on MI in anatectic rocks worldwide. We have identified the natural anatectic melt composition and fluid regime at the onset of crustal melting for this case study otherwise unknown. Hence, MI in migmatites represent a unique tool for the *in situ* characterization of anatexis in its early stages, and provide the only means of determining the volatile fluid content of anatectic melts.

Acosta-Vigil et al. (2010): *Journal of Petrology*, 51/4, 785-821; Cesare et al. (2009): *Geology*, 37, 627-630; Cesare et al. (2011): *Journal of Virtual Explorer*, 40, paper 2.

H1-3 Orale Dini, Andrea

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NATURE OF GRANITE SOURCE(S) IN THE TUSCAN MAGMATIC PROVINCE: NEW INSIGHTS FROM SR-ND ISOTOPE DATA OF PALAEOZOIC BASEMENT

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Key terms: Granite; Crustal melting; Sr-Nd isotopes; Palaeozoic basement; Tuscany

Despite granite magmatism represents the major mechanism for past and ongoing large-scale crustal differentiation and it is, therefore, central to understand the evolution of the continental crust, the processes that produce the chemical and isotopic variations displayed by granites remain poorly constrained. Miocene to Pleistocene granites from Tuscan Magmatic Province have been studied since XIX century but it is during the last two decades that a large number of geological, geochemical and isotopic data have been published (see Dini et al., 2009 and references therein). Theories about the origin of these granites changed through time, from the early highly speculative idea of a pure crustal anatexis (e.g. Marinelli, 1967) to the much more constrained hypothesis of mingling-mixing between crustal- and mantle-derived magmas (e.g. Poli, 1992). The involvement of mantle-derived magma (thermal source for overstepping of breakdown reactions in lower crust as well as a geochemical end-member in mingling-mixing processes) has been largely accepted for many Tuscan granites although in some cases (e.g. granites cored in the Palaeozoic basement of the Larderello geothermal field; Dini et al., 2005) its role has been considered relevant only in providing extra heat for the partial melting of the crust. In previous works (van Bergen et al., 1983; Poli et al., 2002), the micaschists from the Larderello basement, due to their fertile mineralogy, have been assumed to be a potential source of the Tuscan granites. However, available Sr-Nd isotope data for these Palaeozoic rocks do not fit the isotope composition of granites and different crustal sources (not exposed and/or unsampled) have been invoked. It is worth noting that the lack of appropriate sources in terms of isotopic composition is a common feature in Hercynian plutonic complexes (Pyrenees, Central Spain, Armorican Massif, Bohemian Massif, etc., Villaseca et al., 1998). A detailed geochemical and isotopic study of metagneous and metasedimentary rocks from the Palaeozoic Tuscan basement (exposed: Apuan Alps, Elba Island; buried: Larderello geothermal field) was performed in order to characterize the potential crustal sources of Larderello granites. Metagneous rocks are represented by metabasites and metarhyolites (porphyroids), while studied metasedimentary rocks are mainly micaschists. In some studied outcrops and cores (Larderello, Elba Island), amphibole-rich metabasites are interlayered with biotite-rich micaschists. Sr and Nd isotope data indicate the existence of three distinct isotopic crustal reservoirs: metasediments (87Sr/86Sr = 0.730; 143Nd/144Nd = 0.5119); metarhyolites (87Sr/86Sr

$^{87}\text{Sr}/^{86}\text{Sr}$ 0.750; $^{143}\text{Nd}/^{144}\text{Nd}$ 0.5122); and metabasites ($^{87}\text{Sr}/^{86}\text{Sr}$ 0.716; $^{143}\text{Nd}/^{144}\text{Nd}$ 0.5126). These reservoirs do not fit the isotope composition of Lardereño granites but partial melting of a metabasite-metasediment layered source can explain both the observed geochemical and isotopic variation in granites. The existence of Palaeozoic interlayered domains at depth could explain the apparent lack of appropriate anatectic sources, providing alternative mechanisms for the origin of Tuscan granites.

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H1-4 Orale Rolfo, Franco

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LOW-PRESSURE ANATEXIS IN THE HIGHER HIMALAYAN CRYSTALLINES OF EASTERN NEPAL REVEALED BY CORDIERITE-BEARING LITHOLOGIES

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Key terms: low-pressure anatexis; cordierite; Himalaya; microstructures; P-T pseudosections

In the eastern Himalaya, partial melting is widely documented in the Higher Himalayan Crystallines (HHC), a high-grade, several km thick lithotectonic unit located at the higher structural levels of the Himalayan belt (e.g. Goscombe et al., 2006; Searle et al., 2008). In the lower structural levels of the HHC, anatexis occurred at medium to high-P (8-12 kbar) and is recorded in Ky-bearing granulites (Barun Gneiss and Jannu-Kangchenjunga Gneiss). Toward structurally upper levels of the HHC, peak-P significantly decreases down to 4-5 kbar, as revealed by the widespread occurrence of Crd-bearing and Ky-free gneisses (e.g. Imayama et al., 2010; Streule et al., 2010; Mosca et al., 2010), locally named Namche Migmatites and Black Gneisses (e.g. Bordet, 1961; Lombardo et al., 1993).

This contribution focuses on the cordierite-bearing lithologies occurring at the higher structural levels of the HHC, by describing in detail three Crd-bearing gneisses (samples 09-29, 07-26 and 05-17) from different geological transects in Eastern Nepal from Everest to Kangchenjunga. The studied samples differ in terms of bulk composition, likely reflecting different sedimentary protoliths (from pelite to psammite), though they all consist of quartz, K-feldspar, plagioclase, biotite, cordierite and sillimanite in different modal percentages. Garnet occurs in two samples, as a relict phase in very low modal amounts. In all the studied samples cordierite is spectacularly well preserved.

Most of the observed microstructures may be interpreted in terms of melt-producing or melt-consuming reactions, such as for example: (i) Crd porphyroblasts including Sil and Bt never in mutual contact, suggesting that Crd is a peritectic phase grown at the expenses of both Sil and Bt; (ii) coarse-grained Kfs poikiloblasts containing abundant inclusions of Bt, rounded Pl and Qtz, and minor Sil, suggesting that Kfs is a peritectic phase grown at the expenses of Pl, Bt, Sil and Qtz; (iii) thin films of Qtz, Kfs or Pl with cusped shape locally occurring between adjacent grains of Qtz, Bt or Kfs possibly interpreted as pseudomorphs of liquid-filled pores (e.g. Holness & Sawyer, 2008), thus suggesting that some melt crystallized in the interstices between grains.

The lack of retrograde rehydration suggests that either the studied samples experienced a significant melt loss so that the interactions between melt and solid phases during cooling were limited, or the amount of melt produced was scanty. The results of P-T pseudosection modeling suggest that the first hypothesis is the most likely for the metapelitic samples 09-29 and 07-26, whereas the second hypothesis applies well to the metapsammite sample 05-17.

The P-T evolution of the studied samples, reconstructed combining microstructural observations, mineral chemical data and pseudosection modeling, is discussed in the framework of the "channel flow" model, which is one of the most popular paradigms to explain the tectonometamorphic evolution of the HHC and, more generally, the first-order geologic features of the Himalayan-Tibetan orogen.

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H1-5 Orale Groppo, Chiara

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THE ROLE OF HEATING VS. DECOMPRESSION ON PARTIAL MELTING IN THE BARUN GNEISS (EASTERN NEPAL HIMALAYA)

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Key terms: medium-pressure anatexis; decompression; Himalaya; microstructures; P-T pseudosections

Partial melting of deep continental crust may occur during either prograde heating or decompression. Although the effect of temperature on crustal melting has been widely investigated, only few experimental studies address the question of the influence of pressure on crustal anatexis, and the effectiveness of decompression melting in the production of large amounts of melt in the deep crust is still far from being universally demonstrated.

In the eastern Himalayan chain, partial melting is widely documented in the Higher Himalayan Crystallines (HHC), a high-grade, 5-6 km thick lithotectonic unit located at the higher structural levels of the Himalayan belt. Crustal anatexis in the HHC has been generally ascribed to decompression melting (e.g. Harris & Inger, 1992; Harris & Massey, 1994; Patiño Douce & Harris, 1998; Harris et al., 2004; Streule et al., 2010; Searle et al., 2010), and gave rise to significant amounts of granitic bodies and dykes crosscutting widespread migmatites and granulites. The HHC thus represent an ideal natural laboratory in which to investigate the actual influence of decreasing P on partial melting processes.

In this study we have investigated in detail the P-T evolution of two garnet-K-feldspar-kyanite-sillimanite anatectic gneisses from different structural levels of the same Unit (Barun Gneiss) in the lower portion of the HHC (Arun-Barun valley, eastern Nepal). Although the mineral assemblage is identical (Qtz + Pl + Kfs + Bt + Grt + Ky/Sil + Rt), several microstructural and microchemical features, combined with the results of P-T pseudosection modeling, suggest that the two samples experienced a different P-T evolution, dominated by decompression (sample 07-16) and heating (sample 07-35) respectively.

P-T pseudosection modeling shows that the melt productivity, related to the muscovite- and biotite dehydration melting reactions, depends on: (i) the slope of melt isomodes in the P-T space (which in turn is an expression of the slope of the reaction curve), and (ii) how the P-T trajectory crosses the melt isomodes. For the two studied samples, given the constrained P-T paths and their relations with the main melt-producing reactions in the P-T space, it can be concluded that melt production was mainly triggered by heating, with or without the combined effect of decompression. Decompression alone is not able to explain the production of large amounts of melt, in contrast to what is often suggested for the HHC.

In addition, metamorphic and petrologic data derived for the Barun Gneiss match well with the predictions of the "channel flow" model, one of the most popular paradigms to explain the tectonometamorphic evolution of the Himalayan-Tibetan orogen.

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H1-6 Poster Dini, Andrea

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PERITECTIC PHASES ENTRAINMENT AND MAGMA MIXING: THE ORIGIN OF THE CHEMICAL VARIABILITY OF THE LATE MIOCENE GRANITIC COMPLEX FROM ELBA ISLAND (ITALY)

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Key terms: granite; peritectic phase; entrainment; mixing; Elba Island

The comparison between the chemical variability exhibited by the granitic rocks of the Elba Island granitic complex (Italy) and the composition of fluid-absent experimental melts indicates that these rocks have Fe+Mg, Ti and Ca contents that are too high to represent pure crustal melts.

Therefore, their origin demands the addition of a ferromagnesian, Ti- and Ca-rich component to an anatectic melt. Various authors, on the basis of textural and chemical data, have interpreted the chemical variability exhibited by the Elba Island granitic rocks as reflecting the progressive hybridization of an original crustal melt with mantle-derived magma(s). However, a simple mantle-crustal magma mixing hypothesis is challenged by the observation that some elements (e.g. Ti and Ca) are highly correlated with Fe+Mg, while others (e.g. Sr, K, Na) are not, as well as by the scattered major and trace element composition of the mafic microgranular enclaves. This contribution focuses on reconsidering the role of mantle-derived magmas in the petrogenesis of the Elba Island intrusive system from the perspective of the constraints imposed by crustal melt compositions. On the basis of the major- and trace element geochemical data, as well as petrographic data such as amphibole clots replacing former pyroxene and garnets in some of the Elba granitic rocks (possibly representing evidences for the occurrence of entrained peritectic phases), we propose that at least part of the compositional variations displayed by the Elba Island intrusive complex is primary, i.e. reflect the magma composition that ascended directly from the source. Following this hypothesis, the final composition of magmas may be controlled by two main factors: (i) the stoichiometry of the melting reaction(s) and the composition of reactant phases in the source, that control the composition of the anatectic melt; (ii) the degree of entrainment of peritectic mineral phases, whose nature will be dependent by (i), as well as by the P, T conditions of melting. The magma mixing relevant to the bulk of the Elba igneous products then occurred between successive (different ?) magma

batches generated by anatexis of heterogeneous source rock volumes. Mantle-derived magmas are only involved in the genesis of the most mafic magma batches.

H1-7 Poster Langone, Antonio

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CRUSTAL XENOLITHS FROM TALLANTE (BETIC CORDILLERA, SPAIN): INSIGHTS FOR AN INTERLAYERED CRUST-MANTLE BOUNDARY?

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Key terms: *crustal xenoliths; Betic Cordillera; P-T conditions; crust-mantle boundary; partial melting*

The geology of the Betic area has been characterized by several tectono-magmatic episodes related to multiple orogenic cycles and extensional phases (Puga et al., 2011; Bianchini et al., 2011 and references therein) ultimately leading to widespread subduction-related and anorogenic volcanism. The last magmatic phase (Pliocene) is represented by Na-alkaline basalts at Tallante that entrained and exhumed abundant deep-seated xenoliths of both mantle and crustal provenance. These xenoliths attracted an intense petrological interest testified by an impressive number of scientific papers. Unfortunately, most of these studies focused on the ultramafic xenoliths ignoring the crustal lithologies that were investigated only by the paper of Vielzeuf (1983). In this contribution we present new data on felsic (i.e. crustal) xenoliths from Tallante that integrate the petrological information provided by the ultramafic parageneses, highlighting the deep lithosphere stratigraphy of the area as well as constraints for the interpretation of geophysical data and models.

The felsic xenolith is characterized by a metamorphic peak assemblage composed of quartz + spinel + sillimanite. The occurrence of cordierite rims between spinel and quartz is related to post-peak metamorphism. To obtain P-T information from this texture, we calculated a P-T pseudosection for the specific mineral reaction texture spinel + quartz = cordierite. The microbulk composition was modeled in the SiO₂-Al₂O₃-FeO-Fe₂O₃-MgO system. Water has not been taken into account in order to simulate the likely anhydrous conditions occurring during the peak metamorphic stage.

The observed paragenesis Spinel-Quartz-Sillimanite indicates temperature around 1000 °C for pressure of 7 kbar, increasing to 1125 °C at 9 kbar. The formation of cordierite rims between quartz and spinel requires, in the chosen system, decompression down to < 6 kbar (T < 950 °C). This evolution was accompanied by partial melting testified by glasses films and blebs.

Therefore, felsic xenoliths from Tallante attained P-T condition overlapping those recorded by the ultramafic xenoliths of mantle provenance that are represented by spinel-plagioclase peridotite. This suggests that an intimate association of crust and mantle lithologies with pervasive interlayering and interfingering at metric to hectometric scale characterizes the Moho discontinuity in this area.

Melting preferentially occurred in the crustal domains (characterized by lower solidus conditions) generating silica-rich magmas that veined the surrounding peridotite domains, also inducing orthopyroxene-rich metasomatic aureole.

The proposed petrological scenario is discussed taking also into account the investigations on the neighboring massifs of Ronda and Beni Bousera where the fossil crust-mantle boundary is exposed, providing fresh insights for the configuration and evolution of the Moho discontinuity in collisioned plate boundaries, that are widespread throughout the peri-Mediterranean realm. The hypothesized tectonic crust-mantle boundary would represent a suitable source region for exotic magma types such as lamproites that are common within the Mediterranean area (Tommasini et al. 2011).

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SESSIONE H3

Evoluzione pre-mesozoica dei basamenti circummediterranei

H3-1 Orale Piccarreta, Giuseppe

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GEOLOGICAL EVOLUTION OF THE SOUTH EUROPEAN VARISCAN FRAGMENTS FROM CALABRIA INFERRED FROM P-T COMPUTATIONS AND U-PB ZIRCON AGES.

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Key terms: *P-T-t path; South European Variscan chain; U-Pb zircon ages; Calabria*

In Calabria (southern Italy) fragments of south European Variscan chain consisting of ortho- and para-derivates affected by low- medium- high-grade metamorphism crop out.

Ortho-derivates involved by green schist to granulite facies metamorphism characterize middle and deep continental crust units.

Metagabbros and metabasites affected by granulite facies metamorphism are associated with felsic granulites and migmatitic metapelites of the lower continental crust unit of the Serre.

U-Pb spot analyses on zircon separates (performed by SIMS and LA-ICP-MS) have provided constraints on the ages of protoliths and on chronology of Variscan metamorphism.

The age of magmatic protoliths of the orthogneisses and of the metabasic rocks was fixed at ~540 and ~580 Ma, respectively, representing a

bimodal magmatic contribution to Pan-African crust in Early Cambrian-Neoproterozoic times. Mafic and felsic magmas were emplaced in the Pan-African/Cadomian basement preserving memory of older terrains belonging to West African Craton. These peri-Gondwana terrains were reworked by Variscan orogenesis and look like the blocks occurring in the east European chain from the Alps to Turkey. The effects of Variscan metamorphism depend on P-T conditions and rock chemical compositions. A time memory, step by step, of the Variscan evolution was preserved in rock-types where the re-growth or re-crystallization of zircon happened. So the U-Pb zircon ages together with the petrological data in granulite-amphibolite facies metamorphic rocks of the Serre allow to depict the Variscan evolution.

Ages around 450 Ma were recorded in the metagneous rocks which coincide with the age derived from Rb-Sr isochron relative to metasedimentary rocks; this age can be related to an Ordovician tectonothermal activity or to Eo-Hercynian events.

Cluster ages of 347-340 Ma, 323-318 Ma, 300-294 Ma and 279 Ma were measured in metagabbros and metabasites from the lower portions of the section. Age peaks around 323, 300 and 270 Ma are recorded in overlying migmatitic metapelites. Undated thin luminescent rims of zircon are the only evidence of post-Ordovician events in orthogneisses interleaved with migmatitic metapelites.

Conventional thermobarometer, Thermocal calculations and pseudosections indicate clockwise trajectories Ky-Sil-And-Ky and Ky-Sil-Ky for the migmatitic metapelites and metabasites, respectively, from the deep continental crust unit of the Serre. The P-T conditions in the

metabasic portion indicate a possible P peak (P₂~1.08 GPa and T<850°C)

predating the T-peak (T=850-900°C and P~1.08 GPa) at 347-340 Ma,

probably followed by quite isothermal decompression (P=0.8 GPa) at

323-318 Ma and successive decrease of T (~750°C); a new

decompression at P about 0.65 GPa around 300 and 280 Ma ago, occurs.

During the decompression stages pervasive partial melting episodes, producing leucogranitic and trondhjemitic melts, interested these rocks in

which luminescent overgrowths mantle primary zircon cores.

The re-constructed P-T path shows even for the upper migmatitic

metapelites, P-peak at 0.9 GPa and T=650° pre-dating T-peak (750°C)

under quite isobaric conditions 323 Ma ago and a multistage

decompression at 300, 280 Ma up to 270 Ma with incremental partial

melting episodes.

An integrate approach involving U-Pb analyses on zircon and REE

distribution in garnet orthopyroxene and zircon on thin section, relatively

to the mafic granulites better constrain the Variscan evolution.

H3-2 Orale Fiannacca, Patrizia

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GEOCHRONOLOGICAL CONSTRAINTS ON THE ORIGINS AND EARLY GEODYNAMIC EVOLUTION OF THE PELORITANI MOUNTAINS, SOUTHERN ITALY.

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Key terms: *Sediment provenance; U-Pb zircon geochronology; Latest Proterozoic; Peloritani Mountains*

In situ SHRIMP U-Pb ages have been obtained, for the first time, for detrital zircons from metasedimentary and metagneous rocks from the Peloritani Mountains (NE Sicily), allowing some firm constraints to be put on the formation age and origins of this still poorly known

peri-Mediterranean chain. The greywacke protoliths of the paragneiss

forming the most common rock-type in the Peloritani Mountains were

deposited at c. 550 Ma, the age of the youngest detrital zircon population,

just before the intrusion of granitoid plutons at c. 545 Ma. Large portions

of flysch-type sequences including deeper equivalents of the c. 550 Ma

greywackes underwent partial melting, producing large volumes of

granitoid rocks now exposed as augen-gneisses in north-eastern Sicily, as

well as in southern and northern Calabria. Age spectra of detrital and

inherited zircons from paragneiss and augen gneiss, respectively, indicate

sediment derivation from the erosion of Neoproterozoic to Late Archaean

sources. The main components are c. 540-850, 900-1100 and 2400-2700

Ma and minor ones c. 1.60, 1.80 and 3.20 Ga. These age groups reflect a

peri-Gondwanan affinity and are consistent with deposition in a marginal

basin located at the northern Gondwana margin, between an old cratonic

area and the Avalonian-Cadomian magmatic arc (Nance et al., 2010; and

reference therein). The high abundance of Grenvillian zircon, together with

the occurrence of c.1.56-1.80 Ga grains, makes it quite unlikely that the

amphibolite facies basement of NE Sicily was derived from the West

African Craton, contrary to what is suggested for similar coeval rocks from

Calabria. Although Grenvillian zircons are known from various sectors of

northern Gondwana, such as the Saharan craton and the Arabian-Nubian

Shield, a stronger affinity with Amazonian-derived terranes, such as NE

Bohemia, NW Turkey and the autochthons of NW Iberia, is more

suggestive of an Amazonian linkage for that part of NE Sicily at the

Precambrian-Cambrian transition. Later, the Peloritani Mountains were

involved in break-up processes linked to opening of the Rheic Ocean and,

finally, in a short-lived Mid-Ordovician orogenic cycle. Magmatic activity

related to this Early Paleozoic evolution is documented, respectively, by

Cambro-Ordovician alkali metabasites and Caradocian meta-andesites and

felsic porphyroids from the volcano-sedimentary sequences of the

southern Peloritani Mountains (Trombetta et al., 2004; Cirrincione et al.,

2005). The depicted nearly continuous geodynamic evolution suggests a

basement-cover relationship between the Latest Neoproterozoic basement

rocks of NE Peloritani and the Paleozoic volcano-sedimentary sequences of

SE Peloritani. Inherited Mesoproterozoic zircon from the Mid-Ordovician

porphyroids (Trombetta et al., 2004) supports both the Amazonian

provenance and the basement-cover relationship of the northern and the

southern Peloritani Mountains. The results of the present study are in

substantial agreement with former models proposed by Acquafredda et al.

(1994) and Ferla (2000) and additionally provide the first reliable

geochronological information on the real age and early history of the

medium-high grade Peloritani basement.

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H3-3 Orale Fornelli, Annamaria

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EVIDENCE OF EXTENSION IN THE GRANULITE FACIES LOWER CRUST OF CALABRIA DURING THE HERCYNIAN OROGENY.

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Key terms: *Calabrian crust; extension; microstructures; pseudosection; geothermobarometry*

Quartz-monzodioritic dykes have intruded the Hercynian continental lower crust of Calabria 323±5 Ma ago, according to zircon spot age data. We have constrained the emplacement depth of these dykes by the construction of pseudosections and the calculation of multiple reactions using the internally-consistent dataset of THERMOCALC. Our calculations show that the quartz-monzodioritic dykes have intruded the metapelitic-migmatitic country-rocks at a depth of about 32 km. After the intrusion the dykes together with country-rocks were deformed under granulite facies conditions. This is supported by microstructural evidence and by the application of geothermometry. The analysis of fabric elements contained within the deformed dykes and the country-rocks suggests that deformation has occurred in an extensional regime. The onset of deformation can be placed to before 306 Ma, because the deformed quartz-monzodioritic bodies are locally cut by undeformed leucocratic dykes connected to the granulite masses that intruded the Calabrian crust between 306 and 300 Ma. Intrusion of these granulites has occurred during extension at mid-crustal levels. Decompression during extension of the Calabrian crust under granulite facies conditions has been pinpointed so far to the intrusion of these granulite masses. We can show that in the lower crust the extension started earlier, suggesting that it was asynchronous within the Calabrian crust, and has propagated with time from deeper to mid- and upper crustal levels. Alternatively, the whole Hercynian crust underwent thinning almost synchronously at different crustal levels.

H3-4 Orale Romano, Vanessa

10.1474/Epitome.04.0631.Geoitalia2011

GENESIS OF INTERMEDIATE-FELSIC CALCALKALINE MAGMAS AT THE END OF THE HERCYNIAN OROGENY: THE HIGH-MGO ANDESITE AND DACITE-RHYODACITE DYKES OF THE SERRE MASSIF (SOUTHERN ITALY)

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Key terms: *post-collisional dyke magmatism; southern Calabria; andesite/boninite association; dacite-rhyodacite*

Diffuse dyke swarms with intermediate to felsic composition and calcalkaline affinity crop out in the Serre Massif (Calabria, Southern Italy). These are part of the widespread late- to post-collisional magmatism affecting most southern European basements during the waning stages of the Hercynian orogeny. The dykes are andesitic and dacitic-rhyodacitic in composition, with medium- to high-K₂O content, and show typical features of subduction-related magmas, such as LILE and LREE enrichment and HFSE depletion. Chondrite-normalized REE patterns are weakly to strongly fractionated (LaN/YbN = 8.5 to 14.0 for andesites and 2.3 to 16.3 for dacites-rhyodacites) with slightly negative to positive Eu anomaly for the andesites and markedly negative Eu anomaly for the dacites-rhyodacites.

The petrogenesis of the late- to post-Hercynian calcalkaline rocks is usually linked to an extensional post-collisional setting involving thinning of the continental lithosphere and progressive upwelling of the asthenospheric mantle. In such a context, both pure mantle, crustal and hybrid melts are likely to be generated. The andesitic dykes show mineral and whole-rock major and trace element composition resembling boninitic rock associations (anomalously high MgO, Mg#, Cr and Ni, coupled with high SiO₂, relatively low TiO₂, high Mg# in clinopyroxene, high Al₂O₃/TiO₂, high Zr/Hf, moderate LREE enrichment, low HREE and negative Nb-Ta troughs in primitive mantle-normalized diagrams). Petrological investigations suggest that they were probably produced by partial melting of an enriched mantle source metasomatized by crustal fluids/melts during former subduction of oceanic lithosphere and then suffered minor, if any, assimilation of lower crustal metapelites. Most dacite-rhyodacites were instead likely derived by hybridization in various proportions of crustal and mantle melts, whereas pure crustal metasedimentary sources, and more or less efficient restite unmixing processes, were involved in the generation of the most silica-rich rhyodacites.

H3-5 Poster Fiannacca, Patrizia

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POST-COLLISIONAL GRANULITE MAGMATISM IN THE CALABRIA-PELORITANI TERRANE DURING THE FINAL STAGES OF NORTH GONDWANA ASSEMBLY

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Key terms: *Augen gneiss; Ediacaran; peri-Gondwanan terranes; post-collisional magmatism; Peloritani Mountains*

Augen gneisses covering an area of about 80 km² in the Peloritani Mountains (NE Sicily) have been found to be 570-540 Ma granulites after SHRIMP zircon U-Pb dating of a representative sample from each of three different areas. Similar coeval rocks are also exposed in Calabria,

indicating the presence of a large Ediacaran granulite province in the Calabria-Peloritani Terrane, currently extending from NE Sicily to northern Calabria. Two of the studied augen gneisses, from the eastern Peloritani, have many zircon grains composed of a thick ~ 545 Ma melt-precipitated rim surrounding a core ranging in age from Late Archean to latest Proterozoic. These cores are interpreted as detrital grains from sediments that were part of the source of the granulite magmas, and suggest that that source was largely composed of rocks akin to the protoliths of northern Peloritani paragneisses, which have similar patterns of detrital zircon ages. The third augen gneiss, from the western Peloritani, has a protolith emplacement age of ~ 565 Ma and contains inheritance-free zircon, implying that the magma was strongly zircon undersaturated and/or high-temperature, or derived from a zircon-poor source. The Late Ediacaran emplacement ages of the granulite protoliths of the inheritance-rich augen gneisses, together with typical high-K calcalkaline post-collisional geochemical features and strong evidence for dominantly crustal sources from zircon inheritance and isotopic features, are consistent with the widespread crustal melting and post-tectonic granulite emplacement at c. 550-540 Ma reported by many authors (e.g., Murphy et al., 2001; Linnemann et al., 2008; Nance et al., 2010) as marking the transition from subduction to strike-slip tectonics at the northern margin of Gondwana at the end of the Neoproterozoic. It has been proposed that some of the peri-Gondwanan terranes were formed in back-arc environments located between cratonic (south-American or north-African) and arc-related (Avalonian or Cadomian) domains. After a late stage of arc magmatism at c. 580-560 Ma, possibly represented in the Peloritani Mountains by the 565 Ma protolith of the western Peloritani augen gneiss, inversion of back-arc basins related to collision of the magmatic arcs with mainland areas led to the deposition of turbidite sequences at 545-540 Ma. In some cases (e.g. Lausitz Group in Saxo-Thuringia; Linnemann et al., 2007) these sequences were rapidly deformed before the intrusion, at ~ 540 Ma, of large volumes of granulites, probably derived from melting of the same turbiditic graywackes, as suggested by comparable zircon age patterns and geochemical and isotopic compositions. Many of the ~ 545 Ma igneous rims on zircon from the two studied eastern Peloritani augen gneisses overgrow virtually coeval Ediacaran inherited cores, indicating deposition of the sediments only very shortly before magmatism. This interpretation is reinforced by the c. 545 Ma deposition age obtained for the metagreywacke protolith of an eastern Peloritani paragneiss. These results may be framed in a model involving rapid erosion, burial, sediment deformation and metamorphism up to partial melting conditions in less than about 10 million years. A similar model has been envisaged by Nance et al. (2010) for the Saxo-Thuringian zone. They proposed that these latest Proterozoic examples of extremely rapid geological evolution were caused by a short-lived regime of high heat-flow linked to slab break-off resulting from ridge-trench collision. In this context, evidence for a mantle contribution to the petrogenesis of the c. 545 Ma granulites may be found in their geochemical and isotopic features, and the documented presence of coeval gabbroic rocks in the same region.

H3-6 Poster Lo Pò, Deborah

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ESTIMATE OF HERCYNIAN METAMORPHIC PEAK IN UPPER CRUSTAL METAPELITES OF THE MANDANICI UNIT VIA GARNET ISOPLETH THERMOBAROMETRY (PELORITANI MOUNTAINS; NORTH EASTERN SICILY)

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Key terms: *PT pseudosections; Hercynian Orogeny; Peloritani Mountain Belt*

The Peloritani Mountain belt is a segment of the European Alpine orogen that preserves pre-Alpine basement relics. Very low to high grade metamorphic rocks are exposed in the present-day tectonic stack of the chain. Up to now very few PT paths are available for the basement tectonic slices of the Peloritani Mountains, due to the common absence of suitable parageneses in the low and very low grade metamorphic rocks, as well as to the pervasive late Hercynian thermal re-equilibration in the medium-high grade metamorphic rocks. In this view, to estimate the relic peak PT conditions of the Hercynian evolution of this southern Alpine chain sector, phase diagram calculation method was applied, modelling the upper greenschist facies garnet-muscovite-chlorite schists outcropping in the uppermost levels of the Mandanici Unit. The investigated fine-grained metapelite are characterized by a dominant lepidoblastic texture, with ilmenite and poikilitic garnet porphyroblasts surrounded by alternating muscovite+paragonite+chlorite and minor quartz+plagioclase layers, with apatite, monazite and zircon as accessory phases. Three schistosity surfaces were recognized: S1 consists in a partially obliterated isoclinal folding schistosity developed during the first identifiable deformational event (D1); S2 is related to a penetrative microfolding (D2) producing pervasive crenulation schistosity; S3 is consequent to an extensional-shearing event (D3). Porphyroblast-matrix relationships, investigated via optical and electronic microscopy allowed the blasto-deformation sequence to be reconstructed. The attention was focused especially on garnet zoning pattern analysis. Garnet porphyroblasts have cores characterized by quartz and rare ilmenite inclusion trails with folding pattern linked presumably to the D2 event. Idioblastic rims grow over the crenulated garnet, thus representing a late to post-D2 growth stage. Fe-Mn-Mg-Ca X-ray maps and compositional profiles outlined a weak compositional growth zoning, consisting in a bell-shaped profile, with increasing almandine and decreasing spessartine contents toward the rims. P-T pseudosection was calculated in the TiMnNCKFMASH system, using the XRF bulk-rock composition of metapelite samples mainly exhibiting assemblages consistent with peak or near-peak conditions. Retrograde evolution is locally represented by garnet breakdown to chlorite. Garnet inner core isopleths intersections indicate T of 510°C at P of 0.483 GPa, just nearby the garnet-in curve, in agreement with pyrophanite isopleths composition of porphyroblastic ilmenite. Garnet outer core isopleths intersections define similar P-T conditions of T = 525°C and P = 0.485 GPa. These P-T estimates are linked to the first identifiable metamorphic stage in which isoclinal folding event (D1) and garnet core developed. Garnet rim isopleths intersections gave values of the peak metamorphism at T of 535°C with slightly lower P of 0.430 GPa, attained during the crenulation deformational event which obliterated most of the previous foliation. All the obtained intersections belong to the same pseudosection PT field characterized by chl+ms+pl+ilm+grt+pg assemblage, in agreement with the observed mineralogical assemblage. Subsequent retrograde evolution is depicted in the pseudosection PT space by garnet breakdown reaction into chlorite

with T of 500±20°C at P of 0.32±0.03 GPa, consistent with the observed partial to complete pseudomorph replacements. PT estimates obtained via garnet isopleths thermobarometry can be interpreted as the peak PT climax of the Mandanici Unit reached during the Hercynian crustal thickening at upper-middle crust conditions, while the following retrograde evolution depicts a typical retrograde clockwise PT trajectory consistent with the initial exhumation stage of the Hercynian orogen.

H3-7 Poster Sacco, Valentina

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EVIDENCE OF HERCYNIAN HIGH TEMPERATURE RELICS REPLACED BY ALPINE MYLONITIC OVERPRINT: NEW IMPLICATIONS FOR THE TECTONO-METAMORPHIC EVOLUTION OF THE CASTAGNA UNIT (CALABRIAN PELORITANI OROGEN, SILA PICCOLA MASSIF)

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Key terms: Polyorogenic evolution; Shear Zone; Sila Massif

Petrological and microstructural investigations have been integrated to unravel the tectono-metamorphic evolution of the Castagna Unit. This unit represents a pervasively mylonitised horizon located in the lower-intermediate portion of the northern Calabride continental crust section, sandwiched at the bottom by the low grade metapelite of the Bagni Unit and at the top, by the granulite facies rocks of the Sila Unit. Evidence of Hercynian high temperature relics have been observed for the first time, preserved as low strain domains within the pervasive mylonitic foliation of the metapelite horizons.

In this view, petrological, structural and microstructural analysis on mylonitic paragneiss and leucogneiss, allowed to yield reliable P-T constraints aimed to depict the tectono-metamorphic history for this little-known and discussed portion of crystalline basement in the northern Calabrian Peloritani Orogen.

Locally, low strain domains composed of garnet-sillimanite paragneiss, with intermediate to low Ti-biotite and oligoclase-andesine plagioclase, are preserved in the metapelite horizons. The quasi-absent garnet crystal zoning, suggesting the presence of pervasive re-homogenising effects of garnet interiors, represents a petrological evidence of long residence time at high T conditions in the lower crust. The narrow high Mn rim content in garnet depicts an anti bell-shaped profile suggesting a clear evidence of retrograde metamorphism.

Thermodynamic modelling, by means of pressure-temperature (P-T) pseudosection computations, in the MnNaCaKFMASH system, not allowed to yield any reliable P-T constraints about the prograde metamorphic event coeval with the former garnet growth stages. The narrow retrograde rims of this re-homogenised garnet, allowed reliable P-T constraints to be detected, with P ranging from 5.7 to 6.8 Kbar at T of 595 °C, consistent with the former stages of the retrograde metamorphic trajectory at upper amphibolite facies conditions.

The subsequent pervasive mylonitic retrograde evolution is mainly recorded in the leucogneiss horizons, characterised by ribbon-like quartz levels wrapping feldspar porphyroclasts and low phengite mica fish. Syn-mylonitic white mica shows a bimodal distribution of phengite content: a) an high phengite white mica (e.g. 3.23-3.4 a.p.f.u) can be interpreted as the result of an high pressure mylonitic stage ranging from 4 to 8 Kbar; b) a low phengite one, could represent the relic of a previous mylonitic stage developed at lower pressure conditions.

Quartz c-axis orientation pattern analysis allowed to constrain shearing temperature consistent with lower greenschist facies conditions (i.e. 400-450 °C) with subordinate evidence of prism c-slip system activation consistent with higher shearing temperature, both characterised by the same sense of shear.

New implications on the evolution of the Castagna Unit suggest as the pre-mylonitic relics preserved as low strain domain in metapelite, can be interpreted as the result of an Hercynian granulite facies mineralogical association, as supported by the re-homogenising effect on garnet interiors, affected by the former stage of retrograde evolution in upper amphibolite facies conditions, constrained by means of garnet rim isopleth thermobarometry. In this view, the Castagna Unit can represent the basal mylonitised and retrogressed portion of the originally granulitic Sila Unit, during a former late Hercynian lower pressure stage. Undeformed aplitic-pegmatitic dikes, linked to the Sila Batholith emplacement, crosscutting the mylonitic foliation, support this interpretation. The subsequent well-developed HP-LT mylonitic overprint, can be interpreted as a pervasive Alpine re-activation.

In this scenario, the "Castagna Unit's shear zone" can be interpreted as a post-Hercynian "detachment zone", postulated in order to justify the exhumation of the deepest parts of the continental crust, reworked during the building of the Alpine Orogen.

SESSIONE H4

La litosfera oceanica dallo spreading alla subduzione: indicazioni strutturali, geofisiche, geochimiche e petrologiche per la comprensione dell'evoluzione del pianeta Terra

H4-1 Key Lecture Tribuzio, Riccardo

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ORIGIN OF GABBROIC SEQUENCES FROM ALPINE JURASSIC OPHIOLITES: IMPLICATIONS FOR LOWER CRUST GENERATION AT SLOW SPREADING SETTINGS

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Key terms: ophiolite; oceanic lithosphere; gabbro

The Alpine Jurassic ophiolites are lithospheric remnants of an embryonic slow spreading basin that developed in conjunction with the opening of the Central Atlantic Ocean. These ophiolites are locally characterized by up to km-scale gabbroic bodies intruded into mantle peridotites. In particular,

large-scale gabbroic sequences occur in the Chenaillet ophiolite from the western Alps (Manatschal et al. 2011), the Internal Ligurian ophiolites from the northern Apennines (Cortesogno et al. 1987; Sanfilippo and Tribuzio 2011) and the Balagne ophiolites from Corsica (Saccani et al. 2000). These gabbroic sequences mostly consist of troctolites, olivine-gabbros and clinopyroxene-rich gabbros and include sparse olivine-rich troctolites, olivine-gabbronorites and oxide-gabbros. The large-scale gabbroic bodies from the Alpine ophiolites locally also enclose up to 100 m thick mantle bodies and bear striking structural and compositional resemblances to the gabbroic sequences from modern slow spreading ridges.

Field observations and petrological and geochemical data are used to constrain a conceptual model for the formation of the gabbroic sequences from the Alpine ophiolites. The proposed model begins with a "hot" mantle evolution under plagioclase facies conditions, in which melt transport occurred mostly in the form of grain scale porous flow. In particular, reactive channeling of primitive olivine-saturated melts formed replacive dunitic conduits, whereas residual orthopyroxene-saturated melts led to melt impregnation of the mantle section. The "hot" lithospheric evolution is followed by an evolution characterized by melt transport through fractures, which started with crystallization of melt into troctolite to olivine gabbro dykes. This dyking event is presumably correlated with the formation of the olivine-rich troctolites within the gabbroic sequences, by infiltration of MORB-type melts within dunitic conduits (Renna and Tribuzio 2011).

As the mantle section cooled significantly, the dip of the melt migration structures evolved from sub-vertical to sub-horizontal. This is shown by the occurrence of sill-shaped gabbroic intrusions that locally crosscut the gabbroic dykes. The growth of the gabbroic sequences is attributed to accretion of gabbroic sills. In particular, petrological variations and cooling rate estimates as a function of the stratigraphic height document that the large scale architecture of the gabbroic sequences is produced by the association of variably evolved sills that were derived from different primitive melt injections. After their solidification, the gabbroic sequences underwent high temperature ductile shearing, from near solidus to amphibolite facies conditions. The amphibolite facies shear zones occurred close to the ductile-brittle transition and record the penetration of seawater-derived fluids within the gabbroic sequences.

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H4-2 Orale Rebay, Gisella

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SUBDUCTED HYDROTHERMALLY ALTERED OCEANIC CRUST: WHAT HAPPENS IN SUBDUCTION ZONES? A MODELLING PERSPECTIVE FROM THE WESTERN ALPS OPHIOLITES

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Key terms: hydrothermally altered; ophiolite; subduction; thermodynamic modelling

Eclogitised oceanic crust preserved in sutures of collisional zones has very often undergone pervasive high-pressure metamorphism, but nonetheless preserves evidence of parts of its previous history, such as hydrothermal alteration that took place in oceanic environment. The existence of this alteration is well documented in present-day and past oceanic crust. Altered oceanic rocks that enter the subduction zone are amongst the principal carriers of fluids into the mantle, and may have a profound impact on the water budget. It is thus interesting to understand in detail what happens to such hydrated rocks when they undergo high pressure metamorphism, and we have investigated this through forward modelling of mineral assemblages in the NCKFMASHTO system, using the THERMOCALC software. A bibliographic survey has been performed in order to have an idea of the composition of altered oceanic rocks, considering both present day and fossil examples. Moreover some eclogitised hydrothermal systems have been considered as well. Once a compositional line expressing the complex chemical variations in oceanic rocks was defined, modelling has been undertaken producing 4 PT pseudosections representing the progression of composition during alteration. They have then been linked with TX pseudosections in order to represent a line through compositional space, to evaluate the effect of bulk composition on the high pressure mineral parageneses. Calculated modal composition of rocks has then been determined in order to compare results with what observed in the rocks. Predicted mineral assemblages cover all the observed high-pressure rocks described in altered oceanic crust, ranging from "true" eclogites, through glaucophanite, talc-schists to chlorite schists. The modelling shows the importance of bulk composition on metamorphic mineral assemblages, even though the effects of fluid availability and of oxidation state may be also playing a crucial role. This work shows that when considering bulk composition, it is important to take into account all oxides, even those that are present in the rock in small quantities.

H4-3 Orale Fumagalli, Patrizia

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EXPERIMENTALLY-DERIVED CA-NA PARTITIONING BETWEEN PLAGIOCLASE AND CLINOPYROXENE: A NEW GEOBAROMETER FOR MANTLE ROCKS

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Key terms: plagioclase peridotite; mantle exhumation; experimental

petrology; Na/Ca partitioning; geobarometry

The crystallization of plagioclase-bearing equilibrium assemblages in mantle peridotites is commonly considered witness of lithospheric mantle exhumation at shallow depth (e.g. Rampone et al., 1993; Ozawa & Takahashi, 1995; Newmann et al., 1999). Experimental works have pointed out that at subsolidus conditions plagioclase lherzolite assemblages are stable up to 1 GPa. Subsolidus experimental data in the complex chemical system $\text{TiO}_2\text{-Cr}_2\text{O}_3\text{-Na}_2\text{O-FeO-CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2$ on depleted and fertile lherzolite compositions (Borghini et al., 2010) have documented systematic compositional variations in coexisting minerals at decreasing pressure within the plagioclase stability field, similar to what observed in equilibrated plagioclase peridotites. In these experiments, Ca-Na partitioning between plagioclase and clinopyroxene is strictly dependent on pressure, with plagioclase composition varying significantly ($An=59\text{-}83$) in a narrow range of pressure. In a recent paper, Borghini et al. (2011) have defined the anorthite isopleths in plagioclase as a function of P and T in a specific fertile lherzolite composition, and they have demonstrated that plagioclase-facies equilibrium pressures can be estimated by comparing experimental data on a fertile lherzolite and microstructural-chemical observations in natural samples with the same bulk composition. This latter method represents a first-order empirical tool to trace the decompressional evolution of the lithospheric mantle up to very low-pressure and it is potentially applicable to natural plagioclase peridotites of different origin. Nevertheless, the composition of plagioclase at variable bulk Na₂O/CaO ratios has been not fully discerned yet, making this approach directly applicable to a limited bulk composition range. Here, we present the results of new experiments on a Na-enriched lherzolite (bulk Na₂O/CaO ratio = 0.13), representative of many refertilized lithospheric peridotites at extensional settings, thus enlarging significantly our investigated compositional spectrum (Na₂O/CaO = 0.08 - 0.13). The goal of this work is to provide a formulation for a geobarometer analysis based on Ca-Na plagioclase-clinopyroxene partitioning on a larger experimental data set which takes into account the effect of bulk Na₂O/CaO ratio, and is consequently applicable to a wider compositional range of mantle rocks.

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H4-4 Orale Roda, Manuel

10.1474/Epitome.04.0638.Geoitalia2011

THE EFFECTS OF THE OVERRIDING PLATE THERMAL STATE ON THE SLAB DIP IN AN OCEAN-CONTINENT SUBDUCTION SYSTEMRODA Manuel¹, MAROTTA Anna Maria², SPALLA Maria Iole²¹ - Università degli Studi di Milano, Dipartimento di Scienze della Terra, Sezione di Geofisica² - Università degli Studi di Milano, Dipartimento di Scienze della Terra, Sezione di Geologia

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Key terms: *Lithosphere thermal state; Numerical models; Slab dip; Subduction zones*

To evaluate the effects of variations in the thermal state of the overriding plate on the slab dip in an ocean-continent subduction system, a 2-D finite element thermomechanical model was implemented. The lithosphere base was located at the depth of the 1600 K isotherm. Numerical simulations were performed while taking into account four different initial thicknesses for the oceanic lithosphere (60, 80, 95 and 110 km) and five different thicknesses of the overriding plate, as compared in terms of the continental-oceanic plate thickness ratio (100, 120, 140, 160 and 200% of the oceanic lithosphere thickness). The results of numerical modeling indicate that a high variability of the subducting plate geometry occurs for an oceanic lithosphere thickness ranging from 60 to 80 km, while the variability decreases where the oceanic plates are thicker (95 and 110 km). Furthermore, the slab dip strongly depends on the thermal state of the overriding plate, and, in particular, the slab dip decreases with the increase in the upper plate thickness. The model predictions also confirm that a direct correlation between the slab dip and the age of the oceanic lithosphere does not exist, at least for subduction plates thinner than 110 km. These conclusions are supported by the good agreement between the model results and the natural data referring to worldwide ocean-continent subduction zones.

H4-5 Poster Piccardo, Giovanni Battista

10.1474/Epitome.04.0639.Geoitalia2011

NECKING, PERCOLATION AND IMPREGNATION: THE LOVE STORY OF THE LIGURIAN LITHOSPHERE-ASTHENOSPHERE SYSTEM DURING TRIASSIC - JURASSIC EVOLUTION.PICCARDO Giovanni Battista¹, RANALLI Giorgio²¹ - DIPTERIS, University of Genova, Italy² - Earth Sciences, Carleton University, Ottawa, Canada

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Key terms: *Continental extension; Asthenosphere partial melting; Melt percolation through the extending mantle lithosphere; Melt impregnation of the shallow mantle lithosphere*

Mantle peridotites record the deep mantle processes that follow the structural evolution of the asthenosphere-lithosphere during continental rifting.

Continental lithosphere extension by far field tectonic forces lead to thinning of the lithospheric mantle and its progressive exhumation. In fact, the original sub-continental lithospheric mantle, which is still preserved in ophiolites deriving from the passive margins of the basin (e.g., External Ligurides, Erro-Tobbio, North Lanzo, Upper Platta) maintain structural-paragenetic features indicating progressive exhumation. Their provenance from the deep lithosphere ($P > 2.5$ GPa) is marked by the presence of rounded mm-cm wide clusters of orthopyroxene+spinel(+clinopyroxene) formed by destabilization of precursor mantle garnet when passing to spinel-peridotite facies conditions ($P < 2.5$ GPa) and by the sporadic presence of garnet in pyroxenites ($P > 1.5$ GPa).

Most of the spinel peridotites (P between 2.5 and 1.0 GPa) show km-scale extensional shear zones with tectonite-mylonite fabrics that have been dated to 220 Ma (Lu-Hf age) and 225 Ma (40Ar/39Ar amphibole age).

These data indicate that a significant lithosphere extension and mantle exhumation was already active during Upper Triassic, having already exhumed the lower mantle lithosphere from garnet- through spinel- to plagioclase-facies conditions by a network of extensional shear zones. In fact, field and petrographic-structural investigations indicate that shear zones were formed during the whole evolution of the mantle lithosphere. After significant continental extension and lithosphere reduction, the upwelling asthenosphere underwent incipient decompressional melting during almost adiabatic upwelling. This relatively early magmatism is well consistent with the reduction of about 50% of the lithosphere width and the near-adiabatic upwelling and partial melting under spinel-facies conditions of the DM asthenosphere. Isotopic dating of the early gabbroic bodies in the mantle lithosphere suggest that this early melting occurred during (upper Triassic?) - lower Jurassic.

Spinel-facies shear zones were injected and percolated by MORB-type single melt increments and, subsequently, peridotites were percolated and impregnated by melts under plagioclase-facies conditions. Peridotites were widely impregnated and refertilised by melts percolation via porous flow as conductive heat loss prevailed on percolation heating and melt stagnated in the upper lithospheric mantle.

Shear zones formed at plagioclase-facies conditions were frequently infiltrated by aggregated MORB melts and transformed by focused and reactive porous flow to dunite channels, sometimes 10-100-meters wide. These high porosity channels are generally considered the fastest way in plastic regimes to deliver oceanic MORB to shallow levels. These melts form the gabbroic intrusions and the basaltic extrusions of the lower Jurassic oceanic crustal rocks.

Peridotites were intruded by gabbroic bodies starting from Lower Jurassic [180+/-14 Ma - Erro-Tobbio; 179+/-9 Ma - External Ligurides] and stopped presumably during Upper Jurassic (155-150 Ma - Monte Maggiore - Corsica).

In conclusion, the concomitant effects of dry extension along shear zones, inception of mantle asthenosphere, and asthenospheric melt migration through the extending lithosphere (e.g., focused melt percolation in dunite channels and porous flow migration through the mantle lithosphere) caused the intimate evolution of upwelling asthenosphere and extending (thinning) mantle lithosphere, preceding oceanization of the Ligure-Piemontese basin.

Structural and petrological-geochemical studies on the ophiolitic peridotites furnish, accordingly, significant contributions from a mantle perspective to the understanding of the geodynamic evolution of the Ligure-Piemontese system during continental extension leading to oceanic opening.

H4-6 Poster Cirillo, Daniele

10.1474/Epitome.04.0640.Geoitalia2011

OPHIOLITIC SEQUENCES FROM THE CENTRAL SECTOR OF THE CATENA COSTIERA, (CALABRIA)FILLICE Francesco¹, LIBERI Francesca¹, CIRILLO Daniele², PANDOLFI Luca³, MARRONI Michele³, PILUSO Eugenio¹¹ - Dipartimento di Scienze della Terra, Università della Calabria² - Dipartimento di Scienze, Università di Chieti³ - Dipartimento di Scienze della Terra, Università di Pisa

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Key terms: *Accretionary wedge; ophiolite sequences; HP-LT metamorphism; Bagni Unit; Calabrian Arc*

Mesozoic ophiolites crop out in the Catena Costiera (Northern Calabrian Arc). The Northern Calabrian Arc is characterized by the superposition of three structural elements: the uppermost Hercynian continental section intruded by late-Variscan granitoids (Calabrian Nappe), the intermediate ophiolitic Nappe and the lowermost Mesozoic passive margin carbonate sequences (Apenninic Units).

The studied area is located in the central Catena Costiera where the ophiolitic sequences are characterized by both aphyric and porphyritic metabasalts with a T-MORB affinity. They represent the basement of a pelitic-arenaceous metasedimentary sequence, previously interpreted as a pre-Mesozoic continental basement (Bagni Unit of Amodio-Morelli et al., 1976). In the metasedimentary cover, a remarkable increase in the carbonatic supply is noticed moving from south to north of the study area. Two stratigraphic sequences have been defined: the northernmost San Martino di Finita ophiolitic sequence, characterized by metabasites, volcanoclastic metasediments and calcschists, and the southernmost Cozzo Cervello ophiolitic sequence, characterized by: metabasites, thin levels of volcanoclastic metasediments, rare metacarbonates, metapelites and metarenites.

The studied rocks underwent a polyphase deformation history with three main (D1-D3) deformation phases recognized:

D1, characterized by a S1 foliation, preserved as microlithons inside the S2 main foliation;

D2, a N-S trending isoclinal folding event (F2) is responsible for the formation of the S2 foliation, that represent the main surface recognizable in the field;

D3, characterized by asymmetric folds (F3) developed at different scales and showing a WNW-ESE trending axes. An incipient foliation (S3) is locally developed in the phyllosilicate-rich levels.

The petrographic analysis allows to define the mineralogical assemblage of the different lithotypes.

The metabasites are characterized by the mineralogical assemblage: Epidote + Na-amphibole ± Lawsonite + Phengite + Chlorite + Albite ± Calcite ± Quartz + Magnetite. Metapelites and metarenites are characterized by: Epidote + Phengite + Magnetite + Stilpnomelane + Pumpellyite + Chlorite + Albite + Quartz + Magnetite. The calcschist are constituted by: Calcite + Phengite + Chlorite + Albite + Calcite + Quartz + Magnetite. The described mineralogical assemblages suggest that the studied rocks underwent P-T conditions typical of the blueschist facies as suggested by the blastesis of Na-amphiboles, lawsonite, stilpnomelane and phengite along the S2 foliation.

The following metamorphic retrogression developed in the prehnite-pumpellyite facies and is characterized by a static recrystallization.

The field study and the tectonometamorphic evolution reconstructed for the ophiolitic sequences cropping out in the central sector of the Catena Costiera of Calabria show that a subduction and exhumation history inside an accretionary wedge can be proposed.

In particular, the characterization and the definition of the complex relationships existing within the ophiolitic metasedimentary cover allow us to propose:

- the source area was composite, with both carbonatic and siliciclastic contributions;
- the presence of terrigenous deposit, even in the lowermost part of the

sedimentary sequence, seem to indicate that this part of oceanic crust was located close to the continental margin;
 iii) the San Martino di Finita type sedimentary cover can be correlated with that of the Malvito ophiolitic unit (sensu Amodio-Morelli et al., 1976), cropping out in the northernmost sector of the Catena Costiera;
 iv) the subdivision between the Bagni and Gimigliano-Monte Reventino Units, as proposed by Dietrich and Scandone (1972) and Amodio-Morelli et al. (1976) for the study area, is not supported by the data collected in this work.

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H4-7 Poster Tartarotti, Paola

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OCCURRENCE OF A FE-GABBRO-TRONDHJEMITE SUITE IN THE GRIVOLA-URTIER UNIT, PIEMONTE OPHIOLITE NAPPE (NW ITALY)

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Key terms: Alpine ophiolite; trondhjemite; Fe-gabbro; Grivola-Urtier

In the Grivola-Urtier Unit (Urtier Valley, southern Aosta Valley, Italy), the Piemonte ophiolite nappe mainly consists of serpentinized peridotites including pods and boudinaged layers of Fe-metagabbro and trondhjemite transposed in the main foliation together with calcschists and micaschists. Chloritescist and rodingite locally mark the contact between serpentinites and Fe-metagabbro/trondhjemite. In the Vallone delle Acque Rosse, the studied rocks retain a high pressure metamorphic imprint of Eocene age (44.3±0.3 Argon plateau age; 45.6±1.4 Ar isocron; Rb/Sr = 42±0.4 Phengite). High pressure parageneses are omphacite/chloromelanite-garnet-rutile-glaucophane-phengite, in the Fe-metagabbro, and plagioclase-quartz-phengite-garnet, in the metatrondhjemite, respectively. Bulk-rock major and trace elements in addition to O isotope analyses were performed in the two rock types. Fe-metagabbros are characterized by MgO wt% ranging between 6.11 and 9.63%, $\Sigma\text{REE} = 20 \div 101$ ppm, (La/Yb)_N = 0.22±0.91; trondhjemites have SiO₂ 43%, Al₂O₃ ranging between 21 and 24%, CaO ranging between 17 and 20%, $\Sigma\text{REE} = 172 \div 272$ ppm, (La/Yb)_N ranging between 1.78

and 13.70. $\delta^{18}\text{O}$ is 5.9 ‰ in a Fe-metagabbro sample and 7.4 ‰ in a trondhjemite sample, suggesting that the studied rocks have been affected by a weak oceanic (low T°C?) alteration. The Alpine HP imprint thus did not delete the primary isotopic signature.

H4-8 Poster Crispini, Laura

10.1474/Epitome.04.0642.Geoitalia2011

THE LAVAS-DIKES BOUNDARY IN SUPERFAST SPREADING CRUST: INFERENCES FROM STRUCTURE AND GEOPHYSICAL LOGS AT IODP HOLE 1256D (EQUATORIAL PACIFIC)

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Key terms: Basalt; Layer 2B/2C boundary; ODP-IODP Hole 1256D; Superfast spreading crust; East Pacific Rise

The boundary between seismic layer 2B (basalt extrusives) and layer 2C (sheeted dike complex) in the oceanic crust created at fast and superfast-spreading ridges is commonly characterized by intense rock fracturing and occurrence of breccias hosting metal sulfides. In ODP-IODP Hole 1256D (East Pacific Rise, Cocos Plate) the layer 2B/2C boundary corresponds to the Transition Zone (TZ) located between the overlying Sheet and Massive Flows and the underlying Sheeted Dike Complex. The TZ is about 60m thick and consists of basaltic sheet and massive flows, a cataclastic unit, and hyaloclastic breccias cemented by sulfides, quartz, anhydrite, calcite, and minor amphibole. It separates two contrasting metamorphic zones, the shallowest basalts being altered at low temperature conditions, and the deeper basalts being affected by greenschists-facies alteration. The upper and lower boundaries of the TZ have been defined at 1004mbsf and 1061mbsf, respectively. However, due to low recovery rates in Hole 1256D, especially from brecciated intervals and fracture fillings, these two boundary depths do not perfectly fit with those suggested by wireline geophysical logs and by structural data on cores. Namely, steep fractures and cataclases, likely related to the stress field induced by intrusion of dikes at depth, are concentrated up to ca. 800 mbsf, in accord with FMS and UBI images. The seismic structure of the crust is affected by fracture shape, namely, low aspect ratio (thin fractures) have much more effect on compressional wave velocity than wide open pores, with varying porosity. By integrating structural/microstructural data with physical properties investigations and geophysical logs, the actual thickness of the TZ can be revised and defined more precisely. We used structural data from cores, thin section observation, and X-ray tomography on fractured samples for characterizing the crack porosity and shape, in order to calibrate the geophysical signals along the TZ. The thickness and position of the TZ are crucial for controlling the pattern of crustal permeability and hydrothermal fluid circulation.

SESSIONE H5

Magmatismo e geodinamica: rifting, plumes di mantello e processi di subduzione

H5-1 Orale Avanzinelli, Riccardo

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MANTLE MELTING AND THE ORIGIN OF THE BIMODAL MAGMATISM OF PANTELLERIA VOLCANO, SICILY CHANNEL: CONSTRAINTS FROM COMBINED U-SERIES AND SR-ND-PB ISOTOPES

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Key terms: U-Th-Pa disequilibria; mantle melting; withinplate magmarism; peralkaline rocks; Pantelleria

In the southernmost sector of Italy continental within-plate volcanism (e.g. Sicily Channel, Etna, Ustica) occurs in close geographical and geodynamic association with both subduction-related magmatism (e.g. Aeolian Islands) and ocean spreading (Tyrrhenian seafloor). Magmatism in the Sicily Channel (Pantelleria and Linosa) is due to the passive up-welling of asthenospheric mantle in response to the development of pull-apart basins related to south-eastward roll-back of the subduction of the Ionian plate with respect to the rest of the subducting African plate. Within the Sicily Channel, Pantelleria, the type locality of pantellerite, is a Late-Pleistocene magmatic system characterised by a bimodal association of alkali basalts and peralkaline rocks (trachytes to pantellerites), separated by a large compositional gap in SiO₂ (50-67 wt.%). The relationships between basaltic and differentiated magmas at Pantelleria, and in bimodal magmatic suite in general, have been the focus of debate in the last three decades. In particular the evolved per-alkaline products are interpreted either as derived from basaltic parental magmas by fractional crystallisation or by re-melting of a gabbroic cumulate. This study presents new 238U-230Th isotope data along with Sr, Nd and Pb isotope ratios and trace element contents of both the mafic and the felsic peralkaline products of Pantelleria volcano. 235U-231Pa disequilibria have also been measured on two samples with basaltic and hawaiitic composition. The aim of this contribution is to investigate i) the melting regimes responsible for the generation of the least differentiated alkali basaltic products, and ii) the relationships existing between mafic and differentiated peralkaline magmas.

Pantelleria mafic products have ubiquitous 230Th excesses ranging from 7% to 21%. This range is due to a rather wide variation of (238U/232Th) at an almost constant (230Th/232Th). A notable exception is constituted by two hawaiitic samples that presents comparable 230Th-238U disequilibria with alkali basalts, but at significantly lower (230Th/232Th) and (238U/232Th). Hawaiites also display similar (231Pa/235U), but different Sr, Nd and Pb isotopes with respect to alkali basalts suggesting these two types of magma derive from two distinct mantle sources, but similar melting regimes.

Trachytes and pantellerites also have (238U/232Th) similar to those of alkali basalts, but slightly lower (230Th/232Th). This feature argues against the possibility of generating the peralkaline products by re-melting of a gabbroic cumulate, favouring an origin through fractional crystallisation in timescales comparable to the half-life of 230Th

H5-2 Orale Callegaro, Sara

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GEOCHEMISTRY OF EASTERN NORTH AMERICAN CAMP DIABASE DYKES

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Key terms: CAMP dykes; eastern North America; geochemistry; radiogenic isotopes

Swarms of diabase dykes and a few sills of the Central Atlantic magmatic province (CAMP) intruded the Piedmont area of the Appalachians and the coastal plains of eastern North America (ENA) between 201 and 199 Ma. Three different trends were aeromagnetically recognized, radiating from NW (mostly in the south), to N-S (in North and South Carolina) and turning NE to the north. Based on crosscutting relations, an age progression can be defined from NW- to N- and NE-oriented dykes. 70 dykes and a sill were sampled from Georgia to Virginia. ENA diabases grade in texture from ophitic to intergranular or intersertal, with few porphyritic samples, and grain size varies from sub-pegmatitic to nearly aphanitic. A typical basaltic mineralogy is observed, with ubiquitous plagioclase (An₄₇₋₅₄), pyroxenes (augite En₇₃₋₅₆Fs₉₋₃₀Wo₁₇₋₄₂, pigeonite, and rare orthopyroxene) and Fe-Ti oxides, flanked by either olivine (Fo₄₈₋₅₉) or micropegmatite, in olivine- and quartz-normative samples, respectively. SiO₂ (46.2-54.3 wt%) and alkali (1.28-4.38 wt%) contents classify these rocks as basalts and andesitic basalts with tholeiitic affinity, showing a characteristic Fe-enrichment trend with fractionation. A wide range in MgO (4.74-16.99 wt%), Al₂O₃ (12.94-18.68 wt%) and TiO₂ (0.36-1.35 wt%) suggests different degrees of low pressure fractional crystallization for this magmatic suite, controlled mostly by plagioclase, pyroxenes and olivine. Mg-, Cr-, and Ni-enrichments reflect also accumulation of mafic minerals in some samples. Incompatible trace element contents are fairly homogeneous and generally low, e.g. La/Yb_N (0.54-2.39), a characteristic typical of melts derived from a quite depleted shallow mantle-source. All the 40 samples analysed for trace elements by ICP-MS show negative Ti, Ta and Nb anomalies, suggesting either a source inheritance or the effect of crustal contamination (though discarded by other observations). Incompatible trace element contents are not correlated with isotopic compositions of ENA dykes, which display a considerable spread in initial isotopic signatures, unlike other CAMP suites, e.g. ⁸⁷Sr/⁸⁶Sr_{200Ma} (0.7043-0.7088), $\epsilon\text{Nd}_{200\text{Ma}}$ (-6.8-+2.1) and ²⁰⁶Pb/²⁰⁸Pb_{200Ma} (17.41-18.61). Pb isotopic compositions plot above the NHRL, at positive $\Delta 7/4$ (10-17) and $\Delta 8/4$ (19-73). Low ¹⁸O/¹⁶O_{200Ma} compositions (0.127-0.144), obtained for 12 selected rocks, argue for negligible amounts of crustal contamination, and coupled with the large range of Sr-Nd-Pb isotopic compositions, they

suggest generation from a strongly heterogeneous mantle source for these magmas, probably a metasomatized lithospheric mantle. Moreover, geochemical variations are not systematically linked to dyke trends, basement composition or geographic position of these intrusives, again suggesting small scale heterogeneities in the mantle source. The alternative hypothesis of a deep enriched and heterogeneous mantle-plume source, is not supported by the crystallization temperatures calculated for high-Fo (up to Fo₉₅) olivines (ca. 1350 °C), that do not argue for a very hot (i.e. mantle-plume) origin. Geochemical correlations between ENA intrusives and CAMP flows from North America (i.e. flat REE patterns, Ti negative anomaly) suggest that these dykes and sills may have fed extrusives chemically similar to Preakness and Hook Mt. flows (i.e. the youngest flows from the Newark basin and other Triassic rift basins in North America) whereas none of the analyzed dykes yields geochemical compositions similar to the slightly older Orange Mt. basaltic flows.

H5-3 Invitato Macera, Patrizia

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THE GARROTXA VOLCANIC FIELD (NE SPAIN): NEW GEOCHEMICAL CONSTRAINTS

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Key terms: Quaternary volcanism; Geochemistry; Isotopes; EAR; Europe

The Quaternary volcanism of the Garrotxa area (NE Spain) developed during the rift-type extensional tectonics affecting the eastern margin of Iberia since the late Oligocene and related to the opening of the Valencia trough. Location of the eruptive centres is controlled by the main NW-SE faults that limit the different elevated or depressed blocks configuring the tectonic structure of the area. The Garrotxa volcanic activity is characterised by small strombolian cones and lava flows formed by very short monogenic eruptions, occasionally preatomagmatic. As result of this activity, more than 40 volcanic cones and about 30 main lava flows can be recognised in this region.

The volcanic rocks consist of basanites, alkali basalts, and trachybasalts that are aphanitic, vesicular, hipohialine and porphyritic in texture, in which olivine and clinopyroxene (\pm plagioclase and oxides) are the main mineral phases.

They show relatively homogeneous geochemical features, with FeOT/MgO and Na₂O/K₂O weight ratios \geq 1. For most of the samples, major and trace element correlations exclude significant stagnation and magmatic evolution in crustal reservoirs. Primitive mantle-normalized multi-element diagrams are characterized by a typical bell-shaped, OIB-like trend, with progressive enrichment of the most incompatible elements, except for Th, Pb, K and Rb, and significant peaks at Ta and Nb, sharing their geochemical patterns with the whole Cenozoic anorogenic magmatism of the European-Mediterranean area.

Significant variability of ¹⁴³Nd/¹⁴⁴Nd and ²⁰⁶Pb/²⁰⁴Pb ratios in the Garrotxa volcanics testify for a common heterogeneous mantle source, and are likely related to mixing processes occurred between the local lithospheric mantle and a sublithospheric, geochemically enriched component. Sr-, Nd-, and Pb-isotope compositions of the Garrotxa magmas confirm their similarity to the EAR (Enriched Asthenospheric Reservoir)-derived basalts of the Mediterranean region, showing a HIMU

(High μ = high ²³⁸U/²⁰⁴Pb)- DMM (Depleted MORB Mantle) signature. Noticeable, the Garrotxa basalts display geochemical features that are very close to those of Cape Verde, a key "end-member" in the petrogenesis of the European magmatism since the Cretaceous (Piomallo et al., 2008). In our model, the rift-related extensional tectonics favors upwelling of sub-lithospheric, plume-like mantle into the local lithosphere, originating EAR-type basalts via adiabatic decompression melting. In conclusion, the Garrotxa volcanic activity must be included within the members of the within-plate Tertiary-Quaternary magmatism of the European-Mediterranean area.

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H5-4 Orale Beccaluva, Luigi

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ULTRATITANIFEROUS BASALTS AND PICRITES FROM THE OLILOCENE ETHIOPIAN PLATEAU: INSIGHTS ON THE PLUME RELATED MANTLE METASOMATISM

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Key terms: MANTLE PLUMES; AFAR; PICRITE BASALT; MANTLE METASOMATISM; ULTRATITANIFEROUS MAGMAS

Geochemical and petrological data indicate that the 30 Ma Northern Ethiopian continental flood basalts and picrites were generated in connection with the "Afar plume". Previous studies [1] show that: a) Basaltic lavas appear zonally arranged with Low-Ti tholeiites (LT) in the west, High-Ti tholeiites (HT1) to the east and very High-Ti transitional basalts and picrites (HT2, TiO₂: 4-6.5 wt%) closer to the Afar triple junction; b) the P-T conditions of magma generation increased from 1,3 GPa/1200 °C to 3 GPa/1500 °C from west to east; that is, from the outer zones (LT) to the core of the plume head where HT2 ultra-titaniferous picrites were generated.

Further sampling has been carried out in the inferred plume axial zone (Lalibela area) focusing on picrite rocks, as well in the Yemeni counterpart where analogous HT2 products (including picrites) are recorded in the Manakha section.

The observed parageneses dominated by olivine and clinopyroxene phenocrysts, within a groundmass containing clinopyroxene, plagioclase, Fe-Ti oxides, alkali feldspar, phlogopite and apatite are consistent with the transitional character of these lavas and their overall enrichment in the most incompatible elements and fractionated REE patterns (La_n/Yb_n up to 26).

New isotopic data carried out at the IGG-CNR Institute of Pisa integrated with those available in the literature [2] show correlations between TiO₂ (and other incompatible elements) and Sr-Nd-Pb isotopic data, thus defining the isotopic fingerprint of the plume-related metasomatic agents. These metasomatic agents can be envisaged as alkali-silicate melts that integrate various geochemical components (e.g. Titanium and related high field strength elements, low field strength elements, light rare earth elements, H₂O) scavenged and pooled along the plume axis, and derived from heterogeneous mantle materials mixed during the plume rise. Petrological modeling indicate that the resulting metasomatized mantle sources were characterized by hydrous, iron-titanium-alkali rich exotic parageneses including amphibole, phlogopite and Ti-bearing minerals such as ilmenite.

A debate is still open on the ultimate origin of the metasomatic Fe-Ti rich fluids, in turn related to depth of the plume convective cell. A direct core contribution is not plausible, and most Authors favor long-term mechanisms of Oceanic Crust (Fe-Ti basalts/gabbros and their metamorphic equivalent, i.e. eclogites) recycling deep in the mantle via ancient subductions [3]. Accordingly, the uprising plume could have remobilized domains from the mantle Transition Zone which may include relicts of older subducted slabs. Within these remobilized domains, characterized by the coexistence of peridotite and eclogite and referred to as a "piclogite" association, the eclogites melt preferentially generating Fe-Ti rich melts that infiltrates and metasomatizes the shallower lithospheric mantle.

Alternative views, suggested by studies of high-TiO₂ basalts of lunar provenance, hypothesize primordial "magma ocean" stages in which vast mantle zones were molten and subsequently differentiated with the formation of discrete Fe-Ti-rich mantle domains [4], [5], [6].

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H5-5 Orale Natali, Claudio

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THE AXUM BASALT-TRACHYTE COMPLEX: A PARASITIC VOLCANOTECTONIC ACTIVITY AT THE PERIPHERY OF THE AFAR PLUME

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Key terms: NORTHERN ETHIOPIA; NEPHELINE SYENITE; FRACTIONAL CRYSTALLIZATION; TRACHYTE-BASALT; PLUME PERIPHERY

The Axum-Adwa sector (Tigray, Northern Ethiopia) is characterized by a transitional basalt-trachyte magmatic complex which took place at the northern periphery of the Oligocene Northern Ethiopian Continental Flood Basalts (CFB), which are related to the Afar plume.

This complex consists of basaltic, trachyandesitic and trachytic flows and subvolcanic dome-shaped syenitic intrusions, the latter mostly occurring around Axum.

These intrusive rocks - quarried by the Axumites as the ideal material to carve their famous obelisks - bear variable amounts of nepheline/aeirine aggregates that probably developed during late- to post-magmatic stages. Major and trace element modeling by PLE and MELTS software using bulk rocks and constituent minerals, indicates that trachyandesitic and trachytic magmas could derive by shallow fractional crystallization processes from the associated transitional basalts.

Magma vents are set along an ENE-WSW lithospheric fault system that may have favored magma generation deep in the mantle, as well as their differentiation at shallower levels in the crust.

This tectonomagmatic setting, nearly perpendicular to the Red-Sea spreading axis and parallel to that of Gulf of Aden, appears to be geodynamically related to the extensional phases which radiated from the Afar triple junction after the paroxysmal eruption of the Northern Ethiopia CFB.

H5-6 Invitato Faccenna, Claudio

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SMALL SCALE CONVECTION IN THE MEDITERRANEAN MOBILE BELT.

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Key terms: Mediterranean; Subduction; Mantle Convection

Mobile belts are long-lived deformation zones composed of an ensemble of crustal fragments, distributed over hundreds of kilometers inside continental convergent margins. The Mediterranean represents a remarkable example of this tectonic setting: the region hosts a diffuse boundary between the Nubia and Eurasia plates comprised of a mosaic of microplates that move and deform independently from the overall plate convergence. Surface expressions of Mediterranean tectonics include deep, subsiding backarc basins, intraplate plateaux and uplifting orogenic belts. Although the kinematics of the area are now fairly well defined, the dynamical origins of many of these active features are controversial and usually attributed to crustal and lithospheric interactions. However, the effects of mantle convection, well established for continental interiors, are expected to be particularly relevant in a mobile belt, and modeling may constrain important parameters such as slab coherence and lithospheric strength. Here, we compute global mantle flow based on recent, high-resolution seismic tomography, to investigate the role of buoyancy-driven and plate-motion induced mantle circulation for the Mediterranean. We show that mantle flow provides an explanation for much of the observed dynamic topography and microplate motion in the region. More generally, vigorous small-scale convection in the uppermost mantle may also hold the key for understanding other complex mobile belts such as the North American Cordillera or the Himalayan-Tibetan collision zone.

H5-7 Orale Baccheschi, Paola

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SEISMIC ATTENUATION TOMOGRAPHY AND ANISOTROPY BENEATH A RETREATING SUBDUCTION SYSTEM: THE SOUTHERN TYRRHENIAN SEA CASE STUDY

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Key terms: subduction zone processes; mantle flow; mantle wedge; anisotropy; attenuation

The Southern Tyrrhenian subduction system shows a complex interaction among asthenospheric flow, subducting slab and overriding plate. To shed light on the deformations and mechanical properties of the slab and surrounding mantle, we investigated the attenuation and the anisotropic structure through the subduction region. The 3D attenuation results show high-attenuation shallow regions corresponding to the crustal layers, while the slab is imaged as a low-attenuation body bounded by high-attenuation regions located beneath the Aeolian magmatic arc. Between 100-200 km depth, in correspondence of high concentration of earthquakes, the slab is characterized by a spot of high attenuation. Such a feature could be related to the dehydration processes associated to the slab metamorphism. A high-attenuation anomaly is present in the mantle wedge beneath the Aeolian volcanic arc and could indicate mantle melting and slab dehydration and also to the large-scale serpentinization. We also investigated the anisotropic structure of the subduction zone by analyzing shear-wave splitting of the slab earthquakes. Seismic anisotropy reveals a complex pattern of anisotropy across the subduction zone. S-rays sample mainly the slab, showing variable fast directions and delay times. Comparison of S splitting measurements to P-wave velocity anomaly at 100-200 km depth shows that where the rays primarily sample the slab the delay times are small. In contrast, where S rays sample the mantle wedge, the delay times are quite high. This across-subduction variation of delay time depicts the slab as a weakly anisotropic region relative to the mantle above and below and suggests that the main source of anisotropy in the subduction zone is the deformation of the mantle above and below the slab induced by the retrograde motion of the slab.

H5-8 Orale Chiarabba, Claudio

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UPPERMOST MANTLE VELOCITY ANOMALIES AND MAGMATISM IN THE BACK ARC OF THE ADRIA-IONIAN SUBDUCTION

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Key terms: slab; delamination; magmatism

Recent tomographic models of the central Mediterranean region yield the definition of the Vp and Vs structure in the uppermost mantle. Broad low velocity anomalies are identified along the Tyrrhenian margin of the Apennines at about 50-100 km depth, coherently with the intense stretching and the development of Quaternary volcanism. On the contrary, low velocity anomalies seem to be absent in the southern Tyrrhenian wedge in front of the Ionian slab and underneath the Eolian volcanoes, i.e. where the magmatic signature shows the most clear subduction-related components. These latter volcanoes have localized shallow (40-50 km depth) and small low Vp volumes indicative of isolated magma chambers located at the base of the crust.

This apparent controversy is tentatively explained by a model in which low velocity anomalies in the Tyrrhenian and peri-Tyrrhenian domains represent large asthenosphere up-welling that sustained the stretching of the European lithosphere and the opening of the back-arc basins. In the Apennines, the highly heterogeneous Quaternary magmatism testifies the more recent stage of the stretching process, triggered by the delamination of the Adria continental lithosphere. Conversely, the lack of seismic evidence of asthenospheric up-welling in the mantle wedge of the Ionian slab suggests that the Eolian volcanism is fed by small magma chambers originated before the (local) onset of the stretching induced by the Ionian slab retreat.

H5-9 Orale Piccinini, Davide

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SEISMIC ATTENUATION AND MANTLE WEDGE TEMPERATURE IN THE NORTHERN APENNINES SUBDUCTION ZONE (ITALY) FROM TELESEISMIC BODY WAVE SPECTRA

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Key terms: Seismic Attenuation; Subduction; Mantle

We analyze P and S wave spectra from moderate- to deep-focus teleseisms recorded at the Retreating-Trench, Extension, and Accretion Tectonics (RETREAT) temporary broadband seismic network to assess the variations of the Earth mantle attenuation in the northern Apennines region (Italy). For each earthquake, we compute the ratio between the spectrum at each station and the average spectrum, in order to estimate t* residuals (Δt^*) from the spectral ratio decay. The number and distribution of the teleseisms useable for the P wave t* calculation allow for a gross azimuthal analysis; although the (Δt^*) values at single station display, in most cases, azimuthal-dependent fluctuations, their overall distribution shows a partition of the study region into two main areas, whose gross features remain almost unchanged over the whole azimuthal range. This partition is confirmed by the S wave t* mean values, computed for each station over the set of useable events. We distinguish a relatively high attenuation area on the western, Tyrrhenian side and a relatively low attenuation area on the eastern, Adriatic side. By correlating our Δt^* estimates and the velocity structure derived from the existing tomographic models, we compute the ranges of possible P and S wave Q values in the mantle wedge above the Apennines slab (on the Tyrrhenian side) and in the asthenosphere below the Adriatic region. Furthermore, the determined attenuation properties are used to draw some inferences on the thermal state of the uppermost mantle and on the physical properties of the tectonic elements, which constitute the subduction system in the region.

H5-10 Orale Lustrino, Michele

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THERMAL STATE AND GEOCHEMICAL COMPOSITION OF THE MANTLE. WHAT CAN WE INFER FROM IGNEOUS ROCKS?

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Key terms: Petrology; Tomography; Mantle; Geochemistry

The geochemical and mineralogical compositions of mafic igneous rocks have been classically considered powerful tools to infer the composition of their magma source(s). At the same time, geochemical models (e.g., the existence of the mantle end-members DMM, HIMU, EMI, EMII, EMIII, FOZO, C-, PHeM, LONU, LOMU, HRDM, and so on) have been commonly, and dangerously, translated to physical concepts and specific seismological subdivisions of the mantle (e.g. upper mantle, lower mantle, D'). Despite the vigorous research activity and the wealth of data and hypotheses developed during the last forty years, the thermal state and the chemical composition of the upper mantle are far from being fully understood. Concepts considered well acquired, like the significance of terms like upper mantle, lithosphere and asthenosphere, the rheological behaviour of mantle rocks, the seismic wave velocity perturbations, the presence of olivine-poor lithologies, the chemical reactions and the metasomatic effects of percolating melts in the upper mantle, the origin of non-basaltic melt compositions (e.g., carbonatitic or ultra-potassic) still need profound re-thinking. Often fundamental assumptions (e.g., upper mantle with depleted compositions, presence of active upwelling of deep-rooted mantle plumes, potential temperature, geotherm(s), the definition itself of "ambient", "normal", "anomalous" and "exotic" mantle) force the conclusions towards unrealistic results.

The following remarks should be taken in mind when performing petrological models based on geochemical and geophysical arguments: 1) there is no reason to hypothesize a homogeneously depleted upper mantle; 2) the asthenosphere is not necessarily depleted nor fully convecting; 3) tomographic images based on Vs and Vp anomalies cannot be considered as thermometers; 4) positive Vs and Vp anomalies can be related with the presence of less dense material (e.g. depleted harzburgite, seismic lid) and low-velocity anomalies can be dense eclogite; 5) the presence of thermal anomalies in the form of mantle plumes is not required by any discipline; 6) the potential temperature of the mantle is not the classical 1273 °C value; 7) the concept itself of mantle potential temperature should be considered in relation to the depth of magma formation; 8) if the composition of the upper mantle is not entirely peridotitic and if olivine-poor lithologies are not volumetrically insignificant, the concept of Mg# to determine the primitiveness of a basaltic magma needs to be rethought; 9) the geochemical similarity of two magma batches cannot be considered as the proof for the derivation from the same physical mantle; 10) a given magma with a particular geochemical signature (e.g., carbonatitic, leucitic, basaltic, alkali sodic) can be generated in different tectonic settings; 11) the geochemical composition of a magma cannot be necessarily considered as a reflection of its mantle source, being very likely the possibility of strong chromatographic exchange reactions en route to the surface; 12) high magma productivity is not necessarily related with high absolute temperatures, but rather to high homologous temperatures or even ambient mantle temperature, which can be higher than MORB temperatures; 13) the geological history of the area where given igneous districts is developed can be relevant; 14) shear heating at the base of the lithosphere can contribute to the generation of magmas in intraplate settings.

With these assumptions, the source depth of the Earth's volcanism can be mostly dominated by the asthenosphere (the upper mantle boundary layer); upper 200 km of the mantle, without a significant signature of the geochemical composition of the deeper levels of the mantle, whose composition remains mostly unsolved. Some of these remarks may seem very obvious, but the scientific literature is full of oversimplifications and of models based on unconstrained and unrealistic assumptions.

H5-11 Orale Beltrando, Marco

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WHAT GOES INTO SUBDUCTION? NEW CONSTRAINTS ON THE LITHOLOGICAL COMPOSITION OF THE WESTERN TETHYAN SLAB

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Key terms: Ocean-Continent Transition zone; subduction; Western Mediterranean magmatism

The lithological composition of subducted lithosphere is likely to exert a first-order control on the generation of the fluids/melts leading to magmatic activity along convergent plate margins. In the Western Mediterranean, the Africa-Europe convergence, which started in the Cretaceous, has been accompanied by magmatism especially active since the Eocene. Plate convergence was accommodated by deformation along plate margins and by subduction of the Western Tethys lithosphere, whose lithostratigraphy can be studied directly in Alpine tectonometamorphic units that underwent subduction to high-pressure depth and were then exhumed. This study, which focuses on the Zermatt-Saas Zone and the Internal Valaisian Domain in the Western Alps, shows that a significant part of the subducted Tethyan lithosphere consisted of variably serpentinized subcontinental mantle locally overlain by slivers of continental basement and pre-rift continental shelf sediments, prior to the deposition of post rift-deposits.

The Zermatt-Saas Zone, in the Valtournenche area, consists of abundant serpentinized mantle, intruded by Jurassic gabbros and locally overlain by slivers of continental crust and pre-rift sediments, with relatively minor amounts of syn- to post-rift sediments, which underwent Alpine metamorphism at P>2.5 GPa at ca. 48-44 Ma. The association of continental basement rocks, pre-rift sediments and ophiolites has generally been ascribed to the formation of a tectonic mélange during the Alpine orogeny. However, zircons from Permian plutonic rocks of the Etirol-Levaz continental basement slice show a distinctive phase of growth at ca. 170-160 Ma. High U/Th ratios and zoning patterns suggest that zircons grew as a result of melt infiltration related to the intrusion of mafic magmas, also dated at ca. 170-160 Ma, in the underlying serpentinites.

Therefore, the continental basement slices and the oceanic basement rocks were already juxtaposed in the Jurassic and they were probably part of an Ocean-Continent Transition Zone.

The Pointe Rousse-Breuil Unit, which is part of the Internal Valaisan Domain, is located in a more external part of the Western Alps with respect to the Zermatt-Saas Zone. This unit is composed of serpentinitized subcontinental mantle in contact with slivers of continental basement and polymictic breccias, passing upward to radiolarian schists and calc-schists (Aroley - Marmontains - St. Christophe lithostratigraphic units), which underwent Alpine metamorphism at $P > 1.5$ GPa at ca. 38-36 Ma. Cataclases and gouges, developed at the expense of granitic rocks and ultramafics, are commonly found along the interface between mantle and crustal rocks, but no evidence of brittle deformation is found in the overlying meta-sedimentary sequence. These observations are interpreted as indicating that ultramafics and continental basement were juxtaposed during Mesozoic rifting by the activity of low angle detachment faults, prior to the deposition of the overlying sedimentary cover at the bottom of the Valaisan Basin.

Therefore, our results indicate that a significant portion of the Western Tethyan slab, that was consumed during the Alpine orogeny, was markedly different from a typical Oman-type ophiolite. The lithostratigraphy of the Valaisan Domain and of the Piemonte Zone is indeed comparable to the Ocean-Continent Transition Zones that have been described in 50% of present-day rifted margins and in the less deformed/metamorphosed Eastern Alps. Such domains, which can be up to 200 km wide, are characterized by a different lithostratigraphy with respect to typical 'oceanic' and 'continental' lithosphere, with windows of exhumed serpentinitized mantle between slivers of continental crust. Pre-rift sediments (typically dolostones) are present only rarely as extensional allochthons and syn- and post-rift sediments (typically thin radiolarian cherts followed by thick marbles, marls and pelites) seal the extension-related lithostratigraphy.

H5-12 Orale Tumiatì, Simone

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MELTING OF CARBONATED PHLOGOPITE LHERZOLITE AT FLUID-SATURATED CONDITIONS: EXPERIMENTAL CONSTRAINTS

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Key terms: COH fluids; carbonatite; trachyandesite; high pressure; experimental petrology

Mixed H₂O-CO₂ fluids, as H₂O-only fluids do, are thought to play an important role in magma genesis, triggering melting processes by lowering solidus temperature of mantle rocks (e.g., Dasgupta et al., 2007). Compared to H₂O-only and CO₂-only fluid compositions, experiments concerning high-pressure peridotite and mixed fluids are limited. In particular, experimental data on solidus relations of complex peridotite compositions are restricted to date to the two studies of Olafsson & Eggler (1983) and Wallace & Green (1988). However, these studies show many discrepancies, likely due to the different experimental strategies used.

We carried out experiments in the system KNCFMAS+COH at $P=1.8-2.8$ GPa, $T=1050-1100^\circ\text{C}$, $f\text{O}_2=\text{NNO}$, under fluid saturated conditions. A spinel lherzolite -30% olivine + 5% phlogopite (cf. Konzett & Ulmer, 1999) has been used as starting material to model a metasomatized lithospheric mantle. Seeded gels were loaded in a piston-cylinder apparatus using conventional double capsule technique. COH fluids have been generated by addition of 10 wt.% oxalic acid dihydrate and excess graphite.

The near-solidus melt at low pressure is silicatic and potassic. At 1.8 GPa, 1075°C melt pools, coexisting with orthopyroxene + augitic clinopyroxene + olivine (Fo0.91) + garnet, are characterized on average by $\text{SiO}_2=58.1$ wt.%, $\text{K}_2\text{O}=9.2$ wt.% and $\text{Na}_2\text{O}=1.0$ wt.%, being trachyandesitic (shoshonitic) in composition. Similar melts have been produced by Conceição & Green (2004) in CO₂-free, water-saturated K-bearing peridotite at similar P-T conditions (1 GPa, 1050 °C). Mass-balance calculations suggest that the amount of partial melting in our experiments at these conditions is about 5.5 wt.%.

The near-solidus melts above 2.1 GPa is magnesiocarbonatitic and display quench-related textures, showing dendritic intergrowth of about 2/3 nearly stoichiometric dolomite and 1/3 K-silicate glass. The melt composition is comparable with published data concerning experimental carbonatites (e.g., Thibault et al., 1992). Carbonatitic melt is in equilibrium with restitic orthopyroxene + garnet + olivine/magnesite. Melting takes place at the expenses of Ca-minerals, in particular amphibole, dolomite and orthopyroxene. Mass-balance calculations suggest that the amount of partial melting is about 15.1 wt.% at 2.6 GPa and 1060°C. The residual water (2.62 wt.%) should dissolve into the melt up to water-saturated conditions, which are unknown at present in this P-T range.

In conclusion, phlogopite lherzolite saturated with H₂O and CO₂ starts melting in a T range of 1050-1100°C at P between 1.8 and 2.8 GPa, with a minimum melting temperature located at about 2.3 GPa. The shape of solidus determined in this study is similar to that proposed by Green (1973) for H₂O-saturated peridotite, with a temperature shift of about +50°C due to the lower activity of water in CO₂-bearing systems. The solidus is consistent with Olafsson & Eggler (1983), especially for $P > 2.3$, while melting temperatures found by Wallace & Green (1988) are about 100°C lower.

The geotherm of lithosphere below a continental rift will intersect the determined solidus at about 2.1 GPa and 1050°C, suggesting that lithospheric mantle could start melting at approximately 60 km depth provided that COH fluids are available.

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H5-13 Orale Dallai, Luigi

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THE OXYGEN ISOTOPIC COMPOSITION OF XENOLITHS FROM TALLANTE (SOUTHERN SPAIN): EVIDENCE FOR CRUST RECYCLING INTO THE MANTLE

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Key terms: oxygen isotopic composition; mantle xenoliths; Betic Cordillera; subduction; crust recycling

Mantle xenoliths from Tallante (Betic Cordillera, Spain) include samples recording a peculiar distinct style of metasomatism that induced orthopyroxene, plagioclase, phlogopite and amphibole crystallization and generated "hydrous" opx-rich mantle domains. The latter are locally crosscut by felsic veinlets containing plagioclase and orthopyroxene \pm quartz \pm phlogopite \pm amphibole. The observed parageneses and available Sr-Nd-Hf isotopic data suggest that metasomatic agents were related to recycling of crust components within the mantle, plausibly in connection with subduction processes occurred during the Cenozoic Betic orogenic cycle.

In this study we investigated representative samples of composite xenoliths consisting of peridotite crosscut by felsic veins (varying in size from centimetric to millimetric) and unveined peridotites, measuring the ¹⁸O/¹⁶O ratios of the constituent minerals by laser fluorination. Results show that the narrow O-isotope compositional "typical" of mantle rocks, and the limited oxygen isotope fractionation at mantle temperatures, make oxygen isotopes a powerful tool for identifying recycled crustal material in the

mantle. Orthopyroxene and plagioclase of the centimetric vein show $\delta^{18}\text{O}$ values of +9.8 and +10.6‰, respectively, whereas clinopyroxene of the surrounding peridotite country rock has $\delta^{18}\text{O} = +6.2$ ‰. Plagioclase of two

distinct millimetric felsic veins show $\delta^{18}\text{O}$ of 7.6 and 7.3‰. The $\delta^{18}\text{O}$ values significantly higher than typical mantle ones provide insights to the genesis of the Cenozoic subduction-related magmas of the Betic region that include silica-oversaturated calcalkaline (s.l.) and lamproite products, possibly resolving source vs. shallow level crustal contamination of the magmatic rocks. Moreover, the different O-isotope composition recorded in veinlets characterized by different thickness could provide insights into diffusion-assisted O-isotope equilibration of mantle rocks, thus constraining the time for "crust digestion" into the mantle.

H5-14 Orale Agostini, Samuele

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GEODYNAMIC IMPLICATIONS OF INTERACTIONS BETWEEN SUBDUCTION-MODIFIED AND INTRAPLATE-LIKE MANTLE SOURCES IN THE GENESIS OF NEOGENE CENTRAL ANATOLIA VOLCANISM.

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Key terms: Eastern Mediterranean; Volcanism; Petrology; Isotope Geochemistry; Geodynamics

In Central Anatolia, between Konya and Kayseri, and Eastern Anatolia, in the region enclosed among Adana, Sivas and Diyarbakir, Neogene volcanic rocks largely outcrop: large ignimbrite sheets and continental sedimentary rocks are found along with lava flows, strato-volcanoes, volcanic domes and plateau lavas.

Some of these products have calc-alkaline affinity and the typical geochemical characters of subduction-related rocks; they have a compositional range from basalts to rhyolites, without any compositional gap. Some others are alkaline, mostly sodic, are strongly SiO₂-undersaturated and reveal an intraplate-type mantle source: they are basanites, tephrites, alkali basalts and trachy-basalts.

The occurrence of subduction-related and intraplate-type volcanic products in the same region is a common feature with surrounding areas in Aegean-Anatolian region. However, Central Anatolian lavas and pyroclastics have some peculiarities. Indeed, these two kind of lavas may be found in the same area, but have usually different time distribution: for instance in Western Anatolia, Central Aegean and Thrace calc-alkaline products are remarkably older than alkali basalts. In addition, mantle sources of subduction-related and intraplate-type lavas are easily distinguished by their Sr and Nd isotope ratios in Central-Eastern Mediterranean region: alkali basalts usually have ⁸⁷Sr/⁸⁶Sr around 0.7030-0.7035 and calc-alkaline and shoshonitic rocks show distinctly higher values (0.7050-0.7080).

Interestingly, in the studied rocks, there is no any clear time and/or space separation between calc-alkaline and alkaline rocks, and no sharp chemical and/or isotopic boundary may be traced. Rather there is a gentle transition, with many samples characterized by intermediate features. As an example, alkaline rocks have ⁸⁷Sr/⁸⁶Sr varying from 0.7034 to 0.7055 and Ba/Nb from 5.0 to 11, whereas the same parameters span in the ranges of 0.7039-0.7056 and 11-163, respectively, in the calc-alkaline basaltic samples. Thus, all the observed data point out for the involvement of two different mantle sources in the genesis of this magmatism, and most samples seem to be derived from interactions of these different sources. Furthermore, the distribution of calc-alkaline rocks is not strictly linked with respect to subduction dynamics. Large volumes of very young (<2 Ma) calc-alkaline rocks are found in Kapadokyan region, in Central Anatolia, even if current subduction is very slow, or stopped at all. More to the east, some calc-alkaline rocks, are found both predating and postdating the 15 Ma Arabia-Eurasia collision, either in the upper Turkish plate or the Arabian foreland. Alkali basaltic plateau lavas are sometimes remarkably older than calc-alkaline lavas and ignimbrites, as those around Sarkisla, dated at 15.7-14.0 Ma ago, and south of Sivas, which gave K-Ar ages of 5.1-4.8 Ma ago.

The Neogene Central-Eastern Anatolia calc-alkaline rocks are sourced in a subduction-modified mantle wedge. Anyway, the lacking of strict connections with the subduction dynamics and geometry indicate that the metasomatizing event of the mantle wedge may be decoupled from the event responsible for the partial melting. Intraplate-type magmas are sourced in the underlying asthenosphere, not affected by any subduction imprint. The occurrence of calc-alkaline magmas intimately connected with intraplate-type magmas and the presence of transitional samples point out for a contemporaneous involvement of two different mantle sources, located at different depths. This magmatism may be explained by the peculiar tectonic setting of the region, linked to the North Anatolian Fault and to the East Anatolian Fault. The occurrence of vertical strike-slip faults, as well as pull-apart basins, may explain contemporaneous melt extractions at different mantle depths.

H5-15 Orale Bianchini, Gianluca

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SUBDUCTION-UNRELATED/SUBDUCTION-RELATED MAGMATISM IN NORTHERN APENNINES. THE EARLY OLIGOCENE AVETO-PETRIGNACOLA VOLCANICLASTIC SUCCESSION

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Key terms: calc-alkaline; volcanoclastic succession; Early Oligocene; Apennines; subduction

During the Early Oligocene, the ~800 m thick Aveto-Petrignacola volcanoclastic Formation (APF) was deposited in a relatively short time (~32-29 Ma) in the Northern Apennines. The APF volcanic rocks are mostly basaltic andesites, andesites and dacites, with minor rhyolites and gabbroic compositions found as pebbles ~0.001-0.5 m³ in size (with average diameter ranging from ~5 to 30 cm). This volcanoclastic succession is interpreted as the product of subaerial effusive to explosive arc magmatism and is associated to turbidite sedimentation. Petrographic, mineral chemical, major and trace element content, as well as Sr-Nd-Pb isotopic ratios are all compatible with a calc-alkaline magmatism generated as consequence of the metasomatic modifications of mantle sources related to the subduction of oceanic lithosphere.

The APF volcanic rocks are a puzzle in the geodynamic evolution of the Italian area. This Formation is now part of the Apennine thrust system, developed as consequence of the West-directed subduction system that involved recycling of the oceanic lithosphere of the Mesogeane/Liguride ocean(s) beneath the southern paleo-continental margin of Europe. Such a subduction system was associated with production of abundant calc-alkaline/arc tholeiitic magmatism starting from Late Eocene/Early Oligocene in SE Spain (Malaga arc tholeiitic dykes), Sardinia (e.g., Calabona microdiorite) and SE France (Esterel microdiorite). During the Middle-Late Eocene, the Alpine Tethys subduction system had already ceased, followed by Adria-Europe continental collision. In other words, during the emplacement of the APF subduction-related volcanic rocks, the Alpine subduction system was already shut down, whereas the Apennines subduction system was fully developing. Notwithstanding this, we propose that the APF volcanic rocks are genetically connected to the Alpine subduction system rather than the Apennines.

We propose that the APF volcanic rocks are generated by a mantle source modified by components of the Alpine slab detached during Middle-Late Eocene, and still wandering beneath the Adriatic lithosphere after the closure of the Piedmontese (Liguride) Ocean. The effects of the "zombie" slab would be a metasomatic modification of the original peridotitic matrix, allowing hydration with the consequent formation of amphibole. Local effects of stress release in the Apennines foreland and in the Alps hinterland would have played an important role to trigger magmatism. Paradoxically, the subduction-related igneous activity in the APF area developed several Ma after the cessation of oceanic lithosphere subduction in an area that, few Ma later, would have been involved in a completely different orogenesis (Apennines tectonics).

In summary, the APF volcano (now completely eroded) would have been generated as consequence of Alpine tectonics, but would have been involved in the Apennines thrusts soon after its formation. According to this view, the APF and the Mortara volcanoes, the latter now buried beneath the Po Plain, would have the same origin. The formation of the Po Plain (representing the foreland of the Apennines and the retro-foreland of the Alps back-thrusts) would have prevented the Mortara volcano from being eroded, leaving it in its original position on the north-western margin of Adria.

H5-16 Poster Beccaluva, Luigi

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PB-HF-ND ISOTOPIC DECOUPLING IN PERIDOTITE XENOLITHS FROM MEGA (ETHIOPIA): INSIGHTS INTO THE MULTISTAGE EVOLUTION OF THE EAST AFRICAN LITHOSPHERE

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Key terms: Southern Ethiopia; East African Rift; mantle xenoliths; Nd-Hf isotopes

New Hf and Pb isotopic data from clinopyroxenes from East African Rift (EAR) mantle xenoliths (Mega, Sidamo region, southern Ethiopia), coupled with recently published Nd isotope and trace element compositions, provide compelling evidence for multiple episodes of mantle depletion and metasomatic enrichment. Radiogenic values (ϵ_{Nd} up to +22.5 and ϵ_{Hf} up to +1076) suggest that mantle domains currently located beneath the Main Ethiopian Rift suffered extreme melting regimes, possibly in the presence of residual (majorite?) garnet, effectively fractionating Sm/Nd, Lu/Hf and Nd-Hf systematics. Positively correlated Lu/Hf and $^{177}\text{Hf}/^{177}\text{Hf}$ provide an apparent ingrowth of 1.96 Ga, close to the CHUR model age of the most radiogenic sample (1.95 Ga) and is consistent with other local records of Proterozoic melting events. Pb isotopes are clearly decoupled from the Nd-Hf systematics, displaying $^{208}\text{Pb}/^{206}\text{Pb}$ up to 20.1, $^{207}\text{Pb}/^{206}\text{Pb}$ up to 15.70, and $^{208}\text{Pb}/^{232}\text{Th}$ up to 39.8. These data suggest vigorous convection cells, possibly triggered as a far field dynamic consequence of the Afar plume impingement, preferentially occurred beneath this site, where important lithospheric discontinuities exist between the Archean/Early Proterozoic Tanzanian craton and the Late Proterozoic Pan-African mobile belt. Such deep mantle dynamics may contribute to stabilizing distinct EM1 and HIMU metasomatic components in the EAR lithospheric mantle.

H5-17 Poster Bianchini, Gianluca

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ORIGIN AND EVOLUTION OF PONTINE ISLANDS MAGMATISM (TYRRHENIAN SEA, ITALY): GEOCHEMICAL CONSTRAINTS FROM SUBMARINE VOLCANICS

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Key terms: Pontine Archipelago; submarine volcanics; calc-alkaline rocks; alkaline (potassic) rocks; subduction

The spatial-temporal distribution and compositional variability of Plio-Quaternary magmatic products emplaced in the Tyrrhenian and surrounding regions is related to subduction processes and extensional phases, which acted in different ways in the northern and the southern part of the basin. In this framework, the magmatism of the Pontine Islands is very interesting as 1) emplaced at the boundary between the Tuscan and the Roman Magmatic Provinces; 2) strictly related to geodynamic processes involved in the opening of the Tyrrhenian oceanic domain.

Previous studies defined that: 1) Pleistocene volcanic episodes were represented by potassic products, with basic to intermediate rocks in the islands of Ventotene and Santo Stefano and with intermediate to highly evolved rocks (trachytes up to peralkaline rhyolites) in the south-eastern part of Ponza and Palmarola island; 2) Pliocene volcanic episodes are represented by calcalkaline products, with silica-rich volcanic units constituting the dominant products in Ponza and Zannone islands; the latter were characterized by lack of primitive rocks raising questions on the petrological processes as well as on the tectonic mechanisms that triggered magma genesis.

In this contribution we present new data including the investigation of the Pontine submarine portions carried out in four oceanographic cruises (aboard RV Urania), during which seafloor samples were dredged. An important result is that off-shore sampling also recovered less-evolved terms, i.e. basalts and andesites, of the calcalkaline series.

The new sample collection has been characterized through major/trace element data and Sr-Nd isotopic analyses, implementing the data-set already available in the literature to provide better constraints on the genesis of both calcalkaline and potassic series.

Previous studies (Conte and Dolfi; 2002; Cadoux et al., 2005) interpreted the Pontine magmatism in the framework of a transition from subduction-related to intraplate geodynamic settings. The new data suggest that such transition has not been fully accomplished, pointing to ubiquitous and persisting subduction-related signatures in the Pliocene-Pleistocene mantle sources. In particular, geochemical and isotopic characters of the mafic products indicate highly heterogeneous mantle sources, in turn related to crustal components recycled in the mantle via subduction. Further assimilation of crustal materials possibly occurred as result of shallow level processes in the plumbing system, contributing to define the observed isotopic fingerprint.

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H5-18 Poster Natali, Claudio

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HIGH TiO: PICRITE BASALT/RHYOLITE BIMODAL ASSOCIATION AS INDICATOR OF INITIAL RIFTING AT A "PLUME AXIS": THE CASE OF NORTHERN ETHIOPIAN PLATEAU

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Key terms: RHYOLITE; CONTINENTAL FLOOD BASALT; CONTINENTAL RIFTING; AFAR PLUME; TECTONOMAGMATIC SETTING

Voluminous felsic volcanism has been recently associated to 1) mafic Large Igneous Provinces (LIP) where rhyolites are comparable to A-type granites or 2) continental convergent margins Silicic LIP (SLIP) where rhyolites share similarities with S- and I-types granites [1]. An intriguing petrological debate has concerned the genesis of bimodal silicic-mafic volcanism in continental LIP [2]. In several Continental Flood Basalt (CFB) provinces of the Gondwana realm - such as Paraná-Etendeka, Karoo, Ferrar, Deccan, Madagascar, Seychelles and Afro-Arabian region - extensive (104-105 Km²) rhyolitic volcanics occur, generally late in the sequence and sometimes interbedded with basalts [3].

In this contribution we present petrological and field data on the high-TiO: picrite basalt/rhyolite bimodal association in the north-eastern Ethiopian plateau (Lalibela area) which is considered the axial zone of the 30 Ma CFB activity related to the Afar plume [4].

In this area the volcanic sequence consists of ca. 1700 m of mostly very high TiO₂ (4-6.5%) picrite basalts, covering an area of ca. 15000 km², topped by an average thickness of ca. 300 m thick rhyolitic ignimbrites and lavas which discontinuously extend over an area of ca. 10000 km².

Petrogenetic modelling, using rock and mineral chemical data and phase equilibria calculations (by PELE and MELTS), indicates that: 1) very high TiO₂ picrite basalts could generate rhyolitic, sometimes peralkaline, residual melts (liquid fraction 9-16%) with persistently high TiO₂ content (0.4 - 1.0%); 2) by closed system fractional crystallization processes developed at 0.1-0.3 GPa pressure range, 1400-750 C° temperature, at QFM fO₂ conditions; 3) the highest crystallization rate - involving 10-13% of Fe-Ti oxide removal - in the temperature range between 1070 and 950 C°, represents an "ephemeral" fractionation stage, resulting in the absence of erupted silica intermediate products (Daly gap). The eruption of highly differentiated products capping the basic volcanics implies a rapid change from "open" to "closed" tectono-magmatic system, which favoured trapping of parental picrite basalts and their fractionation in upward zoned magma chambers, ultimately leading to low aspect ratio fluorine-rich rhyolitic ignimbrites and lavas. This tectono-magmatic evolution resulted from the onset of continental rifting at the plume axis, with faulting and block tilting, allowed magma differentiation in shallow - N-S elongated - fissural chambers parallel to the developing Afar Escarpment. In this scenario, rhyolitic eruptions represent the transition between the plateau basalt stage to the incipient rifting progressively evolving to continental break-up and formation of the Red Sea basin.

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H5-19 Poster Romano, Vanessa

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TRIASSIC THOLEIITIC AND ALKALINE BASALTIC MAGMATISM IN WESTERN-CENTRAL SICILY (SOUTHERN ITALY): GEOCHEMICAL AND ISOTOPIC CLUES TO MANTLE SOURCES INVOLVED DURING EARLY CONTINENTAL RIFTING

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Key terms: Triassic basalts; Sicily; tholeiitic; alkaline; continental rift

During Early Mesozoic, a diffuse magmatic activity developed in western-central Sicily in relation to the extensional tectonics associated with the opening of the Neotethys Ocean. In this work, we report and discuss geochemical and Sr-Nd isotopic data for Sicilian Triassic tholeiitic and alkaline volcanic rocks. Tholeiitic basalts from western Sicily are characterized by relative HFSE enrichment, high HFSE/LILE ratios, flat REE patterns (La/Nb = 2.27-2.48), Ti, Sr and K negative anomalies and Pb peaks in primitive mantle-normalized diagrams. The Sr ($87\text{Sr}/86\text{Sr} = 0.707\text{-}0.708$) and Nd isotopic compositions ($\epsilon\text{Nd} = \text{from } -1.7 \text{ to } -2.2$) are compatible with an origin from enriched mantle sources. Additionally, the relatively high Sr isotopic ratios and diagnostic trace elements ratios, such as La/Nb (~ 1.7), La/Nb (~ 1.20), Nb/U (~ 20) and Pb/Nd (~ 0.3), could reflect involvement of the lower crust in the magmatic evolution of the tholeiitic rocks.

Alkali basalts from central Sicily preserve a clear geochemical signature despite the intense alteration. The behaviour of immobile elements such as the low Y/Nb and Zr/Nb and high Th/Yb and Ta/Yb ratios, positive

Nb-Ta-Ti anomalies, and the radiogenic Nd isotope ratio ($\epsilon\text{Nd} = +3.4 \text{ to } +3.7$) suggests an OIB-like source. The LREE/HREE ratio (La/Nb = 7.43-8.76) is higher than in the tholeiitic samples, suggesting a possible role of residual garnet in the magma source, or a lower degree of partial melting, or both. The behaviour of mobile elements, such as the Sr isotopic composition ($87\text{Sr}/86\text{Sr} = 0.706\text{-}0.707$) and the K depletion, does not contradict this.

On the basis of trace elements and Sr-Nd isotopic composition, the Sicilian Triassic dykes could reflect the early stages of rifting in a continental setting, including initial lithospheric thinning, passive upwelling of hot asthenosphere, and related processes of partial melting involving differently enriched mantle reservoirs.

H5-20 Poster Paonita, Antonio

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NEW EVIDENCES OF MANTLE HETEROGENEITY BENEATH HYBLEAN AREA (SICILY) AS INFERRED FROM NOBLE GASES AND GEOCHEMISTRY OF ULTRAMAFIC ENCLAVES

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Key terms: noble gas; trace elements; radiogenic isotopes; mantle geochemistry

We carried out a geochemical investigation of the mantle beneath Hyblean area through ultramafic enclaves (peridotites and pyroxenites) found in Miocene age Hyblean volcanics. Major and trace elements, in the whole rock and in the single mineralogical phases and Sr-Nd isotopes in clinopyroxenes were analysed together with noble gases entrapped in CO₂-rich fluid inclusions hosted in olivines and pyroxenes.

The pattern of REE, the Zr/Nb and $143\text{Nd}/144\text{Nd}$ ratios highlighted clear compositional differences between the peridotite group ($\text{Zr}/\text{Nb} = 14$; $143\text{Nd}/144\text{Nd} = 0.5129$) and the pyroxenites ($\text{Zr}/\text{Nb} = 20$; $143\text{Nd}/144\text{Nd} = 0.5130$). Also, the REE analyses suggested the presence of cryptic metasomatic events which would have re-fertilized the peridotitic layer previously depleted by extraction of melts. In this context, the metasomatizing agent, namely a deep-seated magmatic liquid intruding the peridotites at different levels, would be represented by the pyroxenites, as suggested also by their finding as veins in peridotitic nodules.

The noble gas analyses confirmed the above compositional difference between the peridotites and the pyroxenites. In particular, we focused our attention on the $3\text{He}/4\text{He}$ and $4\text{He}/40\text{Ar}$ ratios because they represent important tracers of mantle processes. The $3\text{He}/4\text{He}$ and $4\text{He}/40\text{Ar}$ ranges measured in the fluid inclusions of peridotites (7.0-7.4 Ra and 0.4-8.0, respectively) were in average lower than that shown by the pyroxenites (respectively 7.2-7.6 Ra and 0.6-15). In order to explain the observed mantle heterogeneity in noble gas systematics, we hypothesized a mixing between two end-members:

- 1) a shallow peridotitic layer having R/Ra of ≈ 7 and $4\text{He}/40\text{Ar}$ ratio lower than that the typical production range ($4\text{He}/40\text{Ar} \approx 2\text{-}5$), due to melt extraction events;
- 2) a deep pyroxenitic metasomatizing melt characterized by a R/Ra of ≈ 7.6 and with a variable $4\text{He}/40\text{Ar}$ ratio due to degassing processes connected with the ascent of magma at different levels of the hosted peridotite.

The whole geochemical dataset therefore suggests the presence of two different mantle sources for the above highlighted peridotitic and pyroxenitic groups, respectively a shallower HIMU-type source for the former and a deeper DM-type source for the latter.

H5-21 Poster Punturo, Rosalda

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PETROPHYSICAL AND PETROLOGICAL FEATURES OF DEEP- SEATED

XENOLITHS FROM MIOCENE TUFF-BRECCIAS OF THE HYBLEAN PLATEAU: SUGGESTIONS FOR A LITHOSPHERIC MODEL BENEATH SOUTH-EASTERN SICILY

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Key terms: Hyblean xenoliths; Petrophysics; Lithospheric column

As it is known, deep-seated xenoliths act like an "open window" to the inaccessible portions of lithosphere, and permit lithological models to be set out with a great detail.

In this work, attention focused on xenoliths collected within Miocene tuff-breccias from the Hyblean Plateau (south-eastern Sicily, Italy). According to main petrographic features, the studied xenoliths may be grouped into: a) ultramafic, which consist of spinel facies peridotite and pyroxenite (some garnet bearing); and b) feldspar-bearing suite, represented by mafic granulite and minor metagabbro and anorthosite. Spinel facies peridotite rocks (harzburgite and harzburgitic lherzolite) exhibit protogranular to (rare) porphyroclastic texture; they are constituted by olivine (Fo₈₉₋₉₁), orthopyroxene (En₈₈₋₉₁; mg# 90-92), clinopyroxene (Cr-diopside: En₅₁₋₅₄Fs₂₋₄Wo₄₄₋₄₈), Cr-rich spinel (Cr#23-35). Very rare phlogopite occurrence testifies that the Hyblean mantle underwent metasomatic event.

Pyroxenite specimens classify into: Cr-diopside websterite (Cr-diopside, Ca-poor pyroxene, Cr-Al spinel +/- olivine and amphibole); Al-diopside websterite (Al-diopside, Ca-poor pyroxene, Al-spinel, garnet (Py₅₄5Alm₃₂Gr₁₃5). Al-augite pyroxenite (interpreted as igneous adcumulitic products) are composed of Al-clinopyroxene, Al-spinel, garnet (Py₆₄Alm₂₅5Gr₉6). Finally, feldspar-bearing xenoliths are mostly represented by mafic granulite (plagioclase, Ca-pyroxene, Ca-poor pyroxene and Al-spinel +/- amphibole). Metagabbro and metadorite (plagioclase, Ca-pyroxene, Fe-Ti oxides, apatite) and anorthosite (plagioclase +/- Al-spinel and pyroxene) occur at a lesser extent. Pressure-temperature estimates, based on two pyroxene and garnet mineralogical assemblage within pyroxenite provided equilibration values of 0.98GPa at 740°C for spinel pyroxenite and 1.32GPa at 1040°C for garnet pyroxenite.

In addition, petrophysical investigation was carried out on three selected lithotypes (peridotite, pyroxenite and mafic granulite), whose large size of collected xenoliths allowed laboratory seismic measurements (Vp, Vs, Poisson's ratio, seismic anisotropy) at various P-T conditions (up to 600MPa at 600°C).

Since investigated xenoliths are considered to be representative of large scale lithological units, petrophysical results combined with petrological information permit available geophysical data to be constrained and interpreted at a better extent and may provide useful suggestions for a lithospheric model underneath the Hyblean Plateau.

H5-22 Poster Giovanardi, Tommaso

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JURASSIC U-PB ELA-ICP-MS ZIRCON AGES FOR SEGREGATION OF HUGE CHROMITITE LAYERS IN THE FINERO MANTLE BODY: NEW INSIGHTS INTO THE GEODYNAMIC EVOLUTION OF THE SOUTHERN ALPS

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Key terms: Finero; Chromitite; Geochronology; Zircons

The mafic-ultramafic Finero complex represents the northernmost sector of the Ivrea-Verbano Zone (IVZ), Southern Alps. It consists of a mantle body, surrounded by a mafic-ultramafic intrusive sequence [1], documenting an association of mantle and crustal rocks inferred to be placed at the bottom of the continental crust of the Adria plate before the opening of Ligurian-Piedmontese branch of the Jurassic neo-Tethys.

Nevertheless, the Finero complex shows several tectonic and petrochemical differences with respect to those of the central IVZ. For instance, published geochronological U-Pb zircon data constrain the emplacement of the Mafic Complex in the central sector of the IVZ at 280-to-295 Ma ([2] and references therein). Conversely, the intrusion age of almost part of the Mafic Complex in the Finero area (SHRIMP U-Pb zircon dating) indicate that the External Gabbro, the largest unit forming the Finero Mafic Complex, intruded the bottom of the Kinzigite Formation during Ladinian [3]. A Triassic ages have been also determined for the multiple metasomatic and intrusive events affecting the associated mantle body ([4] and references therein). This is mainly formed by harzburgite modally enriched in phlogopite and amphibole and with large LILE contents. Based on the geochemical and isotopic composition, several authors proposed that the growth of phlogopite-bearing assemblages was related to the migration of melts containing significant crust-derived components. With the aim to place constraints on the timing of melt migration through the Finero mantle body, zircons were separated from three, dm-thick chromitite bands enclosed in huge dunite bodies outcropping along the Cannobino River and on the Mt. Sasso Rosso. U-Pb ELA-ICP-MS data result in concordant ages comprised in the range of 188-186 Ma, which is believed to date the segregation of the chromitite bands during channelled porous-flow melt migration. These ages are significantly younger than that determined through conventional multigrain dating by [4], whose data define an intercept Triassic age of 208±2 Ma. Although the studied chromitite bands do not show primary phlogopite, the major and trace element mineral chemistry point to a cognate origin with the migrating melts forming the phlogopite harzburgite. The finding that the porous-flow ascent of LILE-enriched melts through the Finero mantle unit postdates the emplacement of the Finero Mafic Complex, and the absence in the latter of the record of this magmatic stage, suggest that the Finero mantle unit might have been emplaced tectonically in contact with the lower crust at some time after lower Jurassic. This hypothesis is supported by the observation that the contact between mantle unit and Mafic Complex is always tectonic. As a whole these data confirm that the northernmost part of the IVZ, represented by the Finero complex, cannot be longer considered as a part of the central IVZ, thus suggesting that the entire geological setting of the area should be revised.

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H5-23 Poster Giovanardi, Tommaso

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U-PB ZIRCON DATA FOR TUFFACEOUS LAYERS FROM THE SEDIMENTARY COVER OF THE STRONA-CENERI ZONE AND PO PLAIN: CONSTRAINTS ON THE TRIASSIC GEODYNAMIC EVOLUTION OF THE SOUTHERN ALPS

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Key terms: Tuffites; Zircon; Geochronology; Triassic; Magmatism

In the western sector of the Southern Alps, tuffaceous levels are occasionally found in the Triassic sedimentary sequences. The direct age characterisation of these layers is very limited: in fact, a U-Pb zircon age of 245±1 Ma is available only for the tuffites from Mt. San Giorgio area (Lugano, CH: [1]), which results slightly older than that expected according to the stratigraphic position. Besides, no geochemical information is presently available for these layers and the geodynamic setting of the related volcanism is still matter of debate. Thus, with the aim to place further constraints of the geodynamic evolution of the Southern Alps in Mesozoic times and increase the accuracy of the age record of the sedimentary sequence, we have performed a mineralogical, geochemical and geochronological study on tuffaceous deposits outcropping within the Anisian-Ladinian succession of the sedimentary cover of the Strona-Ceneri Zone in the Borgosesia area [2,3] and recovered at the same stratigraphic position in wells of the Villafortuna-Treccate oil field (western Po Plain, Piedmont region, NW Italy: [4]). CO₂ concentration was determined by Dietrich-Frühling calcimeter. XRD data indicate that such tuffaceous deposits are constituted by a variable mixture of magmatic and sedimentary components. Major and trace element compositions, assessed by means of XRF analysis, suggest a calc-alkaline affinity for the magmatic component. To provide accurate geochronological constraints, zircons have been separated with conventional methods from four tuffaceous outcrops, namely "Lembo di Sostegno", "Lembo di Crevacuore" and "Lembo di Monte Fenera" outcrops, as well as from a buried tuffaceous sample of the Villafortuna-Treccate oil field. Zircons were mounted in epoxy resin and characterised under cathodoluminescence (CL). Based on colour, morphology and internal structure, they have been divided in two populations. One group is constituted by light-pink coloured zircons with prismatic habits and tight oscillatory zoning suggesting growth under magmatic conditions. The zircons from the second group are colourless, rounded in shape and with only relics of magmatic zoning, consistent with metamorphic recrystallization. U-Pb ELA-ICP-MS data point to ages of 237±8 Ma and 229±9 Ma for the magmatic growth of the zircons from the tuffites of "Lembo di Crevacuore" and "Lembo di Sostegno", respectively, which are in agreement with their stratigraphic position. The volcanic activity producing these layers might be linked to the intrusive Triassic magmatism documented in the Finero Complex (NE Ivrea-Verbanio Zone [5,6]). Conversely, the zircons from the "Lembo di Monte Fenera" and Villafortuna-Treccate oil field produce a very large range of crystallisation-recrystallisation ages, which span from Proterozoic to Paleozoic to the Permian-Triassic boundary, thus indicating a dominant contribution of the crystalline basement to the zircon population. References. [1] Mundil, R., Brack, P., Meier, M., Rieber, H., Oberli, F. (1996): Earth and Planetary Science Letters, 141, 137-151; [2] Carraro, F., Fiora, L. (1974): Riv. It. Paleont. Strat., 80, 167-191; [3] Fantoni, R., Decarlis, A., Fantoni, E. (2004): Atti Tic. Sc. Terra, 44, 97-110; [4] Fantoni, R., Bello, M., Ronchi, P., Scotti, P. (2002): Extended Abstracts Book EAGE Conference Florence; [5] Zanetti et al (2011), J. Pet. Submitted; [6] Stähle, V., Frenzel, G., Hess, J. C., Saupé, F., Schmidt, S.Th., Schneider, W. (2001): Permian metabasalt and Triassic alkaline dykes in the Northern Ivrea Zone: clues to the post-Variscan geodynamic evolution of the Southern Alps. SMPM, 81, 1-21.

H5-24 Poster D'Adamo, Francesco

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LATE NEOPROTEROZOIC DYKES SWARMS AND EARLY PALEOZOIC BASIC INTRUSIONS IN BOHEMIAN MASSIF (CZECH REPUBLIC): PETROLOGY AND GEODYNAMIC IMPLICATIONS IN ARMORICAN MICROPLATES.

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Key terms: Armorica; Bohemian Massif; Dykes Swarms; Late Neoproterozoic; Geodynamic Implications

In the Bohemian Massif (Czech Republic), the Moldanubian (M) and the Tepla-Barrandian (TB) terrains were assembled during Variscan orogenesis. In ancient times, both regions were the site of quite coeval basic intrusions which identified extensional geodynamic contexts. In M such "igneous" rocks are mainly represented by amphibolites and by quite rare transitional slightly metamorphosed dykes with a supposed age of 600-550 Ma (Janoušek et al., 2008). These cut the paleoproterozoic granitoids of the Svetlik formation and suggest an original continental-cratonic setting. While amphibolites appear to be chemically spread, the dykes show a strong elemental OTB (Sun & McDonough, 1989) affinity (Dy/YbCN = 1.3 vs 1.68; La/SmCN = 2.07 vs 2.33; La/NdCN = 1.48 vs 1.86). In TB, scarcely metamorphosed basic bodies have been intruded by rare dykes swarms (524 Ma; Dörr et al., 2002) showing a fairly cumultic

texture, a quite high silica content coupled with a high mg#, a N-MORB (Sun & McDonough, 1989) like REE pattern (La/SmCN = 0.54 vs 0.55; Dy/YbCN = 1.15 vs 0.97; La/NdCN = 0.61 vs 0.66) and an evident negative Nb anomaly followed by a positive Ti one. Differences in the mantle sources involved in the TB and M dyke genesis could be also explained by the La/Ce (0.3 vs 0.4) and La/Yb (1.0 vs 1.4), the first being a direct feature of the source and the second a possible consequence of variable amount of garnet in the residual source mantle. Notably, such behavior cannot be easily modified by sub-solidus processes.

To explain the genesis of the TB dykes, an extensional event which immediately followed the evolution of an Island Arc system has been suggested by several authors (Dörr et al., 2002; Zulauf et al., 2004). Indeed, for the M Late Proterozoic magmatism, which outcrops in a region strongly tectonized where the amphibolites were mainly investigated, a clear geodynamic context is also undefined.

Notwithstanding, the supposed ages of the magmatic event and the chemical behaviors of the slightly metamorphosed dykes, could be inserted within the recent 600-500 Ma plate reconstructions proposed by Pisarevsky et al. (2008). So, such magmatic event could be interpreted as a minor occurrence of the plume related continental extension responsible of the Baltica-Amazonia-Laurentia-Avalonia break-up, which should represent the last great extensive-transpressive moment between the Rodinia Break-up and the Great-Gondwana assemblage.

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H5-25 Poster Rizzo, Giovanna

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GARNET COMPOSITION IN RODINGITE OF FRIDO UNIT (SOUTHERN APENNINE, ITALY): EVIDENCES FOR METASOMATIC ALTERATION, PRELIMINARY DATA

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Key terms: Southern Apennine chain; Frido Unit; Rodingites; Metasomatism; Garnet

The Southern Apennines chain is a fold-and-thrust belt derived from the collision between the African and European plates starting in Upper Oligocene. The ophiolitic sequences occur in the Southern Apennine Chain as remnants of the Liguride accretionary wedge. The Liguride tectonic units derived from the western Tethys ocean which separated the European plate from the African one. The studied ophiolitic rocks emplaced in the Ligurian domain of the Alpine Tethys Ocean during the middle Jurassic. These units outcrop extensively in the southern Apennines in the northeastern slope of the Pollino Ridge. Liguride Units of the Southern Apennine include sequences characterized by HP/LT metamorphic overprint in the Frido Unit. They consist of sedimentary sequences ranging from the Upper Jurassic to the upper Oligocene ages and several bodies of oceanic and continental crust. The ophiolitic rocks occurring in the Frido Unit consist of serpentinites derived from mantle lherzolite and subordinately harzburgites. Rodingites outcrop as dikes cutting through serpentinites and are a few centimeters thick, grayish-white and show a ductile deformation. Petrography and mineral chemistry of rodingites facilitated the finding of the igneous and metamorphic mineral assemblages related both to the primary magmatic protolith and to the subsequent metamorphic evolution. Rodingites show granuloblastic texture. The primary igneous assemblage consists of plagioclase and clinopyroxene; these minerals cannot be preserved in rodingites due to a more accentuated rodingitic alteration. The metamorphic mineral assemblage consists of garnet, prehnite, chlorite, pumpellyite and quartz. Accessory minerals are titanite, epidote, opaque minerals, zircon and apatite. In order to obtain mineral chemistry electron microprobe analyses were performed on the garnet. Brown-yellow garnet crystals show a sub-idiomorphic and xenomorphic habit and/or replace plagioclase. Garnet crystals have coronas and rims of titanite and epidote crystals. Garnet overgrowing on plagioclase is mostly hydrogrossularite-grossularite rich and range between 79.107 and 95.071 Mol%, in the structural formula recalculated on the basis 22 oxygens; end member are Prp, Alm, Grs and Sps (pyrope, almandine, grossularite, and spessartine). Ocean-floor metamorphism occurs with the metasomatic processes of rodingitization typical of dike-cut serpentinite. Rodingitization produces Ca-rich basic rocks during serpentinization. Rodingitization metasomatic reactions in rodingitic dikes are demonstrated by the replacement of plagioclase by hydrogrossularite.

SESSIONE H6

Evoluzione sedimentaria, magmatica, metamorfica e geodinamica della catena varisca sud-europea

H6-1 Orale Compagnoni, Roberto

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NEW DATA ON THE GEOLOGICAL HISTORY OF THE ARGENTERA MASSIF AND COMPARISON WITH THE MONT BLANC-AIGUILLES ROUGES AND MAURES-TANNERON MASSIFS

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Key terms: Variscan crust; External Crystalline Massifs; HP granulite; migmatite; geochronology

The "External Crystalline Massifs" of the Western Alps (Aiguilles Rouges, Mont Blanc, Grandes Rousses, Belledonne, Pelvoux, and Argentera) consist of a polymetamorphic Variscan basement, which was only marginally reworked during the Alpine tectonometamorphic cycle. This contribution focuses on the magmatic and Variscan metamorphic history of the Argentera Massif, the southernmost and largest of the External Crystalline Massifs exposed in Italy. Its evolution is compared to that recorded in the Mont Blanc-Aiguilles Rouges Massif, the other External Crystalline Massif extensively exposed in the Italian Alps, and to that recorded in the Maures-Tanneron Massif of Provence, France, the area of Variscan Europe nearest to Argentera. Some speculations on tectonic models for this evolution are also proposed. The main geological events recorded by these Massifs are similar. They experienced: a) pre-Carboniferous intrusions of both acid and basic magmas; b) a Carboniferous Variscan history consisting of subduction with metamorphic peak at ca. 700°C and 1.5 GPa, continental collision developing amphibolite-facies metamorphism, anatexis, and emplacement of granitoids; c) Carboniferous exhumation to shallow crustal levels. A few of the events well documented in the Mont Blanc-Aiguilles Rouges and Maures-Tanneron have not yet been characterized in the Argentera Massif. In particular, the Late Proterozoic emplacement of granitoids in a (meta-)sedimentary sequence documented in the Maures and the Late Ordovician granite plutonism documented in the Mont Blanc Massif, still await to be confirmed in the Argentera by geochronological data, though field observations generally support the occurrence of these magmatic events. On the other hand, the age of the high pressure (HP) metamorphic event documented by eclogites and HP granulites found in all the massifs is well constrained so far only in the Gesso-Stura-Vésubie (GSV) Terrane of the Argentera Massif, where Carboniferous ages at ca. 340 Ma were obtained for zircons in the Frisson HP granulites. The LP metamorphism and partial melting in the GSV Terrane are not directly dated, but a Late- to Mid-Carboniferous age for migmatization has been proposed on the basis of a zircon lower intercept age obtained from the Meris eclogite. These geochronological data link together in a single orogenic cycle the HP and the amphibolite-facies metamorphisms, and suggest that the evolution of the Variscan belt of the Western Alps and Provence may resemble that of present-day collisional settings, such as the Himalayan belt. Similarities between the Variscan and the Himalayan orogenies include the conditions of HP granulite-facies metamorphism, and the rapid (within 20 Ma) succession of HP peak metamorphism, fast exhumation and widespread late anatexis.

H6-2 Orale Ferretti, Annalisa

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QUO VADIS, NORTH GONDWANA? EVIDENCE FROM INTEGRATED STUDIES OF LOWER PALEOZOIC SEQUENCES OF THE CARNIC ALPS (AUSTRIA)

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Key terms: Carnic Alps (Austria); Lower Paleozoic; paleobiogeography; sedimentology; chronostratigraphy

Significant advances in reconstruction of the geodynamic processes that controlled the dispersal of the North Gondwana margin between Early Ordovician and Carboniferous times are now emerging. Diverse lines of investigation within this regional and temporal context are being applied to the Paleozoic sequences of the Carnic Alps (Austria), in particular to the critical Late Ordovician-early Silurian interval.

Acquisition of paleontological and paleoenvironmental data by study of pelagic faunal exchange, microfacies and climate sensitive sediments of this pivotal middle paleolatitudinal temperate sector of the Southern Variscan Realm has highlighted critical new evidence based on this non-geochemical method of dating paleocontinent position and opening/closure of seaways. Faunas suggest plate movement from a moderately cold environment of c. 50°S latitude (Late Ordovician) to a reef belt of c. 30°S (Devonian). Eustatic changes are correlated across four paleocontinents (1).

Sedimentological evidence records the Hirnantian glaciation cold water influx as diamictites within the successions at the Nöblinggraben and Raichkofel South sections, now precisely constrained biostratigraphically, thus adding further data for timing this event along the North Gondwana Margin. This level is characterized by pyrite and phyllosilicate, (mainly chlorite) -rich arenites and rudites. The coarser detrital fraction includes subrounded mm to cm sized crystalline clasts, interpreted as dropstones. Their composition of finely banded gneisses characterized by ribbon quartz layers and quartzites, suggests erosion and reworking from a polymetamorphic area. The sulfide rich matrix suggests a cold reducing environment. Mineralogical and petrologic analyses are ongoing. Further evidence for the Hirnantian Stage is based on the recent

identification of the $\delta^{13}C$ Excursion (HICE) in the Cellon Section (2). Documentation of igneous activity within this sector of the Southern Alps provides a valuable database for unravelling the related geodynamic history, in particular for the Late Ordovician-early Silurian interval. 97 K-bentonites have been recorded from the Upper Ordovician (Hirnantian) to Lower Devonian (Lochkov) sequences, constrained biostratigraphically within the international standard biozones (3). Volcanism belongs to a tectonically active terrane dominated by calc-alkaline mafic lavas of clear volcanic arc affinities, most samples fall within the andesite and rhyodacite/dacite fields. Upper Ordovician K-bentonites are rare and have few European equivalents. Abundant Llandovery - middle Ludlow levels similar to those in the British Isles, Sweden, Canada and North America may document widespread volcanism related to the closing of the Iapetus Ocean, however, a local origin within northward drifting microplates derived from the Northern margin of Gondwana is considered more likely. Pridolian K-bentonites compare with those from Podolia with a source area in the Rheic Ocean. Characterization by petrography, isotope geochemistry and U/Pb radiometric dating on zircon of these ash levels will yield reliable geotectonic and paleogeographic inferences and

internationally important time-lines for chronostratigraphy within both a regional and global context.

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H6-3 Orale Elter, Franco Marco

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THE VARISCAN SEGMENT OF SARDINIA (ITALY) AND ITS RELATIONSHIPS WITH THE EAST VARISCAN SHEAR ZONE (EVSZ) IN RELATION TO THE LATE PALEOZOIC CONSOLIDATION OF PANGAEA

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Key terms: NE Sardinia; EVSZ; Variscan belt; Pangaea

Recent studies define that the Variscan orogeny should be considered as the result of accretion of peri-Gondwanian terranes rather than a continent-continent collisional belt. The origin of the peri-Gondwanian terranes is linked to a continue evolution and fragmentation of the northern Gondwana margin which started, at least, since the Cambrian with the opening of the Rheic Ocean and the separation of Avalonia. From Devonian times, the northern Gondwana margin has been further affected by separation of continental masses, due to the opening of the Paleotethys, with the formation of a narrow terrane known as Hun superterrane or Galatian ribbon continent. The closure of the Paleotethys, due to the northward motion of Gondwana, started at ~ 330 Ma and led to the final collision and continental amalgamation between Gondwana, Gondwana derived continents (e.g., Avalonia and Armorica) and Laurussia, with the formation of Pangaea, at ~ 300 Ma. In this geodynamic context, the high-grade metamorphic rocks outcropping in the Variscan segment of NE Sardinia experienced an oblique collision under a transpressive tectonic regime during the Early Visean (c. 340 Ma)-Bashkirian (c. 320 Ma). Field evidences and finite strain analyses carried out on the HT rocks of NE Sardinia, define that the exhumation of these rocks could have been driven by telescoping processes along a regional "snake" strike-slip shear zone. Such a shear zone could have induced shear heating processes which led to crustal melting in the order of 3-5%.

The restored direction of this shear zone allow us to identify it with the East Variscan Shear Zone (EVSZ). The EVSZ is a NNW-SSE dextral transpressive regional shear zone running from Brunia to the Calabria-Peloritani arc affecting the scattered Variscan Massifs of the Alps as well as the Maures-Tanneron massif, the Corsica-Sardinia massifs and the basement of Northern Apennines.

In more recent times, the EVSZ could have represented a pre-existing intra-continental band of weakness on which the following tectonic processes will develop: the Permian-Triassic rifting, the Alpine cycle, the Apenninic cycle and the Miocene-Pliocene opening of the Tyrrhenian Sea.

H6-4 Orale Gaggero, Laura

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U-PB RADIOMETRIC DATING OF THE LEPTYNO-AMPHIBOLITE COMPLEX IN THE ASINARA ISLAND (SARDINIA): UNRAVELLING A LONG-LIVED GONDWANAN BASEMENT

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Key terms: Amphibolite Complex; U-Pb LAM ICP MS; Neoproterozoic; Cambrian; Ordovician

In northern Sardinia, the inner zone of the Southern Variscan belt includes a Medium Grade Metamorphic and a High Grade Metamorphic, mainly migmatitic, Complex, originated in igneous and sedimentary protoliths. The igneous ones were recently recognized of Ordovician ages (Cortesogno et al. 2004; Palmeri et al. 2004; Giacomini et al., 2006; Oggiano et al., 2010). A kilometre-thick mylonitic mélange zone (Posada Asinara line) exhibits ductile deformation and occurs between the HGMC and the other medium to low grade Variscan Nappes (Casini et al. 2010). Also in the Asinara Island (Oggiano and Di Pisa, 1992), juxtaposed tectono-metamorphic units exhibit an intermediate to high grade granulitic crustal section. In particular, at Punta Scorno, a millimetre to decimetre layered leptino-amphibolite complex (Ca-amphibole+plagioclase+garnet) occurs characterized by cm to meters thick leucocratic (quartz+plagioclase+garnet) layers including sparse amphibole-dominated ultrabasic and metagabbroic boudins with relic coarse-grained hypidiomorphic textures. The peak metamorphic conditions for this association were estimated under granulite (740°C and P > 0.8 GPa) followed by amphibolite facies (500-600°C and P 0.3-0.4 GPa; Di Pisa et al., 1993). The metagneiss bimodal complex is associated with a K-feldspar-phyrlic orthogneiss presently re-equilibrated under HT/LP high grade metamorphic conditions evidenced by staurolite surrounded by biotite + andalusite coronitic intergrowths and sillimanite + cordierite ± K-feldspar; the tectonic contact between the two lithologies is parallel to their main schistosity.

The leucocratic layers of the basic complex and the associated orthogneiss were selected for U-Pb radiometric dating on zircons separates by ELA ICP MS at CNR - IGG Pavia.

The preliminary elaboration highlights several populations of U-Pb Concordia ages: in the orthogneiss, an early Paleoproterozoic event at 2006 ± 25 Ma and a second Neoproterozoic between 623 ± 13 and 579 ± 12 Ma. A subsequent Cambro-Ordovician age interval is recorded between 478 ± 11 and 437 ± 11 Ma, followed by a Devonian event 413 ± 11 and 403 ± 7.4 Ma.

In the "leptino-amphibolite" complex with granulite relics, each leucocratic layers yielded different ranges of Concordia ages, starting from a

Neoproterozoic time interval (stepped between 672 ± 12 and 588 ± 16 Ma) until a Cambrian system closure (514 ± 22 to 506 ± 15 Ma). An Early Ordovician group of Concordia ages spans between 491 ± 13 and 474 ± 12 Ma. Late Ordovician - Early Silurian ages fall in the 461 ± 10 to 435 ± 12 Ma time interval. Some Devonian and Carboniferous age values are also recorded mainly from homogeneous metamorphic cores. Some considerations thus derive: i) the orthogneiss contains evidence of an ancient basement, older than Neoproterozoic which was previously excluded in the north Gonwana margin (von Raumer et al. 2002), in fact the presence of ca. 2 Ga old inherited Pb component in zircon suggests this crustal residence age of the inferred metasedimentary protolith i) the U-Pb system of the orthogneiss opened diachronous with respect to the basic complex iii) within the leptino-amphibolic complex, different age population arise from different felsic layers, likely pointing out that each of them recorded a different timing of events or that they have different protolith ages. This could occur for instance by several steps of partial melting that caused multiple injections of felsic magmas within a deep crust; iv) the orthogneiss and the amphibolite shared a common evolution since the Devonian.

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H6-5 Orale Zanchetta, Stefano

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UNRAVELLING A PERMIAN VOLCANIC SUCCESSION: PALEOENVIRONMENTS AND TECTONICS IN THE VALGANNA AREA (SOUTHERN ALPS)

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Key terms: Permian volcanic; Southern Alps; paleoenvironments

In the Southern Alps, at Permian times, post-Variscan extension is commonly associated with widespread plutonic and volcanic activities [1, 2]. We addressed a poorly investigated succession outcropping in the western Southern Alps between Lugano and Maggiore lakes (Valganna area). The Permian volcanic to subvolcanic (Valganna granophyre) sequence is almost tectonically undisturbed. In the area 3 volcanic series [1, 3, 7] were investigated and our field and petrographic observations suggested different environments of subaqueous lacustrine and subaerial emplacement.

Series I (basal series): this extrusive series, directly deposited upon a non-conformity surface over the Scisti dei Laghi basement [4], consists of a few metres-thick volcanoclastic mass-flow followed by lithic-crystal and crystal tuffs interbedded with thin cinerite levels. The M. Piambello rhyolite lava flow ends this series.

Series II: it starts with andesite to dacites agglomerates in turn covered by tuff and cinerite levels, the Alpe Tedesco rhyolite flow and a final ignimbrite (P. Ganna ignimbrite), whose geometrical relationships with the youngest Valganna granophyre are unclear.

Series III: it starts with the M. Piambello dacite lava flow followed by lithic-crystal and crystal tuffs and a rhyolitic ignimbrite.

The whole of volcanic products from the three series show high-K calc-alkaline affinity with similar PM- and REE-normalized patterns, which are characterized by LILE and LREE enrichment relative to HFSE and HREE, respectively. Whereas the andesite to dacite extrusive products show very similar geochemical behaviour, the most outstanding differences are among the acidic volcanic products. The rhyolite tuffs and ignimbrites, as well as the very homogeneous rhyolite lava flow of the Series II, mainly differ from those of the Series I and III in: 1) higher K₂O, Rb, Nb and Y and lower Na₂O, MgO, CaO, TiO₂, Sr and Zr contents; 2) more pronounced negative Ba, Nb, Sr, P, Zr and Ti and positive Th, K, Pb spikes in PM- normalized multielement diagram; 3) higher HREE, but similar LREE, contents that lead to a flatter REE pattern with a more pronounced Eu anomaly.

In Valganna, the petrography of the volcanic complex reflects different environments of emplacement. The basal extrusive series (1800-2000 m-thick) was probably emplaced in a shallow lacustrine environment, whereas the Series II could reflect a subaerial apron. The Series III suggest a syntectonic emplacement along an active lineament at the boundary of the paleo-lake (Series I) and its shoulders (Series II). Petrographic and geochemical data reveal an igneous evolution by fractional crystallization within each series together with density selection during the emplacement. The enrichment in LILE and LREE observed from Series I to III could originate in the different abundance of the crustal component or in different source levels in magma genesis. Moreover, the association of high-K-calc-alkaline (Series I and III) with K-rich transitional Series II is consistent with a transtensional setting, probably driven by Permian strike-slip faults at regional scale, as already reported for the Collio and Orobian basins [2, 5].

In progress SHRIMP U-Pb geochronological dating of the key-units will allow to make regional scale correlations with volcanic rocks of similar age and evolution [1, 2, 6].

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H6-6 Poster Caggianelli, Alfredo

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THE TRANSITION FROM LOW-P TO CONTACT METAMORPHISM IN CALABRIA RELATED TO PLUTON GROWTH IN THE INTERMEDIATE CRUST

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Key terms: Hercynian granitoids; low-P metamorphism; numerical modelling

Granitoids represent a large proportion of the Hercynian crustal sections exposed in Calabria. In the Sila and Serre massifs the granitoid stack has a cumulative thickness of 9 to 13 km and includes tabular intrusions of tonalitic to granitic composition with minor dioritic and gabbroic bodies. Emplacement of the granitoids occurred sometime between 300 and 290 ± 10 Ma during the extensional tectonic stage, following collapse of the Hercynian chain. The heat advected by granitoids was considered responsible both for contact metamorphism in the upper crust and regional low-P metamorphism in the lower to intermediate crust. This was shown by static and dynamical numerical models. A main limitation of the models was the instantaneous emplacement assumed for the magmas. In the light of the general consensus existing on the idea that large magma chambers can be filled through dykes in a short time (< 100 kyr in Petford, et al., 2000), the instantaneous emplacement was considered a permissible simplification.

In recent years, the rapid growth of plutons has been questioned, on the basis of radiometric dating at different levels of the magmatic body (e.g., Glazner et al., 2004). Even though the melt flow entering in the magma chamber can be high, feeding may be discontinuous. Consequently, pluton accretion by repeated melt injections can be completed in some million years (Matzel et al., 2006). Another interesting point raised is the way the pluton grows (downward or upward) because this affects the intensity of thermal perturbation above and below the magmatic body (Annen, 2011). On the basis of these arguments we have formulated a new 2D thermal model, to be applied on the Calabria crustal sections, that takes into account the incremental growth of the pluton. We examined the consequences of the end-member processes of pluton accretion and of different growth rates.

In case of under-accretion, contact metamorphism in the upper crust occurs before regional low-P metamorphism in the intermediate to lower crust. Model indicates that pluton growth must be completed in a short time (< 200 kyr) to reproduce observed peak temperatures (540-590 °C) in the contact aureole. Deformation structures related to pluton growth, overprinted by peak T minerals, must be formed in an even shorter time interval. In case of over-accretion, an opposite sequence of low-P and contact metamorphism is produced and peak temperatures can be generated even when pluton construction lasts for 5 Myr.

In comparing data of the Calabria crustal sections with results of under- and over-accretion models, the second option is preferred. Model results suggest also that the smooth transition from regional low-P to contact metamorphism may reflect upward pluton growth and concurrent exhumation by extensional tectonics.

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H6-7 Poster Spiess, Richard

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MELT PRESENT DEFORMATION OF THE MAFIC LOWER CRUST EXPOSED IN CALABRIA

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Key terms: lower crust; granulite facies; partial melting; melt segregation; shear zones

Introduction

In the Serre Massif of Calabria an about 8 km thick sequence of granulite facies rocks constitutes the lower crust of the former Variscan orogen. The base of this lower crustal section is made up of layered garnet-bearing meta-gabbros which are interspersed with lenses of metapelite and layers of metapyroxenites and meta-hornblendites (Moreti et al., 1978; Schenk, 1984). Single zircon conventional and spot U-Pb isotopic analyses place the age of the gabbroic protoliths into the Precambrian (Schenk, 1984, 1990; Micheletti et al. 2008).

The main metamorphic overprint under granulite facies conditions of the gabbros has occurred during the Variscan orogeny. Zircon dating constrained the metamorphic peak close to 300 Ma in coincidence with the emplacement of huge masses of granitoid magmas in the middle crust (Schenk, 1984; Caggianelli et al., 2000; Micheletti et al., 2008). Reaction microstructures have induced Schenk (1984) to infer that the lower crust of the Variscan orogen in Calabria was subjected to isothermal decompression immediately after the thermal maximum. He has deduced that the lower crust became decompressed from about 750 to 550 MPa at 800° C and then affected by slow isobaric cooling down to 200° C over the next 250 million years.

Acquafredda et al. (2008) have shown that decompression occurred during two different stages and involved a much thicker continental crust than previously assumed. Internally consistent thermodynamic modelling of the pre-decompression mineral assemblage results in 900° C and 1.1 GPa for the metamorphic peak conditions.

New data

We can now show that metagabbros became deformed under melt present conditions. This is evidenced by the occurrence of cm-thin shear zones wherein the partial melt was drained. Shear-zone development occurred in a general deformation regime, with shortening partitioned next to the shear zone resulting in an intense crenulation of the earlier Variscan foliation. Ti-rich pargasitic amphibole layers were involved in this crenulation deformation and recrystallized. Recrystallized amphiboles have the same chemical composition as those tracing the older layering. Application of the semi-quantitative "Ti-in-amphibole" geothermometer of Ernst and Liu (1998) to the recrystallized pargasites results in a deformation temperature of 870° C, whereas application of the amphibole-plagioclase thermometer (Holland & Blundy, 1994) results in temperatures of 818 to 857° C (in the pressure range 0.5 to 1 GPa). Minimum pressure conditions of 500 MPa can be assessed using the semi-quantitative Al-in-amphibole geobarometer of Ernst and Liu (1998). However, application of the crystal structure modelling geobarometer of Nimis & Ulmer (1998) to clinopyroxene in equilibrium with the plagioclase-rich melt of the shear zones shows that pressures during deformation have been rather close to 1 GPa. Melt present deformation of the mafic complex was followed by cooling starting from temperature conditions closely identical to that registered by the recrystallized amphiboles. Reaction seams of quartz+phlogopite around Opx suggest that a dehydration reaction of the type phlogopite (Phl) + quartz (Qtz) = orthopyroxene (Opx) + melt has been crossed backwards during cooling. Peterson & Newton (1989) place this reaction above 800° C.

Conclusion

The recognition that plagioclase/Cpx melt-bearing shear zones developed at about 1GPa pressure and 870°C temperature suggests that incipient melting of the mafic complex of the lower crust may have triggered the extensional tectonics in Calabria.

H6-8 Poster Micheletti, Francesca

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TIMING OF HIGH-GRADE SOUTH EUROPEAN VARISCAN EVOLUTION: CONSTRAINTS FROM TRACE ELEMENT PARTITIONING IN GARNET, ZIRCON AND ORTHOPYROXENE ON U-PB ZIRCON AGES.

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Key terms: south European Variscan evolution; trace element partitioning; in situ U-Pb zircon ages

U-Pb zircon ages and chemistries of zircon, garnet and orthopyroxene from different structural sites of a thin section of a granulitic rock from the Serre (Calabria, southern Italy) have been considered in order to reconstruct the evolution of a fragment of south European Variscides. The rock consists of Pl+Grt+Bt+Opx+Qtz+K-feld and accessories as zircon, apatite and opaques. The matrix shows layers containing different abundances of biotite and orthopyroxene. One porphyroblastic garnet (~3 cm in diameter) rimmed by a Opx+Pl+Bt+opaques+Zrn+Ap symplectitic corona occurs.

Ten zircon grains are exposed in the thin section: eight in the Bt-rich matrix, one within the corona and one in the rim of the garnet. Zircon shows generally core-rim structures. Frequently, zircon cores appear chaotic, consistently with modification induced by high-grade metamorphism and some are rimmed by unstructurless lobate rims, invading cores, commonly related to interaction with fluids and/or melts. U-Pb analyses have been performed in situ by LA-ICP-MS (IGG-CNR, Pavia). Two core domains of zircons from the matrix give the oldest concordant ages: 357±11 and 334±12Ma; five concordant data ranging from 324±12 to 320±11Ma give a mean concordia age of 323±2Ma. Two younger concordant ages (305±9 and 300±9Ma) are relative to low luminescent inner rims and similar apparent ages have been determined on luminescent zircon rims from matrix, symplectitic corona and garnet rim.

Trace element compositions were collected on specific domains of zircon, garnet and orthopyroxene in different textural sites by LA-ICP-MS. Two trace element profiles relative to porphyroblastic garnet were performed. Garnet is very rich in middle-REE and shows nearly flat profile in the core and fractionated pattern in the rim. The transition zone from core to rim (outer core) is poorer in HREE. Zircon is characterized by a steep pattern with low LREE and high HREE contents both in cores and rims in which, however, the MREE and HREE are lower than in garnet, apart from its outer core region. The orthopyroxenes show fractionated patterns of MREE and HREE.

The apparent DHREE between zircon-garnet and orthopyroxene-garnet pairs have been calculated and compared with literature data considered as suggestive of equilibrium relatively to natural samples and experimental results.

The calculated DREE_{Zrn/grt} and DREE_{Opx/grt} define linear and positive trends for zrn or opx/core and outer core combinations of grt evidencing regular, but variable partitioning and reaching even values higher than unity. So the calculated DREE values seem to be indicative of steps of approaching equilibrium.

The combination zrn rim/grt rim, instead, indicates disequilibrium suggesting that the zircon rim formed earlier than garnet rim, which subsequently broke down producing corona. The combination with the outer core of garnet gives higher D than the combination with the inner core suggesting, according to experimental results, lower temperature for the former; this is in agreement with the petrology.

The calculated DREE_{Opx/grt} approach those suggestive of equilibrium from Er to Lu in the combination opx matrix-grt core. The combination opx corona-grt rim is far from the equilibrium. Probably, orthopyroxene from corona is a residue of the matrix.

Accordingly, a well constrained contribution to PTt path relatively to fragments of south European Variscides emerges: the Variscan metamorphism of the lower part of the Serre crust section peaked much earlier than previously assumed (at least ~340Ma ago against 300Ma) and the multistage Variscan decompression after the metamorphic peak lasted tens millions of years, at least locally. The decompression probably protracted after 300Ma.

H6-9 Poster Carosi, Rodolfo

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U-TH-PB DATINGS OF VARISCAN SHEAR ZONES IN SARDINIACAROSI Rodolfo¹; MONTOMOLI Chiara¹; TIEPOLO Massimo²; FRASSI Chiara

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Key terms: Variscan belt; shear zone; geochronology; transpression

A transpressive geodynamic setting has been recognized since a long time in the Variscan belt of Sardinia (CAROSI & OGGIANO, 2002; CAROSI & PALMERI, 2002). Crustal scale shear zones and folds, with diffuse strain partitioning, have been well documented in the inner zone of the belt (CAROSI ET AL., 2004; IACOPINI ET AL., 2008; CAROSI ET AL., 2009). Only recently a similar geodynamic setting has been proposed for some other branches of the European Variscan belt (GIACOMINI ET AL., 2008; CORSINI & ROLLAND, 2009; GUILLLOT & MENOT, 2009). The overall change of the shortening direction in a large sector of the orogenic belt with the occurrence of increasing orogen-parallel displacement, may be regarded as a general mechanism affecting the exhumation of rocks and preventing the overthickened and thermally softened collisional crust from undergoing a diffused gravitational collapse. Shear zones represent efficient ways to exhume deep-seated rocks in collisional orogens (PASSCHIER & COELHO, 2006), transpressional belts (GOSCOMBE & GRAY, 2009; FRASSI ET AL., 2009) and extensional settings.

As consequences, assessing the geometry and kinematics of mylonitic belts provide important informations to individuate the mechanisms of exhumation (XYPOLIAS & KOUKOUVELA, 2001; LAW ET AL., 2004; CAROSI ET AL., 2006, 2010; LARSON ET AL., 2009) whereas the timing of shear activity is fundamental to constraint the tectono-metamorphic evolution of the exhumed rocks.

Several systems of shear zones have been distinguished in the inner zones of the Variscan chain in Sardinia pointing out opposite sense of shear (FRASSI ET AL., 2009). Structural relations point out that dextral shear zones deform sinistral ones.

U-Th-Pb geochronology has been applied on zircons and monazites sampled from both systems of shear zones.

The new isotopic data led to constrain at ~320 Ma the activity of both systems so that a switch from the sinistral simple-shear- to the dextral pure-shear-dominated regime has to be invoked. The dextral shear belt remained active at upper structural levels before the emplacement of the larger part of the late Variscan batholith.

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H6-10 Poster Cruciani, Gabriele

10.1474/Epitome.04.0677.Geoitalia2011

PETROPHYSICAL PROPERTIES OF VARISCAN MYLONITIC LEUCOGRANITE OF MONTE GRIGHINE, WEST-CENTRAL SARDINIACOLUMBU Stefano¹; CRUCIANI Gabriele¹; FANCELLO Dario¹;FRANCESCHELLI Marcello¹; SPANO Maria Elena¹

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Key terms: Petrophysical properties; Protomylonite; Ultramylonite; Monte Grighini; Real density, Porosity

Monte Grighini Complex consist of a pile of variscan Nappes and of a suite of granitoid rocks, mostly tonzogranite and leucogranite (Musumeci, 1992), that intrudes the tectonic unit of Monte Grighini. Rb/Sr and Ar/Ar radiometric data give, for granitoid rocks, an age of about 305-300 Ma (Carmignani et al., 1987; Laurenzi et al., 1991). A late variscan shear zone affects the SW side of the complex and produces a wide cataclastic and mylonitic zone, along which leucogranite can be mostly found. In this zone an outcrop, that shows a rapid change in the intensity of mylonitic deformation, has been investigated in detail. The outcrop is affected by a pervasive N162-170° foliation dipping 60-65° W.

Petrographic and XRD analysis show the following mineralogical assemblage: quartz, k-feldspar, plagioclase (albite), muscovite, biotite, iron oxides and ± tourmaline ± apatite ± zircon ± epidote. Almost all samples are characterized by k-feldspar porphyroclasts in a quartz-phyllonitic matrix.

On the basis of porphyroclast/matrix ratio protomylonite, mylonite and ultramylonite layers have been identified. In protomylonitic layers k-feldspar phenocrysts are fractured and sometimes perthitic. Quartz occurs in microcrystalline lens and bands following the foliation. Phyllonitic matrix consists of biotite, subordinate muscovite and chlorite. Mylonitic layers are similar to the previous ones but show a decrease in grain-size. Ultramylonitic layer consists of rare k-feldspar relics in a very fine-grained phyllonitic matrix.

The following physical properties have been determined in 12 series of samples with varying degree of deformation: the open porosity, the total porosity, the real and apparent density, the water imbibition coefficient, and the water saturation index. To calculate the closed and total porosity

the real density of ground samples were determined. The ultrasonic velocity of the studied samples has been determined in three directions: 1) perpendicular to the foliation, 2) parallel to the foliation and to the direction of mineral stretching lineation, 3) parallel to the foliation and perpendicular to the direction of mineral stretching lineation. The overall results indicate that the samples of protomylonite, mylonite and ultramylonite have different physical properties values. The average values of the real density of samples vary from a minimum of 2.66 ± 0.02 g/cm³ in the protomylonitic samples, to a maximum of 2.72 ± 0.01 g/cm³ in the ultramylonitic samples. The mylonitic samples show intermediate values with an average of 2.68 ± 0.01 g/cm³. The open porosity shows a similar trend; it ranges from $4.1 \pm 0.2\%$ in the protomylonitic samples, to $6.3 \pm 0.9\%$ in the mylonitic samples, to $9.2 \pm 0.5\%$ in the ultramylonitic samples. Therefore, there is a positive correlation between the degree of mylonitization and these physical parameters.

The ultrasonic velocity values show on one side of the greater porosity of ultramylonites than proto-mylonites and mylonites, on the other side confirm a higher anisotropy degree in the ultramylonitic samples revealed perpendicular to the foliation. Preliminary results seem to suggest a relationship between the petrographic and petrophysical characteristics of the layers.

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H6-11 Poster Cruciani, Gabriele

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P-T EVOLUTION OF THE METABASITE WITH ECLOGITE-FACIES RELICS FROM PUNTA DE LI TULCHI (NE SARDINIA, ITALY) AS REVEALED BY THE PETROLOGICAL APPROACH OF PSEUDOSECTIONS

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Key terms: Metabasite; Eclogite facies; P-T pseudosection; Variscan orogeny; Sardinia

The Punta de li Tulchi metabasite crops out as a N80/60-oriented decametric lens, hosted in the migmatites of the High Grade Metamorphic Complex in NE Sardinia. The metabasite consists of brownish clinopyroxene + garnet (Cpx+Grt) layers alternated to greenish amphibole + plagioclase (Amp+Pl) layers from a few centimeters up to 50 cm in thickness (Franceschelli et al. 1998, Min. Petrol., 62, 167-193). The Cpx+Grt layers mainly consist of millimetric garnet (with inclusions of omphacite) embedded within a fine-grained clinopyroxene + plagioclase symplectite matrix. Orthopyroxene also occurs in these layers, as well as minor amphibole and quartz. Garnet in contact with symplectite is rimmed by amphibole + plagioclase coronas.

The Amp+Pl layers consist of millimetric to submillimetric-sized white pods of plagioclase + amphibole + garnet relics set in a amphibole-rich matrix. Less abundant minerals in these layers are quartz, titanite, ilmenite, rare biotite, and chlorite.

Four main metamorphic stages have been recognized basing on microstructural features: (i) a M1 pre-symplectite stage, (ii) a M2 symplectite stage, (iii) a M3 coronitic stage, and (iv) a M4 late retrograde stage.

The pre-symplectite (M1) and symplectite (M2) stages have been modeled using the P-T pseudosection approach in the NCKFMASH model system (calculated in the range 550-950°C and 1-25 kbar, at aH₂O=0.5), and using the bulk rock composition of a representative Cpx+Grt layer. Garnet core composition and Na content in omphacite allow to define a M1c stage at T=610-640°C and P up to 17 kbar corresponding to the field Cpx+Amp+Grt+Bt+Qtz+Rt. Garnet compositional zoning indicates a progressive increase in both temperature and pressure during garnet growth from the M1c stage up to a M1r stage (T=620-660°C; P=19-22kbar), allowing to reconstruct a prograde segment of the P-T path. The peak pressure was reached in the M1r stage under amphibole-eclogite-facies P-T conditions. As revealed by the composition of the symplectitic minerals, the M1r stage was followed by heating and decompression, resulting in the formation of clinopyroxene + plagioclase symplectite (M2 stage) at T=750-800°C and P=9-12 kbar (granulite-facies conditions).

The coronitic stage (M3) has been modelled in the NCFMASH model system at aH₂O=1.0 by using the bulk composition of the effectively reacting microdomain, calculated from mineral compositions and stoichiometric coefficients of the corona-forming reaction. By comparing the measured composition of coronitic minerals with the modeled compositional isopleths, amphibolite-facies P-T conditions (T = 580-640°C, P = 5-7 kbar) have been obtained for this stage.

The P-T conditions of the M4 stage can be estimated at about 300-400°C and <2-3kbar.

The P-T path reconstructed for the Punta de li Tulchi metabasite has significant analogies with that described by Giacomini et al. (2005, Lithos, 82, 221-248) for the retrogressed eclogite of Golfo Aranci, NE Sardinia, and with that of the Punta Orvili metabasite from the Metamorphic Complex with Mainly Amphibolite Facies Assemblages described by Cruciani et al. (2011, Lithos 121, 135-150).

H6-12 Poster Cuccuru, Stefano

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THERMAL MODELING OF THE SARDINIA VARISCIDES

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Key terms: HT-metamorphism; Corsica-Sardinia Batholith; Thermal modeling; Matlab

This note focuses on the thermal evolution of the Sardinian Variscan crust

during the post-collisional stage. One-dimensional thermal modeling has been performed by a Matlab-derived code (geothermMOD1.2), which allows us to simulate the past crustal geotherms for a given model crust with variable distribution of heat-producing elements such as ²³⁸U, ²³⁵U and ⁴⁰K. Heat flow is assumed to be controlled only by conduction, hence geotherms have been calculated by solving the second-order partial differential equation $d^2T/dz^2 = -A/z$ (1), where the term A represents the heat-production rate [W/m³], z is depth [m] and T is temperature. The term A is calculated from the content, within each layer, of ²³⁸U, ²³⁵U and ⁴⁰K at the relevant model times. The past vertical distribution of these elements is inferred from a data sets including about 400 samples acquired directly in the field with a portable NaI(Tl) gamma-ray spectrometer, and about 100 samples measured in laboratory with a HPGe spectrometer. In a first step, the heat-production rate of each layer is calculated at the model age by back-correcting for the radioactive decay. The corrected A values and two boundary conditions T₀ = surface temperature [°C], and Q_b = basal heat flow [W/m²], were finally used to solve numerically the eq. (1).

The evolution of the Variscan crust of north Sardinia has been modeled by two sets of numerical experiments covering the time span 350-280 Ma. In the first group of experiments, which address a fully crustal evolution, Q_b is assumed to be constant throughout time within each experiment. The value of Q_b increases linearly with time in the second set of experiments, to simulate an increasing heat flow contribution from the mantle. In all experiments, crustal sections are designed at 320, 310, 300 and 285 Ma with specified thickness, whereas the geometry is based on present-day seismic profile, and Al-in hornblende barometry of dated granitic plutons. The validity of the two models, i.e. the 'fully crustal' and the 'mantle contribution' ones, is checked out by comparing the experimental geotherms with the available petrological data sets.

H6-13 Poster Padovano, Matteo

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ANALOGUE MODELS VS GEOLOGICAL STRUCTURES: THE STUDY CASE OF NE SARDINIA (ITALY)

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Key terms: Analogue models; NE Sardinia; Variscan

Recent studies defined that the emplacement of the Variscan HT metamorphic rocks outcropping in NE Sardinia occurred in a transpressional tectonic regime, induced by the oblique collision of Gondwana derived terranes with Laurussia during the Middle-Upper Carboniferous. The possibility to exhumate deep crustal rocks by compressional/transpressional kinematics has been tested through an experimental approach based on the production of several analogue models. They consist of three layers, put one on the top of each other: the bottom and the middle layers are made of plasticines with a power-law rheology simulating the behaviour of lower and middle crust; the uppermost layer consists of sand, in order to simulate the brittle behaviour typical of the upper crust. The models have been thus deformed by a thermomechanical apparatus, located at the "Institut für Geowissenschaften Johann Wolfgang Goethe-Universität, Frankfurt am Main", that induced compression coeval to orthogonal extension, following different finite strain percentages. The temperature and the strain rate conditions have been set in order to generate a viscosity contrast between bottom and middle layers of 2/3 orders of magnitude, reproducing thus the real viscosity contrast deduced for the lower and middle continental crust.

The experiments performed at 20% and 30% of finite strain show processes of cylindrical folding, while at higher finite strain conditions (40% and 50%) the processes of uplift of the lower crust become dominant. In fact, from the observation of cross sections perpendicular to the direction of extension, it is possible to notice that the uplift of the lower crust starts at 40% of finite strain and becomes even more evident at higher strain conditions (50%). The uplift is facilitated by the development of brittle/ductile shear zones which attract the deepest material to shallower levels, (i.e. processes of telescoping), leading in some cases to the formation of laccolith-like structures. The observation of sections parallel to the direction of extension, at the same finite strain conditions, highlights a dome-type geometry, where the long axis of the dome is parallel to the main direction of extension of the system. The top view of the models shows that the fractures responsible for the telescoping processes described above, are characterized by lateral displacements and reproduce en-echelon structures.

Being aware that the analogue models represent an oversimplified representation of natural cases, it is nevertheless possible to outline some correlations between experimental structures and geological observations:

- 1) The dome-type geometry obtained with the experimental approach has been already proposed in literature, on the basis of geological-structural data, for the High Grade Metamorphic Complex (HGMC) of Sardinia; 2) The Variscan granitic bodies of southern Corsica and NE Sardinia are bounded by sets of shear zones which often show lateral displacements and resemble en-echelon structures; 3) Several geological cross sections of the HGMC show that the contacts between high-grade and middle/low-grade Variscan units are often overturned. The same geometries are observable in numerous cross sections of the analogue models, where the lower crust overrides the middle one during its uplift driven by the development of shear zones; 4) The laccolithic bodies observed in the models are directly observable in the HGMC of Sardinia (i.e. Capo Ferro area), where Variscan syn-tectonic granitoids are emplaced within regional shear zones.

The results obtained by the analogue models, compared with the natural geological structures, confirm and strengthen the hypothesis that the HT Variscan rocks of NE Sardinia could have been exhumed by the action of regional shear zones, which developed under a main transpressional tectonic regime.

H6-14 Poster Franceschelli, Marcello

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PETROGRAPHICAL AND GEOCHEMICAL CHARACTERIZATION OF A METAVOLCANIC-SEDIMENTARY SEQUENCE IN THE VARISCAN CHAIN OF NE SARDINIA, ITALY

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Key terms: Metavolcano-sedimentary; Paleozoic; Geochemistry; Variscan Chain; Sardinia

An interesting metre-sized metavolcano-sedimentary sequence was discovered a few km south of the Lula village during a geo-petrographical survey within the Variscan Chain in NE Sardinia. A detailed petrographical and geochemical study of the collected samples allowed eight different layers from bottom (Layer A) to top (Layer H) in that sequence to be distinguished.

Layer A, a few decimetres thick, is rich in 4-5 mm-long albite crystals, showing submillimetric muscovite inclusions and ubiquitous epidote overgrowths, locally concentrated in the crystal cores. A submillimetric matrix made up of quartz, albite to oligoclase grains, chlorite, muscovite, epidote and minor chloritized biotite surrounds the albite phenocrysts. The main foliation is defined by muscovite, chlorite and minor Fe-oxides. Epidote occurs as anhedral 0.2-0.3 mm-sized zoned crystals when scattered in the matrix, and as patches with patchy zoning when replacing albite. Rounded apatite grains also occur.

Layer B, 5-8 cm-thick, albite-rich, light-coloured, consists of an aggregate of several micrometric (<50 microns in size) albite grains enveloping 2-3 mm-sized albite crystals. The foliation is defined in the matrix by biotite-chlorite-Fe-oxide trails. Quartz occurs as submillimetric-thick veins or as clusters of anhedral grains. Apatite and monazite also occur.

Layer C, 10 cm-thick, similar to layer A as regards microstructural features, differs from it for higher phyllosilicate content, widespread occurrence of late-crosscutting muscovite, more pronounced foliation, more evident microfolds and quartz-filled veins.

Layer D, 20 cm-thick, light-coloured and poorly foliated, shows up to 1.5-2.0 mm-sized albite crystals surrounded by a quartz-albite matrix, with a grain-size <70-100 microns and albite/quartz ratio ~1, including poorly oriented scattered muscovites, clusters of chloritized biotites, apatite and Fe-oxides.

Layer E: thin, cm-thick dark metapelite bed.

Layer F, 40 cm-thick, shows almost the same microstructural features exhibited by Layer A.

Layer G, 15 cm-thick, medium/coarse grained, contains 5x2 mm-sized albite crystals embedded in a quartz-albite-chlorite-biotite foliated matrix. Unlike layer A, muscovite is rare; neither epidote growth, nor inclusions in albite were observed.

Layer H, 40-45 cm-thick, is characterized by up to 0.7-0.8 cm-sized albite porphyroblasts with several inclusions of titanite, epidote, chlorite and apatite. The quartz-albite matrix is striated by elongated muscovite-chlorite-chloritized biotite S2-oriented trails. A relict foliation is revealed by preserved microfoliations.

The Lula layers, compared with the Lower Paleozoic paragneisses and Ordovician metapelites from Sardinia reveal: 1) a strong enrichment in Na₂O and depletion in CaO, K₂O, Rb, Ba, that could suggest an albitization process of the whole sequence and in particular of the Layer B, whose composition is almost pure albite; 2) major and trace element contents similar to those of the Sardinian metavolcanites, the nearest ones, and significant differences with the farther Sarrabus-Gerrei metavolcanites; 3) some low SiO₂, high Al₂O₃ and V contents suggesting a possible contribution of a clay component to a probable altered volcanic or volcanoclastic protolith; 4) high contents of FeOtot, MgO, Cr, Co, Ni indicating a significant mafic component in the protolith; 5) a significant depletion in P₂O₅, LREE, HREE, Th, U that could be explained in two ways: a) they are original features of the igneous protolith; b) they are the product of alteration or sedimentary reworking processes of an igneous protolith. Further research is needed to clarify which is the correct hypothesis.

H6-15 Poster Perotti, Cesare

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PERMIAN STRATIGRAPHY FROM SELECTED CONTINENTAL REGIONS OF SOUTHERN EUROPE: PALAEOGEOGRAPHIC AND GEODYNAMIC IMPLICATIONS

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Key terms: Southern Alps; Late Palaeozoic; Interregional correlation; Geodynamics

The Late Palaeozoic South-Alpine successions can be subdivided into two main and well differentiated tectono-sedimentary Cycles, which are separated by a regional unconformity sealing a gap of as-yet imprecise duration (10 to 20 Ma).

In the Southern Alps, which represent the main reference sector of this review and, more generally, in the selected south European or western Mediterranean areas, these cycles mirror two very different "worlds" in terms of tectonics and sedimentation.

The Lower Cycle, up to a maximum thickness of more than 2000 m, consists of calc-alkaline, acidic-to-intermediate igneous products and alluvial-to-lacustrine sediments, both infilling fault-bounded intracontinental basins, generally interpreted as strike-slip or pull-apart basins affected by a transcurrent regime. Based on palaeontological evidence (macro-microfloras and tetrapod footprints) and isotopic ages, this Cycle ranges from the Carboniferous (Moscovian) to Early Permian (Kungurian).

The Upper Cycle, which is devoid of volcanics, is wider but less thick than the Lower Cycle and dominated by an extensional regime linked to the Variscan crustal thinning. It mainly includes the Mid?-Late Permian Verrucano Lombardo/Val Gardena Sandstone fluvial red clastics (up to about 800 m thick), in part laterally and upwardly replaced, east of Val d'Adige, by gypsum-bearing sabkha sequences and the shallow-marine carbonate of the Bellerophon Formation. According to many authors, this Cycle is regarded as the beginning of the "Alpine Cycle".

The comparison with some continental successions in southern Europe allows to reconstruct their evolution and set up correlations. A marked stratigraphic gap shows everywhere between the aforementioned Cycles.

As in the Southern Alps, it began during the Middle Permian, near the Illawarra Reversal geomagnetic event (~265 Ma). In western Europe, however, as in Provence and Sardinia, this gap persists upwardly to Late Permian and Early Triassic or slightly younger times, even though in northeastern Spain (Iberian Ranges, Balearic Islands) it is generally interrupted by late Guadalupian to Lopingian deposits.

The major regional angular unconformity between the two Permian cycles was probably caused at least in part by a deformation pulse, which

induced faulting, gentle folding, uplift and erosion or non-deposition. This tectonic event, connected to the transformation from a strike-slip to an extensional tectonic regime, and to a change of the relative plate directions, can be related to the so-called "Mid-Permian Episode". Therefore, in this geological context, the above Cycles reflect two main geodynamic events, which are respectively characterised by the Late Carboniferous-Early Permian transformation of the Gondwana-Eurasia collisional margin into a diffuse dextral transform margin and the Middle-Late Permian opening of Neotethys, with the onset of a generalised extensional tectonic regime and a progressive westward marine incursion.

In our reconstruction this dextral megashear between Gondwana and Laurasia should be due to the onset of the subduction of the Palaeotethys active oceanic ridge. The dextral shear would be induced and supplied by the nature of the triple junction itself, and is compatible also with the classical Pangaea A configuration.

SESSIONE I1

Geochimica dei fluidi in ambiente idrotermale e vulcanico: metodi ed applicazioni per prospezione geotermica, rischio vulcanico ed impatto ambientale

I1-1 Orale Voltattorni, Nunzia

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STUDY OF THE GEOTHERMAL POTENTIAL OF TETITLAN AREA (NAYARIT, MEXICO) USING FLUX AND SOIL-GAS GEOCHEMISTRY

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Key terms: soil-gas geochemistry; geothermal system; degassing estimation

The soil-gas method has been widely used to infer the nature of subsurface geology/geochemistry since gases released from active geothermal systems, can freely rise through overlying cover to be detected in the near-surface. The high mobility of some gases makes them the best pathfinders for concealed natural resources. Indeed, the gases produced and/or accumulated in geothermal reservoirs can escape towards the surface by diffusion, through transportation by rising hot fluids and by migration along fractures and faults.

The Tetitlan area (Nayarit, Mexico) has been investigated by CFE (Comisión Federal de Electricidad) since nineties by means of exploratory wells for geothermal purposes and gravimetric prospectings. On the basis of obtained results, a potential deep geothermic reservoir has been inferred in spite of the scarcity of evident surface manifestations (e.g., hot springs, vents).

A total of 154 soil-gas samples and 346 CO₂ and CH₄ flux measurements were collected in an area of 72 square kilometres. The performed soil-gas and flux geochemical surveys highlighted a general rising patterns linked to local fault system. Experimental variograms confirmed the presence of anisotropies highlighting different spatial domains. The contour maps elaborated on the basis of the calculated experimental variograms, demonstrated that gas emission at the surface is not spatially heterogeneous within studied area with the important implication that the highest fluxes, as well as concentrations, could be used in undeveloped geothermal systems to identify main upflow regions and areas of increased and deep permeability.

Further, the total natural gas emission has been calculated in order to estimate the exploitation potential of the inferred system. The overall calculated levels of CO₂ and CH₄ emissions (2.35 10⁴ t/day and 6.6 10³ t/day, respectively) from the Tetitlan system is found to remain within the range of normalized emissions measured for geothermal, volcanic, non-volcanic and hydrothermal systems worldwide.

I1-2 Orale Carapezza, Maria Luisa

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CARBON DIOXIDE DIFFUSE SOIL DEGASSING: A PRECIOUS TOOL FOR IDENTIFYING PRODUCTIVE GEOTHERMAL RESERVOIRS

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Key terms: geothermal exploration; diffuse CO2 soil flux; evaluation of reservoir permeability

In geothermal exploration it happens rather frequently that deep wells find high temperatures but are not productive because they don't cross any permeable fractured reservoir. Because of the high cost of deep drillings, this aspect represents one of the main economic risk of geothermal exploration. The aim of this paper is to show that a detailed survey of diffuse CO₂ soil flux allows to identify from the surface the permeable portions of a deep-seated actively degassing geothermal reservoir, drastically reducing that risk. The first application of the method has been made in the Quaternary Latera caldera, North of Rome. We will show that productive wells were all located on high CO₂ flux zones, whereas the not-productive wells were sited on low flux areas. In addition the survey allows to identify some as yet unexplored portions of the geothermal reservoir where future wells should be conveniently located. The same technique has been applied in the geothermal exploration of Platanares and Azacualpa, Honduras and of Las Pailas, Costa Rica. Obviously, CO₂ flux cannot provide any estimate of temperature at depth, which has to be assessed with other geochemical or geophysical exploration techniques.

I1-3 Orale Ricci, Tullio

10.1474/Epitome.04.0685.Geoitalia2011

EXTENDED FLUID GEOCHEMISTRY INVESTIGATIONS AT TURRIALBA VOLCANO, COSTA RICA

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Key terms: Turrialba volcano; fluid geochemistry; diffuse degassing; hazard assessment

Turrialba volcano (3340 m a.s.l.) is a stratovolcano located in the Easternmost sector of the Cordillera Central (Cartago Province, Costa Rica). Its volcanic products belong to the calcalkaline serie, ranging from basaltic andesites to dacites. The eruptive activity of the past 10 ky is mainly characterized by Strombolian to sub-Plinian eruptions. Turrialba volcano last erupted in 1864-66. Since 1996, after 150 years of quiescence, it progressively underwent deep modifications like the appearance of new fumaroles and fractures, the increasing in the fumaroles temperature and gas discharge as well as of deep magmatic components and seismicity. On the 4th of January 2010 volcanic activity reached its peak with a series of phreatic explosions occurred at the South-West crater. Turrialba volcano is presently considered to be in a phase of eruptive unrest showing signs of potential reactivation.

The final goal of our surveys in a such a delicate phase was the evaluation of the present volcanic activity at Turrialba volcano through extensive geochemical surveys, considering that fluid geochemistry of high-temperature fumaroles, gas plume, and diffuse soil gas are precious tools in evaluating the state of the volcano.

Two field works were carried out by the Authors in the past three years. The first one, on March 2008, was a preliminary study mainly addressed to understand if the damages to the vegetation along the volcano Western flank were caused by diffuse gas emission from the soil rather than from windborne plume gases. Soil gas samplings and an extended CO₂ soil diffuse degassing coupled with soil T measurements in the crater area were carried out. In addition 5 profiles across Ariete fault, a major volcano-tectonic feature located on Turrialba's Southern flank, were performed. The March 2011 investigation was a comprehensive and more detailed geochemical study and it consisted on the repetition of the 2008 survey with the purpose of comparing the two datasets and to define the new degassing path system in the summit area. Chemical and isotopic analyses from sampled soil, fumaroles and plume gases were performed in order to provide a geochemical model of the volcanic degassing system. A total of 973 CO₂ soil flux and soil T measurements on a surface of 0.81 km² (840 measurements and 0.78 km² on 2008) were carried out in the crater area on a nearly regular grid of 30 m spacing permitting to realize detailed CO₂ soil flux and T maps. The total CO₂ diffuse degassing output obtained for the 2011 survey is 277.4 tons/day (308.6 tons/day on 2008, before the opening of the phreatic vent acting as a preferential gas discharge pathway as inferred from the T map). In 2011, 5 CO₂ soil flux and T profiles were carried out on the volcano Southern flank across the Ariete fault and in its proximity showing CO₂ and T anomalies on 4 profiles whereas on 2008 only the 3 uppermost profiles were characterized by anomalous values displaying the down slope expansion of hydrothermal activity. Soil gas was sampled on 229 sites and then analyzed by means of a portable gas analyzer. Furthermore 10 fumaroles (Tmax 470°C) were sampled in order to define their chemical composition and the isotope ratios of He, C, Ar, dD and d18O while the plume was sampled to characterize its F, Cl, Stot, and metals content.

In order to define the expected eruption, of primary importance for the hazard assessment, the identification of the magma likely present in the feeding system of Turrialba volcano by volcanological studies and their petrological and geochemical characterization are needed. In addition its reology and fluid content have to be investigated by experimental petrology studies.

I1-4 Orale Coppola, Diego

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APPROACHING 10 YEARS OF RADON MEASUREMENTS AT STROMBOLI VOLCANO

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Key terms: radon gas; RADON network of stations; STROMBOLI; threshold, anomaly; Multiple Linear Regression statistic

Radon emissions at Stromboli volcano, were collected by means of different, passive, measurements since May 2002. A network of 21 sampling sites has been deployed onto the NE sector of the island. Periodic measurements with track-etch detectors and EPERM electrets allowed us to record variations in radon emissions during 2002-2007. The large dataset acquired by using EPERM electrets gave us the opportunity to perform a statistical analysis to detect background and threshold values, as well as anomalies for each measurement site. However, considering the entire network and data set, radon activity values were ranging (in space and in time) from 0.3 to 30 kBq/m³. Results confirm a close relationship between volcanic activity and 222Rn concentrations and shows that structural alignments (such as faults and fracture systems) represent a preferential pathways for radon migration toward the surface, particularly those that rim the crater area. These fractures may be affected by periodic self-sealing likely due to variable degassing regimes.

Since May 2007 we installed two real-time, fully-automated stations measuring radon concentrations, soil temperature and atmospheric pressure at selected sites. Data were acquired every 15 minutes. The two automatic stations were deployed within the summit area (named PZZ at 890 m a.s.l.), and nearby an historical eruptive fissure (LSC at 500 m a.s.l.). Average radon values are 12 kBq/m³ and 1.7 kBq/m³, respectively.

Negative correlations are observed between radon emissions, soil temperature and, to a lesser extent, atmospheric pressure. In contrast, an increase in radon concentrations have been observed during periods of higher rainfall conditions. Therefore, trends in radon concentrations may be decoupled from those of other geochemical parameters (CO₂ fluxes and CO₂/SO₂ plume ratios) during periods of heavy to moderate rainfalls. Multiple Linear Regression statistics (including the effects of tidal forces) led us to compute the residuals given by the difference of measured and calculated 222Rn concentrations. The cross-check between the daily measured radon activities and the absolute variations in radon residuals, for the data collected at the summit station, give us the opportunity to suggest a methodological approach that can be used in the attempt of predicting some major changes in volcanic activity.

I1-5 Orale Donnini, Marco

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QUANTIFICATION OF CO₂ DEGASSING AND MODELLING OF BAGNI SAN FILIPPO GEOTHERMAL SYSTEM (TUSCANY, ITALY).

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Key terms: CO₂ degassing; thermal water; conceptual model; physical model

The area of Bagni San Filippo is located in the NW periphery of the Mt. Amiata volcano, in the eastern side of the Siena-Radicofani graben, is part of the Mt. Amiata geothermal region and is located within a regional CO₂ flux anomaly interesting the whole Perityrrhenian sector of central Italy. The geological framework of BSF is characterized by outcrops carbonate-evaporite triassic-giurassic formations in the western side and by ligurides flysch overlying the carbonate-evaporite sequence on the eastern side. BSF is affected by a strong and widespread CO₂ emission that emerges as vents, diffuse soil emissions, large travertine deposits and as CO₂ rich thermal water outflows of HCO₃⁻-SO₄²⁻-Ca-Mg composition and temperatures from 23 to 48°C. The strong CO₂ emission represents a natural hazard in the area as indicated by the lethal accidents occurred to humans also in recent times. A multi-parametric geochemical study of the BSF area was performed in order to quantify the CO₂ degassing, to define the conceptual model of the degassing process and to constrain a physical-numerical modeling of the system. A general soil CO₂ flux survey showed the presence several degassing structures that were investigated by specific surveys. The mapping of CO₂ flux, by geostatistical method, highlighted that the larger CO₂ degassing structures are associated to faults involving the carbonate formations and to areas of actual or "fossils" water outflow (i.e., where travertine outcrops). A total CO₂ release of about 200 t/d was estimated. A geochemical reaction path model of water-rock-gas interaction was then applied to the thermal waters in order to model the dissolved carbon content and the composition of dissolved gas. The comparison of experimental data with the model supports that the thermal waters are the result of the mixing between shallow groundwater and a hot, CO₂ rich, vapour phase reasonably derived by an underlying geothermal system. Coupling together the results of the CO₂ flux survey with geochemical, hydrogeological and geological data the following conceptual model was derived for upper part of BSF system: the groundwater recharge, from local carbonate outcrop, infiltrates and circulates in the buried carbonate aquifers where it is heated (up to 60°C) and enriched in CO₂ (up to 10 bar of P_{CO₂}) by the input of geothermal vapor. This anomalous and relatively shallow aquifer feeds both CO₂-soil degassing and the thermal water outflow. The physical feasibility of such conceptual model was successfully tested by a physical-numerical simulation using the TOUGH2 code.

I1-6 Orale Frondini, Francesco

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ELEMENTAL FLUXES AND ADVECTIVE HEAT FLOW ASSOCIATED TO THE REGIONAL GROUNDWATER FLOW IN THE NARNI-AMELIA AQUIFER SYSTEM (CENTRAL ITALY).

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Key terms: aquifer; heat flow; carbon dioxide

The elemental fluxes and the heat flow associated to large aquifer systems can be significant both at local and global scale. In fact, the large amounts of heat transported by regional groundwater flow can cause changes in the subsurface thermal regime, and the amount of matter discharged toward the surface by large spring systems can be significant if compared to the elemental fluxes of surface waters. The Narni-Amelia regional aquifer system (Central Italy) discharges toward the surface more than 13 m³/s of groundwater characterized by a slight thermal anomaly, high salinity and high PCO₂. During circulation in the regional aquifer, groundwater react with the host rocks (dolostones, limestones and evaporites) and mix with deep CO₂ rich fluids related to the mantle degassing process that characterize Tyrrhenian Central Italy. This processes cause the transfer towards the surface of large amounts of dissolved substances, in particular carbon dioxide, and a considerable amount of heat. Considering that practically all the water circulating in the Narni-Amelia system is discharged by few large springs (Stifone-Montoro), the enthalpy of these springs can give a good estimation of the total heat transported by advection from the entire system towards the surface. By means of a detailed mass and energy balance of the aquifer, and considering the soil CO₂ fluxes measured from the main gas emission of the area, we computed for the whole Narni-Amelia system a total CO₂ discharge of about 900 t/d and an average heat flow of 554 ± 120 mW/m². The CO₂ discharge is relevant both at local and global scale and it is comparable to the gas discharged by several active volcanoes. The advective heat flow is much higher than the conductive regional heat flow and is of the same order of magnitude of the heat flow measured in geothermal areas of Tyrrhenian Central Italy.

I1-7 Orale Granieri, Domenico

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DISGAS, A NEW MODEL FOR PASSIVE GAS DISPERSION. EARLY APPLICATIONS FOR THE WARM GASES EMITTED BY SOLFATARA (CAMPI FLEGREI, ITALY)

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Key terms: Gas dispersion; Carbon Dioxide; Solfatara (Campi Flegrei);

Disgas; Greenhouse gas

A model to describe the cloud dispersion of gas denser than air is presented here. The dispersion of heavy gas is basically governed by the gravity but, when the density contrast (gas vs air) is not important the dispersion is controlled by the wind and atmospheric turbulence (so-called "passive dispersion"). DisGas is a model for dense gases which are dispersed under passive conditions, based on the full solution of the advection-diffusion equations for the gas concentration (Sankaranarayanan et al., 1998). The wind field can be assumed with a horizontally uniform profile calculated in accord to the Monin-Obukhov similarity theory or it can be estimated by the so-called DIAGNO, a Diagnostic Wind Model (DWM) developed by the US Environmental Protection Agency, the latter option requiring topographic data, average wind and atmospheric stability information within the computational domain. The model is able to forecast gas dispersion over large and complex terrain. Following the study of Costa et al., (2005), we present here an application of DisGas on the gas dispersion from the crater of Solfatara (Campi Flegrei) which releases a large quantity of CO₂ into the surrounding densely-inhabited areas. For the simulated cases, the soil CO₂ flow rate was assumed to be about 800 ton/day, such as the average of twelve different surveys carried out in the period 1998 to 2008 (Chiodini et al., 2010). Local atmospheric dynamics (3-components of the wind, friction velocity, Monin-Obukhov length) were derived by a two-year period of observations with micrometeorological technique inside the Solfatara crater. Our main finding showed that the urban area of Naples is affected by the CO₂ buildup above the normal air CO₂ content for this "natural" contribution, particularly in the no windy nocturnal situation. Estimated values show the absence of any risk to the population safety at the present emission rate but suggest that volcanic CO₂ contributes towards deteriorating and warming the urban air of Naples. DisGas model is able to simulate the dispersion of a heavy warm gas accounting for obstacles, topographic effects, variation of atmospheric conditions and wind direction. So, a possible application is the cloud dispersion of pollutant and/or greenhouse gases emitted by industrial chimney over urban or suburban environmental.

I1-8 Invitato Inguaggiato, Salvatore

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FLUXES OF VOLATILES DISCHARGED FROM OPEN AND CLOSED VOLCANOES SYSTEMS: A CASE OF STROMBOLI AND VULCANO ISLANDS (AEOLIAN ARCHIPELAGO, ITALY)INGUAGGIATO Salvatore¹
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Key terms: Geochemical Monitoring; CO₂ fluxes; Stromboli volcano; Vulcano Island; SO₂ fluxes

Stromboli is an open conduct volcano characterized by "Strombolian" activity. This activity is the result of a "delicate" dynamic equilibrium between continuous refilling of deep volatiles exsolved from the magma batch and superficial degassing. In particular, the main peripheral manifestations are represented by dissolved volatiles in the basal hydrothermal aquifer, as well as structurally controlled soil degassing at the lower parts of the volcanic edifice. Summit degassing is manifested by active and passive degassing. During "normal" Strombolian activity this dynamic equilibrium allows the discharge of the volatiles in the atmosphere arriving from the depth. During overpressure of the plumbing system, paroxysmal activity is necessary to maintain the dynamic pressure equilibrium, so allowing the dynamic equilibrium between deep and superficial volatiles. In fact, through the opening of new fractures and consecutive lava flow or by major explosions and paroxysms the system decreases the total pressure of volatiles and restores the dynamic equilibrium of the Stromboli plumbing system. On the basis of the experiences acquired during the last two eruptions (2002-2003 and 2007) we improved our geochemical monitoring network by installing new equipments for remote continuous monitoring. In particular, we installed an automatic equipment for measuring dissolved CO₂ in the thermal well located in the N-E side of Stromboli (Stromboli village) and two UV-scanning DOAS to measure SO₂ plume fluxes.

Vulcano is characterized by a solphataric activity state since the last eruption occurred in the 1888-90. Total CO₂ output discharged from fumaroles, soil gases, bubbling and water dissolved gases was estimated. The preliminary results indicate an overall output of about 500 t/day of CO₂ from the island. The main contribution to the total output is from the summit area of the active cone (453 t/day) being 362 t/day and 91 t/day from crater fumaroles and crater soil degassing, respectively. These preliminary data allow the estimation of the background mass release and related thermal energy from the volcanic system and represent the first complete data set, collected during moderate volcanic activity. On the basis of the acquired information, through this geochemical survey, an automated CO₂ soil monitoring station has been installed on the summit area of Vulcano island in September 2007. Here we report the first three years of CO₂ flux measured hourly. The first preliminary data of continuous CO₂ flux (2007-2010) highlight a good correlation with the recorded variations of gas/steam ratio and temperatures of fumaroles. Moreover a clear increase of solfataric activity was recorded in the period September-December 2009 and corroborated from the plume SO₂ fluxes data acquired in continuous with UV-scanning DOAS.

I1-9 Orale Capecchiacci, Francesco

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HALOCARBONS IN FUMAROLAS AND AIR FROM THE ETNA VOLCANO SUMMITCAPECCHIACCI Francesco¹, TASSI Franco², VASELLI Orlando¹, CAPACCIONI Bruno²1 - Department of Earth Sciences, University of Florence, Italy
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Key terms: ETNA VOLCANO; VOC'S; FUMAROLAS; AIR QUALITY

Non-methane volatile organic compounds (VOCs) are commonly found in fumarolic fluids discharged from geothermal and volcanic systems (e.g. Isidorov et al., 1990; Tassi et al., 2010). In the present study, VOC composition in fumarolic fluids from Etna volcano (Sicily, Italy) with outlet temperatures between 94 and 337 °C is presented and discussed to investigate their origin. A particular attention was devoted to the

qualitative and quantitative determination of CFCs, HCFCs, furans and dioxins. VOCs in air samples collected from several sampling stations located at the Etna summit were also analyzed to evaluate the local impact of the fumarolic activity and the behavior of these compounds once released into the atmosphere. VOC analyses were performed by GC/MS on samples collected using solid traps (ST) consisting of stainless-steel three phase adsorbent tubes. VOC composition in fumarolic gases is largely dominated by alkanes, alkenes, aromatics, thiophenes and furans. CFCs and HCFCs were also recognized at concentrations ranging between 0.05 and 0.79 ppbv. These compounds have a strong environmental impact, since they participate to the chemical reactions occurring in the stratosphere and are responsible for the destruction of the ozone layer (Anderson et al., 1986). The measured concentrations of CFC11, CFC12, CFC13, CFC113 and CCl₄ in the fumarolic gases are consistent with those expected considering the air fraction contaminating these fluids, suggesting that the origin of these compounds is totally atmospheric. On the contrary, HCFC and others halocarbons concentrations (e.g. CHClF₂, CH₃Cl, CH₂Cl₂, C₂H₂Cl₂, C₂HCl₃) concentrations are too high to be ascribed to the air fraction in the gas samples, suggesting the occurrence of a significant endogenous production of these compounds. Compounds pertaining to the group of furans, although at relatively low concentrations (from 0.2 to 6.8 ppbv), were also detected. This feature is not surprising, since these compounds are typically enriched in high-temperature gases (Tassi et al., 2010). Conversely, dioxins, whose formation can occur through furan condensation and combination with Cl, i.e. processes theoretically possible in the Cl-rich magmatic-related fluids released from the Etna fumaroles, were not recognized. These results, although preliminary, may have important implications for evaluating the environmental impact of naturally discharged fluids. Moreover, systematic investigations of these compounds may shed light on their geochemical cycles that are presently almost unknown. Consequently, further studies of these classes of VOC in fumaroles from different volcanic and geothermal systems are currently in progress.

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I1-10 Orale Caracausi, Antonio

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MANTLE-DERIVED FLUIDS RELEASED FROM THE EXTINCT VULTE VULCANO: A RE-EVALUATION OF THEIR FLUX AND ASSESSMENT OF THE RELATED VOLCANIC HAZARD.CARACAUSI Antonio¹, NUCCIO Pasquale Mario¹
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Key terms: Geochemistry; mantle-derived fluids; crater lakes; volcanic hazard

In 1984 and 1986 two disastrous events, when huge amounts of CO₂ were released from Monoun and Nyos crater lakes (Cameroon), located on volcanoes which are no longer active. These dramatic events, causing loss of human life, draw attention of the scientific community towards those crater lakes able to accumulate massive amount of CO₂, which could be catastrophically released. Hence, investigations on other crater lakes have been carried out with the purpose of evaluating the gas hazard related to an instantaneous release of dissolved gas. Obviously, crater lakes, where the probabilities of dissolved CO₂ accumulation are higher, have been the preferred selected targets, even though volcanic activity was definitely ceased.

With this in mind, we studied two small crater lakes, formed about 140 ka ago and located along a NW-SE system faults, cutting the Mt. Vulture volcano, the easternmost occurrence of the Quaternary Italian volcanism. According to historical reports, both lakes have been repeatedly affected by sudden degassing. In fact, a 6-m-high water column formed in LGM on 1 June 1810 and a new event was observed two months later on 31 July. Ten years later, a similar event occurred in LPM, when a waterspout reached a height of 5 m, and a lot of dead fishes were found on the land, indicating the explosive nature of the event. During the 10 years leading up to 1820, every so often LPM reached similarly explosive conditions. Our previous investigations have shown that a hypothetical instantaneous release of dissolved CO₂ and CH₄, would produce a volume of gas of 2.3 x 10⁵ m³ for LGM and of 5.8 x 10⁵ m³ for LPM.

Our additional investigations have confirmed that LPM displays a heat flow of 75 mW m⁻² in excess at least of 20 mW m⁻² if compared to the expected values. Also, they have shown that major dissolved volatiles are biogenic methane and inorganic CO₂, having an isotopic signature in the range of mantle-derived CO₂. Indeed, dissolved He displays a seasonal variation of its isotope ratio between 6.1 and 5.3 Ra, within the range of values measured in the olivine fluid inclusions both of mantle xenoliths and ejecta.

We also measured the isotopic composition of He dissolved in aquifers of Mt. Vulture and its isotopic signature fits with He of the lakes water, supporting a diffuse degassing of mantle-derived He on regional scale all around the volcano. Our new dataset of spring and well waters suggest that the CO₂ flux is up to an order of magnitude higher than values reported in literature and comparable to that of Flegrea Fields. In this framework we realized that an active degassing of mantle-derived He occurs more than 20 km away from Mt. Vulture margin along the prolongation of the NW-SE tectonic lineament crossing the LPM.

Taking into account that:

- ° the Mt. Vulture volcanic activity was characterized by long lasting inter-eruptive periods (up to 350 ka);
 - ° the mantle isotope signature of both He and CO₂;
 - ° degassing of mantle-derived fluids (i.e. He, CO₂) from the entire edifice of the volcano and controlled by the main regional tectonic discontinuities;
 - ° the C/3He ratio of 8.3 x 10⁹, in the range of sub-continental mantle;
 - ° the estimated 3He/heat ratio of 2.13 x 10⁸ atoms/J;
 - ° the historical reports of gas bursts occurred in both lakes;
- although the last Mt. Vulture volcanic activity occurred 140 ka ago, we evaluated the possibility that a degassing magma is present at depth and the related hazards for dangerous gas bursts, triggered either by crustal accumulation of mantle-derived CO₂, and/or by a resuming of explosive volcanic activity. For these reasons, in our opinion, further investigations are strongly recommended.

Finally, we hope that our study will draw attention towards all those crater lakes located in volcanic areas apparently no longer active with a special attention to those situated in areas of tourist interest, where gas risk is probably underestimated or even ignored.

I1-11 Invitato Liotta, Marcello

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SAMPLING AND ANALYTICAL METHOD FOR GEOCHEMICAL SURVEY OF DISSOLVED GASES IN BRACKISH THERMAL WATERS

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Key terms: Dissolved gases; Brackish thermal waters; Gas solubility

Dissolved gases are often utilized in geochemical studies for investigating hydrothermal and/or magmatic contributions to shallow aquifers. Between the several methods applied for analyzing dissolved gases in water, the head space equilibration technique is probably the most used because it does not require any strain before or during the water sampling in the field and can be adapted to various aims in the laboratory, with multispecies analysis by common gas chromatography. This type of technique has been developed and applied. We propose a revised method of gas-liquid partitioning at equilibrium that allows a host gas aliquot to be introduced directly into the gas chromatograph (GC) and accurate analysis of dissolved O₂, N₂, He, CO₂, CH₄, CO, H₂, and Ar in water samples with salinities ranging from 0 to 40 PSU. Provided that the analyzed gases represent close to 100% of the originally dissolved gases, a mass balance relative to the host gas can be used to obtain an independent estimate of the overall quality of the major species determination. The method allows the rapid characterization of several sites and represents a useful tool for geochemical surveys. A comparison between replicate samples analyzed using different procedures demonstrates the efficiency of the method and indicates that the abundances of the main dissolved gases can be obtained, which is helpful for determining the underlying geochemical processes. A rigorous numerical approach allows the molar fraction in the headspace to be estimated when the natural abundances of dissolved gases are known within a given range, thus allowing the optimal choice of the volume ratio between the headspace and solution to conform to the detection range of the used GC.

I1-12 Orale Tassi, Franco

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PRESSURE-DEPENDENT VOCs IN GASES FROM MUD VOLCANOES: A NEW TOOL FOR EVALUATING THE FLUID SOURCE DEPTH

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Key terms: Mud volcanoes; VOCs; thermogenic; biogenic; Azerbaijan

Mud volcanoes are usually cone-shaped edifices of variable dimensions, or craters and bubbling pools discharging a three-phases (gas, water and sediment) mixture. The origin and distribution of this natural phenomenon are widely discussed in the literature (e.g., Dimitrov, 2002; Etiope & Milkov, 2004, and references therein). More than 900 mud volcanoes are recognized on land (Etiope & Milkov, 2004), whereas more than 1000 mud volcanoes supposedly occur in the oceans (Milkov, 2000). Methane is the main gas species discharged from mud volcanoes. The origin of methane is generally assessed on the basis of the stable carbon and hydrogen isotopes and chemical composition of light alkanes (Schoell, 1983; Bernard et al., 1978). However, misleading information from these geochemical parameters can be caused by secondary processes, such as oxidation and molecular separation during migration of the CH₄-rich fluid. According to the classification proposed by Etiope et al. (2009), more than 76 % of the terrestrial mud volcanoes from 12 different countries discharge thermogenic methane.

In this work we present data of hydrocarbon composition in gas emissions from mud volcanoes located in different areas of Italy (Northern Apennines, and Sicily) and eastern Azerbaijan. Chemical analysis of hydrocarbons, focused on the determination of C₄-C₁₀ alkanes, cyclics and aromatics, were carried out by GC-MS. The main gas species were analyzed by GC-FID. Methane is the most abundant component of all the investigated gases, with the exception of those from Sicily (Salinelle mud volcanoes) that are rich in carbon dioxide. Non-methane hydrocarbon composition is dominated by alkanes, mainly composed of ethane (up to 99.7 %). Aromatics, consisting of benzene, toluene, ethylbenzene and xylenes, are a significant fraction of all the collected samples, and are particularly enriched (up to 36 %) in the two CO₂-rich Sicilian gases. The most relevant feature of hydrocarbon composition is represented by the presence of more than 20 different cyclics in most of the methane-rich gases. Noteworthy, these hydrocarbons are almost absent in the two CO₂-rich samples, as well as in the mud volcanoes and gas seeps located in the southeastern sector of the Northern Apennines (i.e., the Romagna Apennines; Dragone, Bergullo, Portico, Bagno di Romagna). The four Romagna gases can be also distinguished on the basis of the isotopic signature of methane, which is significantly more negative (¹³C/¹²C < -60 permil V-PBD and ¹H/²H < -190 permil V-SMOW) than that characterizing the other Italian gases, as well as those from Azerbaijan (¹³C/¹²C > -50 permil V-PBD and ¹H/²H > -180 permil V-SMOW). This would indicate that the presence of cyclics is related to a thermogenic deep source, suggesting that the formation of these compounds occurs at high pressure conditions, likely thought the "closure" of the C-C chains of linear and branched alkanes. This is consistent with the structural setting of the Northern Apennines. "High pressure" gases are in fact expelled from mud volcanoes lying where the Ligurian Units (uppermost in the Apennine nappe pile) provide a thick, impermeable cover that may exceed 2-3 km in thickness; in contrast, comparatively lower pressure conditions result from the Romagna gases where this cover is much thinner or absent. These results imply that the cyclic compounds may play an important role

as tracers for evaluating the origin of fluids from mud volcanoes, as well as from other type of hydrocarbon-rich natural fluid emissions.

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I1-13 Orale Paonita, Antonio

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MIXING BETWEEN DEEP AND SHALLOW MAGMATIC FLUIDS BELOW MOUNT ETNA AND ITS KEY ROLE DURING THE 2006 AND 2008 ERUPTIONS

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Key terms: noble gas; fumaroles; geochemistry; magmatic processes; modeling

Here we display the results of five-years long geochemical survey of some fumaroles at Voragine crater rim of Mt Etna, coupled to the synchronous monitoring of some well-known peripheral emissions, with the aim to reveal the genetic relations of the discharged gases. Our geochemical study has joined together the isotopic compositions of Ar, He and CO₂ besides to chemical compositions.

Once the effects of post-magmatic shallow processes have been recognized, quantified and removed, the geochemistry of gas emissions at Mt. Etna volcano has provided key information about the magma dynamics in the feeding system. Our study has in fact displayed that the summit crater fumaroles are aligned along the identical degassing path of the peripheral sites in terms of He/Ar versus Ar/CO₂ ratios. Interestingly, the carbon isotope composition of the fumaroles, coupled to noble gases, put into evidence that a part of the exsolved magmatic gases at high depth interacts with gases from magma batches stored at shallow levels and modifies the compositional ratios of the main geochemical indicators of magmatic degassing. The crater fumaroles therefore result from a two-endmember mixture of magmatic gases, composed by a deep member coming from variable pressures of 400 to 200 MPa depending on time, and a shallower one exsolved at about 130 MPa. The same as the crater fumaroles, the He isotopic compositions of the peripheral sites, coupled to the He/Ar* ratios, highlight similar processes of mixing between a deep gaseous endmember and a shallow one whose exsolution pressure seems to be very variable in time. More importantly, coupled peripheral and crater emissions show that the He isotopic marker of magmas stored at shallow levels and/or in the most external portions of the plumbing system is sensibly lower, in terms of R/Ra, than that of the parental magmas from the deep source. Resident magmas can also be modified as a consequence of massive recharges of the primitive, high-R/Ra melts. This probably occurs when, besides the fluids, batches of the recharging magmas reach the shallow reservoirs. Our investigation thus reveals a complex magma dynamics and even more complex evolution of the fluid phase, in agreement with recent geochemical and petrological studies on Mt. Etna. The time variation of He isotopic compositions, as well as their spatial distribution, are coherent with the idea of a multipart plumbing system made of dykes, sills and reservoirs barely interconnected, in agreement with the most recent views of Mt. Etna structure arising from geophysical studies.

The geochemical resolution of the deep and shallow gaseous endmembers allows to distinguish the periods during which the deep magmatic fluids become more important and/or new magmas coming from depth invade the shallow levels of the Etnean plumbing system. This result provides key information on volcanic activity in the middle and long term. The recognized episodes of magma recharge below Mt Etna have in fact accompanied periods of rising volcanic activity, such as those preceding the 2006 and 2008 eruptions. The final months of the 2010 have been once more marked by the increase of such replenishment from depth, suggesting that the volcano is again experiencing a phase of high eruptive potential.

I1-14 Orale Tardani, Daniele

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CHEMICAL EVOLUTION OF THE POAS FUMAROLIC FIELD IN THE LAST DECADE

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Key terms: Poàs; Geochemical monitoring; Volcanic fluids

Geochemical monitoring of fluid discharges from active volcanoes can be used to mitigate the volcanic hazard. Many authors (e.g., Tedesco and Sabroux, 1987; Martini, 1989; Gigenbach, 1996) have stressed the importance of periodical monitoring of the chemical and isotopic composition of volcanic gases in order to predict changes in the volcanic activity. The physical and chemical characteristics of the fluids circulating in a volcanic environment reflect the different contributions from magmatic, hydrothermal and meteoric sources. Unfortunately, long-term geochemical observations are available only for a few volcanic systems, including White Island and Phlegrean Fields in Italy, Showna-Shinzan in Japan, Wulke Island in New Zealand and Mount Ebeko in Russia. In this work we describe the evolution of gas chemistry of the crater fumaroles from Poàs volcano (Costa Rica) recorded in the last 12 years, in order to investigate the mechanisms regulating the compositional modifications affecting these fluids in this span of time during which migration of fumarolic vents and phreatic eruptions have been occurred. The basaltic-to-dacitic volcano of Poàs (2708 m a.s.l.) is one of the most active in Costa Rica and is characterized by three N-S oriented craters: Von Frantius, Botos and the Active crater. The latter two host a volcanic lake: Botos is cold with the latest eruption dating back to ca. 7,500 years ago; Laguna Caliente is one of the most acidic lakes of the world (pH=0) and is the site where phreatic, phreato-magmatic and strombolian events have occurred since 1828. In 1988-1991 the acidic lake dried out revealing sulfur vents and fumaroles with temperatures up to 900 °C.

Since 1998 a discontinuous geochemical sampling and analysis has started at the fumarolic vents of Poas volcano. The first sampling was only concerning a relatively vigorous fumarole (no longer existing) discharging in the southern sector of the inner crater. Significant modifications of the fumarolic field location were recorded since then as the fluid discharges moved to the east. Then, new vents opened in the NE flank. Since 2006 several phreatic events (the first after that occurred in 1994) have shaken Poas volcano also during the Chinchona earthquake (8th of January, 2009). Presently, the fumarolic activity is centered at the interface between the Dome and the acidic lake and has increased in the last five years likely also due to the diminished lake water level in the last decade (15 m). Despite the phreatic activity no significant variations of the fumarolic outlet temperatures close to the Dome (always ranging between 90 to 120 °C) are reported until July 2008, when a jet-fumarolic discharge has shown a temperature of 650 °C. In June 2010 despite of the increasing difficulties to reach the sampling site the highest temperature (800 °C) was achieved since the 1988-1991 crisis. As far as the chemical variations are concerned, the Dome fumaroles evidence an overall increment in time of the concentrations of magmatic-derived gases (e.g. SO₂, HCl, HF) as well as those of the temperature-dependent species, such as H₂, CO and H₂S.

The complex interplay between the magmatic and hydrothermal components is likely regulated by permeability variations. Overpressuring and hydrofracturation may be responsible for the increasing release of deep fluids originating the observed phreatic events that so far have only produced relatively large vapor blasts and ballistic products. The proximity of a spine of magma close to the surface (about 500 m), the increasing values of the outlet temperatures and of the magmatic species in the fumarolic discharges cannot rule out the possibility of more explosive events.

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11-15 Orale Cinti, Daniele

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FLUID GEOCHEMISTRY OF DEEP AND SHALLOW RESERVOIR(S) IN THE WESTERN SECTOR OF THE SABATINI VOLCANIC DISTRICT AND THE TOLFA MOUNTAINS (CENTRAL ITALY): IMPLICATIONS FOR GEOTHERMIC EXPLOITATION

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Key terms: geochemistry; water; gas; geothermal energy; central Italy

The western sector of the Sabatini Volcanic District (SVD) and the Tolfa Mountains (TM) are characterized at depth by the presence of a horst-graben system bordered by extensional faults, along which recent volcanic activity occurred. Two different geological domains are recognized: i) a sedimentary domain, exposed in the TM, constituted by silico-clastic turbidite deposits and Plio-Pleistocene clays and ii) a volcanic domain formed by acid products of the Tuscan Magmatic Province and Quaternary undersaturated alkali-potassic volcanic rocks of the Roman Magmatic Province. The volcanic products overlie a sedimentary sequence which ends with a thick Mesozoic carbonate formation containing a pressurized geothermal reservoir from which fluids escape to the surface producing thermal waters and CO₂ dominated gas emissions. A total of 197 fluid discharges (cold waters, thermal waters and bubbling pools) and 15 gas emissions have been sampled to define the processes governing their chemical and isotopic composition. Two main reservoirs are recognized at different depth. The deepest one is hosted in the Mesozoic limestones and shows a Ca-SO₄(HCO₃) composition, likely produced by fluid-rock interaction at high temperature involving Triassic anhydrite layers at the base of the carbonates. The shallower one is hosted both in the volcanic and in the sedimentary domains and displays a Ca(Na, K, Mg)-HCO₃ composition. Significant contribution of CO₂-rich gases rising from depth into the shallow aquifers produce acidic cold waters, while low-pH (<4) acid-sulphate waters are produced from the near surface oxidation of H₂S, accompanying CO₂ in the uprising gas phase, to H₂SO₄. deltaD and delta18O data indicate that water recharging deep and shallow aquifers has a meteoric origin, while isotopic exchange between water and CO₂ or evaporation processes prevail for CO₂-rich water and bubbling pools.

Carbon dioxide, largely dominating the free gas phase, has a twofold origin, being related to mantle degassing and thermo-metamorphic reactions occurring in the carbonate reservoir. Helium shows a crustal isotopic signature, but the R/Ra values (from 0.37 to 0.62) indicate low but significant presence of mantle He. Methane and H₂S seem to be mainly produced by thermogenic reduction of CO₂ and of the Triassic anhydrites, respectively. Upraising of thermal waters and deep gases occurs along the extensional faults bordering the structural highs. Their distribution seems to be mainly controlled by NNE-oriented tectonic lineaments, in correspondence with the boundary between the volcanic domain of the SDV and the sedimentary domain of the TM, that represents an important hydrogeological barrier.

Exploration surveys investigated this area during 70's-90's for geothermal purpose, but the area still results unexploited. The presence of thermal waters and of anomalous heat flow, together with demographical growing of the last years, make this site a suitable location for the exploitation of the geothermal resource.

11-16 Poster Cabassi, Jacopo

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GEOCHEMISTRY OF WATER DISCHARGES AT MT. AMIATA VOLCANIC COMPLEX IN RELATION WITH THE REGIONAL TECTONICS

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Key terms: Mt. Amiata; geochemistry of water; regional tectonics; geothermal system; discharging fluids

The Mt. Amiata geothermal area (southern Tuscany, central Italy) is located in an extended continental crust, where extensional structures developed from the Middle Miocene to the Quaternary, whilst collisional structures occurred from the Cretaceous to the Early Miocene. The recent extensional stages are divided in: a) Middle-Late Miocene, when widespread extensional segmentation, mainly affected the Tuscan Nappe via normal faults with staircase geometry, produced space accommodation of the sediments filling the neighboring Neogene basins; b) Pliocene-Quaternary, when marine sediments filled the relic Miocene structural depressions, which were affected by intense faulting activity. In the Pliocene a magmatic body was emplaced in the thinned continental crust. The observed high heat flow is due to this magmatic body which is located about 6-7 km below sea-level and not completely cooled down. The body is responsible for a negative Bouguer anomaly and localized uplift of around 3,000 m centered on the Mt. Amiata volcano. At the top of the convex structural culmination, a crustal fissure striking N50° produced the eruption of the Mt. Amiata volcano during the Late Pleistocene.

Hydrothermal circulation typifying the Bagni di S. Filippo and Bagnore areas is mainly concentrated at the intersection between this crustal fissure and two normal faults striking N160° and 180°. Mt. Amiata is the most recent (3-200 ka) and the largest volcanic apparatus of the Tuscan magmatic Province. The Amiata geothermal system is characterized by the presence of two reservoirs: the shallower one, having a temperature of 200-230 °C, is at depth of 500-1000 m in the carbonate-evaporite formations, whereas the deeper one (depth > 3000 m) is within the metamorphic basal complex where temperature are up to 350 °C. Both reservoirs are bi-phase systems and used for the production of the electrical energy by ENEL.

In this work, a relatively large data-set of chemical and isotopic compositions of discharging fluids was acquired in order to investigate if the deep-seated fluids may interact with the shallower volcanic aquifer. Thermal and cold springs associated to a CO₂-rich gas phase are mainly located in the north-eastern and south-western sectors of the Mt. Amiata volcanic edifice. These types of fluid emergences are practically missing in other sectors of the volcano. The studied waters are chemically characterized by i) a Ca-SO₄ composition, ii) relatively high TDS (total dissolved solids) values, iii) an associated CO₂-rich gas phase and iv) anomalously high concentrations of B, Li, Cs, HS and NH₄⁺. A Ca-HCO₃ shallow aquifer, having low TDS being directly recharged by meteoric water, is hosted within the fractured volcanic sequences, above the low permeable Ligurian Units that prevent a hydraulic connection with the deep hydrothermal aquifers. This aquifer fed cold springs that can abundantly be recognized all around the volcano. Accordingly, the spatial distribution of the CO₂-rich Ca-SO₄ thermo-mineral waters confirms that they are controlled by regional faults and tectonic structures in the area.

11-17 Poster Capaccioni, Bruno

10.1474/Epitome.04.0699.Geoitalia2011

THE ORIGIN OF THE ALKALINE, NA-HCO₃ THERMAL WATERS OF RIO VALDEZ, ISLA GRANDE DE TIERRA DEL FUEGO (ARGENTINA)

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Key terms: alkaline Na-HCO₃ waters; geothermal area; Tierra del Fuego

The small geothermal area of Rio Valdez is located in the central portion of the Isla Grande de Tierra del Fuego (South Argentina), ten kilometres south of the south-eastern sector of Fagnano Lake. It is characterized by a series of thermal springs distributed in an area of less than 1 km², with low discharge rates and temperatures in the range of 20-33°C. Thermal waters can be defined as partially equilibrated, alkaline, Na-HCO₃ waters with low salinity but relatively high fluorine contents. Thermal waters are characterized by slow circulation at depth, possibly driven by deep tectonic discontinuities connected with the Magallanes-Fagnano Fault (MFF) system. According to geothermometric calculations, thermal waters reach temperatures in the range of 100-150°C and an almost complete chemical equilibration with the alkali-feldspars of the rocks they interacted with. The relatively high fluorine contents can be explained by the slow ascent and cooling of deep groundwaters, followed by a progressive re-equilibration with F-bearing, hydrated Mg-silicates, such as chlorite, which has been recognized as an abundant mineral in the meta-volcanics of the Lemaire Formation. As a matter of fact, deep rock-water interactions with the alkaline intrusives belonging to the Fuegian Potassic Magmatism may also have contributed to the high fluorine contents of the thermal waters. Finally, the isotopic composition of the investigated samples is consistent with the infiltration of meteoric water from local snowmelt at altitudes in the range of 610-770 m asl.

11-18 Poster Caracausi, Antonio

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MANTLE-DERIVED FLUIDS DISCHARGED AT THE BRADANIC FOREDEEP/APULIAN FORELAND BOUNDARY: THE GEOTHERMAL MASCHITO GAS EMISSIONS (CENTRAL-SOUTHERN ITALY)

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Key terms: geothermal system; mantle fluids; tectonics

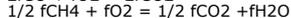
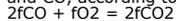
Twenty kilometers away from the Mt. Vulture volcanic edifice (Central-Southern Italy) is located the Maschito Mefita, known since historical times as lake Fetente. Actually no evidences of the lake subsist. A surface of 300 m² is lacking of flora and rests of died animals are frequently found all around the area, which is characterized by smelly

exhalations. It is located along a regional tectonic discontinuity, close to the boundary between the foredeep and Apulian foreland.

The gas is CO₂ dominated (98%), followed by H₂S (<1%), CH₄, N₂ and other hydrocarbons. He, Ne and Ar are in trace amounts. CO₂ isotopic composition falls in the range of the main active Italian volcanic gases. The helium isotopic ratio (4.7 Ra) fits with values measured in Mt. Vulturno volcano and particularly in olivine fluid inclusions of ejecta of the last volcanic activity (140,000 years). 40Ar/36Ar isotopic ratio of 392 suggests a non atmospheric contribution and, following the Schoell classification,

both $\delta^{13}C$ and δD values of methane indicate its thermogenic origin. Multiple equilibrium temperature of gases at depth have been carried out:

1) Assuming that a boiling biphasic system (liquid/vapour) is present at depth, we estimated the equilibrium temperature among H₂O, CO₂, CH₄ and CO, according to the following reactions:



The computed temperature is 195°C. The calculated fH₂O value falls into the typical field of the geothermal systems.

2) The equilibrium reaction which involves light alkanes, 2C₂H₆ = C₃H₈ + CH₄ gives temperature of 180°C.

3) carbon isotope geothermometer based on CO₂-CH₄ equilibrium gives a temperature of 174°C.

4) H₂/Ar geothermometer give a temperature of 140°C.

These results support the existence in the area of a biphasic (liquid/vapour) thermal system with a temperature in the range of 140°C-195°C.

The estimated CO₂ fluxes from the area are around 3200 Tons/year, which are comparable with those of several emissions from geothermal fields in Italy. The calculated mantle-derived helium flux is 2x10¹⁰ atoms m⁻²s⁻¹, three orders of magnitude higher than typical stable continental crust and characteristic of the region where addition of mantle-derived fluids in the crust occurs. Moreover the C/3He ratio (2.9x10⁹) is in the typical range of magma released fluids. These results strongly support an active degassing of mantle-derived fluids feeding the recognized geothermal system. Therefore, considering that Maschito gas emissions falls along the same faults system where the Monticchio maars formed during of the last activity of Mt. Vulturno are located, our results strongly support the possibility that such fault system is connected to a magma body at depth.

It is worth of note that recent aeromagnetic studies have identified an anomaly located at a few kilometres towards North of Maschito area, interpreted as a sill intrusion, also confirming the main role of tectonics in controlling magma transport through the crust.

11-19 Poster D'Alessandro, Walter

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FIRST APPLICATION OF ACTIVE BIOMONITORING TECHNIQUES (MOSS-BAGS) TO MAP THE DISPERSION OF VOLCANIC EMISSIONS

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Key terms: Biomonitoring; Moss-bags; Trace elements; Volcanic emissions

Biomonitoring may be defined as the use of organisms and biomaterials (biomonitors) to obtain informations on certain characteristics of a particular medium (atmosphere, hydrosphere etc.). In particular, mosses accumulate large amounts of trace metals, making them good bioaccumulators to estimate atmospheric pollution. The moss-bags technique, introduced in the early 1970', has become very popular. Such active biomonitoring technique is particularly useful in highly polluted areas and has been extensively used in industrial and/or urban areas to examine deposition patterns and to recognize point sources of pollution. The main objective of this study, which represents the first application of the moss-bags technique in an active volcanic area, was to test its efficacy in such environment. Complementary objectives were: to determine the different behavior and the geographic dispersion of volcanogenic elements emitted from Mt. Etna; to check the usefulness of a simpler analytical techniques (leaching instead of mineralization of the moss samples).

A mixture of Sphagnum species was picked in a clean area, treated in laboratory (washed, dried and packed) and exposed in field for 1 month. Sites were chosen considering the prevailing wind at Mt. Etna's summit. Milled samples were analysed for major and trace elements concentrations, after microwave digestion (HNO₃ + H₂O₂), by ICP-MS and ICP-OES techniques. The same elements were also analyzed after simple leaching with deionized water (1/50 weight ratio for 4 hours). Leaching solutions were also analyzed by IC for F, Cl and SO₄.

Analyses clearly showed the efficacy of the moss-bags technique also in this peculiar environment. Several elements were strongly enriched in the mosses exposed to the volcanic emissions. The highest enrichment was measured on the rim of the summit craters, but evidences of metals bioaccumulation were also found in down wind sites, at several km from the volcanic source. The accumulation factor (exposed/unexposed moss) allowed us to distinguish a group of elements (Tl, Bi, Se, Cu, As, Cd, S), which are highly mobile in the high temperature volcanic environment. Also alkali metals showed a significant increase in their concentrations, probably because of their affinity for the halide species carried by the volcanic plume.

Also the simple and cheap leaching technique gave important indications on the plume dispersion pattern, especially for highly volatile elements (F, Cl, S, Tl).

11-20 Poster Inguaggiato, Salvatore

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SUMMIT CO₂ DEGASSING AT VULCANO ISLAND 2007-2011 PERIOD

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Key terms: CO₂ Fluxes; Geochemical monitoring; Vulcano Island; SO₂

fluxes

Vulcano Island, located in the Aeolian Archipelago, is an active volcano that has been in state of solphataric activity since last eruption (1888-1890). Today, the main exhalative activity is located in the northern part of the island and is characterized by the presence of a) a wide fumarolic field, on the active part of the edifice of "La Fossa" crater, (100°C < T < 450°C); b) low temperature fumaroles (T < 100°C) and seawater bubbling gases in the Baia Levante area; c) strong soil degassing occurring in the Vulcano Porto area and around the volcanic edifice, where the active tectonic discontinuities drive CO₂ to the surface. The estimation of CO₂ degassing budget from volcanic systems has a relevance both for geochemical and monitoring activities.

The total CO₂ output of 571 t d⁻¹ was estimated for the whole Vulcano Island area considering discharged fluids from fumaroles, bubbling and dissolved gas and soil degassing (Inguaggiato et al. 2009).

The main contribution, at these degassing processes, is the fluids discharged from the summit area of the active crater (532 t d⁻¹), with 362 and 91 t d⁻¹ from crater fumaroles and crater soil degassing areas respectively.

On the basis of the acquired information, through this geochemical survey, an automated CO₂ soil monitoring station has been installed on the summit area of Vulcano island in September 2007.

Considering that the summit area represents the main contribution to the degassing fluids from the whole Vulcano Island, we decided to make several campaigns for measuring CO₂ fluxes on the crater soil degassing areas.

In particular, 7 surveys of CO₂ flux budget have been carried out from 2007 to 2011 for monitoring the solphataric degassing process from the summit area and for comparing it with the continuous CO₂ flux measured with the automatic station located on the North-East side of the crater. Two anomalous degassing processes were recorded in 2009 (September to December) and in 2011 (February-May). The results show a good correlation between the discontinuous surveys and the continuous flux measurements on time, suggesting that the continuous CO₂ flux measured on the summit area (VCS) is representative of the whole degassing process of the crater area.

Finally, the SO₂ flux from the "plume", acquired in continuous with UV-scanning DOAS, and the gas/water ratio of the fumaroles were also measured to better constrain the observed geochemical variation.

SESSIONE I2

Il contributo della microanalisi nello studio dei sistemi vulcanici

I2-1 Orale Rosciglione, Alberto

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PRESENT-DAY MT. ETNA ACTIVITY FED BY A HETEROGENEOUS MANTLE SOURCE: INFERENCES FROM MELT INCLUSIONS STUDY

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Key terms: Mt. Etna; melt inclusions; trace elements; mantle sources; ghost-plagioclase signatures

Mount Etna, the largest volcano in Europe, displays the peculiar condition of lying on continental crust and close to the subduction-related Aeolian volcanic arc, while its products shows typical affinities with Ocean-Island Basalts (OIB). The finding of subduction-related geochemical tracers in the volcanic products of the last thousand years, along with an increased explosivity of eruptions, led to develop a model for Etnean magmas that states that the mantle source is progressively undergoing metasomatic influx by slab-derived fluids released from the Ionian slab (Tonarini et al., 2001).

We present the results of a geochemical study of olivine-hosted melt inclusions (MIs) from 2001-2006 Mt. Etna basaltic lavas. Two different suites of MIs were observed. They represent different magma batches that variously evolved inside the feeding system before their entrapment in host olivines. Type-1 MIs share their trace element signatures with bulk-lavas and closely approach OIB-like magmas whereas type-2 reveal "ghost plagioclase signatures", namely lower concentrations in strongly incompatible elements and positive Sr, Ba and Eu anomalies. Noticeably, both melt types occur in 2006 MIs, which, more importantly, include composite inclusions consisting of plagioclase surrounded by type-1 melt. Trace-element critical ratios, namely Ce/Nb, Ba/La and K/La, which are not or poorly affected by process of global differentiation, provide evidence that sources of type-1 MIs are highly heterogeneous in composition, with signatures that are intermediate between those of HIMU/FOZO-like and EM-like sources. Differently from type-1, type-2 MIs testify for en-route processes that are peculiar for eccentric eruptions. These latter are strongly controlled by tectonics or flank instability, which occasionally promote the upraise of undegassed and more primitive magma that may interact with variable volumes of crystal mush and plagioclase-rich cumulates before reaching the surface. Previously formed plagioclase crystals are thus trapped in olivine, possibly along with minor reacted melt, and then forced to react and melt due to the high magma temperature, as suggested by Danyushevsky et al. (2003, 2004) to explain the "ghost plagioclase signatures" in MORB olivine-hosted MIs. It is also emphasized that the occurrence of melt inclusions with distinct geochemical signatures, rather than different melt types and sources, may reflect important en-route processes that are occasionally recorded only on a micro-scale and cannot be identified from chemical investigations of bulk-lavas.

I2-2 Orale Schiavi, Federica

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SOURCE METASOMATISM BENEATH STROMBOLI: A STUDY OF TRACE ELEMENTS AND PB-BI ISOTOPES IN OLIVINE-HOSTED MELT INCLUSIONS

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Key terms: Stromboli; source metasomatism; melt inclusions; isotopes; trace elements

Several studies provide evidence that magma sources beneath the Aeolian arc volcanoes were contaminated by variable amounts of metasomatic agents released from the subducting slab. It has been proposed that the composition of the mantle wedge beneath Stromboli is strongly influenced by the addition of a recycled sedimentary component, and that two distinct enrichment events triggered by slab-released aqueous fluids and supercritical liquids were responsible for its source metasomatism (Tommasini et al., 2007).

We carried out an elemental and isotopic (Pb, B and Li) characterization of olivine-hosted melt inclusions (MIs) to explore the sources of Stromboli magmas and to assess nature and relative contributions of slab components and metasomatic agents involved in the source metasomatism. The studied MIs have primitive calc-alkaline to high-K calc-alkaline basaltic compositions; they are trapped within early-formed highly forsteritic (Fo_{83-91}) olivine phenocrysts, which were collected from lava (San Bartolo lava) and pumices erupted in historical times. The studied melts cover a compositional range far wider than that exhibited by the whole-rocks and differ in key trace element ratios. San Bartolo melts are characterized by lower incompatible trace element abundances, higher LILE/HFSE, LILE/REE, U/Nb, Ba/Th, U/Th and Pb/Ce, and lower La/Yb ratios relative to the pumice-hosted MIs and pumiceous melts erupted during paroxysmal events. The MIs Pb isotope composition is highly heterogeneous and extends from EM2 (Enriched Mantle)-like compositions (San Bartolo sample) to lower $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ values that are similar to those observed in lavas from the central and western Aeolian volcanoes and point to a FOZO-like fingerprint. The MIs B isotope compositions for San Bartolo and pumice samples are slightly

heavier ($\delta^{11}B \sim -2.0\%$) and significantly lighter ($-8.6 \div -13.7\%$) than whole-rock compositions, respectively. Their Li isotope signature of olivine-hosted MIs from pumices is more heterogeneous and significantly lighter than bulk-rock samples.

These features testify small-scale heterogeneities in the source regions of magmas feeding the present-day and >2 ka Stromboli activity. Isotopic melt compositions are consistent with a two-stage mantle enrichment process during which supercritical liquids and aqueous fluids partially overlapped on the same mantle domain. Variable amounts of Th-rich supercritical fluids mainly released from the altered basaltic oceanic crust are required to explain the composition of both olivine-hosted MIs from pumices and the high $^{208}Pb/^{206}Pb$ ratios of San Bartolo melts. However, the distinct geochemical and isotopic fingerprint of San Bartolo melts can be modeled only assuming a later metasomatic event driven by U-, B-, Ba- and Pb-rich aqueous fluids. These latter were probably expelled at relatively shallow depths from both sediments and basaltic crust (~30 and 70%, respectively) and promoted higher degrees of melting. In contrast, a later flux of aqueous fluids is not necessary to model the geochemical signatures of olivine-hosted MIs from pumices. Rather, their light Li and B isotope compositions indicate that they formed from mantle sources modified by supercritical liquids escaped from dehydrated metabasalts and metasediments constituting the deep portion of the slab. An overall important contribution from laterally heterogeneous subducted sediments characterized by high Th and U contents and variable Th/U ratios was most likely responsible for the large variations observed in Pb isotope ratios.

Reference: Tommasini S, Heumann A, Avanzinelli R, Francalanci L (2007) The fate of high-angle dipping slabs in the subduction factory: an integrated trace element and radiogenic isotope (U, Th, Sr, Nd, Pb) study of Stromboli volcano, Aeolian arc, Italy. *J Petrol* 48:2407-2430

I2-3 Orale Khalili Mobarhan, Shahram

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CHEMICAL VARIATION DURING MAGMA ERUPTION AT MT. BDKHAN (IRAN)

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Key terms: Bidkhan; A.F.C; crustal contamination; F.C; magma mixing

Mt. Bidkhan's volcanic rocks (South-east Iran) cover a compositional spectrum from andesite to dacite. A plot of K_2O+Na_2O Vs SiO_2 suggests a medium to high calcalkaline for volcanic products. The geochemical trends of the Bidkhan volcanics are depicted through the use of the harker diagrams. Many of compositional arrays of Bidkhan samples are linear (e.g. Fe, Ca, Y) which support amagmatic differentiation in parental magmas. Some element arrays, however, are scattered (e.g. Ba, Sr, P) or curvilinear (e.g. Al, Na). These suggest that processes such as crystallization, and assimilation also probably operate in the magma chamber. In addition, some features such as high amounts of Th/Nb and Zr/Nb ratios in Bidkhan samples, suggest crustal contamination has been played an important role in the evolution of Bidkhan parental magmas. Field observations and whole rock chemistry for Bidkhan rocks suggest that the last melts that have differentiated and erupted from shallow magma chambers had been intermediate (probably andesitic) melts and have been repeatedly invaded by newly intermediate batches of magmas during differentiation. Then we have to search the traces of magma mixing in mineral chemistry, especially plagioclase crystals in the Bidkhan rocks. Bidkhan's plagioclases can be divided in 4 category: 1) Normal zoned plagioclases, in this type, An mol% varies from 53 in core to 10 in the rim; 2) Reversely zoned plagioclase crystals that make up a significant percentage of the Bidkhan plagioclases and occur in all of the rock types, with a compositional range from 30 An mol% in core to 55 in rim; 3) Normal oscillatory zoned plagioclases that also occur in all of the rock types; their An mol% fluctuates from core to rim, The ΔAn in oscillations are relatively small (~5 An mol%), that suggest newly melts were nearly similar in composition; 4) Reverse oscillatory zoned plagioclases, in this group of plagioclase crystals, An mol % content fluctuates and increases from their core to rim overally. Investigation of chemistry data in Bidkhan reveals that there are some plagioclase crystals with calcic cores (An 75 mol %) in andesites. These features must be established due to magma mixing. This situation that has stated by Toothil (2007) means a combination of

fractionation and magma mixing, where crystals growth in a relatively shallow magma chamber has periodically been interrupted by injection of other melts, with nearly similar composition of some many plagioclase phenocrysts. All these data suggest that, in Bidkhan, before and during eruption, some phenomena like fractional crystallization (F.C), assimilation and crystal fractionation (A.F.C), crustal contamination and magma mixing processes have a greater role to construction of Bidkhan's volcanic products.

I2-4 Orale Nicotra, Eugenio

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LARGE-VOLUME EFFUSIVE ERUPTIONS AND CALDERA COLLAPSES AS THE RESULT OF UNCOMMON MAGMA STORAGE CONDITIONS AT MT. ETNA VOLCANO (SOUTHERN ITALY)

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Key terms: Etna; plagioclase; cicirara; magma chamber; ascent dynamics

The emission of plagioclase megacryst-bearing lavas, locally known as "cicirara", is rare throughout the volcanic record of Mt. Etna and generally related to unusual volcanological dynamics. Highly porphyritic lavas were emitted either during the final phases of the Ellittico volcano (14-16 ka) in association with a caldera collapse or during long-lasting and large-volume, effusive events of the XVII century. This eruptive period culminated with the catastrophic 1669 AD eruption, which was followed by the formation of a caldera at Piano del Lago (ca. 2500 m a.s.l.), as reported by detailed historic chronicles.

We tried to decipher the magma chamber processes and the structural features of the plumbing system that led to the formation of large plagioclase crystals (up to 1.5 cm). Selected plagioclase megacrysts, belonging to the final phase of the Ellittico and to the XVII century, were investigated through high-resolution BSE images and core-to-rim compositional profiles for An% and FeO wt%. A similar approach recently provided key information on the feeding system and ascent dynamics at Mt. Etna for mildly porphyritic lavas of the historic and recent eruptive record (Viccaro et al., 2010). Larger crystals (>7 mm) showed patchy zoning at the core followed by oscillatory-zoned envelopes. Crystals with size 1-7 mm display coarse sieve-textures at the core followed by oscillatory-zoning towards the rim. The most frequent texture is oscillatory-zoning, which is recorded by crystals of the dimensional class <7 mm. Three types of oscillations, characterized by different wavelength and frequency of An content, were observed. Oscillatory zoning can be interrupted towards the rim by other textures such as stripes of melt or fluid inclusions or strongly sieve-textured envelopes. Patchy zoning provides important indications on the styles of magma ascent between the plagioclase nucleation threshold and the volatile saturation depth (~6 km beneath the summit craters), suggesting limited ascent in the deep levels of the plumbing system. At shallower, water-undersaturated levels ascent might be faster, as testified by crystals smaller in size affected by coarse sieve-textures. Conversely, oscillatory zoning and the other textures give information on the magma evolutionary processes during storage at shallow, water-saturated levels (above 6 km of depth). Stripes of melt or fluid inclusions and strongly sieve-textures towards the rim are an indication that other physical and chemical perturbations occur at shallow levels. Stripes of melt inclusions can be associated with steps of magma ascent coupled with volatile loss, whereas layers of fluid inclusions may be related to episodes of volatile influx into the residing system. Finally, strongly sieve-textured envelopes with an increase and constant FeO (found exclusively in lavas of the XVII century) may be related to mixing with magmas similar in composition but more volatile-rich. The manifestation of "cicirara" lavas in some specific periods of the volcanic record is evidence that the plumbing system structure underwent a progressive coalescence of the complex network of dykes and sills as a response to increasing magma supply rate from depth, which finally led to a large reservoir at shallower depth. Huge amounts of magma withdrawal during long-lasting, purely effusive eruptions from this reservoir may be linked to episodes of summit instability that caused major caldera collapses at Mt. Etna in the past.

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I2-5 Orale Donato, Paola

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MICROANALYSIS AS A TOOL FOR DEFINING THE MAGMATIC SYSTEM: THE EXAMPLE OF LIPARI- VULCANO HISTORICAL ACTIVITY

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Key terms: LA-ICP-MS analyses; Aeolian Islands magmatism; Lipari-Vulcano magmatic system

Trace elements distribution in volcanic minerals is influenced by a number of factors including, beside the composition of the magma, also its temperature, pressure, oxygen fugacity and volatile contents. Comparing the trace elements content in crystals of products of different eruptions can allow to understand whether they formed in the same conditions and if they are, therefore, related to the same magmatic system. We applied this principle to the products of historical eruptions occurring almost simultaneously along a N-S tectonic alignment on the island of Lipari, Vulcano and on the Vulcanello peninsula, with the aim to demonstrate that during the last 1000 years, in this sector of the Aeolian arc, eruptions were fed by a common deep magmatic reservoir. The historical magmas of Lipari and Vulcano range in composition from shoshonites (Vulcanello, 1100-1600 A.D.) to rhyolites (Rocche Rosse; Lipari, 1230±40 A.D.; Commenda and Palizzi; Vulcano, 1200 A.D.; products of 1888-90 eruption on La Fossa). Mafic enclaves of latitic composition are present in the obsidian rhyolitic lava flows of Rocche Rosse and Commenda, or are emitted as lavas (Palizzi) and/or pyroclastics (Vulcanello). In order to compare minerals in equilibrium with the same melt composition we focused our study on these intermediate products. Many similarities exist between the different latites in terms of petrography and whole rock chemistry. Clinopyroxene ($Wo_{43-46}En_{39-44}Fs_{13-15}$, $Mg\# = 0.72-0.76$) is always

the most abundant phase, followed by plagioclase (An₂₅₋₄₀Or₁₂₋₈), sanidine (An₁₅₋₃₅Or₅₀₋₇₀) and olivine (Fo₅₀₋₇₀). A detailed LA-ICP-MS microanalytical study on all the mineral phases showed that the pyroxenes of the different latites have very similar trace elements and REE patterns, with an Eu negative anomaly of about 0.65. Also plagioclase and K-feldspar show almost superimposed trace elements and REE patterns. Due to their small size it was possible to analyze olivine crystals only in Vulcano and Rocche Rosse latites; their FME contents are also very similar. The strong geochemical similarities of the latites suggest a common origin, i.e. the same volcanic system or the same magma. On the basis of geochemical models drawn using major, trace and isotopic data, a possible common parental magma has been recognized in the shoshonitic basalt found in the olivine melt inclusion within La Fossa cone 1888-1890 products [2]. The present work supports the hypothesis of Davi et al. 2009 and 2010 [3,4] suggesting a common deep feeding system for both islands in historical time. Mafic melts of the deep system can directly reach the surface (e.g. at Vulcano) and/or periodically refilling shallower magma batches with latitic to rhyolitic composition, enabling the rhyolitic eruption. Hazard evaluation in the southern sector of the Aeolian islands should consider Lipari and Vulcano as a unique magmatic system.

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I2-6 Poster Martelli, Mauro

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NOBLE GASES IN MAFIC PHENOCRYSTS FROM EXTRUSIVES AND ULTRAMAFIC NODULES OF STROMBOLI: A COMPARISON TO PRESENTLY-RELEASED FLUIDS

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Key terms: Helium; Isotopes; Stromboli

Noble gas compositions (He, Ne, Ar) and isotopic ratios (He, Ar) in olivine- and clinopyroxene-hosted fluid inclusions were measured for the (i) present-activity basalts, i.e. Low Porphyritic (hereafter LP) pumices and High Porphyritic (hereafter HP) scoriae, and (ii) ultramafic nodules within the ~2 ka old San Bartolo basaltic andesite lavas. The ultramafic nodules (mostly wehrlites) are igneous cumulates consisting of clinopyroxene and olivine crystals with abundant fluid and melt inclusions. Textures and mineral chemistry of the wehrlites suggest that they are the products of early crystallization of primary basaltic magmas at mantle conditions. In addition, ultramafic cumulate and LP pumice crystals show similar major oxide composition (olivine and clinopyroxene) and trace element patterns (clinopyroxene). The gas content in mafic crystals decreases from ultramafic nodules to LP pumice and finally to HP scoria. This is probably due to the decreasing pressure (and depth) of fluid entrapment. In agreement with previous knowledge, the HP crystals are severely degassed and, as a result, the measurement of their 3He/4He ratio was unsuccessful. The 3He/4He of LP pumices and San Bartolo ultramafic nodules converge to a range of 4.2-4.7 Ra that we interpret as the magmatic value of the least degassed actual feeding system of Stromboli. This also allows the helium isotopes of the thermal waters of the Stromboli basal aquifer to be considered a mix between mantle-derived and atmospheric fluids. Therefore, the 3He/4He values measured in the Stromboli rocks represent the upper limit that should be expected in thermal fluids during long-term monitoring in case of events such as lava effusions and/or paroxysms.

I2-7 Poster Rosciglione, Alberto

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OXYGEN FUGACITY VARIATION RECORDED BY SULFUR SPECIATION IN ETNEAN OLIVINE-HOSTED MELT INCLUSIONS

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Key terms: Mount Etna; sulfur speciation; melt inclusions; oxygen fugacity

Although sulfur is a minor element in magmas it plays key roles in processes of magma evolution, volcanic degassing and eruption. As a dissolved species in magmas, sulfur mainly exists as sulfide (S²⁻) under reducing conditions, and sulfate (S⁶⁺) under oxidizing conditions. Probing sulfur in magma is challenging because more than 90% of the sulfur initially dissolved is released at the time of eruption. Silicate melt inclusions trapped within early crystallized olivines provide a means of preserving melt compositions prior to significant modification of the magma such as assimilation, crystallization and degassing. Melt inclusions can provide reliable estimates of melt oxidation state at the time of inclusion entrapment.

Oxidation state in melt inclusions has been assessed by electron microprobe (EMP) measurements of sulfur speciation, determining the relative proportions of S²⁻ and S⁶⁺, on the basis of the sulfur K α X-ray peak shift method. This technique provides relatively rapid analysis of

small samples (~30 μ m) and is therefore ideal for application to melt inclusions.

A selection (30 to 40) of olivine-hosted melt inclusions and relative matrix glasses from 2001-2006 Mt. Etna eruptions, embedded in epoxy resin, were considered for this investigation. The selected samples have been previously characterised as for texture, major, minor and volatiles (including S). All the studied inclusions are hosted by forsteritic olivine (Fo78-82) and sulfur concentrations widely range from approximately 400 to 8000 ppm. Pyrite, Troilite, Sphalerite, Cinabro, Barite and Celestine

mineral grains were used as reference materials to define the peak position for SK α for a wide range of different S⁶⁺/S^{total} ratios and defining the peak position for pure sulfide and sulfate. With the aim of better constraining the oxygen fugacity in our MIs we also measured, by EMP,

iron speciation (Fe²⁺/Fe³⁺) by using the iron L α /L β intensity ratios. Aim of this study is to characterise the variations of sulfur speciation in melt inclusions as a result of natural magmatic processes. Based on sulfur X-ray wavelength measurements, calculated oxygen fugacities for etnean basaltic melt range from -0.4 to +2.5 log units (Δ NNO), with the highest calculated oxygen fugacity from the 2006 eruptive products. S⁶⁺/S^{total} ratio in melt inclusions generally well correlate with that of relative matrix glasses, although we observed a wider range in the former. Large ranges in measured sulfur speciation in naturally quenched melt inclusions may be related to degassing of the melt synchronous with entrapment in the olivine host crystals during closed-system ascent of etnean basaltic magma.

We normally observed that dissolved water and sulfur contents in melt inclusions simultaneously decrease during melt degassing, and according to that melt inclusions with higher S⁶⁺/S^{total} (more oxidized) appear to correspond to high water concentrations.

A notable exception was observed in some melt inclusions of 2002 eruption showing a very different behaviour, mainly characterised by large differences in S content at almost constant K₂O, and displaying an inverse relation between H₂O and S. The former condition is compatible with a rapid decompression accompanied by a limited crystallization processes, that causes rapid degassing with irrelevant chemical evolution of the melt. An attempt to explain the opposite variation of H₂O and S occurring in some primary etnean melt inclusions was made taking into account the involvement of an immiscible sulphide melt phase which has been observed and documented in some etnean melt inclusions.

I2-8 Poster Viccaro, Marco

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PLAGIOCLASE TEXTURES AND COMPOSITIONS TO UNRAVEL THE FEEDING SYSTEM DYNAMICS AT AVACHINSKY VOLCANO (KAMCHATKA, RUSSIA)

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Key terms: Subduction zone; Volcanism; Sieve texture; Patchy zoning; Oscillatory zoning

Aim of the work is the identification of the feeding system processes and styles of magma ascent before the 1991 eruption at Avachinsky through whole rock and textural/compositional data of plagioclase crystals obtained by high-resolution BSE images and core-to-rim profiles. The 1991 volcanics at Avachinsky are porphyritic basaltic andesites and andesites with low-K (tholeiitic) affinity. Major oxides are within the compositional range of other Kamchatka products of similar evolutionary degree. Trace elements define two trends: some samples show a progressive evolution from basaltic andesite to andesite that can be ascribed to crystal fractionation, whereas other products are not in accordance with a differentiation process driven by crystals removal. A two-steps fractionation modeling for both major and trace elements was performed to justify the basaltic andesite and the andesite compositions. Results of the first step show that basaltic andesites are consistent with fractionation from a poorly-evolved basaltic andesite of 27 wt% ~An80 plagioclase, 12 wt% aegitic clinopyroxene, 4 wt% orthopyroxene and 6% opaque oxide (P = 150 MPa; T between 1150°C and 1000°C; initial H₂O = 2.0 wt.%; fO₂ at the QFM+1 buffer). The second fractionation modeling justifies the andesite starting from the less evolved basaltic andesite of the 1991 eruption dataset. Results show that the andesite can derive from the basaltic andesite by fractionation of 24 wt% An75 plagioclase, 7 wt% aegitic clinopyroxene, 4 wt% orthopyroxene and 3 wt% opaque oxides (P = 50 MPa; T between 1150°C and 1000°C; initial H₂O = 2.6 wt.%; fO₂ at the QFM+1 buffer). Trace element geochemistry suggests the occurrence of other differentiation processes beyond the two-steps fractionation. The coupled increase of Zr - Ba/Sr - Rb/Sr for some samples indicates that some assimilation may have occurred during the evolution from basaltic andesite to andesite. Other basaltic andesites keep Ba/Sr and Rb/Sr rather constant at increasing Zr, ruling out the contribution of a crustal component. Thus, a hypothesis of new magma recharge was verified through the integrated textural and compositional study of plagioclase crystals. Several texture types were found: 1) small and large-scale oscillation patterns; 2) disequilibrium textures at the crystal core (patchy zoning, coarse sieve-textures, dissolved cores); 3) disequilibrium textures at the crystal rim (strongly sieve-textures); 4) growth textures consisting of melt inclusion alignments at the rim. Disequilibrium textures found at the cores testify episodes of destabilization at variable decompression rates under water-undersaturated conditions, which suggests different pathways of magma ascent at depth. At shallower, water saturated conditions, plagioclase textures and compositional profiles suggest that crystallization continues in reservoirs not affected by important chemical and physical perturbations (oscillatory zoning develops). Strongly sieve-textured rims are evidence for the occurrence of a mixing process prior the 1991 eruption: the behaviour of An and FeO suggests that the recharging magma was geochemically-distinct at rather comparable evolutionary degree and with higher temperature and volatile contents than the residing one. Assuming a certain degree of undercooling, the timescales derived to develop this envelope indicate less than 4 months. The occurrence of only two types of textures that cut the oscillatory zoning (strongly developed sieve-textures or thin alignments of melt inclusions) evidences that crystals underwent common histories at shallow levels, favouring the hypothesis of the existence of a large magma reservoir at ~5 km of depth, more than several separated batches. The presence in a hand-size sample of these two types of textures also implies that crystals mix mechanically at very shallow levels, supporting the existence of a small magma reservoir at ~1.5 km of depth.

SESSIONE I3

Processi di genesi, intrusione, risalita ed eruzione di magmi: un approccio multidisciplinare

I3-1 Orale Sinigoi, Silvano

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CRUSTAL FERTILITY AND GENERATION OF A LARGE SILICIC MAGMATIC SYSTEM TRIGGERED BY UNDERPLATING IN THE IVREA-VERBANO CASE.

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Key terms: magmatic system; underplating; caldera; Ivrea; Sesia magmatic System

The Sesia magmatic system allows direct study of the links between silicic plutonism and volcanism in the upper crust and the coeval interaction of mafic intrusions with the deep crust. In this talk we focus on the chemical stratigraphy of the pre-intrusion crust, which can be inferred from the compositions of crustal-contaminated mafic plutonic rocks, restitic crustal material incorporated by the complex, and granitic rocks crystallized from anatectic melts. These data sources independently indicate that the crust was compositionally stratified prior to the intrusion of the Mafic Complex, with mica and K-feldspar abundance decreasing with depth and increasing metamorphic grade of the restites. Reconsideration of published zircon age data suggest that the igneous evolution initiated with sporadic pulses at around 295 Ma, when mafic sills intruded deep granulites which provided a minor amount of depleted crustal contaminant. At increasing rates of the intrusion, between 292 and 286 My, mafic magmas invaded a significantly more fertile crustal level, consisting of amphibolite-facies paragneisses, so generating hybrid rocks with distinct chemistry. At this point, advanced anatexis produced a large amount of silicic hybrid melts that fed the incremental growth of upper-crustal plutons and volcanic activity, while the disaggregated restite was largely assimilated once ingested by the growing Mafic Complex. This "igneous climax" was coincident with an increasing rate of intrusion, when the upper Mafic Complex began growing according to the "gabbro glacier" model and, at about the same time, volcanic activity initiated. In conclusion, the fertility of "under/intra-plated" crust plays a crucial role in governing the generation of large volumes of continental silicic magmas.

I3-2 Orale Mazzarini, Francesco

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MONOGENETIC VENTS DISTRIBUTION AND CRUST MECHANICAL LAYERING IN THE MAIN ETHIOPIAN RIFT

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Key terms: monogenetic vent; basaltic volcanic field; continental rift; Main Ethiopian Rift; East Africa

Basaltic volcanic fields, formed by several volcanic constructs, are common features in the main Ethiopian Rift. Their age spans from 3 Ma to Holocene and are distributed along belts in the rift floor and clustered along magmatic belts close to the western rift margin. The strict relation between vent and dike allows analysing the vent spatial distribution in relation with tectonic features and crust layering. Observed vent distribution suggest a strong control in vent location by crust layering and by tectonic features. Moreover, vent distribution is defined by power-laws (fractal distribution). These distributions are defined by upper and lower cut-off lengths, where the upper one shows scaling relationship with the thickness of the crust beneath the volcanic field. This point suggest that vent distribution could be used as a proxy in defining the distance between the reservoirs and the sink, that in the case of basaltic magmas often represent the crust thickness.

I3-3 Orale Francalanci, Lorella

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THE 2010 ERUPTION OF EYJAFJALLAJÖKULL VOLCANO, ICELAND: CONTRIBUTIONS FROM CHEMICAL AND SR-ISOTOPIC MICROANALYTICAL DATA ON TEPHRA

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Key terms: volcanic ashes; geochemistry; isotope data; microanalytical analyses; Eyjafjallajökull volcano

During the 39 days of summit activity at the Eyjafjallajökull volcano (14 April-22 May 2010) a nearly continuous injection of tephra in the atmosphere with a large production of ash caused disruption to the aviation over Europe. The activity consisted of an initial intraglaciale phase (14-19 April) of Vulcanian-type explosions, followed by intermediate phase (19 April-3 May) of weak magmatic explosions and lava emission; a final renewed phase of pulsatory explosions occurred between 3 May-22 May. The eruption emplaced about 0.1 cubic km (DRE) of benmoreite tephra with 10-20% of fine ash (< 10 micrometers) (Thordarson et al., 2011, G.R.A., 13, EGU2011-12046). The summit activity was preceded (20 March-12 April) by a mildly Na-alkaline basaltic fissure eruption on the East flank (Fimmvörðuháls) of the Eyjafjallajökull volcano, where up to 150-m-high lava fountains, emplaced 0.025 cubic km of lava (Thordarson et al., 2011, G.R.A., 13, EGU2011-12147).

We sampled a pristine fallout sequence packed in the snow 5 km East from the vent, representing the opening, the 14-15 April and the 17 April activity, respectively. A sample of falling particles was also collected 5.5 km from the vent on 6 May. Lapilli and lava of the Fimmvörðuháls basaltic

fountains were also collected. Samples were processed for grain size analyses; juvenile clasts were hand-picked in the range 0.710-1 mm and selected clasts were analyzed and characterized with SEM imaging. Matrix glasses of the chosen tephra clasts have silica ranging between 58-64 wt%, FeO between 7-10 wt% and K2O between 2-3 wt%. Compositions are extremely homogeneous within single clasts but slight variations can also occur between different clasts of the same sample. Major and trace elements and isotope data on whole-rock samples were also performed. Tephra samples show small compositional variations (SiO2: 58-64 wt%, MgO: 1.5-3.0 wt%, FeO: 8-10 wt% and K2O: 1.6-2 wt%). Although a good correlation between trace elements and silica exists, the trends of incompatible elements cannot be simply explained with fractional crystallization of the present mineral phases (olivine, clinopyroxene, plagioclase, magnetite and apatite). Matrix glasses of variably-vesiculated clasts, showing different composition and crystallinity, were also micro-milled and analysed for Sr isotope ratios by TIMS at the University of Florence. We found a range in 87Sr/86Sr values that nearly encompass that of Iceland magmas at the Eyjafjallajökull latitude (Sigmarsson et al., 2008, Jökull, 58), with the exception of some higher values which seem to be correlated with the phase of eruption and/or with magma evolution. No correlation has been found between 87Sr/86Sr and vesicularity or microlite content of the groundmass.

Magma mixing and/or mingling between a new basaltic melt and a residing evolved magma is proposed to be occurred before the explosive eruption, with end-members that changed in composition with time (Sigmarsson, 2011, G.R.A., 13, EGU2011-12589). Our data help to shed light on this hypothesis and on the eruption dynamics, although they also highlight a more complex plumbing system.

I3-4 Orale D'Albore, Filomena

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A NEW INTERPRETATION OF PHLEGRAEAN FIELDS CALDERA USING ANALOGUE MODELS

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Key terms: analogue models; caldera; Phlegraean Fields

Recently, to better understand structures and deformations of volcanoes new data became available by the use of analogue models that reproduced natural events in laboratory, simplifying them reducing the number of variables, and allowing to characterize the main phases of the processes by a well defined scale ratio between the events and their reproductions in laboratory. We used an analogue model by gelatine as a material analogue to the crust, in order to identify a new mechanism explaining the origin of the Phlegraean Fields Caldera, a volcanic structure that extends over the city of Naples and its western surroundings and formed during a distensive tectonic phase associated with the opening of the Tyrrhenian Basin and eastward migration of Apennine Chain.

The volcanic field is constituted of two calderas and of several monogenic cones. The oldest caldera is related to the Campanian Ignimbrite eruption that occurred about 39 ka B.P., and the youngest caldera formed 15 ka B.P. with the Neapolitan Yellow Tuff eruption.

An accurate analysis of the volcanic history of the Phlegraean Fields area and of the data available from the literature brought out doubts on two issues: 1) source of Phlegraean volcanism; 2) actual location of the limits of the Campanian Ignimbrite (CI) Caldera.

Our research began with previous interpretations that at the origin of the Neapolitan volcanism there is a mantle upwelling occurring about 2 Ma B.P., associated with tensile tectonics generated by the opening of Tyrrhenian Basin. In order to simulate a rising plume in the Neapolitan area we built two analogue models, set by volcanological, geophysical and geochemical constraints. The models were built using a layer of gelatine in order to obtain a spatial distribution of fractures in the material, source pressure values, scaled elastic parameters, a 3D model constrained by geological data. The difference between the models was the type of source: in the first model, a silicon balloon was placed at the bottom of the gelatine layer and was slowly inflated to simulate a rising plume; in the second model, animal fat was injected in the gelatine through a conduit in order to constrain it during the upward migration.

The effect of the experiment by the silicon balloon was the tumescence of the surface of gelatine layer with the formation of fractures just like a triple junction, followed by detumescence when the source pressure decreases.

For the second model, experiments were realized by varying the overburden thickness, hence the source depth. The effects were different: by greater source depth, a fat sill expanded in the analogue crust triggering the formation of a horizontal fracture, from sill to the surface, and it was followed by a triple junction. In the second case, by a shallower source, the fat sill only triggered the formation of a triple junction. The analogue models allowed to obtain the pressure of the magmatic source necessary for the overburden uplift and the formation of triple junction, in the Phlegraean Fields, and were used to determine the plume diameter. Therefore, the evolution time of deformation phenomenon in the analogue model allowed to scale the time of pre - Campanian Ignimbrite Caldera volcanism: the formation of CI Caldera was preceded from a fracture along which volcanic activity would develop initially and then migrate to the Gulf of Pozzuoli favoring a director E-W corresponding to the fault scarps of half graben basement of Campanian Plain; during this process of activity migration, a triple junction grows slowly giving rise to the Campanian Ignimbrite eruption and the subsequent collapse; the time between the first activity along fracture and the formation of the CI Caldera is about 25 ka scaled by the analogue model; a further triple junction was generated as a result of a new rising magma inside the CI caldera giving rise to the formation of Neapolitan Yellow Tuff caldera about 15 ka BP.

I3-5 Orale Civetta, Lucia

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THE CAMPANIAN IGNI MBRITE CATACLYSMIC ERUPTION THAT SEGREGATED AND DISCHARGED A HUGE AMOUNT OF VOLATILES AND GENERATED EXTREMELY DILUTED PYROCLASTIC DENSITY CURRENTS.

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Key terms: Campanian Ignimbrite; magmatic degassing; residence time; caldera collapse

The late Pleistocene trachytic Campanian Ignimbrite (CI; 300 km³ DRE) covers the Campanian Plain near Naples, and is found behind ridges more than 1,000 m high at 80 km from source, the Campi Flegrei caldera (CFC). Distal ignimbrite deposits reveal downhill and/or downvalley flow directions prior to deposition, whereas in the absence of significant topography, deposition came from a flow moving in a roughly radial direction. These features point to very dilute currents, that together with the huge amount of discharged magmatic material, suggest a magma reservoir highly enriched in volatiles, rather than fluid entrainment from hydrothermal bodies or seawater. Petrologic and geochemical modelling of erupted products and their chemical and textural zoning, together with MI-based studies of gas-melt saturation, corroborate this view and show that the CI huge volume differentiated and mixed at shallow depth (6-3 km). With respect to compositionally similar but also smaller CFC eruptions (e.g. Agnano-Monte Spina, A-MS), the large amount of volatiles discharged by IC was likely due to fractional crystallization and longer residence times of volatiles sourced by the subducting Apenninic slab. This yielded high-water contents (up to 6-7 wt%), as well as high void fractions (~70-80% for IC, ~45% for A-MS) and also produced an overpressurized CO₂-dominated gas cap (about 150 km³), uniformly distributed at the top of the magma chamber. The onset of the eruption tapped this cap, with consequent depressurization and fast volume decrease that facilitated or even drove the caldera collapse, and allowed the water-rich magma to be discharged during the pyroclastic current phase. The gas saturation-based estimates of the tapped foamy magma are compatible with the extent of magma chamber roof collapse, strong expansion revealed by textural data and transport and deposition mechanisms, reflecting depressurization and magma inflation within the collapsed and laterally confined caldera.

I3-6 Orale Gaeta, Mario

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CALCITE-BEARING FOIDITIC LAVA FLOWS FROM COLLI ALBANI VOLCANIC DISTRICT

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Key terms: Lava flows; Calcite; Colli Albani

The Colli Albani (hereafter CA) ultrapotassic volcanic district (near the city of Rome, Central Italy) belongs to the Roman Province whose magmatism is thought to result from the combined effects of crystal fractionation and crustal assimilation on a parental magma derived from a metasomatized mantle source. The CA district represents one of the most peculiar volcanic districts on the Earth because of its liquid line of descent

characterized by differentiated, low silica ($\leq 45\text{wt}\%$), K-foiditic magmas. Field, geochemical, and experimental studies have demonstrated that such a differentiation trend, starting from trachybasaltic parental magma, is mainly due to magma-carbonate interaction (Gaeta et al. 2009 and references therein). Despite many studies have investigated petrological and geochemical features of the Colli Albani magmas, several questions remain unanswered. One of these concerns the occurrence of calcite crystals in the groundmass of some lava flows. In general all CA lava flows are made up of leucite and clinopyroxene phenocrysts; some deposits (corresponding to less evolved products) also contain forsteritic olivine. The groundmass, is generally made up of leucite, clinopyroxene, and Ti-magnetite; more evolved products may also contain amphibole or, and these are the object of our study, calcite, usually associated with nepheline.

The textural study of calcite-bearing lava flows, by means of Field Emission SEM, revealed that calcite usually occurs as interstitial phase, intergrows with nepheline and, in some cases, contains inclusions of oxide (e.g. hematite) or fluorite. Calcite is also present: i) as spherical "ocelli" with tangentially arranged crystals of clinopyroxene; ii) interstitial at clinopyroxene rim and leucite; and iii) rarely, around coronitic texture of leucite produced at the expense of K-feldspar xenocrysts. All these textural features indicate that calcite occurring in the lava flows groundmass crystallize above the solidus temperature.

The high activity of calcium in the lava flow groundmass is also supported by the mineral chemistry of silicate phases. For example, olivine crystals in groundmass are enriched in FeO and CaO (up to 4 wt.%) and a positive correlation between CaO in olivine and melt differentiation (i.e. Mg#) is observed. Carbon and oxygen isotope values, as well as trace elements abundance, have been determined on calcite and phenocrysts occurring in the CA lava flows. Oxygen isotope values (25-26 ‰ SMOW) result higher than that of phenocrysts (6-8 ‰ SMOW) and, interestingly, coupled with very low carbon isotope values (-14.4 - -15.7 ‰ PDB). Trace elements abundance in calcite is lower than abundances measured in both clinopyroxene phenocrysts and bulk rocks (LREE ≤ 100 chondrite).

Textural and mineral chemistry data indicate, unambiguously, that calcite in the CA lava flows has crystallized from a carbonate-bearing melt in a magmatic environment (Freda et al., 2011). Although carbon isotope values could suggest a mantle origin for the carbonate-bearing melt, oxygen isotopic composition and trace element abundance suggest a different origin. We propose that calcites in CA lava flows form as result of a mingling process between Ca-rich melts, originating in skarn environment and/or during sin-eruptive carbonate assimilation, and potassic magmas.

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I3-7 Orale Viccaro, Marco

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LONG-TERM VS. SHORT-TERM GEOCHEMICAL CHANGES OF MT. ETNA LAVAS: THE PUZZLING EFFECT OF A VARIATED MANTLE

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Key terms: Southern Italy; Volcanism; Mantle heterogeneity; Metasomatism; FOZO

Mt. Etna volcano fascinated the scientific community during the last decades due to its unusual geodynamic location and geochemical signature of the erupted lavas. Although the edifice is placed above the front of a compressive regional tectonic setting, volcanic products have a marked intraplate signature. The volcano has shown a complex geochemical variability during the half-million years of life, with sub-alkaline products erupted during the early stage of volcanism up to ~220 ka ago, then followed by a Na-alkaline stage. The alkaline stage also exhibit short-term changes in some periods. For example, an increase in some LILEs and volatiles together with marked changes of the Sr-Nd-Pb-Hf isotope ratios are observed since the 1971 (Viccaro and Cristofolini, 2008; Viccaro et al., 2011). Mt. Etna can surely be considered as one among the most studied volcanoes on Earth, although the features of the source are still matter of discussion. The absence of mantle material (xenoliths), which is efficiently fractionated in the deep levels of the feeding system, makes more intricate the picture. Thus, indirect information can be only attained from magma compositions. The behavior of incompatible trace elements for mantle-equilibrated magma compositions of the Ellittico (60-15 ka) and Recent Mongibello (15 ka-present), and of their enrichment ratio show that the Etnean magmas are produced by a variable, low degrees of partial melting. The enrichment ratio also reveals that magmas can be generated from a classic garnet peridotite variably enriched by metasomatic mineral phases (amphibole-phlogopite). The Zr/Nb vs. Ce/Y and Ba/Th vs. Lu/Hf diagrams highlight the enriched signature of the Etnean mantle. The Zr/Nb vs. Ce/Y diagram evidences the progressive contribution of metasomatic phases with time. The Ba/Th vs. Lu/Hf diagram shows the short-term coupled increase of the contribution by metasomatic agents and partial melting degree during the last 400 years of volcanic activity. In terms of mantle components, the integration of Sr-Nd-Pb-Hf isotopic ratios suggested that FOZO is the dominant component in the Etnean source (Viccaro et al., 2011). However, the FOZO component is not able to fully account for the isotopic changes from the Ellittico to Recent Mongibello magmas. Indeed, the isotopic compositions of the Ellittico and Recent Mongibello volcanic products can be explained by addition of an EM1-type component (up to 10%) to a dominant FOZO. The integrated analysis of Sm/Hf and Th/Hf ratios, together with Hf isotope ratios, gives evidence that the enriched component may be metasomatizing silicate melts. Long-term vs. short-term compositional changes at Mt. Etna are here related to partial melting of a recycled, altered oceanic lithosphere, infiltrated by metasomatizing silicate melts. Variable amounts of the enriched component participating to partial melting are able to affect its degree and the geochemical signature of the produced magmas.

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I3-8 Orale Corsaro, Rosa Anna

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RELATIONSHIP BETWEEN MAGMATIC PROCESSES IN THE PLUMBING SYSTEM OF MT. ETNA AND THE DYNAMICS OF THE EASTERN FLANK: INFERENCES FROM THE PETROLOGIC STUDY OF THE PRODUCTS ERUPTED FROM 1995 TO 2005

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Key terms: Mt. Etna; Magmatic processes; Flank instability; Recent eruptive activity

Mt. Etna is located in a quite complex tectonic context and large sectors of the eastern and south-eastern flanks of the edifice move downward at very different rates. During last years, the flank slip has been somehow related to the magmatic intrusions refilling the shallow and deep portion of the volcano plumbing system, suggesting a feed-back between flank dislocation and magma emplacement within the volcano. The petrologic studies performed during last decades at Mt. Etna, evidenced that the plumbing system of the volcano has a quite complex geometry, variable in space and time and consisting of storage zones at different depth, where magma ascending to the surface experiences complex processes such as mainly fractional crystallization and mixing.

In this framework it's quite interesting to further investigate if a possible cause-effect relationship exists between the displacement of the volcano East flank and the pre-eruptive magmatic processes in the plumbing system. We went into this matter with a petrologic study of the products erupted in the decade 1995-2005. In particular we analyzed the petrography, mineral chemistry, geochemistry, Sr and Nd isotopes emitted by the four summit craters of Mt. Etna (South-East, North-East, Bocca Nuova and Voragine) from 1995 to 2001 and integrated them with petrologic data already available in literature for the investigated decade. This approach allowed us to better constrain the temporal evolution of the main magmatic processes occurring in the plumbing system of Mt. Etna (mainly mixing between compositionally distinct magmas and fractional

crystallization) and to make inferences on the geometry (shape and depth) of the shallow (>5 km b.s.l.) storage zone. In the studied decade, the comparison between petrologic data and deformational patterns evidences that, from 1995 to July 2001, the aforementioned pre-eruptive magmatic processes did not significantly influence the displacement of the flank, which maintained slow and quite-regular downward movement throughout these years. Differently, the onset of the 2001 flank eruption leads to an accelerated displacement of the movement, up to 2005. Well-known petrologic published data evidence that during the 2001 activity (and 2002-03 too) a primitive, volatile-rich, sub-aphyric basalt upraised directly from a deeper (8-10 km b.s.l.) reservoir to the surface. In conclusion, at least for the investigated period, the pre-eruptive magmatic processes in the shallow portion (<5 km b.s.l.) of Mt. Etna plumbing system, do not seem to directly affect the movement of the volcano eastern flank. Conversely, a magma intrusion which forcefully opens a new path from a deeper zone (8-10 km b.s.l.) of the plumbing system, causes a dramatic increase of deformational pattern, which strongly accelerates the slide of the volcano eastern flank, as it occurred during both 2001 and 2002-03 eruptions.

I3-9 Orale Giacomoni, Pier Paolo

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PLAGIOCLASE AS A TOOL FOR UNDERSTANDING MAGMA DYNAMICS - THE 2001-2006 ERUPTIVE PERIOD AT MOUNT ETNA

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Key terms: Mount Etna; Plagioclase textures; Magma chamber processes; Crystallization conditions

Mount Etna activity is characterized by different eruptive styles, from effusive to highly explosive, involving both central and lateral feeding systems, not accompanied by significant variation in lava compositions. The most important parameter in determining the eruptive styles is therefore the dynamic of magma within the feeding systems. Plagioclase is the most common phenocrysts in all terms of the etnean magmatic suite (~50% in volume). Its stability field is dependent on chemico-physical variations of the melt and it can be used as a tool to highlight the dynamics of magma uprising. Textural and compositional study of plagioclases has thus performed on the products emitted during the 2001-2006 eruptive period, and compared with theoretical models that constrained its stability field and with the eruptive mechanisms put forward by various authors. During 2001-2006 eruptions plagioclase with an average length of about

1mm present i) clear crystals (about 800µm in size), rich in An (An90-85) with oscillatory zonation pattern or ii) phenocrysts with clear or dusty cores lower in An content (An85-75) with complex dissolution textures

(4-500µm): when simple dissolution occurs cores are rounded and clear, while if partial dissolution occurs cores are dusty due to numerous glassy inclusions (coarsely sieved cores) (Tsuchiyama, 1985). In the latter case both cores are followed by a lower An overgrowth ranging in size from 100

to 400 microns. Finally two types of rims (max 100µm) can be also recognized: i) partially dissolved dusty rims, with An-rich composition and ii) a more albitic rims characterized by alignments of melt inclusions along crystallographic planes.

MELTS calculations have been performed to constrain the crystallization conditions, starting from the most primitive magma (2004/2005 eruption) under different pressure (2500-0 bars) and water contents (3.5-0 wt%). Based on whole-rock composition the program estimates the liquidus temperature, which were decreased by step of 20°C down to 1030°C. Volatile saturation depths were estimated using VolatileCalc and water content in Etnean lavas by the plagioclase-liquid hygrometer/thermometer of Lange et al. (2009). Independent determinations of oxygen fugacity (fO₂) of the system have been calculated using the method of France et al. (2010), indicating a range of values varying from ΔQFM=0.3 to ΔQFM=2.8, with an average of ΔQFM=1.8.

These simulation indicate that An-poor (An75-85) plagioclases crystallized at about P=2500 bars and 1 wt% H₂O, while An-rich (An85) plagioclases is stable only at P=800 bars and 2.5 wt% H₂O. Thus clear An-rich (>An85) crystals can be obtained only at very shallow pressure (<1000 bars) with water content of about 2.5-3.3 wt%.

Clean or dusty dissolved cores An85-75 in composition cannot be in equilibrium with high water content at depth greater than 3km. Dissolution processes suggest disequilibrium conditions within the deep magma reservoir which can be related to an input of new undegassed magma or decompression during magma ascent which rise the water pressure. The more albitic overgrowth probably develops at shallower level where the magma can rest, followed by water oversaturation and degassing. The outermost narrow rims can be explained by i) input of new basic magma or ii) rapid growth due to degassing just prior to the eruption.

Textural and compositional study reveals a dependence of plagioclase liquidus on water content dissolved in the melt. Furthermore, the textures at the crystal rims suggest different trigger mechanism of the eruption: an active one, induced by magma mixing and a passive one, promoted by decompression due to fracture opening, probably associated to regional tectonics.

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I3-10 Orale Alesci, Giuseppe

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PETROLOGICAL AND GEOCHEMICAL STUDY OF PRODUCTS AND LAVAS EMITTED DURING THE BILATERAL 2002-2003 ERUPTION EVENT AT MOUNT ETNA

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Key terms: Mount Etna; 2002-2003 eruption; Petrography; Fractionation model; Magma dynamics

The 2002-2003 eruptive event of Mount Etna lasted from 26th October 2002 to 28th January 2003 and was characterized by the contemporaneous activity at the NERS (North East Rift System) and SRS (South Rift system).

A detailed and stratigraphically controlled sampling was developed along the SRS between 2,900 and 1,700 meters a.s.l. Whole rock major and trace elements analyses were carried out and results compared with those obtained from the NERS (Ferlito et al., 2009). Eight main eruptive stages were distinguished on the basis of Catania-INGV daily Reports. The first stage, T1, correspond to the beginning of volcanic activity at SRS on 26 October 2002, although samples referable to this period are no longer accessible. From T2 to T5 the activity was concentrated along the NERS with the opening of three main fracture segments and the contemporaneous emission of several lava flows that reached the touristic centre of Piano Provenzana. The last three stages, from T5 to T8, developed on the southern flank.

On the base of petrographic (P.I.) and geochemical features (mainly K₂O, Rb, Nb), three different magmas have been recognised: (1) High-K Porphyritic (HKP) group with high-potassium contents (K₂O>2 wt%) and P.I. ranging between 20 and 32%; (2) High-K oligophyric (HKO) group with high-potassium content (K₂O>2 wt%) and P.I. ranging between 10 and 18%; (3) Low-K oligophyric (LKO) group with low potassium content (K₂O<2 wt%) and P.I. between 10 and 17%. Low-K lavas are only present at the NERS. HKP lavas emitted at T5 on the southern flank of the volcano are similar to those found on the lowest segment of the NERS, although the former are less differentiated. Quarzarenitic xenoliths are present in lavas from both sides of the volcano.

Major and trace elements mass balance and Rayleigh fractionation models were developed on representative NERS and SRS samples. The modeling indicates that NERS T5 lavas can be fractionated from those outpoured at SRS, suggesting a common fractionation trend. Textural and petrological studies of plagioclases enclosed in these lavas also suggest that chemical-physical conditions at depth were similar, while at shallow levels lavas evolve independently.

These new geochemical and mineralogical data, together with published seismotectonic data, support the idea that the main magma feeding the eruption was common on both sides of the volcano even though magma ascent probably occurred through the South Rift fractures and was intercepted from the NE Rift system only at relatively shallow depth. New magma inputs were recognized at SRS where eruption lasted until the end of January. On the other hand at NERS eruption, which was most probably passively triggered by tectonic activity, lasted only for few days.

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I3-11 Poster Nicotra, Eugenio

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A NEW RECONSTRUCTION OF THE VAL CALANNA VOLCANIC SUCCESSION (MT. ETNA, ITALY): INFERENCES ON A NEWLY DISCOVERED, SMALL-SIZE ERUPTIVE CENTER

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Key terms: Valle del Bove; geological survey; magma differentiation; crystal fractionation; shallow feeding system

Since the beginning of its activity about 500 ka ago, Mt. Etna has been characterized by the growth and destruction of several eruptive centers. Our knowledge on the most ancient of them derives from the study of the steep and friable walls of Valle del Bove, carved on the eastern flank of the volcano edifice. The understanding of long-term variation in terms of volcanological and geochemical evolution of basaltic magmas at Mt. Etna can lead to a more global view of the volcanic system. Within this frame, a multidisciplinary study on ancient eruptive centers can also offer new insights for interpreting the current volcanic activity, providing general models of magma evolution and eruptive behavior. An integrated study embracing geology, petrography and geochemistry was undertaken on the Val Calanna area, located at the south-eastern end of the Valle del Bove. The volcanic succession of Val Calanna is of interest for the study of the Mt. Etna evolution, as the remains of several eruptive centers attributed to the first stages of the alkaline activity outcrop on its flanks. The new geological survey of the Val Calanna area, along with petrographic and geochemical data, highlighted some differences in the volcanic succession with respect to that previously reported in literature.

Our study confirms that the most ancient volcano-stratigraphic Unit of the VdB crops out at Mt. Calanna, recently interpreted as a dyke swarm. The Mt. Calanna Unit is overlain by the 80-m-thick lava succession of the Salto della Giumentata Unit, one of the Ancient Alkaline Centers, which at its top is mantled by pyroclastic flow and epiclastic deposits. Above this, volcanics of the Mt. Zoccolaro Unit constitute the frame of the present-day homonymous ridge with a 200-m-thick succession of benmoreitic lava flows characterized by amphibole megacrysts and showing features similar to those of the Trifoglietto phase (80-60 ka). The eastern portion of the Mt. Zoccolaro edifice is overlain by the volcanic succession of a newly recognized, small-sized, eruptive center: the Fior di Cosimo (FdC).

The FdC Unit is constituted of a sequence of alternating lavas and pyroclastic deposits which dip radially away from an inferred vent hypothetically located in the middle of Val Calanna. The relationship between major oxides of FdC lavas and their stratigraphic position shows an increasing degree of differentiation through time, from basalts to benmoreites. Simulations of crystal fractionation through MELTS revealed that the most evolved FdC lavas can be derived by subtraction of 54% of solid phases (An66-82 plagioclase, augitic clinopyroxene, Fo68-72 olivine, Ti-magnetite and traces of apatite) from a basaltic composition. The proposed model for the FdC magmatic evolution is therefore the intrusion of a slightly differentiated magma at shallow crustal levels. Magma supply should have then ceased forming a reservoir that allowed differentiation by crystal fractionation, gradually leading to an increase of the volatile pressure of the system. This favored amphibole crystallization, as observed in the last-emitted products. The available data suggest that FdC can be attributed to a pre-Ellittico eruptive phase.

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13-12 Poster Scalera, Giancarlo

10.1474/Epitome.04.0722.Geoitalia2011

VOLCANO-SEISMIC EVENTS ALONG THE ANDEAN MARGIN

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Key terms: Earthquakes-eruptions correlation; Global geodynamics; Natural disaster forecasting; Cause of PM and TPW; Expanding Earth

Scalera (2007, 2008) using the data available in 2006 in the Smithsonian Institution Catalogue of volcanic eruptions revealed evidence that South-American Wadati-Benioff zone earthquakes with $M > 8.4$ are associated to enhanced rates of volcanic eruptions.

The occurrence of the Chilean Maule earthquake of 27 February 2010 ($M=8.8$) has been the occasion to rework all the data adopting a non-compressional framework of mountain building. This framework suppose a common secular process involving the complete South American Pacific margin linked to TPW. Indeed, in the expanding Earth schema both PM and TPW are explained by assuming an emplacement of mass in the Southern Hemisphere on the Nazca region. The TPW path through geological time is then naturally linked to the slow displacement of the region of maximum planetary expansion.

Passing from the older Andean volcano-seismic correlation events to the 2010 one, it is clear the trend - as soon as the data have become more precisely located on the time axis - of an enhanced rate of eruptions before the main seismic event.

The 1868 event - In this case data were collected only by visual witness, listening inhabiting of localities nearest the volcanic apparatuses or people passing for a direct inspection. The date of the eruptions may be confused with the observation date, displacing the event many months ahead and possibly one or more years ahead. The peak of eruptions after the quake, can be then an artifact.

The 1906 event - This event is a pair of great earthquakes (Ecuador, January 31; $M=8.8$; Chile, August 16; $M=8.4$) that occurred in the same year separated by very long distance. Only the southern district appears to have a peak of eruptions correlated to the earthquakes. The maximum is one year after the seismic event but the growing of the eruptions' amount starts in the same year of the quake. Then the real distribution on the time axis must be different and considering the reasons explained above in the preceding 1868 case, some of the real onsets could be occurred many months before and also one year before.

The 1960 event - The earthquake occurred (1960, Chile, $M=9.5$) in the times of more modern scientific instrumentations and surveying facilities (quick transportations, airplanes, helicopters). This time the maximum eruption rate is in the same year and the growing of the rate starts before the quake occurrence.

The 2010 event - This time all the onset date of the eruptive events are known thanks to modern surveillance methods. The rate of eruptions occurred in the northern and southern volcanic district increased from one-two erup/year to five in 2009 and we expect that an enhanced rate will be revealed until the end of 2010. The northern volcanic district was active in 2007-2009, while the central district did not contribute to the constitution of the volcano-seismic correlation event. There is then a precursory behavior of the northern and southern volcanic activity in this case.

Moreover, a possible synchronicity should be considered. If on the same plot both the secular polar motion (from 1846 to 2009) and the time of occurrence of the volcano-seismic events of correlations are represented, it is possible to see: i) Only three volcano-seismic events, 1906, 1960 and 2010, can be correlated to the series of PM data 1846-2009. ii) The PM data preceding 1900 are not homogeneous with the 1900-2009 ones. iii) The events of 1960 and 2010 occur about 12 years after a five-years window of 'stasis' of the secular PM (a very low velocity, witnessed by the extreme proximity of the annual averaged points in the plot). Albeit the data are not against the same mutual pattern between the event of 1906 and the PM data of the last decade of the XIX century, the non-homogeneity of data do not allow a positive conclusion. iv) To ascertain the reality of this synchronism with the Markowitz oscillation of PM, a greater amount of volcano-seismic events is needed.

13-13 Poster Cigolini, Corrado

10.1474/Epitome.04.0723.Geoitalia2011

STRUCTURAL AND PETROLOGIC FRAMEWORK OF STROMBOLI PLUMBING SYSTEM

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Key terms: mineral-melt equilibria; thermobarometry; magma reservoir; strain rates

Structural, geophysical and petrological data are used to refine current models on the inner plumbing system of Stromboli volcano. Active vents are located on a NE trending fracture zone affected by pure extensional regimes that controls the geometry of the plumbing system. Fine thermobarometry, based on a grid of selected reactions, have been used to define the stability field of mineral-melt equilibria and constrain the P-T regimes of the magma reservoir. Current primitive Stromboli basalts equilibrate at $\sim 0.27-0.12$ GPa for temperatures approaching 1170-1150 °C, and progressively crystallize, cool and degas before being erupted. Pure extensional regimes and recent geophysical data suggest the existence of a prolate ellipsoidal magma chamber below Stromboli. Stress regimes are likely proportional to the geometry of the reservoir and constrain its volume at approximately 1 km³. It is suggested that the cyclic onset of effusive phases is modulated by variable strain rates associated with spreading along the NE summit fracture zone. Current average strain rates are of the order of $10 \exp(-13)$ sec⁻¹, typical of regimes generated within thermoelastic shells surrounding active magma chambers.

13-14 Poster Cigolini, Corrado

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GEOLOGY AND PETROLOGICAL FEATURES OF THE

POST-COLLISIONAL OLIGOCENE MIAGLIANO STOCK (WESTERN ITALIAN ALPS)

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Key terms: Miagliano stock; Ivrea Verbano Zone; calcalkaline; comagmatism

The Oligocene small Miagliano stock together with the Adamello batholith are the only Periadriatic plutons that outcrop to the southwest (or south) of the PFS (Periadriatic Fault System). The Oligocene Miagliano stock is represented by two intrusive bodies, volumetrically defined in a main and a minor one with different petrographic features, located in the Ivrea Verbano Zone, in proximity of the Canavese Line. These masses are close to the main Valle Cervo pluton (part of an Oligocene volcano-plutonic complex), which is located about 3,5 km NW of Biella (Western Italian Alps). The main intrusive body is cross-cut by the Cervo Valley and ranges in composition from Hornblende-Biotite Gabbro (peripheral and intermediate sector) to Hornblende-Biotite Diorite/Tonalite. The inner part consists of Hornblende-Biotite Leucotonalite with plurimillimetric (up to 7-8 mm long) pectilic hornblende crystals. An enrichment in alkali-feldspar characterizes the NW sector of the main mass where Granodioritic rocks locally outcrop (being in contact with gabbros and monzonites deriving from the plutonic rocks). The minor mass is located NE of the main body and shows a "peripheral" of Biotite-Muscovite Granodiorite and a "core" of fine-grained Biotite-Muscovite Tonalite. The Miagliano Tonalites belong to a calcalkaline calcalkaline H-K series with high contents in LILE and HFSE. The rocks of the main body are more enriched in TiO₂, P₂O₅, Sr, Y e Zr and depleted in Rb, Ba and La with respect to the minor mass. The latter shows highly fractionated REE patterns [(Ce/Yb)_N around 13] with respect to the main mass [(Ce/Yb)_N around 6]. All samples analyzed show a weak to moderate Eu anomaly. REE patterns, spider-diagrams and Pearce element ratios suggest comagmatism with the rocks of the nearby volcano-plutonic complexes (Valle Cervo pluton, Valsessera satellite intrusives, and the calc-alkaline-shoshonitic volcanics of the cover series of the Sesia Zone). It is concluded that the above plutonic rocks likely represent the remnants of the magma chambers that were active during Oligocene times.

SESSIONE I6

Eruzioni esplosive, deformazione dei vulcani e processi di trasporto e deposizione dei prodotti

I6-1 Invitato Di Traglia, Federico

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VULCANIAN ERUPTIONS AT THE ISLAND OF VULCANO (SOUTHERN ITALY) DURING THE ADXV-ADXIX CENTURIES

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Key terms: Vulcanian eruptions; Island of Vulcano; Tephra fall deposits; Pyroclastic density currents; Aeolian Islands

Historical chronicles reported several eruptions at the Island of Vulcano during the ADXV-XIX centuries from the Fossa cone, the most currently active center of the island.

In this work the internal stratigraphy of all eruption of la Fossa cone (i.e. the chronology of the eruptive events), including the last eruption Vulcanian eruptions (AD1888-90, Mercalli and Silvestri 1891), was studied in detail together with the main emplacement mechanisms of both primary and reworked materials. In addition, the morphological evolution of the summit crater area of the Fossa cone resulting from these eruptions has been characterized.

Based on the analysis of the historical chronicles, the Fossa cone renewed its activity in the AD1444 with an high-energetic steam-blast eruption (Forgia 1), that occurred eccentrically with respect to the summit crater area of the Fossa cone, in its northern flank and affecting an area currently occupied by the Vulcano Porto town. This eruption "opened" a new stage of the activity of the Fossa cone, characterized by the ascent of viscous plugs of magma that powered at least 8 discrete eruptions lasted from days to years. These eruptions were mainly of Vulcanian style, including the first historically described Vulcanian eruption (AD1888-1890), but frequent steam-blast explosions occurred, generally before the onset of the main magmatic phase. One effusive phase (Pietre Cotte lava flow) characterized the long-lasting, complex eruption that occurred on AD1731-39. The erupted volume ranged between 0.001 and 0.01 km³, affecting a wide area that comprised at least the northern Sicilian coast and probably reached the Mt. Etna (De Fiore et al 1922), about 70 km far from the island.

Comparing the pre- and post-AD1888-90 topography of the summit crater area, a minimum value (0.0165 km³) of deposited material was produced. This volume approximately corresponds to 88% of the tephra volume (0.0185 km³) calculated by the methods of Bonadonna and Houghton (2005), confirming the evidence of high-deposited volume in the summit crater area during these stage of eruptions. During this eruptive crisis, the summit crater area of the volcano grew at an average rate of 0.34 m³/s in a period of ~ 20 months.

The data on emitted tephra volumes during the AD1444-1890 eruptions suggested that the Fossa cone experienced eruptions ranging between 1 and 3 in the VEI classification (Volcanic Explosivity Index, Newhall and Self 1982), without a clear evidence of waning. These data are useful for future "short-term" hazard evaluations for the Island of Vulcano, that should consider an eruption of VEI 3 as the most likely scenario. Widespread and long-lasting fallout events and lahars represent a frequent phenomenon associated to Vulcanian eruptions in Vulcano and, therefore, should be considered in a comprehensive hazard assessment of the island.

Data on the AD1444-1890 eruptions provide an opportunity to improve the hazard assessment at the Island of Vulcano and neighboring islands. In particular, the abundance of ash-rich fallout deposits associated with Vulcanian eruptions, previously interpreted as mainly associated with dilute PDCs, pose an high hazard level not only on the Island of Vulcano, linked to proximal to medial tephra accumulation, but also in the

neighboring Island of Lipari, due to the toxicity of breathable ash and potential damage to lifelines, transport networks and agriculture. Recent or on-going eruptions (e.g., Eyjafjallajökull 2010, Iceland) also have shown how moderate explosive eruptions can cause widespread damage to aviation and regional economy if combined with unfortunate wind conditions.

16-2 Invitato Cioni, Raffaello

10.1474/Epitome.04.0726.Geoitalia2011

THE APRIL -MAY 2010 EYJAFJALLAJÖKULL ERUPTION (ICELAND): TEPHRA FEATURES, ERUPTION DYNAMICS, AND ROLE OF MAGMA-ICE-WATER INTERACTION

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Key terms: Ash eruption; Eyjafjallajökull volcano; tephra studies; eruption dynamics

The 2010 eruption at Eyjafjallajökull volcano (Iceland) clearly demonstrated that mid-intensity explosive eruptions can have a large societal and environmental impact. In addition, the direct observation of the eruption confirmed the importance of studying the eruptive processes driving this type of events, often characterized by a complex sequence of eruptive phenomena which can pose problems to hazard assessment and crisis management.

Following an initial effusion of alkali basalt on the northeast flank of the Eyjafjallajökull volcano which continued from 20 March to 12 April, activity resumed from the summit caldera on 14 April, characterised by complex, sustained, explosive to mixed activity, and more evolved (trachyandesitic) magma. The first phase of the summit eruption (14 to 17 April) was initially characterised by interaction between glacial melt water from the icecap and erupting magma, and by two main pulses during which dark ash plumes were dispersed to the SE and S, reaching heights of 8-10 km. In the following phase (from 19 April to 4 May) a decrease in the intensity of the explosive activity was associated to the emission of a lava flow. Activity renewed in intensity on 5 May, when an ash-laden plume, up to 10 km in height, was continuously dispersed until 18 May. After this phase, activity progressively declined and eruption closed on 9 June.

In the frame of the PRIN 2008 AshErupt project, a collaborative work with researchers of several institutions was initiated immediately after the eruption onset, and volcanological, geophysical, geochemical and experimental data were collected by direct observations of eruption dynamics and tephra dispersal and on selected samples of the different eruption phases.

Tephra samples were collected in the field from the deposits of April 14 and 17 (the two main eruptive pulses of the first phase of the eruption), from the deposits of the mixed, explosive-effusive phase, and directly during fallout from the plume in the period 5-8 May. Ash samples were characterised by their grainsize, componentry, ash morphology and textural features of juvenile material, and time-related compositional and isotopic variations of the juvenile material were also investigated on glass and groundmass minerals. Indirect data on the volatile phase occurring in the plume were obtained from ash leaching experiments. The substantial variations observed in the analyzed parameters can be related to the eruption dynamics, from the initial phreatomagmatic activity to the prevalent magmatic-driven, final stage of the eruption. Due to the low intensity of the eruption, an important role of clast recycling was expected. In order to characterize this process, experiments on high temperature transformations on juvenile clasts were performed, highlighting the importance of this phenomenon.

Finally, information on sedimentation dynamics was derived from direct measurements of sedimentation rate and from samples collected during the 5-8 May activity, confirming the importance of ash aggregation in driving both proximal and distal sedimentation. Aggregation processes were inferred by using SEM images and leachate data on undisturbed samples. An estimate of the total grainsize distribution of the material erupted during the 5-8 May activity was also obtained by using grain size data integrated with radar satellite data.

16-3 Orale Pistolesi, Marco

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TEPHRA SEDIMENTATION DURING THE 2010 EYJAFJALLAJÖKULL ERUPTION (ICELAND) FROM DEPOSIT AND RADAR OBSERVATIONS.

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Key terms: particle aggregation; settling velocity; tephra deposit; weak plume

The 14 April - 21 May 2010 eruption of Eyjafjallajökull volcano (Iceland) was characterized by a nearly continuous injection of tephra in the atmosphere up to 9 km above sea level with a large production of ash that was mainly dispersed towards the east and south-east reaching as far as the southern parts of Europe and causing significant damage to vegetation and various economic sectors in Iceland and a global-wide interruption of air traffic. During 4-8 May 2010 various experiments and sampling were carried out in order to investigate particle sedimentation and characteristics.

Tephra accumulation and tephra accumulation rate varied between

0.02-0.68 kg m⁻² and 0.06-7 x 10⁻⁴ kg m⁻² s⁻¹ respectively at different locations between 1.5 - 55 km from the vent and over collection periods between 600 and 8220 seconds. Associated tephra deposits show one or two populations with M_{dphi} and sorting varying between -0.9 - 4.5 phi and 0.8 - 1.2 respectively. Accumulation rate show two exponential segments with break-in-slope at about 18 km from the vent, whereas M_{dphi} shows a linear increase until about 18 km from vent reaching a plateau between 18-55 km of about 4.5 phi. Volcanic particles fell as ash clusters, coated particles, structureless pellets and liquid pellets. Nonetheless dedicated collections showed that aggregate typologies changed spatially and that a same location can be characterized by different types of aggregates. Particle and aggregate settling was investigated with the Doppler-radar PLUDIX (i.e., X-band Doppler radar designed for the detection of hydrometeors). For the first time, the PLUDIX was calibrated to transform frequency shift and power spectrum in size distribution and intensity of ash fall applying adapted inversion methods of Gouhier and Donnadieu (2008), which showed very promising agreement with observations. For three selected samples we have i) analyzed the Doppler spectrum, ii) derived the associated settling velocity spectrum by inversion, iii) calculated the grainsize distribution and iv) compared the PLUDIX-derived grainsize distribution with the grainsize distribution observed in the field. Quantitative ash cloud characteristics have also been retrieved using MSG-SEVIRI satellite measurements during May 6, 2010, which has been recorded as the most powerful episode of the April-May, 2010 Eyjafjallajökull eruption. Satellite data well complement ground-based techniques as they provide insights on the dynamics of ash cloud far from the vent (>100 km). Minimum sedimentation and sedimentation rate is ~ 24 t/s and 0.2 to 0.4x10⁻⁶ kg/m²/s respectively which is in good agreement with ground observations for that day. Typical ash concentrations calculated during this event range between 0.5 to 4 mg/m³, with 3 distinct ash radius modes of 1.2, 2.8, and 4 µm.

16-4 Orale Coppola, Diego

10.1474/Epitome.04.0728.Geoitalia2011

RADIATIVE HEAT FLUX AT STROMBOLI VOLCANO DURING 2000-2010: A DECADE OF MODIS OBSERVATIONS

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Key terms: RADIATIVE HEAT FLUX; STROMBOLI; MODIS; STROMBOLIAN ACTIVITY; EFFUSIVE ACTIVITY

A decade of night-time MODIS (Moderate Resolution Imaging Spectroradiometer) observations, has been analysed to detect and quantify the radiative heat flux of Stromboli volcano (from March 2000 to December 2010). Using an accurate background subtraction of the MODIS

signal at 4µm, we were able to discriminate two main regimes of radiative power, related to different levels of volcanic activity. Effusive eruptions (occurred on December 28, 2002 and February 27, 2007) radiated at a time averaged rate of 170 and 470 MW, respectively, which is about 1 order of magnitude higher than the mean radiative energy detected during the typical strombolian activity (~12 MW). Although during an effusive eruption the radiative heat flux is basically controlled by the lava discharge rate, we found that during the strombolian activity the energy radiated is essentially correlated with the explosive rate (number of daily explosions) detected in the crater area. In particular, during the weeks that preceded the two effusive eruptions, as well as during periods of very high explosive activity an heat flux higher than 50 MW has been measured. This was associated to sustained spattering from active vents, which eventually accompanied small lava outflow. We suggest that a MODIS-derived radiative flux of 150 MW separate the two thermal regimes (effusive and strombolian) and may be considered a threshold value that may lead to minor lava outflow or the onset of an effusive cycle. We suggest that this methodological approach may be applied in monitoring other open-system volcanoes and may contribute to improve volcano surveillance.

16-5 Orale Maerker, Michael

10.1474/Epitome.04.0729.Geoitalia2011

RECONSTRUCTING THE PALEO-TOPOGRAPHY AND PALEO-ENVIRONMENTAL FEATURES OF THE SARNO RIVER PLAIN (ITALY) BEFORE THE AD 79 ERUPTION OF SOMMA-VEUVIUS VOLCANIC COMPLEX

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Key terms: Sarno River Basin; Roman paleo-topography; Paleo-environment; Stratigraphical core drillings; Classification regression trees

The Plinian eruption of Somma-Vesuvius AD 79 that destroyed the ancient city of Pompeii, resulted in a nearly complete burial of the Sarno River plain. Hence, the pre-AD 79 paleo-surface and paleo-stratum of that entire landscape were conserved. To reconstruct the pre-AD 79 paleo-topography and paleo-environmental conditions of the Sarno River plain we collected, localized and digitized a total of 1,840 core drillings to gain a representative network of stratigraphical information covering the entire plain. Besides other stratigraphical data including the characteristics of the pre-AD 79 stratum, the depth to the pre-AD 79 paleo-surface was identified from the available drilling documentation. Instead of applying a simple interpolation of the drilling data, we reconstructed the pre-AD 79 paleo-surface with a sophisticated geostatistical methodology using a machine based learning approach based on classification and regression trees.

We hypothesize that past and present-day geomorphic processes are related to terrain characteristics that can be described by topographic indices (elevation, slope, curvature etc.). Hence, deposition, erosion and transport processes during the eruption of Somma-Vesuvius AD 79 were controlled by the pre-AD 79 topography. Consequently, the present-day topography reflects the ancient topography and gives valuable clues for reconstructing the ancient conditions. Therefore, a high resolution, present-day digital elevation model (DEM) was generated and a detailed terrain analysis was carried out to deduce

15 different primary and secondary topographic indices. Then, a classification and regression model was generated combining the present-day topographic indices to predict the depth of the pre-AD 79 surface. This model was calibrated with the measured depth of the pre-AD 79 surface from the drilling data. To gain a pre-AD 79 digital elevation model (DEM) the modeled depth of the pre-AD 79 surface was subtracted from the present-day DEM.

To reconstruct some paleo-environmental and paleo-geomorphological features the modeled pre-AD 79 DEM was compared with the classified characteristic of the pre-AD 79 stratum, identified from the drilling data. Hence, the paleo-coastline, the paleo-Sarno River and its floodplain, alluvial fans near the Tyrrhenian coast as well as abrasion terraces of historical and protohistorical coastlines were delineated. It is the first time that the paleo-topography and paleo-environmental features of the Sarno River basin were systematically reconstructed using a detailed database of input variables and sophisticated data mining technologies.

16-6 Orale Mundula, Filippo

10.1474/Epitome.04.0730.Geoitalia2011

THE DIAPYRIC STRUCTURES OF THE "SERRA DI PARINGIANU" WELDED IGNIIMBRITE (SW SARDINIA, ITALY): A MODEL OF EMPLACEMENT.

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Key terms: diapir; blister; welded ignimbrites; Serra di Paringianu; San Pietro Island

Welded ignimbrites commonly show a wide variety of rheomorphic structures. The time scale of cooling below the glass transition temperature represents the upper limit for the duration of the process of plastic deformation. The field characterization of deformational structures, coupled with the results of numerical models able to reproduce the cooling-compaction history of welded ignimbrites, allows to constrain the time scale for the development of specific rheomorphic structures and to derive the main physical properties of the ignimbrite.

The Serra di Paringianu rhyolitic ignimbrite (SEP) is the youngest major ignimbrite of the Cenozoic volcanism of SW Sardinia. It widely crops out on San Pietro and Sant'Antioco islands, while scattered outcrops are present in the Sulcis mainland. At "La Punta", north of San Pietro Island, SEP is constituted by a single cooling unit, subdivided into four eruptive units: 1) a lower unit (U1), comprising basal, dm thick, argillified fall and surge deposits, overlain by a 1.4 m thick, black ignimbrite (vitrophyre)

and by a 10-12 m thick, densely welded ($\rho = 2200 \text{ kg m}^{-3}$), red ignimbrite with parataxitic texture; 2) an intermediate lower unit (U2), comprising a 10 m thick, lithic rich, white to pink to red, partially welded

ignimbrite ($\rho = 1600 \text{ kg m}^{-3}$); 3) an intermediate upper unit (U3),

represented by a 5-6 m thick, red to pink, densely welded ignimbrite ($\rho = 2200 \text{ kg m}^{-3}$) with eutaxitic texture 4) an uppermost 4 m thick, grey-violet, partially welded ignimbrite unit (U4).

At the same locality, tens meters-sized mushroom-shaped diapiric structures (DS) and metric to decametric lens-shaped voids, (blisters) have been observed within SEP. DS are constituted by the partially welded intermediate unit (U2) intruding the upper densely welded cover (U3). DS are generally connected with their source region and their roots, characterized by vertical re-orientation of flattened purple scoriae, are placed about 8-10 m below the roof, within the U2. In plane-view, stem region is generally elongated and characterized by sub-vertical dip of the foliation planes. Cup region presents horizontal cross-sectional shape, varying from circular to elliptical to lobate. Within the cup, foliation shows an approximately concentric distribution, with dip increasing from the margins to the center. Eutaxitic structures as well as flow banding, foliations and contact-transit between the different eruptive units are mainly sub-horizontal at "La Punta". These structures deviate from their planar-horizontal character close to the contact with blister and inside and outside DS.

Blisters have horizontal, circular to elliptical, cross-sectional shape and vertical, lens to cupola cross-sectional shape. Horizontal vs. vertical dimensions ratio ranges between 3 and 4. Foliation seems to envelope completely the blisters, reproducing their shape close to the contact with them.

We present a plume-like model in which the formation of diapiric structures is triggered by the density-driven buoyant rise of partially welded lithofacies into the densely welded cover in a time scale of few months. The model of emplacement of the diapiric structures takes into account: - the rheology of the host and intruding rocks; - the textural and physical modification experienced by the partially welded lithofacies during rise; - the textural and physical modification induced in the host rock. After the vertical rise of the lighter material ceased, it started to expand laterally and degas. Diapiric structures are in fact closely associated in space to meter sized, lens-shaped voids (blisters), occurring in the upper densely welded lithofacies, interpreted as degassing structures where upward escape of gas was prevented by the impermeable nature of densely welded ignimbrite. In this case, blisters could represent gas filled voids partially fed by the degassing head of the diapires.

16-7 Orale Moretti, Roberto

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THE DEEP PLUMBING SYSTEM OF THE ISCHIA ISLAND: A PHYSICO-CHEMICAL WINDOW ON THE FLUID-SATURATED AND CO₂-SUSTAINED NEAPOLITAN VOLCANISM (SOUTHERN ITALY)

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Key terms: fluxing; Neapolitan volcanoes; caldera resurgence; redox state

Ischia, a volcano island located 18 miles NW offshore Naples (Southern Italy), is a densely populated active caldera (last eruption 1302 A.D.). Melt inclusions (MIs) in phenocrysts of the Vateliero and Cava Nuclele shoshonite-latitude eruptive products (VI-IV century B.C.) constrain structure and nature of the Ischia deep magmatic feeding system. The volcanic rocks of Ischia bear clear evidence for CO₂ dominated gas fluxing, under very oxidized conditions, and consequent dehydration of magma portions stagnating at major crustal discontinuities. The geochemical features of the studied products make Ischia a natural borehole probing the deep physico-chemical conditions of magmas generated in a mantle contaminated by slab derived fluids largely dominated by CO₂. Volatile concentrations in MIs require gas-melt equilibria between 3 and 18 km depth. MI-based evidence for CO₂ fluxing is further supported by selective enrichment of K and related trace elements during magma differentiation. Accordingly, the budgets of magma degassing show that at Ischia there is much less magma than that needed to directly supply the amount of released magmatic fluids, thus constraining the role of CO₂ rich deep fluids in originating the volcanism and generating caldera resurgence. The acquired data, together with those from the other Neapolitan volcanoes (Procida, Campi Flegrei -CF-, and Somma-Vesuvius -SV-) show that, despite the compositional and eruptive style differences within the poorly extended Neapolitan Volcanic area, the different kinds of volcanism are mostly linked by supercritical CO₂ fluids produced by devolatilization of subducted terrigenous-carbonatic metasediment, that infiltrate the mantle wedge, generate magmas and control their ascent up to eruption. Geochemical features of Ischia and the other volcanoes reveal that the extent of fluid contamination of the pre-subduction asthenospheric-mantle was similar at Ischia, Procida, CF and SV. However, the different isotopic composition (more enriched in radiogenic Sr at Ischia, CF, SV with respect to Procida) and water amount in the source (almost double at Ischia, CF and SV than at Procida), reflect the different flow-rate of deep slab-derived fluids through the mantle wedge that, in turns, controls the amount of magma generation. The high bulk permeability below Ischia, CF and SV, determined by the intersection of regional NW-SE normal and NE-SW transfer fault systems, favours fluid upraise and accumulation at crustal levels, with consequent magma production and storage larger than at Procida, that is located along the NE-SW system.

16-8 Orale Orsi, Giovanni

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CALDERA RESURGENCE AND VOLCANISM AT PANTELLERIA OVER THE PAST 15 KA

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Key terms: Pantelleria; Caldera resurgence; Peralkaline magmatism; Peralkaline volcanism

Pantelleria, the type locality for pantelleritic rocks, is an active volcanic field in the Sicily Channel Rift Zone, dominated by a nested, resurgent caldera. Regional tectonism and volcano-tectonism have exerted a striking control on both evolution of the magmatic system and distribution of the vents of eruptions fed by magmas of variable composition. The island is divided into two sectors by a NE-SW fault system, which likely represents a crustal discontinuity along the axial ridge of the rift. The north-western sector, affected only by NW-SE crustal structures, includes most of the exposed basaltic rocks. The south-eastern sector includes silicic peralkaline rocks. Eruption of differentiated magmas and occurrence of the nested caldera, suggest that crustal magma chambers were established in this sector, probably at the intersection of the main tectonic lineaments. The youngest caldera has been affected by resurgence through a simple-shearing mechanism. The results of geological, geochronological, volcanological and petrological studies have allowed us to re-evaluate the recent volcanic and deformation history of this caldera, including its magmatic feeding system. In particular timing of the younger-than-15ka volcanic activity, through ¹⁴C dating, chemical and isotopic composition of the erupted magmas, and location of the eruption vents have been assessed. Volcanism was concentrated in two periods of activity. It produced only pantelleritic eruptions, mostly explosive and subordinately effusive. The explosive eruptions generated prevalently pyroclastic sequences of fallout deposits, mostly in proximal facies, and only very scarce pyroclastic density current deposits. Effusive eruptions produced lava domes, many of which collapsed in the later stages of their growth and generated variably extended lava flows. The eruption vents active during each of the two identified periods of activity, were located in a specific structural position, characterised by different structures, although all related to resurgence. The erupted magmas range in composition from comenditic trachyte to pantellerite, matching the typical range of evolved peralkaline composition of Pantelleria. Both macroscopic and microscopic textural, as well as mineralogical and geochemical features that bear evidence for mingling/mixing among less and more evolved peralkaline magmas, are very common.

The results of a combined interpretation of all the data contribute to stress the intimate interplay among magmatic processes, volcanism and deformation. Such relationships have to be taken into account in any attempt to perform a volcanic hazards assessment and eruption scenarios forecasting, in case of renewal of volcanism in short-mid terms at Pantelleria.

16-9 Orale Luongo, Giuseppe

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INSTABILITY PROCESSES IN THE NEAPOLITAN VOLCANOES: EXPLOSIVE CALDERA, COLLAPSE CALDERA, RESURGENCE CALDERA, AVALANCHE CALDERA

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Key terms: Neapolitan volcanoes; Caldera; Regional tectonics; Mechanical model; Convection process

The onset of volcanism in the Neapolitan area and the tensile tectonics of the Tyrrhenian margin of the Apennine chain have been related to the opening of the Tyrrhenian Basin, which may have resulted in horizontal asthenosphere flow giving rise, in turn, to crustal distension, local mantle upwellings and ensuing volcanism.

The last in this area could be associated with doming of the Mantle which started in the Quaternary. We hypothesize that this doming process generated radial fractures in the continental crust along three branches, equally separated by 120° angle: one branch developed in the Campi Flegrei and at Vesuvius; another along the Campi Flegrei - Island of Ischia; the third branch could be related to extinct or aborted volcanism in the Campanian Plain. The structural continuity of the volcanic activity from the Island of Ischia to the Campi Flegrei through the island of Procida and from the Campi Flegrei to Vesuvius through the eruptive centres of the city of Naples, supports our hypothesis that volcanism is confined to fractures radiating from the Campi Flegrei area. Such fracture mechanism was analyzed with analogical, analytical and numerical models in physical terms on the assumption of an elasto-plastic behaviour of the crust and with reference to "limit analysis theorems".

The focus of volcanic activity in the last 10,000 years to some nodal points as Vesuvius, Campi Flegrei caldera, Island of Ischia, permits to hypothesize that in these areas the magma volumes are much higher than in other zones along the radial fractures. The concentration of higher quantities of hot magma at these spots would facilitate the rise of additional magma from the depth, acting as a heat insulator. Thermal conditions would have stabilised the activity at the three main eruptive centres, while in intermediate zones of the radial fractures thermal conditions were less stable due to the presence of limited volumes of magma.

The obtained models provide information about the size and depth of the source, the size and shape of the caldera associated with the process hypothesized, the size of the surrounding area involved and the acting stress field together with associated deformations.

Somma Vesuvius consists of an older, repeatedly collapsed strato-volcano, currently forming the semicircular Mt. Somma caldera rim, and a more recent cone, Vesuvius, built inside the caldera. Its load onto the weak sedimentary substratum and the tensile regional tectonics induce gravitational spreading which generates volcano summit extension and basal compression. This process appears to influence the style of eruptions and the chemistry of the erupted products.

Campi Flegrei caldera is a resurgent nested caldera resulting from two main collapses related to the Campanian Ignimbrite (CI - 39 ka BP) and Neapolitan Yellow Tuff (NYT - 15 ka BP) eruptions, respectively. The quasi-time cyclicity of volcanic activity and up-down ground motion at Campi Flegrei are generally assumed to be related to successive magmatic injections from the mantle. The interpretation of the dynamics of this system does not necessarily require a new input of magma from outside. In fact these phenomena might be explained in terms of a non-linear evolution of convective cells operating at decreasing time and spatial scales to interpret the volcanic activity starting from the CI phases, through the NYT, up to Mt. Nuovo and the recent bradyseismic crisis, well schematized by the so-called Lorenz equations.

A model of caldera resurgence was applied to the Island of Ischia to explain uplift of Mt. Epomeo and avalanche caldera collapse of southern side of island, as well as historical seismicity and slow ground movements recorded for the past 2000 years. The uplifted block of Mt. Epomeo has been undergoing to dismantlement processes during the resurgence. These processes have produced a horseshoe-shaped morphology of Mt. Epomeo and large hummocky deposits.

16-10 Orale Macedonio, Giovanni

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NUMERICAL INVERSION OF TEPHRA FALLOUT DEPOSITS

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Key terms: volcanic ash fallout; inversion problem; Vesuvius; HAZMAP model

A common problem in volcanology is the reconstruction of the eruption parameters starting from sparse measurements in the volcanic deposits (eg: deposit thickness and density, grain size distribution, etc.). The objective of the inversion procedure is the definition of the total erupted mass, bulk particle size, density and shape distribution, column height and shape, and the wind field.

The approaches to this problem are different, ranging from methods based on the numerical integration of the deposit volume to methods based on the best fit of ash dispersal models with the deposit, under different input and environmental conditions. Here a method based on the best fit of an ash transport model with the sampled deposit is presented. This method is based on the repeated simulation of the deposit using a simplified numerical model (eg: HAZMAP, Macedonio et al., 2005) under different input conditions, until a best fit with the deposit is found. This procedure is very time consuming and is not immune from risks. In fact, as in other inversion problems, different input conditions (solutions) may produce comparable fits. A typical source of the ambiguity is caused by the insufficient number of deposit samples or samples distributed in a too restricted area. This is particularly true when the procedure involves the estimation of the mass of the fine particles which mostly fall outside the sampled area of the deposit.

In this work, we present a new procedure for solving the inverse problem related to the reconstruction of tephra fallout deposits of an eruption for which only few sampling data are available.

Moreover, we present an application of the procedure to the reconstruction of the sub-Plinian 472 AD eruption of Vesuvius.

16-11 Poster Acocella, Valerio

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CALDERA TYPES: HOW END-MEMBERS RELATE TO EVOLUTIONARY STAGES OF COLLAPSE

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Key terms: caldera; structure; evolution

Currently proposed caldera types (downsag, piston, funnel, piecemeal, trapdoor) are mainly based on field evidence and are each viewed as end-members. An overview of recent experiments on caldera formation, under different conditions, shows remarkably consistent results and suggests four experimental stages characterized by progressive subsidence. Distinctive structural features of each stage are found in many calderas, highlighting an overall consistency. The evolutionary stages adequately explain the architecture and development of the established caldera end-members along a continuum, where one or more end-member may correspond to a specific stage. While such a continuum is controlled by progressive subsidence, specific collapse geometries result from secondary factors, such as roof aspect ratio, collapse symmetry and pre-existing faults.

16-12 Poster Cannata, Chiara Benedetta

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PELE'S HAIR: MORPHOLOGIC FEATURES AS A FUNCTION OF ENVIRONMENT OF FORMATION, MELT COMPOSITION AND ERUPTIVE DYNAMICS.

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Key terms: Pele's hair; basaltic activity; volcanic glass micro-textures

Pele's hair are long, thin strands of volcanic glass formed when small drops of magma are thrown into the air and spun out by the wind into long hair-like strands. In literature the origin of these thin strands of glass has been linked to lava fountains from Hawaiian basaltic eruptions. Beside the high fountaining, Pele's hair are actually found in other volcanic environments and not only as products of basaltic volcanoes. We investigated in detail Pele's hair from three different environments of formation at Hawaiian volcanoes: high fountaining, weak explosive activity and lava ocean entry (magma-water interaction) together with a 40 cm thick Pele's hair deposit recently found in the Stromboli products outcropping on the Vulcanello peninsula. Samples have been characterized in terms of micro-textural and morphological features. Pele's hair of different provenance all consist of long strands of gold sideromelane, showing variable length, from an half to tens of mm, sometimes including Pele's tears inside or at the end. Their surfaces are mostly rough, with 'ploughs' of different sizes and large cavities. Vesicles are visible in the cross sections of Pele's hair. There are two mostly size population of bubbles: one elongated, central and parallel to the axis of elongation of the hair and the other one smaller and rounded, dispersed across its cross section. Beside these common features, Hawaiian samples from the three volcanic environments have different shapes, surface textures and micro-textures. Pele's hair from Halemaumau (weak explosive activity) show the most elongated shapes, typically hair-like shaped. Instead those from Kilauea Iki (lava fountain) are the smallest and the tubbiest. A strong variability can be observed, in terms of aspect ratio: samples from lava lake of Halemaumau vent are long, with thin shapes and smooth surfaces, showing an inner channel parallel to the axis of elongation linked to bubble coalescence phenomena. Pele's hair from lava fountain are smaller than Halemaumau. They are short, with stubby shapes and rough surfaces, showing a lot of small ploughs. In the inner section vesicles seem to be mostly elongated, parallel to the axis of elongation of the fragment, maybe due to bubble coalescence, and also rounded. Instead Pele's hair from Waikupanaha 2009 eruption (magma-water interaction) show textural features intermediate between the Halemaumau and Kilauea Iki products. They have thin shapes, with rough surfaces and large ploughs. As for surface texture, their length is intermediate between the two end-members and they still show an inner channel of bubbles parallel to the elongation of the fragment. Almost all contain Pele's tears inside or even at their end. Samples from Vulcano Island closely resemble the inner shape of Pele's hair from Hawaiian lava fountain. Even if they show bigger sizes and are more stubby shapes than Hawaiians, all fragments have almost two populations of bubbles: one elongated and another one smaller and rounded, with bubble coalescence phenomena. They also show micro-phenocrysts in the groundmass that form small knots in the hair, around which the glass adapt their shape. Crystals are present also in the samples from Kilauea Iki 1959 eruption, but not in Halemaumau ones. Pele's hair from magma-water interaction even show sometimes micro-phenocrysts. All these features give inferences on the mechanism of formation of Pele's hair among the different eruptive environments. Halemaumau activity showed, at the time of sampling, passive degassing and Pele's hair formed inside the vent; Kilauea Iki 1959 eruption produced a lava fountain hundred meters high, in which Pele's hair formed at the outer side of the fountain, as well as those from magma-water interaction (2009 Waikupanaha eruption). Pele's hair from Vulcano represents a fall like deposits, and their similarity to the Kilauea Iki ones could reflect a similar origin.

16-13 Poster Di Genova, Danilo

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THE VISCOSITY OF H₂O- AND CO₂-BEARING MAGMAS FROM PANTELLERIA, ETNA AND PHLEGREAN FIELDS.

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Key terms: viscosity; magmas; volatile-bearing; adam & gibbs theory

The rheological properties of silicate melts control fluid-dynamics of transport, eruption style and rates of physico-chemical processes (degassing and crystallization) in natural magmas. The most widely used parameterization of viscosity is the empirical three parameter Tamman - Vogel - Fulcher (TVF) equation. One of the most significant limitations of this parameterization is that it does not account for the effect of dissolved mixture of volatiles and the fact that it is an empirical function with no sound theoretical basis. In fact, no single model exists that considers the effect of composition and water, and the presence of minor volatile (CO_2 , F, Cl, Br, S-species). In this study we investigated the effect of H₂O and CO_2 on the liquid viscosity on several multicomponent systems. Viscosity measurements were carried out using a micropenetration technique on four sets of samples. Pantelleritic (Khaggiar dome, Pantelleria), trachytic (Agnano Monte Spina eruption, Phlegrean Fields), latitic (Fondo Riccio eruption, Phlegrean Fields) and trachybasaltic (Etna 1992 eruption) compositions have been analyzed over a range of water contents from anhydrous up to 5.3 wt% and CO_2 content up to 4000 ppm. Viscosity ranged from 10^6 to 10^{13} Pa s with decreasing temperature from 1100 to 630 K.

The Adam-Gibbs theory represents a reliable way to incorporate the viscosity data into a model, as it is based on strong theoretical framework which allows confident extrapolation beyond the range of conditions of the viscosity measurements. We therefore decided to fit experimental data according to the Adam & Gibbs theory in which configurational entropy (S_{conf}) is the main factor controlling the viscosity of melts. Using this theory the viscosity variation with temperature is directly correlated with the thermodynamic properties of the melts. From calorimetric measurements, and assuming that the vibrational contribution to the liquid C_p remains constant above T_g , we determined the configurational contribution to $C_{p,\text{liq}}$ and thus calculated the variation of the S_{conf} as a function of T and water content in the liquid state. Combining viscosity measurements with the configurational entropies for our liquids, we parameterized the variation of viscosity as a function of temperature and volatile content within the framework of the Adam and Gibbs theory of structural relaxation.

16-14 Poster Gentili, Silvia

10.1474/Epitome.04.0738.Geoitalia2011

THE MINERAL-CHEMISTRY OF THE PYROCLASTIC DEPOSITS FROM ORVIETO-BAGNOREGIO FORMATION, ROMAN MAGMATIC PROVINCE, CENTRAL ITALY.

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Key terms: Pyroclastic rocks; Pyroxenes; Quantitative analysis; SCXRD; XRPD

The Orvieto-Bagnoregio Ignimbrite (OBI) is a pyroclastic flow cropping out over a wide area, in the eastern sector of the Vulsini volcanic district, northern Roman Magmatic Province (Peccerillo, 2005). Emplacement age varies from 0.49 to 0.32 Ma. The juvenile components consist of pumices and scoriae ranging from trachybasalt and phonolitic tephrite to trachyte and tephritic phonolite, with potassic to ultra-potassic alkaline affinities. Geochemical and mineralogical investigations have been focused on three key outcrops of the OBI, at Orvieto, Civita di Bagnoregio and Porano. Both juvenile components and matrix have been investigated. Quantitative determination of abundances of amorphous and crystalline material was performed by Rietveld method on the bulk rocks, by using X-Ray powder diffraction data and Topas software, whereas geochemical characterization for juvenile material and single phases was obtained by EMPA and LA-ICP-MS analyses. Detailed crystal-chemistry analysis of the pyroxenes selected from juvenile components was also carried out by using geometrical data from a full three dimensional refinements with SCXRD data and chemical data from EMPA and LA-ICP-MS analysis. The main phases found in samples from all outcrops are clinopyroxene, biotite, anorthite, leucite, analcime and zeolite, in particular phyllipsite and chabazite, Cl-scapolites, REE-Si rich apatites, magnetite are common accessory minerals. Quantitative mineralogy analysis indicated large relative variations among phases, and in particular between sanidine and amorphous material. Along the Orvieto sequence, the amorphous ranges from 0.6 to 22 wt%, sanidine from 9% to 61% and chabazite from 6% to 68%. Sanidine and zeolite abundances are negatively correlated, and sanidine/ratios change rhythmically along the sequence. Texture analysis by SEM indicate that zeolite likely derives from the devitrification of volcanic glass. The variation in zeolites/sanidine content across the pyroclastic sequence indicates strong variation on the relative abundances of glass and crystal across the deposit. Such a feature was likely acquired during emplacement of the pyroclastic flow by variable degrees of loss of glassy ash material from the body of the flow via elutriation processes. Rhythmical variation of sanidine/zeolite at Orvieto suggests that the pyroclastic deposit consists of various flow units. Anticorrelation between sanidine and zeolite is also observed at Civita di Bagnoregio and Porano, but no rhythmic variations are observed in these outcrops, suggesting emplacement by a single flow unit. The clinopyroxene composition ranges from salite to Fe-salite and shows same trend of major and trace elements in three outcrops. The M2 site shows high Ca, low Na and low Mg contents, in M1 both VAl and Fe³⁺ were found. The sum R_{M1}^{3+} show an increase from pumices to scoriae. Geometrical data confirm a good correlation of M₁-O₂ distance with R_{M1}^{3+} content as found in different clinopyroxenes of potassic alkaline rocks. Similar chemical compositions and structural lattice parameters of samples from OBI indicate a common mineralogical and petrogenetic affinity. The cell and M1 volume of clinopyroxenes, suggest very low pressure of crystallization in comparison with data obtained in other magmatic province (Nazzareni et al. 2001). Incompatible element contents in juvenile clasts and clinopyroxenes show very high content in all samples as expected for this magmatic province. More detailed features of REE and trace elements distribution evidence a variation along the sequence with a decrease of the REE content moving from the bottom to the top of the Orvieto sequence, a clear indication of the chemical zoning of the magmatic chamber.

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16-15 Poster Lucci, Federico

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THE "UNCOMPAGHGRITIC PEGMATITE" AT SAN VENANZO VOLCANO (CENTRAL ITALY): AN EXAMPLE OF LATE CRYSTALLIZATION CONTROLLED BY FLUIDS CARRIED IN THE VENANZITE LAVA FLOW

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Key terms: Ultrapotassic volcanism; volatile compounds; Venanzite; fluids; SanVenanzo

Pian di Celle tuff rings is the major vent of SanVenanzo volcanic complex: an explosive-effusive center (<2Kmq) located 30Km NNE to the Vulsini Complex, on the western edge of Tiber Valley Graben (TVG) in an area controlled by NW-SE extensional and NE-SW transensional elements. Volcanic rocks present a kamafugitic composition (Lct+Ol+Mel+Kfs+Phl+Cpx or Venanzite) associate to a minor carbonatitic compound. Pian di Celle, defined by authors as "tuff-ring", shows a complete explosive - effusive cycle: i) initial lapilli-ash tuff sequence (surge-like stratification and subordinate fall deposits at crater); ii) a massive unwelded channelized pyroclastic deposit with coarse lapilli, bread-crust bombs and sedimentary lithics; iii) tephra beds (rich of lapilli and lava-bombs) with reomorphyc flows; iv) final production of two venanzite (VNZ) lava flows for decompressional uprise of the magma. At the head of the northern and major VNZ flow, an outcrop of macrocrystalline uncomphagrite (known as leucite-olivine-melilitolite pegmatite (PEG)) is present. Authors have defined PEG as an irregular sill body intruding, with dykelets pattern, the overlying VNZ. PEG presents a well-defined fabric, but also difficulties in definition of strikes and dips, since there is no regular structural control or correlation between injections and joints of hosting VNZ. Even if at mesoscale the contact between PEG and VNZ could appear relatively sharp, at microscale it is possible to observe a progressive almost continuous rapid texture transition from porphyric microcrystalline in VNZ to equigranular macrocrystalline in PEG.

Moreover transition is characterized by evolution of mineral assemblage: 1) normal trend of Ol+Cpx from fosterite-diopside to chrysolite-hedembergite; 2) modal content growth of apatite+phlogopite; 3) phlogopite+calcite growth along foid-phases crystal edge, and in microveins and amygdalae, following fluidal directions.

On the basis of field data and mineralogical observations, this preliminary work points on incompatibility of such texture-fabric transition with intrusive path. An afterward emplacement of melilitolite magma from a cogenetic different pulse is rather improbably owing the following arguments: 1) venanzite is a volcanic rock, and it is unlikely to have been affected by intrusive bodies after its cooling at such a shallow level, 2) no structural control of intrusion has been observed, 3) the qualitative definition of Ol+Cpx evolution demonstrated a classical continue differentiation to Fe-richer phases.

In addition, we first report here the new finding inside the VNZ, at Pian di Celle crater, of a decimetric amygdale with similar uncomphagritic composition. Considering no connection between the two melilitolite bodies, and the general amygdale geometry, again it is quite complex to explain PEG as "intrusive" event.

In this view we reinterpret PEG as product formed by crystallization of an evolved melt derived through FC of hosting venanzite magma. PEG crystallized preferentially in upper cooling fronts of the lava pond (i.e. the 20m thick head of VNZ flow, or at emission vent where a rounded scoria convolute body was produced by the effusive activity). In this view, "pegmatitic" texture was developed by relative flux-enrichment in melt (PO₄, H₂O and CO₂ generating apatite, phlogopite and calcite respectively) that inhibited nucleation and viscosity and favored the rate of crystal growth. Considering the explosive-effusive monogenetic evolution, VNZ and PEG represent the evidence of a melt system separated in two immiscible phases in which pegmatitic bodies correspond to the one enriched in hydrate and carbonatite components.

Therefore, San Venanzo Lct-Ol-Melilitolite could not only be ascribed at flux compounds in originary melt, but also define typology of volatiles that, under overpressure conditions, triggered the initial explosive activity and controlled the dispersion of pyroclastics of this monogenetic ultrapotassic center.

16-16 Poster Mulas, Maurizio

10.1474/Epitome.04.0740.Geoitalia2011

PHYSICAL AND PETROGRAPHIC FEATURES OF A SLIGHTLY PERALKALINE, RHEOMORPHIC WELDED IGNIMBRITE: THE MONTE ULMUS UNIT (SW SARDINIA)

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Key terms: welded; ignimbrite; peralkaline; rheomorphic; Sardinia

The Monte Ulmus ignimbrite (15.5 ± 0.5 Ma - Morra et al. 1994) is a high-grade, low-aspect-ratio rhyolitic to comenditic ignimbrite, related to the magmatic arc activity which developed in Sardinia between 32.4 and 13.8 Ma [Lecca et al. 1997; Savelli et al. 2002, and reference therein]. The overall deposit has a thickness varying between 8 to 98 m; it is locally rheomorphic and, spreads over an area of 300 km², representing one of the last eruptive events of the Oligocene-Miocene volcanic activity in the Sulcis area (Cioni et al. 2001). About 41 stratigraphic sections, sited in San Pietro, Sant'Antioco and Sulcis-Iglesiente areas, have been studied and described. The Monte Ulmus unit is constituted by a single cooling unit and has been subdivided into four main eruptive subunits: a basal fall-out deposit followed by three welded pyroclastic flow deposits (named A, B1 and B2). Sub-unit A is a 2 to 32m thick, reddish, fine grained, high-grade, rheomorphic ignimbrite that reaches its maximum thickness in Sant'Antioco island. Sub-unit B crops out mainly in San Pietro Island and Sulcis area where it reaches its maximum thickness. It is a 3 to 52 m thick, poorly porphyritic (Qtz+Sd-bearing), high grade ignimbrite constituted by two beds (B1 and B2) separated by a sharp contact. This sub-unit is locally rheomorphic and it is characterized by a high concentration of, randomly oriented, juvenile pyroclasts of three different lithotypes, possibly related to different physical conditions of deposition. Study of physical and petrographic features are focused on 23 samples collected from three representative stratigraphic sections, characterized by different post-emplacement history (Punta Senogio - San Pietro Island, Golfo di Mezzaluna-Sant'Antioco and Matzaccara-Sulcis area). Bulk density data show different vertical trends in relation to the presence of rheomorphic structures and respect to the paleotopography at deposition. At Punta Senogio, the ignimbrite deposits are not affected by post-emplacement

rheomorphic processes and they are localized on a topographic high. Vitrophyre has bulk density values varying between 1.75 and 2.25 gr/cm³ while the bulk ignimbrite has an average value of 2.16 gr/cm³. At Matzaccara, where rheomorphic ignimbrite thickness is lower than 8 meters, bulk densities range between 1.84 and 2.10 gr/cm³, and the vertical trend shows a discontinuity at the contact between unit A and B. Instead, at "Golfo di Mezzaluna", the Monte Ulmus unit is 23 to 30 m thick and it is located on a topographic low. Bulk density values range between 1.98 and 2.35 gr/cm³. The post-emplacement rheomorphism seems to affect the bulk density trend that decrease from bottom to three-quarters of deposit and increase in the upper portion. According to Schmincke (1974), this non linear correlation between bulk rock density and welding intensity could be related to post emplacement secondary vesiculation process that can cause the inflation of the hot tuff.

16-17 Poster Redolfi, Marco

10.1474/Epitome.04.0741.Geoitalia2011

CHARACTERIZATION OF THE VULCANIAN SUCCESSION OF PALISI IN PANAREA, AEOLIAN ISLANDS. IMPLICATIONS FOR THE DETERMINATION OF THE ERUPTION STYLE.

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Key terms: Panarea; Vulcanian explosions; Palisi succession

Panarea island, located in the eastern-central Aeolian Arc (Italy), is part of the most active coastal regions of the Mediterranean Basin. Its location between the western central sector of the Aeolian Arc and the active volcano of Stromboli is critical to the comprehension of the arc volcanism. During 2002-2003, the island has experienced a phase of gas unrest, in coincidence with paroxysmal explosions of Stromboli volcano. Despite, the explosive activity of Panarea is not well known. Recent studies have testified the young age of the pumice deposits present on the island and the related explosive activity has been constrained between 31± 7 to 20 ± 2 ka (Dolfi et al. 2007) and a new scenario for the evolution of the Panarea and surrounding islets have been proposed (Dolfi et al. 2007; de Rita et al. 2008; Cimarelli et al. 2008). For these reasons the characterization and the definition of the nature of the recent Panarea explosive activity may provide a contribution to the volcanic risk evaluation of the Aeolian archipelago. We have analyzed in detail the Palisi succession interpreted as derived by tephra fallout deposited from vent plumes of Vulcanian explosions (Cimarelli et al. 2008). The succession has been sampled every 20 cm and for each level grain size and component analyses have been made. In each level, 5-10 pumice clasts have been selected to determine density and vesicularity. Chemical analysis for each level have been also performed.

Results show reasonable congruence evidencing two main pulses, each of which is characterized by a gradual increase of the pumice clast size, of the juvenile component and of the vesicularity of pumice clasts, and a correspondent decreasing of the relative densities of the pumice clasts until to reach a maximum after that all the parameters register an inversion of the trend.

Data also evidence that the second pulse had a much more violent character reaching the maximum size of pumice and lithic clasts and a higher values of vesicularity.

If the general trend of the eruption may be interpreted as related to normal vulcanian type eruptions triggered by overpressure in the conduit, the character of the second pulse seems much more compatible with the participation of an external cause. The hypothesis of magma mixing processes is therefore discussed.

16-18 Poster Vona, Alessandro

10.1474/Epitome.04.0742.Geoitalia2011

THE COMBINED EFFECT OF CRYSTALS AND VESICLES ON THE MULTIPHASE RHEOLOGY OF MONTE NUOVO TRACHYTIC MAGMA (CAMPI FLEGREI, ITALY)

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Key terms: Multiphase; Rheology; bubble-bearing; crystal-bearing; Monte Nuovo

Rheology of partially crystallized trachytic magmas characteristic of the second stage of activity of the 1538 AD Monte Nuovo eruption, was investigated by a series of controlled deformation rate experiments using an unconfined uniaxial deformation apparatus. The overall crystal fraction

with respect to the solid matrix is $\Phi = 0.47$. Open porosity ranges between 39 to 47%. Experiments were performed isothermally by deforming crystal- and vesicle-bearing cylindrical specimen at constant displacement rates (CDR) or at constant load (CL). Both methods produce constant strain rates measurements. The experiments were carried out at T=600-800°C and applied strain rates between 10⁻² and 10⁻⁴ s⁻¹. The measurements are in the viscous regime and show non-Newtonian shear thinning behavior. Effective viscosity in the range of 10¹⁰-10¹³ were derived. Fitting of experimental data revealed that at the investigated conditions, no yield stress was ever observed and the fitting yielded a parameterization of the flow behavior in terms of consistency K and flow index n. Brittle and ductile failure were observed at T=600°C and strain rates of 10⁻⁵ s⁻¹ and at T=800°C for the higher applied strain rate (10⁻⁴ s⁻¹), respectively.

We derived the combined effect of solid and gaseous particles by normalizing the measured multiphase viscosity (liquid+crystal+bubbles) to the viscosity of the suspending liquid. To separate the net effect of vesicles from a crystal-bearing non-porous melt with the same crystal fraction and using recent parameterization of the effect of crystal on the multiphase rheology of magmas. The results reveal that the presence of vesicles has a major impact on the rheology of magmas and can lead to a marked decrease of the viscosity. At the same time, the presence of bubbles leads to a strong decrease in the shear strength of the magma inducing local and temporal variation in the deformation regimes (viscous vs. brittle). During lava flow emplacement, this may explain the origin of the flow banding textures observed in many silicic obsidian lava flows.

SESSIONE J2

Il patrimonio mineralogico italiano

J2-1 Orale Bosi, Ferdinando

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MN²⁺-DOMINANT TOURMALINE FROM PEGMATITE POCKETS OF GROTTA D'OGGI, SAN PIETRO IN CAMPO, ELBA ISLAND, ITALY: A NEW TOURMALINE MINERAL?

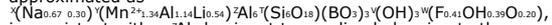
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Key terms: tourmaline; new mineral species; Elba island

Mn-rich tourmalines, structurally and chemically characterized by Bosi et al. (2005), occur in a druse of aplitic dike of Grotta d'Oggi (Elba island) associated with quartz, K-feldspar, plagioclase, elbaite and schorl. Among these Mn-rich tourmalines, there is one sample (Tsl2g) which could be considered as a new species in accord with the recommendations of Henry et al. (2011). In fact, the ordered empirical formula of this sample, approximated as



is consistent with a ²Al-dominant tourmaline belonging to the alkali-subgroup 1: Na-dominant at the X position and OH+F > O²⁻ at the W position of the general formula X₃Y₂Z₆T₆O₃₆(BO₃)₃V₃W. As the content of Mn²⁺ is larger than that of 2Li at the Y position (1.34 and 1.08 apfu, respectively) and because no tourmalines have yet been documented as ²Mn²⁺-dominant, this tourmaline could be classified as a new species. As the OH and F contents at W are statistically equal, 0.39±0.16 and 0.41±0.02 (respectively), the correct name can be assigned on the basis of inverse correlation between F and Mn²⁺. As such a correlation indicates that the F content decreases with increasing Mn²⁺, the excess of O²⁻ at the

W position can be related to the substitution ²Al + ²O²⁻ ⇌ ²Mn²⁺ + ²OH rather than to ²Al + ²O²⁻ ⇌ ²Mn²⁺ + ²F. Through the former substitution, ²O²⁻ is replaced by ²OH (as well as ²Al by ²Mn²⁺) giving a composition X(Na_{0.67}^{0.30})(Mn²⁺_{1.5}Al_{0.5}Li_{0.5})₂Al₆(Si₆O₁₈)(BO₃)₃(OH)₃(²OH_{0.6}F_{0.4}) that falls in the hydroxyl subgroup with ²OH > ²F.

Minor constituents can be related to the substitutions ²Na + ²Mn²⁺ ⇌ ²X + ²Al, 2²Mn²⁺ + ²OH ⇌ ²(Al + Li) + ²F and 2²Mn²⁺ ⇌ ²(Al + Li), which would lead to the end-member composition NaMn₂Al₆(Si₆O₁₈)(BO₃)₃(OH)₃OH.

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J2-2 Orale Capitani, Giancarlo

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ELECTRON MICROSCOPY INVESTIGATION OF A FLOWER-LIKE MINERALIZATION ON BI-SULFOLTS FROM ALFENZA (CRODO). A NEW BI HYDRATED SULFATE?

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Key terms: Bi hydrated sulfate; SEM; TEM

A flower-like mineralization of white, micrometre-sized crystallites, occurs on Bi sulfosalts from the Alfenza Mine (Crodo). With a standard optical stereomicroscope each single crystal is hardly resolvable. At the scanning electron microscope (SEM), the crystallites show perfect, pseudo-hexagonal, randomly oriented platelets forming a hemispheric aggregate up to several tens of microns in radius. The EDS spectra show distinct S, Bi, O peaks, pointing to a Bi sulfate (or Bi hydrated sulfate). As far as we know, only two natural phases, cannonite [Bi₂O(OH)SO₄] and riomarinaitite [Bi(OH) SO₄·H₂O], have been reported with a composition that qualitatively match the observed one. However, available physical properties for these minerals (habit, color, cleavage...) do not match with those observed in our case.

In order to solve the puzzle, few mineral aggregates were peaked up with a knife tip, dispersed in ethanol, ultrasonicated, and pipetted on a holey-carbon Cu grid for TEM analyses. Preliminary results show a Pmm projected symmetry down the pole of the pseudo-hexagonal platelets consistent with a monoclinic or orthorhombic system, 2D cell parameters = 17.2(4) and b = 15.9(3) Å, (gamma = 90°), and systematic absences consistent with a 2₁ screw along the b-axis.

A comparison of the observed electron diffractions with those simulated for (synthetic) cannonite and riomarinaitite reveals substantial differences, excluding these two phases as possible and opening to the possibility for a new mineral. Deeper investigations are in progress.

J2-3 Invitato Cuccuru, Stefano

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THE M. MAZZOLU QUARRY: A NEW MINERALOGICAL LOCALITY

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Key terms: Pegmatite; M. Mazzolu quarry; Corsica - Sardinia Batholith
Sardinia, due to its "geo-diversity", is rich of mineralogical localities. The minerals are mostly related to hydrothermal and/or pneumatolitic processes which mainly affect the low-grade metamorphic basement and the tertiary volcanites. The minerals associated with the granites of the Corsica-Sardinia Batholith are less known for their scarce economic relevance. However, the Batholith hosts a large variety of rare minerals related to the pegmatitic stage. Recently, detailed works allowed to

discover new mineralogical sites with rare minerals (Gamboni & Gamboni, 2006). This note focuses on the M. Mazzolu quarry, a location where several species of minerals, including some rare varieties, occur because related to the chemistry and to the emplacement level of the intrusion. Among the plutons until now identified, the Arzachena intrusion is the largest. It crops out in the north eastern sector of Sardinia and has a roughly ellipsoid shape, elongated NW - SE. Recent works Casini et al. 2008, Oggiano et al. 2005) allowed to identify the bulk geometry of the pluton, as well as its internal architecture. The apical zone was identified around the M. Mazzolu area, where the magmatic flow markers describe some circular trajectories matching the inferred shape of the pluton shell. This area is characterized by widespread pegmatitic pockets, aplitic dikes, wall-rock xenoliths, and biotite schlieren. The relatively low confining pressure and the occurrence of structural traps allowed the formation of pegmatitic pockets where centimetric quartz, K-feldspar, plagioclase, and "biotite" crystals occurs. Accessory minerals are: allanite-(Ce), babingtonite, bavenite, calcite, chabazite-Ca, clinzoisite-epidote series, epidote, apatite-(CaF), fluorite, "garnet" (almandine-spessartine), goethite (resulting from the weathering of pyrite), graphite, heulandite-Ca, laumontite, magnetite, molybdenite, monazite-(Ce), muscovite, opal, prehnite, "pumpellyite", pyrite, rutile, stilbite-Ca, titanite, zircon. Kaolinite, montmorillonite and some minerals of chlorite group results as alteration products.

The apical zone of the Arzachena intrusion due to the widespread occurrence of pegmatites is a new noticeable site for the occurrence of rare minerals of naturalistic and scientific relevance.

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J2-4 Orale Pagano, Renato

10.1474/Epitome.04.0746.Geoitalia2011

THE GUALTERONI COLLECTION: AN INTERIM REPORT

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Key terms: history of mineralogy; mineral collections; mineral dealers

A significant mineral collection was assembled by Camillo Gualteroni (1861-1908), a gentleman of means who lived in Ornica, a small town on the mountains of the Bergamo area in Northern Italy. Most of Gualteroni's acquisitions were made between 1890 and 1900. In that year Gualteroni married and soon had children, so his mineral activity was greatly reduced, although the collection was carefully preserved. Gualteroni tried to obtain a sample of all the species known at the time. His collection, which today would be considered a species collection, included more than 2,000 mineral specimens; each of them was placed in a pasteboard tray with a concise external label and a neatly handwritten label with full details inside the tray. Original dealers' labels were also saved in the tray under the specimen along with Gualteroni's own labels. The collection was preserved in the original state in the residence of the Gualteroni family for almost 120 years, and was complete with its catalogue and original letters from most of the European dealers and Italian collectors of that time. Various other significant mineralogical items (Gualteroni's books, instruments, crystal models, etc.) were also kept with the collection.

The entire mineral collection, including the original cabinets, has been purchased by the Museum of Natural History of Milan from the Gualteroni family. The specimens and their labels are now being restored and studied.

The Gualteroni holdings provide a very unusual insight in the activity of a collector of that time - a real time capsule worthy of being preserved for the future generations.

J2-5 Poster Campostrini, Italo

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NEW MINERAL SPECIES FROM VULCANO, AEOLIAN ISLANDS, SICILY, ITALY

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Key terms: Vulcano Island; New minerals; Crystal structure

Since 2006 Vulcano Island was the object of a joint project concerning the study of fumarole minerals of Italian volcanoes, carried out in collaboration with Istituto Nazionale di Geofisica e Vulcanologia sezione di Napoli - Osservatorio Vesuviano.

At present, the mineral species found at Vulcano are over 100; the island is the type locality for 23 species, 17 of which were discovered by us, and is the unique occurrence for 20 of them. Besides the already IMA-approved "official" species, there are at least 38 potentially new minerals currently under examination. By far the main occurrence for these minerals are the fumaroles located at La Fossa crater which provide especially halides (fluorides, chlorides) and sulfides/sulfosalts together with abundant native sulphur and boric acid; there are however other localities, which are especially rich in sulfates, a few of them very rare and interesting. Another interesting locality is the "Grotta dell'Allume", a partially collapsed cavity whose walls are completely encrusted by sulfates of different colour.

In spite of the lowering of temperature of the fumaroles with respect to 1990, our research already in 2006 provided remarkable specimens of very interesting and new mineral species. The most important of these is the thallium lead chloride hephaestosite $TlPb_2Cl_5$, and three rare fluorides such as demartinite K_2SiF_6 , knasibite $K_2Na_2[SiF_6]_2[BF_4]$, and thermessite $K_2[AlF_7][SO_4]$. As a result of further trips to the island, considerable additions to the list of new minerals were made. These include a new series of sulfohalides: demicheleite-(Cl), demicheleite-(Br) and demicheleite-(I) BISX (X = Cl, Br, I) the lead-ammonium chloride

brontesite $(NH_4)_2PbCl_5$ as well as other interesting chlorides such as panichiite $(NH_4)_2SnCl_6$ and steresite Tl_2BiCl_6 and the sulphates aiolosite $Na_2(NaBi)(SO_4)_2Cl$, adranosite $NaAl(NH_4)(SO_4)Cl(OH)_2$, and pyracmonite $(NH_4)_2Fe(SO_4)_2$. Additional species recently approved by IMA are

coassaite $(Mg_{0.5}\square)Al_2(SO_4)_2(HSO_4)F_2 \cdot 36H_2O$, alunococquimbite, $AlFe(SO_4)_2 \cdot 9H_2O$, clinometaborite, HBO_2 and adranosite-(Fe), $NaFe_2(NH_4)_4(SO_4)_4Cl(OH)_2$.

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J2-6 Poster Garavelli, Anna

10.1474/Epitome.04.0748.Geoitalia2011

NEW FUMAROLE MINERALS AT VULCANO: LUCABINDITE

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Key terms: lucabindite; new mineral; sublimates; fumaroles; Vulcano

Lucabindite is a new As(III)-oxygen phase, with ideal formula $(K,NH_4)As_2O_5(Cl,Br)$. It was found among medium-temperature fumarole encrustations ($T=170^\circ C$) collected in 1998 during a sampling field at the "La Fossa" crater of Vulcano island, Aeolian archipelago, Italy. Individual single crystals of lucabindite are very rare. Generally it appears in aggregates of minute, hexagonal, and platy crystals of micrometer-size

(up to $70 \times 70 \times 3 \mu m$) directly deposited on the surface of the pyroclastic breccia. In places, the lucabindite aggregates appears covered by a vitreous reddish crust containing mainly sulfur and arsenic. Associated minerals are arsenolite, salammoniac and realgar.

The new phase from La Fossa crater volcano is colorless to white, transparent, non-fluorescent, has a vitreous lustre and a white streak. The calculated density is 3.679 g/cm^3 . Chemical analyses were obtained by SEM-EDS methods. The ammonium content was deduced from the K content, taking into account the $(K,NH_4)As_2O_5(Cl,Br)$ stoichiometry ($K+NH_4=1 \text{ apfu}$). The presence of ammonium was confirmed by FTIR spectroscopy. Analytical data (in wt.%) are the following: K:O 3.67-6.70 (average 5.14, σ 0.70), As_2O_5 80.52-88.84 (average 84.62, σ 2.90), Cl 1.90-5.81 (average 3.63, σ 1.41), Br 3.70-10.31 (average 6.92, σ 2.24), F 0.27-1.21 (average 0.77, σ 0.27), $(NH_4)_2O$ 1.72-3.13 (average 2.51, σ 0.35), O=F,Cl,Br -1.84, total 101.75.

The empirical chemical formula, calculated on the basis of 5 anions per formula unit, is $[(K_{0.51}(NH_4)_{0.45})\Sigma_{0.96}As_2O_5]_{0.93}(Cl_{0.46}Br_{0.40}F_{0.19})_{0.97}$. The simplified formula is $(K,NH_4)As_2O_5(Cl,Br)$; the end-member formula is KAs_2O_5Cl , which requires: K:O 10.02, As_2O_5 84.15, Cl 7.54, O = Cl: -1.71, total 100.00 wt.%. Single crystal X-ray studies showed hexagonal symmetry, space group $P6_3/mmm$, with the following unit-cell parameters: $a = 5.2386(7) \text{ \AA}$, $c = 9.014(2) \text{ \AA}$, $V = 214.23(7) \text{ \AA}^3$, $Z = 1$. The strongest reflections in the calculated X-ray powder-diffraction data [d in \AA , (I relative to 100)] are: 5.20, (100); 2.62 (66.57); 4.51, (51.64); 4.54 (30.49); 1.98 (28.01); 1.485, (20.99); 1.60 (20.28); 2.26 (18.89).

The structure of lucabindite is topologically identical to that of the synthetic compounds MAs_2O_5X ($M = K, NH_4$; $X = Cl, Br, I$) described by Pertlik (1988). It consists of neutral As_2O_5 sheets arranged parallel to (001). Each As_2O_5 sheet is formed by AsO_3 pyramids ($As-O = 1.796(5) \text{ \AA}$) connected by shared oxygen atoms. The As atoms of two neighbouring sheets point at each other and the sheets are separated by interlayer M ($= K, NH_4$) and X ($= Cl, Br, F$) atoms. The M and X atoms show hexagonal prismatic coordination with twelve oxygen atoms and twelve arsenic atoms, respectively. Refinement of the occupancy of the M site gave $K_{0.52(4)}Na_{0.48}$, in good agreement with the chemical data. Occupancy of the site X was assigned as 0.5 Cl, 0.3 Br and 0.2 F on the basis of the results of chemical analyses.

The name is in honour of Luca Bindi (1971), head of the Division of Mineralogy of the Natural History Museum of the University of Florence. Both the mineral and the mineral name have been approved by the IMA-CNMNC commission (IMA 2011-010).

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J2-7 Poster Garavelli, Anna

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NEW FUMAROLE MINERALS AT VULCANO: ADRANOSITE-(FE)

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Key terms: adranosite-(Fe); new mineral; sublimates; fumaroles; Vulcano

Adranosite-(Fe), $(NH_4)_2NaFe^{3+}_2(SO_4)_2Cl(OH)_2$, is the Fe^{3+} -analogue of adranosite and corresponds to $(NH_4)_2K_2Fe_2(OH)_2(SO_4)_2 \cdot 9NaCl$, an anthropogenic product recovered from a burning coal dump at the Anna mine near Aachen, Germany (<http://www.mindat.org/min-38898.html>). Both the mineral and the mineral name have been approved by the IMA-CNMNC commission (IMA 2011-006).

The history of the discovery of adranosite-(Fe) is curious: it was independently and simultaneously identified by the two different research groups of the University of Bari and Milano in fumarole products collected at La Fossa crater of Vulcano (Aeolian Islands, Italy) in different years and around different high-temperature fumaroles. It's a long time that the two research groups are intensively studying rare or new fumarole minerals from Vulcano so, after exchange of information, the researchers were

happy to join the results and to work together at the characterization of the new phase.

The group of the University of Milano found adranosite-(Fe), in association with thermessite, pseudocotunnite and bismuthinite, on a sample collected in 2007 from fumarole F11; the group from Bari University found the new mineral, associated with barberite, salammoniac, anhydrite, sassolite and sulphur, in a sample collected in 1996 from the intracrater fumarolized area (IC area, T = 250°C). Besides the mineralogical association, the two occurrences mainly differ for the size of the crystals: up to 0.3 mm in the 2007 sample, micrometer-sized in the 1996 material. Due to the too small dimensions of crystals deposited in 1996 a complete determination of the physical properties could be possible only in the 2007 sample, which was consequently considered and described as the holotype material. The occurrence of adranosite-(Fe) in both the fumarole deposits of 1996 and 2007 is related to the reaction of fumarole vapours with rocks crossed by the fluids rising to the surface. Adranosite-(Fe) occurs around La Fossa crater fumaroles as a spray of pale-yellow, elongated, prismatic crystals covering the pyroclastic breccia. The mineral is tetragonal, space group: $I4_1/acd$ with a 18.261(2), c 11.562(1) Å, V 3855.5(7) Å³ and Z = 8. The strongest six reflections in the X-ray powder-diffraction pattern are: $[d_{obs}$ in Å(I/I₀)(hkl)] 9.134(100)(020), 4.569(83)(040), 3.047(79)(152), 6.462(36)(220), 3.232(29)(251) and 2.156(7)(660). The average result of chemical analyses (wt.%) is: Na₂O 5.01, Fe₂O₃ 15.77, Al₂O₃ 5.11, K₂O 0.82, (NH₄)₂O 15.76, SO₃ 50.96, Cl 3.71, H₂O 2.75, -O=Cl -0.84, for a total of 99.05. The measured density is 2.18(1) g/cm³, calculated density is 2.195 g/cm³. The mineral is uniaxial (-) with $\omega = 1.58(1)$, $\epsilon = 1.57(1)$ (l = 589 nm). Using single-crystal diffraction data, the structure was refined to a final R = 0.0415 for 670 observed reflections [$I > 2\sigma(I)$]. Building blocks of the structure are FeO₆ octahedra [Fe-O in the range 1.929(1)-2.034(1) Å] and SO₄ tetrahedra, which are linked together to form spiralling chains parallel to [001], and NaO₄Cl octahedra [Na-O 2.327(1), Na-Cl 2.891(1) Å], linked together by sharing the Cl corners. The ammonium ions occupy the voids in the resulting framework and interact with the Cl ions via hydrogen bonds.

J2-8 Poster Carbone, Cristina

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SrV₃O₇·4H₂O, A NEW MINERAL FROM MOLINELLO MINE, VAL GRAVEGLIA, EASTERN LIGURIA, ITALY

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Key terms: Liguria; new minerals; chemical composition; crystal structure

The sample containing the new mineral SrV₃O₇·4H₂O was collected at the Molinello mine, Val Graveglia, eastern Liguria, northern Apennines, Italy. In the Val Graveglia mines, Mn ores occur as braunite-bearing layered massive lenses, and boudins near the stratigraphic base of the cherts of the "Diapri di M. Alpe" Formation, overlying ophiolitic basement [1]. Mineralizations are characterized by a braunite + quartz association equilibrated under prehnite-pumpellyite facies conditions [2,3] during the tectono-metamorphic evolution which affected both ophiolites and cherts. Hydrothermal fluid circulation along later extensional fractures, at decreasing metamorphic conditions, induced the concentration of dispersed elements such as As, Ba, Cu, Sr, and V and the precipitation of great variety of uncommon minerals. The new mineral SrV₃O₇·4H₂O was found in association with rhodonite, pyroxmangite, quartz and braunite. Electron microprobe analyses carried out on the same crystal used for the structural investigation led to the following empirical chemical formula: (Sr_{0.97}Ca_{0.02}Na_{0.01})V₃O₇·4H₂O. H₂O was calculated by stoichiometry from the results of the crystal-structure analysis and its presence was confirmed by Raman spectroscopy. SrV₃O₇·4H₂O is monoclinic, space group P2₁/m, with a = 5.313(3), b =

10.495(3), c = 8.568(4) Å, $\beta = 91.14(5)^\circ$, V = 477.7(4) Å³ and Z = 2. Its crystal structure [R = 0.0209 for 1148 reflections with Fo > 4 σ (Fo)] consists of layers of VO₅ pyramids (with vanadium in the tetravalent state) pointing up and down alternately, with Sr between the layers (in nine-fold coordination). The mean bond distance for the VO₅ pyramids (range 1.871-1.906 Å) is in excellent agreement with those observed for synthetic AV₃O₇ (A = Ca, Sr) V⁴⁺-oxovanadates [4]. Despite the fact that the hydrogen atoms were not located in the difference Fourier maps, bond valence calculations clearly indicate that three oxygen atoms belong to water molecules which assure linking between the layers. The similarities of the crystal structure of SrV₃O₇·4H₂O with that of the anhydrous mineral cavitoe, CaV₃O₇[5], will be discussed.

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J2-9 Poster Ciriotti, Marco E.

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CHURCHITE-(ND) FIRST WORLD OCCURRENCE FROM COSTA BALZI ROSSI, LIGURIA, ITALY: CHEMICAL DATA AND RAMAN SPECTROSCOPY

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Key terms: Churchite-(Nd); Discreditation; Costa Balzi Rossi; First world occurrence

Monoclinic churchites (formerly "weinschekite") are members of the gypsum supergroup which includes the phosphates brushite, Ca(PO₃OH)₂·2H₂O and churchite-(Y), Y(PO₄)₂·2H₂O, the sulfate gypsum, Ca(SO₄)₂·2H₂O, and the arsenate pharmacolite, Ca(As₅+O₃OH)₂·2H₂O. A mineral, which is included in the IMA list of the valid species as Rn (renamed) was described by Podporina et al. (1983) and considered the

Nd-dominant member of the churchites. Instead the chemical data in the above paper clearly demonstrate that the natural phase ("n. 2 Nd-churchite from Kazakhstan") is only a Nd-bearing variety of churchite-(Y). So the first, and at today the only described occurrence of churchite-(Nd) is not correct and the validity of the species (based on the Podporina et al., 1983 paper) must be reconsidered and discredited. All members of the gypsum supergroup has an isotopic layer structure, the layers being parallel to (010) face. The two sheets of sulfate ions are intimately bound together by calcium ions so as to form a strong double sheet. These double sheets are separated by sheets of water molecules. Each calcium ion is eight coordinated by six O atoms belonging to sulfate groups, and by two water molecules. The arrangement of the square-antiprismatic CaO₈ groups and sulfate tetrahedra consists of centrosymmetric pairs of chains along [101]. The tetrahedral sulfate group is not regular.

Due to the paucity and the micrometric size of the elongated needle crystal aggregates a diffraction for the new find of the natural Nd(PO₄)₂·2H₂O, from Costa Balzi Rossi, Magliolo, Savona, Liguria (Italy), resulted impossible.

The two specimens in which churchite-(Nd) occurs, always on xenotime-(Y) crystals, were used, the first for chemical analysis (semi-quantitative energy-dispersive electron-microprobe analysis on unpolished crystals) and the second for a Raman spectroscopy. The analytical results demonstrate the Nd-dominance on all REE and also on Ca and Sc. The stoichiometric formula (O = 4) is: (Nd_{0.31}La_{0.11}Sm_{0.10}Pr_{0.07}Ca_{0.05}Y_{0.05}M_{0.31})S₂=1(PO₄)₂·2H₂O (where M is exactly the sum of all other REEs and Sc, Al and Fe for which the values are between 0.04 and 0.01 apfu).

The comparison with the Raman spectrum of churchite-(Y) (Frost et al., 2010) would seem to be confirmed as Nd-dominant churchite. A similar comparison is provided with the synthetic Nd(PO₄)₂·2H₂O.

Costa Balzi Rossi is a recent well known locality in which the following REE minerals were found: aeschinite-(Y), allanite-(Ce), bastnäsite-(Ce), churchite-(Y), fergusonite-(Y), monazite-(Ce), parniite-(Y), thortveitite and xenotime-(Y) (Balestra et al., 2011).

If the IMA CNMNC will recognize the invalidity of the Kazakhstan occurrence, Costa Balzi Rossi should be the type-locality of the actually first natural churchite-(Nd).

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J2-10 Poster Camara, Fernando

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A NEW MINERAL WITH A PYROCHLORE-RELATED STRUCTURE FROM EUGANEI HILLS, PADOVA (ITALY)

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Key terms: new mineral; pyrochlore-related structure; Euganei Hills

The mineral was found by Mr. B. Fassina at Monte delle Basse, Euganei Hills, Galzignano Terme, Padova (Veneto, Italy) in millimetric secondary vugs of a sanidine-bearing rock. These sanidinites are xenoliths hosted by calcisilicate rocks metamorphosed by the intrusion of syenitic-gabbros. Calcisilicate rocks are formed by wollastonite, gehlenite, grolite, hibschite, kilchoanite, pectolite, rankinite and sanidine. The new mineral forms fan-shaped groups of platy crystals, a few microns in thickness, brown-orange in color, and up to one millimeter in length. Minerals associated are colorless to grey titanite and dark yellow to dark brown hibschite garnet.

Electron microprobe analyses yield the empirical formula (Ba_{1.93}Ca_{1.20}Sr_{0.53}Na_{0.25}Fe_{2.70}Li_{0.27}Nb_{2.87}Ti_{2.05}Ta_{0.07}Zr_{0.01}V_{5.70}Si_{0.50}SiO₇[(P_{0.15}Si_{0.12}S_{0.07}O)_{0.64}(OH)_{0.64}][F_{0.09}(OH)_{0.27}]_{0.36}, on the basis of (18+2x)(O,F) pfu with x = [P+S+(Si-1)] < 0.5 apfu.

Single-crystal X-ray studies show that the mineral is orthorhombic, space group $Fmmm$, with a = 7.4105(4), b = 20.675(11), c = 21.4471(11) Å, V = 3189.4(5) Å³ and Z = 8. The structure was solved using Superflip. Weighted full-matrix least-squares refinement on F² was performed using SHELXL 97. The structure consists of a framework of Nb(Ti)-octahedra and BaO₇₍₊₂₎ polyhedra sharing apices or edges, and isolated Si tetrahedra sharing apices with Nb(Ti)-octahedra and BaO₇₍₊₂₎ polyhedra. There are three Nb(Ti)-octahedra, two of them are Nb dominant and one is Ti dominant. Chains of CaO₈ octahedra extend along [100] and are surrounded by Nb-octahedra. There are channels formed by six Nb(Ti)-octahedra and two tetrahedra, or four BaO₇ polyhedra, alternating along [100]. The channels are partially occupied by [PO₂(OH)]₂ in two mutually excluding positions, alternating with fully occupied Ca(Na)O₇ polyhedral pairs. Each P atom at the P sites of the [PO₂(OH)]-groups is coordinated with two (OH) groups and two different pairs of oxygen atoms, which are mutually exclusive, depending on the P site occupancy. Therefore, in terms of formula normalization, if the P site is vacant it means that there are 17 oxygen atoms per asymmetric unit plus one (OH) group, i.e. 18 anions. An occupation of the P site of x requires 2x additional oxygen atoms present. Thus, the total amount of anions is (18+2x), being x the occupation of the P site [i.e., P+S+(Si-1)]. x cannot be > 0.5, and therefore the maximum quantity of anions is 19 pfu. The observed structure is related to the pyrochlore structure with the addition of a slab of SiTiO₃ [PO₂(OH)]_{0.25}O_{0.25}(OH)_{0.25} every 0.5 b translation parallel to [110] of pyrochlore. Other pyrochlore-related structures have been described, although they have alternate one [K-nenadkevichite (Na,K)(Nb,Ti)₂[Si₂O₇](O,OH)₂ 1.6 H₂O], two [fersmanite (Ca_{5.49}Na_{2.37}Sr_{0.08}Fe_{0.06})(Nb_{1.6}Li_{1.2})(Si₂O₇)(O,OH)₂ 1.6 H₂O], or three [Na-komarovite Na₅Ca_{0.8}La_{0.2}Ti₁₀Nb₅Si₄O₂₆F₂·H₂O] octahedra-thick (100)-pyrochlore slabs with (SiO₄) groups showing different degrees of polymerization (four-membered rings being the most frequent unit). This new structure thus represents a novel type of pyrochlore-related structure, which includes further anionic groups other than (SiO₄).

J2-11 Poster Nestola, Fabrizio

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Pb2(CO3)(S2O3), THE FIRST MINERAL WITH COEXISTING CARBONATE AND THIOSULFATE GROUPS FROM TRENITINI MINE, VICENZA, ITALYNESTOLA Fabrizio¹, BINDI Luca², GUASTONI Alessandro³, ZORZI Federico⁴, NASDALA Lutz⁴1 - Dipartimento di Geoscienze, Università di Padova
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Key terms: Veneto; New minerals; Chemical composition; Crystal structure

The sample containing the new mineral here described was found in the Trentini mine, Mount Naro, Torrebelticino, Vicenza, Italy. The mine is in the Vicentine Alps metal-bearing district, exploited for lead, zinc, and silver from ancient times. From a genetic point of view, the mineralization is linked to Mid-Triassic calc-alkaline magmatism. Hydrothermal fluids related to volcanism deposited sulfides, barite, and Fe- and Mn-bearing minerals mainly at the boundary between Ladinic volcanites and carbonates of the Mount Spitz. Oxidation and hydrothermal alteration minerals are very common [1] and are represented by sulfates, carbonates and arsenates of Zn, Pb and Cu. The new mineral described here was found in association with galena, quartz, and anglesite. Electron microprobe analyses carried out on the same crystal used for the structural investigation led to the following empirical chemical formula $Pb_2.09C1.05S1.82O_6$ (based on 6 O apfu), ideally $Pb_2(CO_3)(S_2O_3)$. The presence of both carbonate and thiosulfate groups was confirmed by Raman spectroscopy.

The crystal structure of $Pb_2(CO_3)(S_2O_3)$ consists of rods of Pb-polyhedra that extend along the [010] direction. Among such rods there are, alternatively, CO_3^{2-} and the $S_2O_3^{2-}$ groups. The latter point alternatively left and right, considering the apex occupied by sulfur as the atom giving the direction. Pb atoms are nine-coordinated with 7 oxygen atoms (Pb-O 2.41-3.18 Å) and 2 sulfur atoms (3.22-3.31 Å). In the thiosulfate group, the central sulfur is linked to three O atoms at a mean distance of 1.48 Å and to a sulfur atom at 2.03 Å, the four anions forming a very distorted tetrahedron. Carbon makes two C-O bonds at 1.25 Å and one at 1.32 Å. Bond valence sums are 1.96 (Pb), 5.60 (S1), 4.13 (C), 2.02 (O1), 2.06 (O2), 1.87 (O3), 2.11 (O4), and 1.66 (S2).

To our knowledge, the new mineral here described is the third thiosulfate-bearing mineral known to occur in Nature (after sidpietersite [2] and steverustite [3]). There are other two minerals which are reported to contain the thiosulfate group, bazhenovite, $Ca_{55}CaS_{203}6H_2O_{20}H_2O$ [4], and viaenite, $(Fe,Pb)_4S_8O$ [5]. For bazhenovite, Bindi et al. [6], studying the type-sample, did not detect the presence of the thiosulfate group either by structural analysis or spectroscopic investigations. Viaenite was only poorly characterized because of the scarce amount of material available and its very low quality.

Natural $Pb_2(CO_3)(S_2O_3)$ was found in a matrix consisting of a mixture of fine-grained minerals with a strong predominance of galena. Together with $Pb_2(CO_3)(S_2O_3)$ it is possible also to find anglesite. $Pb_2(CO_3)(S_2O_3)$ is considered to be secondary after galena. We suggest that thiosulfate formation occurred during an intermediate stage of oxidation as the assemblage moved toward complete oxidation and subsequent formation of sulfate (anglesite) with decomposition of galena.

J2-12 Poster Pegoraro, Sergio

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MINIERE E MINERALI DELL'ALTO VICENTINO - I MONTI D'OROPEGORARO Sergio¹

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Key terms: Alto Vicentino; Miniere; Minerali; Amalgama; Esplosivo in miniera

In the High Vicentino, the geological area that includes the adjacent valleys of Agno, Leogra and Posina, known as the "Recoarese", is the southernmost part of the Southern Alps (Sudalpino) and differs from all areas neighboring to the emergence of the so-called "Crystalline Basement". About 230 million years ago, in mid-upper Ladinic (Triassic), intense volcanic phenomena occurred in this area which led to the deposition of acid lava, forming the rocks now outcrop in the hills that surround the Mercanti Valley (Torrebelticino, Vicenza). This volcanic activity has resulted in a rich mining area with the formation of a series of metalliferous deposits of pyrite and polymetallic sulfides.

The Repubblica Serenissima di Venezia, where the Senate was particularly interested in the search for noble minerals like gold and silver for the supply of its brand and under whose rule, in the early 400, handed the territory of Schio, exercised careful control over mining activities in the Vicenza area, increasing the investigations and funding cultivations. The periods of most mining operations by the Serenissima covered the years ranging from 1450 to 1515. In the Sixteenth Century, the clash between the Emperor Maximilian and the Venetian Republic (War of Cambrai, 1509-1518), began Venetian mining in crisis with the result that all the mines were closed one by one, deliberately, hidden or abandoned. The most important mines opened, in this period, in the mountains that surround the Mercanti Valley were named Sant'Alvise, Santissimo Nome di Dio, San Martino, San Marco, Sant'Isidoro, San Giacomo, Madonna del Rosario, etc.

In these mines it can be found native elements, oxides, hydroxides, fluorides, carbonates, sulfates, arsenates, phosphates, wolframates, molybdates, vanadates and silicates. Monte Trisa is the type locality of cerussite and montetrisaite and studies are under way on possible new species.

In the early '500, in the field of mining technology, probably for the first time in the world, in the mining district of Schio, two historic innovations were implemented: i) in 1507 the use of amalgam to separate the silver from other minerals; ii) in 1572 the use of gunpowder in order to break the rock in the tunnels.

Vannoccio Biringuccio from Siena, who lived for more than two years in the Veneto, described that in the mining district of Schio was in use a new system to separate the silver: "the amalgamation".

The merit of this novel technique is of two Veronese men, Ioannes Antonius De Mauris and Thomaso de Cusano, who, on January 19, 1507, wrote to the Consiglio dei Dieci a plea for a twenty-five years deprivation in some mines of the Schio mining district, petition granted January 30,

1507.

According to literature, the amalgamation was first introduced in Europe around 1613 in Freiberg (Saxony) by Martin Weigold; this is the prevailing version, but according to others that use began in 1627 to Schemnitz, present-day Banská Štiavnica in Slovakia.

The documentation at the Archivio di Stato di Venice confirms that, without a shadow of doubt, in December 1572 in the Schio mining district, in the mines owned by Giovanni Battista Martiniengo, the use of the gunpowder in the tunnel for break the rock was currently. Unfortunately, these two important innovations, for some unknown reason, are not reported in the major publications.

J2-13 Poster Cadoni, Marcella

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WAKEFIELDITE-(Y) FROM MONTALDO DI MONDOVÌ (ITALY): NEW DATA AND CRYSTAL STRUCTURECADONI Marcella¹, CIRIOTTI Marco E.², FERRARIS Giovanni¹

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Key terms: Wakefieldite-(Y); New data; Crystal structure; Zircon-type structure; Montaldo di Mondovì minerali

Wakefieldite-(Y) was first reported in quartz cavities from a zoned granite pegmatite of the Evans-Lou quarry [near Lac Saint-Pierre (Wakefield Lake), Val-des-Monts, Québec, Canada] as canary-yellow to tan pulverulent masses intimately associated with hellandite-(Y), quartz, kainosite-(Y), montmorillonite, thogorummite, Y-bearing fluorapatite, fine grained xenotime-(Y) and some unidentified compounds (Miles et al., 1971). The definition was based on X-ray powder diffraction (XRPD) and spectrographic chemical data obtained from a mixture of the new mineral with quartz, hellandite, kainosite-(Y) and montmorillonite. Following the identification in the XRPD pattern by comparison with synthetic YVO_4 , the authors assigned yttrium (Y) dominance to the chemical composition of the new species. This assignment was not obvious because in the studied mixture hellandite-(Y) and kainosite-(Y) were Y-bearing species too. Other three world finds of wakefieldite-(Y) are known, but all of them are verified by microprobe SEM-EDS tests only.

Wakefieldite minerals and dreyerite represent the vanadate members of a group of minerals with zircon-type structure that includes also arsenates (chernovite-(Y)), borates (behierite and schiavinatoite), chromates (chromatite), phosphates (pretulite, xenotime-(Y) and xenotime-(Yb)) and silicates (coffinite, hafnon, stetindite, thorite, thogorummite and zircon). Wakefieldite-(Y) with composition $(Y_{0.40}Nd_{0.15}Ce_{0.15}Ca_{0.15}Th_{0.15})(V_{0.92}As_{0.08})O_4$ is now reported as small group of vitreous reddish-brown microcrystals (up to 0.15 mm in size); the rhombododecahedral garnet-like crystals were implanted on quartz-calcite matrix and associated with tilasite (or, possibly, svabite), hematite and montmorillonite, from an abandoned Fe- and Mn-ores mine located at Borgata Oberti, Montaldo di Mondovì, Cuneo, Piedmont, Italy. The mine was operated since 1855 for about one century extracting Fe- and Mn-ores (Kolitsch et al., 2011). Due to the paucity and tiny dimensions of the available material, only semi-quantitative energy-dispersive electron-microprobe analysis could be carried out on unpolished crystals. The semi-quantitative data unambiguously indicate $Y > Nd \approx Ce \approx Ca \approx Th$ and V by far higher than As; minor quantities of La and Gd were detected. X-ray single-crystal diffraction data for wakefieldite-(Y) were collected on an Oxford Gemini R Ultra diffractometer equipped with a CCD area detector (50 μ m, 40 mA;

graphite-monochromated MoK α radiation). The zircon-type crystal structure (space group $I4_1/amd$; $a = 7.2591$ Å, $c = 6.4255$ Å) has been refined ($R = 0.017$ for 175 independent reflections) using X-ray diffraction data collected on a crystal from this locality. That confirms the validity of the species which previously had been only roughly defined using an impure pulverulent sample from Wakefield Lake (Québec, Canada). The substantial (30%) joint replacement of Ca^{2+} and Th^{4+} for Y^{3+} in the present wakefieldite-(Y) expands the cell volume of pure YVO_4 and could anticipate the existence of minerals with zircon-type structure and $A^{2+}A^{4+}T^{2+}O_4$ composition.

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J2-14 Poster Russo, Massimo

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AMMINEITE, MATLOCKITE AND POST 1944 ERUPTION FUMAROLIC MINERALS AT VESUVIUSRUSSO Massimo¹, CAMPOSTRINI Italo²

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Key terms: Vesuvius; Eruption of 1944; Fumarolic minerals; Ammineite; Matlockite

The 1944 eruption of Vesuvius began on March 18th and ended on the 29th of the same month. It was the last eruption of Vesuvius and marked the transition from an open conduit to a closed conduit state.

The eruption took place during wartime so that nobody was interested to sample fumarolic minerals before and after the eruption. The only mineralogical work was made by Parascandola (1951), but most interesting were his comments on the temperature of the fumaroles and his observations about fumarolic minerals in the period between 1947 and 1960. Parascandola indicated the presence of about ten mineral species found on the fumaroles.

As a part of a joint project concerning the study of fumarole minerals of the Italian volcanoes, carried out in collaboration with the Università degli Studi di Milano - Dipartimento di Chimica Strutturale e Stereochimica Inorganica, a systematic investigation of old fumarole mineral samples was undertaken. Two old fumarolic sites, unfortunately almost completely destroyed by man and landslides has been identified and sampled. In

these sites several Vesuvius-rare and Vesuvius-new mineral species were found, many of which were not mentioned by Parascandola, probably because of the inadequacy of the analytical instruments of the time or/and because some of these minerals could have formed later. The first site is a fumarole that was active in 1944 and has currently a temperature of 70-80° C; the second one is a fumarole with a temperature of about 100° C and the occurrence of H₂S, located at the bottom of the crater. Ammineite, CuCl₂(NH₃), is one of the most interesting minerals found; this species was recently described for the first time in a guano deposit, in contact with plutonic rocks at Pabellón de Pica in Chile by Bojar et al. (2011), therefore the finding at the fumaroles of Vesuvius represents not only the second occurrence of this species in the world, but also the first in a totally different environment. The mineral occurs in bluish crusts associated with altered tenorite, opal and artroite. Matlockite, PbFCl, was identified as colorless platy crystals up to 1 mm, together with artroite, tenorite and calcioaravaipite. Other species of great interest, new for Vesuvius, are gearksutite, hemimorphite and caledonite.

On post-eruption fumaroles the following minerals have been found: alum-(K), ammineite, anglesite, antlerite, artroite, baryte, calcioaravaipite, calcite, caledonite, cerussite, chalcocolloite, cotunnite, chrysocolla, cumengeite, erythrosiderite, fluorite, gearksutite, gypsum, halite, halotrichite, hematite, hydrozincite, linarite, matlockite, metatolite, mimetite, opal, pickeringite, salammoniac, sassolite, sulphur, sylvite, tenorite and, on the scoriae, siderazot.

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J2-15 Poster Campostrini, Italo

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THE OCCURRENCE OF LAFOSSAITE AT VESUVIUS

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Key terms: Lafossaite; Vesuvius; Thallium chloride

As a part of a joint project concerning the study of fumarole minerals of the Italian volcanoes, carried out in collaboration with the Istituto Nazionale di Geofisica e Vulcanologia sezione di Napoli - Osservatorio Vesuviano, a systematic investigation of old fumarole mineral samples was undertaken. The presence of natural thallium chloride lafossaite, first described at La Fossa crater, Vulcano Island by ROBERTS *et al.* (2006), was detected on two small samples from "Atrio del Cavallo" dated 1906 and obtained together with other fumarole material from an old collection belonging to the "Istituto Geomineralogico Italiano", a mineral-dealer society active in the '20s of the past century. In our samples lafossaite forms small aggregates or colorless cubic crystals, up to 0.05 mm, associated with realgar, dimorphite in small orange-yellow crystals, anhydrite and an unknown thallium mineral containing S, Cl, K, As. Differently from that of Vulcano, lafossaite from Vesuvius contains only small amounts of bromine. The unit-cell parameters obtained by least squares method from X-ray powder diffraction are also in good agreement with those of pure TlCl.

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J2-16 Poster De Lucia, Maddalena

10.1474/Epitome.04.0758.Geoitalia2011

THE "MARIANO CARATI" COLLECTION OF THE MUSEUM OF OSSERVATORIO VESUVIANO

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Key terms: Museum; Somma-Vesuvio; Minerals; Osservatorio Vesuviano

The Istituto Nazionale di Geofisica e Vulcanologia, sezione di Napoli | Osservatorio Vesuviano began actions for the acquisition (by donation) of the mineral collection of Mariano Carati, Neapolitan collector of Somma-Vesuvius minerals. The collection, set up in about forty years, consists of both personal findings and acquisitions of parts of existing collections, such as the important one (60 samples) of Antonio Parascandola, who was professor of mineralogy at the faculties of Science and Agriculture at the University of Naples, and the one (27 samples) of Roberto Palumbo, a well known Roman collector, as well as of specimens got by exchange with other collectors.

The collection consists of 444 mineral specimens of great scientific value, four medallions of lava, two lava samples incorporating a coin, two cases containing thin sections of minerals, one of which belonged to Eugenio Scacchi, professor of mineralogy at the University of Naples and son of the famous Arcangelo, "the father of mineralogy of Vesuvius", and another belonged to Ferruccio Zambonini, mineralogist known throughout the world and great scholar of Vesuvius mineralogy, and other rarities from the world of mineralogy.

Samples of minerals found by Carati were collected in a period between 1970 and 1994, mostly in caves and ravines of the volcano Vesuvius. The collection includes about 130 of the 230 mineral species currently known at Somma-Vesuvius.

Extremely rare species are represented: apthitalite, avogadrite, bassanite, cotunnite, hematite, euclorine, hauyne, lazurite-lapislazuli, litidionite, magnesioferite, mallardite, millerite, rinneite, vesuvianite, and others.

Many of the Carati collection minerals are not present in the section "Vesuvius minerals" of the prestigious Museum of Mineralogy of the

University of Naples; for this reason, with this acquisition, the museum of the Vesuvius Observatory aims to become a valuable complement of the major Neapolitan museum, in the field of mineralogy. Examples of such minerals are: åkermanite, albite, artroite, chabazite-K, chrysocolla, ettringite, fluoborite, fluoro-potassicrichterite, geikelite, gismondine-Ca, hibschite, magnesite, marialite, montesommaite, natrolite, norbergite, pargasite, piypite (ex caratiite), quadridavyne, thaumasite, thortite, tremolite, zirconolite. The Museum of Vesuvius Observatory will display the collection in a permanent exhibition, in specifically made cabinets, using criteria inspired by educational and scientific needs of the museum itself, which has an audience mainly composed of middle and high school students.

J2-17 Poster Russo, Massimo

10.1474/Epitome.04.0759.Geoitalia2011

BEYOND VESUVIUS: MINERALS FROM CAMPANIA: CAMPI FLEGREI, ROCCAMONFINA, GYPSUM-SULPHUROUS AND SEDIMENTARY FORMATIONS

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Key terms: Minerals of Campania; Campi Flegrei; Roccamonfina; Fiano; gypsum-sulphurous and sedimentary formations

After the completion, in 2004, of the monography: Russo, M. and Punzo, I. (2004): I Minerali del Somma-Vesuvio, by the Associazione Micromineralogica Italiana (AMI), the authors are finishing a new book which deals with the mineralogy of the whole Campania area, excluding Vesuvius, again for the AMI.

The mentioned areas are many and many of them are of remarkable scientific interest, though always overshadowed by one of the most famous volcanoes in the world: the Somma-Vesuvius. For example, Campi Flegrei are type locality for misenite of the Grotta dello Zolfo, for marialite of Pianura, for nacholite of Stufe di Nerone and the alum-(K), dimorphite and voltaite of Solfatarà di Pozzuoli.

Other areas of interest are those of Fiano, close to Salerno, for fluoborite (ex nocerite), Roccamonfina for leucite, etc. It is a modern work, whose release is scheduled for 2013, suitable to both professionals, and collectors, and learned readers.

J2-18 Poster Rizzo, Roberto

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MINERALOGICAL HERITAGE AND ENHANCEMENT OF THE ABANDONED MINING SITES IN SARDINIA

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Key terms: mineralogical heritage; abandoned mining site; Sardinia

In recent decades, the birth of Geoparks focused the need to protect and enhance the abandoned mining heritage. In the experience of the Authors, the knowledge of the mineral species in the abandoned mining sites, in terms of study and scientific disclosure, can provide a great contribution to their enhancement. In scientific and popular ambit good results were obtained in the past twenty years, which led to the definition of new mineral species and the publication of valuable monographs. This justifies the possibility of a regulated access to the collection and study of minerals in the abandoned mining areas, even to amateur mineralogists. The present study compares the increase of knowledge of the mineralogical species from some "classic" sites with others until recently nearly forgotten, precisely thanks to the collaboration between professional and amateur mineralogists.

J2-19 Poster Scacchetti, Maurizio

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CAMPOTRERA OPHIOLITE (REGGIO EMILIA, NORTHERN ITALY): A NATURAL PRESERVE FOR GEOLOGY AND MINERALOGY

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Key terms: natural preserve; ophiolite; pillow-lavas; datolite

The Natural Preserve of Campotrera, in the Enza river valley (Reggio Emilia province, Northern Apennine), was established in 1999 and its management was entrusted to Canossa municipality, where the preserve is present. This Natural Preserve includes a huge ophiolitic outcrop, composed by pillow-lavas basalts and subordinately by polygenic and ophiolitic breccias.

Campotrera ophiolitic block, together with nearby Rossena and Rossenella ones, represents an ophiolite (Campotrera ophiolite) belonging to the External Ligurian Units, composed by ophiolitic slide-blocks embedded in a sedimentary melange that marks the base of flysch-like sequences of Cretaceous-Eocene age. These basalts underwent a low-grade metamorphism (oceanic metamorphism), represented by prehnite-pumpellyite to greenschist-facies assemblages. The main chemical effect of this transformation is silica liberation and calcium mobilization. In ophiolitic basalts plagioclase is transformed into albite+prehnite±epidote±pumpellyite association, clinopyroxene is partially replaced by chlorite+amphibole (actinolite) and Fe-Ti oxide phases are frequently converted into titanite. Many hydrothermal veins, up to 30 centimetres in thickness, are hosted in basalt-pillows and breccias, and here several minerals occur: datolite, calcite, prehnite and to a lesser extent natrolite, analcime, barite, hematite, magnetite. Sometimes these minerals can occur as well-faceted crystals. Indeed, Campotrera is one of the most famous places in Italy for the beauty and the size of its minerals, especially centimetric red datolite crystals. Since 2000, the SRSN has been cooperating with Canossa municipality in order to reconstruct the quarrying history of these ophiolitic bodies (Borghi

& Scacchetti, 2002) and to investigate their mineralogy. For this purpose, the SRSN established a collaboration with the University of Parma (Department of Physics and Department of Earth Sciences) and with the Department of Applied Geological Sciences and Geophysics of Leoben (Austria).

At the beginning of this collaboration, according to the Canossa municipality provisions, we sampled and then identified by micro-Raman spectroscopy the major number of mineralogical phases (Bartoli et al., 2003). Afterward, several rock samples from Campotrera ophiolite were analyzed by electron microprobe and a fluid inclusion study (Zaccarini et al., 2008) along with a crystal chemistry characterization (Rinaldi et al., 2010) were carried out on datolite crystals. Micro-Raman spectroscopy enabled the discovery of new minerals in the ophiolite, such as magnetite, pumpellyite, and hematite. The latter is present as solid micro-inclusions in datolite and analcime crystals. Thin sections obtained from a single datolite vein show a symmetrical structure with coarse grained datolite in the vein core, characterized by mosaic texture, triple junctions, and palisade-like aggregates of minute datolite crystals typically elongated normally to the contact with the wall rock.

Two-phase (L+V) fluid inclusions were observed, texturally identifiable as primary and secondary. Microthermometry analyses suggested a NaCl-H₂O system for all inclusions. The calculated salinity is in the range of 10-16 wt% NaCl equivalents. Paragenetic considerations and mode of occurrence of datolite from these ophiolitic basalts indicate that the mineral precipitated from hydrothermal fluids circulating through the ophiolitic rocks during some post-magmatic stage.

The chemical analyses show no significant site substitution. The single-crystal structure refinements confirm the structural model of

datolite previously reported (with $a \sim 4.83$, $b \sim 7.61$, $c \sim 9.63$ Å, and $\beta \sim 90.15^\circ$, space group P2₁/c).

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J2-20 Poster Costa, Emanuele

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THE HISTORY OF THE DISCREDITED MOHSITE (OF COLOMBA)

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Key terms: Mohsite; Colomba; Chrichtonite; Mineralogy; Museology

Mohsite is a discredited mineral, and is now recognized as a member (chrichtonite) of the sénéaite-chrichtonite series, but the history of its description and identification is of notable interest for the mineralogy of the Susa Valley. The authors had the opportunity to examine and investigate the samples of "mohsite" described by Colomba, an Italian eminent mineralogist, in 1902. These samples were lost during years and found again some years ago, after more than a century, in the historical mineralogical collection of the Turin University, now in the Piedmont Council Museum of Natural Science of Turin. These new analysis proves that the mohsite of Colomba has a high Sr content, and should thus be identified as chrichtonite.

Mohsite was first reported by Lévy in 1827, on material probably from the Dauphiné Region, in France. The chemical composition was unknown, and the description was mainly morphological. The original samples of Lévy was never traced again. In 1901 Lacroix found some other samples in the Haute Alpes, again in the Dauphiné. This material was not chemical analyzed because of its very small amount but, being these samples morphologically similar, they became neotype.

In 1902 Colomba found similar material from near the Dora Riparia, Oulx, Italian Alps, some ten km from the previous locality but in the Italian sector of the mountain chain. Some qualitative analysis performed at that time showed that the samples contained titanium and iron, as well as small quantities of Ca and Mg, and for this reasons Colomba identified these small black crystals as mohsite.

Kelly et al (1979) obtained a sample of Lacroix's specimen from the Museum National d'Histoire Naturelle de Paris, and they found that the main cation was Sr and so identifying the samples as chrichtonite, and in the same time discrediting the name "mohsite" due to temporal priority of the name "chrichtonite" (De Bournon, 1813).

The authors, as a consequence of the rediscover of the Colomba's samples, submitted these 1902's specimens to SEM-EDS and micro-XRF analysis, and found that the small crystals were made of a complex oxide of titanium, iron and vanadium with Sr as main bivalent cation, followed by Y and small amount of U and Yb. The formula of this oxide as mean of many analysis could be written, as (Sr_{0.9}Y_{0.7}U_{0.2}Yb_{0.1})(Ti_{13.7}Fe_{7.3}V_{0.3})O₃₈ on the basis of 38 oxygens. This formula is close matching with the one of chrichtonite (Sr,Y,U,Yb)₂₁(Ti,Fe,V)₂₁O₃₈, the Sr-bearing term of the group (the other important terms being senaite if Pb is the main large cation, davidite for REE, landauite for Na and loveringite for Ca). Thus, the mohsite of Colomba is in fact a sample of chrichtonite, and probably Colomba may have misidentified Ca with Sr in the old analysis, or these analysis were performed on dirt samples with interference from others minerals.

SESSIONE J3

Idrogeno nei minerali nominalmente anidri o idrati: un elemento chiave nei processi crostali e nel mantello terrestre

J3-1 Key Lecture Bellatreccia, Fabio

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INFRARED SPECTROSCOPY CHARACTERIZATION OF H IN MINERALS

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Key terms: FTIR spectroscopy; Hydrogen; Imaging; FPA detectors; HT-FTIR

Hydrogen can be a major, a minor or a trace constituent of a large variety of minerals. It is usually bonded to oxygen to give H₂O, OH⁻, or more rarely H₃O⁺, H₂O², H₂O⁺ units, but also NH₄⁺ or organic compounds. It can be a structural component in stoichiometric hydrates, hydroxides, and in many silicate minerals, or can be non-stoichiometrically present as a major extraframework component in microporous minerals (e.g. zeolites). Hydrogen also occur as a minor constituent in structural defects of nominally anhydrous minerals (NAMs) [1]. H exerts a strong influence on the chemical and physical properties of minerals; hence it has a controlling effect on many high-temperature geological processes (e.g. magma genesis, kinetic of phase transformations, etc.), as well as low-temperature alteration processes. Unfortunately, H is a rather elusive element, specially when it occurs in very low amounts, as in NAMs. Conventional micro-analytical techniques (EMPA) and X-ray diffraction are generally unsuitable to characterize this element; secondary ion mass spectrometry (SIMS) and neutron diffraction are not easily accessible and requires complex, time-consuming, analytical procedures. A possible alternative is offered by spectroscopy: Raman, Fourier-transform infrared (FTIR) and nuclear magnetic resonance (NMR). FTIR is particularly suitable for hydrogen, since the O-H (C-H and N-H) bond absorbs the infrared radiation very efficiently. The relatively low cost, ease of use and ease of sample preparation makes the FTIR technique an extremely powerful tool for the study of H-bearing minerals [2]. Using FTIR spectroscopy we can: a) quantify hydrogen, b) study its distribution [3], c) distinguish its speciation, d) define the structural orientation of the O-H dipole, e) study phase transitions associated with H loss, and f) study thermal processes [4]. We present here the recent developments of the FTIR activities at Roma Tre and describe the new facilities which are currently available in our laboratories (high temperature stages, Focal Plane Array detectors). We will use, as examples, the most recent results obtained by our group, including studies on beryl, cordierite, feldspaths, phosphates and hydrocarbons-bearing materials.

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J3-2 Orale Cruciani, Giuseppe

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WATER IN ZEOLITES: RELATIONSHIPS BETWEEN THERMAL STABILITY AND ENERGETICS

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Key terms: zeolites; thermal behaviour; structural modifications; thermodynamic properties; stability index

The relation between heat and water in zeolites has attracted great interest since their discovery as 'boiling stone' minerals, being able to dehydrate reversibly. The contribution of water to zeolite thermodynamic properties has been matter of debate. In fact, it is generally assumed that zeolites are thermodynamically metastable phases. On the other hand, it has been suggested that hydrated aluminosilicate zeolites can have true stability fields near room temperature because the exothermic enthalpy of hydration more than compensates for the metastability of the anhydrous framework. Nevertheless, due to the large differences in the enthalpy values determined by different techniques, no consensus exists about the magnitude of the total energetic stabilization imparted by H₂O. In any case, zeolite thermodynamic stability is limited to T < 400-500 K by the large positive entropy of dehydration. As far as the effect of water on the thermal behavior and stability of zeolites it is known that zeolite structures subjected to dehydration by heating give rise to several intriguing phenomena from crystallographic, chemical, and physical viewpoints. Understanding the zeolite thermal stability from both the kinetic and thermodynamic standpoints is of particular importance in order to model, optimize, and design zeolite-type materials with promising performances in many fields (industry, environment, energy). As a first attempt to quantify and predict the zeolite behavior upon heating, it was recently introduced a stability index (S.I.) ranging from 1 to 5 as a function of increasing thermal stability [1]. This index displays systematic correlations with chemical composition of both the zeolite framework and extraframework (EF) cations.

The present study aims to improve the quantitative relationships established between the zeolite thermal stability index and the zeolite chemical and structural features, and to explore the possible correlations existing with the thermodynamic data taken from the literature.

The critical review of experimental data, in particular those from in situ X-ray diffraction studies, for thermally induced transformations in zeolites has been extended starting from previous work [1]. As discussed in the latter paper, several intrinsic chemical and structural factors have been suggested to control the thermal behavior of zeolites, affecting the dehydration and collapse/breakdown temperatures: i) the framework Si/Al ratio; ii) the (weighted) ionic potential (Z/r) and size of EF cations; iii) the coordination of bare cations after H₂O expulsion; iv) the framework topology. In addition, the temperature at which dehydration and structural collapse/breakdown occur can be affected by several extrinsic factors. In fact, the structural modifications occurring in the same zeolite framework can be different when heated in 'near-' or 'far-equilibrium' conditions. The present study enforces the previously found generalizations [1]:

zeolites with $Si/(Si+Al) \leq 0.6$ ($Si/Al \leq 1.3$) or/and $Z/r \geq 0.187$ always

have S.I. < 3 (poor thermal stability), while zeolites with $Si/(Si+Al) \geq 0.8$

($Si/Al \leq 4$) or/and $Z/r \leq 0.072$ are very stable (S.I. ≥ 3). The largest

group of zeolites do not show definite trends as simple functions of Si/Al and Z/r. However, the definition of a 'combined factor' which accounts for both the latter two variables plus a parameter newly introduced to quantify the ring/channel size and geometry in different zeolite topologies, greatly improves its relationship with the S.I. and allows to recognize a correlation, never reported before, with zeolite thermodynamic data.

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J3-3 Orale Prencipe, Mauro

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WATER IN BERYL: A CONTRIBUTION FROM THEORETICAL CALCULATIONS AT THE AB INITIO LEVEL, AUGMENTED BY AN EMPIRICAL DISPERSION TERM

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Key terms: beryl; water; dispersion forces; quantum mechanical calculations

Dispersion forces can be modeled by none of the *ab initio* Hamiltonians currently available, either at the purely DFT level (no matter if LDA or GGA), or at the hybrid HF/DFT one. The reason is related to the fact that DFT functionals are specifically designed to deal with *short* range electron correlation effects (dynamic correlation), whereas *long* range effects (static correlation), which encompass dispersion energy, are not taken into account [1]. It is possible to augment the *ab initio* Hamiltonian by a London type empirical term, which is parametrised in such a way to properly deal with dispersion energies [2]. The approach has been applied to the case of beryl, to model the behaviour of water inside its structural channels. Calculations confirmed previous findings which located the water molecule at the 2a Wyckoff position (Space Group *P6/mcc*), with a type I orientation having the H-H axis parallel to [001] (see for instance [3]). The calculated hydration energy (-20 Kcal/mol) is in reasonable agreement with experimental measurements (-13 Kcal/mol, [4]). The activation energy for the diffusion of the molecule through the structural channels has also been calculated, and it amounts to 38 Kcal/mol: a result which is not far from the experimental datum of 32 Kcal/mol [5]. The approach can thus reliably be used to model the position of the water molecule in minerals, and the involved hydration energy, even in cases of weak bindings of dispersive type.

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J3-4 Orale Cesare, Bernardo

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DEHYDRATION AND REHYDRATION OF BIOTITE DURING ANATEXIS: CONSTRAINTS FROM MICROSTRUCTURALLY-AIDED SIMS ANALYSIS OF HYDROGEN

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Key terms: anatexis; biotite; dehydroxylation; SIMS

The SIMS-based study of Ti-H relationships in biotite during the prograde and retrograde phases of HT metamorphism and anatexis (Cesare et al., 2008) has been expanded with the addition of three new case studies that help providing a coherent scenario for metapelitic rocks. Two of the three sample suites are enclaves or xenocrysts in lavas, which have been demonstrated to be the ideal setting for the preservation of the primary composition of biotite from high-grade anatectic metapelites (Cesare et al., 2003).

In a Spl-Crd enclave from El Hoyazo, Spain (Alvarez-Valero et al., 2005) biotite shows TiO₂ contents ranging from 2.5 to 7.5 wt.%. The Ti contents are microstructurally controlled: small biotite inclusions in the core of garnets have the lowest contents, whereas the coarser grained crystals toward the garnet rims have the highest. Biotite in the matrix outside garnet shows intermediate Ti contents. Like in the samples of Grt-Bt-Sil enclaves from the same lavas, the measured H contents are negatively correlated with Ti along a trend that provides further support to the Ti-oxy exchange. Furthermore, the decrease of H₂O contents from 4 to 2.5 wt.% show the progressive dehydroxylation of biotite associated to the growth of garnet which records the development of partial melting of the rock with increasing temperature.

Biotite inclusions have been studied also in garnet and cordierite xenocrysts and in enclaves of the Crd-bearing lavas from Lipari (Aeolian arc, Italy; Di Martino et al., 2011). Here the range of Ti contents (3 to 11 wt% TiO₂) includes the highest reported values in the literature, whereas analysed H contents include the lowest (from 1.9 down to 0.2 wt.% H₂O). These data extend the occurrence of a Ti-oxy exchange to Ti contents not previously investigated. In addition, they suggest that the (OH+F+Cl) content of extremely Ti-rich biotites may decrease to almost zero.

The third case study is represented by the metapsammite granulites (*leptynites*) of the Kerala Khondalite Belt (India), in which Cesare et al. (2008) suggested the occurrence of retrograde hydroxylation and fluorination during the slow cooling of these regional anatectic rocks. SIMS

profiles at high spatial resolution (1.8 μm spot size, 2-4 μm scan step) combined with EMP traverses demonstrate that H, Ti, Fe, Mg, and F

diffusion profiles are preserved in the outermost 50 μm of biotite in contact with garnet. These patterns indicate an increase of H, F and XMg, and the simultaneous decrease of Ti, in accordance with an inverse Ti-XMg relationship and the Fe-F avoidance.

The new data integrate and confirm previous findings or inferences, showing that:

- Ti-oxy is the dominant exchange mechanism over the entire TiO₂ range so far investigated in biotite from metapelitic rocks;
- during prograde heating and continuous melting biotite is progressively dehydroxylated mainly through Ti uptake, until it may eventually become OH-free;
- in most granulites and migmatites the halogen and hydrogen contents of micas are probably increased by retrograde diffusion, and biotite may

preserve evidence of such reequilibration in thin (a few tens of μm) rims at the contact with garnet.

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J3-5 Poster Della Ventura, Giancarlo

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THE TEMPERATURE BEHAVIOUR OF WATER IN LEUCITE

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Key terms: leucite; nominally anhydrous minerals; FTIR; thermal behaviour

Naturally leucite crystallizes in the cubic phase, with space group *Ia3d* (Pearce, 1968). On cooling below $T = 625^{\circ}\text{C}$ it undergoes a phase transition to a tetragonal *I4/a* form (Mazzi et al. 1976); there are indications, however, that an additional tetragonal phase is stable over a narrow temperature interval (Lange et al. 1986). Palmer et al. (1997) have shown that the displacive phase transition to tetragonal symmetry is due to twisting of tetragonal prisms of corner-linked (Al,Si)O₄ tetrahedra about [001] and a collapse of the [111] structural channels with concomitant volume reduction. Although nominally anhydrous (NAM), leucite typically contains significant amounts of water; this feature was reported for samples from Roccamonfina (Balassone et al., 2006) and the Alban Hills volcano (Della Ventura et al., 2008). Della Ventura et al. (2008) have shown in addition that H₂O may be significantly zoned, thus providing a potential tool to monitor the evolution of the magmatic conditions with time. More recently, Martucci et al. (2011) studied the dehydration of synthetic B-substituted leucite (KB₅SiO₈) by synchrotron powder diffraction and concluded that the structural modifications accompanying the tetragonal - cubic transition is associated with the migration of H₂O molecules through the [111] channels.

We relate here a single-crystal high-T in situ FTIR study of a set of natural inclusion-free leucite phenocrysts occurring within lava flows, pyroclastic rocks or ejecta in the Roman Comagmatic Province. The spectra show broad absorptions in the 4000-3000 cm⁻¹ region consisting of overlapping components around 3604, 3500 and 3250 cm⁻¹. Interestingly, two different types of spectra are observed in the H₂O stretching region, indicating that water molecules may be trapped in leucite in two different environments (hereafter "type I" and "type II"). These different H₂O types are systematically associated with samples from different volcanic areas, thus suggesting a possible role of the petrological conditions (pressure, temperature) of crystallization on the H₂O entrapment in leucite.

FTIR-FPA images show significant H₂O zoning across the samples; crystals with homogeneously-distributed water were selected for the dehydration experiments, done using a Linkam T600 heating stage fitted under a NicPlan FTIR microscope at University Roma Tre. The evolution of the water loss as a function of T was monitored by measuring the principal H₂O water absorption. The data indicate a continuous water loss with a break in the trend; in "type I" leucite the slope change occurs at ~ 500°C, and dehydration is complete at T > 600°C, probably close to the transition temperature. In "type II" leucite, the slope change occurs at ~ 350-400°C, and dehydration is complete at ~ 500°C. This behaviour is compared with isostructural materials like analcime or pollucite.

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J3-6 Poster Radica, Francesco

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THE QUANTITATIVE ANALYSIS OF H₂O AND CO₂ IN CORDIERITE USING SINGLE CRYSTAL POLARIZED-LIGHT FTIR MICROSCOPY

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Key terms: Cordierite; Volatiles; FTIR; Microspectroscopy

Cordierite is a unique case of a microporous mineral stable under geological conditions spanning from the amphibolite facies to UHT metamorphism to crustal anatexis (Harley et al., 2002; Bertoldi et al., 2004). Because of its structural channels, it is able to trap H₂O and CO₂ (Armbruster and Bloss, 1980), and for this reason the analysis of the volatile constituents of cordierite may help constraining the geological conditions and the composition of coexisting fluids during its formation (Vry et al., 1990; Harley et al., 2002). It follows that the quantitative evaluation of the channel constituents is crucial in petrologic studies. We address here this point by studying, using a multidisciplinary approach, a set of cordierite samples from different occurrence and with different H₂O/CO₂ content. The aim of the study was a calibration of reliable absorption coefficients to be used for the quantitative microanalysis of H₂O and CO₂ in cordierite based on single-crystal polarized-light FTIR spectroscopy. The specimens were fully characterized by a combination of techniques including optical microscopy, single-crystal X-ray diffraction, EMP (electron micro probe), SIMS (secondary ion mass spectrometry), and FTIR

spectroscopy. All cordierites are orthorhombic *Cmm*; the 2V_∞ optic axis angle is linearly related to the CO₂ content. According to the EMP data, the Si:Al ratio is always close to 5:4; X_{Mg} ranges from 76.31 to 96.63 and additional octahedral constituents occur in very weak amounts. Extraframework K and Ca are negligible, while Na may reach values as high as 0.84 apfu. SIM spectrometry shows H₂O up to 1.52 and CO₂ up to 1.11 wt.%. Optically transparent single-crystals were oriented using a spindle-stage and examined under polarized light. On the basis of the literature data and the polarizing behaviour, the observed bands were assigned to water molecules in two different orientations and to CO₂ molecules in the structural channels. The spectra also show the presence

of ^{13}C and ^{18}O , and weak amounts of CO in the samples. FTIR imaging

done using the novel FPA detector system clearly shows that at a μm -scale the distribution of H and C in this mineral may be significantly inhomogeneous, and this must be taken into account when collecting analytical data for petrological purposes. This feature is probably less important for carbon molecules than it is for H_2O , whose distribution within the crystal can be strongly affected by the geological history of the mineral after its formation.

J3-7 Poster Schingaro, Emanuela

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TI-GARNETS: INVESTIGATION BY EPMA, SIMS, SCXRD AND MÖSSBAUER SPECTROSCOPY AND QUANTIFICATION OF THE HYDROGARNET COMPONENT

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Key terms: Ti-rich garnets; crystal chemistry; SIMS; substitution mechanisms; hydrogarnet component

Ti-garnets commonly occur as accessory phases in silicocarbonatite and carbonatitic rocks. They are believed to be tracers of magma evolution [1, 2] and the speciation of Fe and Ti is of relevant petrological interest [3, 4]. In Ti-garnets, hydrogen may be incorporated via the hydrogarnet substitution, where a SiO_4 unit may locally be replaced by a H_2O_4 tetrahedron. However, more complex mechanisms have also been proposed [5]. In the present work, a crystal chemical study was undertaken on a suite of Ti-bearing garnets of different origin (igneous and metamorphic). The garnet samples underwent multiple technique investigation, which consisted in the combination of chemical (EPMA, SIMS), structural (SCXRD) and spectroscopic (Mössbauer) techniques. In particular, SIMS has been used to analyse hydrogen (quantified conventionally as H_2O , wt%), fluorine and lithium. Salient chemical analytical data (wt%) are: CaO (31.34 - 33.23), FeO_{tot} (18.01 - 20.53), Al₂O₃ (0.86 - 2.46), TiO₂ (5.57 - 17.10), ZrO₂ (0.01 - 2.87), SiO₂ (25.70 - 32.89). SIMS investigation yielded: H₂O 0.091(7) - 0.46(4) wt%; Li 11.3(1.6) ppm; F 42(8) - 483(28) ppm. Mössbauer analysis provided spectra with different complexity, which could be fitted with a number of components variable from one ($^{57}\text{Fe}^{3+}$ (Y)) to five ($^{57}\text{Fe}^{2+}$ (X), $^{57}\text{Fe}^{2+}$ (Y), $^{57}\text{Fe}^{2+}$ (Z), $^{57}\text{Fe}^{3+}$ (Y), $^{57}\text{Fe}^{3+}$ (Z)). However, the $^{57}\text{Fe}^{2+}$ (Z) component has been

reinterpreted by some authors ([6]) as due to $^{57}\text{Fe}^{2+}$ (Y) \rightleftharpoons $^{57}\text{Fe}^{3+}$ (Z) electron hopping. From X-ray data, such garnets were expected to have tetrahedral substitutions and a hydrogarnet component. FTIR preliminary spectra in the OH⁻ stretching region evidenced that the samples were characterized by various degrees of hydration.

The comparison with data obtained by X-ray site scattering refinement and Mössbauer spectroscopy allowed to ascertain that the combination of $^{57}\text{Ti}^{4+}/^{57}\text{M}^{3+}$ ($^{57}\text{Fe}^{3+}/^{57}\text{Si}^{4+}$ (schorlomite substitution) and $^{57}\text{M}^{2+}/^{57}\text{Ti}^{4+}/^{57}\text{Fe}^{3+}$ (morimotoite substitution), with $\text{M}^{3+} = \text{Fe}^{3+}$, Al^{3+} , and $\text{M}^{2+} = \text{Fe}^{2+}$, Mg^{2+} , Mn^{2+} , can explain most of the chemical variation of tetrahedral and octahedral sites.

In our samples the hydrogen is incorporated uniquely via the hydrogarnet substitution. In all cases excellent agreement was found between charge balance and SIMS determined OH⁻ groups per formula units (g.p.f.u.). Specifically, in igneous garnets samples the OH⁻ content ranges from 0.08 to 0.20 g.p.f.u. Out of the two metamorphic garnets considered, one has low OH⁻ content (0.05 g.p.f.u.), while the other has the highest OH⁻ content of the suite (0.26 g.p.f.u.). Fluorine was considered as OH⁻ substituent following the recent literature [7].

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SESSIONE J4

Minerali e materiali cristallini di sintesi: caratterizzazione, trasformazioni, proprietà e potenzialità di utilizzo

J4-1 Invitato Cruciani, Giuseppe

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PROBING THE DYNAMICS OF MATTER BY TIME-RESOLVED DIFFRACTION WITH SYNCHROTRON RADIATION: STATE-OF-THE-ART AND TRENDS

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Key terms: X-ray diffraction; synchrotron radiation; non-ambient conditions; time-resolved studies; transient states

The intense, tunable and highly collimated synchrotron X-ray sources have opened the possibility to investigate the dynamics of condensed matter under perturbed states (e.g. chemical gradients, magnetic or electrical fields, etc.) or at non-ambient conditions (increasing temperature or pressure). In particular, time-resolved X-ray scattering experiments performed at in situ conditions are increasingly attracting the interest of crystallographers, chemists, physicists, Earth and material scientists. The paramount importance of recording transient and non-quenchable states

of perturbed matter in order to obtain a deep understanding of its properties is documented by a selection of recent studies performed by 'in situ' time-resolved diffraction in order to follow processes in a continuous way at different time-scales (from hours, to minutes, to seconds, to picoseconds). Among those, the study of the structural modifications upon heating of zeolites and zeolite-like microporous materials in far-from-equilibrium conditions has allowed to shed light on water confinement and diffusion processes, and to discover phenomena like the 'trap door' and 'molecular gate' effects which are exploited in ton-scale industrial applications. Similarly the 'breathing effect', recognized by time-resolved diffraction experiments in the new class of metal-organic frameworks, makes these materials very promising for hydrogen and carbon dioxide storage/capture. The structural tracking of molecular reactions or electronically excited states in solution, with time-scale of pico-seconds, has been achieved in a number of systems by the pump-probe time-resolved X-ray scattering experiments performed at synchrotron light sources. All the above studies show that there is still plenty of justification to design and build synchrotron radiation beamlines dedicated to multimodal time-resolved experiments. These stations will fruitfully complement the forthcoming free-electron laser based instruments.

J4-2 Invitato Bersani, Danilo

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RAMAN INVESTIGATION ON MGAL2O4 - MGCR2O4 AND MGAL2O4 - COAL2O4 SPINEL SERIES

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Key terms: Co-spinel; raman spectroscopy; Cr-spinel

Raman spectroscopy, like other spectroscopies, provides a mean to investigate the local environment in different crystallographic sites. This is useful when the local structure in solid solution has to be investigated. In the case of spinels, it was observed by changes in UV-VIS-NIR absorption spectroscopy of Cr (Halenius et al. 2010) that only partial relaxation occurs at the Cr site in solid solutions along the join MgAl_2O_4 - MgCr_2O_4 . It is expected that such feature should be apparent also from Raman spectra, and likely found in several spinel solid solutions involving transition elements. We have therefore undertaken Raman analysis of twelve synthetic spinels of the series MgAl_2O_4 - MgCr_2O_4 and ten of the series MgAl_2O_4 - CoAl_2O_4 . The spinels were previously analyzed by electron microprobe. Raman spectra were collected with a Jobin Yvon LabRam micro-spectrometer using two different laser wavelengths. A 632.8 nm He-Ne laser was used for the samples with high Cr content, while in the samples containing Co and in those with the lower Cr content the spectra were recorded with a 473.1 nm wavelength from a solid state laser, to avoid the fluorescence. The spectral resolution was about 2 cm^{-1} at 473.1 nm and 1.5 cm^{-1} at 632.8 nm. The laser power on the sample was selected by inserting a neutral density filter to avoid heating effects (2-5 mW).

Along the MgAl_2O_4 - MgCr_2O_4 series a marked change in intensity and position of the Raman peaks is observed. A peak at 410 cm^{-1} is evident in the Al richest portion of the series and disappears at about the 50% of the series (corresponding to Cr 1.00 atoms per formula unit, apfu): according to the existing literature, it is ascribed to Al ion bending (Cynn et al., 1992). A peak at 685 cm^{-1} dominates the Cr richest portion of the series and increases its wavenumber with a step by 15 cm^{-1} up to 730 cm^{-1} for Cr decreasing and sample composition approaching Cr 0.70 apfu (that is, corresponding to Al:Cr ratio of 2:1). Furthermore, another signal at about 650 cm^{-1} appears in intermediate compositions only. The observed sudden change in the peak at 650-730 cm^{-1} is likely related to a change in the O site local environment, represented by one tetrahedron and three octahedra. Given that the tetrahedron is (almost completely) centered by Mg, the observed Raman spectra modifications must be ascribed to the progressive substitution of Al by Cr in the octahedra. Along the MgAl_2O_4 - CoAl_2O_4 two distinct profiles of Raman spectra may be observed. Up to intermediate compositions the spectra show the peaks at 410 cm^{-1} , 670 cm^{-1} and 770 cm^{-1} , typical of the spinel s.s. (Cynn et al., 1992), whereas in the Co-richest region all spectra have a Raman band at ca 530 cm^{-1} which is attributed to the Co-O stretching vibration (Kock and De Waal, 2007). This trend is due to both compositional change

($\text{Co}^{2+} \rightarrow \text{Mg}$ substitution) and cation distribution. Indeed Co^{2+} strongly prefers the tetrahedral coordination with respect to Mg and only starts to disorder into the octahedrally-coordinated sites after 50% of the series. Cynn H., Sharma S.H., Cooney T.F. and Nicol M. (1992) *Physical Review B* 45, 500-502. Halenius U., Andreozzi G.B. and Skogby H. (2010) *American Mineralogist* 95, 456-462. Kock L.D. and De Waal D. (2007) *Journal of Raman Spectroscopy* 38, 1480-1487.

J4-3 Orale D'Ippolito, Veronica

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CATION DISTRIBUTION AND OPTICAL PROPERTIES OF MGAL₂O₄-COAL₂O₄ FLUX-GROWN SINGLE CRYSTALS

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Key terms: cobalt-spinel; cation distribution; optical absorption; blue colour

Co-spinels are important compounds for many different uses as ceramic pigments, catalysts, and gemstones. Studies of cation distribution in these spinels are of considerable interest for a better understanding of relationships between structure and physical properties (such as colour). Spinel single crystals having different compositions along the MgAl_2O_4 - CoAl_2O_4 series were synthesized by flux growth method with $\text{Na}_2\text{B}_2\text{O}_7$ as solvent. Low cooling rates (2°C/h) and linear temperature profiles were applied in the temperature interval 1200-800°C, and a continuous flow of CO_2 -H₂ in the ratio of 100/4 cm^3/min was adopted to obtain a reducing atmosphere (with the oxygen fugacity ranging from 10^{-8} to 10^{-15} bars at 1200 and 800 °C, respectively). Selected crystals were analysed by single-crystal X-ray diffraction (CCD detector), electron microprobe and

optical absorption spectroscopy. The crystals obtained were found to be chemically homogeneous, with the Co^{2+} content ranging from 0.06 to 1.00 atoms per formula unit, and varied in colour from light blue to intensely dark blue with increasing Co^{2+} content. The progressive substitution of Co^{2+} for Mg causes a large increase of tetrahedral bond length (from 1.919 to 1.944 Å), which is responsible for the observed increase of both unit cell parameter (from 8.079 to 8.100 Å) and oxygen positional parameter (from 0.2622 to 0.2635). Optimized structural formula show that the cation inversion between tetrahedrally- and octahedrally-coordinated sites is directly correlated with equilibration temperature. At the constant temperature of 800 °C, the inversion degree decreases from 0.23 to 0.14 with increasing Co^{2+} content. With respect to Mg, Co^{2+} shows a higher preference for tetrahedral coordination, and its site preference for octahedral coordination (e.g., ${}^{\text{V}}\text{Co}^{2+}/\text{Co}^{\text{VI}}$) increases from zero to 0.14 with increasing Co^{2+} content. The optical absorption spectra, measured between 4000 and 35000 cm^{-1} , show a set of three bands at ~ 4300 , 7200 and 17,000 cm^{-1} marking spin-allowed electronic d-d transitions of Co^{2+} in tetrahedral coordination. The absorption bands of Co^{3+} are absent, in agreement with the highly reducing conditions imposed during crystal growth. The observed transitions are due to Co^{2+} in tetrahedral coordination, and are the only responsible for the characteristic blue colour of cobalt spinels.

J4-4 Orale Fregola, Rosa Anna

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SINGLE CRYSTAL SYNTHESIS AND SPECTROSCOPY OF $\text{Mg}_{(1-x)}\text{Cu}_x\text{Al}_2\text{O}_4$ SOLID SOLUTION SPINELS

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Key terms: synthesis; spinel; cuprospinel; solid-solution; spectroscopy

This work aims at exploring the character and mechanisms of structural relaxation in minerals, through a detailed spectroscopic study of the real structure and compositional dependence of T-O and M-O bond distances of Cu centered TO_4 and MO_6 polyhedra in synthetic spinel-cuprospinel single crystals.

Large (up to mm-sized) spinel single crystals with variable composition in the binary $\text{Mg}_{(1-x)}\text{Cu}_x\text{Al}_2\text{O}_4$ were synthesized by the flux-growth method. This method employs a mixture of nutrient oxides (MgO , Al_2O_3 and CuO , in this case) and $\text{Na}_2\text{B}_2\text{O}_7$ as flux compound as starting material, which was put in a Pt crucible. The synthesis experiments were conducted in air in a muffle furnace. The temperature was first raised to 1200°C and then left constant for 24 hours, to allow complete dissolution of the nutrient oxides and homogenization of the melt. The temperature was then decreased by 4°C/hr down to 800°C, and subsequently cooled more quickly to ambient conditions. The proportions of the nutrient oxides and the flux compound were changed in order to obtain spinel single crystals of different compositions, aiming to cover the entire range between the two end members spinel *stricto* MgAl_2O_4 and cuprospinel CuAl_2O_4 . Up to now, we have successfully synthesized single crystals in the $\text{Mg}_{(1-x)}\text{Cu}_x\text{Al}_2\text{O}_4$ series with nominal compositions in the range $x = 0 - 0.7$. Single crystal optical absorption spectroscopy in the UV/VIS-NIR spectral range confirms that Cu actually entered the crystal structure. Furthermore, the optical absorption spectra demonstrate that Cu^{2+} is present in both T and M sites of the spinel structure, with a strong preference for the T sites. Absorption bands, resulting from spin-allowed electronic d-d transitions in Cu^{2+} at T and M sites, were observed at $\lambda = 6900 \text{ cm}^{-1}$ and $\lambda = 13900 \text{ cm}^{-1}$, respectively. The intensity of these bands increase with the Cu content of the spinel. The crystal field splitting energy for Cu^{2+} at the tetrahedrally coordinated T site is predicted by ligand field theory to correspond to 4/9 ($\lambda = 0.44$) of the splitting energy for octahedrally coordinated Cu^{2+} at the M site. Considering that Cu^{2+} -O distances are somewhat shorter than M-O distances in Cu-substituted spinel, the experimentally derived value of 0.49 is in excellent agreement with theory. In addition, the fact that no significant composition dependent energy shifts of the absorption bands caused by Cu^{2+} at T and M sites are observed in the present spectra indicates that MO_6 and TO_4 polyhedra are structurally strongly relaxed in this solid solution series. Both the synthesis experiments and the spectroscopic measurements were performed at the Department of Mineralogy of the Swedish Museum of Natural History (Stockholm). This project (SE-TAF_893) received support from SYNTHESIS which is financed by the European Community - Research Infrastructure Action under the FP7 "Capacities" Specific Programme.

J4-5 Orale Dondi, Michele

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NI-FREE, BLACK CERAMIC PIGMENTS BASED ON CO-CR-FE-MN SPINELS: A REAPPRAISAL OF CRYSTAL STRUCTURE, OPTICAL PROPERTIES AND TECHNOLOGICAL BEHAVIOUR

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Key terms: ceramic; pigment; spinel; crystal structure; optical properties

The pigments used to impart black shades to ceramic wares are mostly synthetic spinels. The best colouring performance in the industrial practice is ensured by complex mixed oxides (Cr, Fe, Mn, Co, Ni, and sometimes further transition elements). This turns the black pigments as the most expensive ceramic colorants after those based on noble metals or cadmium selenide. The design criteria followed in the industry basically consist in admixing different transition metal oxides in order to get into the spinel structure as much ionic species as possible (e.g. Cr^{3+} , Fe^{2+} , Fe^{3+} , Mn^{2+} , Mn^{3+} , Co^{2+} , Co^{3+} , Ni^{2+}) each able to absorb in the visible spectrum, so contributing to achieve the best black colour. From the colourimetric viewpoint, the target is a minimal brightness without significant chroma contributions. Besides spinels have been deeply investigated and the relationship between crystal structure and properties is well known for binary (and to some extent ternary) compositions, the complex systems used in ceramic pigments are not modelled and the

application of conventional XRD and spectroscopic approaches is complicated by the occurrence of several transition metals. Both health regulations (preventing the use of carcinogenic compounds like Ni-bearing oxides) and technological innovation (digital decoration and particularly ink-jet printing) are changing the market demand towards high performance and safe pigments. This is not an easy task, because some pigment properties are ensured by the undesired elements (e.g. Ni was used to improve the chemical resistance in Zn-rich glazes). From this standpoint, a reappraisal of crystal structure, optical properties and technological behaviour of black spinels is needed to define the best compositions in the Co-Cr-Fe-Mn system and disclose the pigment-glaze interactions affecting the final crystallochemical features after the ceramic process. For this purpose, 21 ternary and quaternary spinel formulations were designed, using the crystallochemical criterion of Cr³⁺ occupancy of the octahedral site (with Co, Fe and Mn sharing the tetrahedral site): progressive decreasing of chromium (from 2 to 1.5, 1, 0.5, and 0). Spinel pigments were prepared from these batches, simulating the industrial processing (firing at 1300°C) and characterizing the powder samples through XRD (Rietveld refinement); optical and Raman spectroscopy; technological testing (in different glazes). Spinel pigments are monophasic (but when the sum Cr+Fe exceeds the occupancy of the octahedral site, resulting in spinel+hematite assemblages). The colour ex synthesis is uniformly black (but when Cr occupancy=2). The colouring performance depends on the chemical composition and firing temperature of the glaze: black shades are kept when Cr occupancy is between 1 and 1.5 apfu, while for values <1 the spinel reacts with the glass causing bubble formation and eventually bloating phenomena. Suitable black spinels exhibit unit cell parameter in the 8.35-8.40 Å range and anionic parameter in the 0.258-0.262 range. The best colouring performance in glazes rich in alkaline-earth elements correspond to quaternary batches; in particular, the best behaviour in zinc-rich glazes is ensured by high cobalt amounts (nominally half occupancy of the tetrahedral site). More suitable for high temperature glazes (rich in alkalis) are spinels richer in Fe and/or Mn. Therefore, the mechanisms controlling the colouring performance seem to be the partial occupancy of the octahedral site by Cr³⁺ and the amount of cations with a strong affinity to the tetrahedral site to contrast the formation of solid solution with Mg and Zn that would turn the colour to brown shades. Preliminary Raman observation has shown that samples with best colour are heterogeneous, with strong local spectral differences, and highly disordered, with large Raman peaks, prompting for further EDS and XRD characterization (run within the PRIN project SPIN GEO-TECH).

J4-6 Orale Zanelli, Chiara

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NI-TI CO-DOPED HIBONITE (CAAL12O19) CERAMIC PIGMENTS: SYNTHESIS, CRYSTAL STRUCTURE AND OPTICAL PROPERTIES.

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Key terms: ceramic; pigment; hibonite; crystal structure; optical properties

Hibonite, with general formula $[\text{12}]\text{A}[\text{6}]\text{M}[\text{1}][\text{5}]\text{M}[\text{2}][\text{4}]\text{M}[\text{3}][\text{6}]\text{M}[\text{4}][\text{2}][\text{6}]\text{M}[\text{5}]\text{O}[\text{19}]$, is the natural counterpart of the synthetic calcium hexa-aluminate (CaAl_2O_7) which crystallizes with the magnetoplumbite-type structure (space group P63/mmc, Z=2). Calcium occurs in a 12-fold coordination site (A), whereas Al³⁺ ions are distributed over five different sites, including three distinct octahedra (M1, M4, and M5), a tetrahedra (M3), and an unusual trigonal bipyramid (M2) that gives rise to a fivefold oxygen-coordinated site. Minerals of the magnetoplumbite-group habitually contain significant amounts of metals with different valences (e.g. divalent as well as tetravalent and pentavalent cations). Of great importance is the tendency of these metal ions to be hosted at definite sites. As a matter of fact, M2+ ions are usually hosted at M3 site, while M4+ and M5+ ions are preferentially accommodated at the M4 site. The ions of different charges tend to improve the local charge balance in the crystal structure. Therefore, the introduction of divalent ions is thought to be achieved by co-incorporation of tetravalent or pentavalent cations which are mainly ordered over the octahedral sites in the face-sharing interlayer doublet. This ability to accommodate such a wide variety of ions, with different valence and coordination, makes the hibonite structure very interesting to be used as a ceramic pigment. In this work, the electroneutrality of the hibonite lattice

was ensured by the following coupled substitution: $2\text{Al}^{3+} \rightarrow (\text{Ni}^{2+} + \text{Ti}^{4+})$. Hibonite ($\text{CaAl}_{12-2x}\text{Ni}_x\text{Ti}_x\text{O}_{19}$ where $x=0.1-2.0$) is a refractory phase hard to synthesize by the conventional solid state reaction. Therefore, kinetic hindrances were overcome through a combustion synthesis performed at 400 and 1200 °C. In order to maximize the exothermic effect, fuel mixtures (urea, glycine, beta-alanine) were selected, based on their compatibility with metal nitrates used as raw materials. These synthesis strategies allowed the formation of hibonite structure directly during the combustion reaction, without any further annealing. The behavior during combustion was monitored by thermal analysis, which revealed that highly exothermic redox processes are responsible for the formation of the designed oxide compound. The hibonite characterization was performed by X-ray powder diffraction, microstructure analysis (SEM), and diffuse reflectance spectroscopy (DRS). At the lower combustion temperature, the hibonite structure is the main phase, but secondary phases were also detected, such as spinel (NiAl_2O_4), perovskite (CaTiO_3), and gamma alumina ($\gamma\text{-Al}_2\text{O}_3$). With the increasing of the combustion temperature to 1200°C, the XRD profile exhibits sharper peaks and a better peak to background ratio. The hibonite structure shows an expansion of lattice parameters that is proportional to the degree of nickel and titanium substitution for the smaller aluminium ion. In terms of optical parameters, Ni²⁺ is incorporated at two different coordination sites, M3 and M4, preferentially in tetrahedral coordination up to saturation of the M3 site. The crystal field strength of nickel in tetrahedral coordination is regularly decreasing implying an elongation of the local Ni-O distance, coherent with the volume increasing from AlO₄ to NiO₄ tetrahedra. Ti⁴⁺ ions are accommodated at the octahedral site M4, in competition with Ni²⁺, and secondarily at the 5-fold coordinated site M2. The combined XRD+DRS approach allows to understand the mechanisms of dopant incorporation into the $\text{CaAl}_{12}\text{O}_{19}$ structure and the origin of its colour on the right track for engineering of hibonite ceramic pigments.

J4-7 Orale Ardit, Matteo

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STRUCTURAL PROPERTIES OF $Al_{1-x}Cr_xNbO_4$ JOIN: A XRPD AND EAS COMBINED APPROACH

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Key terms: $AlNbO_4$ -type structures; Crystal structure; Optical properties; Structural relaxation

Nb and Ta are geochemically related elements which typically give rise to isomorphous series of oxides as accessory minerals in granitic pegmatites (e.g. columbites, pyrochlores, fergusonites, etc.). However, in spite of the natural occurrence of orthorhombic aluminantite ($AlTaO_4$), its Nb counterpart is only known as a synthetic product. $AlNbO_4$ crystallizes with monoclinic symmetry (s.g. $C2/m$) and was early described with a strict ordering of Nb and Al, respectively over M1 and M2, the two non-equivalent octahedral sites in the structure [1]. This model was revised by successive refinements showing that a partial disorder occurs in $AlNbO_4$ with a ~20% inversion degree [2,3]. $CrNbO_4$ is a disordered $MM'O_4$ compound, crystallizing with the rutile structure (s.g. $P4_2mm$)

while $FeNbO_4$ crystallizes with wolframite (s.g. $P2_1/c$), orthorhombic Cc - PbO_2 -type, rutile, or $AlNbO_4$ -type structure as the temperature increases. This brief review shows that, even at room conditions, the chemical nature of the metal cations M3+ strongly affects the crystal structure of $MM'O_4$ -type oxides. In order to better understand the substitution mechanisms, the cationic ordering, the structural stability, and the phase transition processes for $(M3+)(Nb5+)_2O_4$ compounds, six samples along the $(Al_{1-x}Cr_x)NbO_4$ join (x: 0.0-0.5) were synthesized by the solid-state reaction process and investigated by means of a X-ray powder diffraction (XRPD) and electron absorption spectroscopy (EAS) combined approach.

Monophasic up to $x(Cr)=0.125$ apfu ($AlNbO_4$ -type structure), the samples along the join become biphasic (the former plus the $CrNbO_4$ -type structure) for $x(Cr)>0.125$ apfu, indicating the impossibility to have a complete solid solution between $(Al,Cr)NbO_4$ oxides. The lattice parameters increasing with the Al-Cr substitution defines a structural expansion limit ($x(Cr)>0.24$ apfu) that is ascribed to the maximum chromium content that the structure can accept. The samples up to $x(Cr)=0.25$ also exhibit the typical optical spectra of Cr^{3+} in 6-fold coordination, involving d-d electronic transitions. Ascertained that the proposed octahedral ordering models were corrected [2,3], through different refinement strategies, the global instability index, GII [4], was calculated over the un-doped structure by varying the Al/Nb ratio in the two metal sites. Unpredictably, even the minimal values of GII obtained are very close to the limit of 0.20 v.u. that implies strained structures. With a crystal field strength that decreases moving from $x(Cr)=0.06$ to 0.50 apfu, and both the Racah parameters and the nephelauxetic trends nearly constants, no significant change in the degree of covalency and polarization of the Cr-O bond are found. The 10Dq decreasing suggests an elongation of the local Cr-O distance for Cr^{3+} increasing at site M2 and to a minor extent at site M1, fitting well the structural data on the long-range mean bond distances. The degree of structural relaxation around Cr^{3+}

was also assessed by means of the relaxation coefficient ϵ , until the structure will maintain the same symmetry. The $AlNbO_4$ lattice has a limited propensity to relax ($\epsilon=0$) and the $AlNbO_4$ structure follows the Vegard's law. In contrast with the well known Al-Cr joins in garnets, spinels, perovskites and corundum, the $AlNbO_4$ structure is strongly constrained by other factors, like cation ordering and electrostatic charge balance. Indeed, the M2 site hosting Al^{3+} is underbonded and Cr^{3+} can be accommodated at this site without significant strain for that the lattice does not need to relax around the bigger ion.

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J4-8 Orale Cametti, Georgia

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A COMPARISON OF THE STRUCTURAL AND MICROSTRUCTURAL FEATURES DETERMINED FROM RIETVELD REFINEMENTS AND PAIR DISTRIBUTION FUNCTION ANALYSES OF IRON OXIDE NANOPARTICLES

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Key terms: Pair Distribution Function; maghemite nanoparticles; Rietveld analysis

Rietveld method is by now the conventional crystallographic method for structural analysis. However, in the past few years total scattering technique has become increasingly important for crystalline materials that show reduced long-range periodicity. Data are evaluated by the Pair Distribution Function technique, that allows analyzing simultaneously Bragg and diffuse scattering, revealing short and intermediate range order of the material. This function is defined in real space, in terms of atomic coordinates. The aim of this work is to compare the results from Rietveld and Pair Distribution Function analyses applied to powder diffraction data on iron oxide nanoparticles. Diffraction data were obtained from the ADXD (Angular Dispersive X-Ray Diffraction) method, using a parallel beam Bruker AXS D8 Advance diffractometer operating in transmission mode in $\theta-\theta$ geometry, and from a non conventional EDXD (Energy Dispersive X-Ray diffraction) diffractometer characterized by a $\theta-\theta$ vertical geometry. ADXD data were analyzed by the Rietveld method while EDXD data were evaluated by the PDF method using PDFFITGui (Farrow *et al.*, 2007) software. Samples are maghemite nanoparticles of different nominal size (10nm, 7nm, 5nm, 3.5nm). They were synthesized by condensation in aqueous medium by controlling temperature, Ph and system composition ($Fe^{2+}/Fe^{3+} + Fe^{3+}$).

Both techniques (Rietveld and Pair Distribution Function analyses) apply least-squares full profile refinements: the first operating in reciprocal space and the second in direct space. Cell parameter, atomic displacement parameters, x coordinate of the oxygen site, and size of nanoparticles

were common parameters refined with both approaches. A big problem to be faced of with ADXD data was the very large absorption. Two different series of refinements were performed using GSAS&EXPGUI (Larson and Von Dreele, 2004; Toby, 2001) and TOPAS v.4.2 (Bruker AXS, 2009) programs. TOPAS implements the Fundamental Parameters Approach FPA (Cheary and Coelho, 1992), a convolution approach in which the peak-shape is synthesized from a priori known features of the diffractometer and the microstructural features of the specimen. This approach is believed to provide more accurate microstructural parameters than a conventional Rietveld refinement. In the case of the Rietveld refinements, individual isotropic displacement parameters were refined with the full ionization model (Ballirano, 2003) for the oxygen atom. The PDF technique allowed the refinement of the individual anisotropic displacement parameters that were found systematically larger than those from the Rietveld analyses possibly because of correlations among parameters. Only FPA provided a meaningful analysis of the microstrain. As expected, strain decreases with the increase of the particles diameter due to the reduction of the specific surface. The cell parameter a obtained from Rietveld refinement (ca. 8.353 Å) was very similar for all analyzed samples: it was slightly smaller than that reported for other nanocrystalline maghemite (Di Marco *et al.*, 2009, 2006), and greater than that of microcrystalline sample (Greaves, 1983; Shmakov *et al.*, 1995). The x coordinates of the oxygen site obtained from the Rietveld refinements (ca. 0.254) didn't show any significant difference from reference data as well as those from PDF analyses. Therefore both conventional and FPA Rietveld and PDF approaches can provide reliable information on the atomic displacement parameters and on the x coordinate of the oxygen site. Moreover, nanoparticles size has been reliably estimated only by PDF and FPA Rietveld analyses.

J4-9 Orale Mantovani, Luciana

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SYNTHESIS AT ROOM AND HIGH PRESSURE OF PYROXENES ALONG THE JOIN $CaCoSi_2O_6-Co_2Si_2O_6$

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Key terms: Co-pyroxene; Synthesis; X-ray diffraction; Raman spectroscopy

The study of pyroxenes along the join $CaCoSi_2O_6-Co_2Si_2O_6$ has an interest in mineralogy and in ceramic sciences. As for ceramics, Co-bearing silicates can act as blue to pink pigments. Blue color stems from Co in tetrahedral coordination, like in $CoAl_2O_4$ spinel (blue cobalt), whereas higher coordination drives to a pink hue. In $CaCoSi_2O_6-Co_2Si_2O_6$ pyroxenes the substitution occurs in two different sites M1 and M2 at different coordination, being M1 a regular octahedron and M2 a distorted polyhedron with 6-8 fold coordination, and the effect of Co for Ca substitution on the pyroxene color can therefore be investigated. As for mineralogy the series is an analogue to the series diopside-enstatite ($CaMgSi_2O_6-Mg_2Si_2O_6$) and hedenbergite-ferrosilite ($CaFeSi_2O_6-Fe_2Si_2O_6$) of quadrilateral pyroxenes. The comparison on the crystal chemistry and phase transitions of the effect of the solid solution of Ca for Co on the M2 site, vs that of Ca for Mg and for Fe, can provide the basis for an extensive model of solid solutions in pyroxenes. Preliminary results on the synthesis and characterization of $CaCoSi_2O_6-Co_2Si_2O_6$ pyroxenes are here reported.

Previous experimental data on $CaCoSi_2O_6-Co_2Si_2O_6$ pyroxenes are confined to the end members, $CaCoSi_2O_6$ which was synthesized at room pressure, and $Co_2Si_2O_6$ which was synthesized above 3 GPa and 7 GPa in the orthorhombic and monoclinic polymorphs respectively. In the present study eleven compositions along the series, at step of 10 mol % of the $CaCoSi_2O_6$ component, were synthesized at room and high pressure. Room pressure syntheses were achieved by calcinations at 1000 °C for 12 hours of stoichiometric mixtures of the oxides. Combined SEM/EDS, Raman and XRD investigation gave evidence of an incomplete reaction for the starting materials, with the presence of residual amorphous silica. Clinopyroxene, with a composition close to $(Ca_{0.9}Co_{0.1})CoSi_2O_6$, was found in all samples except that with stoichiometric composition $Co_2Si_2O_6$, where an assemblage of Co-olivine (Co_2SiO_4) and silica was found. Co-olivine was observed in all samples, less in Ca-richer compositions. Co-ackermanite ($Ca_2CoSi_2O_7$) was observed between $CaCoSi_2O_6$ and $(Ca_{0.6}Co_{0.4})CoSi_2O_6$. The color changes from pink to blue together with increasing ackermanite and decreasing olivine.

To obtain wider pyroxene solid solution, high pressure synthesis on the same starting materials was carried out with piston cylinder apparatus at P = 3 GPa and T = 1200 °C, for 4 to 20 hours. XRD and Raman analyses show that between $CaCoSi_2O_6$ and $Ca_{0.4}Co_{0.6}Si_2O_6$ a clinopyroxene solid solution is the only phase. In the sample with starting composition $Ca_{0.2}Co_{0.8}Si_2O_6$ we obtain the coexistence of clinopyroxene, orthopyroxene and quartz, and in $Co_2Si_2O_6$ only olivine and quartz, without formation of a pyroxene phase.

Cell parameters follow the same trend with composition previously observed in $C2/c$ pyroxenes along the series diopside-enstatite and hedenbergite-ferrosilite. Changes observed in Raman spectra may be interpreted as in pyroxenes along the diopside-enstatite. Single crystal XRD and optical spectroscopy investigations, as well as attempts to synthesize $Co_2Si_2O_6$ clinopyroxene by means of a multi-anvil apparatus, are in progress.

J4-10 Orale Pandolfo, Francesco

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THERMOELASTIC BEHAVIOUR OF $C2/c$ OMPHACITE

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Key terms: omphacite; high-pressure; high-temperature; single crystal; X-ray diffraction

Omphacite shows an intermediate composition along the binary jadeite-diopside join of the Na-pyroxene solid solution. Most of the interest in this mineral has been focused on the order-disorder

phenomena which it undergoes, causing a $P2/n \leftrightarrow C2/c$ phase transition [1]. Although omphacite plays a key role in high-pressure and high-temperature geological environments, *in situ* studies on its thermo-elastic behaviour under non-ambient conditions are definitively scarce. Some experimental results have been reported on the omphacite high-pressure *in situ* behaviour [2,3] and, more recently, the thermal expansion and the thermal equation of state were studied by [4] and by [5] respectively. However all these data were collected using different experimental conditions, by both powder materials and single crystals and often off the omphacitic composition. Therefore they do not provide a systematic on the high-pressure and high-temperature behaviour. In order to constrain the correct value of the compressibility and thermal expansion of omphacite we have studied a natural sample by high-pressure and high-temperature *in situ* single crystal X-ray diffraction (in two separate experiments). Two twin and inclusion-free single crystals of $P2/n$ omphacite from the Münchberg Mass (Bavaria) eclogitic rock were selected for this study. Its composition, $Jd_{0.5}Di_{0.5}Hd_{0.5}En_{0.5}CaTs_1$, is very close to pure $Jd_{0.5}Di_{0.5}$ omphacite. In order to obtain fully disordered $C2/c$ omphacite crystals, isothermal annealing at 1000 °C for 300 hrs was carried out using a vertical temperature control furnace. Intensity data collections were performed to verify the absence of the $h+k = 2n+1$ reflections, and data were refined in the $C2/c$ space group. Unit-cell parameters were determined by SCXRD at 16 different pressures up to about 7 GPa. A continuous decrease of the unit-cell parameters and volume was observed as a function of pressure up to the maximum P reached (volume decreases about 5.2% up to 7 GPa). A third order Burch Purnaghan equation of state was used to fit the experimental pressure-volume data. We obtained the following coefficients: $V_0 = 421.04(7) \text{ \AA}^3$, $K_{T=0} = 118.65(1.84) \text{ GPa}$, $K' = 5.7(6)$. The compressibility

scheme $b > c > a$ is similar to that of other clinopyroxenes. High-temperature experiments were carried out measuring lattice parameters at intervals of 50°C in the 25-800°C T range both on increasing and decreasing temperature. Continuous increasing of the unit-cell parameters and volume was observed as a function of temperature with a volume increase of about 2.3% up to 800°C. The thermal expansion obtained using the approach by [7] yielded $\alpha = 3.03(3) \times 10^{-5} \text{ K}^{-1}$.

We obtained two different behaviours as a function of pressure and temperature: 1) even if further experimental data are necessary for intermediate compositions, our data show that the bulk modulus value for disordered omphacite is in very good agreement with a linear combination of the bulk moduli of the Jd and Di end-members; 2) otherwise the thermal expansion value is slightly higher than that expected for a linear combination of the volumetric thermal expansion of the two end members.

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J4-11 Poster Alvaro, Matteo

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THE EFFECTS OF TEMPERATURE ON THE CRYSTAL STRUCTURE OF A NATURAL EPIDOTE

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Key terms: Epidote; Low Temperature; High Temperature; Neutron single-crystal diffraction; X Ray single-crystal diffraction

The effects of temperature on the crystal structure of a natural epidote from the intrusive/metamorphic complex of Val Sissone, Valmaenco, [Ca_{1.925}Fe_{0.795}Al_{1.265}Ti_{0.000}S₃037O₁₂ (OH), $a=8.8924(7)$, $b=5.6214(3)$, c

$=10.1547(6) \text{ \AA}$ and $\beta = 115.396(8)^\circ$ at room conditions, Sp. Gr. $P2_1/m$) have been investigated with a series of structure refinements at low T (293 - 100 K) by means of single-crystal X-ray diffraction (SC-XRD) and at high T (293 and 1070 K) by means of neutron single-crystal diffraction. The low- and high-T experiments confirm that epidote is stable within the whole T range investigated (i.e. 100 K-1070 K) and that the space group $P2_1/m$ is maintained. At high T, a positive thermal expansion is observed along all the three crystallographic axes (with $\Delta a/a \sim 0.55\%$, $\Delta b/b \sim 0.91\%$, $\Delta c/c \sim 1.00\%$ and $\Delta V/V \sim 2.4\%$ between 293-1070 K). At low T, within the precision and accuracy of our CCD data, the unit-cell constants do not vary significantly, and only a slight decrease of the monoclinic angle is observed.

The refinements performed on the whole T range confirm that Fe³⁺ occupies, along with Al³⁺, the M(3) site [%Fe(M3)100K = 69.6(4)% X-ray data, %Fe(M3)1070K = 74(2)% neutron data]. In other words, the M(1) and M(2) sites are fully occupied by Al. Moreover, the high-T structural refinement shows that no dehydration effect occurs.

Over the whole T range investigated, the structure behaves without any drastic change on most of the geometrical parameters; only little variations on inter-atomic bond distances, thermal vibration of all the atomic sites, and inter-polyhedral tilting occur. The main low-T effect is observed on the vibrational regime of the atomic sites; a significant monotonic reduction of the magnitude of the thermal displacement ellipsoids, with a variation of U_{eq} (defined as one third of the trace of the orthogonalised U_{ij} tensor) by $\sim 40\%$ is observed for both the Ca-sites between 293 and 100 K. However the vibrational regime of the two Ca-sites is slightly different within the T-range investigated: the Ca(1) site shows a lower U_{eq} and a less pronounced anisotropy, (represented by the ratio R1/R3 respectively the longest and the shortest components of the root-mean-square components of the thermal ellipsoids) with respect to Ca(2) at any temperature. This is basically due to the different coordination shell of the two cationic sites, with longer bond distances for Ca(2).

Within the T range investigated, the thermal displacement ellipsoids of the oxygen sites are only slightly pronounced; the most significant anisotropy is observed for the three oxygen of the two corner-sharing T-sites [O(3), O(8) and O(9) oxygen sites, with R1/R3 < 3 at low T and R1/R3 ~ 2 at high T]. This effect might be driven by rotation of the Si(2)-tetrahedron

due to the presence of Fe³⁺ at the M(3) site. The nuclear refinements show that two possible hydrogen bonds, with O(2) and O(4) as acceptors [i.e. O(10)-H(1)¹⁰⁰⁰O(2) and O(10)-H(1)¹⁰⁰⁰O(4)] occur. However, the topological configuration of the bonds suggests that the O(10)-H(1)¹⁰⁰⁰O(4) is energetically more favourable, as H(1)¹⁰⁰⁰O(4) = 1.9731(28) Å, O(10)¹⁰⁰⁰O(4) = 2.9318(22) Å and O(10)-H(1)¹⁰⁰⁰O(4) = 166.7(2)°, whereas H(1)¹⁰⁰⁰O(2) = 2.5921(23) Å, O(10)¹⁰⁰⁰O(2) = 2.8221(17) Å and O(10)-H(1)¹⁰⁰⁰O(2) = 93.3(1)° (at 293 K). The O(10)-H(1) bond distance at 293 K corrected for "riding motion" is 0.9943 Å.

J4-12 Poster Andreozzi, Giovanni B.

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SPINEL AND AMPHIBOLE AS RECORDERS OF OXYGEN FUGACITY IN THE LITHOSPHERIC MANTLE OF NORTHERN VICTORIA LAND (ANTARCTICA)

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Key terms: Northern Victoria Land (Antarctica); mantle xenoliths; metasomatism; oxygen fugacity; spinel

Northern Victoria Land (Antarctica) mantle, sampled by spinel peridotite xenoliths found in basalts of Mt. Melbourne Volcanic Province, brings evidence of a metasomatic event related to Cenozoic volcanism. This metasomatic signature varies across the volcanic province: at Baker Rocks (BR) metasomatism is characterized by the occurrence of amphibole as disseminated grains or in veins hosted in lherzolite and harzburgite xenoliths carried by alkali basalt; at Greene Point (GP, about 80km north of BR) cryptic metasomatism provides variable enrichments of incompatible elements in clinopyroxenes from lherzolite/harzburgite xenoliths that were transported to the surface by a nephelinite-basanite lava.

In this work we check the effects of the two styles of metasomatism on oxygen fugacity, estimating the redox state of anhydrous xenoliths with different metasomatic signatures, by means of the spinel-orthopyroxene-olivine oxybarometer. At BR, we estimated also the redox state of the metasomatic agent (the crosscutting amphibole-bearing veins) by applying the Popp et al. (2006) method to the crystal-chemical data obtained from amphiboles crystallized in the veins.

Xenolith mineral chemistry was determined by electron microprobe, and the ferric iron content of spinels and amphibole were measured by 57Fe Mössbauer spectroscopy. Amphiboles were also characterized by single-crystal X-ray structure refinement, which allowed quantification of dehydrogenation by the method proposed by Oberti et al. (2007).

Results show that oxygen fugacities recorded by the xenoliths range from -0.2 to -1.6 log-bar units ($\Delta \log fO_2$) with respect to the

fayalite-magnetite-quartz (FMQ) buffer. The $\Delta \log fO_2$ values calculated from amphiboles are about -0.6 log-bar units, thus in the range found for metasomatic amphibole of mantle xenoliths from the same area of

northern Victoria Land ($\Delta \log fO_2 = -1.4 : -0.4$ log-bar units, Nazzareni et al. 2010).

In detail, fO_2 data shows that i) beneath Greene Point, metasomatism

increased fO_2 by $\sim 1 \Delta \log fO_2$ log-bar units, whereas in Baker Rocks lithospheric mantle the metasomatic melt/rock interactions did not produce any significant change in fO_2 ; ii) within each suite, there is no evident correlation between fO_2 and the degree of mantle depletion, as indicated by spinel Cr#; iii) in GP xenoliths no direct correlation is found between fO_2 and the enrichment in incompatible elements in clinopyroxenes.

In conclusion, as evidenced by Baker Rocks xenoliths, mantle metasomatism leading to amphibole formation does not necessarily imply mantle oxidation; in contrast, the variability of fO_2 obtained for Greene Point xenoliths highlights that the silicate melts responsible for the last metasomatic event recorded by xenoliths acted as an effective oxidiser of the depleted shallow upper mantle.

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J4-13 Poster Benna, Piera

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HIGH-PRESSURE PHASE TRANSITIONS IN ALKALINE-EARTH FELDSPARS

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Key terms: high-pressure studies; alkaline-earth feldspars; phase transitions

While the structural and thermodynamic behaviour of the phase transitions induced by temperature in feldspars was subject to several investigations and is now well described, their high-pressure behaviour has been investigated only in more recent times.

At room conditions, in alkaline-earth feldspars, a triclinic $P\bar{1}$ symmetry is observed with Ca as M cation, whereas the symmetry becomes monoclinic I2/c when the larger Ba or Sr cations replace Ca, as in celsian (BaAl₂Si₂O₈, Cls) and Sr-feldspar (SrAl₂Si₂O₈, SrF). High-pressure investigations on anorthite (CaAl₂Si₂O₈, An) were performed by Angel (1988), that observed a reversible first-order phase transition

from $P\bar{1}$ to $I\bar{1}$ between 2.6 and 3 GPa. Along the An-SrF join, with increasing pressure, the An₂₀SrF₈₀ feldspar shows a displacive first-order $I\bar{1}$ -I2/c phase transition at about 4.3 GPa,

analogous to the displacive second-order $I\bar{1}$ -I2/c transition observed with increasing temperature at room pressure for the same feldspar. Both high-pressure and high temperature I2/c monoclinic structures are characterized by an increase of the coordination number of the Ca/Sr cations, which can be ascribed to an increase of the r_1/r_2 ratio, where r_1 is the ionic radius of the non-tetrahedral cations and r_2 is the ionic radius of

oxygen. In particular, the triclinic-monoclinic $I\bar{1}$ -I2/c high-pressure transition can be justified by the higher compressibility of the oxygen atoms with respect to the non-tetrahedral cations, causing the increase of the r_1/r_2 ratio. At about 7.3 GPa, the $An_{20}Sr_{80}$ feldspar shows a further first-order transformation from monoclinic I2/c to monoclinic P2₁/c (Nestola et al. 2004; Benna et al. 2007). In pure Sr-feldspar, Pandolfo et al. (2011) observed the same I2/c-P2₁/c phase transition at about 6.6 GPa.

In the present work the results obtained in celsian, by single-crystal *in situ* high-pressure X-ray diffraction up to 6.5 GPa, show the same I2/c-P2₁/c transition between 5.5 and 5.9 GPa. The results highlight the significant reduction of the transition pressures in comparison to $An_{20}Sr_{80}$ and Sr_{100} feldspars. This allows to correlate the decrease in the transition pressures with the increase of the average ionic radius in alkaline-earth feldspars along the An-SrF and SrF-ClS joins. Considering the well known morphotropic phase transitions occurring at room condition with changing composition, the results obtained on celsian allow to draw, along the Ca-Sr and Sr-Ba-feldspars joins, the stability fields of the observed phases between 0 e 7.5 GPa.

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J4-14 Poster Capitani, Giancarlo

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TOWARDS HIGHLY-ORIENTED NANOSTRUCTURED THIN FILMS OF NATURAL AND SYNTHETIC MINERALS: NEW CHANCES FOR NANOTECHNOLOGY

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Key terms: phyllosilicate; inosilicate; liquid phase deposition; nanostructures; magnetic anisotropy

In recent years, many efforts have been made on the synthesis of new self-assembled materials, and on scientific understanding of the formation mechanism from building molecules. With the aim to develop new functional materials, layered inorganic compounds recently attracted considerable interests for the preparation of nanoscale organic/inorganic hybrids. A large class of minerals presents inherently nanostructured morphologies. Within this group, we cite, to name a few, chrysotile, crocidolite, and montmorillonite, being examples of crystalline aggregates of nanotubes, nanorods, and nanosheets, respectively. On this basis, synthetic "geo-inspired" materials are being developed, with the aim to enhance their possibility to be employed as nanomaterials in technological applications. On the other hand, the surface of such minerals is rich of chemical groups which can bind covalently or electrostatically organic compounds capable to confer technological functionalities to the ultimate hybrid system. In order for a transition from bare mineral to functional material to be achieved, the development of processes for the deposition of highly-oriented thin film phases of such mineral nanoparticles are mandatory. Indeed, their marked anisotropic morphology influences also their physical properties, which may vary to a great extent depending on the probed direction. Here, we show the results of a scanning probe and electron microscopy, X-ray diffraction, and IR optical analysis of nanostructured thin films of natural and synthetic minerals obtained by liquid phase deposition of colloidal solutions. By assisting the deposition process with a static magnetic field, we demonstrate the possibility to induce a preferential orientation of the deposited nanoparticles, thanks to the anisotropy of their diamagnetic or paramagnetic susceptibilities. This effect is also studied in minerals deliberately doped with paramagnetic species such as Fe(II) and Fe(III) ions. Hybrid inorganic-organic colloids are synthesized by reacting chrysotile nanotubes with ionic derivatives of metal-phthalocyanines, organic molecules which display semiconducting character in the solid state. The structure, morphology and optical properties of the magnetically driven ordered deposits of hybrid nanoparticles are analyzed and compared with those of the bare minerals. Some conclusive remarks for their technological application and perspectives are drawn.

J4-15 Poster Curetti, Nadia

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HIGH-PRESSURE STRUCTURAL CONFIGURATIONS OF CELSIAN

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Key terms: crystal structure; high-pressure studies; phase transitions

Single-crystal *in situ* high-pressure X-ray diffraction was performed at P = 0.0001, 2.1, 4.2, 5.5, 5.9 and 6.5 GPa on celsian ($Ba_{0.97}K_{0.03}Al_{1.95}Si_{2.04}O_8$) from Jakobsberg, Sweden. The evolution of the unit-cell parameters as a function of pressure shows a discontinuity at pressure between 5.5 and 5.9 GPa (mainly in β angle and b parameter) and highlights a displacive

first-order transformation.

The data collections between 0 and 5.5 GPa show only a-type and b-type reflections (a: h+k=even, l=even; b: h+k=odd, l=odd) confirming the I2/c space group of celsian. The I2/c structures show only minor modifications mainly involving a shortening of the average < M-O > distances.

The data collections at 5.9 and at 6.5 GPa show the presence of also c-type and d-type reflections (c: h+k=even, l=odd; d: h+k=odd, l=even) indicating a primitive lattice. As in the high-pressure P2₁/c configurations of the feldspars of composition $Ca_{0.2}Sr_{0.8}Al_2Si_2O_8$ ($An_{20}Sr_{80}$) and $SrAl_2Si_2O_8$ (Sr_{100}) (Benna et al. 2007; Pandolfo et al. 2011), in celsian the scheme of intensity of the different reflections is: $a > d > b \geq c$. Only reflections h0l, 00l and 0k0 with l and k even were observed, confirming the P2₁/c space group. At pressure between 5.5 and 5.9 GPa, the I2/c-P2₁/c phase transition involves a reduction of the symmetry with the loss of the two-fold axes and of one-half of the centers of symmetry. In the P lattice the numbers of independent atomic sites is doubled and pairs of atoms related by the pseudo-body centering (a+b+c)/2 vector are present. The most significant changes in the P2₁/c configuration are: the deformation in the Ba polyhedra and the variation in the T-O-T angles. In particular, the T2(00)-OC(0i)-T1(0i) angle decrease to 112.24° at P = 6.5 GPa. The very small value of this angle in celsian at P = 6.5 GPa is related to the large changes in the OC oxygens in the M(0)-polyhedron.

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J4-16 Poster Ferraris, Cristiano

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HIGH ANGLE ANNUAL DARK FIELD (HAADF) MICROSCOPY: A NEW LOOK INTO CRIPTED SUB-NANO DOMAINS IN MINERAL SCIENCES

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Key terms: HAADF; HRTEM; nanodomains; mineralogy; crystallography

A major challenge to the development of a full understanding of mineral and ceramic nano-structures, including unit cell defects and distortions and local charge balance problems, is to identify contaminant (<10 ppm) elements and characterize their environment at the nano-scale.

Atomic-scale techniques, such as conventional transmission electron microscopy, although powerful, are limited by the extremely small amounts of material that are examined. However, recent advances in electron microscopy provide a number of new analytical techniques that expand its application in environmental studies, particularly those concerning trace elements with high atomic number compared to those of the hosting phase.

High-angle annular dark field scanning transmission electron microscopy (HAADF-STEM), STEM-energy-dispersive X-ray spectrometry (EDX), and energy-filtered TEM (EFTEM) can be effectively used to identify and characterize these elements.

The technique of high-angle annular dark-field (HAADF) imaging, allows forming images by collecting high-angle scattered electrons using an annular dark-field detector in a dedicated scanning transmission electron microscopy (STEM) instruments. This technique, in contrast to common TEM ones, is not limited to fully electron transparent sample areas, but also slightly thicker sample volumes are good for investigations. The contrast of HAADF images is i) strongly dependent on the average atomic number of the scatterer encountered by the incident probe, ii) not strongly affected by dynamical diffraction effects, iii) not strongly affected by defocus and, finally, iv) not strongly affected by sample thickness variations; the spatial resolution is limited by the size of the focussed incident probe.

Furthermore, the high sensitivity of HAADF image contrast to the average Z-number of the specimen atomic columns has allowed the use of this methodology to study the presence of single atoms of dopants in a crystal structure, or to derive the chemical profile of buried layers in a host matrix.

As examples, both gold nano-crystals in olivine and iridium nano-clusters in rutile have been identified by HAADF-STEM and STEM-EDX mapping and subsequently characterized by high-resolution TEM (HRTEM). The combined use of these techniques greatly expands the effective application of electron microscopy in mineralogical studies, especially when applied to heavy elements of very low concentrations. Examples of how this electron nano-beam technique can be used to characterize a low concentration of heavy metals (a few ppm) on nano-scale particles are discussed.

J4-17 Poster Gianfagna, Antonio

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FIBROUS ORTHOPYROXENE IN THE ETNEAN VOLCANICS FROM S. MARIA DI LICODIA (SICILY, ITALY).

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Key terms: Fibrous orthopyroxene; Mineralogy; Etnean volcanics

The south-western area of the Mt. Etna volcano has been studied because the presence of peculiar mineralogical association. In our previous study we investigated the Biancavilla area, a dome and dyke system with auto-brecciated portion. In the Biancavilla volcanic system the metasomatic process led to the formation of new minerals, fluoro-edenite and fluorogopite [1] [2], and some rare minerals, such as pseudobrookite and As-apatite(Ca, F) (under study).

In this work we studied the Santa Maria di Licodia area, a dome located on the East side of the Biancavilla volcanic area. Some significant differences are present respect to the Biancavilla, such as the presence of a fibrous orthopyroxene instead of fibrous fluoro-edenite. Fibrous orthopyroxene is rare, and was found in ultramafic xenoliths and interpreted as an autometasomatic product of hydrous magmas [3].

With the aim to investigate a possible metasomatic process in S. Maria di Licodia area, a detailed sampling was executed on both the unaltered lava portion (massive rocks) and the altered portion (massive and brecciated rocks) of the dome. Combining mineralogical and petrographic data the presence of fibrous orthopyroxene in both massive and brecciated portion was evidenced. Besides the fibrous opx, the secondary mineral phases also include alkali-feldspars (Na), augitic clinopyroxene, apatite, Fe-Ti oxides.

Orthopyroxene show different morphology, such as prismatic, acicular and fibrous. In the massive rocks, fibrous orthopyroxene appears at the expense of probable olivine, in veins and in reaction rim. Here the orthopyroxene forms radiating aggregates totally replacing the previous crystal. The acicular morphology is only present in the pores of the rocks. Finally, in the brecciated portions the orthopyroxene is characterized by loose fibers.

Different morphology correspond to differences in composition, in particular in the iron content. The EMPA analyses on the orthopyroxene from the massive rocks evidenced high content of FeO (until 18 wt%), while SEM-EDS micro-analyses on the fibers of the brecciated portion highlighted a more large variability, ranging from 4 to 14 wt % FeO. X-ray investigation on brecciated (fine) portion allowed to individuate and identify the orthopyroxene as an enstatite ferroan, as also confirmed by the EDS micro-analyses. Further mineralogical investigations are in progress to better define and characterize this rare fibrous orthopyroxene.

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J4-18 Poster Lenaz, Davide

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CHARACTERISATION OF SYNTHETIC SPINELS IN THE $Fe^{2+}(Al, Cr)_2O_4$ SERIES BY MEANS OF SINGLE CRYSTAL XRD, ELECTRON MICROPROBE AND MOSSBAUER SPECTROSCOPY

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Key terms: crystal chemistry; synthetic spinels; single crystal XRD; electron microprobe analyses; Mössbauer spectroscopy

Single crystals along the hercynite-chromite join were synthesised using a flux-growth method. Analytical grade Al_2O_3 , Cr_2O_3 , Fe_2O_3 powders were dehydrated and dried at 900 °C for 12 h before mixing with $Na_2B_4O_7$, used as flux compound. Around 6 g of starting material was ground under acetone in an agate mortar and mixed with flux/nutrient ratio ranging from 1.3 to 2.0 depending on nutrient compositions. The mixture was loaded in a 10cc Pt/Au (5%) crucible with a lid. For thermal runs an ENTECH vertical tube furnace equipped with programmable temperature controller and controlled atmosphere flow system was used. In order to obtain a homogeneous melt, the load was heated at 1200 or 1300 °C for 24 h. Subsequently the temperature was linearly decreased by 300 °C with a cooling rate of 4°C h⁻¹. A reducing atmosphere was provided by a continuous flow of high-purity CO₂ and H₂ gases through the furnace. The CO₂:H₂ ratio was maintained by TYLAN flow controllers and was kept constant at 1:2. Oxygen fugacity ranged from 10⁻¹¹ to 10⁻¹³ bars at 1200 and 900°C, respectively. The thermal runs were ended turning off the furnace and the product was allowed to cool more rapidly to room temperature.

For single-crystal XRD analyses, synthetic spinels were mounted on an automated KUMA-KM4 (K-geometry) diffractometer, using MoK α radiation monochromatized by a flat graphite crystal. The unit cell (a_0) was determined by 24 equivalent reflections of (12 8 4) (about 90° of 2 θ), accurately centred at both sides of 2 θ . Data collection was made according to Della Giusta et al. (1996) up to 2 θ = 55°. Structural refinement was carried out against F_o^2 in the Fd-3m space group (with origin at -3m), without chemical constraints, using the SHELX-97 program (Sheldrick, 1997). Cell edges varies within the range 8.1534 (6) Å - 8.3672 (1) Å, while the oxygen positional parameter is comprised between 0.2645 (2) and 0.2628 (1).

Structural parameters a_0 , T-O and M-O increase with chromite content while u decreases.

Mössbauer spectra were acquired at room-temperature using a conventional spectrometer system operated in constant acceleration mode. The spectra are dominated by a relatively broad absorption envelope consistent with ferrous iron. Several samples show also weaker contributions from ferric iron, despite the strongly reducing conditions prevailing during the synthesis procedure. The amount of ferric iron appears to increase with the chromite component of the samples.

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J4-19 Poster Lepore, Giovanni Orazio

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COMPRESSIBILITY OF SYNTHETIC $\bar{A}S_2S_4$: IN SITU HIGH-PRESSURE SINGLE-CRYSTAL X-RAY STUDY

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Key terms: high pressure; arsenic sulfide; X-ray diffraction

Arsenic sulfides are widely studied for their great technological potential and $\bar{A}S_2S_4$ compounds in particular are of interest to material scientists owing to their high infrared transparency, photo-structural sensitivity and doping ability [1, and references therein]. Most of them consist of a packing of cage-like, covalently bonded $\bar{A}S_4$ ($n = 3, 4, \text{ and } 5$) molecules held together by van der Waals forces, and the investigation of their thermodynamic properties, such as thermal expansion and compressibility, can usefully contribute to the understanding of the interactions governing the structure and its stability.

The crystal structure of the \bar{A} modification of $\bar{A}S_2S_4$ (i.e., the mineral realgar) has been recently investigated by *in situ* X-ray single-crystal and powder diffraction methods up to 43 GPa [2]. On the other hand, no data

on the compressibility and structural behaviour of $\bar{A}S_2S_4$ at high pressure have been reported in the literature so far.

Under ambient-pressure conditions, $\bar{A}S_2S_4$ crystallizes in the C2/c space group with $a = 9.957(3)$, $b = 9.335(4)$, $c = 8.889(5)$ Å, $\beta = 102.48(4)^\circ$ [3]. The structure consists of $\bar{A}S_4$ cage-like molecules, characterized by a D_{2d} molecular symmetry, with each As atom bonded to one As and two S

atoms. Crystals of $\bar{A}S_2S_4$ were obtained by heating crystals of realgar under vacuum at 295 °C for 24 hours. The quenched product was used to collect single crystal intensity data at pressures up to 4.8 GPa using two different diamond anvil cells loaded with different crystals in a methanol-ethanol (4:1) mixture. Unit-cell measurements have been performed in a ETH-type DAC using a STOE STADI IV four-circle diffractometer equipped with a point detector (University of Padova). The measurement of unit-cell parameters became impossible beyond 2.8 GPa because of a dramatic broadening of reflections. The whole intensity data collections were carried out at different pressure steps up to 2.7 GPa using an Oxford Diffraction Xcalibur2 diffractometer equipped with a CCD detector (Bayerisches Geoinstitut) using a Bolher-Almax DAC. The diffraction study has been combined with a microRaman investigation throughout the whole experiment. The compressibility data were fit through a Birch-Murnaghan equation of state truncated at the 3rd-order with resulting bulk modulus $K_0 = 10.9(2)$ GPa, and its first pressure derivative $K'_0 = 8.9(3)$. These values are substantially identical to those found for the low temperature polymorph [2] which is characterized by the same kind of molecule. The response to pressure is almost isotropic and the dramatic decrease of the unit-cell volume (from 805.17 to 702.7 Å³ at 2.7 GPa) is mainly due to the reduction of intermolecular distances, whereas molecules remain substantially unchanged. In particular, the volume of the $\bar{A}S_4$ disphenoidal group does not decrease significantly while the molecular volume contracts by approximately 1.6 %, due to the shortening occurring along the S3-S3 [30-1] and S1-S2 [010] directions. Further experiments, carried out at higher pressures with a thinner crystal, only led to a rough measurement of the unit-cell parameters

showing that $\bar{A}S_2S_4$ does not undergo any phase transition in the whole pressure range investigated, in spite of a compression to about 80% of the initial volume.

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J4-20 Poster Periotto, Benedetta

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THE ROLE OF THE LONE ELECTRON PAIRS AND Fe^{2+} IN THE HIGH-PRESSURE BEHAVIOR OF BERTHIERITE

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Key terms: berthierite; lone electron pair; high-pressure; sulfosalts

Berthierite is a sulfosalt with composition $FeSb_2S_4$ (space group $Pbam$) presenting several interesting aspects like magnetic properties (Winterberger et al., 1990) and phase transition in the temperature range 323-365 K (Lukaszewicz et al., 2001). Moreover, berthierite structure features antimony in a trivalent state and is characterized by its lone electron pair (LEP) with pronounced steric effect. In this study, high-pressure single crystal X-ray diffraction experiments have been performed on a natural sample of berthierite in order to determine its equation of state (EoS) and high-pressure crystal structure evolution. Structural relation to stibnite and galenobismutite is also presented and the high-pressure development of the three structures compared. The purpose of this work is to contribute to the compressibility systematic for LEP compounds with the aim to outline a mechanism of their structural deformation and to define better the changes in the LEP activity as a function of pressure.

Two needle-like single-crystals of berthierite were selected from a natural sample collected in the Herjia deposit (Romania), the first one for

high-pressure unit-cell determination (183 x 80 x 40 μm^3) and the other

one for intensity data collection (175 x 75 x 40 μm^3). High-pressure single-crystal diffraction experiments were performed for each sample in an ETH-type diamond-anvil cell (DAC), equipped with diamond culets of

600 μm in diameter and diamond backing plates. Stainless steel gaskets

preindented to a thickness of 90 μm and with a spark eroded hole of 250 μm in diameter were used. A mixture of methanol and ethanol (4:1) was used as a pressure-transmitting medium and a single-crystal of quartz as an internal pressure standard. For the EoS determination, the measurements were performed using a four-circles STOE STADI IV diffractometer equipped with a point detector and controlled by the SINGLE software. No phase transitions were indicated in the investigated pressure range. The third-order Birch-Murnaghan equation of state calculated using high-accuracy volume-pressure data up to 8.046(12) GPa gave the following coefficients: $V_0 = 608.78(7)$ Å³, $K_0 = 37.2(2)$ GPa and $K'_0 = 7.0(1)$. The crystal selected for structure analysis was measured from room pressure up to 7.408 GPa, including one measurement on decompression. Complete intensity data collections were performed using a STOE STADI4 four-circle diffractometer, equipped with an Oxford Diffraction CCD detector.

As in the case of stibnite and bismuthinite, the crystal structure can be divided into rods comprising the short Sb-S bonds and the intervening space, which is sterically affected by the lone electron pairs of Sb. In all three structures the latter space accommodates most of the compression. The LEP activity has been quantified by the eccentricity of the Sb coordination polyhedra. With increasing pressure the eccentricity decreases indicating a reduction of the LEP activity. The Fe octahedron, which is the stiffest coordination polyhedron in berthierite, increases its distortion between 3 and 5 GPa exhibiting an increasing in the Jahn-Teller effect with a more clear distinction between two shorter and four longer bonds.

J4-21 Poster Princivalle, Francesco

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OUTLIER RECOGNITION AND ROBUST WEIGHTING PROCEDURES APPLIED IN CATION ORDERING-DISORDERING KINETIC DATA PROCESSING.

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Key terms: intersite cation exchange; kinetics; least squares processing; outliers; leverage analysis

An efficient protocol, based on advanced statistical diagnostics and robust fitting techniques applied to the least-squares processing of cation ordering-disordering kinetic data, is here presented and discussed. The study of the intersite cation exchange in rock-forming minerals constitutes a powerful tool for modeling the thermal history of the host rocks. In recent decades many experiments have been conducted on cation ordering-disordering in different rock-forming silicates with the aim of quantifying cation ordering as a function of chemical composition, equilibration temperature, and time. This makes it possible to estimate both the closure temperature and the cooling rate of silicates from terrestrial rocks and meteorites. The kinetics of cation ordering in minerals is less well known than the thermodynamics. This is mainly due to the scarcity of experimental data and to difficulties in interpreting the kinetic data. Moreover, as a consequence of a number of factors, kinetic data are often affected by the presence of strong outliers, i.e. data points markedly distant from the main part of the system. This fact turns into a large discrepancy between the observed and calculated data points and into an incorrect modeling of the experiment. The effect of trying to fit an outlier is to make the fits of all other data points a little bit worse with consequent biasing of the parameter estimates. This is particularly true when the outlier is also an influential point (i.e., a point that remarkably affects the model).

Bearing in mind these considerations, we proposed a protocol for processing cation ordering-disordering kinetic profiles aimed at obtaining a greater accuracy of the estimates of the least-squares optimizing procedures. The procedure, which consists in the identification of the outliers that remarkably impair the fitting by means of the so-called "leverage analysis" and some related diagnostics, has been applied to different set of synthetic data generated on the basis of the Mueller kinetic model. Random errors taken from a normal population with mean and standard deviation comparable to those obtained from experimental measurements have been added to the calculated data points. The effect of the number of experimental data points and of the distribution of them across the kinetic profile, on the reliability of the procedure and on the parameter estimates, has been also investigated. It has been found that the proposed approach allowed the elimination of the actually aberrant observations from the data set and/or their robust weighting to inhibit the negative effects induced on the data fitting, with consequent reduction of the bias introduced into the parameter estimates and a significant improvement in the regression results.

J4-22 Poster Princivalle, Francesco

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FeCr2O4 SYNTHETIC SPINEL: HEATING EXPERIMENTS AND OXIDATION KINETICS.

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Key terms: CHROMITE SPINEL; HEATING EXPERIMENTS; SXRD DIFFRACTION; EMPA-SEM EBS; IRON OXIDATION

Single crystals of FeCr2O4 were synthesized using a flux-growth method. Analytical grade Cr2O3 and Fe2O3 powders were dried at 900°C for 12 h before mixing with Na2B4O7, used as flux compound. About 5-6 g of starting material was ground under acetone in an agate mortar and mixed with flux/nutrient ratio.

The mixtures were loaded in 10 cc yttria-stabilised Pt/Au (5%) crucibles and covered with a lid. For thermal runs, an ENTECH muffle furnace with programmable temperature controller were used.

In order to obtain a homogeneous melt, the load was heated at 1,200°C for 24 h. Subsequently the temperature was linearly decreased to 900°C with a 4°C h⁻¹ cooling rates. The thermal runs were ended turning off the furnace and the product was allowed to cool rapidly to room temperature. The reducing atmosphere was provided by a continuous flow of high-purity CO2 and H2 gasses into the furnace. The CO2 :H2 ratio was maintained by TYLAN flow controllers and was kept constant at 1:2 Oxygen fugacity ranged from 10⁻¹¹ to 10⁻¹⁷ bars at 1200-900°C, respectively, which is ca. -0.1 log units from the iron-wüstite solid buffer.

Additional details on the spinel syntheses can be found in Lenaz and Skogby (2003).

Previous studies (Lenaz et al. 2004) showed that Cr completely fills the octahedral site, and that iron occurs almost exclusively as tetrahedral Fe2+.

As Cr should not be oxidized in spinels, we would expect that heating affects only the iron cations present in the T site. Heating in hercynite spinels, FeAl2O4, causes exchange of the Fe and Al cations between the two non-equivalent sites and oxidation of Fe2+ to Fe3+ (Lavina et al. 2005).

Consequently, as Cr cannot fit into a tetrahedral site, the only possible effect is the oxidation of Fe2+ to Fe3+ and, possibly, the formation of T

site vacancies.

To reach this purpose crystals were put in a thin-walled quartz tube and heated in a vertical tube furnace at different temperatures from 600 to 1000°C. Heating runs were performed at room pressure in air. Run temperatures were accurately measured and controlled by means of a calibrated Pt/Pt-Rh thermocouple located near the sample; the uncertainty is estimated to be about ±5°C.

Since the cell parameter (a) and the oxygen positional parameter (u) changes with time and temperature, a strongly correlated relationship between the heating process and the iron oxidation was supposed. At the end of the oxidation process the crystals were polished to about the median plane in order to see if and how the oxidation develops into the crystals.

In order to verify the presence of ferric iron and the formation of vacancies, SEM EBS as well as EMPA analyses have been performed and successively compared with previously performed data obtained from single crystal XRD, EMPA and Mössbauer spectroscopy.

References:

Lavina et al. 2005, Phys Chem Miner, 32: 83-88

Lenaz et al. 2003, Per Mineral, 72: 69-78

Lenaz et al. 2004, Phys Chem Miner, 31: 633-642

J4-23 Poster Sciascia, Luciana

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ELECTRONIC, MAGNETIC AND STRUCTURAL PROPERTIES OF NiO AND FeO THIN FILMS EPITAXIALLY GROWN ON SURFACES OF Cu(001) : AN AB-INITIO DENSITY FUNCTIONAL STUDY

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Key terms: epitaxial growth; ab-initio; magnetic properties; Bader's theory

In the present project we have simulated the properties of ultrathin layers of nickel and iron oxide epitaxially grown on copper (001), which represent a new class of materials with potential applications in microelectronics, magnetic tunnel junctions, flat panel displays, model supports of catalytic systems, etc. The interest in these systems comes mainly from the theoretical possibility to tune the electronic and geometric properties of the films so as to obtain new desired properties by simply varying the lattice parameter through a proper choice of the appropriate metal substrate, by modifying the film thickness or the nature of the interface, by selectively introducing hetero-atoms or defects in the structure. On the other hand, the fact that sometimes the films possess a different geometric and electronic structure is one of the fascinating aspects of these materials, and opens new perspectives for their use in various applications. Another property of interest is related to the magnetic behavior. This can be modified in principle by interfacing a nonmagnetic metal with a magnetic oxide or simply by changing the lattice mismatch. The nature of the bonding at the interface is essential in determining the final magnetic properties of the system.

Bearing in mind the great interest in this field, we decided to undertake the present study where the properties of ultrathin layers of nickel and iron oxide epitaxially grown on copper (001) have been determined, by adopting a periodic slab model, consisting of five layers of Cu covered on both sides with NiO and FeO monolayers.

The choice of the metallic substrate was dictated by the need to improve and further develop applications based on copper, in view of recent advances in microelectronics and other advanced technologies. The electronic, magnetic and structural properties of the oxides and of the complex systems have been determined. Moreover, the topological analysis of the investigated structures in the framework of the Bader's theory has been performed.

The calculations have been performed by exploiting the ab-initio CRYSTAL09 program at the HF/DFT level. Different Hamiltonians and basis sets have been tested in order to choose the computational setting which better reproduced the experimental observations.

The present studies have shown that the presence of the copper substrate modifies indeed the structural and electronic properties of an epitaxial oxide monolayer; for example, it has been noted that the conductive properties of the materials change significantly, as shown by the analysis of the density of states and band structures. Moreover the antiferromagnetic properties of the films supported by the metallic substrates don't differ significantly from those of the unsupported ones; both unsupported and supported films show an antiferromagnetic ordering.

J4-24 Poster Tribaudino, Mario

10.1474/Epitome.04.0793.Geoitalia2011

Fe-Mg SUBSTITUTION IN PIGEONITE: A STUDY BY RAMAN SPECTROSCOPY

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Key terms: pyroxene; pigeonite; Raman spectroscopy; meteorites; peak position-composition relations

The Raman spectra of 10 samples containing the mineral pigeonite, a Ca poor P21/c variety of the mineral pyroxene, were measured. Seven of the studied samples come from the achondritic meteorites belonging to the family of ureilites, two are from volcanic rocks, and one is synthetic; the studied samples have an mg content [mg = 100Mg/(Mg+Fe)] between 52 and 100. The differences in Raman spectra with C2/c and Pbc21 pyroxenes are highlighted; the peak position of the main peaks changes linearly with mg, whereas, likely for the small difference in Ca content, no correlation is present with Wo. Changes in peak position with mg of the major peaks at 340 and 670 cm⁻¹ are significantly lower in C2/c compared to Pbc21 and P21/c pyroxenes. This feature is interpreted as changes in the major peaks are most related to major structural modifications in the M2 polyhedron; such structural modifications are lower in C2/c pyroxenes. Peak width in natural pigeonite is higher than in synthetic one, owing to the defective texture of the former.

The present results may provide a basis for on site analysis of pyroxenes by means of Raman spectroscopy of planetary bodies in space exploration.

SESSIONE J5

Petrofisica e deformazione delle rocce: dai rischi naturali alle implicazioni sociali

J5-1 Key Lecture Moia, Fabio

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NUMERICAL MODELING EXPERIENCE APPLIED TO CO2 POTENTIAL GEOLOGICAL RESERVOIRS IN ITALY

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Key terms: CCS; CO2 FATE; GEOLOGICAL/NUMERICAL MODELING; RESERVOIR CO2 CAPACITY

As argued by the European Commission - Directorate General for Energy and several international bodies, like among the others the Carbon Sequestration Leadership Forum (CSLF), the Carbon Capture and Storage (CCS) is accepted as a reasonable solution for reducing greenhouse gas emissions, figuring in perspective as a countermeasure against the climate change. In particular, there is a general agreement to consider the CO2 storage in geological formations as a feasible technique and Weyburn-Midale CO2 Project (Canada Saskatchewan) and Sleipner Project (Norway-North Sea) seem to demonstrate it. Yet the safe and effective approach in a long-term perspective (500-1000 years) is still largely not proven. Thus the understanding of the long-term transport and fate of CO2 and associated physical processes is still a crucial issue in view of the deployment of the technology.

CO2 can be stored in different geological reservoirs as: depleted oil and gas fields, unminable coal seams and deep saline aquifers. The porous rocks with salt waters offer the highest CO2 storage potential and the injection should take place in geological reservoirs located at least 800 meters of deep where the conditions of temperature and pressure are suitable for injecting CO2 in supercritical conditions and with the characteristics of a fluid. The reservoir must be covered by a clay (or equivalent) geological formation, which can prevent the leakage of CO2 into geological formations above.

The characterization of the caprock-reservoir system for CO2 geological storage includes several processes as for example: well integrity, chemical reaction, thermal flux, multiphase flow and transport, stress/strain change, induced fracturing and fault reactivation. In this complicated contest, it is undeniable that the numerical modeling is the only tool available for predicting the long-term behavior of CO2.

The paper describes the geological models created for three different potential reservoirs in Italy: a) Offshore Sibari basin (denominated Calabria Ionica) where the geological caprock is represented by a thick clay formation (Pleistocene) locally with thin silt or sand layers and the reservoir is represented by high porosity and salt water arenaceous/gravel-sand formation (upper Miocene), b) Offshore North Adriatic sea where the caprock is represented by clay with silt and thin layers of sand (Pleistocene) and the reservoir is represented by high porosity and salt water sands with few thin clay intercalation (Pleistocene-Middle Pliocene), c) Area onshore around Malossa oil and gas field in Lombardia region in which the caprock is represented by a clay formation known as Santerno Clay of Pliocene age and the reservoir is a conglomerate formation with salt water known as Serignano Gravel of upper Messinian age.

The numerical modeling results of CO2 injection and fate by using the Integrated System for Modeling Analysis (SIAM) developed by RSE Company are also shown with particular relevance to CO2 plume extension during the 30 years of supposed injection and extended to more than 500 years after the start of the CO2 injection process itself. The stress conditions generated around the injection wells, inside the reservoirs and at reservoir-caprock interfaces are also shown to verify the safety pressure criteria. The injection of 1 Mton/year of CO2 for a 30 years period is considered for case a) and b) while, for case c) we considered a CO2 injection rate of 0,3 Mton/year. The CO2 storage capacity of each saline-aquifer reservoirs has been estimated by using the method proposed in the EU Geocapacity Project with different values of the storage efficiency factor and compared with the more sophisticated procedures related to numerical modeling.

J5-2 Invitato Quattrocchi, Fedora

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REMAINING GAPS FOR A "SAFE" GEOLOGICAL STORAGE OF CO2: THE CO2GAPS VISION CHALLENGES OF "LEARNING BY DOING"

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Key terms: CO2 Gaps; geochemical-geochemical data; public acceptance

CO2GAPS vision of the INGV (which is jointed recently with other research groups of CNR, ETHZ, EUCENTRE, etc.... by an European Proposal still confidential and under evaluation, as a whole) intends to fill key GAPS concerning the main risks associated to the storage of CO2 and the consequent liability of the "storage" part in the entire Carbon Capture and Storage (CCS) process. These still constitute a real obstacles for the large scale industrial development of CCS. A better "site specific" risk assessment and the development of reliable multi-disciplinary monitoring protocols will be then supported by "peer reviewed" processes and patented analytical procedures and techniques. The outcome results should be also embedded in the updating of the Annex 2, EU Dir. 2009/31/EC. The vision of the INGV group, as part of the partnership, is to apply a multidisciplinary approach, integrating geochemical-geochemical data with seismic tomography and crustal rocks anisotropy, induced/triggered seismicity, gravimetry, EM techniques, and "early alarm" procedures for leakage in shallow geo-spheres and abandoned wells.

Moreover geochemical and geochemical data are necessary for a reliable 3D-Earth modelling and a full merging with reactive transport codes, as well as the improvement of numerical modeling codes itself (updating "site specific" siting - Annex 1). CO2GAPS vision will apply and verify these themes working on several European selected sites, taking

also into account complex systems such as "inland" active faulted blocks close to the off-shore storage sites, ECBM faulted prone-areas, "inland" injection test site, and CO2 natural analogues. The purpose of these future activities will focus on the study of long-term fate of stored CO2, leakage mechanisms through the cap-rock/abandoned wells, geochemical/geochemical reactivity of cement wells, as well as the effects of impurities in the CO2 streams, their removal costs, the use of tracers and role of biota.

J5-3 Invitato Tuccimei, Paola

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RADON AND THORON EMISSIONS FROM HIGH TO LOW POROSITY ROCKS UNDER INCREASING DEFORMATION

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Key terms: radon emission; rock deformation; seismic surveillance; rock porosity

Anomalous radon and thoron emissions are regarded as valuable precursors of earthquakes and volcanic eruptions and are related to increasing damage of the medium. However both positive and negative anomalies are observed in the field prior ruptures, thus indicating competing deformation mechanisms. Initial porosity (P) plays a key role for natural lithologies in controlling damage accumulation and strain localisation processes. Thus investigating how elastic properties of low to high porosity rocks are affected from increasing loading is required to quantitatively interpret the positive and negative anomalies observed. Here we present an experimental dataset where measurements of radon (²²²Rn) and thoron (²²⁰Rn) emissions are carried out on low to high porosity lithologies incrementally loaded up to failure. The following samples are investigated: a high porosity lithophyse-rich tuff (P = 47.0 %) and a low porosity phonolitic lava flow (P = 3.6%). Cylindrical samples of 120 (length) x 60 (diameter) mm, have been uniaxially loaded at constant strain rate in servo-controlled uniaxial machines. Samples have been either 1) mechanically damaged to the end of the elastic phase, before the onset of dilatancy or 2) loaded up to the failure. Radon and thoron exhalation rates are carried out by using a solid-state alpha detector, connected to a small accumulation chamber kept at the constant temperature of 60°C. Measurements are performed on two samples at once to achieve stronger signals and repeated several times in order to verify their reproducibility. Results show that a decrease of radon and thoron emissions are evidenced at the end of the 'damage phase' for the high porosity tuff, while a slight increase is observed for the low porosity lava flow. At the end of the elastic phase the tuff reduces its radon and thoron exhalation rates, because of pervasive pore collapse of the macropores, with a P reduction up to 40.1%. In contrast, for the lava flows the loading slightly increases the crack damage and, consequently, P increases up to 5.1%. This change does not significantly affect the radon exhalation. At the failure, new rupture surfaces are generated. The total exhaling surface of the samples increases and an increase of radon emission is observed for both lithologies.

J5-4 Poster Zappone, Alba

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PHYSICAL AND MECHANICAL CHARACTERIZATION OF POTENTIAL RESERVOIR AND CAP ROCKS FOR GEOLOGICAL STORAGE OF CARBON DIOXIDE IN SWITZERLAND: WORK IN PROGRESS

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Key terms: CO2 geological storage; porosity; permeability; physical properties; Swiss Molasse Basin

The potential for storage of CO2 in geological formations in Switzerland has recently been evaluated by Chevalier et al. (2010). A score was assigned to each aquifer/seal pair in the Swiss Molasse basin and Jura mountains, based on an international reference scale (Bachu, 2003). The upper Muschelkalk/Gipskeuper aquifer/seal pair scored highest.

However, the spatial heterogeneity of this aquifer, combined with lack of data coverage, warrants a more thorough investigation of the potential aquifer/seal pair, with emphasis on the following questions:

- 1) How is porosity and permeability spatially distributed in the Muschelkalk?
- 2) Can we use existing geophysical data (i.e., seismic lines) to provide information about the physical properties of the Muschelkalk?
- 3) How has the physical properties of the Muschelkalk developed over geological time?

To answer these questions we aim to compile existing published data and gather new data by laboratory measurements, where it is needed. Several sources for information are available at present, including academic literature and industry records.

Laboratory investigations on elastic properties, density, porosity and permeability are ongoing, using experimental equipment at the rock deformation laboratory in Zurich.

The work will present a state of the art of the of these studies in the perspective of a feasibility study of a pilot project of Carbon capture and Storage in the Swiss Molasse Basin.

J5-5 Poster Zappone, Alba

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CARMA - CARBON MANAGEMENT IN POWER GENERATION GEOLOGICAL STORAGE IN SWITZERLAND

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Key terms: CO₂ geological storage; injection induced seismicity; mineral carbonation; Laboratory experiments; Switzerland

The CARMA project aims to explore the potential for and the feasibility of Carbon Capture and Storage (CCS) in Switzerland within the framework of future energy scenarios. We aim to exploit the available expertise to develop new CCS technologies and know-how, which might be applied in Switzerland and worldwide. We intend to evaluate the economic, environmental, societal, and institutional implications of CCS and to assess the potential CO₂ geological storage capacity in Switzerland. We also intend to build on the strengths, experience and available equipment of the research groups involved, focusing on mineral carbonation, as a means of fixing CO₂ in stable, mineral form. CARMA brings together the research groups from various universities and industries in Switzerland. The project started in January 2009, with a total runtime of 4 years. This poster reports the achievements with respect to geological storage of CO₂ in Switzerland during the first half of the project.

An estimate of the theoretical storage potential in the subsurface was completed in August, 2010. The methodology followed an existing evaluation scheme developed in Canada, based on geological criteria only. Modifications were introduced to suit the geological setting and available data in Switzerland. The study relies on quantitative and semi-quantitative attributes derived from analysis of existing laboratory, drill-hole, geological, and geophysical data. The weighted combinations of these attributes have been ranked in order to visualize Switzerland's storage potential in the form of a contour map. The theoretical storage capacity of the suitable sandstone and limestone aquifers is approximately 2.6 Gtons of CO₂, i.e. 65 times Switzerland's current annual CO₂ emissions.

Through geological investigations, laboratory testing and one or multiple field tests would be imperative to prove its feasibility and safety. The potential seismic hazard related to CCS operations is carefully assessed within CARMA. The activities that have been carried out focused on the compilation of known cases of induced seismicity due to fluid injection. The compilation includes enhanced geothermal systems, passive geothermal plants, liquid waste disposal, and CCS projects. A classification methodology has been proposed according to the type of operation, operative plant parameters, tectonic regime, state of stress and background seismicity of the injection area.

An alternative approach to that offered by subsurface storage is ex-situ mineral carbonation in a controlled industrial setting. This involves the dissolution of CO₂ into an aqueous phase, leaching of magnesium/calcium from a natural mineral feedstock and the precipitation of Mg-/Ca-carbonates, thus fixing CO₂ in a stable, environmentally benign form. The reactions involved are exothermic overall, but their kinetics is slow under ambient conditions. This makes an energy intensive, mechanical or thermal activation of the mineral feedstock inevitable. While this adds to costs, mineral carbonation offers the possibility of fixing CO₂ directly from an industrial off gas stream, thus obviating the costly capture step. Within CARMA, we are investigating an aqueous process, where a flue gas is bubbled through a stirred tank containing the mineral feedstock in suspension. We have built a set-up to perform mineralization experiments under a variety of temperature, pressure, gas composition and solution chemistry conditions, using several optical and physicochemical analytical techniques to monitor the different phases in-situ and online further downstream. Currently, the dissolution behavior of thermally activated serpentine is being studied. Hitherto, olivine was found to be the natural silicate feedstock exhibiting fastest dissolution kinetics. When directly compared to olivine, we found that activated serpentine dissolves 2 to 3 orders of magnitude faster under identical conditions.

J5-6 Poster Apuani, Tiziana

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MECHANICAL CHARACTERIZATION OF THE SERGNANO RESERVOIR BY ULTRASONIC WAVE VELOCITY MEASUREMENTS

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Key terms: Ultrasonic wave velocities; elastic properties; Santerno Shale; Sergnano oilfield

Proper design and planning of gas storage in natural reservoirs takes advantage of the numerical modeling of the injection process. The numerical simulation must be supported not only by a thorough knowledge of the geological and structural features of the concerned area, but also by an adequate geomechanical characterization of the involved units. Static and dynamic methods can be applied, by in situ tests or at laboratory scale.

With the final goal to furnish the input data for numerical modeling, the mechanical properties of the rocks making up the Sergnano oilfield were preliminarily investigated by ultrasonic wave velocity measurements on rock samples.

The Sergnano oilfield (CR-Italy) is located in the Pliocene-Quaternary foredeep of the Po basin; discovered in 1953, it was converted into a methane gas storage tank in 1965. The reservoir rocks belong to the "Ghiaie di Sergnano unit", overlying the Gallare marl (Marne di Gallare). The cap rock is represented by the Santerno shale (Argille di Santerno).

Samples were collected from the two cores gently offered by Eni s.p.a.: six in the cap rock at the depth between 1330-1340 m, and two at the base of the reservoir at about 1710 m b.s.l.. The mineralogical clay nature of the Santerno shale was derived from x-ray diffraction analysis and their behavior defined by the Atterberg limits. The physical properties of bulk and specific unit weight were measured and porosity calculated, both for the cap rock unit then for the bottom one.

P and S high frequency wave velocities, measured in different directions, normal and parallel to the bedding plane, allowed to define a poor anisotropic behavior. The effect of increase confining pressure, up to 290 MPa, was explored and correlation equations between wave velocity and pressure were attempted. The dynamic elastic properties were then calculated: Bulk modulus (K), Elastic modulus (E), Shear modulus (G),

Poisson's ratio (ν).

J5-7 Poster Punturo, Rosalda

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RELATIONSHIP BETWEEN STRUCTURAL, PETROLOGICAL AND PETROPHYSICAL FEATURES ON STRAIN EVOLUTION IN THE KAVALA SHEAR ZONE (RHODOPE MASSIF, NORTH-EASTERN GREECE)

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Key terms: textural and seismic anisotropy; mineralogical changes; Kavala shear zone

Mylonitic shear zones represent the binary which drives the structural evolution of mountain belts; for this reason they can be considered as "natural laboratories" where it is possible to observe and concentrate the investigation on microstructural and textural characteristics related to the changes in physical and mineralogical properties of progressively deformed rocks.

Our attention focussed on the Kavala (Symvolon) pluton, which crops out in north-eastern Greece and is mainly composed of early-Miocene granodiorite deformed at various extents during syn-shearing emplacement. According to the Authors, it represents the south-western termination of the Rhodope Core Complex, which was exhumed as a result of large scale extension from mid-Eocene to mid-Miocene times.

Structural features of mylonitic textures highlighted the presence of a NE-SW monotone stretching lineation consistent with the shape elongation of the outcropping pluton, with intensity in deformation increasing towards the contact with the host gneiss. Despite gneiss rocks experienced a longer deformation history, any previous fabric was completely reworked by the Alpine mylonitic shearing activity. Such a peculiar outcrop conditions set aside samples to be collected by taking into account progressive deformation.

Bulk rock geochemical and petrographic investigation allowed the characterisation and selection of representative samples for both Kavala granitoid and country gneiss rocks. They mostly classify as metaluminous to weakly peraluminous granodiorite and strongly peraluminous granite, respectively, and define distinct parallel trends in specific major and trace element variation diagrams. Geochemical trends have been used to check for any possible modification of the different rock types associated with mylonitization, as well as to identify original magmatic compositions. Mineral chemistry investigation accompanied by multivariate statistical analysis of multispectral X-ray maps highlighted well preserved original porphyroblast zoning within low strain domains, whereas a complete compositional re-homogenisation was observed in widespread high-strain domains. Moreover, several generations of syn-mylonitic mineral growth inducing local strength-softening have been detected. Quantitative microstructural investigation was performed on thin sections cut parallel to the stretching lineation. Optical assisted-image technique analysis on quartz grains (800 ca. grains per sample) revealed a mean axial ratio (AR, i.e. the ratio between major and minor axis of particles) ranging between 2.2 and 3.2 (AR max = 15) and average grain size of 20

μm . 2. Calculated flow-law equation describing the rheological properties of quartzite suggests a mean shear strain rate value of $4.87 \times 10^{-12} \text{ (s}^{-1}\text{)}$ for the studied samples.

Finally, petrophysical investigation on progressively deformed granodiorite at confined pressure conditions (up to 400 MPa) highlighted that Vp are distributed with the highest and lowest values orientated within and normal to the main foliation plane, respectively. Vp related seismic anisotropy ranges from 2.16 to 6.92%. Vs related acoustic birefringence shows its maximum along the stretching lineation direction. Vp/Vs ratios are in the range of 1.67 - 1.70.

Preliminary correlation between petrophysical and quantitative microstructural features opens new perspectives in the calculation of strain rate estimates of progressively natural sheared rocks.

J5-8 Poster Martin, Silvana

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CAN CARBONATE FAULTS BE MELT-LUBRICATED?

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Key terms: Carbonate pseudotachylite; Fault lubrication; Earthquake; Grigna Massif

There is natural and experimental evidence that faults are normally lubricated during seismic faulting. In particular, carbonate fault lubrication is thought to be driven principally by decarbonation reactions. Here we present the natural example of the Canalone Porta fault (Grigna Massif, Southern Alps, Italy) which shows the existence of carbonate pseudotachylites, suggesting that low-viscosity melts can promote melt lubrication processes.

The Canalone Porta fault, developed within dolomitic and marly limestones, hosts fault- and injection-veins of dominant carbonate composition. Vein texture is characterized by a fine-grained reddish matrix supporting millimetre-sized clasts. This matrix is composed of micrometre-sized globular aggregates of micrometre- to nanometre-sized calcite and dolomite crystals, bound together by a K-bearing aluminosilicate glass. Bulk-rock geochemical compositions of veins are very similar to those of the host fault-core rocks. However, veins display a Mg/(Ca+Mg) ratio (XMg) definitely lower than the host rocks.

In the calcite-dolomite system, carbonate melting occurs in the ~660-1100 °C range of temperature, depending on the water content. The estimated melting temperature of the studied rocks falls within this temperature range (~700 °C). Besides, the average XMg of the matrix (0.26) is in keeping with the theoretical value (0.2-0.3) for similar compositions at crustal pressures. The observed aluminosilicate glass can be derived from disequilibrium melting of muscovite.

Structural, chemical, mineralogical and petrological observations suggest that the Canalone Porta veins have not been formed by simple mechanical comminution, but are the quenching product of friction-induced

carbonate-rich melts (i.e., carbonate pseudotachylytes) produced at $T \approx 700$ °C and $P \approx 0.1-0.2$ GPa. The existence of pseudotachylytes of dominant carbonate composition along faults implies the presence of low-viscosity melts promoting fault lubrication during those earthquakes nucleating in the carbonate sedimentary levels of the shallow crust.

J5-9 Poster Sassi, Raffaele

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ULTRASONIC EMISSIONS RELATED TO ROCKS CRACKING PRECURSORS: FIRST RESULTS FROM ROCK SAMPLES TESTS

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Key terms: *Petrophysics; Elastic properties of rock; Ultrasonic emission; Fiber optic-based sensors; Rock landslides*

The analysis of stress accumulation and crack-induced vibrations of an unstable slope before failure is considered an effective tool in rock-fall disaster forecasting. The national project SMILAND (Innovative Integrated Systems for Monitoring and Assessment of High Risk Landslides) aims at development of innovative solutions for rocky landslides early-warning based on optical fiber sensors. Within this project, a petrophysical characterization, based on different laboratory methods aims to detect the elastic properties, has been carried out on different type of rock samples. The acoustic emissions (AEs) released during the rock fracturing of laboratory samples has been also studied. Nowadays, the implemented AE monitoring techniques, used both in laboratory and in the field, are mainly based on seismometers, geophones or also microphone arrays. These devices, although accurate and reliable, may be difficult to install in the field and are liable to lighting and electromagnetic interference (EMI). In recent years, the interest in fiber optic-based sensors (FOS) has experienced a rapid increase, fostered by the advantages that these sensors offer in comparison with the classical ones. In particular, their intrinsic robustness to EMI and lightning, their remote operability and distributed sensing ability, make the FOS suitable to the distributed monitoring of several parameters (e.g. strain and temperature) in hard environment conditions too. The application of such sensors to landslides and cliff collapses is nowadays mainly limited to displacement measurements.

Nonetheless, the application of fiber sensors to the characterization and monitoring of seismic precursory patterns of unstable rocks or cliffs is still an unexplored research field.

Interferometric sensors have shown very high sensitivity, that consists an extremely important feature for detecting small wave amplitude precursor AEs related to initial rock cracking development.

Considering that the correlation between the rock behavior to different stress conditions and internal resistance variation is principally due to the mechanical properties of the rock mass, different rock types samples (marble, dolomite and trachyte) has been used in laboratory tests to detect the elastic properties of rocks related to mineral composition, fabric, structure and porosity.

Elastic properties of rock samples have been measured by using different laboratory methods such as uniaxial apparatus, ultrasonic static and dynamic multifrequency instrument. The comparison of data results have shown a substantial homogeneity from elastic modulus obtained by different methods.

In this frame, all the rocks involved in the testing phase have been characterized from the mineralogical-petrographical and structural point of view. Such a complete characterization has been carried out on three mutually perpendicular sections with respect to the macroscopic fabric elements of the rock. Grain and bulk densities of the rocks will be also measured.

Laboratory testing of FOS have been carried out coupling the developed sensors with several rock samples, having different lithological, structural and mechanical features.

Key terms: *MICAS; GIXRD; AXANES; NEXAFS; P-EXAFS*

Intercalation means the reversible insertion of a guest chemical species (atom, ion, molecule) in a virtually unchanged host crystal structure. Any type of layer-structured material may give rise to intercalate compounds, the guest species being inserted between the host sheets without loss of their planarity. Layer silicates, in particular, may be considered intercalated structures in which interlayer guest species and complexes are inserted between the silicate layers. The most common guest species is water, which is generally present under natural conditions in layer silicates such as smectites, vermiculite and halloysite. From the outset, attention was focused on their swelling/shrinking behaviour with respect to water, and also on the non-stoichiometric, heterogeneous complexes they formed with organic liquids such as ethylene glycol and glycerol. At present, the unique combination of the layer-silicate features (small crystal size, high surface area) and the low concentrations necessary to effect a change in the matrix, both coupled with the advanced characterization techniques now available, have generated much interest for the special field of nanocomposites, as far as for graphene, which can also be considered as an intercalated layered structure. In general, any guest material inserted into an interlayer space causes a main modification in the structure, with size changes in a particular crystallographic direction (d-spacing). After a brief introduction on conventional and synchrotron-based X-ray techniques used to define crystal size and thickness, the essentials of the grazing-incidence diffraction (GIXRD) technique will be given. The additional, complementary information arising from X-ray absorption spectrometry (XAS) such as short-range order and detailed local information on atomic positions by angle-resolved X-ray near-edge structure (AXANES), polarized extended X-ray absorption fine structure (P-EXAFS), and near-edge extended absorption fine structure (NEXAFS) spectroscopies will also be analyzed and discussed.

J7-4 Orale Lacalamita, Maria

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CRYSTAL CHEMISTRY OF TRIOCTAHEDRAL MICAS-2M: FROM BUNYARUGURU (SW UGANDA) KAMAFUGITE

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Key terms: *Ugandan 2M-phlogopites; crystal chemistry; substitution mechanisms; Mössbauer; FTIR*

In trioctahedral micas, polytype 2M occurs less frequently than 1M one. For such a reason, trioctahedral 1M-polytype has been extensively studied up to date whereas studies on 2M-polytype are relatively rare. In several cases 2M-micas have been reported as coexisting with 1M-micas [1, 2, 3, 4, 5]. Other studies were focused on the characterization of phlogopite-anite 2M micas with peculiar composition [6, 7, 8, 9, 10]. The crystal chemistry of 2M micas from Bunyaruguru (south west Uganda) kamafugite was studied by Electron Probe Microanalysis, Single Crystal X-ray Diffraction, Mössbauer and Fourier Transform Infrared spectroscopy. To the best of our knowledge, this is the first integrated crystal chemical study of phlogopite from Ugandan kamafugites, and was undertaken to get an insight into the crystal chemistry of the trioctahedral mica 2M-polytype.

Chemical analyses showed that the studied crystals are Ti-rich, F-poor phlogopites with an annitic component, $Fe_{\text{total}}/(Fe_{\text{total}} + Mg)$, ranging from 0.15 to 0.23. Unit-cell parameters from single crystal X-ray data are in the range: $5.3252(1) \leq a \leq 5.3307(1)$, $9.2231(3) \leq b \leq 9.2315(3)$,

$20.1550(6) \leq c \leq 20.1964(8)$ Å and $94.994(2) \leq \beta \leq 95.131(2)^\circ$.

Anisotropic structure refinements, in the space group $C2/c$, converged to

$2.80 \leq R_1 \leq 3.56$ % and $2.91 \leq wR_2 \leq 4.08$ %. Mössbauer spectroscopy showed that the studied sample has: $^{57}Fe^{2+} = 60(1)$ %, $^{57}Fe^{3+} = 24(1)$ % and $^{57}Fe^{3+} = 16(1)$ %. FTIR investigations pointed to the occurrence of Fe³⁺-oxy substitutions and ruled out the presence of vacancy mechanisms. The overall crystal chemical features are consistent with the following substitutions: tetraferriphlogopite; Ti-oxy and Al, Fe³⁺, Cr-oxy; Al, Fe³⁺-Tschermak; kinoshitalite and $^{IV}K^{+} + ^{VI}Al^{3+} \leftrightarrow ^{IV}Si^{4+} + ^{VI}Al^{3+}$.

The estimation of the OH⁻ content for Ugandan mica-2M was obtained, for the first time, from the linear regression equation $c = 0.20(2) \times OH^- (\text{gpfu}) + 19.93(2)$ derived from literature data of 2M-samples with known OH⁻ content.

The orientation of the O-H vector with respect to c^* was found in the range from 2.8 to 12.6°, consistently with literature values [11].

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J7-5 Orale Elmi, Chiara

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CRYSTAL CHEMISTRY AND SURFACE FEATURES OF A 2M PARAGONITIC MUSCOVITE

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SESSIONE J7

I siti anionici nei fillosilicati: implicazioni cristallografiche, cristalochimiche e petrologiche

J7-1 Key Lecture Ferraris, Giovanni

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THE PHYLLOSILICATE LAYERS: AN OVERVIEW ON TOPOLOGY AND MODULARITY

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Key terms: *Phyllosilicates; Layers; Topology; Modular structures; Crystal Chemistry*

On the basis of the specific purposes of Symposium J7, the keynote aims to present an introductory overview on the structural characteristics of the phyllosilicate layers. With particular reference to the TOT layer, emphasis will be given to the features that support complex crystal chemistry, polytypism, polysomatism and twinning.

J7-3 Orale Mottana, Annibale

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ADVANCED TECHNIQUES TO DEFINE INTERCALATION PROCESSES

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Key terms: paragonitic muscovite; crystal chemistry; surface

The paragonitic muscovite considered $[(K_{1.722}Na_{0.255}Ba_{0.010})^{VI}(Fe^{2+}_{0.140}Al^{3+}_{0.789}Cr^{3+}_{0.003}Mg_{0.074}Ti_{0.012}Mn_{0.002})^{IV}(Al_{1.89}Si_{1.103})O_{20}(F_{1.09}OH_{1.891})]$ came from Antarctica, it is monoclinic, 2M₁ polytype, with symmetry C2/c and unit

cell parameters $a = 5.1969(1)$, $b = 9.0138(3)$, $c = 20.0835(7)$ (Å) and $\beta = 95.763(2)$ (°).

By using a multi-analytical approach this study describes the crystal chemical features of muscovite determined both in the bulk and on the uppermost surface layers.

The bulk structure was refined by single crystal X-ray diffraction and the final refinement yielded the following agreement factor $R = 0.0299$. The

two tetrahedral sites, T1 and T2, present similar distances ($\langle T1-O \rangle =$

1.643 Å and $\langle T2-O \rangle = 1.647$ Å) and distortion parameter values, thus evidencing a disordered distribution of ^{IV}Si and ^{IV}Al in tetrahedral sites.

Tetrahedral ring is significantly distorted ($\alpha = 11.2^\circ$) and the tetrahedral basal oxygen atoms plane is remarkably wavy ($\Delta z = 0.224$ Å). tetrahedral ring distortion affects not only the topology of the cleavage plane, but also the coordination of the interlayer cation, which reduces from twelve to eight.

Crystal chemical modifications at mineral surface were investigated via X-ray Photoelectron Spectroscopy (XPS), by comparing data related to surface to the ones characterizing the bulk.

A peculiarity of muscovite from Antarctica is a limited Na for K interlayer substitution, which was found in the bulk as well as on the mineral surface. It is well known that in micas the coordination of the interlayer cation can vary from twelve to six, depending on the distortion of the hexagonal tetrahedral ring, as measured by α angle, as observed and predicted by Weiss et al. [1].

The interlayer cation K (binding energy = 293.36 eV) is confirmed to be eight-fold coordinated [2]. Na (binding energy = 1071.02 eV) substitutes K both in the bulk and at the surface. Na coordination, at mineral surface, reduces from eight to six. The six-fold coordination presented by Na is consistent with $\alpha \approx 16^\circ$, which is typical for paragonite, whose interlayer is completely occupied by Na. Chemical composition at the surface was compared to bulk chemical composition obtained by electron microprobe analysis. This comparison highlights a decrease in K content, which can be explained by its location on the cleavage surface, since the cation is expected to be distributed equally along the two surfaces generated after cleavage, and an increase in Na which can be related to Na domains close to the cleavage surface.

These aspects may relate muscovite cleavage processes to the presence of "defects", or better inhomogeneities in layer crystal chemistry. This fact may thus suggest that Na content in paragonitic muscovite could not be only attributed to a solid solution mechanism, where this cation substitutes for K, but rather to the presence of Na-dominant clusters.

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J7-6 Orale Mesto, Ernesto

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MULTIMETHODIC INVESTIGATION OF COEXISTING 1M- AND 2M₁-MICAS FROM KASENYI (SW UGANDA) KAMAFUGITE

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Key terms: Ugandan 1M-2M₁ phlogopites; crystal chemistry; comparison in the 2M₁ setting

Several diffraction studies on coexisting 1M and 2M₁ polytypes have been carried out to date [1, 2, 3, 4, 5, 6] in order to draw informations on their differences by comparing unit layer structure and/or the crystal chemical details of the two polytypic forms. Some of the quoted studies contain implications on polytype formation in micas [1, 2].

In the present work, the crystal chemistry of 1M and coexisting 2M₁ micas from Kasenyi (south west Uganda) kamafugite was investigated by Electron Probe Microanalysis, Single Crystal X-ray Diffraction and Mössbauer spectroscopy. The aim of the present study is to compare crystal chemical and unit layer structural features of the coexisting polytypic forms and to make comparisons to literature data.

EPMA investigation yielded similar composition for 1M and 2M₁ polytypes. They are Ti-rich, F-poor phlogopites with an anionic component, $Fe^{2+}/(Fe^{2+} + Mg)$, of about 0.14. The room temperature Mössbauer spectrum of the sample yielded three Fe-species: $^{57}Fe^{2+} = 58(1)\%$, $^{57}Fe^{3+} = 23(1)\%$ and $^{57}Fe^{3+} = 19(1)\%$. A typical crystal chemical formula is: $(K_{0.96}Na_{0.04}Ba_{0.01})(Mg_{2.22}Al_{0.09}Fe^{2+}_{0.21}Fe^{3+}_{0.08}Ti_{0.28}Cr_{0.04}Ni_{0.01})(Si_{2.87}Al_{1.06}Fe^{3+}_{0.07}O)_{10.65}F_{0.05}OH_{1.30}$.

Average cell parameters are $a = 5.326$, $b = 9.224$, $c = 10.231$ Å, $\beta =$

100.06° for polytype 1M and $a = 5.325$, $b = 9.223$, $c = 20.206$ Å, $\beta = 95.08^\circ$ for polytype 2M₁. The interatomic distances are similar for the two polytypes and consistent with the relevant site chemistry.

The comparison among atomic coordinates of 1M and 2M₁ micas from this study and from the literature in the 2M₁ setting evidenced a remarkable agreement between all atomic coordinates, with the exception of the y values of the octahedral oxygen atoms. Specifically, the difference between y values was 0.004 in the study samples, 50 times the estimated standard deviations. Similar differences were found for the literature data [1].

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J7-7 Orale Curetti, Nadia

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ON THE CRYSTAL CHEMISTRY AND ELASTIC BEHAVIOUR OF A PHLOGOPITE 3T

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Key terms: phlogopite; high pressure; compressibility; single-crystal X-ray diffraction; synchrotron powder diffraction

The crystal chemistry and the elastic behaviour under isothermal conditions up to 9 GPa of a natural, and extremely rare, 3T-phlogopite from Traversella (Valchiusella, Turin, Western Alps) $[(K_{0.99}Na_{0.05}Ba_{0.01})(Mg_{2.66}Al_{0.28}Fe^{2+}_{0.21})[Si_{2.71}Al_{1.29}O_{10}](OH)_2]$ space group P3₁12, with $a = 5.3167(4)$, $c = 30.440(2)$ Å, and $V = 745.16(9)$ Å³ have been investigated by electron microprobe analysis in wavelength dispersion mode, single-crystal X-ray diffraction at 100 K and in-situ high pressure synchrotron radiation powder diffraction (at room temperature) with a diamond anvil cell. The single-crystal refinement confirms the general structure features expected for tri-octahedral micas, with the inter-layer site partially occupied (using the potassium scattering curve alone), iron almost homogeneously distributed over the three independent octahedral sites, and the average bond distances of the two unique tetrahedra suggesting a disordered Si/Al-distribution (i.e. $\langle T1-O \rangle \approx 1.658$ and $\langle T2-O \rangle \approx 1.656$ Å). The location of the H-site confirms the orientation of the O-H vector nearly perpendicular to (0001). The refinement converged with $R(F) = 0.0382$, 846 unique reflections with $F_o > 4\sigma(F_o)$ and 61 refined parameters, and not significant residuals in the final difference-Fourier map of the electron density (+0.77/-0.37 e-/Å³). The high-pressure experiments showed no phase transition within the pressure range investigated. The P-V data were fitted with a Murnaghan (M-EoS) and a third-order Birch-Murnaghan equation of state (BM-EoS), yielding: 1) M-EoS, $V_0 = 747.0(3)$ Å³, $K_{T0} = 44.5(24)$ GPa and $K' = 8.0(9)$; 2) BM-EoS, $V_0 = 747.0(3)$ Å³, $K_{T0} = 42.8(29)$ GPa and $K' = 9.9(17)$. A comparison between the elastic behaviour in response to pressure observed in 1M- and 3T-phlogopite is carried out.

J7-8 Poster Scordari, Fernando

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FLUOROPHLOGOPITE FROM MT. ETNA VOLCANO: CRYSTAL CHEMISTRY AND IMPLICATIONS FOR THE PHYSICO-CHEMICAL CRYSTALLIZATION CONDITIONS

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Key terms: Fluorophlogopite; 1M twin; single crystal X-ray refinement; EPMA; volatile-induced differentiation

In the present study, a systematic investigation of fluorophlogopite from Mt. Etna volcano (Italy) was performed. The mica sample studied here is among the most Fe- and Ti-rich fluorophlogopite found in nature. It occurs in a bonemoreitic lava from the prehistoric volcanic activity of Mt. Etna (post-caldera phase of the "Ellittico" volcano; ~15 ka BP)[1]. Fluorine-rich minerals are important indicators of the halogen activity in magmatic systems, so that their investigation offers the opportunity to get important information on the processes of magma differentiation acting in the shallow portions of the volcano plumbing system. This study was based on electron probe microanalyses (EPMA), and single-crystal X-ray diffraction (SCXRD).

EPMA data yielded the following chemical formula for the mineral under consideration: $(K_{0.817}Na_{0.148}Ca_{0.003})(Fe^{2+}_{0.535}Fe^{3+}_{0.004}Mg_{2.223}Al_{0.003}Ti_{0.227}Mn_{0.008})(Al_{0.958}Si_{3.042})O_{10}(Cl_{0.010}F_{1.388}OH_{0.152}O_{0.450})$. The X-ray analysis indicated that the sample represents an example of twinning of 1M polytype simulating the diffraction patterns of a 3T polytype [2]. Structure refinements, which was performed on three crystals using twin laws, converged at $R = 0.03-0.04$, with cell parameters in the range $a = 5.323-5.324$, $b = 9.219-9.222$, $c = 10.116-10.119$ Å, $\beta = 100.13-100.25^\circ$. Major substitutions are $OH \rightleftharpoons$

F^- , and the Ti-oxy substitution: $^{VI}M^{2+} + 2(OH)^- \rightleftharpoons ^{VI}Ti^{4+} + 2O^{2-} + H_2 \uparrow$. The replacement of OH with F⁻ affects mainly the octahedral sites reducing the misfit between tetrahedral and octahedral sheets. The short c parameter is due to the reduced repulsion between the interlayer cation and the hydrogen depleted anion site in O4. In the studied sample the structural effects due to the high-F content are enhanced by those due to oxy-type substitution. The crystal chemical features of this fluorophlogopite from the summit portions of Mt. Etna are intermediate between those from Biancavilla [3] and the Ti-rich fluorophlogopite from Presidente Olegario, Brazil [4]. Although the fluorophlogopite from Biancavilla and that studied here were found in products of the same eruptive period at Mt. Etna, the different structural and chemical features may reflect distinct physico-chemical conditions of crystallization. The Biancavilla fluorophlogopite occurs as phenocryst together with the "classical" Etnean mineral assemblage, whereas those of the summit portion crystallized inside the lava vesicles during the post-eruptive phases [1]. In the last instance, the fluorine available during crystallization of fluorophlogopite crystals should be lower than that of the active Biancavilla lava domes, where the continuous volatile flux by halogen-rich fluids may have brought to such fluorine enrichment. The anomalous high Fe content of the studied fluorophlogopite may have been inherited by the lower degree of differentiation of the hosting lava than that of the Biancavilla volcanic rocks.

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J7-9 Poster Diella, Valeria

10.1474/Epitome.04.0810.Geoitalia2011

INFLUENCE OF UNCERTAINTIES AFFECTING ELASTIC PARAMETERS ON THE GIBBS ENERGY CALCULATION: THE CASE OF 3T - 2M₁ PHENGITEPAVESE Alessandro¹, DIELLA Valeria²

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Key terms: elastic parameters; deformation energy; 3T-2M₁ phengite

The stability of 2M₁ (S.G. C</>2/c) versus 3T (S.G. P3:12) polytype is dependent on the P/T ratio of formation: large P/T values are supposed to promote crystallisation of 3T phengite, presumably because of 3T having a more flexible structure than 2M₁ to arrange cations in the octahedral sheet. In fact, the trigonal polytype provides two symmetry-independent octahedral sites (M2 and M3), against only one in 2M₁. (Ferraris and Ivaldi 2002 and references therein). All this is related to the occurrence of cation order, which Pavese et al. (2003 and references therein) have extensively investigated by neutron powder diffraction. However, the stability of 3T vs. 2M₁ phengites is still an open question. On the basis of experimental works (Curetti et al. 2006, Gatta et al. 2010) we infer that the stability of 3T increases as a function of P, though the Gibbs energy difference between the two polytypes still keeps small. Such a behaviour is due to that K'(3T) < K'(2M₁), and K₀(3T) is very similar to K₀(2M₁): at sufficiently high pressures 2M₁ becomes less compliant to P than 3T, and therefore the deformation energy contribution to the Gibbs energy is supposed to favour the latter. The relative stability between trigonal and monoclinic polytypes remains a matter of thermodynamic inference. In this view, hence, the ability to fix the uncertainty on the elastic properties, and to determine how it propagates onto the calculated deformation energy, is a fundamental step to support any prediction of stability of a given polytype at high pressure. In a study about the accuracy of the calculated Gibbs energy, depending on the uncertainties on elastic parameters (bulk modulus, its first derivative versus pressure and molar volume) we revised the relative stability, controlled by pressure, between 3T-2M₁ phengite. Above a few GPa the uncertainty due to the deformation energy and dependent on the parameters governing the equation of state grows the dominant contribution to the total uncertainty on G(T,P), and it is imperative to make efforts to abate the uncertainties on K₀ and K' so that one can achieve fully distinguishable deformation energy contributions. Using another approach to discuss on how to manage the role of the elastic properties in the relationship between polytypism and stability for phengite 2M₁ and 3T, we developed the general concept of "distinguishability" between sets of elastic parameters used to calculate the contribution of deformation to the Gibbs energy. This notion bases on that different contributions of deformation are actually observed if the related elastic parameters sets lie in the K₀-K' spaces sufficiently apart, in terms of a variational principle formulated using the experimental uncertainties. The results of the comparison between the two polymorphs of mica showed that a P increase does favour their distinction and promote the stabilization of 2M₁: even if this behaviour is appreciable only in the high pressure, a regime very different from the actual field of stability of micas but that stresses the role of pressure in differentiating the two polytypes. Once more the large errors that affect the elastic observables and the relevant proximity between the elastic parameters are responsible of the difficulties in distinguishing the behaviours of the considered polytypes off ambient conditions.

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J7-10 Poster Schingaro, Emanuela

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3T-PHLOGOPITE FROM KASENYI (SW UGANDA) KAMAFUGITE: CRYSTAL CHEMISTRY AND STRUCTURESCHINGARO Emanuela¹, SCORDARI Fernando¹, LACALAMITA Maria¹, MESTO Ernesto¹

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Key terms: 3T trioctahedral mica polytype; Single crystal X-ray refinement; crystal chemistry

3T trioctahedral micas are rarer than it is thought. This is likely due to the occurrence of apparent polytypism, so that 1M polytype twins result in a diffraction pattern simulating a 3T periodicity [1, 2]. Most of the 3T trioctahedral micas found in nature to date belong to muscovite-polythionite-annite system [3, 4, 5, 6]. X-ray diffraction studies on these micas have often reported partial tetrahedral ordering and/or different patterns of octahedral ordering [3, 6]. In the present work, a 3T trioctahedral mica from Kasenyi (south west Uganda) kamafugite was studied via Electron Probe Microanalysis (EPMA) and Single Crystal X-ray Diffraction (SCXRD). Main EPMA data gave: SiO₂ = 38.7(2), Al₂O₃ = 13.08(9), MgO = 20.4(2), TiO₂ = 4.8(1), FeO_{tot} = 5.51(9), Cr₂O₃ = 0.90(7), K₂O = 9.64(5), Na₂O = 0.29(1), BaO = 0.15(5) and F = 0.13(5) wt%. The analysed crystal may be classified as a Ti-rich, F-poor mica with a composition intermediate between the annite and phlogopite end members. Anisotropic single crystal X-ray refinement was performed in the P3:12 space group and converged to R₁ = 4.34 and wR₂ = 3.33 %. Unit cell parameters were: a = b = 5.3235(3) and c = 30.188(2) Å. Mean bond length distances of M1, M2 and M3 follow the pattern M1 = M2 < M3, suggesting partial octahedral cation ordering. Conversely, mean bond

lengths of T1 and T2 point to a disordered cation distribution over tetrahedral sites.

Finally, the overall crystal chemical features indicates the occurrence in the studied sample of the following substitution mechanisms: tetraferriphlogopite; Ti-oxy and Al, Fe³⁺, Cr-oxy; Al, Fe³⁺-Tschermak;

kinoshitalite and $^{39}K^{+} + ^{27}Al^{3+} \rightleftharpoons ^{29}Si^{4+} + ^{39}Ca^{2+}$. Such substitutions are the same as those found in 1M-2M₁ coexisting micas from the same rock sample [7].

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J7-11 Poster Elmi, Chiara

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LAYER CHARGE LOCATION IN LAYER SILICATES AND ITS IMPLICATIONSELMI Chiara¹, BRIGATTI Maria Franca¹, Malferrari Daniele¹

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Key terms: Layer charge; muscovite; heterovalent substitutions

Layer charge value and location are commonly considered key factors for predicting interaction of layer silicates with external agents, such as, for example, pollutants, bio-molecules, and, more generally, ionic complexes. Several methods are discussed in literature for the experimental determination of layer charge, always, however, giving an average value from the different micro-crystals used for the analysis. The most commonly used methods are: the structural formula method [1, 2], the alkylammonium method [3] and the potassium saturation method [4]. The purpose of this paper is to demonstrate that the determination of the average value of the layer charge can sometimes lead to inconsistent results, as not correctly representing the layer charge location at mineral surface. This goal was achieved by analyzing crystal chemical results obtained from different crystals of muscovite characterized by a different content of celadonitic substitution. Muscovite sometimes presents heterovalent substitutions both in tetrahedral (e.g., Al³⁺ for Si⁴⁺) and in octahedral sites (e.g., Mg²⁺, Fe²⁺, and vacancies for Al in octahedral sites). Our results seem to demonstrate that these substitutions can be ascribed to trioctahedral cells, all occupied by cations different than Al, in a dominating dioctahedral pattern, with *cis*-octahedral sites entirely occupied by Al and the *trans*-site vacant. This interpretation suggests that mean layer charge may not represent effective layer charge at mineral surface because it refers not to randomly distributed substitution, but to domains showing different chemistry which can be locally charge-neutralized. Furthermore, also distortion parameters which affect tetrahedral topology and that can also affect the formation of surface complexes, such as α angle and Δz oxygen plane flattening, can be different inside a same structure and locally not corresponding strictly to the determined mean value via single crystal diffraction.

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J7-12 Poster Brigatti, Maria Franca

10.1474/Epitome.04.0813.Geoitalia2011

CRYSTAL CHEMISTRY OF LIZARDITE-17 FROM NORTHERN APENNINES OPHIOLITES (ITALY)LAURORA Angela¹, BRIGATTI Maria Franca¹, Malferrari Daniele¹, GALLI Ermano¹, RÖSSI Antonio¹, FERRARI Massimo²

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Key terms: lizardite; ophiolite; crystal chemistry; exchange mechanisms; metasomatism

This study investigates the crystal chemical features of six lizardite-17 crystals sampled in four ophiolitic outcrops (Pompeano, Sassomorello, Varana, and Santa Scolastica) in the Modena Apennines (Italy). Notwithstanding the extensive contributions already present in literature, this is the first study dealing with lizardites from Modena ophiolites. As evidenced by one of our samples, the whole rock composition affects lizardite composition, which results to be sensible to the overprint of secondary, metasomatic events. In our study, particular attention was devoted to the effects of octahedral Fe for Mg and of Si-Al(Mg,Mn,Fe)²⁺¹ (Al,Cr,Fe)³⁺ exchange mechanisms on the structure. Our results suggest that Fe for Mg substitution induces an increase in the octahedral M-04 length, and a decrease in the octahedral site distortion. Both these effects are also observed to influence unit-cell parameter c. The effect of the Si⁴⁺

Al(Mg,Mn,Fe)²⁺-(Al,Cr,Fe)³⁺ substitution is a decrease in the M-O1 distance and a concomitant increase in the T-O1 distance.

J7-13 Poster Sciascia, Luciana

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ADSORPTION OF WATER MOLECULES ONTO 1:1 DIOCTAHEDRAL CLAY MINERALS: A BADER'S TOPOLOGICAL ANALYSIS OF THE AB-INITIO ELECTRON DENSITIES

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Key terms: kaolinite; dickite; adsorption; ab-initio; Bader's topological analysis

The interaction between water molecules and clay minerals has been investigated by means of ab-initio computational methods. The interest in this field comes from the considerations that water-clay systems play a central role both in natural and industrial processes. Clays, as natural inorganic component of soils, significantly affect transport, distribution, and stability of dissolved chemical species. In this context, special focus has to be paid to toxically active species, such as radionuclides, pesticides, heavy metals. Clays also found a lot of industrial applications as effective storage materials for nuclear waste or as potential catalysts for refining processes used in the oil industry. In many of the above processes, water plays a crucial role as a natural solvent and as a transport medium for chemical species, therefore the understanding of the structure and chemistry of the water-clay interface is of considerable importance. In spite of the great number of experimental investigations in this field, a thorough understanding of clay mineral-water interactions is still lacking. Computer simulation techniques can provide interesting insight concerning a structural characterization of adsorption sites and of interactions between surfaces and adsorbed molecules at the molecular level. In the light of these considerations, the present computational study has been undertaken in order to make a theoretical characterization of each compound and then to get strategic information in predicting its behavior. In particular, we decided to investigate two polytypes of the kaolinite group, namely kaolinite and dickite, since it is well known that the holes in the tetrahedral and octahedral surfaces of these structures are favorable interactions sites for adsorption of different molecules.

Bulk and slab geometry optimizations have been performed and the topology of the electron density and its Laplacian distribution have been studied on the basis of Bader's 'Atoms In Molecules' (AIM) theory to determine the conditions required for the adsorption of different organic molecule on the tetrahedral and octahedral surfaces of the mineral. The analysis of the Laplacian critical points allowed to recognize the reactive sites of the structures and provided an efficient tools that guides in the determination of the sites of adsorption and of the geometry of the reactant relative to the surface site. The results of this analysis indicated that the octahedral and tetrahedral holes in both basal surfaces are favorable interaction sites for adsorption of small polar molecules and that the electronic reactivities of the two different polytypes are very similar, which means that the chemical behavior of the analyzed structures is comparable.

In a second step, in order to test the possibility of absorbing water in each position predicted by the topological analysis the geometrical optimization of mineral-water system has been performed.

The information coming from both the theoretical prediction of the reactivity of the molecules involved and the simulated structural and energetic features of the investigated system actually represent an engineering approach that can allow to "calibrate" the experimental work as well as to explain the experimentally observed behaviors. Moreover, this kind of data base actually represents a good "launching pad" for all the subsequent theoretical simulations of the interactions between clay minerals and different guest molecules of interest.

J7-14 Poster Malferrari, Daniele

10.1474/Epitome.04.0815.Geoitalia2011

CHARACTERIZATION OF GENTAMICIN-BENTONITE COMPLEX

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Key terms: MONTMORILLONITE; BENTONITE; GENTAMICIN; THERMAL ANALYSES; DRUG CARRIER

Clays are common ingredients in pharmaceutical and cosmetic formulations, used as active substances (gastrointestinal protector, osmotic oral laxatives, anti-diarrhoeals, topical antibacterials and anti-inflammatories) and excipients in solid (tablet, capsules, powder), liquid (suspensions, emulsions) or semisolid (ointments, creams) forms. The present work aims to evaluate the intercalation of gentamicin molecules into a montmorillonite rich clay (i.e., bentonite, here after BNT) to obtain a drug delivery carrier for antibiotic treatment in a perspective to decrease gentamicin side effects and to improve systemic adsorption. In addition clay antibacterial activity could produce a synergistic effect. BNT-gentamicin complexes, obtained via a batch treatment, were characterized by chemical analyses, thermal analyses (thermogravimetric and thermo-differential) coupled with evolved gasses mass spectrometry, and X-ray powder diffraction at non-ambient temperature conditions. Chemical analyses indicates that gentamicin is adsorbed by the clay in a percentage varying between 2.0 and 2.3 (weight %) in relation to the pH of the treating solution. Thermal analyses show that the gentamicin treatment influences both the dehydration and the dehydroxylation reactions of montmorillonite and, in particular, highlights that in the treated sample the dehydroxylation reaction related to cis-vacant sites is shifted to an higher temperature respect to the natural clay. Basal periodicity was measured via XRPD diffraction on (001) oriented mounts of the air-dried samples in the temperature range 25- 400°C (heating rate 2 °C/min) using a powder diffractometer equipped with an area detector. In the natural sample the layer periodicity reach the closest 2:1 packing (i.e., 0.99nm) at about 160°C, whereas this value in the gentamicin treated sample is reached only after 400°C (i.e., after the thermal decomposition of the organic molecule).

J7-15 Poster Malferrari, Daniele

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SODIUM HEXAMETAPHOSPHATE INTERACTIONS WITH ILLITE AND MONTMORILLONITE: PRELIMINARY OBSERVATION ON THERMAL BEHAVIOR

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Key terms: DEFLOCCULANT; ILLITE; MONTMORILLONITE; SODIUM HEXAMETAPHOSPHATE; THERMAL ANALYSES

The interaction of an efficient deflocculant, sodium hexametaphosphate (NaHMP), with two different illites (IMt-1 from Silver Hill, Montana USA and from Schwäbisch Hall, Württemberg Germany) and two different Ca-montmorillonites (STX-1 from Gonzales County, Texas, USA and from Santa Rita, New Mexico, USA) was investigated.

Adsorption measurements of the NaHMP anion were performed on Na-exchanged illite IMt-1 as a function of temperature by means of inductively coupled plasma technique (I.C.P.). The thermodynamic parameters of the adsorption process, together with an estimation of the maximum adsorbed amount on the Na-illite were obtained and compared to the corresponding data previously obtained for Na-kaolinite.

The effect of NaHMP on the natural illites and montmorillonites was analyzed using different techniques. I.C.P. measurements of the concentration of P, Na, Si, Al, Ca, Mg, and K of the deflocculant solutions in contact with the clays were performed in order to detail the adsorption, dissolution and exchange phenomena which accompany the deflocculant activity.

Thermal analysis (thermo-gravimetric, thermal-differential) and XRD measurements at non ambient temperature conditions were used to characterize the clay solid samples after the interaction with NaHMP. Thermo-gravimetric analyses indicate that NaHMP-treated illites and montmorillonites are less hydrated than natural samples, whereas the dehydroxylation reaction seems to be not influenced by the NaHMP treatment. Basal periodicity was measured via XRPD diffraction on (001) oriented mounts of the air-dried samples in the temperature range 25 - 400°C (heating rate 2 °C/min) using a powder diffractometer equipped with an area detector. No significant variation of layer periodicity was observed, thus indicating that NaHMP molecules are adsorbed on the edge and/or in the interlayer without modifying natural layer periodicity.

J7-16 Poster Brigatti, Maria Franca

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TEXTURAL STUDY OF METAMORPHIC ROCKS BY MEANS OF A CONVENTIONAL X-RAY SOURCE

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Key terms: morphological preferred orientation; metamorphic rocks; textures; X-ray diffractions; phyllosilicates

The aim of this study is the textural characterization of very low to greenschist facies metamorphic rocks by means of a conventional X-ray source, possibly establishing a relationship between the extent of morphological orientation of mineral grains and metamorphic degree. For a long time geologists investigated the morphological orientation of mineral grains in polycrystalline rocks by means of petrographic microscope equipped with a Universal stage. More recently diffraction of conventional X-ray sources as well as diffraction (or transmission) of hard X-rays, electrons and neutrons has been applied to these kind of study. However, whereas X-ray conventional sources can be regarded as a routine technology, hard X-ray, electron and neutron sources are only available in a few facilities around the world.

Phyllosilicates such as smectite, illite, muscovite, chlorite and biotite play a key role in the textural characteristics of the mineral assemblages of rocks characterized by increasing metamorphic degree. The present study is focused on the variation of the X-ray intensities of selected reflections of these phases. In short, if a morphologic orientation of the grains of a certain phyllosilicate is present, a variation of the intensity of these reflections will be measured when the rock sample is rotated in a goniometer keeping constant both the incident beam angle and the position of the detector.

The samples selected for the study are the following: 1) a Ms, Chl, Qtz, Pl fine grained metapelite from Frassenetto (UD, Italy) (very low grade metamorphism, Anchizone) with some detrital muscovite flakes recognizable by their coarser grain size; 2) Ms, Chl, Qtz, Pl fine grained metapelite from Chiadenis (UD, Italy) (low grade metamorphism, Epizone) with some detrital muscovite flakes recognizable by their coarser grain size; 3) a Ms, Chl, Ilm, Qtz, Pl layered phyllite from Villabassa (BZ, Italy) (Greenschist facies metamorphism, Ms-Chl-Bt), with crenulated main foliation and axial planes defining a second spaced foliation; 4) a Ms, Bt, Grt, Ilm, Qtz, Pl layered phyllite from Luson (BZ, Italy) (Greenschist facies metamorphism, Ms-Bt-Grt), with crenulated main foliation and axial planes defining a second spaced foliation.

SESSIONE K1

Patrimonio culturale

K1-1 Orale Massacci, Giovanna

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DIAGNOSTIC AND PETROGRAPHIC INVESTIGATIONS FOR THE RESTORATION AND SEISMIC REHABILITATION OF THE CHURCH OF S. AUGUSTINE IN OFFIDA (AP, ITALY)

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Key terms: materials; mortar; non destructive diagnostics; thermography; sonic tests

This work deals with the petrographic and archaeometric studies and the non destructive and non invasive diagnostic tests done on the S. Agostino church in Offida (province of Ascoli Piceno, Italy); these activities are propaedeutic to strengthening structural interventions to improve the building seismic response.

The Church is a large building, made of bricks, whose construction started in 1338 and finished in 1441 and, as a first step, its history has been fully studied and an architectonic survey conducted.

Petrographic and archaeometric study of stone and lithoid materials (bricks and mortars) has been conducted to investigate the composition and conservation state of the travertine employed for the main portal, and of terracotta romanico-gothic decorative elements positioned on the upper part of the north façade; beside this, the lithological typology of materials and their provenience have also been investigated, in order to increase the historical and artistic knowledge of the building. Also the characteristics of inerts and binders employed for the mortars have been analyzed, along with the employed raw materials (mainly clays, sands and other incoherent substances). A methodology has thus been developed that has led to a high resolution screening of materials and a detailed determination of provenience areas. In the end, comparative analysis of geo-materials and lithoids has made possible to identify alteration processes and to individuate best conservative actions, procedures and materials for gradual cleaning and restoration interventions. Physical/mechanical diagnostic tests have been addressed to the evaluation of both the structural consistency of the building and the presence of excessive humidity; tests have been conducted inside the building, with an extensive thermographic survey and localized evaluations of masonry humidity content, and outside the building, again with a thermographic survey and sonic tests, the latter ones applied on important cracks on the main and north façades. Tests have thus revealed the presence of critical structural areas, rain infiltrations from the roof and a diffused presence of raising dampness; the integration of these investigations with the petrographic ones and with the historical and architectonic surveys has thus been possible to formulate an accurate plan for the restoration and the seismic response improvement of the ecclesiastical building.

K1-2 Orale Giammartini, Barbara

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A VIRTUAL RESTORATION OF THE MAIN FAÇADE OF ST. GIULIANA CASTLE (UMBERTIDE, ITALY) THE USE OF COMPUTER APPLICATIONS IN RESTORING A CULTURAL HERITAGE

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Key terms: virtual restoration; archaeometric analysis; medieval castle; N-W Umbria (Italy)

Virtual restoration, is the set of calculations performed with the help of two-dimensional or three-dimensional computer graphics for reconstructing an artwork or building. This can provide a set of hypothesis for actual intervention.

The medieval castle of St. Giuliana (XIII-XIV century A.D.), is one of the best examples of a fortified settlement located on Mt. Corona (708 m a.s.l.), situated near the town of Umbertide (N-W Umbria, Italy). The virtual restoration performed on the main façade shows us how the archaeometric analysis of the building is essential for a correct restoration of it.

The analysis of macroscopic, microscopic and geochemical characteristics was carried out on samples of the materials in place on the façade of the castle. This allowed a precise identification and characterization of these materials and of their provenience (in the Municipality of Umbertide). On such a basis it was possible to propose a proper active restoration through the use of materials compatible with the original.

The main façade built with stones of local origin, shows the use of sandstone and limestone belonging to the Umbria-Marche stratigraphic succession.

A lithological mapping of the materials of the façade has allowed a quantitative estimate showing that the prevailing natural stones, are represented by limestone belonging to the Scaglia Rossa and Maiolica formations. In addition, there are also samples of Scaglia Variegata and Marnoso Arenacea formations which, together with bricks, were used in the various stages of restoration, carried out over the years. These casual materials, or those readily available locally, changed the original look of the façade.

An important part of the wall was altered by the misuse of mortar that was literally "spread" over a few ashlar. This was used as gap filler replacing the original stones. Part of the wall has succumbed to alteration phenomena such as black crusts, and some ashlar show fractures by climbing plants.

The virtual restoration, using CAD "Computer Aided Design" and graphic processing of the images software, has allowed the creation of a digital clone of the monument on the basis of the archaeometric studies that were carried out.

A working hypothesis regarding a project intervention was made, which involves the exchange of mortar and materials improperly used with the original ones and the cleaning of masonry surfaces from black crusts and climbing plants. It appears that similar processes of study and analysis are essential today for restoration work.

K1-3 Orale Carabetta, Maria Teresa

10.1474/Epitome.04.0820.Geoitalia2011

PETRO-ARCHAEOLOGY OF MEDIEVAL ORNAMENTAL MATERIALS FROM THE NORMAN-GOTHIC MESSINA CATHEDRAL (SICILY, ITALY)

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Key terms: Norman-Gothic Messina Cathedral; original lower order of façade; Middle Age ornamental materials; sedimentary and metamorphic rocks; petro-archaeometry

The present research has enabled the determination of the petro-archaeometry of the ornamental slabs and mosaics characterizing the lower order of the Messina Cathedral façade. This paper also discusses the origin of these decorative materials which have never been documented in the historical reconstruction.

This Basilica, only second in majesty to the Palermo Cathedral in Sicily, was erected between 1120 and 1168. It was rebuilt many times because of several anthropic and natural calamities, with continual stylistic and architectural modifications.

The present edifice, reconstructed in 1929, exhibits a Latin Cross plant in the three naves.

The façade is divided into two orders: the upper is sober and completely restructured, the lower exhibits three Norman-Gothic portals with Renaissance decorative elements, and a Late-Middle Age polychrome ornamental covering.

The sculptures of column-bearing lions situated on both sides of the central portal are ascribed to the Romanic Epoch, the ornamental covering to 1320, and the elements of the portals (bas-reliefs, aedicles, string-courses and statues) realized between 1468 and 1640.

In the covering, characterized by a geometrical ornament, there is a 9 repetitive pattern of 1 to 4 horizontal cross-sectional bands of rock slabs and floral polychrome inlays of heterogeneous tesserae. The pattern has been also used in the lateral arcs, and in two old portals. The same decorative materials are used on the landing and the entrance steps to the Cathedral.

In the ornamental stones, mesoscopic and microscopic features allow carbonates, metacarbonates, metaultramafics and metamafics to be recognized.

Among the 11 types of green to grey-greenish metaultramafics and green to pale-green metamafics characterizing the slabs and mosaic tesserae of bands 2 and 4, respectively, three petrographic groups were selected for a first chemical investigation (mineral chemistry and Major oxides and trace element analyses). Data indicates that the first two groups are Tholeiitic Within Plate metaperidotites and metahornblendites. Metaperidotites record three metamorphic processes, documented by forsterite+enstatite+magnetiteI, antigorite+antophyllite+magnetiteII and tremolite+Fe-antigorite+clinochlore parageneses. Metahornblendites are made up of Fe-pargasite+titanite. The third group consists of Na-Alkaline Within Plate Pl-metahornblendites, characterized by Mg-hastingsitic hornblende+oligoclase+quartz.

The compositional and evolutive history recognized in each group supplies important constraints for their geological provenience. This has been confirmed by the petrographic and chemical comparisons with similar rock types of the Peloritani Mts. (Calabria-Peloritani Arc), and specifically with metaperidotites and metahornblendites of the Aspromonte Unit and Pl-metahornblendites of the Mela Unit, sampled in specific relict quarry sites near Messina.

Among the four types of carbonates characterizing slabs and mosaic tesserae of bands 1 and 4, respectively, three petrographic groups were selected: two limestone groups and a dolostone one. The reddish limestones have been classified as micritic wackestones containing re-crystallized bioclasts, ankerite and iron oxides and hydroxides; the grey carbonates are dolostones. Both rock types come from the Mesozoic carbonatic platform of the San Marco d'Alunzio Unit (Pliensbachian), according to comparisons made with analogous rocks sampled in known quarry sites around San Marco d'Alunzio village (W Peloritani Mts.). The whitish limestones are sparitic grainstones which come from the Mesozoic cover of the Piraino Unit, sampled in meter-thick Mesozoic slice sites to the west of Ali (south of Messina).

The whitish metacarbonates characterizing slabs and mosaic tesserae of bands 3 and 4, respectively, are fine-grained muscovite marbles from the Mela Unit basement, as indicated by comparisons with similar rocks sampled in old caves in the Mela Valley (NE Peloritani Mts.).

K1-4 Orale Massacci, Giovanna

10.1474/Epitome.04.0821.Geoitalia2011

ARCHAEOLOGY OF ROCK TESSERAEE FROM THE MOSAICS, MORTARS AND PLASTERS OF THE ARCHAEOLOGICAL SITE OF GRUMENTUM (BASILICATA, ITALY)

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Key terms: mosaics; opus tessellatum; sedimentary and volcanic rocks; mortar; archaeometry

This study is dealing with archaeometry of the rock tesserae from mosaics (opus tessellatum), mortars and plasters characterizing the archaeological site of Grumentum (Alta Valle D'Agri, Basilicata, Italy), a Roman settlement with orthogonal roads and protected by walls, dating back to the III century BC (Grumentum I, Regio III; Lucania et Bruttii).

Grumentum represented for the Romans an important military centre during the Sannitic wars, being located in a strategic area between the Tyrrhenian and Ionian Seas, at the intersection between Via Herculea (coming from Venusia and Potentia to Taranto) and Via Popilia (towards Reggio Calabria). According to the archaeological literature, the main monumental complexes are represented by the "Domus of Mosaics" (a typical Roman house with opus tessellatum, atrium and peristyle dating back to the first half of the II century AD) and the thermae of Republican and Imperial age. Although the chronological reconstruction of the archaeological site is not yet well defined, the thermae utilization should have spread from the second half of I century BC to V century AD. The main entry of the thermae was constituted by an apodyterium with a black and white opus tessellatum, showing numerous fish species, tritons and a marine monster (Scylla) at the centre of the mosaic. Through the apodyterium it was possible to get to the frigidarium, a wide rectangular room with polychromatic opus tessellatum showing plants and geometric patterns. The thermae were also constituted by three rooms heated by two tepidaria and one calidarium where a two-color opus tessellatum with geometric patterns is still visible on the floors.

Preliminary petrographic and archaeometric investigations were mainly focused on the the rock tesserae from the mosaics (sedimentary and volcanic lithotypes), mortars and plasters. As concerning the white sedimentary tesserae from the mosaics, they consist of micrites coming from the Mesozoic limestone platform of the Alburno-Cervati Unit. Gray sedimentary tesserae are represented by microsparitic marly limestones coming from the chert-bearing limestones of the Lagonegro Units,

belonging to the Upper Trias. Red to pink tesseræ are of sedimentary origin as well, represented by a slightly marly, fine-grained limestone which can be classified as a pelagic, fossil-rich, micritic lime-mudstone also containing fine-grained detrital grains of quartz, clay minerals, iron oxide and hydroxides. Red to pink tesseræ should come from the fine-grained calcareous turbidites which characterize, among the Lagonegro Units, the Cretaceous-Oligocene "Red Flysch" Formation. Black volcanic tesseræ consist of leucite-bearing tephrite lavas with low porphyritic index, probably belonging to the Vesuvius or Vulture volcanoes, respectively 135 km to WNW and 75 km to NNW from Grumentum. Major oxides and trace element analyses of the volcanic tesseræ are in progress and should define, according to their chemical fingerprint, the belonging to one of these two volcanoes. Cocciopesto-bearing mortars of the "Domus of Mosaics" were also studied. This allowed a comparison between the red mortar of the Republican thermæ, mainly consisting of volcanic fragments and various types of cocciopesto and that of the Imperial thermæ, constituted by clots of lime putty, quartz and carbonatic fragments. FT-IR spectrophotometry investigations of the red and yellow plasters of the Republican thermæ pointed out the presence of As, Cu, Sr e Mn. Orpiment (As₂S₃) and realgar (As₂S₂) should therefore represent some of the raw materials used in the plasters to obtain the yellow and red colours respectively.

K1-5 Poster Fiore, Antonio

10.1474/Epitome.04.0822.Geoitalia2011

SAFEGUARD OF THE UNDERGROUND ENVIRONMENT, AS A PART OF THE CULTURAL HERITAGE: NEW PERSPECTIVES IN APULIA

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Key terms: caves; safeguard; monitoring; cultural heritage; exploitation

The Apulia karst region shows as main peculiarity the presence of a high number of underground caves, both of natural and anthropogenic origin. Many caves are a significant, if not remarkable, part of the cultural heritage, for their historical and archaeological importance, and/or due to the remains they host. The latter range from man's artifacts, to palaeontological and anthropological remains as the burial in the S. Maria di Agnano cave at Ostuni (a woman in advanced state of pregnancy, dated back to Musterian time) or the bones entirely covered by speleothems of the pre-Neanderthal Altamura Man in the Lamalunga Cave. In addition, many anthropogenic caves are of great importance too, having been for centuries worship sites, decorated with hundreds of frescoes representing saints and holy figures and themes. These are only a few of the many examples which are present in Apulia, and represent a huge value of the local cultural heritage.

Safeguard of this heritage is not an easy task to be reached, due to many reasons, including but not limited to complexity of the underground environment, which results often in heavy difficulty in properly monitoring its main parameters. The recent regional code, established in 2009 by Apulia Region, entitled "Safeguard of the geological and speleological heritage" (Regional Law no. 33) marks an important date in the perspective of protection and exploitation of the underground caves, including (for the first time in an Apulian regional law) those of anthropogenic origin. As a matter of fact, the law allows the possibility of cave exploitation, once their stability conditions, and therefore the safety of likely visitors, had properly been taken into account.

To obtain this goal, monitoring of the cave conditions is mandatory to any activity. Monitoring should include measurements of the main micro-climatic parameters (temperature and relative humidity), plus control of the presence of gases such as carbon dioxide and radon, and of their variations as well. In case of on going or potential stability problems, a specific monitoring program should also be considered, aimed at controlling the discontinuities and/or sectors of the cave identified as the most dangerous. Choice of the monitoring type (manual versus automatic), the sensors to be used (type, sensitivity, measurement ranges, etc.), and the selection of the points to monitor is extremely delicate. Design of the monitoring system has to be carefully planned, possibly following a preliminary collection of data which might help in better defining the final system.

Some considerations about this matter, which is still at a very initial stage of development in Apulia, are presented in the paper, as a first contribution to the best definition of monitoring standards and rules to be adopted in a very peculiar setting as the underground environment.

K1-6 Poster Spizzichino, Daniele

10.1474/Epitome.04.0823.Geoitalia2011

LANDSLIDE RAPID ASSESSMENT IN THE SIQ OF PETRA, JORDAN

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Key terms: Landslide; Petra; rock fall

Rapid onset natural phenomena, such as earthquakes, floods and landslides, pose a major threat to cultural heritage and visitors in Petra. In 1963, 24 tourists died as a result of a sudden flash-flood in the Siq. Assessing the percentage of losses caused by each specific event is very difficult, and whereas earthquakes and floods cause damage to large expanses of land, landslides act more locally, affecting only a specific area and in this the Siq, hence the focus of this research. The Siq is a 1.2 km naturally formed gorge in the sandstone mountains that served, during the Nabataean times, and still serves today as the main entrance to the site of Petra (Jordan), from the urban area of Wadi Musa. It is formed by very steep slopes with variable height from the ground level, from few meters at the entrance to several tens of meters in some areas of the path. The Siq and the hand-carved monuments of Petra are constituted by the sandstones of Umm Ishrin and Disi Cambrian-Ordovician formations, in the form of massive and/or poor stratified rocks. The structural setting of the rock-forming slopes are characterised by discontinuities of various type, mainly related to stratigraphical setting (bedding, generally horizontal), tectonic activity (faults and joints, vertical and inclined), geomorphological evolution of the slope (sub-vertical joints). Such a structural condition determines a rock-fall potential activity that may

involve unstable volumes that may range from from 0.1m³ up to over 1000m³. The latter can be catastrophic according to evolution of the movement (extremely rapid) and involved rock mass volumes. Recent events has involved the rapid deformation of a block located on the south slope of the Siq, approximately 300m from the entrance in a particularly narrow stretch of the Siq, requiring that visitors walk very close to the high risk area. Additionally, during May 2009 a smaller rock (approx. 150kg) detached from the slope and fell to the ground in the area of the Camel Caravan relief. The collapse occurred during the night and fortunately did not result in injuries or fatalities. Due to the acceleration of crack deformation and consequent increasing of rock-fall hazard conditions in the Siq, UNESCO and Jordan local authorities have promoted a project focused on the implementation of a landslide hazard and risk analysis of the Siq as a fundamental tool for the conservation strategy of the site. The first stage of the project has provided the definition of the structural and geological typologies of decay as well as actual and potential instability conditions of the geological formations and selected monuments. The study has been based on data collection by accurate field survey and data analysis and mapping. The first stage has been focused on an in-depth assessment of landslide risks that affect the Siq and its monuments based mainly on engineering geology field survey techniques. All data have been analysed by implementing structural modelling that will provide landslide types identification and kinematics as well as a landslide hazard map. Several thematic maps have been produced such as potential rock-fall inventory map, rock-fall hazard map, vulnerability and risk maps vs. slope instability. The main outputs of the above mentioned investigations have detected unstable slope areas and/or single monuments that necessitate to be consolidated and reinforced. This last objective is aimed at providing the local authorities with a guideline for consolidation works to be implemented in the most hazardous sectors of the Siq and feasible techniques for analysis and conservation of monuments vs. rock-slope instability considering priorities and urgency. A preliminary consolidation works project has been implemented for the reinforcement of unstable blocks located in risk areas whereas guidelines have been provided for other relevant unstable areas to be mainly controlled with long-term monitoring.

SESSIONE K4

Beni Culturali cooperazione Internazionale

K4-1 Orale Rizzi, Gionata

10.1474/Epitome.04.0824.Geoitalia2011

THE BROKEN ARCHITRAVES: STONE CONSOLIDATION IN A ROMAN SITE IN TUNISIA

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Key terms: stone conservation; sunken courts; multidisciplinary approach

Bulla Regia, Tunisia: a site famous for its mosaics (stylistically very close to those of Piazza Armerina in Sicily) and for the subterranean houses. When a collaborative project between the World Monuments Fund and the Institut Nationale du Patrimoine started in 2008, the most beautiful of the "sunken courts" giving light to these houses was so deteriorated that collapse could have occurred at any moments. This paper tells the story of the international effort to save it. The success of this intervention lie, in our opinion, in the multidisciplinary approach that, throughout the project, led an architect, a conservator, a structural engineer, an archaeologist and a geologist to discuss together all the steps of consolidation: from the identification of the causes of decay, to the development of the most appropriate strategy, to the final, extremely difficult, implementation. Use of modern materials and techniques, such as carbon fibers strapping and fiberglass 2 meters long stitching are also described.

K4-2 Orale Tonini, Lisa

10.1474/Epitome.04.0825.Geoitalia2011

ARCHITECTURAL SURFACES IN SHEKHAWATI REGION (INDIA)

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Key terms: Shekhawati; architectural surfaces; Fresco lustro

The study is a consistent part of the project From the Geosciences to the Material Culture supported by Swiss Agency for Cooperation and Development (KfH) and SUPSI.

The research, developed in Shekhawati region (NE Rajasthan India) aims to identify the material and techniques used considering the entire sequence of the architectural surfaces from the masonry to the final paint decoration. Four different type of structures were selected: Havelis (house palace), temples, wells and cenotaphs. These historical building date to 18th-19th centuries

On the basis of in situ observations, samples were taken and analyzed through optical microscopy (OM) integrated with microanalysis (SEM-EDS). Infrared spectroscopy (FTIR). The results were compared with the consulted bibliography which reports meticulous macroscopic observation referring mainly to local oral tradition.

The results indicate the use of local available materials both for the masonries (calcrete, bricks, lime-based mortar with the addition of cocciopesto) and the renders.

The painted decorations were executed adopting a dry technique, contrary to what is stated in the reference literature.

The identification of the organic binder used for the pictorial layers was not possible as it was completely transformed into calcium oxalate; this patina acted as a protective coating allowing murals preservation in an extreme climatic region.

There were no substantial difference between the different types of structures analyzed.

The complete absence of protection largely contributed to the decay of the studied monuments.

K4-3 Orale Fabbri, Bruno

10.1474/Epitome.04.0826.Geoitalia2011

ACTIVITIES IN COLLABORATION WITH THE NATIONAL MUSEUM IN DAMASCUS, SYRIA

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Key terms: Ceramics; Cuneiform tablets; Damascus Museum; Diagnostics; Mortar

During the years 2009-10, the Institute of Science and Technology for Ceramics (CNR, Faenza) has managed a project for the organization and starting up of restoration and diagnostic laboratories in the National Museum of Damascus (Syria). The activity was subdivided into theoretical and practical lessons with reference to a wide range of architectonic and archaeological materials. During the practical lessons, some research experiences were done taking into account architectonic structures of Syrian General Directorate for Museums and Antiquities (DGAM) and archaeological objects of the Museum. Of course, it deals with the beginning of wider projects, but the idea was to continue them after the end of the above training project. Unfortunately, the current political situation forced us to suspend the collaboration with the hope that it can profitably continue as soon as possible. In the present paper some examples are given on the work done, in order to demonstrate the importance of the issues and topics covered in the short period of collaboration with DGAM, and the direction of future research.

A lot of mortars samples were collected from different structures of the Citadel complex in Damascus downtown and some of them were analyzed (OM, XRD, DTA-TGA). The results revealed that all the samples had hydraulic characteristics due to the presence of volcanic granules (pozzolana) or fragments of terracotta (cocciopesto) among the aggregate. In addition in two samples the binder was obtained by mixing lime and gypsum, while the presence of traces of magnesite in a sample clearly indicated that the lime used in this case was obtained by calcination of a dolomitic limestone. Finally different quantities of charcoal fragments were recognized in all the samples, as a consequence of the calcination technique used for producing the lime. Of course only a systematic study of a large number of samples will be able to identify the raw materials and technologies used for preparing the mortars in the different periods.

In order to identify the binder used for fixing the colours of a wall painting, in bad conservation state, coming from an ancient house (19th century) in Damascus, and to recognise the product/s used in a restoration work made in the seventies of the last century, some small fragments were analysed by means of FT-IR instrumentation both in transmittance and in ATR system. The analyses highlighted the presence of egg yolk as binder of the colour, and paraloid as restoration product. The data obtained were useful for planning a new and necessary conservation intervention.

An investigation was referring to Syrian painted pottery of the 8th century BC. The main problem was to define the processing technique used for obtaining objects with a surface lighter than the internal parts of the body. At the present state of investigations, we are convinced that they treated the surface with sea water, without applying any slip layer. But some technical questions are open: Did they apply a layer of dehydrated clay in order to obtain a flatter and smoother surface? At which stage of the manufacturing cycle did they treat the surface?

A very interesting experience was developed for the search of conservation methodologies of cuneiform tablets without cooking the artifacts. First of all, it was retained opportune to go into the issue of the degradation causes, taking into account thousands of small clay tablets dated back to the beginning of the II millennium B.C., recovered at Tell Mari, Hariry (Syria). It was realized that in these tablets superficial radial cracks form in correspondence with the growth of gypsum crystals just under the surface. Therefore, now the question to face is the formation mechanism of gypsum: does it form at present inside the deposits of the museum? Or it formed inside the ground in the archaeological site from which the tablets come?

K4-4 Orale Vettori, Silvia

10.1474/Epitome.04.0827.Geoitalia2011

STONES USED IN THE ARCHITECTURAL HERITAGE OF SYRIA

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Key terms: limestone; mortar; architectural heritage of Syria; degradation conditions; Tartous Citadel

Some sirian buildings of the Tartous Citadel (main walls, galleries, Donjon, Knight's Chapel, Hall of the Knights) and the surrounding areas (Arwad Island and the archaeological site of Amrit) have been investigated in the frame of the Euromed Heritage IV project "Mare Nostrum. A Heritage Trail along the Phoenician maritime routes and through the historic port cities" founded by European Union. Main object of this project is to provide data on the systematic analysis (chronological phases, construction techniques, state of preservation) required for preparing conservation guidelines. In Tartous most of the attention was directed at the Citadel which presumably has corresponded with the pre-Roman city and has been redeveloped during the Constantine and Byzantine eras. The phoenician structures along the coasts of Arwad are linked to subsequent constructions through re-use and building taking place over thousands of years, including the period of Islamic control and the Crusades, right down to the more recent traditional architecture in the Ottoman era.

Many archaeological and historical sites are also representative of the geological features and the geo-materials. The main geostructural features of the western Syria are the platform blocks, the anticlines and others sedimentary units, which are mainly composed of limestones (predominantly of marine origin, ranging in age from Triassic to Miocene - with a prevalence of Cretaceous limestone). Lava covers Syria and Jordan (Hawran), and also the architecture used basalts in symbiosis with the limestone, particularly where this is an alternation of sedimentary structures and volcanic soils just as close to the Syrian coast. After identification construction processes that could be considered homogeneous, a representative sampling, of the construction material, on the basis of a schematization of the architectural system of the Citadel into blocks, has been performed.

The petrography, mineralogy, and chemistry of several mortars and stones and their degradation conditions were investigated with the aim of collecting information before planning conservative interventions.

The field analyses, and the laboratory measurements, have allowed us to distinguish at least two different types of limestone. Blocks belonging to inner walls and buildings are constituted by fossiliferous grainstones with carbonatic cement and trace of quartz and with different degree of porosity (due to the loss of carbonatic cement) and major/minor presence of terrigenous component (clay minerals). Blocks, instead, which belong to the outer walls of the Citadel are mainly constituted by carbonatic rocks at highly widespread recrystallization of calcite, that makes the rock very compact. The fossil species are almost entirely replaced by reprecipitated calcite.

Also ancient and restoration mortars have been analyzed and classified on the basis of binder and aggregate composition.

K4-5 Orale Cavallo, Giovanni

10.1474/Epitome.04.0828.Geoitalia2011

RESEARCH AND EDUCATION FOR THE CONSERVATION OF CULTURAL HERITAGE IN GEORGIA

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Key terms: Gelati monastery; architectural surfaces; education; conservation

Georgia has a huge religious cultural heritage suffering the lacking of adequate conservation works. The project, granted by the Swiss National Science Foundation, intends to develop and improve the research and education establishing high standards in the field of conservation and providing high quality of the curricula of the Georgian faculty.

Since 1970s, Tbilisi State Academy of Arts is the single training centre for the conservation in Georgia. The Institutional Partnership project will help the Georgian partner to improve the research at their Faculty also considering the implementation of the scientific laboratory: all the conservation-restoration projects need preliminary scientific investigation aimed at establishing the appropriate procedures for the interventions.

The main goal of the project is the training of young and senior Georgian researchers and the study of architectural surfaces (stones, plasters and wall paintings) for the conservation of Gelati Monastery applying methodologies internationally recognized. This site, located near the city of Kutaisi in western Georgia, is one of the UNESCO sites and preserve wall paintings and decorative stones from 12th to 17th century and has great importance for the historical, religious, cultural tradition of the country.

Georgian partner has no relevant experience in the field of natural stones deterioration and conservation procedures. This is particularly relevant considering that many monuments have historical reliefs and decorative stones, in many cases dated back to the 4th-5th century, relevant for the cultural expression of the country. The stones mainly used (sandstones and tuffs) exhibit serious damages and an adequate strategy is required for their preservation.

The project based on comprehensive approach considering architectural structure as a whole and aiming at the detailed examination of architectural surfaces and elaborating practical solutions, is of urgent importance. Implementation of the project will essentially change the situation in the country as in Georgia there is absolutely no experience in the field of stone conservation and examination. Knowledge obtained through the joint work will be of key importance not only for the Georgian Faculty but the whole scientific society. The project can be considered a start point for the field of stone conservation in Georgia.

K4-6 Poster Pecchioni, Elena

10.1474/Epitome.04.0829.Geoitalia2011

THE ANCIENT MOSQUE OF HAJI PIYADA IN AFGHANISTAN: THE INVESTIGATION FOR THE PRESERVATION OF A FORGOTTEN MONUMENT.

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Key terms: earthen mortars; gypsum mortars; restoration mortars; Afghanistan mosque

The work explains the stages of a structured survey, conducted on the mosque of Haji Piyada in northern Afghanistan by researchers of the University of Florence and ICVBC-CNR of Florence, as part of an international project aimed at the recovery and protection of the monument.

The mosque is located near the ancient city of Balkh in the Mazar al Sharif province, not far from the borders with Uzbekistan, in a flat and quite fertile area. The mosque is almost in ruins, but it is still enclosed on three sides by a perimetral wall and it conserves a system of big columns on which two unsafe arches are still standing. A tripartite arrangement of the sides, thanks to the six central columns (of which only four still standing), was the support for a covering made with nine domes, unfortunately collapsed, but mentioned by the name Noh-Gombah still used in the Dari language. The construction dates from the VIIIth century AD, that is just over one hundred years after the Hijra, and it is therefore the oldest Islamic temple in Afghanistan. A special value of the monument is given not only by the gigantism of drums and arches, but also by a rich plaster coating of all the internal parts, finely carved with motifs of Sassanid ancestry. The mosque is at present filled to a depth of 150 cm, from the debris produced by the collapse of part of the domes and arches and shows signs of gradual deterioration with the risk of collapse for the arches still standing.

A call to rescue of the remaining integrity began in 2007 by the French Archaeological Delegation in Afghanistan (DAFA) which involved, in an international team (France, Iran, Afghanistan), experts in consolidation of ancient buildings belonging to the University of Florence and to ICVBC-CNR. The Italian coordination of the cooperation project is curated by Giovanni Secco Suardo Association, competent for restoration activities in developing countries. The Afghan contacts are the offices for the Protection of Archaeological and Cultural Heritage. In its development the

project has seen successive support of the World Monument Fund and of AKTC (Aga Khan Trust for Culture), the latter being particularly useful for the preparation of an intervention in a region known to be complex and even dangerous, where the local roots is essential, taking into account the fact that the organization of a restoration yard can take a very long time. The mosque complex consists of three building systems: 1. the columns and arches, which are the main load-bearing elements, made of baked bricks, the first walled with gypsum mortar and the second with earth mortar; 2. the first containment wall perimeter, close to the system described, including the filling volume of the vaulted system, made of mud-brick; 3. the outer perimeter, degraded and largely crumbling, made of on site pressed earth.

In order to plan a consolidation intervention of the remaining structures, it has been necessary to analyse samples of material, collected in different missions (2007-08-09) and transported to Italy with the help of French and Italian armies. The samples, representing the various types of bricks, gypsum and earth mortars and the rammed earth of the outer perimeter, were analysed in order to determine the mineralogical, physical and mechanical characteristics. These investigations are essential for the identification of suitable restoration mortars (injection, sealing, filling gaps, masonry mortar) useful to give consistency to the walls, but still compatible with the widespread presence of gypsum and degraded earth mortars. This study will develop a restoration plan that provides for the reinforcement of the building part, the consolidation of the arcs, the elimination of an incongruous support of an arc and the restoration the gypsum decorations.

K4-7 Poster Fabbri, Bruno

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COMPOSITION AND DISTRIBUTION OF SOLUBLE SALTS IN WALL REMAININGS OF THE IMPERIAL PALACE IN ISTANBUL

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Key terms: Brick walls; Imperial Palace; Istanbul; Soluble salts

The Imperial Palace in Istanbul is a complex of buildings that constituted the seat of the Roman Empire. The capital of the Roman Empire was in fact moved in the fourth century AD by Constantine the Great to the ancient Byzantium, which from that moment became known as Constantinople. The first unit of the imperial palace was built on the Golden Horn, the promontory that overlooks the Sea of Marmara, which controls the Bosphorus, a strategic position to control the trade. The Imperial Palace underwent significant changes and additions, especially in the period of Justinian (sixth century AD), during which the port Boukoleon was added. The imperial complex in that period included, as well as buildings used for habitation, by buildings for the cult and for the administration of justice, a thermal complex, a hippodrome and a port area with storage facilities.

In the eleventh century, the emperor's seat was moved and the complex began gradually to decay, so that at the time of the Ottoman conquest in 1453, there were only ruins of the Palace. Currently, the remains of the complex occupy a large area of the Golden Horn, an area that has been proposed for the creation of a historical-archaeological park. This area will be subjected to archaeological recovery, followed by restoration of the structures to make them accessible to tourists. The complex is mostly underground, and many structures are currently almost entirely below the ground level, such as the Apse, a building, probably used to the cult, whose access is permitted only through the windows of the upper level.

The project of creating a historical and archaeological urban park also includes the characterization of construction materials used, including all information necessary for restoration of the walls. The present paper fits into this context through the study of soluble salts in bricks taken from four sites of the ancient complex: Apse, Boukoleon, Sea walls, Tekke. The type and concentrations of soluble salts in the bricks examined were analyzed by ion chromatography. The results indicate that the concentrations of salts vary widely, from less than 1% to over 10% by weight. Nitrate prevails between the anions, followed by chlorine, while calcium and sodium emerge between the cations. Both the total amount of salts and their composition appear to be influenced by different variables, including distance from the sea, the height above ground, exposure to air, local circumstances. On the contrary, nature and distribution of salts appear little influenced by the composition and age of the bricks.

SESSIONE L1

Le Alpi dal break up della Pangea alla strutturazione della catena: una sessione in onore di Luciano Cortesogno e Mario Vanossi

L1-1 Orale Dallagiovanna, Giorgio

10.1474/Epitome.04.0831.Geoitalia2011

FROM FIELD GEOLOGY TO PALEOGEOGRAPHIC AND GEODYNAMIC RECONSTRUCTIONS: THE SYNERGY OF LUCIANO CORTESOGNO AND MARIO VANOSSÌ

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Key terms: Ligurian Alps; Penninic nappes; structural and metamorphic evolution

This session is jointly dedicated to the memory of Luciano Cortesogno and Mario Vanossi who passed away in 2005 and 2008 respectively. Since 1970, Luciano Cortesogno developed investigations addressed to primary, ocean floor and orogenic processes in the oceanic lithosphere. In those years, starting from extensive, accurate, interpretive field survey and mapping, through deep and exhaustive mineralogical, petrographic, petrological analyses, he elaborated original petrogenetic and geodynamic interpretations and resulted a first rank contributor to the Alpine and Tethyan ophiolite geology. A distinctive character of Lucio was the capacity to collaborate and integrate the contribution from other disciplines than petrography: stratigraphy, structural geology, geochemistry and mineralogy. His scientific interests spread then to the

Paleozoic petrogenetic processes in the continental crust of the Ligurian Penninic terranes: Lower Palaeozoic stratigraphy and metamorphic evolution, Late Variscan volcanism, plutonism, stratigraphy, Triassic volcanism. His research, in a fruitful collaboration with Pavia colleagues and friends, firstly Mario Vanossi, was developed across many years of field and laboratory work.

Mario Vanossi has been one of the most complete geologists in the national and international scientific community, endowed with great abilities of analysis and synthesis and helped by a formidable power of concentration. He wrote about 150 publications as only author or in collaboration with Italian and foreign colleagues. In about twenty years, between the 'sixties and the end of the 'seventies, he collected a huge amount of stratigraphic and structural data, then expressed in more than forty scientific publications, edited in ten years only, as well as in several geological maps. One of these was the second edition of the Albenga-Savona Map of the C.G.I., 1:100.000 scale, printed in 1970, which he managed as survey co-director. At the same time, ranging from the Helminthoid Flysch to the Briançonnais and Piedmont successions, and everytime dealing with different topics, from the stratigraphic-sedimentologic to structural, paleogeographic and geodynamic ones, he outlined a general framework for this sector of the Alpine belt which is, up to now, a milestone. As from the early 'eighties the collaboration Vanossi-Cortesogno started and continued for over twenty years producing basic contributions about the genesis and metamorphic evolution of the Paleozoic basements, the stratigraphy of the late-Variscan successions of the Ligurian Briançonnais and their metamorphic Alpine evolution. Even during the draft of his last paper, co-authored with colleagues and friends in the University of Pavia, Mario Vanossi still addressed the structural evolution of the Penninic nappes of the Ligurian Alps, and honoured his scientific engagements, but also accomplished his teaching commitment, another face of his great passion towards the Earth Sciences.

L1-2 Invitato Capponi, Giovanni

10.1474/Epitome.04.0832.Geoitalia2011

GEOLOGY OF THE LIGURIAN ALPS: THE HERITAGE OF LUCIANO CORTESOGNO AND MARIO VANOSSÌ

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Key terms: Ligurian Alps; Voltri Massif; mélange

In this work we want to show the present-day advancements on the geology of the Ligurian Alps, with emphasis on central Liguria. A major contribution to the knowledge of the geology of this area is due to Lucio Cortesogno and Mario Vanossi: the present state of the art could not have been the same without their contributions and we want to dedicate to Lucio and Mario this work.

Central Liguria, i.e. the Voltri Massif and the Sestri - Voltaggio Zone, is in a key geological position, as it represents the easternmost part of the Ligurian Alps, and the physical link with the northern Apennine belt. On the basis of twenty five years of geological mapping and structural analysis, here we want to focus on the structural architecture and the mutual relationships between the main tectono - metamorphic units that characterize this area: the Voltri and the Palmaro - Caffarella units. They derive from mantle and oceanic crust and show different peak metamorphic conditions: the Voltri Unit (as defined by Capponi & Crispini, 2008) re-equilibrated in the eclogite facies, whereas the Palmaro - Caffarella Unit shows blueschist facies peak metamorphic conditions. According to the recently published Geological Map of the area (Foglio 213-230 "Genova" of the CARG project, Capponi & Crispini, 2008), the eastern sector of the Voltri Unit largely consists of serpentinites that enclose bodies of eclogitized metagabbros, metasediments and serpentinitized peridotites, that achieved slightly to severely different P-T conditions, even if they attained peak conditions within the metamorphic eclogite facies.

On the whole, at the regional scale, the Voltri Unit is limited to the east by the Palmaro - Caffarella Unit, in contact along folded and sheared boundaries; nevertheless detailed geological mapping and structural analysis revealed a more complex architecture, showing that disrupted portions of the blueschist Palmaro - Caffarella Unit are boudinated and sheared along the regional foliation inside the Voltri Unit. The result is that highly sheared serpentinites and metasediments of the Voltri Unit host various HP rock slices re-equilibrated at different P-T peak conditions. Metagabbro and peridotite bodies display strong strain partitioning, being much less deformed than the country rocks.

Such evidence indicates that bodies with different metamorphic (eclogite vs blueschist facies) and tectonic evolution float in a low competence "matrix" and therefore suggests that the Voltri Massif, at least its eastern sector, matches the requirements of a tectonic mélange. In particular the Voltri Massif displays a strong strain partitioning, with low deformed rock bodies inside highly sheared country-rocks; such bodies (from m-scale to km-scale) show heterogeneous metamorphic peak conditions, ranging from eclogite to blueschist facies.

The occurrence of a tectonic mélange in the Voltri Massif has been proposed by Federico et al. (2007) that interpreted in this way an hectometric outcrop of foliated chlorite-actinolite enclosing lenses of less deformed metabasites and metasediments, at Cascine Parasi, in the western part of the Voltri Massif. We like to recall that we were introduced to the geology of the Cascine Parasi area by Lucio Cortesogno, who also led the petrographic studies during our Geological Mapping of the CARG project.

Capponi G. & Crispini L. (con la collaborazione di Bonci M.C., Bruzzo D., Cortesogno L., Del Tredici S., Firpo M., Gaggero L., Garofano M., Giammarino S., Lano M., Pacciani G., Piazza M., Perilli N., Piccazzo M., Ramella A., Vannucci G., Vigo E.) - 2008 - Foglio 213 - 230 "Genova" della Carta Geologica d'Italia alla scala 1:50.000. Apat - Regione Liguria, Selca, Firenze.

Federico L., Crispini L., Scambelluri M. & Capponi G. - 2007 - Different PT paths recorded in a tectonic mélange (Voltri Massif, NW Italy): implications for the exhumation of HP rocks. *Geodinamica Acta*, 20/1-2, 3 - 19.

L1-3 Invitato Gosso, Guido

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NATURAL FOOTPRINTS OF THE TRANSITION FROM VARISCAN COLLISION TO CONTINENTAL BREAK-UP IN THE ALPS

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Key terms: Variscan Convergence; Permian-Triassic extension; HT-LP

In the European Alps the exposure of Variscan structural and metamorphic imprints within the present-day Alpine structural domains indicates that before the Pangaea break-up, the continental lithosphere was thermally and mechanically perturbed by Variscan subduction and collision. When continental rifting does not develop on a stable continental lithosphere, geodynamic interpretation of igneous and metamorphic records, as well as structural and sedimentary imprints of rifting-related lithospheric extension, can be highly ambiguous since different mechanisms can be responsible for regional HT-LP metamorphism. While the metamorphic and igneous records of Variscan orogeny are widespread in the European continental crust, a diffuse igneous activity associated with HT metamorphism accounting for a Permian-Triassic high thermal regime is peculiar to the Alpine area. The overprint of HT Permian-Triassic evolution on the HP relics of the Variscan subduction and collision has been interpreted as induced either by late-orogenic collapse or by lithospheric extension and thinning leading to continental rifting (e.g. Lardeaux & Spalla 1991; Diella et al. 1992; Ledru et al. 2001). Even the interpretation of the geodynamic environment responsible for the development of intracontinental basins hosting the Permian volcanic products allows two possible alternatives: one envisaging a strike-slip dominated regime (Arthaud & Matte 1977; Cassinis & Perotti 1994), which is compatible with the evolution of a mature collisional setting (Molnar & Lyon-Caen 1988), the other a continental rifting tectonic setting (Siletto et al. 1993; Selli 1998; Staehle et al. 2001). In both cases the continental rifting promoting Mesozoic opening of the ocean in a lithosphere thermally softened and thinned by slab break-off processes is generally accomplished in the final stages of continental collision. Recently the integrated use of geological data and numerical modeling shows that active extension is required to achieve the thermal conditions allowing partial melting of the crust accompanying gabbroic intrusions and HT-LP metamorphism (Spalla & Marotta, 2007; Marotta & Spalla, 2007; Marotta et al., 2009).

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L1-4 Orale Oggiano, Giacomo

10.1474/Epitome.04.0834.Geoitalia2011

EARLY PERMIAN LATE CARBONIFEROUS VOLCANO-SEDIMENTARY SUCCESSION THERMOMETAMORPHISED BY COMPOSITE GABBRIO-GRANODIORITIC PERMIAN PLUTON: LU FALZU BASIN (NORTH SARDINIA)

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Key terms: late variscan basins; granite; thermometamorphism; Sardinia

In North Sardinia a volcano-sedimentary succession made of clastic sediments and by a thick stack of pyroclastic flows crops as remnant of a Permo-Carboniferous basin. The outcrop to the south is buried by the Tertiary sediments of the Castelsardo basin, whereas to the north it rests on granitoids that intrude the Variscan High Grade Metamorphic Complex, which mainly consists of migmatites. Among the different intrusions in touch with this late Variscan basin, a small intrusion consisting of intergradational, quartzose gabbro-diorite, diorite and voluminous mafic-to-felsic granodiorite is the closest to the best exposition of its infilling.

The clastic sediments consists of fine-grained quartzites, arcoses with silty intercalation and conglomerates; these consist of mud-sustained angular to sub-rounded clasts, derived from the metamorphic basement. The facies of the deposits recall that of some Stephano-Autunian basin of southern Sardinia. The clastic succession is capped by tuffs and by welded lava-like ignimbrites with an exposed thickness of 700m.

The intrusive relationships between the plutonic rocks of the area with the late variscan deposits were already evidenced by Del Moro et al. 1996, who evidenced some metamorphic assemblage in the Permo-Carboniferous sediments.

Actually, the fine-grained sedimentary rocks in contact with the intrusives are deeply transformed, in place resembling those of the High Grade Metamorphic Complex. In any case in thin section they show abundant

andalusite ± cordierite, graphyte and decussate aggregates of muscovite and biotite. Graphyte is particularly abundant in some dark beds as metamorphic product of carbonaceous matter.

New U/Pb zircon analyses on the gabbroic portion of the composite intrusion yielded an age 285.8 ± 1.9 Ma. Such an age is coherent with both the Rb/Sr blocking ages and newly performed Ar/Ar ages - which resulted few hundred thousand years younger - on muscovite and biotite with decussate texture of the thermometamorphic sediments. Moreover amphibole thermobarometry confirmed the shallow emplacement level (2-3 Km) for the composite granodioritic intrusion.

Taking in account that the High Grade Metamorphic Complex on which the Lu Falzu sediments rest is affected by the neo-Variscan HT/LP (≈ 4 Kb - 650 °C) event at about 303 Ma (Macerà et al. 1989) and that erosion and sedimentation must have occurred before the gabbro emplacement, uplift and exhumation of the migmatite that equilibrated

at least 13-14 Km occurred within a time span as short as ten million years.

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L1-5 Orale Gaggero, Laura

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POST- AND LATE COLLISIONAL VOLCANISM IN SOUTHERN VARISCIDES: A KEY TO COLLAPSE AND DISRUPTION OF AN OROGEN

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Key terms: orogenic collapse; Variscan; crust-mantle; volcanism; Permian

The late to post orogenic evolution in southern Variscides is characterized at the Early Permian, by a transtensional geodynamic regime developed along the southern Palaeoeuropean margin, as a result of a dextral megashear between Gondwana and Laurasia. In West-Mediterranean southern Variscides, magmatism and tectonics interplayed during the opening of intracontinental alluvial to lacustrine basins.

The most significant issues to address in the characterization of post-orogenic succession in Southern Variscides are the following: i) within the generalized orogenic collapse, sediment- or volcanic-dominated series develop as a consequence of local tectonic and lithospheric setting.

The volcanic units are characterized by a common stratigraphic succession, beginning with early calc-alkaline andesites and rhyolites, followed by conspicuous rhyolites, and by dacites infilling fault-bounded pull-apart basins. Both andesites and rhyolites show K-normal and high-K calc-alkaline character. However, in different regions and settings, differences in timing, areal distribution and outpoured volumes arise.

ii) opening of pull apart basins is associated with strike slip basins

iii) when tectonic unroofing is active, the volcanism could be associated with HT /LP metamorphism

iv) along with areal distribution of the volcanic field, a chemical zonation is possible parallel to the orogen axis. This character has been evidenced in the Ligurian Alps and also in the collapse of the Balkan orogen (Bulgaria)

v) the relationships between calcalkaline and alkaline volcanism have been demonstrated to occur as subsequent or coeval. In the Ligurian Alps, the volcanic activity is confined between calc-alkaline rhyolites dated 285.6±2.6 Ma and rhyodacites-rhyolites aged 272.7±2.2 Ma (U/Pb LA ICP MS on zircon). In between, intermediate lavas and associated tuffites that have been interpreted as the result of mixing and fractional crystallization originated in partial melting at boundary between lithospheric mantle and lower crust. The interaction with the overlying thickened crust was constrained at ~34 % crystallization by adding ~27 % of contaminant to the parental magma. The final volcanic event is represented by K-alkaline rhyolites at 258.5 ± 2.8 Ma after a Mid-Permian amagmatic and sediment-starved time gap of c. 14 Ma.

Conversely, in Nurra, a mildly alkaline activity occurs at Santa Giusta at 291 Ma; here the basement was a structural high bounded by E-W trending faults since the Late Carboniferous-Lower Permian, and also controlled the development of Mid Permian and Lower Triassic successions. The Lower Paleozoic medium- to high-grade metamorphic basement, the Sardinia-Corsica batholith and the Stephano-Autunian calc-alkaline effusives are cut by transitional dolerite dikes with a N-S trend and subvertical dip. 40Ar-39Ar ages on amphibole at 253.8±4.9 and 248±8 Ma probably represent the emplacement interval.

Finally, a role of volcanic dominated series in plate reorganization has been envisaged: the end of calc-alkaline magmatism and the gap in the sedimentary record may correspond to the major displacement along the megashear zone between Laurussia and Gondwanaland as supported by palaeomagnetic constraints. In the Ligurian Alps, the age of the alkaline volcanic rocks matches the end of the plate reorganization and the onset of the Alpine cycle.

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L1-6 Orale Maino, Matteo

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U-PB CHRONOLOGICAL CONSTRAINTS FOR THE LATE TO POST-VARISCAN MAGMATISM AND METAMORPHISM IN THE LIGURIAN ALPS (ITALY)

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Key terms: U-Pb dating; late/post-Variscan tectonics;

Carboniferous-Permian magmatism; Ligurian Alps

The Alpine chain comprises two major rock groups: one of these only experienced tectonics related to the Alpine cycle, while a second shows pre-Alpine relict metamorphism. The latter recorded a polyphase ante-Alpine history, both Variscan or pre-Variscan in age. The Alpine overprint on the Variscan relict units in general obscures our interpretation

of the preceding history. In particular, the Penninic nappes of the Western Alps comprise several gneissic units, whose age, origin, pre-Alpine metamorphism and tectonic significance are debated. In the Ligurian Alps, one of the basement units of the Briançonnais domain (Barbassiria massif) is made up of orthogneisses derived from K-rich rhyolitic protoliths and, subordinately, rhyolitic dykes cutting a main igneous body. The pervasive Alpine metamorphic and tectonic overprint under blueschist facies conditions on the Barbassiria Orthogneisses preserves little evidence of the Variscan metamorphism. New U-Pb excimer laser ablation ICP-MS dating on zircon separates from the orthogneisses and dykes has been undertaken to unravel the relationships between effusive emplacement and Variscan metamorphic overprint. The results suggest an age for the eruption of the rhyolite protolith of the Barbassiria Orthogneisses of ~ 320 Ma (i.e. Late Carboniferous), and a subsequent dyke emplacement at 260.2 ± 3.1 Ma. The Variscan high-temperature metamorphic event (amphibolite-greenschist facies) is thought to be related to a mechanism of tectonic burial associated with the compressive tectonics during the uppermost Carboniferous late stage of the Variscan collision. The dykes cutting the Barbassiria Orthogneisses at ~ 260 Ma belong to the diffuse K-rhyolite volcanism emplaced at 258.5 ± 2.8 Ma. This age represents the end of the orogenic phase in this segment of the southern Variscides, and enhances the evidence of a ~ 10 - 15 Ma Mid-Permian sedimentary/magmatic gap in its volcano-sedimentary cover.

L1-7 Orale Rebay, Gisella

10.1474/Epitome.04.0837.Geoitalia2011

THE PERMIAN GABBROS OF THE WESTERN ALPS CONTINENTAL CRUST: THE FLY-RECORDER OF THE JOURNEY FROM PANGAEA BREAK-UP TO ALPINE CONVERGENCE

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Key terms: Permian Gabbros; lithospheric thinning; Austroalpine domain; Western Alps

Gabbro emplacement in the continental lithosphere is a marker of lithospheric thinning: association of mantle peridotites, gabbros and continental crust is an important key for the understanding of passive margins. Gabbros included in continental units of orogens are therefore basic tools to infer duration and mechanisms active during ocean opening. Moreover gabbro compositions are diagnostic to develop critical parageneses in subduction-collision environment.

In the Austroalpine domain several gabbro bodies have Permian ages and are often intruded into metamorphic rocks deformed under high-temperature and intermediate- to low-pressure conditions. They are interpreted, with the contemporaneous metamorphism often developed in their country rocks, as signals of a positive thermal anomaly associated to lithospheric thinning, indicated by some authors as precursor of the continental rift that led to the Mesozoic ocean opening (Marotta et al., 2009 and refs therein). Amongst these, mainly in the western portion of the Austroalpine, numerous bodies underwent HP-LT Alpine metamorphic re-equilibrations but still preserve, at places, relicts of pre-Alpine evolution. Corio and Monastero and Sassa gabbro bodies are here investigated to reconstruct their structural and metamorphic evolution in order to decipher the geodynamic scenarios characterizing their pre-Alpine and Alpine tectonic history.

The polyphase Alpine deformation of these gabbros is highly heterogeneous; our detailed structural investigations allow to discriminate between emplacement structural levels: the Sassa body maintains at best the igneous characters over huge weakly deformed volumes and the pre-Alpine subsolidus evolution accounts for an exhumation from the intermediate crust. The Corio and Monastero gabbro is pervasively eclogitized but few low strain domains preserve pre-Alpine fabrics and mineral assemblages pointing to a deep crustal emplacement. Similarly the Alpine evolution differs in the two bodies: Sassa gabbro underwent Tertiary blueschist facies re-equilibration whereas Corio and Monastero gabbro underwent Upper Cretaceous - Paleocene eclogite-facies conditions.

Differences in the P-T paths characterizing the pre-Alpine and Alpine evolutions are the key to unravel differences in the thermal state affecting pre-Alpine continental crust during lithospheric thinning and the Alpine evolving thermal state of the subduction zone.

L1-8 Orale Decarlis, Alessandro

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GEODYNAMIC RECONSTRUCTION OF ALPINE PRE-COLLISIONAL STAGES BETWEEN VARISCAN HERITAGE AND TECTONO-SEDIMENTARY EVOLUTION IN THE LIGURIAN ALPS: A REVIEW.

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Key terms: Ligurian Alps; Geodynamics; Prepidmont; Briançonnais

The renewed interest that has arisen around passive margins leads us to reconsider the stratigraphy and geodynamics of this peculiar and misunderstood sector of the Italian Alpine belt. The Western Italian Alps comprise one of the most extensively studied areas in geological sciences, but the Ligurian Alps, are left out from recent debates and are rarely cited in papers on pre-collisional geodynamic reconstructions. In our opinion this is due to the scarcity of international literature on this Alpine sector, and to the widespread metamorphism and tectonic displacement affecting almost all the sedimentary covers, discouraging field research. Nevertheless, once the complex puzzle of tectonic units has been restored, the Ligurian Alps represent one of the best places to observe a complete section of a Mesozoic passive margin. In addition, in the Ligurian area there is no field evidence of multiple oceans (as in other sectors of the Western Alps), giving the researcher an opportunity to pass directly through the margin towards its transition to the undeformed foreland and to the oceanic domain. Furthermore, the preserved geological records pertain to two distinct orogeneses, the late-Variscan and the Alpine events. The Early-Middle Permian tectonics, considered as the product of a megashear zone evolution or as a response to a changed geodynamic context, affected the Ligurian Alps, as we can see in the Briançonnais

domain, with the rejuvenation or birth of new faults bordering graben/half-graben or pull-apart structures during the emplacement of the different volcanic bodies. During Late Permian-Early Triassic times, the Ligurian sectors underwent extensional tectonics only. At first, graben/half-graben structures filled by Upper Permian K-rhyolites developed, followed by the establishment of suitable gradients for erosion and transport of clastic components of the Verrucano Formation. From the Middle Triassic onwards, the Ligurian Alps area was affected by diffuse extension caused by southeastern subduction of Palaeotethys which led to the opening of multiple oceanic troughs (i.e. Pindos, Maliac and Meliata). At these times, the study area was located in a sector approaching the convergence of the axes of basins, opening like a fan toward the East. The climax of this activity occurred in the Ladinian. Nevertheless, our data show that the extensional basin axes at this time were markedly different from the Alpine Tethys ones that overprint the whole pre-Jurassic geological record. The Late Carnian to Norian was a key point in the evolution of the Mediterranean area: in the Ligurian Alps it represented the transition between the Middle Triassic back-arc/rifting stage and the Alpine Tethys rifting s.s. Field evidence is in favour of an overlap of the two extensional mechanisms rather than a complete switch-off of the first. The Alpine Tethys rifting developed from the Norian and reached its climax in the Early Jurassic, when subsidence increased until the collapse of the margin. This led to the formation of emerged rifting shoulders and deeper inner domains, creating the Briançonnais-Prepidmont differentiation. It follows the oceanisation and successive cooling of the margins. Our research highlights that the Ligurian Alps were a domain in which for over a hundred million years orogenesis, rifting and oceanisation strongly affected the integrity of the upper crust. The rare volcanic effusions testify to a complex chemistry, sometimes apparently in contrast with the supposed geodynamic environment. This may be related to the heterogeneity of the crust that was affected by multiple mantle uplifts, partial melting and extensive faulting over a long period. Thus the last and most important rifting (the Alpine Tethys) developed around a narrow, elongated area of crustal weakness generated by multiple geodynamic events.

L1-9 Orale Federico, Laura

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THE "URBE" 212-2 QUADRANGLE: NEW GEOLOGICAL MAPPING IN THE HP POLYDEFORMED VOLTRI MASSIF (WESTERN ALPS)

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Key terms: geological mapping; structural setting; HP metaophiolites; Voltri Massif; Western Alps

We performed a new geological mapping of the western part of the Voltri Massif at 1:10.000 scale, between autumn 2009 and 2010. The investigated area is approximately 160 Km² and covers a hilly to mountainous region in Liguria (spanning the Savona and Genova provinces), with the highest peak of Mt Beigua (1287 m) at only about 8 Km from the Ligurian Sea.

The mapped area falls inside the HP metaophiolitic Voltri Massif of the Western Alps and thus encompasses rocks belonging to the Ligurian-Piemontese Domain. The bedrock is made up of serpentinites and metasediments, with minor occurrence of metabasite, ilherzolite and metagabbro. Metagabbros frequently crop out as lenses and bodies inside serpentinites and are either eclogite-facies Fe-Ti-oxide gabbros or Mg-rich HP gabbros, largely retrogressed in greenschist facies.

Along the contacts between serpentinites or metabasites and metasediments, levels of hybrid rocks (schists containing chlorite + actinolite/tremolite \pm carbonate \pm ores) often occur, resulting from shearing and metasomatic exchanges; such rocks are schists containing chlorite + actinolite/tremolite \pm carbonate \pm ores

Metabasites encompass rocks with either a magmatic ("Prasinite" Auct.) or metasedimentary origin (pristine mafic breccias or greywackes), completely retrogressed in greenschist facies conditions.

The bedrock is covered by late- to post-orogenic deposits, either belonging to the basal horizons of the Tertiary Piedmontese Basin (TPB) or to Pliocene marly sediments.

The metamorphic rocks are commonly highly deformed and the more evident foliation in the field is a composite fabric (CF) that is parallel to the lithological contacts. More than 2200 CFs have been measured, together with axes and axial planes of folds. The structural analysis and the development of mesoscopic fold interference patterns point out to the occurrence of at least three phases of folding.

The older deformation event (F1+2) is characterized by tight to isoclinal transpositive folds, with generally subhorizontal axial planes and subhorizontal axes; the second one (F3) is characterized by open folds with E-W to NE-SW trending and low plunging axes, that don't produce an axial plane cleavage. Dispersion of AP3 suggests the occurrence of a further folding event (F4) with N-S to NW-SE subhorizontal axes. The resulting interference patterns are both of type 2 and 3, that occur also at the cartographic scale.

In general the CF dips 40-50° towards E-SE in the eastern side of the mapped area, whereas it is subhorizontal in the western part. This structural feature, combined with the fact that further to the east the CF in the Voltri Massif is commonly steeply dipping (CAPPONI & CRISPINI, 2008), points to a general recumbent geometry already depicted in literature but variably interpreted (e.g. CAPPONI & CRISPINI, 2002; VIGNAROLI et al., 2010). This 3D-structural architecture is going to be discussed on the basis of our analysis.

In the studied area brittle structures are widespread and associated to mappable fault rocks. We measured fault surfaces and associated kinematic indicators in the field and mapped the tectonic lineaments resulting from photo-interpretation as well.

Even if lithologic boundaries generally follow the CF, they are locally reworked by brittle tectonics, that in places can be constrained in time by the occurrence of the Pliocene sediments (in the southeastern part of the map) and of the TPB deposits in the northwestern corner.

The new detailed mapping and structural analysis allowed us to make a direct comparison with data recently collected in adjacent areas (CARG Project - CAPPONI & CRISPINI, 2008) to obtain a better insight into the structural setting of the Voltri HP-ophiolites.

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L1-10 Poster Decarlis, Alessandro

10.1474/Epitome.04.0840.Geoitalia2011

TOWARDS A CHRONOSTRATIGRAPHIC DEFINITION OF THE PAROXYSMAL PHASE OF RIFTING IN THE LIGURIAN ALPS (CASE MORTEO RHYODACITES)

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Key terms: Prepidmont; Ligurian Alps; Lias; Volcanics; Rifting

Cortesogno et al. (1981) pointed out the presence of rhyodacite lavas and pyroclastics that form metre-thick layers interfingering with the M. Galero Breccia near Albenga, SV (Case Morteo rhyodacites). Two volcanic events can be recognised: the first led to the deposition of altered acid lava, about 4 metres thick, the second event is formed by 5-6 metres-thick level of altered acid lava that overlies a breccia horizon, reworking and engulfing its clasts, testifying to the true stratigraphic position of the volcanics. The original mineralogical composition of massive lava and pyroclastics was interpreted (Cortesogno et al., 1981) to be formed by plagioclases, amphibole, biotite and quartz and thus considered to be an alteration product of a primary felsic suite that ranges from rhyolite to dacite. The age of volcanics remained unsolved due to both the uncertainty of the chronostratigraphic position of the embedding breccia (traditionally referred by regional comparison to Dogger s.l.) and to the lacking of minerals for the radiometric datation (zircons were searched but not found). Recently, a revision on the stratigraphy of this sector of the Ligurian Alps, (Decarlis & Lualdi, in press) leads to the definition of new lithostratigraphic unit that allow to reconsider the chronological position of some units also by comparison with key-successions in the Western Alps used as geodynamic markers. On this base, the M. Galero Breccia, i.e. megabreccias produced by the dismantling of northern margin of Tethys, has been referred to a Late Liassic age rather than Dogger s.l. Since the opportunity to date this huge amount of clastics (and their equivalent in the Western Alps, e.g. Formation Detritique Rousse, Breche s.l. of the Breccia Nappe) that marks the paroxysmal phase of rifting that closely predates the oceanisation. The relevance of these volcanics is also to be a unique witness of synrift flow on continental crust on the whole Western Alps. The existence of these outflows may prove their run-up in Liassic times along pre-existing faults and their mixing with the falling blocks. As a consequence, they can be considered to be strictly linked to the geodynamic context of the pre-oceanic rifting of the Prepidmont sector of the European margin. It is worth considering that similar pyroclastic product emplacements took place during the Pliensbachian to Toarcian in the Betic cordillera, preceding the effusion of basic lava associated with the western Tethys preanisanion. Unfortunately, the U/Pb radiometric analyses on zircon separates by the EL-ICP MS (excimer laser ablation inductively coupled plasma mass spectrometry) method (CNR - IGG Pavia) did not provide a reliable age due to the alteration of the volcanics and to high normal-Pb content. The latter is probably due to a late hydrothermalization associated with rifting and emplacement of the oceanic crust, recorded by the complex vein network affecting the overlying radiolites. Recently, a detailed sampling has been performed on the coarser grained fraction of the flow that provided a few zircon crystals. Further U-Pb analyses on zircons in progress by SHRIMP (Sensitive High Resolution Ion Microprobe) are aimed to improve the response in order to achieve regional scale correlations. Cortesogno L., Oxilia M., Royant J., Vanossi M., Vivier G. (1981). Témoins d'un volcanisme rhyodacitique du Dogger dans le domaine Prépiémontais des Alpes Ligures. *Ecl. Geol. Helv.* 74: 569-585. Decarlis A., Lualdi A. (in press). Synrift sedimentation on the northern Tethys margin: an example from the Ligurian Alps (Upper Triassic to Lower Cretaceous, Prepidmont domain, Italy). *Int. Journ. Earth Sc. (Geol. Rundsch)*, DOI 10.1007/s00531-010-0587-1.

SESSIONE M1

Micro- e meioorganismi come indicatori ambientali e paleoambientali

M1-1 Orale Frontalini, Fabrizio

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THE POGGIO LE GUAINÉ CORE (UMBRIA-MARCHE BASIN, CENTRAL ITALY): A REFERENCE SECTION FOR THE APTIAN-ALBIAN INTERVAL AT LOW LATITUDES

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Key terms: Oceanic anoxic event; Oceanic red bed; Poggio le Guaine core; Aptian-Albian interval

A continuous core extending from the Albian-Cenomanian boundary down to the uppermost Barremian (~99.5-127 Ma) was drilled at Poggio le Guaine, where the most continuous, complete and best preserved Aptian-Albian succession throughout the Umbria-Marche Basin (northern Apennines, central Italy) is exposed.

The Poggio le Guaine core penetrated 98.72 m of pelagic sediments consisting mainly of limestones, calcareous marls, marls, clays and black shales. The core was continuously drilled with essentially 100% recovery of excellent quality material and completely logged. The cored sequence

records both OAE1a to OAE1d and regional equivalents of widely distributed Aptian-Albian oceanic anoxic events. The Poggio le Guaine core can be considered as a tightly constrained "reference section" for the Aptian-Albian interval at low latitudes and is designated to provide high-ranking informative records for that critical time interval through high-resolution multiproxy studies.

The dataset collected will supply the framework for 1) computing a high-resolution relative paleointensity reference curve for the Aptian-Albian interval of the long normal Cretaceous superchron that would allow us to correlate relative paleointensity curves from other places in the world, 2) building up, at high resolution and using astronomical tuning and absolute dating, a unique and original age model to which refer the sequence of the geological, biogeochemical, oceanographic and climatic events as recorded throughout the Aptian-Albian critical time, and 3) defining the causal linkages among these events as well as their consequences.

M1-2 Orale Rindone, Antonino

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EVIDENCE OF CHLOROBIACEAN ACTIVITY IN THE CENOMANIAN-TURONIAN BLACK SHALES OF NORTHEASTERN SICILY

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Key terms: CHLOROBIACEAE; CENOMANIAN-TURONIAN; BLACK SHALES; NORTHEASTERN SICILY

The Chlorobiaceae, also known as green sulphur bacteria, are strictly anoxygenic photoautotrophic prokaryotes that inhabit the photic zone of euxinic basins usually at the interface between well-oxygenated surface layers and anoxic waters rich in H₂S. Chlorobiaceans fix carbon through a reductive Krebs cycle and play a key role in marine ecosystems acting as an ecological barrier to the diffusion of H₂S in surface layers, thereby allowing the presence of nektonic organisms. These bacteria are adapted to sustain photosynthesis at very low light intensities (Overmann et al. 1992) and produce characteristic pigments, including some aromatic carotenoids. Molecular fossils derived from such pigments can be used to document the distribution of these photosynthesizing prokaryotes in the fossil record, as well as to provide evidence of the occurrence of photic zone euxinia in ancient depositional environments (Summons & Powell 1986; Sinninghe Damsté et al. 1993; Koopmans et al. 1996). A vast array of diagenetic and catagenetic products derived from the pigments characteristic of the Chlorobiaceae have been documented in sediments ranging from Ordovician to Miocene (Koopmans et al. 1996). Examination by gas chromatography/mass spectrometry of Cenomanian-Turonian ichthyolithiferous black shales of Argille Varicolori of northeastern Sicily revealed the presence of isorenieratane and chlorobactane, two sedimentary derivatives of aromatic carotenoid pigments (isorenieratene and chlorobactene) specifically produced by chlorobiaceans. The presence of isorenieratane and chlorobactane is accompanied by a carbon isotopic anomaly (enrichment of ¹³C; Scopelliti et al. 2008), which may be attributable to the unusual carbon metabolism of these bacteria (Siveråg et al. 1977). Aromatic carotenoids, including isorenieratene, are generally labile compounds not very resistant to transport over long distances (Sinninghe Damsté & Koopmans 1997). Therefore, the presence of their derivatives in the sedimentary rocks must be considered as autochthonous.

In summary, the analysis of molecular fossils in the black shales of northeastern Sicily has provided unambiguous evidence of the activity of microbial communities that recorded the development of euxinic conditions at shallow depths along the north African shelf at the Cenomanian-Turonian boundary (Sinninghe Damsté & Köster 1998).

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M1-3 Orale Frontalini, Fabrizio

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THE SELANDIAN-THANETIAN TRANSITION EVENT (STTE) AT GUBBIO (ITALY): A MORE COMPLEX SCENARIO THAN PREVIOUSLY THOUGHT FOR THE ELPE?

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Key terms: STTE; ELPE; Hyperthermal; Paleogene; Contessa Road (Gubbio)

A ~250-kyr long-lasting dissolution interval during the Paleocene, here named Selandian-Thanetian Transition Event "STTE" has been recognized at Western Tethys Contessa Road section (Gubbio, Italy). The uppermost part of the "STTE" includes the short-lived suspected hyperthermal event known as the early late Paleocene event (ELPE, Bralower et al., 2002; Petrizzo, 2005) or mid-Paleocene biotic event (MPBE, Bernaola et al., 2007), which therefore would become part of a more complex scenario. Here we present and discuss high-resolution biochronostratigraphic and geochemical records, and magnetic susceptibility and environmental magnetism data from the western Tethyan Contessa Road section (Gubbio, Italy). The "STTE" falls within the middle-lower part of the planktonic foraminiferal Zone P4b and calcareous nannofossils Zone NP6 with its onset placed in the uppermost part of Chron C26r. The "STTE"

constitutes a precursor for the ELPE that is marked by a drop in $\delta^{13}C$ bulk carbonate and carbonate content accompanied by prominent peaks in low-field magnetic susceptibility. At Contessa Road, the STTE and ELPE exhibit peculiar stressed ecological responses among calcareous nannofossils and foraminifera, which highlight marked environmental perturbation affecting the geobiosphere. Further studies are needed to understand whether the "STTE" represents a regional or global event. However, an abrupt environmental perturbation close to the Selandian-Thanetian transition has been observed in other Tethyan as well as open ocean sites suggesting that the "STTE" might be a possible global prelude to the PETM.

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M1-4 Orale Bancala', Giuseppe

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EVOLUTIONARY ORIGIN OF THE FORAMINIFERAL GENUS HANTKENINA FROM THE MIDDLE EOCENE CONTESSA HIGHWAY SECTION (GUBBIO, ITALY): MAGNETOBIO-CHRONOSTRATIGRAPHIC, CHRONOLOGIC AND PALEOENVIRONMENTAL IMPLICATIONS

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Key terms: *Hantkenina*; evolutionary trend; morphotypes; Middle Eocene; Gubbio

One of the most distinctive and enigmatic bioevents in Cenozoic planktonic foraminifera evolution is the origin of the genus *Hantkenina*, which evolves gradually from the genus *Clavigerinella* by the acquisition of particular morpho-structures called "tubulospines". This evolutionary trend, firstly restricted to the deep water of Tethyan region, occurred during a dramatic climatic change from the extremely warm conditions of early Eocene to the initial rapid phase of Cenozoic cooling between 50 and 48 million years in unusual hydrographic conditions associated with restricted circulation, involving periods of low oxygenated waters follow by upwelling (Zachos et al., 2001). *Hantkenina* origin and speciation might involve divergence from the ancestral genus *Clavigerinella* within deep, cold oxygen starved, nutrient-rich but food-poor environment (Coxall et al., 2003). In this scenario, *Hantkenina* was probably originated through competition for limited food resources and the tubulospines may represent a structural adaptation to this new trophic strategy, allowing the organism to harvest a greater volume of water at minimal metabolic cost (Coxall et al., 2003). In this context, a high-resolution study was carried out on the middle Eocene hard lithologies of the Western Tethys Contessa Highway Section (Gubbio, Italy). The cold acetolysis method enabled the extraction of foraminifera even from indurated limestones, offering the possibility of accurate taxonomic determination and detailed analysis of the foraminiferal assemblages.

We collected numerous and readily identifiable specimens that allow us to build up a continuous and complete evolutionary record, which includes the evolutionary transition forms between *Clavigerinella* and *Hantkenina*. In particular, we recognized a large number of specimens of *Hantkenina gohrbandti*, which is considered to be the real ancestor of the genus *Hantkenina* (Rögl and Egger, 2010, 2011). For the first time, we were able to distinguish three discrete morphotypes of *Hantkenina gohrbandti*, which first appear at different times and would testify a further evolutionary lineage within this species. Based on the recent Contessa Highway astronomical calibration of Jovane et al., (2010), we also provide the timing of the evolutionary steps from *Clavigerinella* to *Hantkenina*.

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M1-5 Orale Boscolo Galazzo, Flavia

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PERTURBATION AT THE SEA FLOOR ACROSS THE MIDDLE EOCENE CLIMATIC OPTIMUM AS RECORDED BY BENTHIC FORAMINIFERA IN THE ALANO DI PIAVE SECTION (BL, NORTH-EASTERN ITALY)

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Key terms: Middle Eocene Climatic Optimum; Benthic foraminifera; Alano di Piave section

The Middle Eocene Climatic Optimum (MECO; Bohaty & Zachos, 2003) is a prominent (~500 Kyr) warming episode that, at 40 Ma, interrupted the overall cooling trend of the middle Eocene (Tripathi et al., 2005; Sexton et al., 2006; Edgar et al., 2007a; Bohaty et al., 2009). MECO is recorded worldwide by pronounced changes of both $\delta^{13}C$ and $\delta^{18}O$ values and is marked by coeval oscillations in global CCD (Bohaty et al., 2009).

The middle bathyal Alano di Piave section (northeastern Italy, central-western Tethys) provides an excellent record of the MECO, offering the opportunity to investigate this event in detail with multi-proxy, high-resolution approaches (e.g. Spofforth et al., 2010). At Alano, a peculiar sapropelic interval, characterized by excursions in both the carbon and oxygen bulk-carbonate isotope records, represents the lithological expression of the post-MECO event. Such organic-enriched interval follows

the $\delta^{18}O$ negative shift, interpreted as the peak of MECO warming (Spofforth et al., 2010). Previous studies on the Alano section, based on calcareous plankton, suggest increased nutrient input and surface ocean water productivity in response to the environmental perturbation associated with the MECO (Luciani et al., 2010; Toffanin et al., 2010). In order to improve our knowledge about the benthic ecosystem response to the MECO, we investigated benthic foraminiferal assemblages of the Alano di Piave section through the analysis of the $\geq 63 \mu m$ fraction and, for

selected samples (e.g. sapropelic interval), of the $\geq 125 \mu m$ fraction. The combined quantitative study of these two different size fractions allowed a detailed reconstruction of the sea-floor conditions during the environmental perturbations associated with the MECO.

Our results of the $\geq 63 \mu m$ fraction show a benthic foraminiferal assemblage characterized by small bolivins (*Bolivina* spp.) which show a cyclical pattern abundance throughout the section. Moreover there are some remarkable peaks of other opportunistic taxa as *Globobuccidulina* spp., *Bulimina thanetensis*, *Bulimina semicostata*, *Oridorisalis umbonatus* and small uvigerinids as *Uvigerina farinosa*.

Within the sapropelic intervals, the study of the $\geq 125 \mu m$ fraction better evidence increased abundance of abnormal big-sized *Uvigerina*, a taxon common in oxygen-depleted, organically enriched settings and other big-sized taxa which peak in these intervals (e.g. *Hanzawia ammophila*, *Plectinella dalmatina*). All these faunal modifications, compared with planktonic foraminiferal and geochemical data (Luciani et al., 2010; Spofforth et al., 2010), were interpreted as a response to remarkable food transfer to the sea-bottom and to the development of dysoxic waters at the sea-floor just above the peak of the MECO warming. Such peculiar conditions were an effect of eutrophication of surface waters, as consequence of the modified, enhanced hydrological cycle in response to the MECO warming.

M1-6 Orale Sideri, Marianna

10.1474/Epitome.04.0846.Geitalia2011

REASSESSMENT OF THE PALEOGENE INTEGRATED STRATIGRAPHY AND CHRONOLOGY OF THE UMBRIA-MARCHE BASIN (CENTRAL ITALY): PALEOENVIRONMENTAL, PALEOCEANOGRAPHIC AND PALEOCLIMATIC IMPLICATIONS

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Key terms: Paleogene; biostratigraphy; magnetostratigraphy; Western Tethys

Within the framework of the "Paleogene Integrated Stratigraphy" (PALIS) project we have reassessed the Paleogene bio-, chrono-, and magnetostratigraphy and chronology of the Umbria-Marche Basin (central Italy), building up a ~42.5-Myr continuous, undisturbed and well-preserved composite section belonging to the Scaglia pelagic sediments and based on the Contessa, Massignano and Monte Cagnero key sections.

It should serve as the Paleogene reference section for the Western Tethys, which will provide a template for future progress to the Cenozoic time scale as well as constraints for on-going paleoenvironmental, paleoceanographic and paleoclimatic studies.

M1-7 Orale Vallefucio, Mattia

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FORAMINIFERAL ASSEMBLAGES IN THE SOUTHERN TYRRHENIAN SEA (SALERNO GULF) FOR THE LAST 600 YR. EVIDENCES OF PALEO-ENVIRONMENTAL CHANGES AND HUMAN IMPACT

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Key terms: planktonic and benthic foraminifera; oxygen stable isotope; southern Tyrrhenian Sea; maunder event; human impact

High-resolution study of southern Tyrrhenian marine record (core C90-1m,

40°35,76'N;14°42,48'E, water depth of 103.4m) from continental shelf of Salerno Gulf, provides a good opportunity to detect the anthropogenic impact on sedimentation during the last 600 years. Based on ²¹⁰Pb and ¹³⁷Cs measurements, the sedimentation rate results of 0.20 cm/yr for the last 100 years. The high resolution of sample investigation (1 cm sample spacing) provide a time resolutions of data around 5 years. Quantitative changes in the planktonic and benthic foraminifera

assemblages combined to ¹⁸O_{carb} variation allows to recognize different paleoenvironmental intervals linked to the global and regional climatic and oceanographic changes. A significant turnover between herbivorous and opportunistic species and carnivorous planktonic foraminifera after the Maunder event reflects changes in river runoff and/or an increase in coastal flood events in the studied area. Human impact induces variations in the microfauna since 1940 AD associated to the building of the dam on the Sele river.

M1-8 Orale Bergami, Caterina

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ENVIRONMENT AND CLIMATE DURING SAPROPEL S1 DEPOSITION IN THE IONIAN SEA. PLANKTONIC FORAMINIFERAL EVIDENCES

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Key terms: Foraminifera; sapropel; temperature; salinity

The youngest sapropel S1 has been investigated by a multiproxy study on a core (ET99-M11) collected in the western Ionian Sea at a water depth of 2800 m, which is considered to represent anoxic conditions in the eastern Mediterranean at the time of sapropel formation.

Planktonic foraminifera have proven to be excellent indicators of sea surface temperature, salinity, food availability and they have been used for the detection of long- and short-term climate changes in the Mediterranean Sea.

Quantitative and qualitative characterization of the planktonic

assemblages, stable isotopes (¹⁸O and ¹³C) and trace elements measurements on the planktonic foraminifers Globigerinoides ruber and Globigerina bulloides have been performed to reconstruct Sea-Surface Temperatures (SST), Sea Surface Salinities (SSS), and riverine inputs at the time of sapropel S1 deposition.

The beginning of S1 is marked by a significant decrease in SSS and by a change in the planktonic foraminiferal assemblage with the increase of warm waters taxa, near absence of Globorotalia inflata and the significant decrease of Neogloboquadrina pachyderma. The ecosystem composition suggest a rising riverine input at the onset of the sapropel deposition and during the sapropel interruption linked to the African monsoon system. The sapropel S1 interval was characterized by a general increase in water temperatures (documented by calculated isotopic temperatures) both at surface and in the sub-surface layers. In addition, several short-term cold oscillation can be correlated with millennial scale climate events in the North Atlantic region. This indicates a possible atmospheric connection between the central Mediterranean and the North Atlantic region and the strong relation between climate and oceanographic changes during the sapropel deposition.

In addition, it is noteworthy that the cold periods can be correlated with intervals of weak Asian southwest monsoon suggesting that the Holocene climate changes in the North Atlantic can be have counterparts in the Asian southwest monsoon system.

Discrepancies between Mg/Ca ratios and calculated isotopic temperature suggest that these ratios during sapropel intervals may be significantly influenced by other factors such as seawater carbonate chemistry, lower salinity, and possibly diagenetic effects.

M1-9 Orale Buosi, Carla

10.1474/Epitome.04.0849.Geoitalia2011

ENVIRONMENTAL PARAMETERS CONSTRAINT ON DISTRIBUTION OF BENTHIC FORAMINIFERA IN THE STRAIT OF BONIFACIO (MEDITERRANEAN SEA)

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Key terms: Benthic foraminifera; Environmental parameters; Currents; Strait of Bonifacio

The Strait of Bonifacio is located between the Isles of Sardinia and Corsica (Mediterranean Sea), its maximum depth is about 100 m. The Strait is the exchange zone between the waters of the Tyrrhenian and Ligurian-Provencal basins and is strongly affected by high current action. Benthic foraminifera were identified in 31 samples collected during an oceanographic cruise ("Bocche 2003" - P.I.C Interreg III Project) that provided new geomorphological and sedimentological data on the western continental shelf of the Strait of Bonifacio.

Several biotic parameters were calculated (species diversity, density, Fisher's α index, Shannon-Weaver index, and Dominance) and multivariate analyses (Cluster Analysis, Principal Component Analysis and Canonical Correspondence Analysis) were performed to identify foraminiferal assemblages in the context of environmental parameters.

Strong current, bathymetry, grain-size, organic matter and food availability are the main factors exerting control on the spatial distribution of benthic foraminifera in the Strait of Bonifacio.

Three groups of assemblages were differentiated according to several sampling sites, which varied mainly due to degrees of energy. The first group included the shallowest station, close to the islands of Corsica and Sardinia, while the two other were typical of high-energy environments and were localized in the central area of the Strait. Cluster C concerns those located at a central position, while cluster B includes those in a more lateral position at the deepest part of the Strait. Elphidium crispum, Eponides concameratus and Textularia agglutinans appeared to be the more adapted species in this high-hydrodynamic system. The dominance of the epibenthic foraminifera (e.g. Lobatula lobatula and Planorbina mediterraneensis), permanently attached to sea grasses (Posidonia oceanica) and algae has been related to both the greater current velocities in the sampled area. The occurrences of Miliolinella subrotunda,

Neonorbina nitida, Quinqueloculina stelligera, Rosalina globularis, R. vilardeboana and Sigmoinella costata appear to be closely related to the abundance of organic carbon and higher C/N ratios. The distribution of S. sagittula appear closely linked with bathymetry. Interaction between multiproxy ecological factors (oxygen, food, toxic substances, biological interactions, transport, light penetration, turbidity, etc.) characterize peculiar microenvironments in the sediment-water interface, allowing different species to occupy different niches within a relatively small area. A detailed understanding of environmental parameters that influence benthic foraminifera distribution in natural systems is a necessary prerequisite for the use of foraminifera as useful tools for ecological and environmental interpretations.

M1-10 Orale Melis, Romana

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FIRST DATA ON THE DISTRIBUTION AND MORPHOLOGICAL ABNORMALITIES OF THE RECENT FORAMINIFERS IN THE MARANO AND GRADO LAGOON (NORTHERN ADRIATIC SEA).

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Key terms: lagoon; foraminifers; test deformation; bioindicator; mercury

The Marano and Grado Lagoon along the northern Adriatic coast, is an environment of naturalistic but also economic value, since it is exploited by man for industrial, farming and fishing activities. At the present, this area is constantly under quality control in accordance with the recent environmental directives.

This environment historically experienced a significant input of mercury (Hg), carried from the Isonzo River draining the cinnabar deposits of the world's second largest Hg mine at Idrija (Slovenia), which has been in activity for 500 years. Recent studies indicate that Hg it is the most common contaminant in the sediments and previous studies have also revealed its presence in the aquatic food chain.

Benthic foraminifers were investigated in the recent sediments collected during the "Miracle Project" (AA.VV., 2010). The diversity index is lowest in the stations in front of the Aussa-Corno River mouth, which is the area mostly affected by environmental stress (mercury pollution and/or natural salinity variations). Here, a greater dominance of brackish forms such as Ammonia tepida, Elphidium granosum, E. gunterii and Haynesina germanica has been recognized. Conversely, slightly higher values of diversity appear in less restricted areas of the lagoon or, at least, where physical parameters such as temperature and salinity are less variable (or more constant). Here, the association is characterized by more thalassic taxa, such as miliolids and arenaceous species.

The greater frequency of E. granosum, E. gunterii and H. germanica is recorded in the western sector of the lagoon (Marano), which is more affected by industrial activities. On the contrary, the greater dominance of A. tepida is recognized in the eastern lagoon (Grado), where the sediments are enriched in Hg, mainly in mineral form.

The deformation tests, carried out mainly on dead specimens, showed very high FAI (Foraminiferal Abnormality Index) values in the lagoon areas highly affected by riverine tributaries compared to the low values found in less restricted areas. However, the types of deformation are very often those involving only limited dimensional changes of the chambers. Concerning the study of some cores, higher FAI index coincides with the highest concentrations of Hg_{tot} in the recent sediments, whereas the index decreases with depth in agreement with the decreasing Hg content. Plotting the concentration values of Hg_{tot} and the deformation of the shell according to the calendar age scale, calculated on the basis of the ²¹⁰Pb activity log distribution (AA.VV., 2010), a sharp increase of pollution and tests deformation following the period of great industrial expansion of 1950 is observed.

AA.VV., 2010 - Messa a punto di un metodo per l'individuazione delle aree da destinarsi alla venericoltura (Tapes philippinarum) a minor rischio di contaminazione da mercurio in Laguna di Marano e Grado. Progetto Miracle. Rapporto tecnico 1- Commissario Delegato per la Laguna di Marano e Grado. Università degli Studi di Trieste, 279 pp.

M1-11 Poster Luciani, Valeria

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A TETHYAN PLANKTONIC FORAMINIFERAL AND STABLE CARBON ISOTOPE RECORD OF THE EARLY EOCENE CLIMATIC OPTIMUM (POSSAGNO SECTION OF NORTHEASTERN ITALY)

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Key terms: PLANKTONIC FORAMINIFERA; PALEOGENE; CLIMATE; EVOLUTION

The Earth experienced in the Early Paleogene a pronounced warming trend that peaked during the Early Eocene Climatic Optimum (EECO; ca. 50-52 Ma) that records the highest global temperature of the past 70 Ma within an extended interval of greenhouse-climate regime (e.g., Zachos et al., Science 2001, Nature 2008). Peak Cenozoic warmth reached during the EECO was followed by a long-term cooling trend through the middle-late Eocene leading to the modern icehouse world at the base of the Oligocene (Miller et al., Journ. Geoph. Res. 1991). A critical issue of the studies of early Paleogene climate is to demonstrate which is the role of climate on the biotic evolution. Woodbourne et al. (PNAS 2009) document dramatic plant and mammal faunal turnover related to the EECO, thus supporting a direct primary evolutionary control played by the EECO warmth. In the marine realm, new evolutionary trends in calcareous nannofossil communities appear linked to the EECO and set course toward modern structure (Agnini et al. EPSL 2006).

The EECO has been recently identified by Agnini et al. (EPSL 2006) in the classical early Paleogene section of Possagno (Venetians Pre-Alps of northern Italy; Bolli, Schweiz. Palaeont. Abhand. 1975) that accounts a reliable magnetostratigraphy and calcareous nannofossil record. This continuous section, deposited in a bathyal setting, provides an exceptional record of the Lower-middle Eocene transition as occurring in a marginal basin of the central-western Tethys. Given the importance of planktonic foraminifera that are extremely sensitive to environmental modifications, the quantification of their changes is an excellent proxy for the

comprehension of past surface-water variations during this interval of extraordinary warmth and for evaluating possible evolutionary pressures on this group across the EEOC.

The quantitative analysis performed at the Tethyan Possagno section highlights significant changes in abundance within the planktonic foraminiferal assemblages. The most marked variations well correlate the geochemical expression of the EEOC event, consisting of a pronounced, composite negative stable carbon isotope perturbation, thus suggesting a planktonic foraminiferal response to the Paleogene maximum warmth. Dominance of the warm-indices acarininids during the EEOC interval coupled with decrease of the cold-indices subbotinids can be straightforwardly interpreted as a consequence of the extreme warmth. The most negative stable carbon-isotope values are mainly associated to high fragmentation of planktonic foraminiferal tests thus suggesting some carbonate dissolution. The synchronicity of the EEOC event and deep-sea carbonate dissolution provides arguments that this was linked to a transient increase in atmospheric carbon dioxide pressure that caused the rise of the carbonate compensation depth and deep-water acidification. Nevertheless, we cannot totally exclude that carbonate dissolution may have differently affected the foraminiferal assemblages.

The most important information that emerges from the Possagno record is the decline of the symbiont-bearing morozovellids that appears as irreversible after the EEOC. Occurring against the profound climatic change represented by the EEOC, the morozovellid decline which correlates with evolution in other planktonic clades, e.g., calcareous nanofossils (Agnini et al., *EPSL* 241, 2006) may allude to critical steps in the reorganization of Eocene pelagic ecosystems that passes from the greenhouse to the doobthouse/icehouse regime. The consequent modification in the water column structure and the reduced carbon-dioxide pressure following the EEOC might have negatively affected the ecological niches of the highly specialized muricate forms and biased the complicated mechanism of the morozovellid symbiosis processes.

M1-12 Poster Villa, Giuliana

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CALCAREOUS NANNOFOSSIL PRESERVATION STATE AS A DISSOLUTION PROXY: A CASE STUDY FROM THE EOCENE-OLIGOCENE TRANSITION AT ODP SITE 1090 (AGULHAS RIDGE, SOUTH ATLANTIC OCEAN)

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Key terms: CALCAREOUS NANNOFOSSIL; EOCENE-OLIGOCENE; SOUTH ATLANTIC; DISSOLUTION

The Eocene-Oligocene Transition (EOT) (~34 Ma) is characterized by global cooling and Antarctic ice-sheet expansion, sea level fall, deepening of the calcite compensation depth (CCD), and significant turnover in marine and terrestrial biota. CCD deepening at the EOT is interpreted worldwide based on an increase in carbonate accumulation at multiple deep ocean sites. In the South Atlantic, the CCD is interpreted to have deepened by ~1 km, but a detailed CCD history across the EOT has not been previously developed for this region. In this study, quantitative analysis of calcareous nanofossil assemblage was carried out within the EOT interval at ODP Site 1090 (42°S; Agulhas Ridge; South Atlantic). The primary goals of this work were: (1) to assess the degree of dissolution affecting nanofossil assemblages; (2) to use the nanofossil dissolution signal as proxy for CCD variation; and (3) to characterize surface-water temperature and nutrient changes during the EOT using paleoecological information provided by nanofossils.

Within the EOT interval of ODP Site 1090, two indices of dissolution were calculated using the preservation state of two common taxa: *Coccolithus pelagicus* and *Reticulofenestra umbilicus* group. A third dissolution index was calculated using characteristics of the entire assemblage. Comparison between the nanofossil indices and carbonate content shows a striking correspondence, indicating that dissolution was a major factor controlling carbonate sedimentation and nanofossil preservation/assemblage composition in the EOT interval at this site. Additionally, there is a good correspondence between carbonate content and *Blackites* and *Clausicoccus* abundance, suggesting that dissolution is also a major factor in controlling the stratigraphic distribution of these taxa.

Variation in nanofossil dissolution indices and carbonate content through the EOT interval of Site 1090 are interpreted to reflect CCD fluctuations. The CCD at this site markedly oscillates in the latest Eocene and then deepens in the earliest Oligocene in correspondence with oxygen isotope ($\delta^{18}O$) Step 2 (coincident with Oi-1). An intense dissolution interval is observed in the latest Eocene immediately prior to oxygen isotope Step 1. Within this dissolution interval, however, only one sample is totally barren of nanofossils and the total abundance varies with carbonate content, suggesting that nanofossil assemblages are good dissolution indicators even in extreme conditions of carbonate under-saturation. Nanofossil dissolution indices also define an interval of carbonate dilution just prior to oxygen isotope Step 2, which results from an increase in bioliteous sedimentation.

A selection of well-preserved samples was used for the paleoecological interpretation of nanofossil assemblages across the EOT at Site 1090. A major assemblage change is observed near the E/O boundary (~33.6 Ma) and is interpreted to reflect an increase in sea-surface nutrient availability, possibly in conjunction with cooling. This event is followed by a gradual increase in fertility associated with cooling which culminated at Step 2. Following Step 2, nanofossil assemblages at Site 1090 indicate nutrient-enriched cold waters during the earliest Oligocene.

M1-13 Poster Musca, Claudio

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THE TRIPOLI FORMATION OF THE PIETRAPERZIA SECTION (SOUTHERN SICILY, CL). REGIONAL COMPARISON

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Key terms: Tripoli Formation; Southern Sicily; Messinian

The stratigraphic interval preceding the beginning of the evaporitic sedimentation (pre 5.96 Ma), in the central Sicily (Caltanissetta basin

Auct.) consists of the well know Tripoli formation.

This unit, between the silico-clastic late-miocenic deposits and the messinian evaporites, is made of a "triplet" of (Decima and Wezel, 1971): a) marly layer, b) brown-red laminites "sapropel" and c) white diatomitic laminites. Each triplet is developed in response to a single precessional cidity (about 21.000 years, Sprovieri et al., 1996).

We describe the results of a detailed lithologic and bio-stratigraphic study performed in the frame of regional research on Tripoli in Sicily (Catalano et al., unpublished). The stratigraphic section outcrops at Serra di Mezzo (SRM, Pietraperzia, CL) and was compared to the Falconara section (FNA, Southern Sicily), is studied by Sprovieri et al., (1996), to underline similarities and differences. The FNA section is considered the representative and complete Sicilian Tripoli section. It is characterized by a deep marine environmental succession, where 40 precessional cycles have been recognized. The biostratigraphic analysis, carried out by Sprovieri et al., (1996), highlighted the presence of well diversified and preserved microassociations, almost for the whole section, and a progressive worsening from cycle 36.

The Pietraperzia section lithologic analysis includes about 14 m below the base of evaporitic limestone. The analysis highlighted a triplet layer organization for each of the 16 precessional cycles. The local base of the Tripoli doesn't outcrop. The detailed sampling (about 2 samples/m) allowed to characterize the studied section from a biostratigraphic point of view and to correlate them with the upper part 16 cycles FNA section. The first 4 cycles of the SRM section (25-28 FNA cycles), are characterized by the presence of a rich assemblage of planktonic foraminifera, containing *Globigerinoides obliquus* s.l. and a few *Globigerina* bulloides. The calcareous nanofossil association is well diversified, but without index forms. Siliceous remains (Diatoms and Silicoflagellate), and fish have been found, sometimes abundant. The middle-upper part of the SRM section, 5 to 16 cycles (equivalent to 29-40 Falconara cycles) showed very different features compared to Falconara. In particular, towards the upper part of the succession the flora and fauna microassociations progressively disappears, until the total sterility. The calcareous nanofossil assemblages occur up to 4th cycle as well the Planktonic foraminifera assemblages disappear in the 3th cycle. The siliceous assemblages decrease in abundance and diversity upwards. Along the whole studied section, there are frequent amber elements, more or less dark, associated with well preserved sporomorphs. Possibly suggesting a proximal depositional environment until isolation from continental supply. In conclusion, the SRM stratigraphic section, is correlated with the upper portion of the complete FNA section. The litho- and biostratigraphic data, obtained from the two compared sections, put evidenciate that within the SRM section, the disappearance of flora and fauna microassociations, would anticipate about 9 cycles (about 190 ky) the same event recorded in the FNA section. The data are explained by hypothesizing that immediately before the Messinian salinity crisis, the paleoenvironmental condition progressive worsening and the isolation of some depositional areas, from the marine areas, was a diachronous, from the present day North to the South (Catalano et al., 2010). This hypothesis is supported by the presence within the SRM section of continental contribution remains, totally absent in the FNA section.

M1-14 Poster Violanti, Donata

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MICROFOSSIL ASSEMBLAGES OF ZANCLEAN DIATOMACEOUS SILTS FROM THE MONFERRATO (PIEDMONT, NORTHWESTERN ITALY): NEW PALEOENVIRONMENTAL DATA

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Key terms: Calcareous microfossils; Siliceous microfossils; Upwelling; Early Pliocene; Piedmont, Northwestern Italy

Massive whitish silty-clayey to sandy silts, yielding mixed calcareous (mainly foraminifers, ostracods, echinoid fragments) and siliceous (sponge spicules, diatoms and radiolarians) were discontinuously recovered in an area of about 40-45 km² of the Monferrato (Piedmont, Northwestern Italy). The diatomaceous silts are local members of the Argille Azzurre (Blue Clay) Formation (Zanclean, Lower Pliocene) (Dela Pierre et al., 2003). Micropaleontological assemblages (diatoms, foraminifers, calcareous nannoplankton, ostracods and radiolarians) were quantitatively studied in the natural section of Castelcebro and La Torretta and in an abandoned quarry near Calliano (Asti). On the basis of foraminifers, they have been dated to the MPI3 biozone (Zanclean) and therefore are the first documentation of Pliocene mixed calcareous and siliceous assemblages in the Piedmont, where only Miocene diatomites or diatomaceous silts were previously described (Bonci et al., 1990; Bonci et al., 1991). The occurrence of rare *Nitzschia jouseae* both at La Torretta and Castelcebro allows the correlation to the *Nitzschia jouseae* diatom biozone (upper Early Pliocene to Late Pliocene). Calcareous and siliceous microfossils show often opposite abundances and suggest conditions of moderate, probably seasonal upwelling on shelf bottoms. Planktonic foraminifers are mainly represented by phytoflagous, eutrophic taxa as *Globigerina* bulloides and *Neoglobobulimina acostaensis*; the infaunal, opportunistic *Bulimina* spp., *Cassidulina carinata*, well adapted to abundant trophic resources and to dysaerobic bottoms, are dominant. Diatoms are more frequent and well preserved at La Torretta, meroplanktonic forms (*Paralia sulcata*, *Thalassionema* group) and *Chaetoceros* resting spores are common to abundant. Stress tolerant taxa are common to dominant also between ostracods (*Costa edwardsi*) and radiolarians (*Dictyocorynids*, *Rhopalastrium zitteli*). Within the calcareous nanofossils, the absence of *Discoaster* spp. is inferred to be due to high nutrient availability in surface waters.

The quantitative micropaleontological study documents rather high productivity episodes and enlightens an Early Pliocene palaeoenvironment more complex and diversified than previously known in the region, where only calcareous assemblages are documented.

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M1-15 Poster Basso, Daniela

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SOUTHERN SINAI STROMATOLITES AND ONCOLITES

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Key terms: microbialites; stromatolites; oncolites; cyanobacteria; Red Sea

Stromatolites are rare today in modern marine, freshwater or hypersaline systems, but occur widely as fossils in many calcareous or dolomitic sedimentary sequences. Stromatolites have been long time defined as layered accretionary structures formed in shallow water by biofilms of microorganisms, primarily cyanobacteria, that trap, bind and cement the sediment in a more or less rhythmic fashion. Recent studies show that the processes of stromatolite formation are both abiogenic (sediments trapping in bacterial mucilaginous) and biogenic (microbially-induced mineralization), and consequently the accepted definition of stromatolite is going to be considerably widened. In agreement with Riding (2009) stromatolites are "subaqueous authigenic crusts, formed by abiotic precipitation and/or by biogenic lithification of microbial mat".

However, the correct interpretation of fossil stromatolites genesis - biogenic or abiogenic - and mechanisms of formation is constrained by the occurrence of specific environmental conditions and thus yields unequivocal palaeoenvironmental information. Although stromatolites are significant in Earth palaeoenvironments that are poorly comparable with the modern ones, present-day stromatolites structure, composition, growth mechanisms and favourable environments remain a substantial source of knowledge for palaeobiologists.

Samples of modern microbialites were collected in Nabq Bay and in Ras Mohamed (southern Sinai, Egypt) in a marine intertidal tropical environment. The studied material included agglomerated, unconsolidated sand, oncolites and crusts at different levels of consolidation/lithification. The sand was analyzed with light microscopy, oncolites were observed with SEM (Scanning Electron Microscopy) and crusts were studied throughout SEM and thin sections. Thin sections were staining with Alizarin Red.

Thin sections of poorly lithified crusts show evidence of bacteria (cyanobacteria and purple sulphur bacteria) among the constituent grains in the form of gelatinous filaments (green and red sheaths), while fully-lithified crusts show presence of microalgal colonies along the outer edge, accompanied by a very high degree of diagenetic alteration. In addition, at the surface and/or inside some crust samples we observed the alternation of planar or irregular dark, superposed layers and clastic layers.

Southern Sinai microbialites show evidence of both sediment trapping in bacterial mucilaginous sheaths and microbially-induced mineralization, supporting the hypothesis of their biogenic nature. In particular we observed widespread filaments of Schizothrix (?) among grains, EPS (Extracellular Polymeric Substance) sheaths connecting particles, calcareous tubes possibly grown around cyanobacteria cells and acicular aragonite. Fringes of acicular aragonite occur around particles and appear locally dissolved. Staining with Alizarin Red confirms the calcareous composition of constituent grains. The presence of magnesium has been confirmed by EDS (Energy Dispersive Spectrometer) analysis. Investigation on cement occurrence and mineralogy are in progress.

SESSIONE M2

Il contributo italiano alla definizione e taratura di scale cronostratigrafiche e geocronologiche

M2-1 Orale Bagnoli, Gabriella

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ITALIAN CONTRIBUTION TO THE CHRONOSTRATIGRAPHIC SUBDIVISION OF THE CAMBRIAN SYSTEM.

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Key terms: Cambrian; Ordovician; Chronostratigraphy

Traditionally, the Cambrian was subdivided into three series: Lower, Middle, and Upper. However, the International Subcommission on Cambrian Stratigraphy has recommended a four-fold subdivision of the Cambrian System to accommodate a thick pre-trilobite interval in the lower part of the system. The base of the Cambrian has been established formally at the base of the Tricophycus pedum Zone, and the base of the Ordovician has been established at the base of the Iapetognathus fluctivagus Zone. However, internal subdivisions of the Cambrian into two or three stages for each series are not yet accomplished. To date, the Terreneuvian Series and Fortunian Stage at the base of the Cambrian System, the Drumian Stage (at the base of the Ptychagnostus atavus Zone), the Guzhangian Stage (at the base of the Lejopyge laevigata Zone), and the Furonian Series and Paibin Stage (at the base of the Glyptagnostus reticulatus Zone), have been ratified.

The Italian contribution to the chronostratigraphic subdivision of the Cambrian included the study of conodont associations from several Chinese sections, in particular the Paibi section (GSSP of the Furonian Series and Paibin Stage), the Luoyixi section (GSSP of the Guzhangian Stage, the last stage of an unnamed series, provisionally termed Series 3), and the Duibian B section (proposed GSSP of Stage 9, the second stage of the Furonian Series, recently approved by the International Subcommission on Cambrian Stratigraphy).

Even though agnostoid trilobites are the primary tools, conodonts helped to constrain the definition of these chronostratigraphic units and proved to be useful for correlation with other areas.

In 2000 the International Union of Geological Sciences (ratified the decision to place the GSSP for the base of the Ordovician System in the Green Point section, Newfoundland, Canada, at a point coinciding with the first appearance datum of the conodont Iapetognathus fluctivagus. Since then search for the taxon and the fixing the boundary in many other

places in the world has been in vain, because firstly the taxon is indeed rare, secondly the chosen taxon does not appear at the boundary but much later and finally the taxon has been misidentified at the Green Point GSSP section.

A re-study of the specimens assigned to Iapetognathus fluctivagus from the stratotype revealed, however, that the primary correlation marker is not present in the boundary interval of the stratotype section. In consequence, the section does not fulfil the biostratigraphic requirements of a GSSP.

This problem is a result of the previous efforts, where different genera and species have been allocated to the same genus i.e. Iapetognathus and distinct different species have been synonymized to become the same species.

A recent re-evaluation of the taxon shows that the genus as previously interpreted is polyphyletic and is composed of at least three lineages, which are Iapenodus (two species), Iapetognathus (three species) and two new unnamed genera both of which represented by one species. As a consequence, a restudy of the GSSP section and the other sections in the Cow Head Group is needed and a revised biostratigraphic definition of the boundary is necessary.

M2-2 Orale Ferretti, Annalisa

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LATE ORDOVICIAN CONODONT FAUNA FROM THE CARNIC ALPS: WHAT ELSE?

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Key terms: Ordovician; Carnic Alps; Cellon Section; conodont biozonation; Amorphognathus evolution

Biostratigraphy alone, even if integrated with information derived from diverse faunal groups, has been shown to be insufficient for identifying with precision any subdivision of a stratigraphic interval.

Chemostratigraphy in primis now plays a dominant role, as in the Late Ordovician where the subdivision of the Hirnantian stage into the two

stage slices H1 and H2 is marked by the end of the global Hirnantian $\delta^{13}C$ excursion (HICE; Bergström et al., 2009).

Conodonts have long been used as important biostratigraphic tools. The Cellon Section of the Austrian Carnic Alps played a prominent role when the original Silurian conodont biozonation was introduced by Walliser (1964). The section is equally significant for the Ordovician, as documenting one of the most continuous Late Ordovician successions preserved in Europe covering both the Katian and Hirnantian stages. At this locality two distinctive stratigraphic sequences are present. The Uggwa Limestone Formation is approximately 4 m thick and consists of limestone strata with intercalated siltstones at the top. The overlying Plöcken Formation, approximately 6 m thick, consists of siltstones with interbedded bioclastic limestone lenses at the base from which the Hirnantia brachiopod fauna has been documented and impure pyrite-rich limestones and sandstones at the top.

Most published biostratigraphic schemes for the Carnic Alps area were based on single group organisms, such as conodonts or graptolites. The recent documentation of the HICE spike event at the Cellon Section (Schönlaub et al., 2011) has renewed interest in checking and comparing the most important biostratigraphic markers present by resampling of the area. These studies are complemented with a precise calibration by identification of chronostratigraphic markers.

As regards conodonts, within the Late Ordovician the appearance of Amorphognathus ordovicicus marks in the Katian the start of the Ka3 stage slice. The same apparatus is known to span through the Late Ordovician up to the Ordovician/Silurian boundary. In the Carnic Alps the Amorphognathus genus is equally present in the Katian and in the overlying Hirnantian glacial deposits of the Plöcken Formation (Ferretti & Schönlaub, 2001). A thorough analysis of the numerous lineages of Amorphognathus reveals how the conodont signature contained within this genus may be highly informative with respect to the biostratigraphic subdivision of this final part of the Ordovician. Thus, a revised conodont biozonation, easily correlated across several paleocontinents and additionally constrained by data from graptolites, chitinozoans and shelly faunas in this stratigraphically significant area, may be derived from the species present. Integrated biostratigraphic data for the Cellon Section have been recently proposed based on the published literature and ongoing fieldwork (Schönlaub et al., 2011).

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M2-3 Orale Histon, Kathleen

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THE EARLY TO MIDDLE PALEOZOIC REVOLUTION (IGCP 591): CHRONOSTRATIGRAPHY AND BIOSTRATIGRAPHY OF SILURIAN SEQUENCES IN THE CARNIC ALPS

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Key terms: Carnic Alps; Silurian; chronostratigraphy; biostratigraphy; lithostratigraphy

The Late Ordovician to Early Devonian interval contains several of the most significant paleoclimate and paleobiological events in Earth history including paleobiodiversity events and/or perturbations to the global

carbon cycle. IGCP Project 591 (www.igcp591.org), of which the author is a co-leader, is designed to provide a forum for the Early to Middle Paleozoic global community to investigate this dynamic and important interval in the history and evolution of life and our planet. Research in progress in the Carnic Alps falls within the framework of the above project and a short overview regarding in particular chronostratigraphic and biostratigraphic studies will be presented so as to highlight the outstanding importance of this area for global correlation. Among the many geological sections located in the Central and Southern Alps those of the Carnic Alps, in particular the Cellon Section, serve as reference sections for the Silurian within this middle paleolatitude North Gondwana Sector. Since the Great War up to the present day scientists from both Austria and Italy have studied the area. The comprehensive study carried out by von Gaertner is of particular importance as he focused his work on the Cellon section and introduced a formal lithostratigraphic subdivision which has partly been in use until the present with most of his Silurian divisions now being formally recognized: Kok, Cardiola and Alticola Formations (Histon et al., in prep). A valuable multidisciplinary data set is now available for the study area across a broad facies range from proximal to basinal settings (Nöbling and Bischofalm Formations).

Biostratigraphical studies on conodonts, graptolites, chitinozoans and bivalves are all important for global correlation and the standard index fossils for Upper Ordovician to Lower Devonian biozones have been identified in the Carnic Alps sequences. Faunal assemblages of brachiopods, nautiloids, ostracods, acritarchs, trilobites and corals provide valuable data with regard to paleoenvironmental and paleobiogeographical reconstructions using both benthic and pelagic faunas. The data facilitate detailed correlation on a global basis and are complemented by a range of studies on sedimentology, microfossils, and C and O isotope analyses that aid in deciphering climatic and eustatic changes on a regional scale. Sequence stratigraphic methods applied to the Silurian sequences highlighted eustatic changes which may be traced across four palaeocontinents (Brett et al., 2009).

K-Bentonites of Upper Ordovician to Lower Devonian age have been correlated with coeval occurrences in other parts of Europe. The ash layers originated from a subduction-related volcanism of an active plate margin, dominated by calc-alkaline mafic lavas of a volcanic arc setting with andesitic-rhyolitic/dacitic magmatism (Histon et al., 2007). The data are of important significance with relation to geodynamics and palaeogeographical reconstructions of the Peri-Gondwanan Terranes as such findings are rare within this middle paleolatitude sector for this interval. Radiometric dating and precise geochemical profiles of these levels will provide significant time-lines for chronostratigraphy and correlation of the full data-set available from the area with regard to global timing of major events identified there during the Early to Middle Paleozoic.

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M2-4 Orale Balini, Marco

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TOWARDS THE DEFINITION OF THE GSSP OF THE NORIAN STAGE: REPORT ON THE ONGOING ACTIVITIES OF THE ITALIAN WORKING GROUP

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Key terms: Upper Triassic; Norian; GSSP; Chronostratigraphy; Integrated stratigraphy

The completion of the chronostratigraphic scale of the Triassic System still requires the definition of 4 GSSPs, namely those for the Olenekian, Anisian, Norian and Rhaetian stages. Some Italian specialists are active in all the Working Groups of the Subcommission on Triassic Stratigraphy, but the contribution of Italian stratigraphers is especially important in the Carnian/Norian and Norian/Rhaetian WGs. For these two intervals some sections located in Italy are also under discussions as GSSP sites. In order to better integrate the activities of the Italian specialists, few years ago research teams from Milano, Padova, Ferrara, Perugia and Palermo universities grouped together under a PRIN entitled "Upper Triassic integrated stratigraphy: GSSP and auxiliary sections in Italy". The project was funded in 2010 and a first international meeting was organized in Palermo (September 12-18, 2010). Here we summarize the activities carried out on the Carnian/Norian boundary during the first year of the project.

The PRIN research units have been working on Carnian-Rhaetian successions in the Southern and Eastern Alps, Lagonegro basin and western Sicily with two major aims. The first is to study in great detail the best sections with potential interest for the definition of the GSSPs. The second is to test their stratigraphic significance and usefulness by means of correlations with as many sections as possible. Ammonoids, halobiids, conodonts and radiolarians, are the best tools for a high resolution bio-chronostratigraphy, that is integrated with sedimentology, sequence stratigraphy, stable isotope variation and, when possible, radioisotopic dating.

As regard the definition of the GSSP of Norian stage, three sections are under study: Pizzo Mondello and Pizzo Lupo (Sicily), and West Union Canyon (central Nevada, USA).

Pizzo Mondello section (Sicani Mountains) was discovered in the 1990s by researchers from Palermo University. This section is one of the two candidate sections for the definition of the GSSP of the Norian stage, together with Black Bear Ridge in British Columbia (Canada). Magnetostratigraphy has been published few years ago (Muttoni et al 2001, and 2004) and in the last 3 years the section has been studied for sedimentology, nannofossils, conodonts, halobiids and ammonoids. Several contributions have been submitted for publication in the proceedings of the Palermo workshop. Magnetostratigraphy and its integration with halobiids, conodonts, ammonoids and radiolarians bio-chronostratigraphy are the main pros of this section.

Pizzo Lupo section (Sicani Mountains). This new site is located in an

quarry and is under study by a team lead by P. Di Stefano. The section has been sampled for ammonoids and halobiids and the study of conodonts is in progress. The section is easily correlated with Pizzo Mondello not only by biostratigraphy, but even by bedding. The preliminary results will be presented in this session by Tripodo et al. West Union Canyon (central Nevada, USA). This site shows the best Late Carnian-Early Norian ammonoid record in North America and is of great importance for the correlations with the Tethys. The last two ammonoid zones of the Carnian of the North American standard scale were defined on the Luning Formation of this area. Moreover this formation also records the first zone of the Norian. Surprisingly, this site has been never studied in the last 50 years, therefore neither conodont nor halobid data are available. For this reason a preliminary sampling of this site was carried out in Fall 2010. Preliminary ammonoid data are presented by Balini et al. in the session GEO/01.

Acknowledgments

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M2-5 Orale Tripodo, Angelo

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THE NEW CARNIAN/NORIAN SECTION OF "PIZZO LUPO" (CASTRONOVO DI SICILIA, SICILY) AND ITS BEARING TO THE DEFINITION OF THE GSSP OF THE NORIAN STAGE

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Key terms: Carnian/Norian boundary; Sicily; ammonoids; pelagic bivalves; Sicilian basin

A well preserved section of Halobia limestones has been recently studied near Castronovo di Sicilia in central Sicily in the framework of a project aimed at the identification of the historical localities where G.G. Gemmellaro (1904) has collected the Triassic ammonoids described in his outstanding monograph "I cefalopodi del Trias Superiore della regione occidentale della Sicilia". This section, that we indicate as "Pizzo Lupo", occur along the abandoned slope of an active quarry. It represents the lower zone of a pelagic succession of Carnian to Cenozoic age pertaining to the Sicilian Basin and occurring as a thrust sheet in the external zone of the Apenninic-Maghrebian fold and thrust belt.

The section exposes about 200 m of slightly folded Halobia limestones (also known as cherty limestones or Scillato Fm. Auct.). The studied zone consists of about 50 m of thick-bedded (30-50 cm) calcilutites, sometimes with chert and irregular marly intercalations. Wackestone or mudstone with radiolarians, halobiids and calcispheres are the common microfacies in this zone. A shelter porosity provided by halobid isorotation is frequent. This section has been sampled for ammonoids and halobiids. Ammonoids are rare, but several well preserved specimens have been so far collected. Late Carnian ammonoids are relatively common, and consist of the short ranging "Anatomites", *Projuvavites* and *Microtropites*, together with long ranging *Hypocladiscites* and *Arcestes*. Higher up in the section the Early Norian *Dimorphites* has been found from levels yielding *Halobia austriaca* Mojsisovics, 1874.

As in other sicilian sections, the halobiids are rather frequent, in terms of both number of fossil-bearing beds and number of specimens. They allow a better identification of the Carnian/Norian boundary. *Halobia radiata* Gemmellaro, 1882, *H. austriaca* and *H. styriaca* (Mojsisovics, 1874) have been so far recognized in succession, from the levels yielding Late Carnian to Early Norian ammonoids.

The new data emphasize the stratigraphic significance of *H. austriaca* and *H. styriaca* as markers of the Lower Norian in the western Tethys, as suggested in literature. Preliminary test samples for conodont biostratigraphy are positive and the study is in progress.

The collected bed-by-bed litho- and biostratigraphic data allow high resolution correlations with the succession exposed at Pizzo Mondello (Bivona), a well known locality at about 15 km to the South West, especially as regard the Carnian/Norian boundary interval and make it possible to consider Pizzo Lupo as an auxiliary section to support Pizzo Mondello as the GSSP of the Norian stage.

M2-6 Orale Premoli Silva, Isabella

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PROGRESSES ON CRETACEOUS STRATIGRAPHY

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Key terms: Cretaceous; Stratigraphy e GSSPs; Italian contributions

A wealth of data on various aspects of Cretaceous stratigraphy had continued to be published up to now providing a continuous amelioration of the multiple stratigraphic framework that today spans the whole Cretaceous in high to frequently very high resolution. Increasing knowledge on carbon isotope stratigraphic patterns and magnetostratigraphy from continuous pelagic successions, including from deep-sea perforations, through the Cretaceous, provoked an increase of interest in the scientific community for a more traditional stratigraphic aspects.

The Italian scientific community in the past decades provided the first order calibration of the magnetic time scale based on calcareous nannofossils and to minor extent calpionellids in the Early Cretaceous interval prior to the Cretaceous Superchiron (Early Aptian) and on nannofossils and planktonic foraminifera after it (Campanian-Maastrichtian).

Recent work, still ongoing, in search of the Berriasian GSSP, extended the calibration across the Jurassic/Cretaceous boundary mainly based on high resolution nannofossil biostratigraphy from the Southern Alps. Specialists on planktonic foraminifera were/are deeply involved in several projects, the most important ones dealing with (1) the taxonomic revision of genera and species and their distribution from Early Cretaceous on-land and in deep-sea successions; (2) the taxonomic description of the planktonic faunas found for the first time across the Aptian/Albian boundary in a new section surveyed in Vocontian Basin nearby that previously proposed as base Albian GSSP (not suitable); (3) the studies in

search of base Campanian GSSP and refinement of Campanian biostratigraphy.

M2-7 Orale Amodio, Sabrina

10.1474/Epitome.04.0862.Geoitalia2011

A CONTRIBUTION TO THE BARREMIAN AND APTIAN GEOCHRONOLOGY FROM ORBITAL CHRONOSTRATIGRAPHY OF SHALLOW-MARINE CARBONATES

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Key terms: shallow-marine carbonates; cyclostratigraphy; orbital time scale; Barremian; Aptian

The duration of the geological time intervals, biostratigraphically bracketed, can be calculated by a combination of methodologies (orbital cyclostratigraphy, paleomagnetism, and stable isotope stratigraphy), that are independent from those based on the decay of radiogenic isotopes. At present the idea of high-frequency cyclicity dominated by conditions external to the depositional environments (alloycyclicity) has been widely accepted, especially for the pre-Quaternary intervals. In this context the Earth's orbital periodicities (Precession, Obliquity, short and long Eccentricity) recorded in both pelagic and shallow marine carbonates, have been often used to determine time length and accumulation rate of given intervals, as well as to assemble the related orbital chronostratigraphy based on the long eccentricity cycles, the latter interpreted in terms of depositional sequence equivalents. In the last twenty years, high-resolution (cm scale) studies of several Cretaceous carbonate platform successions in central-southern Italy have demonstrated that they carry clear evidence of astronomically controlled eustatic oscillations on their hierarchical stacking pattern (elementary cycles, bundles and superbundles). Moreover, these deposits, widely outcropping in the Periadriatic Region as thick stratal successions, exhibit a sequence-stratigraphic configuration, that is well evident in their superbundles (long eccentricity cycles) as well as in the composite mode of their aggradational pattern, laterally consistent also at more than 100 km distance.

Based on cyclostratigraphy and sequence stratigraphy criteria and using appropriate biostratigraphic, isotopic and paleomagnetic markers, high-resolution physical correlations (precision 100 ky) have been traced at regional scale among several lower Cretaceous sections from Southern Italy. In particular, detailed carbon-isotope curves from Barremian to Aptian intervals of S. Maria core (east of Maiella Mountain), Serra Sbragavittelli (Matese Mountains), Monte Faito (Lattari Mountains) and Monte Tobenna (Picentini Mountains) have been correlated with the palaeomagnetically and biostratigraphically dated carbon-isotope stratigraphy of the longest Monte Raggeto (Maggiore Mountain) reference section.

For each of the above sections a chronostratigraphic diagram has been assembled, based on the following sequence-cyclostratigraphy assumptions: (a) superbundles (400 ky cycles) are considered as depositional sequence equivalents, (b) maximum flooding surfaces of the coeval superbundles are isochronous at the scale of the bundles (100 ky cycles); (c) bundles are used as basic chronostratigraphic units. By correlating coeval sections, orbital chronostratigraphy allows: (a) to locate missing bundles or superbundles (if any) along the analyzed successions, (b) to calculate for each superbundle, as well as for each succession, the average accumulation rate, regardless of the gaps occurring in the sedimentary record and (c) to estimate the minimum time required for each succession to accumulate.

On these bases, a numerical estimate of the Barremian and Aptian stage duration is proposed. Taking into account the number of superbundles for each interval, a duration of 5.6 my for the Barremian stage (14 superbundles) and of 8.0 my for the Aptian stage (20 superbundles) has been calculated. These numerical estimates are compared with the "floating" geological time scales available for the above stages (e.g. Gradstein et al., 1994, 2004; Ogg et al., 2008), showing that cyclostratigraphy of carbonate platform sequences, integrated with other stratigraphic methodologies and high precision long distance correlations is a valid tool for the above assessments.

M2-8 Orale Coccioni, Rodolfo

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THE CONTESSA HIGHWAY SECTION (GUBBIO, ITALY): A POTENTIAL CANDIDATE FOR DEFINING THE GSSP OF THE BASE OF THE BARTONIAN STAGE

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Key terms: Lutetian/Bartonian boundary; magnetobiostratigraphy; Contessa Highway section; Italy

An accurate magnetobiostratigraphic definition and astrochronological dating of the Lutetian/Bartonian boundary is provided at the Contessa Highway section (Gubbio, Italy). According to the International Commission on Stratigraphy guidelines, this section represents an excellent GSSP candidate for the base of the Bartonian Stage. The criteria proposed as reliable for driving the "golden spike" that should define the Lutetian/Bartonian boundary are: (1) the first occurrence of planktonic foraminifer *Turborotalia cerroazulensis* that occurs in the upper part of Chron C19r, (2) the last occurrence of planktonic foraminifer *Guembelitroides nuttalli*, which is found just below the base of Chron C19n, (3) the base of Chron C19n, (4) the top of Chron C19n or (5) the first occurrence of calcareous nanofossil *Reticulofenestra reticulata* that falls in the lower part of Chron C18r. Given the apparently close

association of criteria (2 to 5), and also in agreement with the current Geologic Time Scale, we propose the top of Chron C19n as the most useful and best potential for global correlation with an astronomically calibrated age for that event of 41.25 Ma.

M2-9 Orale Villa, Igor

10.1474/Epitome.04.0864.Geoitalia2011

K-FELDSPAR HYDROCHRONOMETRY

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Key terms: Geochronology; Isotope systematics; Diffusion; Petrology; K-feldspar

Microclines are sometimes used to infer cooling rates of rocks by modelling their 39Ar-40Ar systematics. In this study, we present multi-isotopic, imaging, and microchemical data on microclines from the Aar metagranite (Swiss Central Alps) in order to understand what controls their isotope record. One sample displays a staircase-shaped 39Ar-40Ar age spectra that can be modelled following conventional "thermochronology", assuming that 39Ar is the only isotope of interest. However, thermochronological modelling results in a paradox, as overdetermined independent paleothermometry constrains the peak T quite reliably to 430-450 °C and implies that the mylonite zone ca. 1 m away from our sample was apparently active for < 40 years. This leads to a geologically unrealistic slip rate of > 500 mm/a. Alternatively, multiple isotope systematics (Pb and Sr stepwise leaching, 37Ar/39Ar and 38Ar/39Ar ratios) reveal that two diachronically grown K-feldspar generations coexist: Kfs-1 (≥ 35 Ma old, Ca-poor, Rb-Cl-rich, low

87Sr/86Sr, high 206Pb/204Pb) and Kfs-2 (≤ 10 Ma old, antithetic isotopic signatures). Kfs-1 retained its chemical and isotopic signature at 450 °C. The shape of the spectrum and the Arrhenius trajectory are not causally related as asserted by thermochronological modelling. Staircase spectra reflect mixing of distinct feldspar generations rather than within-grain diffusive gradients. Arrhenius rates reflect a sum of unrelated processes, none of which has an a priori linear dependence on 1/T. Chemically heterogeneous microtextures were imaged by cathodoluminescence, back-scattered electrons and element mapping by electron microprobe. Quantitative microanalyses confirm hetero-chemical replacement, such as the addition of water-soluble Ba transported by a fluid, and confirm the heterogeneity predicted by the multi-isotopic systematics. This combined strong chemical and microtextural evidence argues for fluid-dominated recrystallization. The stepwise release of Ar, Pb and Sr must not be modelled as diffusion from a single inert matrix. What feldspars can be used for is to constrain the fluids that interacted with them by multi-isotopic analyses, rather than to model a "cooling history" from 39Ar release alone, ignoring microtextures and the context of all other isotope systems.

SESSIONE M3

Paleobiologia stratigrafica applicata a successioni Quaternarie

M3-1 Orale Scarponi, Daniele

10.1474/Epitome.04.0865.Geoitalia2011

PALEOBATHYMETRIC SIGNATURES OF MOLLUSK ASSOCIATIONS FROM FRONTE SECTION (TARANTO): A CANDIDATE GSSP FOR THE BASE OF THE TARENTIAN (LATE PLEISTOCENE)

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Key terms: Late Pleistocene; Taranto; GSSP; Mollusk; Paleocology

Taranto area is chronostratigraphically very important, as it is one of the few areas in the world where Upper Pleistocene marine successions, uplifted very recently, are well exposed. This area is currently under investigation, in order to find suitable marine sections for defining Late Pleistocene GSSP (Tarentian).

Fronte section is a suitable candidate for the GSSP (or in alternative a parastratotype), cropping out at the gulf of Taranto (Mar Piccolo). This section and two nearby drilled cores (Cimino and Cantoro) were densely sampled for paleobathymetric reconstruction and yielded relatively diverse mollusk associations (263 species and >8.000 specimens distributed in 50 sample), dominated by extant mollusk species with known bathymetric distribution.

Mollusk samples were analyzed with multivariate ordination techniques (Detrended Correspondence Analyses and Correspondence Analyses). The DCA outputs were then calibrated using extant species depth information and provided good estimates of bathymetry.

The bathymetric range of sampled successions seems bracketed between 140 and 0 meters. In particular the Fronte section record a meter scale cyclicity characterized by a deepening upward trend followed by a shallowing upward trend superimposed to an overall shallowing upward tendency.

The results are consistent with the bathymetric interpretation of the DC axis 1 postulated previously for the fossil record, and will be used to implement sequence-stratigraphic interpretations.

*et al.: the Tarentian Team

M3-2 Orale Bracchi, Valentina Alice

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PLEISTOCENE CORALLIGENOUS BUILD-UPS AND ASSOCIATED BIOCLASTIC DEPOSITS OF LE CASTELLA AND CAPO COLONNA MARINE TERRACES, CALABRIA, SOUTHERN ITALY.

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Key terms: *Coralline red-algae facies; Coralligenous build-ups; Pleistocene; Marine terraces; Crotona*

Autochthonous carbonate build-ups are mainly formed by encrusting coralline algae, which are one of the most important carbonate sediment contributors in the benthic communities of the Mediterranean area. They represent one of the most productive ecosystems in temperate regions and currently develop on Mediterranean hard and soft bottoms with a patch distribution along the coast. Light, salinity and temperature seem to be the main environmental factors influencing their distribution. Several types of assemblages have been described so far, due to the high heterogeneity of coralline growth-forms, distributed from the intertidal down to 160 m water depth, from rhodolith-beds to coralligenous build-ups.

In particular, coralligenous build-ups are frameworks with three-dimensional structure that serve as shelter and provide storm protection by buffering wave action along coastlines.

Coralline red-algae build-ups have high potentiality to be conserved in the fossil record. However, few fossil examples have been described in the literature and their evolution in the context of a stratigraphic cycle has seldom been modeled in detail.

Wide marine terraces are preserved in the area of the Crotona peninsula, Ionian Calabria, southern Italy. They are related to the interplay between Pleistocene sea-level changes and the progressive uplift of the Calabrian arc from the middle Pleistocene onwards. These terraces overlie a Plio-Pleistocene slope succession (Cutro Marly Clay Fm).

The two youngest marine terraces have been correlated with Marine Isotopic Stage (MIS) 3 and 5.1.

Many authors have already studied the deposits of these terraces, defining their major stratigraphic features and facies, but very few details exist on their paleontological content.

The deposits up to 10 m thick consist of mixed carbonate and siliciclastic sediments, in which red-algal reefs (= coralligenous build-ups) and other red algal facies are dominant.

Stratigraphic sections in both terraces have been measured and sampled in order to obtain a complete spatial description of the terrace deposits. Samples have been collected both in the red algae facies and in the grainstone and sandstone that occupy the cavities within the main algal bodies.

Thin sections have been prepared for red algae identification. A statistical analysis has been performed on the diagnostic anatomical microfeatures of the algal thalli.

Bio-calcareite have been disgregated in order to separate particles in a conservative way and conduct the quantitative paleontological analysis of the molluscan shell assemblages along with grain-size and chemical analyses. Species identification of bryozoans has been provided for facies dominated by this taxon.

The coralligenous build-ups are dominated by *Mesophyllum alternans* (Foslie) Cabioch & Mendoza and *Titanoderma pustulatum* (Lamouroux) Nägeli usually alternated with bryozoans crusts. Other red algae species like *Lithophyllum stictaeforme* (Areschoug) Hauck, *Phymatolithon calcareum* (Pallas) W.H.Adey & D.L.McKibbin and *Neogoniolithon* sp. rarely occur.

The molluscan assemblages in the grainstone associated to algal build-ups vary from typical coralligenous (C) to coastal detritic (DC), whereas they record an infralittoral environment in the uppermost unit.

The paleontological results have been framed in the context of a genetic-stratigraphic interpretation of the marine terraces.

M3-3 Orale D'Amico, Carmine

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LAND MOLLUSC PALAEOCOMMUNITY DYNAMICS RELATED TO PALAEOCLIMATIC CHANGES IN THE LATE PLEISTOCENE: AN EXAMPLE FROM ALLUVIAL DEPOSITS OF MARCHE APENNINES (CENTRAL ITALY)

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Key terms: *Upper Esino River Basin; Late Pleistocene; Land molluscs; Paleoclimate*

A detailed chronological scheme based on ¹⁴C and U/Th dating of Upper Pleistocene slope and alluvial deposits, containing archaeological remains, pollens and land molluscs in the Upper Esino River Basin (Marches, central Italy), constrains the time-range deposition of stratified slope-waste deposits of cold climatic conditions (Middle and Late Pleniglacial) and coeval alluvial deposits between the Middle Pleniglacial (U/Th 48,000±2,400y BP) and Late Glacial (Coltorti and Dramis 1995).

Near Matelica (Camerino) Upper Pleistocene stratigraphical sections of alternating gravelly and sandy sediments of fluvial environment yielded well preserved non-marine molluscan assemblages of pulmonate gastropods, such as *Succinella oblonga*, *Chondrula tridens*, *Vallonia costata*, *Pupilla muscorum*, *P. triplicata*, *P. sterri*, typical of cold/cool climate and variable humidity. At present, *P. sterri* is Alpine species of very dry exposed calcareous places, characterising loess deposits during the Quaternary in Europe. Quantitative analysis of the molluscan assemblages highlights the palaeocommunity dynamics through the sections due to alternate cool-cold climatic conditions, which is consistent with the sedimentation feature of the study successions: braid plain channel gravelly sediments of middle and upper glacial phases yielded particularly poor in species (oligotypic) assemblages characterizing very dry exposed places (steppe-like), whilst sandy-silty sediments of interglacial phases ("Denekamp-Arcy, Kesselt, Tursac") recorded diversified molluscan fauna with steppe-prairie species accompanied by species of more or less damp conditions (*S. oblonga*), suggesting more humid environment. Dominance or decrease in specimens number of one species or variation in the assemblage composition was strongly influenced by palaeoclimatic changes, that recorded in a stratigraphic succession highlights detailed climatic and palaeoenvironmental variations through time.

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Processes, 6: 235-242.

M3-4 Orale Mazzini, Ilaria

10.1474/Epitome.04.0868.Geoitalia2011

PALAEOENVIRONMENTAL RECONSTRUCTION OF THE COSTE SAN GIACOMO CORE (EARLY PLEISTOCENE, CENTRAL ITALY) THROUGH OSTRACOD ANALYSES

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Key terms: *Ostracod; Temperature; Villafranchian; Italy*

This research deals with the investigation of the 40m deep drill core (CSG1) taken from the sedimentary succession of the Coste San Giacomo locality (Anagni, Central Italy). The site is well known for the abundant fossil mammal remains discovered there since 1978 forming a Villafranchian faunal assemblage. The sedimentary succession underlying the palaeontological level is largely unknown. Only recently, Bellucci et al. (2011) revised the faunal list of the site adding *Hippopotamus* sp. and providing sedimentological and micropaleontological data for the sediment core. Ostracod analyses have been performed on 180 samples. Only in 19 samples, ostracods have been recovered. Many samples were barren and this may be due to chemical dissolution of calcium carbonate related to organic matter decay in an environment where the organic matter flux reaching the bottom was high.

According to the ecological requirements of the 14 recognised taxa (all extant), two main assemblages could be distinguished. The first one (A) typifies a permanent water body with muddy bottom, clear and running shallow waters whereas the second assemblage (B) represents a temporary water body influenced by interstitial and spring waters. The sedimentological characteristics of the sediment core support a floodplain facies for assemblage A and a near-shore facies for assemblage B. The integrate analyses of facies and ostracod assemblage characteristics point to temporary waters linked, most likely, to changes in precipitation regime.

Moreover, the MOTR (Mutual Ostracod Temperature Range, Horne 2007) method has been applied to the most common species (*Candona candida*, *Candonopsis kingslei*, *Herpetocypris reptans*, *Pseudocandona eremita*, *Pseudocandona rostrata* and *Cyclocypris ovum*). The MOTR is a method applied to European species, mostly with Holarctic distribution and refers to a GIS based dataset of distribution in relation to air temperature ranges. Through its application it is possible to calculate mean July (mJu) and January (mJa) temperature ranges. The average temperatures of assemblage A are within the range of the actual average temperatures (mJu= 26°C, mJa= 7°C). Instead, the average temperatures calculated for assemblage B are constantly below the actual means, giving further evidence of the influence of spring waters.

The ostracod assemblages suggest the occurrence of mild climatic conditions in an alluvial environment with clear, running waters, sensitive to the precipitation regime. The aquatic environment was rich in aquatic vegetation (abundance of phytophilic species) and algae (occurrence of characeae) where the herbivorous hippo could thrive.

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Horne, D.J., 2007. A Mutual Temperature Range method for Quaternary palaeoclimatic analysis using European nonmarine Ostracoda. *Quaternary Science Reviews* 26, 1398-1415.

M3-5 Orale Scarponi, Daniele

10.1474/Epitome.04.0869.Geoitalia2011

SEQUENCE STRATIGRAPHIC, EVOLUTIONARY AND ECOLOGICAL IMPLICATIONS OF TREMATODE PARASITISM OF HOLOCENE NORTHERN ADRIATIC BIVALVES

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Key terms: *Trematodes; Bivalves; Fossil; Holocene; Po Plain*

The role of antagonistic organismal interactions in the production of long-term macroevolutionary trends has been debated for decades. Some evidence seems to suggest that temporal trends in predation frequency share a common causative mechanism with genus level diversity.

Whereas studies on the role of parasites in "shaping" the evolutionary process are rare indeed. Digenean trematodes (Phylum Platyhelminthes) infest molluscs in at least one stage of their complex life cycle.

Trematodes leave characteristic oval-shaped pits with raised-rims on the interior of their bivalve hosts, and these pits are preserved in the fossil record. Here we survey 11,785 valves from the Pleistocene - Holocene deposits of the Po Plain and from nearby modern coastal environments on the northeast Adriatic coast of Italy. 205 valves exhibited trematode-induced pits. Trematodes were selective parasites in terms of host taxonomy and host body size. Infestation was restricted to lower shore face/transition to platform paleoenvironments. During the Holocene, individuals from transgressive systems tracts were significantly more likely to be infested than those from highstand systems tracts. Temporal trends in infestation frequency cannot be explained as an ecological/evolutionary phenomenon (e.g., the hypothesis of escalation); instead the trend seems controlled by environmental variation induced by climate-driven sea-level changes and inadequate sampling. Since this interaction appears to be ephemeral, both temporally and spatially, it is not likely that any selective pressure would be continuous over geologic time in this region. Furthermore, these results support the hypothesis that antagonistic interactions are lower in the northern Adriatic Sea in comparison to other mid-latitude shallow marine settings.

SESSIONE M4

Il colore degli eventi nel tempo

M4-1 Key Lecture Preat, Alain

10.1474/Epitome.04.0870.Geoitalia2011

WHY IS 'RED MARBLE' RED : COULD FE-ISOTOPES SHED LIGHT ON THIS QUESTION THROUGH THE STUDY OF THE ITALIAN AMMONITICO ROSSO AND RECENT ORGANISMS?

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Key terms: Iron isotopes; Microbial mediation; Italian Jurassic Rosso Ammonitico; Recent sea urchins and bivalves; Red pigmentation of 'marble'

Eight iron (Fe) isotopic compositions of iron deposits in biofilms and granules found in two Recent burrowing marine invertebrates (the sea urchin *Echinocardium cordatum* and the bivalve *Montacuta ferruginosa*), were obtained by Multiple-Collector Inductively Coupled Plasma Mass

Spectrometry (MC-ICP-MS). $\Delta^{56}\text{Fe}$ values ranged between -1.78 and

-0.74 ‰. The lightest $\delta^{56}\text{Fe}$ is associated with the iron granules in the intestinal wall of *E. cordatum* and may be due to the abiotic oxidation of source Fe(II) with an isotopic composition reflecting that of light reduced Fe in sediment porewater. This lightest value could represent the best value for the pristine value. Fe in the biofilms was typically heavier by up

to +1.7‰, mean \sim +0.7‰. These results are compared with Fe isotopic composition of 17 Jurassic limestones from the Rosso Ammonitico Veronese (Italy) containing red and grey hemipelagic facies. The red facies show clear evidence of iron bacteria and fungi, which are interpreted as a possible equivalent of the iron microbial communities associated with the Recent organisms. Pronounced Fe isotope fractionation was observed in the Jurassic red hardground levels and in the more condensed red facies where bacteria and fungi lived and have

accumulated, with values typically lighter by -1‰ than the grey facies where micro-organisms were absent. This fractionation probably involved the passive accumulation of originally light porewater Fe in the EPS (exopolymeric substances) produced by filamentous bacteria, thereby favouring heavier Fe isotopes. Alternating stages of oxidation Fe(II)/Fe(III) occurred near the sediment/water interfaces as a consequence of microenvironmental changes in the marine porewaters and caused the red/grey facies interlayering. The comparison of the Fe isotopic compositions of the 'biominerals' in the Recent organisms and in the iron minerals of the red and grey Jurassic facies suggests an isotopic

biofractionation of at least \sim +0.7‰. Both studied organisms (the sea urchin and the bivalve) thrive in similar microenvironmental conditions as the micro-organisms of the condensed red facies. Their Fe isotope compositions are the same, as is the range of the probable biofractionation.

The microbial (iron-bacteria and fungi) hypothesis has the merit to be compatible with most observed pigmentation pattern. The pigmentation is due to the dispersion of submicronic (hydro)oxides in various studied Phanerozoic microaerophilic environments at dysoxic-anoxic interfaces or amorphous iron oxyhydroxide gel with phosphates formed by bacterial mediation during early diagenesis in the Recent organisms. The main limiting factor is the oxygen content which is always low in these very quiet microenvironments. Red pigmentation is therefore not linked to alteration or contamination of the studied Phanerozoic limestones. Iron-bacteria were present between the initial micritic components and thrived in the superficial part of the unconsolidated sediment. Omnipresent micritic regular filaments with Fe-rich sheaths and different types of ferruginous morphs are observed. There is no bathymetric influence on the process.

M4-2 Orale Vaccari, Ezio

10.1474/Epitome.04.0871.Geoitalia2011

JUDGING BY COLOR IN THE EARLY HISTORY OF STRATIGRAPHY

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Key terms: history of geology; stratigraphy; color; 18th century

The aim of this paper is to evaluate some significant case studies, particularly during the 18th century, in order to understand how color was used as one of the 'external' features for identifying rock formations, also including fossils, regarded as formed in different times by different causes or events. The reference to color was often considered the main feature used for lithostratigraphical purposes within the so called 'classification' of mountains in the second half of the 18th century, as in the case of the research-work by Giovanni Arduino (1714-1795) in the 1760s and 1770s or Lazzaro Spallanzani's (1729-1799) geological studies in the 1780s and 1790s. Later geologists and mineralogists involved in the early history of stratigraphy, such as Abraham Gottlob Werner (1749-1817), referred to color when a rock formation or specimen appeared to be less defined by other main characters (for example chemical and morphological features).

M4-3 Orale Coccioni, Rodolfo

10.1474/Epitome.04.0872.Geoitalia2011

CRETACEOUS-PALEOGENE ROCK COLOUR CHANGES IN THE UMBRIA-MARCHE BASIN: WHAT DO WE KNOW?

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Key terms: colour changes; Cretaceous-Paleogene succession; Umbria-Marche Basin; Italy

The Cretaceous-Paleogene succession of the Umbria-Marche Basin (Italy) exhibits several rock colour changes from white gray to green-gray and from pink and red (Oceanic Red Beds, ORBs) to gray-black and black, with the dark colours indicating the presence of high contents of organic matter there preserved (Oceanic Anoxic Events, OAEs).

These changes were on a scale of some hundred thousand years to several million years and their occurrence is not a completely random process, in particular with ORBs and OAEs mostly reoccurring alternately. Are these rock colour changes proxy signals for paleoenvironmental conditions? Are these changing scenarios a result of interacting changes in ocean dynamics, tectonics and climate? Are these rock colour changes isochronous and linked to any biotic event and crises in the marine ecosystems? Are these rock colour changes expressions of local or global (geo)events?

In recent years, a range of multidisciplinary studies has been carried out in the Cretaceous-Paleogene succession of the Umbria-Marche Basin so that a comprehensive data set with regard to document oxygen and carbon isotope excursions and paleoenvironmental settings using pelagic and benthic microfossils is now available within a stratigraphically and chronologically well constrained framework mainly based on calcareous nannofossils and planktonic foraminifera.

This succession represents, therefore, an exceptional laboratory to shed light on these issues.

M4-4 Orale Todesco, Rossana

10.1474/Epitome.04.0873.Geoitalia2011

LIFE IN COLOUR. THE SILURIAN OF THE VALENTINTÖRL SECTION (CARNIC ALPS, AUSTRIA)

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Key terms: Silurian; Carnic Alps; Valentintörl Section; conodont biozonation; ferruginous laminated structures

The Paleozoic of the Carnic Alps is represented by almost complete sequences (Middle Ordovician - Late Permian in age) which crop out along the Italian-Austrian border with an east-west orientation. The significance of the Silurian of the Carnic Alps lies in the remarkable variety of facies exposed there and in the abundance of fossils that has enabled a precise biostratigraphic assignment of the sequences. In the area of Lake Wolayer (Carinthia, southern Austria) the Silurian crops out in four stratigraphic sections: Seekopf Base, Rauchkofel Boden, Base of Seewarte and Valentintörl. Whereas data available for the first three sections may provide a general overview of the sequences, information for the latter locality are limited to a preliminary dating carried out during the geological mapping of the area in the 1970s by Schönlaub (1970).

At the Valentintörl locality the successions occur on steep cliff faces and are not easily accessible. However, two sampling campaigns carried out in 2008 and 2009 along four different traverses have allowed a good general overview to be obtained. The section bears at the base a 17 m-thick white massive limestone rich in cystoids and bryozoans dated to the Late Ordovician Katian Stage (Amorphognathus ordovicicus conodont Zone). The extremely condensed Silurian succession is represented by 6 m of reddish cephalopod limestones intercalated with biodebris levels and grey to pink micritic limestones. Detailed conodont sampling has allowed six conodont biozones to be identified: Kockella crassa, Wurmiella hamata, Ancoradella ploekensis, Polygnathoides siluricus, Ozarkodina crispata and Auroradella detortus, thus assigning a biostratigraphic range spanning from the base of the Ludlow (Gorstian) to the Pridoli Series. At the top of the succession 4 m of light grey limestones document the earliest Lower Devonian (Icriodus woschmidti woschmidti conodont Zone). The basal part of the Silurian succession is assigned to the Kok Formation. Furthermore, the Cardiola Formation (Polygnathoides siluricus conodont Zone) has been documented for the first time at this locality, as a discontinuous, thinly developed centimetric layer of dark cephalopod limestone. The upper part of the Silurian succession is assigned to the Altilcola Formation (Oulodus elegans detortus Conodont Zone).

The biostratigraphy of the Valentintörl Section has been studied in great detail. The colour of the limestones exposed here is particularly remarkable, varying from grey to pink to red and even rusty-brown. This colour variation derives from the presence of micro-laminated ferruginous coatings around skeletal fragments (mostly trilobites, some cephalopods and echinoderms) as well as planar laminated structures along discontinuity surfaces such as at the Ordovician/Silurian boundary. These laminations are observed as pink to red and green signatures consisting of different iron phases (chamosite, goethite, magnetite, hematite and subordinate apatite) and have been interpreted as evidence of microbial activity (Ferretti et al., in press).

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M4-5 Orale Histon, Kathleen

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UNRAVELLING THE ENIGMA OF LOWER PALEOZOIC NAUUTOID CEPHALOPOD CONCENTRATIONS: INTERPRETING COLOURS AND EVENTS ACROSS SPACE AND TIME

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Key terms: Nautiloid cephalopods; bioevents; sediment colour; Lower Paleozoic; Paleobiogeography

Enigmatic concentrations of orthoconic nautiloid cephalopods form distinctive colourful strata which are often singled out for use as

ornamental stone in building facades, floors or indeed as pavement slabs in some cities. The most common occurrences are known from the Ordovician, Silurian and Devonian but tend to become rare from the Carboniferous onwards. They display a variety of colours ranging from dark to light red, brown, black and various shades of grey. Most appear to represent shallow water facies with the orthoconic shells often being oriented either by current or wave action on the bedding plane. Studies focused on unravelling the nature of their formation tend to be restricted both spatially and temporally to localized investigations of either the faunas themselves or the successions within which they occur. Various studies have been carried out with regard to their depositional environments, their taphonomy, their use as current indicators and many theories and models have been proposed for their peculiar formation (Holland et al. 1994).

An innovative approach to determining common factors among these particular fossil rich beds by comparing the available lithological evidence and taphonomic features with the color of their enclosing sediments for selected occurrences has highlighted certain recurring features across a broad stratigraphic range and within diverse paleogeographical settings. Those with a predominantly black to gray color generally represent event beds, often mono-specific in nature, while those ranging from red-brown-beige are prevalently time-rich accumulations, often associated with discontinuity surfaces and condensed sequences (Histon, in press). A variety of studies related to the nautiloid faunal composition and the particular taphonomic features presented of the various nautiloid-bearing levels from the Cellon section (Llandoverly-Pridoli) in the Carnic Alps of Austria have been done in recent years and comparative studies with co-eval nautiloid faunas described from other palaeobiogeographical settings have highlighted exchange of these faunas along the North Gondwana margin. However, to date the aspect of the peculiar variety of colors presented by these nautiloid-bearing deposits at this famous Silurian section has not been examined with regard to identification of nautiloid events as outlined above for this middle latitude temperate paleogeographical setting. The findings from this study at a local and regional scale with regard to nautiloid events may be correlated with results from chemostratigraphic studies as was recently done by Manda & Fryda (2010) with regard to climatic events and nautiloid assemblages in the Prague Basin. As the Lower Palaeozoic sequences of the Carnic Alps are stratigraphically well dated by both conodonts, graptolites and chitinozoa and K-bentonite levels have been identified there from various sections the results of this innovative colour comparison approach may be used for regional correlation of these pelagic faunas and nautiloid cephalopod bioevents between the various Peri-Gondwanan Terranes, for palaeobiogeographical reconstruction and paleoenvironmental settings and for timing of significant geodynamic events related to opening and closing of migrational seaways.

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M4-6 Orale Levera, Marco

10.1474/Epitome.04.0875.Geoitalia2011

IN THE SEARCH FOR A "GOLDEN" EVENT TO DEFINE THE GSSP OF THE NORIAN STAGE (UPPER TRIASSIC): BIVALVE EVENTS AND THEIR AMMONOID CALIBRATION

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Key terms: Bivalves; Ammonoids; Upper Triassic; Norian GSSP; calibration

Three out of seven GSSPs of the Triassic have been so far defined, namely those for the Induan, Ladinian and Carnian. Two of them, Ladinian and Carnian, are defined on ammonoids, the group on which by tradition the chronostratigraphy of the Triassic system is based since the XIX century. Ammonoids show during the Triassic very high evolutionary rates, combined with wide paleogeographic distributions. Thus, ammonoids could be considered the "golden" group when a primary marker event has to be selected to mark a "golden spike" for a Triassic unit.

Unfortunately this is not always true. Ammonoids are not very common in the sedimentary record, at least in comparison with conodonts. This group of microfossils became popular in the 1960s, because it is undoubtedly more common than ammonoids in limestone facies and because sometimes it shows interesting evolutionary rates. The quality of conodonts as tool for the definition of a GSSP is documented by the definition of the Induan, based on the FAD of *Hindeodus parvus*.

In recent years, however, conodonts have revealed some weaknesses, mostly due to difficulty in the delimitation of the species and in the reconstruction of the ontogeny and evolutionary trends. Thus, sometimes the FOs are rather diachronous or seems to be influenced by the interpretation of variability of the species. Such problems are strongly influencing the discussions within the Induan/Olenekian and Olenekian/Anisian working groups of the STS.

The discussion over the definition of the Norian stage in part reflects these difficulties, but with one difference. If there are not many paleontologic alternatives to ammonoids and conodonts for the Olenekian and Anisian, for the Norian the pelagic bivalves of the genus *Halobia* seem to be a good solution.

The number of species known from the Late Carnian to Early Norian is relatively low, and of these *Halobia radiata*, *H. austriaca*, *H. styriaca* and *H. beyrichi* are the most useful markers.

The systematic is much more stable and well established than that of conodonts, being mostly based on the same characters taken into account by Bronn in his first description of the species in 1830. As in all mollusca, the ontogeny is directly visible on the surface of the shell and it is often used as a discriminating character in their classification, together with the radial ornamentation and the characters of the auricle.

The stratigraphic range of the species can be compared with that of ammonoids, as they show high evolutionary rates. Furthermore, the duration of the zones is close to that of ammonoids' sub-zones around the Carnian/Norian boundary interval.

The paleogeographic distribution is widespread, as a number of species

occur through the whole Tethys as well as Panthalassa.

The main point to be solved in order to select a primary marker event for the GSSP is the correlatability of the most interesting events recorded in the best sections. This test would require an independent tool, and for the Carnian/Norian boundary the best is to use the ammonoids.

At present some new ammonoid bio-chronostratigraphic data are available from the GSSP candidate section Pizzo Mondello (Sicani Mountains, Sicily), while the work on ammonoids from the second candidate section Black Bear Ridge (BC, Canada) is not over. *Halobia radiata* is typical of the Late Carnian, ranging through the upper part of Tuvalian 3, as its FO closely corresponds to the base of the *Gonoionotites italicus* subzone. *H. austriaca* is now regarded as the best non-ammonoid marker for the lower part of the Lacin 1 (lower *Stikinoceras kerri* zone in North America; lower *Guembelites jandianus* zone in the Tethys), and it is closely followed by *H. styriaca* and *H. beyrichi* (upper *Guembelites jandianus* zone). Some refinement is still necessary but the FO of *H. austriaca* seems to be the most suitable "golden" event around the Carnian/Norian boundary.

M4-7 Invitato Bottini, Cinzia

10.1474/Epitome.04.0876.Geoitalia2011

EARLY APTIAN BLACK-SHALES IN THE BOREAL REALM: CALCAREOUS NANNOFOSSIL AND STABLE ISOTOPE EVIDENCE FOR REGIONAL AND GLOBAL PROCESSES

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Key terms: Oceanic Anoxic Event 1a; Black-shales; Calcareous nannofossil; Stable isotope; Boreal Realm

The early Aptian is marked by a global phenomenon of widespread deposition of organic carbon-rich sediments under oxygen-poor conditions known as Oceanic Anoxic Event 1a (OAE 1a: ~120 Ma). Triggering mechanisms for the OAE 1a are thought to have been the emplacement of the Ontong Java Plateau, associated with global warming and enhanced primary productivity.

In northern Germany the OAE 1a has its sedimentary expression in the "Fischschiefer" characterized by finely laminated black shales rich in organic matter. In the Early Cretaceous northern Germany was part of the Lower Saxony Basin being a marginal epicontinental sea forming the southern extension of the Boreal-Arctic Sea, thus located between the Boreal Realm in the north and the Tethys in the south. The relatively restricted palaeogeographic settings probably exerted a regional control on the deposition of the Fischschiefer.

We investigated the Upper Barremian-Lower Aptian interval in three sites from northern Germany (Alstätte, Rethmar, Hoheneggelsen KB 9) applying a multidisciplinary approach, bringing together the biotic and ocean chemistry responses across OAE 1a. Specifically, we performed calcareous nannofossil (abundance and assemblage composition) and carbon and oxygen stable-isotope analyses.

Calcareous nannoplankton is sensitive to changes in temperature, fertility and chemistry of surface-waters, therefore it is the ideal tracer for reconstructing palaeoclimatic and palaeoceanographic fluctuations. The direct calibration of the nannofossil and geochemical data is fundamental to provide a coherent reconstruction of the perturbations across OAE 1a. The main objective of this study is to reconstruct palaeoclimatic, palaeoecological and palaeoceanographic factors that controlled the deposition of the Fischschiefer in the Lower Saxony Basin.

The results obtained for the Boreal Realm are compared and integrated with biotic and geochemical proxies collected across the OAE 1a from the Tethys (Cismon, N. Italy), with the main purpose of understating the interaction between globally driven changes in the ocean-atmosphere system and regional phenomena related to local palaeoceanographic settings.

SESSIONE N1

Climatologia fisica

N1-1 Orale Giudici, Mauro

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MODELING THE ANTARCTIC ICE SHEET AND ICE SHELVES IN THE LAST 200,000 YEARS

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Key terms: thermomechanical modeling; antarctic ice sheet; ice shelf

Evolution of the cryosphere is of paramount importance to control climate variations at several different scales, in particular for accurate predictions of global change. Therefore accurate modeling of the thermal and mechanical behavior of glaciers, ice sheets and ice shelves is required for proper assessment of past, present and future trends of the Earth's climate.

Here some results of a model of the evolution of the Antarctic ice sheet in the last 200,000 years are shown. The model is based on the classical Shallow Ice Approximation (SIA), which assumes that the aspect ratio between the vertical and horizontal scale lengths which characterize velocity variation is small: actually, this ratio is approximated as the ratio between the vertical and horizontal lengths of the ice sheet. The SIA and the cryostatic approximation permit to simplify the momentum equation, which is nevertheless coupled with the energy equation, since ice rheology is described by a power-law relationship between deviatoric stress and strain rate (Glen's law) whose phenomenological parameters depend on the temperature field. Moreover, the energy equation includes convection and heating produced by ice straining, so that it requires the determination of the velocity and stress fields. The Antarctic ice sheet is connected to the ocean through the ice shelf, where the ice cap can float over the sea, the velocity field is assumed to be horizontal and the Shallow Shelf Approximation (SSA), similar to the SIA, is introduced.

A finite difference model has been developed to solve the set of basic equations of continuum physics (continuity, momentum and energy equations) for this non-linear thermomechanical coupled system and it has been applied to simulate the evolution of the Antarctic ice sheet over the last 200,000 years. At the surface of the ice sheet, temperature and accumulation rate have been assigned following Ritz et al. (2001) by assuming a relationship between these fields at time t with the present day temperature and accumulation rate and the temperature trend recorded in the Vostok log (Petit et al., 1999). Other input data for the model (e.g., geothermal heat flow, bottom elevation, sea level, etc.) have been taken from public-domain data sets (http://websrvr.cs.umt.edu/isis/index.php/Present_Day_Antarctica). The domain is discretized as a staggered grid with spacing of 100 km and the model runs with a time step of 10 years (5 years for some tests when required by numerical stability issues). The results (e.g., the thickness of the ice sheet) are in good agreement with present day observations and permit to assess some properties of the thermo-mechanical behavior of the Antarctic ice sheet, for instance the ice discharge toward the ocean follows the forcing given by variation of accumulation rate with a time delay of about 1,000 years.

N1-2 Orale Lodolo, Emanuele

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THE LAKES OF TIERRA DEL FUEGO AND SOUTHERN PATAGONIA: ARCHIVES OF THE PAST CLIMATE

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Key terms: Holocene lake sediments; Climatic changes; Southern South America

Research on the variability of past climate are an essential requirement in understanding the future evolution of our planet's climate system and its impact on global environmental changes.

The geographic location of the lakes of Tierra del Fuego and southern Patagonia is ideal for reconstructing the environmental conditions of the past. They are in fact within the system of westerly winds from the Pacific Ocean and just north of the Antarctic polar front. In this region have followed glacial phases, with advancing of glaciers that covered much of Patagonia, and interglacial phases, with glacial retreat, which left large sedimentary deposits. The sediments deposited in these lakes represent an irreplaceable archive to reconstruct the history of the dynamics of glaciers, which reflects the climatic changes of the past, particularly those of the last 18,000 years, when some of glacier fronts reached the Atlantic coast.

A group of researchers from the Istituto Nazionale di Oceanografia e Geofisica Sperimentale (OGS) of Trieste, in collaboration with the Instituto de Geofisica "D. Valencio" of the Universidad de Buenos Aires, has carried out on November 2009 and March 2010 a series of data acquisition campaigns, funded by the Italian Ministry of Foreign Affairs. These studies have been focused in the Lago Roca, Lago Yehuin, Lago Chepelmut and Lago Fagnano (the southernmost ice-free reservoir), all located in Tierra del Fuego, and in the Lago Argentino (located in southern Patagonia), which hosts the famous glacier Perito Moreno.

In the course of their research, bathymetric and high-resolution seismic surveys, sediment sampling, and geomorphological studies have been carried out. These are essential information to reconstruct the history of the progress and retreat of glaciers that deposited these sediments in the geological past.

A short video that summarizes the activities carried out during these campaigns will be presented.

N1-3 Orale Budillon, Giorgio

10.1474/Epitome.04.0879.Geoitalia2011

VARIABILITY OF THE AIR TEMPERATURE AND PRECIPITATION FROM 1884 TO 1960 IN THE HISTORICAL TIME SERIES OF MONTEVERGINE (AVELLINO) - PRELIMINARY RESULTS

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Key terms: climate change; variability; trends; air temperature; precipitation

Italy has a long tradition in climate observations and also provides valuable historical time series that have recently been examined as part of National and International projects (eg. Brunetti et al., 2006; Simolo et al., 2010) providing a detailed reconstruction of climate changes in the last 100/150 years, at least with respect to the temperature and precipitation.

The distribution of these observations is not uniform, the center and south of Italy show a lower concentration compared to the northern regions; the Campania region has, for example, only one historical series (Naples), with several gaps, started on 1821. In this context, it was decided to restore and enhance the acquired observations from the meteorological observatory "Montevergine" (AV), located at 1280 asl (40° 56'N, 14° 43'E). This climatological series is one of the oldest of Apennines Mountains and it's very meaningful for high-altitude regions climate's study. The original data set, as often happens in this type of data, is recorded on paper archive and, consequently, required an huge man time to digitalize it. From 2007 up to date the meteorological parameters are, instead, recorded by an AWS.

For this work we analyzed a sub data-set (1884:1960) which includes three daily observations (at 8.00 AM, 2.00 PM and 7.00 PM) of atmospheric pressure, wet bulb temperature, dry bulb temperature, vapor pressure, relative humidity, cloud cover and precipitations (rainy and snowy); moreover, there are also daily observations of minimum and maximum temperature, evaporation and solar radiation, although the records concerning these last two parameters are characterized by several gaps.

In this work we show the preliminary results obtained focusing the attention on the seasonal and yearly anomalies and trends. The analysis of temperature and precipitation series was performed using LOWESS method to detect notable patterns in data and a polynomial model (of first degree) to define trends. The results highlight a slight positive trend for the yearly mean temperature (computed by regards only three daily observations), of about 0.2 K per 50 years. Positive trends are

found also in seasonal analysis, even if they are appreciable only on summer (JJA), 0.5 K/50 years, spring (MAM), 0.2 K/50 years, and winter (DJF), 0.1 K/50 years, while no trend is evident on autumn (SON). As regards the precipitation, the analysis shows a low negative tendency for annual amount, of about -50 mm per 50 years; seasonal examination highlights positive trends on winter, +70 mm/50 years, and autumn +38 mm/50 years, negative trends on spring, -103 mm/50 years, and summer, -45 mm/50 years.

Yearly and seasonal mean temperature trends found in the "Montevergine" time series are less steep than those found in the analysis performed for Italian Peninsula (Brunetti et al., 2006), whose results show an increase of 1 K per century for 1865-2003 period; the different slope is mainly due to the prominent increase of temperature observed in 1980-2003 period, which is not considered in our analysis for the moment. As regard the precipitation trends, they are in good agreement with those found in Brunetti et al. (2006), which observed, for 1865-2003 period, a decrease of 5% per century in the annual precipitation amount, mainly due to the spring season (-9% per century).

N1-4 Orale Von Hardenberg, Jost

10.1474/Epitome.04.0880.Geoitalia2011

EC-EARTH: AN EARTH-SYSTEM MODEL FOR CLIMATE STUDIES

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Key terms: Earth-system models; Climate modeling; Climate impacts

The study of the complex processes at work in the climate system and the creation of future scenarios for evaluating the impact of future climate change, require the development of reliable and innovative tools and models. To this end, EC-Earth (<http://ecearth.knmi.nl>) is a recent earth-system model developed by a consortium of European research institutions and researchers, based on some of the currently most advanced models for the atmosphere, the ocean, sea ice and the biosphere. In particular the model is based on the concept of 'seamless predictions': numerical weather prediction (NWP) models are sophisticated state-of-the-art models which, being based on the same physical principles, may provide advanced atmospheric components for climate models. EC-Earth combines the NWP model by ECMWF with the ocean model NEMO. ISAC-CNR has recently entered the EC-Earth consortium, will contribute to the development of this tool and will apply it for climate studies, with particular interest for climate impact studies in the Alps, the Arctic and the Himalayas. We will present some of these developments and applications in this talk.

N1-5 Orale Ruti, Paolo Michele

10.1474/Epitome.04.0881.Geoitalia2011

THE MED-CORDEX EXPERIMENT: NEW COUPLED REGIONAL PROJECTIONS AND TAILORED IMPACT ANALYSIS.

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Key terms: Regional Modeling; Climate Change; Climate Services

Since early '90s, many research projects analyzed and focused on downscaling of global climate simulations over the Euro-Mediterranean region. Euro-Mediterranean region is considered as particularly vulnerable to climate variability and change, in particular, by its vulnerability to changes in the water cycle and natural ecosystems. The Mediterranean basin has quite a unique character that results both from orographic conditions and demographic trend. The region features an enclosed sea, which is connected to the Atlantic ocean only by Gibraltar strait, surrounded by very urbanized littorals and a complex topography from which numerous rivers feed the Mediterranean sea. This results in many interactions and feedback between ocean-atmosphere-land processes that play a prominent role in climate and, in turn, determine the impact on human activities.

Based on previous stimulating initiatives and on new regional downscaling tools (Regional Coupled Systems), developed for the CIRCE-EU project, the Mediterranean climate research community proposed the Med-CORDEX initiative. MED-CORDEX is a coordinated action between CORDEX and HyMeX international programs. MED-CORDEX is a unique framework where research community will make use of both regional atmospheric and oceanic climate models and regional coupled systems for increasing the reliability of regional climate information.

Here, we provide some examples of the Med-CORDEX initiative and relevance, presenting a quantitative analysis of the changes in the average seasonal cycle of key environmental parameters over the Euro-Mediterranean area, using a A1B scenario simulation performed with a coupled ocean-atmosphere regional climate model driven by the ECHAM5-MPIOM global simulation included in the IPCC-AR4. The analysis is focussed on surface temperature and on the hydrological cycle output from different simulations performed with a coupled regional system. The impacts of climate change is analysed and evaluated in key parameters related to the hydrological cycle.

N1-6 Poster Ruti, Paolo Michele

10.1474/Epitome.04.0882.Geoitalia2011

LOW FREQUENCY VARIABILITY OF PLANETARY WAVES

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Key terms: planetary waves; climate; resonance

Understanding the atmospheric low-frequency variability is of crucial importance in fields such as climate studies, climate change detection, and extended-range weather forecast. The Northern Hemisphere climate features the planetary waves as a relevant ingredient of the atmospheric variability. Several observations and theoretical arguments seem to support the idea that winter planetary waves indicator obey a non-gaussian statistics and may present

a multimodal probability density function, thus characterizing the low-frequency portion of the climate system. We show that the upper tropospheric jet strength is a critical parameter in determining whether the planetary waves indicator exhibits a uni- or bimodal behavior, and we determine the relevant threshold value of the jet. These results are obtained by considering the data of the NCEP-NCAR and ECMWF reanalyses for the overlapping period. Our results agree with the non-linear orographic theory, which explains the statistical non-normality of the low-frequency variability of the atmosphere and its possible bimodality. Analysis of C20C simulations allows us to evaluate the impact of natural and anthropogenic forcing.

N1-7 Poster Loni, Tiziana

10.1474/Epitome.04.0883.Geoitalia2011

SPATIAL AND TEMPORAL VARIABILITY OF GREENHOUSE GASES EMISSIONS FROM TEMPERATE WETLANDS: THE CASE OF LAKE MASSACIUCCOLI (TUSCANY)

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Key terms: greenhouse gases; emissions; wetlands; Massaciucoli

Determining of greenhouse gases (e.g. CH₄ and CO₂) emissions from aquatic systems is of great concern to estimate the influence on climate change. Wetlands can be source and/or sink of these gases, produced mainly by biotic processes (degradation, respiration and photosynthesis). The fluxes of carbon dioxide are driven by the respiration and photosynthesis phenomena, while methane emissions should attributed to the prevailing anaerobic bacterial degradation, as occurring predominantly at the interface with the sediment. This points out the existing relationship between the biosphere and greenhouse gases emissions. However, methane fluxes in wetland are insufficiently investigated, especially in terms of temporal and spatial variability. To study these variations monitoring work has been carried out in a coastal wetland area in North-West of Tuscany, where Massaciucoli lake (mean depth of 2.5 m) is located. The project aims to estimate the greenhouse gases fluxes of CH₄ and CO₂ at air-water interface from the lake. The fluxes have been measured by accumulation floating chamber, manageable (200 mm diameter, 100 mm height, 1.25 kg weight) and provided by a portable CH₄ and CO₂ analyzer. A handheld computer connected to the detectors allowed to compute the flux of gas directly on-site.

To improve the measurement accuracy, floating accumulation chamber was calibrated in laboratory. Monitoring has been carried out during three seasonal periods: autumn (2010 October), winter (2011 February) and spring (2011 April). Fluxes measurements (about 110 points) were performed with a grid 250 m x 250 m, in order to have an adequate number of measurements to represent the spatial variability and to accurately determine the values of total flux.

The methane (Φ_{CH_4}) and CO₂ (Φ_{CO_2}) fluxes measured during autumn ranges between -0.245 and 1.133 mol/m²/day and from -0.046 to 0.386 mol/m²/day, respectively. In winter Φ_{CH_4} varies between -0.931 and

0.392 mol/m²/day and Φ_{CO_2} from -0.037 to 0.220 mol/m²/day. During

spring period Φ_{CH_4} varies between -0.334 and 0.277 mol/m²/day and Φ_{CO_2} between -0.185 and 0.114 mol/m²/day.

Overall, in all of three monitoring periods, there are both positives and negative fluxes for both gases. Methane fluxes are mostly positive, while for CO₂ several negative fluxes are measured in several points around the lake.

Collected data confirm the great spatial and temporal variability of fluxes of CH₄ and CO₂. While the system as a whole emits CH₄, the lake can be sink and source of CO₂ during the three investigated seasons. These first results highlight that pluriannual seasonal monitoring would be necessary to have a reliable estimation of the average annual flux of greenhouse gases from the shallow lake.

N1-8 Poster Minardi, Ilaria

10.1474/Epitome.04.0884.Geoitalia2011

INTEGRATED USE OF AIR QUALITY DISPERSION MODEL CALPUFF AND PRINCIPAL COMPONENTS ANALYSIS TO EVALUATE SOURCES OF PM10 POLLUTION IN A STRONGLY URBANIZED AREA

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Key terms: PM10; Calpuff; PCA

The aim of this study is to identify different sources and to evaluate their contribution to PM10 air quality. The study area is a small town located in Lombardia Region, in the middle of Po Valley, a critical zone especially for PM10 pollution. The local industrial scenario is characterized by the presence of a leader group of particleboard industry.

In order to recognize seasonal differences in PM10 concentration, two seven-day surveys were carried out, one in winter (December 2008) and the other in summer (July 2009). Sampling activity involved five sites: a station inside the factory, a traffic station (located in a high traffic position), two urban stations suitably selected base on meteorology and the distance from sensible receptors (school, park, etc.) and a blank station.

At each monitoring site quartz fiber filters were collected by a Low Volume Sampler (LVS). To single out industrial contribution from other possible sources, filters were collected every 12 hours (at 7 AM and 7 PM), assuming there was no PM10 traffic emission during the night.

Chemical and isotopic analyses were carried out on filters and data were processed by Principal Components Analysis (PCA), a receptor model based on multivariate statistical analysis. Sources affecting the composition of PM10 were identified by Varimax rotated principal components analysis.

In addition, the deterministic model Calpuff was used to calculate the

concentration of PM10 expected at monitoring sites based on the emission from the industrial plant only. The input data to Calpuff consisted in a detailed emission inventory derived from the analysis of the production cycle. This inventory quantifies the diffuse dust emissions caused by wood unloading operations, conveyed emissions from chimney, and traffic emissions of PM10 from trucks for transport of materials (i.e., induced traffic).

The comparison of the results obtained by the PCA receptor model and the Calpuff deterministic model allowed to quantify the contribution of the industrial plant to PM10 pollution in order to improve the knowledge on local source emissions and to adopt strategies for ameliorating air quality.

N1-9 Poster Dalu, Giovanni

10.1474/Epitome.04.0885.Geoitalia2011

NONLINEAR DYNAMICS OF THE HADLEY CELL IN SHALLOW WATER MODELS

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Key terms: Tropics; Hadley cell; Jetstream

The dynamics of the Hadley circulation is studied by producing the solutions to a hierarchy of nonlinear models in the equatorial beta-plane and in the shallow water approximation with one, two, and three layers. The solutions to these models are used for determining, within an ample range of values of the environmental parameters, the width and the intensity of the Hadley circulation, and the position of the intertropical convergence zone (ITCZ). The validity of the weak temperature gradient approximation (WTG) and the validity of the lid assumption as an upper boundary are also discussed.

Results show that the latitudinal width of the Hadley circulation is underestimated by the WTG approximation, and it is overestimated by the adoption of a lid as an upper boundary. The width of the circulation increases as the thermal relaxation time increases and as the frictional losses in the lower layer increase; shallow lower frictional layers produce narrower circulations. In a multi-layer model, this width is narrow when the top layer is almost frictionless. Frictionless flows are centered about the equator, even when the center of the forcing is off the equator. In the presence of friction and with the forcing asymmetric about the equator, the center of the Hadley circulation is on the equatorial side of the center of the forcing, and the ITCZ is on the polar side of it. The distance of the ITCZ from the center of the forcing is larger when the width of the forcing is a large fraction of the width of the Hadley circulation.

SESSIONE N2

Clima e civiltà: mutamenti climatici ed uso antropico del territorio nel corso nell'Olocene tra Mediterraneo e Medio Oriente: un approccio geoarcheologico

N2-1 Orale Martini, I. Peter

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MIGRATIONS AND ADAPTATION OF THE ESKIMO/INUIT OF EASTERN NORTH AMERICA TO LATEST QUATERNARY ARCTIC SETTINGS - REVIEW HIGHLIGHTS

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Key terms: Eskimo; Inuit; Arctic; North America; late Quaternary

Numerous climatic changes have occurred during the late Quaternary and they led to drastic environmental changes. Living organisms have three main choices to react to such changes: adapt, modify, or migrate. We can readily adapt and since antiquity technology has allowed modifications to the environment at times beneficial to human life, others worsening the natural conditions. When natural or anthropogenic conditions become unbearable migration occurs. Notable examples are those of the Maya of Mexico, Vikings of Greenland, and Americans during the dread Midwest "dust bowl". Early inhabitants of extreme hot or cold settings readily could not sustainably mould the environment to their needs so they had to adapt and migrate. This is the case of the Eskimo/Inuit of North America that live in a frozen-coast landscape. In the High Arctic sunlight, temperature, and land and sea ice-distribution change seasonally totally modifying the landscape and the availability of meagre natural resources. Greater climatic variations occurred associated with glacial and interglacial as well as stadial and interstadial periods. These modified the availability of land, such as in Foxe Basin (NE Canada), submerging it either by large glaciers or by early postglacial inundation of glacial seas, and later reopening it by postglacial isostatic rebound. Even smaller climatic variations such as those occurring during the interglacial Holocene, have affected the thickness and distribution of sea ice and the opening and closing of Arctic icy passageways. This has affected the migration and distribution of marine fauna and of large sea mammals such as whales in particular. The Eskimo/Inuit have successfully colonized those extreme, frigid regions. Evidence exists that starting about 6000 years ago Eskimo people migrated eastward from Asia across North America following the marine mammal prey that could move through open icy passageways during warmer periods (~postglacial Temperature Optimum). As frigid conditions returned they adapted in the new lands by changing habits and technology to capture new marine and land preys. Archaeological information, consisting of remnants of habitations and tools, records a first Small Tool tradition that by 4000 yrs BP spread from Alaska across North America as a Paleo-Eskimo culture with microblades, harpoons tipped with small end blades. In Canada these evolved into the Pre-Dorset culture (~4000-2800 yrs BP) with toggling harpoons. They were followed by the Dorset (~2800-1200 yrs BP) culture characterized by sod houses, typical harpoon heads, point, oil lamps, and shaman's artefacts. The Dorset culture faded away, probably due to warming climatic conditions and reduced sea ice cover, and it was replaced by people of the Thule culture (~1000-600 Yrs BP) that migrated from Alaska during the Medieval Warm period. They hunted large sea mammals including bowhead whales utilizing new tools like large boats, new types of harpoons, drag floats. This large prey could provide sufficient food for relatively large

communities living in semi-permanent sub-subterranean sod houses. Subsequent cooling during the Little Ice Age increased the Arctic ice cover, reduced whale hunting and the modern Inuit culture had to re-adapt to hunting land prey, and seals and walrus from sea-ice platforms modifying their customs and technology accordingly. The smaller food supply reduced drastically the size of the nomadic communities. They lived for part of the year in snowhouses, utilized sled dogs, small boats (kayaks), and used different, more appropriate tools. Famine occurred, frequently wiping out entire families. To help those populations and to be able to control them, in the 1960s, the Government of Canada forced them into permanent villages where they were provided with things like housing, health care, southern-style education and subsidies. This has provided advantages, but also many practical and sociological difficulties.

N2-2 Orale Lo Vetro, Domenico

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LIVING ON THE BEACH: MARINE RESOURCES EXPLOITATION DURING THE EARLY HOLOCENE IN THE CENTRAL MEDITERRANEAN

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Key terms: Mesolithic; Sicily; coastal palaeoeconomy

The Mediterranean basin preserves among the oldest evidence of dietary use of coastal resources in prehistoric time, with a robust body of data associated to Mesolithic cultures of the Early Holocene. However, coastal areas of the Mediterranean are scarcely productive, thus it is generally accepted that intertidal and subtidal organisms (e.g. fish, crustaceans, echinoderms, molluscs) probably played only an opportunistic role in the diet of local hunter-gatherer, compared with terrestrial counterparts. In this sense Mesolithic records from NW Sicily (Italy) provide the opportunity to evaluate this economic scenario with a different perspective. On overall archaeological sites testify a variable proportion of both marine and land resources, which is suggestive of an articulated use of coastal environments. Regional records provide compelling evidence that Mesolithic subsistence system in central Mediterranean region may have had different degree of reliance on coastal resources. Small mammals and terrestrial molluscs remains also provide valuable insights into palaeoclimatic and palaeoenvironmental conditions in the Central Mediterranean basin at the time of sites formation.

N2-3 Orale Mozzi, Paolo

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URBAN TOPOGRAPHY AND ANCIENT LANDSCAPES AT ALTINUM (LAGOON OF VENICE)

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Key terms: geoarchaeology; lagoon; alluvial plain; palynology; Venice

Altinum was one of the most important Iron Age and Roman cities in the northern Adriatic, with a harbor located at the inner margin of the Lagoon of Venice. One of the aims of the research is to sort out the possible influence of late Holocene climatic changes and relative sea level fluctuations in allowing human settlement in this fragile, amphibious environment. The city was abandoned in the 5th-7th century AD, as inhabitants moved to the nearby islands of Torcello, Burano, and others; these first stable settlements in the lagoon pre-date the foundation of Venice around the 9th century AD. This migration is generally believed to be due to political problems related to the arrival of Barbarians but climatic instability may have played some role in changing the local river and tidal channel network. The reconstruction of the urban topography and ancient landscapes of Altinum is being carried out through geoarchaeological techniques, with the collaboration of the Archaeological Superintendency and the support of ARCUS s.p.a. and Regione Veneto. Remote sensing has allowed for a detailed mapping of the city walls, street network, dwellings, public and religious buildings of Roman Altinum. The city stood on a 3.5 m high, 1 km² wide mound, surrounded by a complex network of rivers and canals. Two large canals, detected with LiDAR, used to cross the urban center, providing direct connection to the lagoon. The harbor was located at the eastern outskirts of the city. Twenty-five corings were carried out in the city and in the harbour to maximum depth of 8 m. The mound consists of superimposed archaeological layers from Protohistory to late Antiquity. The city canals and the harbor are filled by 2-5 m of organic-rich clayey silt with abundant plant macro remains and lagoonal shells. Pollen indicates phases of deforestation; the great diversity of herbaceous plants suggests a variety of human activities in the area (agriculture, farming, gardening) since the beginning of the common era. The biological proxies of salt/brackish water vary in the core, suggesting fluctuations in the hydrological conditions.

N2-4 Orale Cadeddu, Francesca

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REMOTE SENSING IN ARCHAEOLOGY: A GEOARCHAEOLOGICAL APPROACH TO THE SARDINIAN BRONZE AGE CONTEXT

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Key terms: geoarchaeology; remote sensing; settlement strategies; architectural energetics

Considering the quick evolution of landscape and the resulting changes and destructions, a deep knowledge of archaeological areas is called for to organize interventions and territorial planning. The Earth Observation (EO) methodologies in the last year have been widely used for studying and preserving the archaeological heritage and it's been a long time that geoarchaeology is considered an independent discipline and offers methods and results for a better understanding of the past. On the basis of a multidisciplinary perspective, this paper will provide a methodological approach and new data about the settlement strategies and the economic, political and social organization of the Nuragic civilization, taking into account the EO methodologies and its potential contributions. The approach will be test in a sample area in the North Eastern part of Sardinia (Gallura). This area, well defined by the Limbara mountains, is of particular interest due both to its archaeological and geological features. In addition it has been yet analyzed with some spatial analysis in a GIS environment and the results show a clear definition of its main characteristics.

By evaluating archaeological and geological data through aerial photographs and remote sensing imagery, a territorial characterization will be outlined for identifying hidden structures, as well as for mapping the archaeological monuments already known and discovered. This first phase will allow to plan a survey to verify the results of this first step. The preliminary upshots of this research will be focused on the purpose to define the likely extractive zones used since the Nuragic period and determine the anthropic impact on the environment. From an archaeological point of view, these are among those key to reconstructing settlement strategies and social, politic and economic organization of the Nuragic civilization. These issues are well known, especially in the field of Architectural Energetics and paleo demography, because they allow to gain an insight into the exploitation of natural resources (namely construction materials) and, consequently, the organization of workforce and social structures; in addition it could offer ideas for reconstructing commercial and exchange routes. Even though the discussion is meant to be preliminary, this research can furnish a new integrated methodology that put to use remote sensing, geology and geomorphology applied to archaeological studies. In this paper we show how the knowledge of physical landscape in its different traits can be used for a better understanding of the past and how territorial planning and management can be enhanced through the use of such a multidisciplinary approach. Furthermore the development of standardized research methods allows the use of non-invasive techniques for territorial research and the reconstruction of the landscape and its resources, considering the past in a present perception. In this way is possible to gain a more comprehensive vision of the environment for a new perspective in preserving the natural and anthropized landscape.

N2-5 Orale Mozzi, Paolo

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GEOARCHAEOLOGICAL INVESTIGATION OF A FLUVIAL CITY: PADUA AND ITS ALLUVIAL PLAIN

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Key terms: geoarchaeology; urban geology; alluvial plain; palynology

With origins tracing back to the late Bronze Age, ancient Padua experienced a major development in the Iron Age between the 9th-6th century BC, when it became an important urban center. Since the 2nd century BC it was one of the main Roman cities in NE Italy. The stacked layering of archaeological deposits until the Middle Ages resulted in the upbuilding of a 7 m thick and 1 km² wide anthropogenic mound, which occupies the whole city centre. A research project funded by Fondazione Cariparo has allowed the integrated analysis of the alluvial and archaeological record in and around the urban area, as well as palaeobotanical investigations at selected sites. Methods span from remote sensing and LiDAR to GIS processing of archaeological data, geological field survey and corings, palynology and analysis of plant remains. Alluvial chronostratigraphy indicates that the Brenta River was crossing Padua in the 2nd millennium BC. 3D modelling of the archaeological record and the overall geomorphological evolution of the alluvial plain suggest that during the Iron Age and in Roman times the Bacchiglione River was following its present course through the area, occupying an abandoned meandering bed of the Brenta River. The microscopic plant remains such as pollen grains and seeds/fruits were analyzed in a core in the present city centre (Palazzo Roccabonella, via S. Francesco), on the point-bar of a large meander. The record from the infilling of a probable Iron Age ditch evidence the dominance of herb vegetation. The hygrophilous plants (herbs, trees and shrubs) are quite rare, therefore the soils should have been well drained and suitable for cultivation and dwelling. This is consistent with the high percentage of cereals' pollen and the co-occurrence of seeds and of their weeds (pollen and seeds), as well as ruderal plants. The river changes which occurred at the end of the 2nd millennium BC, possibly related to coeval climatic instability, allowed for the development of Iron Age urban settlements on the stable banks of the underfit Bacchiglione River.

N2-6 Orale Cremaschi, Mauro

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ADAPTING IRRIGATION STRATEGIES TO MID-LATE HOLOCENE CLIMATE CHANGES IN THE SALUT OASIS (SULTANATE OF OMAN)

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Key terms: Oman; irrigation; calcareous-tufa; stable-isotopes; U/Th

The Salut oasis at its apogee, during the Iron age (late 1 millennium BC), may have reached the size of 75 Km² of cultivated land, sustained by irrigation facilities; today its extension is reduced to 6 Km². This suggests

the inactivation of the irrigation system as consequence of late Holocene aridification. The archaeological context indicates that in the area agricultural exploitation begun during the Bronze age, enjoying a mid-Holocene larger water availability confirmed by independent palaeoclimatic data. However, most of the irrigation features were still in use at the beginning of the Islamic era, but they may be referred to the Iron age. U/Th dating on carbonatic tufa (infilling the irrigation canals and falaj) provide evidence for an high standing of the water-table in the Salut plain between the IV millennium BC and the beginning of the Islamic period. Geochemical investigation (O and C isotopes) will clarify changes in water availability in a crucial phase of the late Holocene, marked by incoming aridity. Moreover, the analysis of thin sections of the soils buried in the area surrounding the citadel of Salut permits to elucidate the dynamic of the exploitation of the oasis.

N2-7 Orale Sagri, Mario

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HOLOCENE LANDSCAPE EVOLUTION OF THE AKSUM ARCHAEOLOGICAL AREA (TIGRAY, NORTHERN ETHIOPIA)

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Key terms: geoarchaeology; Ethiopia; landscape erosion

Many recent paleoclimate studies highlighted that repeated climatic changes took place during Holocene both at decadal and multi-century scale. Although these climatic variations have a demonstrated control on vegetational, faunal and geomorphological changes, the role of human activities in favouring or hindering climate-triggered landscape modification is still a matter of investigation.

The town of Aksum is located in Tigray (northern Ethiopia), a region where Holocene climatic changes are well-documented. Between the 3rd and 6th century AD, Aksum was the capital of a kingdom stretching its control as far as the Red Sea coast, the western Sudanese lowlands, and the regions to the west of the Takazza River. The kingdom flourished constantly until the 7th century, when a dramatic decline started.

During Holocene time span, a 6 m thick alluvio-colluvial succession was accumulated in the Abak Creek valley, which is located few kilometers SW of the modern Axum town and cut into tertiary basalts. The Abak succession has been divided into six main units (Abak1-6) bounded by erosive surfaces. The basal unit (Abak1) consists of weakly cemented cross-stratified sandy gravels pointing to a well-developed alluvial drainage. No radiocarbon ages have been obtained from these deposits, which probably accumulated during the Late Pleistocene - early Holocene. Unit Abak2 is made of muddy colluvial deposits containing channelized, gravelly bodies. Radiocarbon datings from charcoals provided a radiocarbon age of 5470-5220 BC and 5540-5370 BC. Unit Abak3 is made of plant-rich, palustrine/floodplain silty sand capped by a vertic soil. Samples from the basal part of the unit provided a radiocarbon ages of 170-40 BC. Radiocarbon datings from charcoals picked about 0.5 m below the vertisol gave an age of 230-350 AD. Unit Abak4 is consists of sand and gravel accumulated in a relatively to high-sinuuous fluvial channels. Subordinate colluvial deposits can occur close to the valley flanks. Unit Abak4 deposits contains abundant axumite pottery fragments, and provided nine coherent radiocarbon ages comprised between 1400 and 1650 AD. Unit Abak5 is deeply cut into the underlying units, and is made of relatively well-sorted fluvial sand. Radiocarbon datings from charcoal fragments point to a modern age (younger the 250 yBP). Unit Abak6 consists of two sub-units (Abak6a and Abak6b) continuously exposed along the creek flanks, and representing two different order of fluvial terraces of modern age.

The present study highlights that after a phase of marked landscape stability, associated with development of vertic soils around 300 - 400 AD. The marked erosive surfaces at the base of units Abak4 and Abak5 testify two major phases of landscape degradation (i.e. soil erosion) followed by aggradation (i.e. valley filling), which occurred around 1400 - 1650 AD (i.e. aggradation of unit Abak4) and modern age (i.e. aggradation of unit Abak5). The present study highlights that the marked antropic pressure acted during the maximum development of the Aksumite Kingdom didn't trigger any landscape degradation, which, on the contrary, started at about 1400 - 1650 AD, when a marked increase in rainfall, punctuated by three main droughts, affected the East Africa.

N2-8 Orale Morandi Bonacossi, Daniele

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ENVIRONMENTAL VARIATIONS AND CULTURAL CHANGES: THE CASE OF THE PALMYRA MOUNTAIN REGION DURING THE LATE PREHISTORY AND THE EARLY HISTORIC PERIODS

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Key terms: Palmyra; desert-kites; climate-change; economic-strategies; oasis

Notwithstanding the importance of the desert region surrounding Palmyra for the economic development of the oasis and the Bronze Age settlement and especially of the great caravan city of the classical period, the Palmyra hinterland has not been the object of systematic and intensive archaeological research. Since 2008 a joint Syrian-Italian mission has been conducting geoarchaeological survey work in the Palmyra oasis and the desert areas to the south and west of it. Palaeoenvironmental proxies from the Palmyrena and the Levant indicate a discontinuity between a wet Late Glacial/Early Holocene and a later dry period, which is presumed to have started at the end of the seventh millennium BC and resulted in the progressive nucleation of the Palmyra oasis on one hand and in a major change in settlement patterns and the exploitation of natural resources on a regional scale on the other. Permanent settlement and agriculture were concentrated within the oasis, where water resources had survived despite reduced precipitation, whereas the surrounding dry steppe was exploited by mobile pastoral and specialized seasonal hunter communities. The paper will explore this major shift in settlement patterns and economic strategies in the region, which is marked by the emergence of

an archaeological landscape characterized by isolated cairns or clusters of cairns, in some cases associated with small groups of huts, and desert-kites.

N2-9 Orale Cremaschi, Mauro

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ENVIRONMENTAL CHANGES AND CULTURAL DYNAMICS BETWEEN THE LATE PLEISTOCENE AND THE EARLY HOLOCENE IN THE PALMYRENA (TADMOR REGION, CENTRAL SYRIA)

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Key terms: Palmyra; Lake level changes; Early Holocene; Geometric Kebaran; PPN/A/PPNB

Evidence of late Pleistocene to early Holocene occupation of the region surrounding the oasis of Palmyra/Tadmor (central Syria) consists of geometric Kebaran, Natufian and early Neolithic archaeological sites. These are distributed along the margin of the Sabkhat al Mouh and in the Abu Fawares area, in connection with lacustrine deposits, suggesting a period with a humid climate dated to the Upper Pleistocene. To the same phase a high stand of the level of the lake in Palmyra basin is dated, followed by arid conditions and the onset of evaporitic environmental conditions during the last Pleniglacial. Erosive surfaces and gypsum aeolian dunes are further geomorphological indicators for enhanced aridity in the Upper Pleistocene. A subsequent high stand of the lake level is indicated by organic lacustrine sediments found in the range of the Palmyra oasis and dated between the late Pleistocene and the early Holocene. The density of open-air sites, located close to the present day oasis and dating from the Late Epipalaeolithic to the Early Neolithic, confirms environmental conditions suitable for human and animal life. Finally, wet environmental conditions turned toward aridity during the early Holocene (IX millennium BP), in correspondence with the early Neolithic exploitation of the region. As a consequence, later archaeological sites were concentrated in the area of the present-day oasis and marginally within the Abu Fawares basin. Possibly, as documented elsewhere in the Near East, an early Holocene arid event favoured a main shift in subsistence strategies and a population relocation; archaeological sites distributed within the limits of the oasis, especially the sequence at site 288 encompassing a span of time from the PPN/A to the Chalcolithic, recorded this phase.

N2-10 Orale Zerboni, Andrea

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THE ORIGIN AND COLLAPSE OF THE GARAMANTIAN KINGDOM IN THE CENTRAL SAHARA: PALAEOCLIMATIC VERSUS HISTORICAL FACTORS

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Key terms: oases-system; Garamantian-kingdom; climate-change; water-availability; Sahara

Throughout the Holocene, climatic changes have been recurrently claimed as one of the major causes for the collapse or flourishing of ancient civilizations; moreover, in arid lands water availability has been recognized as the main factor promoting and accelerating cultural and social dynamics already acting. Concerning the Sahara, the most representative climatic event dated to the late Holocene is the failure of the monsoon system and the consequent progressive decrease in precipitation culminated with the onset of the present hyperaridity. In the central Sahara the response of the environment was rather quick: springs and lakes desiccated and the mountain were almost abandoned, but few ecological niches survived the change. As consequence of geomorphological processes, since 4000 years BP water resources contracted to isolated units of landscape within the mosaic of the desert physiographic features: the oases. A typical example is given by the wadi Tanezzuft that was a large river during the wet Holocene and contracted into an oasis soon after the interruption of the monsoonal circulation. The oasis in the Tanezzuft valley was almost stable in the 4th and 3rd millennia BP, but after several centuries of enhancing aridity its size was reduced. In the course of the 3rd millennium BP the SW corner of the Fezzan region became the southern border of the Garamantian kingdom, and oases were important centers of the caravan routes, connecting the Mediterranean coast to inner Africa. In this framework, Garamantes succeeded in developing a rich agricultural exploitation of the oases environment, introducing large scale irrigation technologies also in the attempt to react against increasing aridity. The Garamantes experienced, thus, the emergence of a complex state formation in the middle of the desert; in the wadi Tanezzuft Garamantian settlements mainly consisted of fortified villages and compounds, located as a protection of the fringes of the oasis, together with fortified citadels strategically located along the main caravan routes. Several minor sites of this age have been found buried inside the alluvial deposits and confirm the exploitation of a wide territory. Sites distribution suggests that the oasis was larger than the present one, and the main rivers were the source of water for the cultivated land. During the 2nd millennium BP the Tanezzuft oasis contracted significantly, possibly also in consequence of several arid spells, evident in the dendroclimatological record of the Cupressus dupreziana. The Garamantian society was well adapted to harsh environmental conditions and possibly resistant to severe dry spells; nevertheless the decline of the Garamantian kingdom occurred in the IV-V century AD. This period corresponded to the decline of the Roman empire and to the consequent almost complete stop of the caravan trade. Political and economic factors have been surely relevant but it is also meaningful to note that this phase also corresponds, in the palaeohydrological record of the SW Fezzan, to a strong decrease of water availability, as consequence of recurrent droughts and climatic instability. Possibly the Garamantian could not halt the encroaching aridification, combined with the collapse of the trans-Saharan trade, and their society underwent a crisis attested both in archaeological and literary sources, which describe a shift from an oasis-based territorial state to the hegemony of the pastoral

tribes of camel herders. The trajectory of the Garamantian kingdom is a paradigmatic case-study illustrating the time and steps of human exploitation of a marginal and fragile environment. The growth of permanent settlements within the oasis, which developed towards a complex chiefdom system, facing a changing landscape, well represents the interconnection between historical socio-economic and climatic factors.

SESSIONE N4

Il ruolo dei carbonati continentali nelle ricostruzioni paleoambientali, paleoclimatiche e tettoniche: realtà e prospettive

N4-1 Invitato Soligo, Michele

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RADIOGENIC ISOTOPE, COSMOGENIC RADIONUCLIDES AND RADIATION DAMAGE METHODS APPLIED TO THE DATING OF CONTINENTAL CARBONATES

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Key terms: uranium-series; radiocarbon; luminescence; Electron Spin Resonance; carbonates

Speleothems, fresh-water tufa and travertines are generally dated using methods based on uranium-series disequilibria, but also on cosmogenic radionuclides and radiation damage. The basic theory of these methods is introduced and related applications in the study of continental carbonates are shown with examples derived from recent research.

U-Th is the most popular method and is based on the measurement of ²³⁰Th formed in situ by radioactive decay of uranium (²³⁴U and ²³⁸U) co-precipitated with CaCO₃. In the absence of detrital minerals (see for example pure speleothems) the extent to which the ²³⁰Th/²³⁴U activity ratio has returned towards unity is a function of time, taking into account also the state of disequilibrium between ²³⁴U and ²³⁸U. Tufa and travertines, however, are impure mixtures of calcium carbonate and incorporated detrital minerals and deserve the recourse to specific correction schemes to determine the authigenic radionuclide component and thus a fitting age. The method extends back to at least 350 ka. The disequilibria between other parent-daughter pairs in ²³⁸U and ²³⁵U decay chains (namely, ²³⁴U/²³⁸U, ²³¹Pa/²³⁵U, ²²⁶Ra/²³⁰Th) are also used in carbonate dating. ²³⁴U/²³⁸U method can be applied to dating carbonates as old as 1.25 Ma, assuming that the uranium activity ratio in the parent fluids has remained constant over time. ²²⁶Ra/²³⁰Th method is used to date continental carbonates younger than 8 ka, presupposing that ²²⁶Ra/²³⁰Th initial activity ratio can be determined on present-day deposition. Recently, the use of the classic U-Pb method has been extended to speleothems dating, opening new perspectives on the study of older speleothems, not datable using standard U-series methods. The use of radiocarbon dating in carbonate chronology is considered problematic, principally because of potential variability in the contribution of "dead carbon" from the host limestone. Actually, precipitating waters may contain a proportion of carbon inherited from the dissolution of a ¹⁴C-free carbonate component in the bedrock. Another problem could arise from the contamination of the material with younger carbon from soil organic matter that might be deposited in the original structure of porous carbonate. In addition to that, bomb-¹⁴C may affect modern precipitation, leading to an inconsistent young age. Because of these problems, relatively few speleothem chronologies are based on ¹⁴C ages. Finally, radiation damage dating methods (electron spin resonance, thermoluminescence, optical stimulated luminescence) are based on the time-dependent accumulation of electrons trapped in the crystal defects of certain crystalline nonconducting minerals, when exposed to ionizing radiation. The trapped electrons cannot return to the ground state, unless a sufficient amount of energy is provided, in the form of heat or electromagnetic radiation (light). Unfortunately, not all the samples are suited for radiation damage dating: indeed, the presence of cationic impurities such as Mn²⁺, Fe²⁺, or Fe³⁺, humic acids (organic matter), can mask the signal of interest, or interfere with it. These methods can be applied to date materials ranging in age from a few hundreds years to about a million year.

N4-2 Invitato Brilli, Mauro

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ON STABLE ISOTOPES AND TRAVERTINE: OLD AND NEW TECHNIQUES

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Key terms: Travertine; Stable isotope; Paleoclimatology; CO₂; Clumped isotopes

Carbon and oxygen stable isotopes were used to characterize the genesis of travertine for the first time by Craig in 1953. To our knowledge, it was Craig who performed the first analysis of the most widely known travertine formations, such as those from Tivoli and Yellowstone. Since then, the study of the stable isotope composition of travertines (and carbonates, in general) has been one of the most active areas of research in carbonate geochemistry.

Carbon and oxygen isotopes in travertine yield two main types of information regarding (i) CO₂ geochemistry and (ii) paleoclimatology. The former is related to the possibility of determining the origin of carbon species in travertine-depositing solutions from the carbon isotope composition. The origin of the carbon species in solution is attributable to several sources: organic or atmospheric CO₂, CO₂ produced by decarbonation reactions from carbonate rocks, magmatic CO₂. The latter is related to the fact that travertine, like all other non-marine carbonates, preserves a valuable record of paleoclimatic conditions.

This applies above all to formations deposited from cold water since the fluid in such cases may have been "ambient" water, the stable isotope compositions of which are determined by local climate conditions. In particular, oxygen isotopes are dominantly indicative of paleoclimatic conditions since the oxygen isotopes of a carbonate in theory directly depends on two factors: temperature and oxygen isotope composition of the water where the carbonate precipitates. Crucial assumptions regarding

the isotopic equilibrium and isotopic composition of water have to be made in order to estimate the temperature of the carbonate formation; these assumptions are often not valid. Nevertheless, reliable high resolution paleoclimatic isotope curves based on travertine sequences have been reported by numerous studies.

The new frontier of isotopes applied to paleoclimate consists of a new carbon and oxygen isotope paleothermometry technique, referred to as clumped isotope thermometry because it measures the temperature-dependent clumping of ¹³C and ¹⁸O (the rare isotopes in the isotope complex of carbon and oxygen) into bonds with each other in the carbonate mineral lattice (Eiler, 2007). The outstanding advantage of this innovative isotope method consists in eliminating the dependence on the isotopic composition of water, as well as most of the common complexities to conventional stable isotope thermometry, such as disequilibrium due to vital effects. Few studies based on this approach have been conducted on different types of carbonates: synthetic inorganic calcite, natural inorganic calcite from a soil, aragonitic otoliths, aragonitic corals, aragonitic mollusks and calcitic brachiopods, and, very recently, speleothems. The application of this technique to travertines is only a matter of time.

A further characteristic of the carbonate clumped isotope thermometry is that it provides a means of rigorously constraining the δ¹⁸O of ancient waters, which can be determined by combining the temperature

estimation with the δ¹⁸O of the carbonate; clumped isotopes are likely to yield a considerable amount of new information that will result in the need to review both early and more recent studies on carbonate isotope geochemistry.

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N4-3 Orale Gandin, Anna

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TRAVERTINE AND CALCAREOUS TUFFA: LITHO- AND MICRO-FACIES AND RELATED DEPOSITIONAL ENVIRONMENTS

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Key terms: travertine; calcareous tufa; litho- and microfacies; petrogenesis; depositional conditions

The depositional facies that characterize old epigeal carbonate bodies can all be recognized in present day fluvial and thermal systems and observed throughout their formation. Both deposits derive from flowing Ca/CO₂-rich waters rising from cool/ambient temperature karstic sources (Calcareous tufa) or warm to hot/thermal spring systems (Travertine).

Their depositional features are quite different:

- in the fluvial environment they reflect the biological activity of a varied micro- and macro-flora and a lower concentration of Ca²⁺.
- Bio/phytohermal constructions related to rapid turbulent flows and muddy palustrine facies prevail in the Calcareous tufa deposition;
- in the thermal system peculiar litho- and micro-facies appear to be mostly controlled by physico-chemical factors. High concentrations of the solution and related cooling and degassing processes associated with the morphology of the substrate and the mechanical properties of the water flow, define the textural characteristics of the Travertine deposits that drastically varies from crystalline crusts connected with rapid laminar or turbulent flows to laminated microbially mediated fabrics such as microbial rafts and mats connected with wetland conditions.

N4-4 Orale Pola, Marco

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THE MONTIRONE TRAVERTINE MOUND: A MULTIDISCIPLINARY APPROACH. IMPLICATIONS FOR THE EUGANEAN GEOTHERMAL FIELD (NE ITALY)

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Key terms: travertine mound; extensional relay zone; Euganean geothermal field; deep geothermal system

The Montirone is a travertine-made hill (max. height 15.75 m a.s.l.) located in the Abano Terme area of the Euganean Geothermal Field (EGF), that extends on a plain band of 36 Km² south of Padova (Veneto-Italy).

The existence of an extensional relay zone, buried hundred meters beneath the alluvial cover, between segments of the Schio-Vicenza fault system (SVFS) has been proposed. This structure accommodates a local extensional regime that keeps open fractures in the subsurface of EGF and enhances the uprising of hot waters. The temperature of thermal waters, used mainly for spa, ranges from 60°C to 86°C. 3H and 14C measurements suggest a residence time greater than 60 years, probably a few thousand years. At present, about 250 wells are active and the total average flow rate of exploited thermal fluids is 15 Mm³/Y.

Until the 1960, the only natural occurrence of thermal waters in Abano was located on the Montirone hill; hot waters fed several pools located on the flat top and at the base of the hill and were partially channeled to move a mill-wheel. The intense exploitation of thermal waters, linked to the increasing number of thermal wells, lowered the potentiometric level from more than 16 m a.s.l. to -15 m a.s.l. (year 1982; at present is 5 m a.s.l.) and dried up the hot springs. The hill has a sub-circular shape, covers an area of 10000 m² and can be classified as a regular shaped travertine mound.

The mound is affected by a network of fractures mainly composed of two sets (WNW-ESE and NNE-SSW) that can be interpreted as a fracture mesh developed in a dilational stepover between strike-slip or transtensional fault segments of the SVFS. The trend of fissures parallels the trend of the main regional structural elements (e.g. SVFS; mainly oriented NW-SE) and is consistent with the direction of the anisotropy depicted in the variogram analysis of transmissivity calculated in the bedrock of EGF (N110°E).

Two drillings (about 1m deep) were made to study the depositional facies of the travertine because of the absence of relevant cross sections. Thin

sections of the core samples show the dominance of layered travertine made of lime-mudstone with paper-thin rafts and laminae of bacterial shrub, locally covered by crystalline crusts made of feather-like calcite. Moreover, soft sediment syndepositional deformations and repeated phases of karstic dissolution and redeposition have been observed. Isotopic analyses on uranium-series, carried out on crystalline crusts sampled during the drillings, have given ages from 30 ± 4 ky to 25 ± 5 ky. Moreover, the low content of U (from 3 to 12 ppb) and the high activity ratio of $^{234}\text{U}/^{238}\text{U}$ (>2) clarify the high interaction between rock and water, typical of a deep geothermal system with high residence time of waters.

Geophysical methods, and particularly Electromagnetic survey (EM) and Electrical Resistivity Tomography (ERT) were used to determine the mound geometry. The map of EM measurements (depth of investigation around 1.5m) shows the presence of two resistive areas along the slope and a more conductive region on the top of the mound. The latter can be interpreted as indicative of the uprising of thermal waters through a more fractured zone. ERT surveys confirm the vertical extent of the conductive and resistive anomalies, and support the interpretation above. The presence of the Montione travertine deposit strongly supports the existence of a releasing structure in the subsurface, which controls the development of the EGF, and an ongoing activity of the SVFS, which is generally considered inactive. The analysis on U-series isotopes gives another important constraint on the deep circulation and a long residence time of thermal waters.

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N4-5 Orale Capezzuoli, Enrico

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FIRST EXAMPLE OF BANDED TRAVERTINE FROM ITALY: THE FISSURE RIDGE OF SEMPRONIANO (GROSSETO - ITALY).

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Key terms: Travertine; neotectonics; Banded travertine; fissure ridge

Travertine fissure-ridges are common morphotectonic features characterizing the travertine deposits from thermal waters rising along fractures in the bedrock.

A typical travertine ridge consists of a central fissure along its long axis, and bedded travertine dipping away from the central fissure. The crestal fissure, often filled by vertical laminated crusts (banded travertine), exactly follows the fractures affecting the bedrock, hidden below the bedded travertines. Consequently, the travertine-fissure ridges are the most significant travertine masses for tectonic investigations. Several examples of banded travertine related to fissure-ridges were described in different geological contexts around the world. Nevertheless, although some fissure ridges were identified from different localities of Central Italy (e.g. Rapolano Terme, Bagni S. Filippo, Canino) they seem not to have banded travertine along their central fissure.

Recent studies on the travertine units in the Albegna Valley (Grosseto - Southern Tuscany) allow the investigation of the travertine cropping out Semproniano, at a quote of 600 a.s.l., where a 400m long and 70m wide continental carbonate deposit was mapped. We refer such a deposit to a wide, vertical banded travertine body precipitated within the central fissure, whereas only in its southern portion, part of the related bedded travertine is still preserved.

In this view, the Semproniano travertine can be interpreted as a partially dismantled fissure ridge where it is possible to characterize in detail the inner, filled in portion along which overpressured hydrothermal fluids can rise upwards.

Presumed age of this structure is surely younger than the fissured Middle Pliocene deposits.

Structural studies on the tectonic context, in which the Semproniano fissure ridge formed, are still in progress and could contribute to the better understanding of the tectonic framework acting in this region during the Quaternary.

SESSIONE O1

Geologia Planetaria

O1-1 Invitato Caprarelli, Graziella

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ANCIENT STRUCTURES ON THE MARTIAN SURFACE SUPPORT MODELS OF AN EARLY NOACHIAN ROTATING LITHOSPHERE.

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Key terms: Mars; Tharsis; dichotomy; structures; volcanism

Two of the most striking geological features of Mars are the crustal dichotomy, marked by a roughly east-west 2.5-6 km deep scarp bounding the elevated and ancient crust of the southern hemisphere and the smooth northern hemisphere plains; and the Tharsis Rise, host to the Tharsis volcanoes: Arsia, Pavonis and Ascraeus. Tharsis volcanism is characterized by younging of the volcanoes from south to north. To explain the younging of the Tharsis volcanoes and their alignment, approximately perpendicular to the crustal dichotomy, Zhong [2009; 1] proposed that in the Early Noachian single plume convection and lithospheric thickness variations initiated differential rotation of the lithosphere relative to the mantle. The lithosphere would have then rested in its present position when the dichotomy came to lie on the plume. The Martian equatorial bulge generated by the rotation of the planet around its axis should cause faulting of a lithospheric shell rotating on it [2]. Melosh [1980; 3] calculated that the fracture patterns resulting from the stresses induced in a rotating lithosphere by the equatorial bulge are oriented according to NW compression and NE extension in the eastern hemisphere, between Tharsis and the Hellas basin.

Recent work provided evidence consistent with Melosh's [1980; 3] calculations. A detailed examination of a small equatorial area centered at

longitude 111°E (north Tyrrhena Terra), using Mars Express HRSC imagery and altimetry, led Caprarelli et al. [2007; 4] to conclude that the observed dominant NW-SE fabric was associated to 308° azimuth normal faults. At mid-latitudes in the western hemisphere Caprarelli and Leitch [2009; 5], using Mars Global Surveyor and Mars Odyssey data, mapped the volcanic rocks and structures in Pickering Crater, approximately 130 km in diameter, located 131°W-134°W and 32°S-35°S. These authors interpreted the fretted character of the rim of the crater (and of other nearby features) as due to an episode of deformation under a strike-slip tectonic regime with a principal compressive stress oriented either N-S or E-W, pre-dating the emplacement of all observable lava flows and the formation of NE-SW trending grabens. These observations are also consistent with Melosh's [1980; 3] predictions.

Further studies must be undertaken to search other regions of the Martian crust for evidence of structures consistent with a lithosphere rotation model. The main difficulty associated to these investigations relates to the fact that the ancient crust has undergone extensive erosion, resurfacing and more recent episodes of tectonism. Future investigations will focus on the Martian subsurface, where traces of ancient structures may have been preserved.

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O1-2 Orale Pozzobon, Riccardo

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MODELLING OF CONCENTRIC AND RADIAL STRUCTURES ON ASCRAEUS MONS (MARS)

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Key terms: Mars; Volcano; Modelling; Finite Element; Ascraeus Mons

Ascraeus Mons was one of the first of the Martian volcanoes to be imaged by the High Resolution Stereo Camera (HRSC) experiment onboard the ESA Mars Express spacecraft. The volcano is entirely covered by high resolution images (12 m/pixel) where details of lava flows, sinuous rilles, flank vents and tectonic features are clearly recognizable. Concentric fractures systems (pit chains, grabens) around the volcano changing transitionally into radial structures systems were cartographed upon a HRSC mosaic. These structures were dated by crater counts on coeval lava flows using a mosaic obtained by Context Camera images (CTX, Mars Reconnaissance Orbiter mission) with a spatial resolution of 6 m/pixel. The resulting ages range from 60 to 100 Ma.

The observed structures on Ascraeus flanks show strong analogies with concentric dykes (cone sheets) and fractures on many terrestrial volcanoes such as Isla Fernandina (Galapagos), Tejeda Complex (Canary Islands) and Cuillins Complex (Isle of Skye, Scotland). This last terrestrial analogue was studied in detail and the shape and depth of the inflating magma chamber that originated the cone sheets was determined by the use of a Finite Element Method (FEM) modeling. In particular, the shape of the magma chamber was discovered to be oblate in shape. By analogy, we tested the presence of an oblate magma chamber below Ascraeus Mons. The diameter of the transition zone between concentric and radial structures on Ascraeus Mons flanks is strongly related to the diameter of the magma chamber itself. In addition, with a FEM model built for the Ascraeus Mons we find the average depth of the oblate magma chamber, which could have originated the concentric structures. The presence of a plume instead of the magma chamber was also tested.

O1-3 Orale Baioni, Davide

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ANALYSIS OF AN EVAPORITIC DOME IN EASTERN COPRATES CHASMA (MARS).

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Key terms: COPRATES CHASMA; KARST; EVAPORITE

Coprates chasma is part of the large Valles Marineris canyon system. It forms part of the backbone of the Valles Marineris canyon system, extending approximately east-west for roughly 966 kilometers (600 miles). Coprates Chasma is the longest and deepest of the Valles Marineris troughs system. In the westernmost part of Coprates chasma, next to the borderline with Melas Chasma an embayment on the northern wall can be observed. In the central part of the embayment, a mound of layered material rises from the chasma floor displaying a characteristic dome-shaped morphology.

The mineralogical characteristic of the dome has been previously determined by analysis of the CRISM image HRL00003752. The dome appears to be constituted by magnesium sulphate materials, showing mainly clear signatures of kieserite (MgSO₄ H₂O) an evaporitic mineral also found on the Earth. Further studies carried out on the characteristics and the genesis of Kieserite both on Mars and on the Earth showed that the dome cannot be constituted entirely by kieserite alone but probably it might be constituted also by the same salts that on the Earth alter to kieserite.

In this work we investigated in great detail the surface features of the dome located in the eastern part of TC, with the aim to try to determine

the processes involved in their formation and shaping. The morphological features of the dome have been investigated through the integrate analysis of HiRISE, HRSC, MOC and THEMIS data, while the morphometric characteristics have been measured on a topographic map (100 m contours lines) built using HRSC and MOLA data.

The observation of the dome surface highlights features created by fluvio-erosional and solutional processes. The solutional surface is characterized by landforms typical of the karst morphology such as karren and dolines that strongly resemble the evaporitic karst morphologies found on the Earth. In some part of the dome characterized by lower inclines of the slope, such as, the down slope area in the south-eastern part, we observed that dolines totally pock some parts of the surface and occupy almost all the space, displaying polygonal karst landscapes. Several eolian features are recognizable in the dome surface. They mainly consist of transverse dark sand dunes and dark sand deposits. Depositional forms such as multiple fan-system deposits can be seen at the foot of the slopes, while they seem to be lacking along the dome flanks.

These landforms indicate the presence of liquid water, probably caused by the melting of ice in a periglacial environment, or permafrost rich soil, suggesting that either the material is ice-rich or was so at one time. The landforms might be consistent with responses to climatological change and the presence of liquid water. During the dome history, there was probably only one episode with available water, a geologically short "cool-wet episode" after which there was no water.

O1-4 Orale Caprarelli, Graziella

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A NEW APPROACH TO IMPACT CRATER DATING OF MARTIAN SURFACES.

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Key terms: Mars; impact craters; depth; diameter; ages

Meteorites impact the surface of all planets. Planetary bodies with thin or no atmosphere, and with ancient surfaces not extensively reworked by processes such as plate tectonics, are ideal laboratories to study the effect of impacts on their surfaces. Impact craters are broadly classified into three categories: simple, complex and large. The shape of simple craters is that of a simple bowl bounded by a rim gently sloping outward in an apron formed by the material ejected during impact. Complex craters are larger and display a central peak. Large craters, often termed basins when they are extremely large, are extensive crustal depressions, displaying multiple rings and sometimes multiple peaks. When the impact craters are undeformed by subsequent impacts or other geological events, mathematical relations among their morphological features exist.

On Mars the transition between simple and complex craters occurs at a diameter value = 7 km. That between complex and large craters is generally set at ~ 100 km diameter [1]. Using Mars Orbiter Laser Altimeter data to measure the dimensions of thousands of Martian impact craters, Garvin and co-workers [1-3] defined a series of power laws describing the dimensional relations between Martian crater diameters, rim heights, floor depths and crater profiles for simple and complex craters. These power laws represent the theoretical Martian relations between these morphometric parameters, and as such they have been broadly used to draw inferences on the composition of Martian surfaces: an impact crater found to have a larger floor depth than that predicted by Garvin et al.'s [2003; 1] depth - diameter power law must sit in very hard material, such as fresh volcanic rocks. If an impact crater is shallower than predicted, the surface on which the impact occurred should be made of soft material. This conclusion is however valid only if the examined craters are pristine.

Caprarelli et al. [2007; 4] used the depth-diameter power law [3] to subdivide the surfaces in which simple craters were located in their study area in north Tyrrhena Terra into three categories: (1) hard surface / basaltic rocks; (2) soft surface; (3) aged surface (no longer pristine). The work we present here builds on these findings.

We hypothesized that depth-diameter power law calculations for the third category could be used to draw consistent inferences about the age of Martian surfaces. We carried out measurements of thousands of impact craters in three Martian regions characterised by broadly different ages and geological histories: Daedalia Planum (younger), Isidis Planitia, Arabia Terra (older). Our preliminary results suggest that impact crater morphometric relations provide a record of the relative ages of the Martian surfaces we investigated, thus supporting our working hypothesis. Further work is under way to model our results into a set of equations of general applicability.

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O1-5 Orale Moggi Cecchi, Vanni

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SERS INVESTIGATION OF EXTRATERRESTRIAL LIFE TRACES: ADENINE ADSORBED ON A MARTIAN METEORITE

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Key terms: Raman spectroscopy; Martian meteorite; SERS; Adenine; Dar al Gani 670

Introduction: Surface Enhanced Raman Scattering (SERS) is a powerful technique for the chemical and structural analysis of minerals and organic molecules. This technique provides a huge enhancement of the Raman

signal by means of the interaction with silver, gold or copper nanoparticles [1]. In recent years, owing to its high sensitivity, this technique has gained an increased attention especially for the study of trace biological molecules.

Since microbial life, if extinct or extant on Mars, would give rise to the formation of biomolecules that could be adsorbed on rocks and sediments, the SERS investigation of nucleic acids is important to understand if and how primitive life originated in extraterrestrial environments. Two main limitations usually impair the employment of the conventional Raman technique for this purpose, the low sensitivity and the occurrence of fluorescence, which could interfere with the observation of vibrational bands. Even if SERS spectroscopy allows overcoming these issues [2,3] its suitability to be used as "in situ" technique for direct investigation on Mars surface still remains to be assessed.

In this contribution we report the results of a SERS investigation on DAG 670 meteorite [4] (Martian shergottite) where adenine, a nucleobase detected in several meteorites [5,6], has been deposited.

Experimental: A thick slide of the meteorite was polished with diamond slurry down to 0.25µm, ultrasonically cleaned with water, rinsed with bidistilled water and air dried. Then, a drop of dilute (~ 10⁻² mol.dm⁻³) water solution of adenine was deposited on the surface. Once the solvent was evaporated a drop of silver colloidal nanoparticles were added.

Results: Aiming to find the optimal experimental conditions for the detection of adenine in a real Martian rock we carried out SERS investigation on three mineralogical phases constituting the main part of the meteorite (olivine, orthopyroxene and ilmenite) by means of three different excitation laser lines; two in the red light region (632.8 nm and 785 nm) and one in the green light region (514.5 nm). In such a way we collect an accurate overview of the Raman signal as function of the substrate as well as the excitation laser wavelength. The results show adenine can be unambiguously identified by detecting the intense SERS band located at ~735 cm⁻¹, which frequency results practically unaffected by the nature of the substrate. However, silicate substrates (olivine and orthopyroxene) result more prone to give intense and sharp peaks respect to the oxides (ilmenite) and therefore they should be preferred for analytical purposes. On the other side, fluorescence phenomena were greatly enhanced when short excitation wavelength were employed turning in a much lower analytical performance for the green light region excitation laser respect to the red ones.

Conclusions: Experimental evidence of the capability of SERS technique to detect traces of adenine on Martian-type rock (Martian shergottite, DAG 670) were provided allowing a clear identification of this nucleobase as small trace (about 10⁻¹g). We also demonstrated the use of red-light laser excitation helps to limit the fluorescence phenomena, while the use of LiCl-stabilised silver nanoparticle does not infer in the technique analytical performance allowing the use of this more stable Ag hydrosol.

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O1-6 Orale Comodi, Paola

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THE STABILITY OF BLOEDITE (NA2MG(SO4)2·4H2O) UNDER HIGH PRESSURE BY SINGLE CRYSTAL SYNCHROTRON X-RAY DIFFRACTION: A CONTRIBUTION TO KNOWLEDGE OF ASTEROIDS AND ICI SATELLITES

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Key terms: bloedite; equation of state; icy satellite brine; synchrotron radiation; hydrogen bond

Bloedite Na₂Mg (SO₄)₂·4H₂O is a common mineral in evaporitic marine sediments. Being one of the phases in the system H₂O-MgSO₄-NaSO₄, it has a large planetological interest. In fact, the density variations in the Mg-Na-H₂O system involve many aspects of the petrogenesis and physical volcanology of icy planets. Namely structural models of icy satellites are controversial since the crust-mantle differentiation are based on buoyancy forces not well known especially at different depth.

The bloedite structure consists of parallel layers of MgO₂(H₂O)₄ and NaO₄(H₂O)₂ octahedra, interconnected through SO₄ tetrahedra and hydrogen bonds. The Fundamental Building Block of the structure is the [Mg(H₂O)SO₄-] with finite hetero-polyhedral clusters linked by low-valence cations. The open sheets of these clusters form a structure module that is also common to 4-types structures (bloedite, leonite, anapaite, schertelite).

This paper intends to investigate the HP behavior of bloedite in order to determine the equation of state (EoS), the density evolution and the water storage capability with P as well the evolution of H-bond in comparison with other sulphates.

The HP single-crystal diffraction was carried out on a bloedite gem quality crystal at ID-09 beamline of ESRF (Grenoble). A diamond anvill cell with 600 micron diamond culets, He as P medium and ruby chip as P calibrant was used. A flat panel detector, Mar555 (with a 555mm diagonal active area) allowed a very high quality of collected data. Lattice parameters and reflection intensity was obtained by CrysAlis software and SHEXLX software was used to refine the structure at different P up to 10 GPa. EoS was determined with data collected up to 12 GPa and EOS-Fit programme (Angel, 2000). The second order Birch-Murnaghan EoS fit yields V₀ = 495.6(9) Å³ with a K₀ = 40.5(7) GPa, whereas a third order Birch-Murnaghan EoS fit yields V₀ = 497.6(4) Å³, K₀ = 34(1) GPa and K'

= 5.8 (4) GPa-1. The lattice parameters compressibility are $\bar{\beta}_a = -0.0074$

(4) GPa-1; $\bar{\beta}_b = -0.0069$ (4) GPa-1; $\bar{\beta}_c = -0.0054$ (2) GPa-1 with an anisotropic ratio of 1: 1.07:1.37. The bloedite structure resulted most incompressible along [001], the direction perpendicular to open sheet. The crystal structure refinements showed that the SO₄ tetrahedra are incompressible whereas the bulk modulus of MgO₆ octahedra is 90 GPa and that of NaO₆ octahedra is 42 GPa.

Due to the difficulty to determine the H-position under HP condition by using X-ray diffraction, the H-bond evolution were followed through the measurements of Odonor-Oacceptor distances. The longer distances

O6-O1 and O6-O4 (2.854 and 2.955 Å at 0.001 GPa), have a compressibility ranging from 2.8(9) to 4.4 (7)10⁻⁴ GPa⁻¹, whereas the shortest ones, O5-O1 and O5-O4 (2.715 and 2.742 Å) have a compressibility of 7.7(6) and 9.2(7) 10⁻⁴ GPa⁻¹ respectively. The arrangements of O5-O1 and O5-O4 are along y axis whereas O6-O1 and O6-O4 are along x axis with a strong component along z axis. This configuration explains the large compressibility of a and b parameters with respect to c lattice parameter.

The comparison of structural evolution of bloedite with Ca-sulphate (Comodi et al. 2008), shows similarities and differences. In fact, the bulk moduli of bloedite and gypsum are quite similar, as well as the compressibility of hydrogen bonds. No phase transition was observed up to 12 GPa in bloedite which remains stable at very HP at room condition, whereas gypsum undergo to a phase transition at 4 GPa. The lack of a strong structural rearrangement, essential to compensate the dehydration process, would suggest that water remains in the structure of bloedite in the investigated P range, while the density increase of about 20 per cent over 10 GPa.

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O1-7 Orale Ferrari, Sabrina

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THERMAL INFRARED SPECTROSCOPY AS A FUNCTION OF TEMPERATURE FOR MERCURY ROCK-FORMING MINERALS: APPLICATIONS TO REMOTE SENSING.

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Key terms: Mercury; temperature; crystal structure; X-Ray Diffraction; TIR spectroscopy

It is well known that the surface of Mercury shows temperature variations extremely large at specific locations (Strom, 1987). The temperature can range in 44 earth days between 70 and 725 K at different latitudes and such variations affect significantly the crystal structure and density of the minerals present on the surface of the planet. As a consequence, several kinds of remote information linked to mineral structures, including relative spectral signatures, are strictly dependent on the environmental conditions and vary according to the surface temperature. By "looking at the planet" in remote sensing, Mercury may change its outer face through time and from place to place as a function of solar irradiation. This could drive to important misinterpretations and limit our capability of inferring compositions and rheological properties of materials from remote sensing acquisition. Thus, we need to investigate the behavior of planetary geological materials in situ, or under extreme temperature environments, and improve the geological interpretation and compositional inferences by applying the knowledge acquired to the analysis of available remote sensing data. Here we present a new in situ multi-methodological laboratory approach comprehensive of X-ray diffraction (single-crystal and powder materials) and spectroscopy. In particular, we used Thermal Infrared (TIR) spectroscopy, in the range 7 to 14 µm on olivines and clinopyroxenes in order to evaluate if temperature variation may cause the same density variation due to a cation substitution. In such wavelength range the spectra can be used very effectively to identify the fine-scale structural properties of minerals (Hamilton, 2010).

We performed laboratory measurements at the Planetary Emissivity Laboratory (PEL) at the German Aerospace Center (Deutsches Zentrum fuer Luft- und Raumfahrt in Berlin), where is available a high-temperature and vacuum spectrometer, to acquire emissivity spectra of several single mineral phase with the aim to monitor how their specific spectral features changes as a function of temperature, reproducing the most likely environmental conditions of the hermean surface. In fact, although a significant number of minerals have been well-characterized by means of TIR spectroscopy (Christensen et al. 2002) in our knowledge no TIR data acquired at high-temperature have been published so far with the exception of those by Herbert and Maturilli (2009) on a labradorite plagioclase. The PEL has been build up over the last 5 years to study systematically the effect of temperature on TIR spectral signature and build up a new spectral library taking these effects into account. This is of special significance, since the Bepi Colombo mission, scheduled for launch in 2014, will carry the first thermal infrared imaging spectrometer (Mercury Radiometer and Thermal Infrared Spectrometer, MERTIS) to map the surface of Mercury from orbit, acting in the wavelength region from 7 to 14 µm. The instrument is under construction at Deutsches Zentrum fuer Luft- und Raumfahrt and at the same time the spectrometer of the Planetary Emissivity Laboratory is working for real measurements on minerals. The produced data allows to build up a new TIR mineral database that will be extremely useful in interpreting the future data acquisitions by remote sensing.

O1-8 Orale Carli, Cristian

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SPECTRAL CHARACTERISTICS OF BASALTS IN THE VNIR AND MIDIR: WHAT WE COULD LEARN INTEGRATING DATA FROM VIHI AND MERTIS THE SPECTROMETERS ONBOARD BEPICOLOMBO

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Key terms: Mercury; VNIR Reflectance; MidIR Emissivity; Basalts

One of the primary objectives of the MESSENGER (NASA) mission, presently orbiting Mercury, and the following BepiColombo mission (ESA and JAXA joint project) is the determination of the surface mineralogy of the hermean planet. To this aim MASCS (Mercury Atmospheric and Surface Composition Spectrometer, on MESSENGER; McClintock & Lankton, 2007), will analyze the reflectance in the 0.2 to 1.4 µm wavelength range, whereas the BepiColombo spectrometers VIHI

(Visible-near Infrared Hyperspectral Imager) will operate in a wider range from 0.4 to 2.0 µm and MERTIS (Mercury Radiometer and Thermal Infrared Imaging Spectrometer) will measure emissivity spectra from 7 to 14 µm (Helbert et al., 2005; Sgavetti et al., 2007; Flamini et al., 2010). Mercury has the largest range in diurnal temperature in the solar system, varying from -173 to 430°C. This extreme temperature excursion is expected to affect the physical processes responsible for the spectral features of minerals and rocks. Recently Helbert & Maturilli (2009) highlighted that the spectra of a labradorite sample show significant changes in spectral features in the mid-infrared with changing temperature. This result suggests that the surface temperature and the thermal history of an observed area must be taken into account in the interpretation of the spectra from an extreme planet such as Mercury. The new MESSENGER's observations have documented that volcanism was important in shaping the surface of Mercury (Head et al., 2009). These new data have shown numerous volcanic vents, in particular around the interior of the edge of the Caloris basin, interpreted as expression of effusive volcanism. A possible shield volcano (100 km in diameter) was suggested, as well as pyroclastic eruptions represented by bright haloes around the vents, particularly distinctive in color data (Head et al., 2009). Moreover the MDIS (Multispectral Dual Imaging System) multispectral images revealed differences in color and thus, possibly, composition of Mercury's crust indicative of lateral and vertical heterogeneities (Denevi et al., 2009).

Here we describe the integrated approach aimed at the spectral characterization of basalts in VNIR reflectance and in the MidIR emissivity, through accurately inter-calibrated data from different laboratories.

We report the preliminary results of a study focused on two basaltic samples from an Etna lava flow collected in different vertical positions within the flow. These samples present similar bulk-rock compositions and mineral phases associations, but different textures, with different degrees of crystallinity, due to the different conditions of crystallization from the inner portion of the lava flow (that has a slower cooling) to the surface (faster cooling, with the formation of a glassy-microcrystall groundmass). Mineral composition has been analyzed by microprobe to relate the compositional characteristics to the absorption band parameters. The samples were spectrally characterized at different grain-sizes and the emissivity measured at three "hot" temperatures.

The VNIR spectra of fine powders reveal a clear absorption band at 1 µm compatible with the presence of pyroxene and olivine (Burns, 1993) for the holocrystalline sample, on the contrary the hyalopilitic sample show a lower albedo and almost featureless spectra. The MidIR emissivity of fine powders show always a CF position at 7.7 µm, and a similar absorption structure between the CF and 12 µm can be observed for both samples.

These preliminary results indicate that an integrated approach can provide a better quantitative determination of the minerals and of their abundances, and will be extremely beneficial to the interpretation of our remote sensing data. The two instruments provide complementary information on composition and texture, which will allow, for instance, to separate different portions of a volcanic lava field with different rock texture and also to improve the interpretation of the surface composition.

O1-9 Orale Serventi, Giovanna

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SPECTRAL CHARACTERISTICS OF MULTIMINERAL ROCK AND REGOLITH COMPOSITIONS: EFFECTS OF PLAGIOCLASE CHEMISTRY AND MODAL ABUNDANCE, AND IMPLICATIONS FOR PLANETARY SURFACE EXPLORATION.

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Key terms: plagioclase; MGM; EGO; mixtures; Hermean planet

Low contrast reflectance spectra are often observed at the surface of different terrestrial planets. Among other causes we outline the interference of adjacent absorptions bands due to different minerals. While the combined effects of Fe²⁺ absorptions in various clinopyroxene (Cpx), orthopyroxene (Opx) and olivine (Ol) mixtures have been widely studied, the spectroscopic effects of plagioclase have been considered only for <0,26% FeO bearing compositions. Here we show the effects that different modal abundances and chemistry of plagioclase can produce on

the absorption bands of Fe, Mg mineral mixture spectra in the 0.8-1.2 µm spectral region.

We analyzed mixtures with various abundance of multimineral grains and pure plagioclase, separated from cumulate rock of a layered intrusion belonging to the anorthosite kindred. Multimineral grain assemblages with two different compositions represent the Fe, Mg components in the mixtures. One consists of orthopyroxene En82 (28.2%), clinopyroxene En45-Wo46 (3.4%), olivine Fo84 (68.4%). The second one includes clinopyroxene En45-Wo46 (43.9%) and orthopyroxene En77 (56.1%). Three distinct plagioclase compositions were systematically mixed to each starting assemblage, having FeO% concentration of 0.1, 0.36, 0.5. The amount of plagioclase in the mixtures ranges between 20% and 90%.

Mixtures with grain sizes of 63-125 µm and 125-250 µm were prepared,

for a total of 64 samples. Absorption features in the 0.35-2.5 µm wavelength interval were analyzed via decomposition with Modified Gaussian Model- MGM (Sunshine et al., 1990) and Exponential Gaussian Model-EGO (Pompilio et al., 2010) algorithms, to determine band spectral parameters such as center position, band intensity, width and asymmetry. Mossbauer spectroscopy has been used to determine the relative concentration of Fe²⁺ and Fe³⁺ in mafic minerals.

The most relevant results regard the absorption centered at about 1.2 µm in both the olivine bearing and olivine free series. In the olivine bearing

mixtures, the 1.2 µm feature results from the combination of olivine band 3 and plagioclase band. The relationship between the spectral parameters

of 1.2 µm band and the FeO volumetric concentrations shows: 1) for a given Mg/Fe ratio in the Fe, Mg silicates and FeO content in plagioclase, the asymmetry increases positively with increasing plagioclase modal abundance; this trend is superimposed on the expected minimum shift toward longer wavelengths and the band intensity attenuation; 2) for the same Mg/Fe ratio in silicate and different FeO content of plagioclase, the band 1 and 3 intensity ratio increases and minimum moves toward longer

wavelength with increasing FeO content in plagioclase. In the olivine free mixtures, the 1 μm feature can be decomposed using 2 Modified Gaussians assigned to Fe²⁺/M2 sites in orthopyroxene (0.9 μm) and clinopyroxene (1.05 μm). One of the effects of increasing plagioclase volumetric FeO concentration in mixtures is the shift of band center toward shorter wavelength, with the 1.05 μm clinopyroxene center moving more than the orthopyroxene center. In parallel, the 1.25 μm band assigned to Fe²⁺ in plagioclase shifts to longer wavelength and both intensity and FWHM increase. Ongoing work is focused on the analysis of very fine samples of the same mixtures. Both the correlations and discrepancies between spectral and compositional parameters contribute to a better understanding of spectra such as those interpreted as ferroan anorthosites on the Moon, featureless spectra characterizing the Hermean surface, and perhaps other spectra observed on different small bodies.

O1-10 Orale Massironi, Matteo

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GEOLOGICAL MAP AND STRATIGRAPHY OF ASTEROID 21 LUTETIA

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Key terms: ROSETTA-OSIRIS; LUTETIA; STRATIGRAPHY; GEOLOGICAL MAP; ASTEROID 21

The OSIRIS images acquired during the recent Rosetta fly-by of Lutetia (10th of July 2010), enabled us to unravel the long geological history of the asteroid. This is recorded on its highly varied surface which displays geological units of disparate ages. In particular, using images of the closest approach, five main regions (in turn subdivided into minor units) have been discriminated on the basis of crater density, overlapping and cross-cutting relationships and presence of linear features (i.e. fractures, faults, grooves, troughs). Other regions, with still unclear stratigraphic position, were also recognized on images of lower resolution on the bases of geomorphological properties such as crater density, relationship with scarp and ridges and sharp morphological boundaries. In this work the geological evolution of Lutetia surface is reconstructed through the description of its main units and related contacts.

The oldest regions imaged during the closest approach (Achaia and Noricum) are pervasively affected by fractures and grooves and display surfaces so heavily cratered to be dated back to a period not far from the Late Heavy Bombardment (yielding Achaia a crater retention age of 3.5 Ga). A crater of 60 km of diameter, named Massilia and corresponding to the Narbonensis region, cuts both Achaia and Noricum regions and probably represents the most prominent event of the Lutetia history. Nonetheless it looks quite old as testified by the high crater density on its floor and walls, the absence of discernable deposits related to the impact event, and the intense deformation of its floor. What appears really young (less than 1 Ga) is the North Poles crater cluster (Baetica Region) associated to smooth ejecta broadly mantling the surrounding units and displaying few craters and no linear features. The North Pole cluster is the product of superimposed impacts; the last one of 21 km of diameter excavated the pre-existing ejecta up to the bedrock which locally outcrops at the crater rim. The ejecta of this last impact were involved in several gravitational phenomena testified by the great variety of deposits made up of mega-boulders diamictons, fine materials, gravitational taluses and landslide accumulations. A part from the big cratering events generating Massilia and the North crater cluster, the Lutetia geological history is also punctuated by minor events still recorded by its stratigraphic record well imaged by the closest approach data.

O1-11 Poster Giacomini, Lorenza

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GEOLOGICAL MAPPING OF THE DAEDALIA PLANUM LAVA FIELD THROUGH MORPHOLOGICAL AND SPECTRAL ANALYSIS

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Key terms: Volcanism; Lava flow morphologies; Spectral analysis

Daedalia Planum is a plain located south west of the Arsia Mons where more than 1500 km-long lava flows were emplaced, over an almost flat terrain (<0.5° and commonly <0.1°). We have analyzed the area from different points of view, beginning with a stratigraphic study and a deep investigation of the flow surface morphologies and concluding with a spectral analysis of the region. By analyzing the higher resolution images of Mars Odyssey THEMIS VIS and IR, Mars Global Surveyor's MOC and MRO/HIRISE images several different morphologies among the lava flows were distinguished. The oldest ones include the most widespread flows of the area showing the typical pahoehoe and platy-ridged surfaces textures whereas the youngest units are represented by numerous narrow lava flows with central channels or with brecciated surface. The high ground-resolution of MOC and HIRISE allowed us to detect in some lava flows several morphological features recalling inflation fingerprints, like tumuli, lava rises and lava ridges. On the base of these morphological differences and stratigraphic relationships among the flows different geological units were distinguished on the Daedalia Planum lava field.

The great variety of morphologies observed on the Daedalia Planum lava flows encouraged a detailed study of their spectral characteristics, in order to obtain some information about lava composition and detect possible differences in the flows spectra. The OMEGA spectra collected in the lava field appear rather similar, with absorptions between 0.8 and 1.4 μm and

1.8 and 2.5 μm , suggesting the presence of mafic minerals, which are typical primary mineral phases of volcanic rocks. Moreover, after the continuum removal, we highlighted the presence of two classes of spectra both compatible with tholeiitic basalts but with different content of Ca in the pyroxene. Above the similar absorption bands, however, Daedalia spectra show also some differences in albedo and spectral slope. By employing the average spectra of the different flow units as endmembers, a SAM classification was performed. The resulting spectral map reveals a good relation between spectral behavior and surface textures of the flows. By integrating the morphologic and spectral units a new geologic map of the area was obtained allowing us to demonstrate the great potential for improving Martian geological maps by integrating morphological and spectral characteristics of the surface.

O1-12 Poster Massironi, Matteo

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RADITLADI AND RACHMANINOFF BASINS ON MERCURY: LAYERING AND CRATER CHRONOLOGY

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Key terms: Crater Chronology; Mercury; Basins; Layering; Physical properties

Raditladi and Rachmaninoff basins are peak-ring basins of about 250 km in diameter discovered during the first and third MESSENGER flybys of Mercury. Both basins have a relatively fresh appearance with continuous smooth plains within a peak ring structure. A crater age determination has been performed using the Model Production Function (MPF) on several terrains associated with these basins. Our analysis constrains the formation age of Rachmaninoff and Raditladi basins to about 3.6 Ga and 1.1 Ga, respectively. In addition, the age of the smooth plains within the Rachmaninoff basin's floor suggests a volcanic activity until very recent time (possibly to about 1 Ga or less), whereas the plains related to Raditladi appear coeval with the basin itself and most probably of impact origin. MPF enable us to retrieve some useful insights also on the target layering beneath the surface. Therefore, with this work we address the importance of considering terrain parameters, as geo-mechanical properties and layering, into the process of age determination.

SESSIONE P2

L'informazione topografica ad alta risoluzione per l'analisi dei processi superficiali

P2-1 Invitato Pirotti, Francesco

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STATE OF THE ART OF GROUND AND AERIAL LASER SCANNING TECHNOLOGIES FOR HIGH-RESOLUTION TOPOGRAPHY OF THE EARTH SURFACE

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Key terms: Terrestrial Laser Scanner; Airborne Laser Scanner; Digital Terrain Models (DTM); Point cloud accuracy

Airborne and terrestrial laser scanning (respectively ALS and TLS) have become, in the past years, well established technologies for measuring spatial characteristics of objects on the earth surface and the geometry of the earth surface itself. Research and development have created the technology for providing a market with a wide choice of instruments. The distinctive data produced by laser scanners is a 3D point cloud with high-quality positional and return-related information (3D coordinates, reflectance, return echo ordinal number etc...). Partially obstructed impulses give multiple returns, thus important added value to the dataset, by penetrating gaps which are present in certain elements (e.g. vegetation) and reflecting the ground surface as last return. In the last years sensors have been developed which provide the digitization of full return waveform. This capability provides significant data for sophisticated classification and reflectance calibration of the targets and a practically infinite number of return targets per emitted pulse (Briese et al., 2008). Terrestrial and airborne laser scanning share many features related to scanning mechanisms and processing methods whereas they also differ in terms of accuracy, range, data-capture modes and project size (Vosselman and Maas, 2010). In this presentation a comprehensive overview of airborne and terrestrial laser scanning technology and processing is presented focusing on aspects related to high resolution topography of the earth surface. Accuracies, error budgets, and processing methods to improve and assess quality of the scan are reported to give an outline of the potential of current laser scanner sensors for providing high resolution models of the earth surface.

P2-2 Orale Nutricato, Raffaele

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ON THE COSMO-SKYMED EXPLOITATION FOR INTERFEROMETRIC DEM GENERATION

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Key terms: COSMO/SkyMed; DEM; Interferometry; High resolution

DEM products for Earth observation space-borne applications are being to play a role of increasing importance due to the new generation of high resolution sensors (both optical and SAR). These new sensors demand elevation data for processing and, on the other hand, they provide new possibilities for DEM generation.

Till now, for what concerns interferometric DEM, the Shuttle Radar Topography Mission (SRTM) has been the reference product for scientific applications all over the world. SRTM mission [1] had the challenging goal to meet the requirements for a homogeneous and reliable DEM fulfilling the DTED-2 specifications.

However, new generation of high resolution sensors (including SAR) pose new requirements for elevation data in terms of vertical precision and spatial resolution. DEM are usually used as ancillary input in different processing steps as for instance geocoding and Differential SAR Interferometry.

In this context, the recent SAR missions of DLR (TerraSAR-X and TanDEM-X) and ASI (COSMO-SkyMed) can play a promising role thanks to their high resolution both in space and time. In particular, the present work investigates the potentialities of the COSMO/SkyMed (CSK) constellation for ground elevation measurement with particular attention devoted to the impact of the improved spatial resolution wrt the previous SAR sensors. The recent scientific works, [2] and [3], have shown the advantages of using CSK in the monitoring of terrain deformations caused by landslides, earthquakes, etc. On the other hand, thanks to the high spatial resolution, CSK appears to be very promising in monitoring man-made structures, such as buildings, bridges, railways and highways, thus enabling new potential applications (urban applications, precise DEM, etc.).

Both SPOTLIGHT and STRIPMAP acquisition modes are analyzed through standard SAR Interferometry as well as multi-pass interferometry [4].

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P2-3 Orale Remondino, Fabio

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3D SURVEYING AND MODELING VERTICAL CLIFFS FOR GEOLOGICAL AND MAPPING PURPOSES

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Key terms: vertical cliff; oblique scanning; LIDAR; Dolomites; reflectance

The article describes the challenging work of 3D surveying and accurately modeling of the vertical cliffs of the "Tre Cime di Lavaredo" (Dolomites mountains). The Tre Cime di Lavaredo are often considered the "true" icon of the Dolomites, because they fully represent, with their shapes and colors, the concept itself of the UNESCO's site and are a typical example of landforms linked to morpho-selection. More specifically the vertical cliffs in Lavaredo show a morpho-tectostatics shape determined by the trends of important displacement and fracture lines and related belts of cataclastic rocks, which facilitate differential weathering and erosional processes. The vertical dimension of these and similar mountain complexes are usually unmapped and poorly resolved in cartographies which are typically produced using nadir acquisitions and surveying. The goal of the project called "Peaks-3D" is the highly detailed 3D surveying of the "Tre Cime di Lavaredo", especially their vertical cliffs, nearly 600 meter high, for digital documentation and conservation, geological and geomorphological analysis, tourism and communication purposes, 3D mapping of the ascent routes, etc. The digital recording of the current situation and the monitoring of ongoing processes are fundamental prerequisites for analyses and establishment of sustainable measures of protection.

The 3D recording is based on a fusion of oblique airborne and terrestrial 3D laser scanning, in order to survey all the relief complex, focusing especially on the vertical cliffs. The aerial acquisitions were performed with the patented Helica system composed of an Optech sensor coupled with a GNSS/INS unit, a Rollei digital camera and a NEC infrared digital camera. The oblique mounting of the laser scanner allows the detailed surveying of complex sites where a traditional nadir acquisition would not be sufficient. To overcome some recording gaps of the airborne surveying, primarily due to occlusions and hidden rock features, two terrestrial field campaigns were necessary. The aerial and terrestrial range data were afterwards co-registered and merged into a unique and seamless 3D point cloud, considering the multi-resolution data and the 3D geometry (not 2.5D). Then, in order to produce photo-realistic 3D results, digital images were mapped onto the 3D geometric data. The availability of accurate and detailed 3D model over such complex cliffs offers the opportunity to systematically study relationships between relief shapes (e.g. rock faces) and the network of planar discontinuity (e.g. faults, fracture, joint and bedding) that can be extracted from the unstructured 3D point clouds or polygonal mesh. The acquired geometric data provided fundamental information to study slopes, stratigraphy and produce accurate and detailed mapping products. The range data delivered also information

regarding the intensity of the surveyed scene that is, in principle, proportional to the surface's reflectance and depends on the physical and chemical properties of the surface. Experiments on reflectance series obtained from TLS data show intensity variations along a stratigraphic section and give an estimate of the rock content variations during the geological time, highlighting cyclicities that can represent the clue of sedimentary cycles. The analyses of the acquired thermal images showed also interesting temperature changes. Results of the geometric modeling and geological analyses will be presented and discussed.

P2-4 Orale Vassena, Giorgio Paolo Maria

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CREST AND TOE AUTOMATIC EXTRACTION IN TLS SURVEY IN CAVE AND MINING SITES

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Key terms: crest and toe; volume extraction; TLS

The paper deals with an innovative approach to the crest and toe automatic extraction from TLS cave and mines sites. The software to manage data coming from Terrestrial laser scanning acquisitions, are often limited to the countour lines extraction. On the other side few software solutions provide the crest and toe automatic extraction that is often an important request from the geologist working on the field. The paper deals with a new software approach able to easily manage the 3D scanned data, to evaluate volumes, countours line and the automatic extraction of the crest and toe informations. The paper describes also the approach for ICP scans alignment and how to manage data coming from different sensors.

P2-5 Orale Lingua, Andrea

10.1474/Epitome.04.0917.Geoitalia2011

GSTOP: A NEW TOOL FOR IN FIELD RECORDING OF 3D GEOLOGICAL DATA

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Key terms: data recording; geological survey; Solid True OrthoPhoto; Quaternary; Germanasca Valley

In the modern geological mapping activities, geomatics technologies can facilitate data collection during the field survey and avoid practical problems related to the data transfer to the topographic map.

These improvements appear particularly important in the geological survey aimed at the production of geological maps which can present many types of information at different levels of detail; a basic map records the rock and landform distribution in a given area and may be a key for the evaluation of the geological history.

Printed geological map can be produced with a GIS layout. Several practical problems can arise during a field survey, particularly during the survey data transfer to a topographic map. The geological bodies, landforms and structures (e.g., outcrops, geological boundaries, scarps, trenches, faults, tectonic contacts) can be incorrectly plotted, especially where the available map is outdated or insufficiently detailed. Structural measures or sampling points can also be erroneously plotted where the surveyor position is not precisely determined. Portable instruments such as GPS and laser distance meters can reduce such errors, but the Solid True Orthophoto (STOP) can minimize the difficulties and sources of inaccuracy encountered during the field survey.

The STOP is a new product that integrates an orthophoto (2D photographic map) with the height values derived from the Dense Digital Surface Model (DDSM) generating georeferenced 3D information. In fact, STOP can be view using an experimental software tool, developed by the authors in Visual Fortran that includes simple query functions, a 3D coordinate viewer, some measurement commands (e.g., angles, 3D distances, areas, planes, volumes), georeferenced note and comment record utilities.

This viewer can be used on a simple netbook or tablet PC permitting the surveyor to acquire, directly on the field, the 3D geological information in a rapid, comprehensive and accurate way. In fact, the GSTOP (GNSS STOP) viewer can manage, in real time, a direct connection with navigation sensors as a low cost GPS/GNSS receiver to define the current location and a low cost IMU sensor to measure attitude angles (heading, pitch and roll) of PC: inside the STOP, the user can view his position (a red circle) and the azimuth of line of vision (a red arrow) and generate a 3D solid image in order to be compared the effective scene.

The application was used to produce a detailed geologic map and the reconstruction of Quaternary evolution of the area. The STOP viewer was tested by producing a digital map of the Quaternary sediments and landforms in a 3-km² area of the Rodoretto Basin, a minor tributary of the Germanasca Valley, shaped in the greenstone and schist of the Piemontese zone (Northwestern Italy).

The Quaternary sediments and landforms in this area was essentially the result of the alpine glacial expansions and gravitative deformations. The previous geological literature did not refer any glacial and gravitative evidence. The production of a new geological map thus focused on the relationships among the landforms and sedimentary bodies that developed during the Quaternary evolution.

In detail, a wide, deep-seated gravitational slope deformation was defined, with evidence of many trenches of various sizes, doubled ridges, and slide scarps. Some glacial evidence, such cirques, lateral and frontal morainic ridges and outwash incisions, was also pointed out, connected to small local Pleistocene glaciers.

P2-6 Orale Soma, Linda

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APPLICATION OF MODERN TECHNIQUES FOR THE CREATION OF QUATERNARY GEOLOGIC MAP OF MENDRISIO (1373-MENDRISIO SHEET, SOUTHERN SWITZERLAND)

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Key terms: landslide; Southern Switzerland; ArcGDS

The Swiss Federal Office of Topography (swisstopo) tasked SUPSI with the creation of the geologic map of quaternary deposits for Mendrisio (1373 - Mendrisio Sheet), part of the Geological Atlas of Switzerland (swisstopo, 2003). The referenced area is located in the Southern part of Switzerland, between Lake Lugano to the North and Lake Como to the East.

The research team has already completed the data integration of quaternary deposits into the 1:25.000 scale geologic map sheet. The map, made using ArcGIS 9.3 software, contains data collected and processed during geological surveys with maps in scale 1:10.000 and integrated with previous GESPOS (IST-SUPSI database) drilling and bibliographic data (Bini et al., 2001).

Modern techniques were used during the data acquisition phase, such as landslide photointerpretation and 2-meter Digital Elevation Model (DEM) analysis to recognize and characterize shapes present in the Mendrisio area. Applying a 2-meter DEM gave the team the advantage to derive additional spatial data, which through ArcGIS tools can help develop hill shades, slopes, landforms and topographic profiles, recreating the territorial complexity. With this new data, the system is able to display different hill shades, orthophoto information, various slope categories, and additional isohypses.

In order to define landslide boundaries, the team used ArcGDS, a new extension of ArcGIS that permits collection, editing and update of 3D features using a stereoscopic 3D interface. This innovative approach may replace traditional stereographic methods in the future as it results in more detailed features. In addition to 2D (X-Y plane) data, ArcGDS captures altitude data (Z) by continuously connecting points in superposed images.

A lithostratigraphic method was applied to distinguish deposit types. Glacial and fluvioglacial deposits were also characterized using the Late Glacial Maximum (LGM) (Ivy-Ochs et al., 2008). To distinguish deposits older than LGM or contemporary to LGM, the team used alteration of granitoid clasts, depth of decarbonation profile, and pedogenic development as categorization criteria.

The followed approach has resulted in the creation of Mendrisio's digital geologic map with a greater level of homogeneity (2-meter DEM) than traditional methods and allows to recognize easier big landslides. The overall process may become the standard for future map development and open the door for the advancement of future technologies.

P2-7 Invitato Trevisani, Sebastiano

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HR-DTMS, GEOMORPHOMETRY AND LANDSCAPE MANAGEMENT: THE PRICE AND THE VALUE OF HIGH RESOLUTION.

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Key terms: engineering geology; high resolution DTM; geomorphometry; surface texture

The last decade has shown a growing interest toward the characterization of the landscape and the related hydro-geological processes. A main step in this direction is the quantitative and detailed characterization of solid earth surface topography. From this perspective the new technology based on airborne LIDAR plays a pivotal role, making possible the derivation of high resolution digital terrain models (HR-DTM) of regional coverage. For example, the "Autonomous Province of Trento" (area 6500 km²) is completely covered by a HR-DTM with cell size of 2 m (1 m for the urban areas).

The availability of HR-DTMs opens new prospects in many aspects of the applied earth sciences: from the geological/geomorphological mapping to the quantitative characterization and modeling of hydro-geological processes. However, the added value of high resolution has a price: advanced geo-computational methodologies are needed to fully exploit the high informative content of the HR-DTMs. In this context the geomorphometry, the discipline of quantitative analysis of solid earth surface, plays and will play a key role in the next future. Another relevant point, relies on the fact that the high resolution available poses special challenges from the side of field validation of the elaborations performed. This presentation is aimed to outline some of the most relevant potentialities and issues related to HR-DTMs information retrieval in the context of hydro-geological issues.

P2-8 Orale Fiani, Margherita

10.1474/Epitome.04.0920.Geoitalia2011

THEORETICAL AND PRACTICAL ASPECTS IN LANDSLIDE MONITORING USING TERRESTRIAL LASER SCANNING TECHNIQUE

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Key terms: LiDAR; Monitoring; Landslide; DTM; Reliability

The Pisciotta landslide (Sa) causes extensive damage to both an important state road and two railway sections of the Tyrrhenian line connecting North and South Italy. Because of the effectiveness of the LiDAR technique in surveying large areas in a fast, low-cost and quick way, it could be a viable alternative to the traditional surveying methods. We carried out a LiDAR "zero" measurement and about three months later a repetition measurement using a long-range terrestrial laser scanner. In order to survey the top of the landslide area the laser stations can be located in a few points on the stable side facing the landslide at several hundred meters away from the area. During each survey two GPS antennas are mounted on two pillars in order to connect them to both the external stable frame, to the laser stations and to a number of targets which are located in the landslide area.

These two points are not sufficient to establish a stable frame. Some other points located ahead of the landslide have therefore been chosen and linked by means of static GPS measurements to four permanent GNSS regional stations and to other points on the landslide surface. These locations must be visible from multiple laser stations. On each of them a spherical calibrated target must be mounted and it must be recognizable

in the laser strips. The target positions are then measured by GPS and these points are thus the "double points" needed to frame all the laser measurements in a single reference one.

Once these steps are done a number of DTMs of the landslide body are available. Once all surveys have been framed it is possible to compare DTMs at different times, by interpolating the point clouds on a grid in order to identify and analyze over time the areas of greatest deformation and the directions of landslide movement. We also made a number of "local" analysis in the lower part of the landslide. For these analysis we assumed that both upstream and downstream railways tunnels, clearly visible on the scans, may not have moved significantly in the time elapsed between the two surveys, and hence they can be considered as a stable reference. The alignment of the two laser scans gives us satisfactory results in terms of precision and we have been able to measure ground motion of even 50 cm in absolute value.

The former two laser surveys brought to light a strong dynamic of the slope but also highlighted some difficulties mostly due the limited precision of the laser scanner. Other difficulties are related to the targets measurement and above all to the presence of canopy. This is why a further measurement campaign was carried out in the spring of 2011. In the latest survey we also used a laser instrument able to analyze the calibrated relative reflectance in the attempt to filter the effect of the obstacles and thus to generate easier a DTM starting from the DSM acquired. In the third campaign we used a Riegl VZ-400 instrument for surveying the upper part of the landslide, the most troubled due to the presence of canopy, and a Leica C10 in the lower part where natural ground motion and man-made actions have bared the soil making easier the shape reconstruction.

The latest generation of TLS systems, similar to airborne sensors, records the sampled waveform of the echoes of the emitted laser pulse (full-waveform TLS). Thus, extracting multiple echoes and deriving several reflecting surfaces becomes possible.

Using two different kinds of laser scanners (full waveform and traditional mono-eco) on the same portion of landslide allow us to make interesting comparisons between the two methodologies for landslide monitoring in a real-world context, where the presence of the vegetation can cause a loss of reliability.

P2-9 Orale Vassena, Giorgio Paolo Maria

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LANDSLIDES AND MOUNTAINS 3D ANALYSIS AND SURVEY, OBTAINED MERGING TERRESTRIAL, AIRBORNE AND CAR-MOBILE LIDAR DATA

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Key terms: volume extraction; LIDAR; multiplatform; LANDSLIDE; VIRTUAL SCAN

The paper deals with a study where lidar data coming from Terrestrial Laser scanners, airborne lidar sensors and mobile systems (Lidar sensors mounted on a car) are combined to obtain one single 3D model. The data are managed using the software developed by the University of Brescia and its Spin Off Company, and uses the innovative "virtual scan" approach, where the data coming from different platforms, are resampled at a regular grid as taken from one single global "Virtual Scan". The Terrestrial data comes from different sensors. The project is georeferenced using GNSS data and managed directly in Cartographic UTM system. The paper also describes how the data can be fully transmitted and measured by internet, in full resolution so to be shared and by different technicians and experts.

The paper describes the method applied to a real dataset of lidar data. The papers ends describing the approach used to extract countour and break lines and to evaluate the volumes of the material interested in the slide.

P2-10 Orale Castagnetti, Cristina

10.1474/Epitome.04.0922.Geoitalia2011

INTEGRATED HIGH RESOLUTION DTMS TO DEFINE GEOMORPHOLOGICAL FEATURES OF ROCK SLIDES

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Key terms: High resolution DTM; Geomorphology; Rock slide; LiDAR; TLS

The Digital Terrain Model (DTM) is a very important tool for a good and reliable description of the geomorphology of a landslide to study and analyze the phenomenon itself along with the way it changes during time, the volumes transportation, the boundaries evolution and further interesting information by means of the comparison of a number of them. The fastest way to have a large amount of information is using a laser scanner which allows the measurement of millions points to carefully describe a large area. However, landslides often present a complex morphology and a wide extension so that it is not easy at all to perform the survey by means of a single technique: the integration between airborne LiDAR and terrestrial laser scanner (TLS) allows to extract high resolution DTMs. The power of LiDAR methodology is highlighted when a large area is involved and/or when a lot of vegetation covers the area, anyway some problems exist, such as the bad resulting DTM when vertical walls of rock need to be surveyed. In this case, few points can be detected by the flying airborne, as a consequence a not reliable description of the wall and a not complete DTM result. Rather than this, the long-range TLS technique can generally acquire point clouds with higher resolution and accuracy if compared to the airborne laser scanner, especially when the observed objects are perpendicular with respect to the laser beam direction such as vertical wall of rocks. One of the main features of airborne LiDAR is that the laser beam can easily reach the ground due to its vertical position of measurement and this allows a more reliable result for dense vegetated areas. The integration between the mentioned technologies appears to be the best choice to provide a high resolution DTM.

The case study, which will be fully presented, is the Collagna Landslide that is located in the North Appennines (Reggio Emilia, Emilia Romagna - Italy). This large scale composite landslide area is made by both a wide rock slide sector affecting more than 2 million cubic meters of calcareous rocks and a more limited earth slide sector that, that, after high precipitation rates, disrupted the National Road 63 in proximity of

Piagneto, Collagna (RE, Italy) in December 2008. According to the previous description, this is the perfect example for testing the integration of the two technologies: LIDAR will survey all the area, carefully describing the ground hidden by vegetation thanks to its vertical view, while TLS will provide a detailed description of the vertical walls of rock thanks to its frontal view. A detailed comparison among several DTMs, each one resulting from different dataset collected over time, will be presented. Such analysis will allow to carefully identify changes in terms of morphology. It will also be helpful to compute the volume transportation and make hypothesis about future processes or at worst for the collapse of rock blocks. Comparing surfaces is not easy at all, thus a discussion about the encountered problems will be taken into account.

P2-11 Invitato Mondini, Alessandro

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MULTIPLE CHANGE DETECTION TECHNIQUE FOR EVENT SHALLOW LANDSLIDE RECOGNITION AND MAPPING.

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Key terms: remote sensing; change detection; landslides; classification; semi-automatic

An important part of the modern landslide research is the semi-automatic recognition and delineation of landslides at the catchment scale, which has increasingly been based on high and very high-resolution (HR and VHR) satellite images in recent years. This study presents a new method that exploits VHR panchromatic and HR multispectral satellite images and combines change detection techniques for mapping shallow landslides. Combination is carried out through unsupervised methods or multivariate models supervised by ancillary information or expert actions. The models classify each image element (pixel) in stable or unstable areas or assign the probability that the pixel contains (or does not contain) a new landslide. Results are further filtered through morphometric constraints, sieving, and clumping processes. We applied the multiple change detection (MCD) technique to map landslides triggered by two typhoons of vastly different magnitudes in Taiwan (2008 and 2009) and to map landslides triggered by strong rainfall in Messina (2009). Results are compared to pre-existing inventory maps and performances of the models are evaluated using four-fold plots and receiver operating characteristic curves. Further developments plan the exploitation of a priori knowledge of morphometric parameters obtained from very high resolution Digital Terrain Models, in a Bayesian framework. The proposed method is fast and it facilitates the rapid production of accurate landslide event-inventory maps over large areas, when event landslides leave features on the land cover, and the land cover changes are impressed faithfully in the post-event images. Application of the method advances our ability to evaluate landslide hazards, and fosters our understanding of the evolution of landscapes shaped by mass-wasting processes.

P2-12 Orale Audisio, Chiara

10.1474/Epitome.04.0924.Geoitalia2011

UNCERTAINTY ESTIMATION IN DIFFERENCE OF DEM ACHIEVED USING GNSS AND PHOTOGRAMMETRY SURVEY. APPLICATION ON CECINA RIVER (TUSCANY, ITALY)

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Key terms: Difference of DEM (DoD); fuzzy logic; Cecina River; Italy

The study of rivers has assumed growing importance over the last twenty years with an implementation over the last decade, mainly due to legislative awareness on river environment enhancement and fluvial geomorphology knowledge. Recently studies focused on morphological fluvial changes and processes has emphasized the need to evaluate the uncertainty associated to fluvial morphometry firstly using maps and aerial photo but also with Digital Elevation Models (DEM). Concerning topographical river measurements, instruments and methods available (total stations, photogrammetry, GNSS, LIDAR, TLS) imply different time consuming, number of operators, skills and budget, but also different levels of precision. All these provide a three-dimensional representation of the field by DEM achieved using suitable software. The questions to be asked are: how could we consider different uncertainty associated to digital models obtained by measurements done with different instruments? If we want to analyze morphological and volumetric variations along a river, or rather the Difference Of DEM (DoD) obtained with different instruments and surveys, what is the mistake that we are making? How good is our morphological changes estimation and sediment budget at reach scale too?

These questions have been tempted to write a response from a method developed by Joe Wheaton through the use of fuzzy logic system. As a matter of facts, the author proposed a method for the estimation of morphological changes using a fuzzy interference system in order to quantify the spatial variability of elevation uncertainty in individual DEM and DoD as well.

The application of the method was carried out on a stretch of about 2 km along the Cecina River. The Cecina River drains a 905 km² basin in Tuscany (central Italy) and its channel is about 53 km long. In the selected reach, the channel is incised in gravel deposits and shows a single-channel thread along two bends of meander. The basin is characterized by calcareous and clayey rocks in the upper part and pelitic in the medium part.

The decision to apply this method on this river reach is due to the availability of three DEM obtained by three different surveys (2007, 2009 and 2010) with two distinct methods. The 2007 and 2010 surveys were carried out with two GNSS measurements, while the 2009 DEM derived a photogrammetric survey. In addition, the river was affected by two floods in March 2009 and January 2010 which have significantly changed the morphology of the site. The work shows the results of the method and discusses the goodness of the DEM used for evaluating the hydromorphological changes along the river.

The determination of elevation uncertainty could be useful to define error

committed in geomorphological measures and, as a consequence, can improve morphological changes and sediment budget evaluations related to short period of time and single flood event. The contributions of the authors to this work can be considered equal.

P2-13 Orale Sofia, Giulia

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DRAINAGE NETWORK DETECTION AND QUANTIFICATION OF WATER STORAGE CAPACITY WITHIN DRAINAGE CHANNELS IN ALLUVIAL PLAINS THROUGH LIDAR DERIVED DTMS

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Key terms: LIDAR; Drainage Network; High-resolution DTM; Feature extraction; Agrarian landscape

Drainage networks in agrarian landscape within floodplains constitute man-made surfaces discontinuities, and they are expected to affect hydrological response during flood events. Drainage network recognition and quantification of water storage capacity within drainage channels, becomes therefore crucial for watershed planning and management. These evaluations require accurate spatial information for the area of interest and in most cases, when studying large catchments, broad datasets of ditches locations and descriptions are not available. In order to characterize drainage networks for large areas, the availability of high resolution topography (DTMs) derived by airborne laser scanner (LiDAR) represents a new tool for drainage systems recognition. LiDAR derived DTMs have been proven to be reliable and accurate for hydrological applications in steep mountain landscape in several recent researches (Sofia et al. 2011, Tarolli and Dalla Fontana, 2009), where the topographic information has been considered at different resolution scales. Only a few studies have been conducted to take into account the specific characteristics of agrarian landscapes, and drainage network identification for agrarian/urbanized areas actually represent the next challenge when using high-resolution topography. The accuracy with which a DTM is able to detect and correctly represent the hydrological asset of a catchment is determined by the strength of the landscape gradient (i.e. flatness and/or slope changes). Alluvial plains are therefore more challenging even when high-resolution DTMs are available: for these environments, network extraction through GRID-derived flow-direction matrices is not applicable due to the low relief of the landscapes. The goals of this research were to propose a method able to (1) identify drainage networks in agrarian/floodplain context, and (2) to estimate some of the network summary statistics (i.e. network length, width, drainage density and storage capacity). A morphometric and semi-automatic methodology is proposed, that relies on consideration of having to extract local small-scale, low-relief features (ditches and channels) and to eliminate as far as possible the large-scale landscape forms from the data. The procedure is applied in two typical alluvial plains areas in the North East of Italy, and tested comparing automatically derived network information with field surveyed ones. The results underline the capability of high resolution topography for drainage network extraction and characterization in the context of agrarian landscapes within floodplains, opening at the same time a new challenge to evaluate hydrological processes in these areas.

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P2-14 Orale Mao, Luca

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TOPOGRAPHICAL DIFFERENCES BETWEEN STATIC AND MOBILE ARMOUR LAYERS

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Key terms: laser scanner; laboratory; armouring; gravel-bed rivers

Gravel-bed rivers typically exhibit an armoured surfaces covering a finer subsurface mix of sediments. The coarser surface has implications for hyporheic flow exchange, fish habitats, and bedload transport estimation. The armour is called static when it is created by a flow that selectively entrains only the finer elements from a non-uniform bed material. Static armour is typical in limited sediment-supply systems, and can be created in laboratory exposing a non-uniform mixture to a constant flow rate with no sediment input. Conversely, a mobile armour layer can coexist with the transport of all available grain sizes, including the coarsest, and its development has been explained using the concept of equal mobility of all grain sizes of a heterogeneous gravel bed. Mobile armours have been developed in sediment recirculating flumes, and the bed surface coarsening is mainly caused by a kinematic sorting process.

A series of laboratory flume experiments under conditions of sediment starvation (zero sediment feeding) and recirculation were conducted in order to identify the temporal evolution and surface properties of static and mobile armour layers. The experiments were carried out in an 8m long flume using a bimodal grain-size mixture (D50 = 6.2 mm) and a range of shear stresses ranging from 4.0 to 8.6N m⁻². The results confirm that a static armour layer is coarser than a mobile one, and that the grain size of a mobile armour layer is rather insensitive to changes in the imposed flow strength.

An analysis of laser scan bed surveys revealed the highly structured and imbricated nature of the static armour layer. Under these conditions the vertical roughness length scale of the bed diminished and it became

topographically less complex at higher forming discharges. The topography of mobile armour layers created by rising discharges differed. They exhibited a greater roughness length scale and were less organized, despite the fact that the grain size of the surface material maintained an approximately constant value during recirculation. Also, the mobile armour tended to create larger cluster structures than static armour layers when formed by higher discharges. These differences were mainly due to the transport of the coarser fraction of bed sediments, which diminished to zero over the static armour because of being hidden within the bed, whereas in the mobile armour the coarser particles protruded into the flow and were actively transported, increasing the vertical roughness length scale. Overall, the results show that an examination of the grain size characteristics of armour layers cannot be used to infer sediment mobility and bed roughness. Detailed elevation models of exposed surfaces of gravel-bed rivers are required to provide critical insight on the sediment availability and sedimentation processes.

P2-15 Poster Godone, Danilo

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ACCURACY EVALUATION IN DIGITAL TERRAIN MODELS INTERPOLATION

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Key terms: Laser Scanner; Classification Analysis and Regression Tree; Validation; GIS

Digital terrain models are key tools in land analysis and management as they are directly employable in GIS systems and other specific applications like hydraulic modeling, geotechnical analyses, road planning...

The diffusion of survey methodologies, like Laser Scanner, giving as a result a point cloud describing survey's target has highlighted the importance of interpolation techniques in order to reconstruct the surveyed object.

In the present study different algorithms, stochastic and geostatistic, will be analyzed in order to spot an optimal interpolation methodology, and particularly: Inverse Distance Weighing, Kriging, Spline and Natural Neighbors. The tested estimators are those usually available in GIS environment like ESRI ArcMap. Computations will be carried out on point clouds obtained either by airborne or by terrestrial, Laser Scanners. Two first data set will be investigated: survey carried out by helicopter-borne sensor for hydraulic modeling purposes and a terrestrial survey performed in order to analyze a mountain slope morphology and its proneness to avalanches.

According to the terrain characteristics the whole dataset will be subdivided into thematic datasets representing different land covers, e.g. a riverbed and its banks, an urban area, an hillside... Datasets will be split into two subsets in order to perform interpolation techniques with a percentage of the entire set of data and then, with the remaining data, to evaluate the interpolation accuracy.

Moreover, a statistic analysis will be carried out, by classification techniques, with the purpose of highlighting critical input data that influences, in the interpolation phase, the quality reduction of the final output. The residuals obtained from the evaluation procedure, from differences between the "test dataset" and the interpolated surfaces will be analyzed in comparison with different morphological variables that may influence the interpolation. The employed analysis methodology is the Classification Analysis and Regression Tree, a robust technique, which allows multiple testing on independent variables and give their importance as functions of dependent variable fluctuations (Breiman et al., 1984; Kittler and Devijver, 1982; Urban, 2002). The final result is a tree diagrams that splits every independent variable according to a split value that defines its range of influence on the dependent one.

Variables, computed in GIS environment by surface and raster analysis are the intensity of reflected beams, pulse density per square meters, terrain slope, curvature and morphological complexity - expressed as elevation's standard deviation computed from a 3x3 moving window (Gloersen et al., 2004).

The analysis, carried out on a helicopter-borne survey, has highlighted, among the tested interpolators, the Inverse Distance Weighing as the best one, with the lower residuals. The CART test performed on the same dataset has drawn the attention to the beam intensity and to the morphological complexity as the main factors affecting interpolation accuracy and thus, causing highest residual values.

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P2-16 Poster Pirotti, Francesco

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DENOISING METHODS TO IMPROVE LIDAR-DERIVED HIGH RESOLUTION DIGITAL TERRAIN MODELS

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Key terms: LiDAR; Denoise; Low pass filter; Topography

High resolution digital terrain models (DTMs) created from interpolation of 3D point clouds from airborne laser scanners can suffer from "noise" attributable to different causes. Noise is usually defined as a random error (white noise), thus with no bias (zero mean) and finite standard deviation. In this presentation we assume a broader sense for noise, including any other causes whose effect is the deviation from a correct representation of the ground surface. It is known that DTMs which are derived from filtered and interpolated laser scanning data have low geo-morphological quality (Kraus and Pfeifer, 2001), with spurious pits in valleys which decrease the

quality of hydrological analysis. LiDAR surveys with high pulse frequencies (used to obtain high point densities) sometimes do not have an homogenous distribution of the point density, thus resulting in lower quality interpolation.

In the following presentation a comparison is carried out of methods which increase the geo-morphological quality of DTMs in mountainous areas. Results show that post-processing with a despeckling method which uses the best orientation of normals (Sun et al., 2007; Stevenson et al., 2010) has the significant characteristic of preserving significant features while virtually eliminating most of the noise. The study compares also the effect of threshold over the method, concluding that a threshold of 0.4 gives best results for obtaining high-resolution DTMs with high geo-morphological quality in mountainous areas. This study can be helpful to document how to process DTMs which have a lower quality due to noise factors.

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P2-17 Poster Angelini, Maria Giuseppa

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PRODUCTION OF CHECKED DTM BY TERRESTRIAL LASER SCANNER (TLS)

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Key terms: Digital Elevation Model; Laser scanner; Gridded data; Numerical algorithm

Has been implemented a procedure of calculation and experimentation addressed to the extraction of DTM and validated elevation values with a distribution pseudo regular by TLS data.

The calculation procedure was developed in MATLAB environment and is able to generate digital terrain models, through two-dimensional functions with assigned structure, from data collected using laser scanning supplemented with data collected by topographical techniques and GPS. The third dimension (height of the points) has been calculated by least squares estimation from some points with surveyed height topographically. Has been made, at first, a field test on which were conducted survey integrated methodologies. In particular, has been surveyed points at a distance minor of two meters, with classical topographic technique, using a total station of good accuracy. On the same points has been conducted simultaneously a kinematic GPS survey mode. Finally, has been made a TLS survey using a TOF instrument, setting the grid acquisition with range and density maximum which corresponded to a mesh of points equal to a 0.05x0,05 m. The results obtained allowed the assessment of the appropriate procedure and simplified for determination of the DTM using laser technology and the possibility of improve and verify the accuracy attainable of the altitude plane. This led to the definition of the relevant procedure simplified and integrated (depending on the required precision with classical topographical and/or kinematic GPS survey) and a calculation method that allows by the creation of gratings digital terrain models altimetrically compensated from TLS data. In the future will be implemented a software for the morphological characterization procedures that will consider also filtering and classification of laser data in order to apply to any type of surface.

P2-18 Poster Angelini, Maria Giuseppa

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TLS SURVEY OF THE VOLCANIC CRATER SOLFATARA (NA) FOR THE GENERATION OF A DETAILED DTM

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Key terms: terrestrial laser scanning; digital elevation model; Solfatara; vegetation filtering

The mapping of the topography and landforms characterizing a certain portion of the earth surface allows to determine the morphology and the changes of a site. Correlations can be defined between the terrain morphology, its lithological features and the environmental shaping factors. The earth surface, composed by rocks, is continuously modified through the action of natural and anthropic processes. Among them, climatic changes (like frost and thaw, rain and wind), tectonic and volcanic phenomena, and deforestation are the most important factors. The study and analysis of the surface processes occurring in areas affected by particular and dangerous natural phenomena, such as in the volcanic areas, require a reliable knowledge of the geomorphological characteristics of the sites. In this context, Digital Terrain Models (DTMs) play undoubtedly a major role for the understanding of earth surface processes. However these modern digital terrain representations depends strongly on the quality of the topographic data. In the last decade, a range of new remote sensing techniques has led to a dramatic increase in terrain information. Both Terrestrial Laser Scanner (TLS) and Airborne Laser Scanner (ALS), using LiDAR (Light Detection And Ranging) technology, now provide high resolution topographic data with notable advantages over traditional surveying techniques. A valuable characteristic of these technologies is their capability to produce sub-meter resolution Digital Terrain Models (DTMs), and high-quality land cover information (Digital Surface Models, DSMs).

This work describes the generation of a detailed DTM of a volcanic area derived from a TLS survey. The study site, called Solfatara, is a shallow volcanic crater located at Pozzuoli, in the Campi Flegrei volcanic area, near Naples (South Italy). It is an ancient dormant volcano, which since about

2000 years still emits jets of steam with sulphurous fumes. The crater floor is a popular tourist attraction, as it has many fumaroles and high temperature mud pools. The survey was performed using the long-range (max. 2000 m) RIEGL LMS-2620 laser scanner. Measurements were acquired from 4 different positions, two located inside the crater and two located along the north-east side of the ridge, which partly surrounds the Solfatara. The average resolution step was set to 10 cm at 300 m standoff distance from the laser scanner. For each laser station a set of GPS measurements were also collected through a rapid-static survey for the georeferencing of the whole 3D model of the crater in the WGS84 reference frame. Post-processing of GPS data was carried out by using three GPS permanent stations (ACAE, IPPO and SOLO) as fixed stations. Laser data processing was instead performed with RIEGL proprietary software, RiscanPro. Here a two-steps procedure was adopted to obtain a unique 3D model from the single point clouds. Firstly, laser scans have been roughly pre-aligned through the so-called Backsighting orientation and the post-processed GPS data. Then the initial alignment of the point clouds has been refined by means of the Multi Station Adjustment (MSA), a Riegl global registration method based on a variant of the Iterative Closest Point (ICP) algorithm. At the end of this step a Digital Surface Model (DSM) of the Solfatara was obtained with a residual registration error of 1.2 cm (1 σ). Finally, vegetation was filtered out from the DSM through an iterative procedure based on the method developed by Axelsson for the filtering of ALS data. The resulting point cloud was then triangulated and a set of contour lines were extracted with 1m interval.

P2-19 Poster Mussio, Luigi

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A DISCUSSION AROUND LOMBARDY AIR BASINS

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Key terms: Air basins; 3D dynamic scenarios; Topology and symmetry; Integrated geodesy approach; Geomatics and human sciences

Topographical information increased in quality and detail with diffusion of new techniques for data acquisition (laser sensors, performing terrestrial surveys as TLS, or installed on airplanes as LiDAR, maybe equipped with synthetic diaphragm on mobile platforms, as SAR). Using all these technologies, a new generation of digital terrain models was born, with a far more high spatial resolution respect to traditional procedures. Availability of data base gives new perspectives to recognizing morphologies of slides and landscapes: final result would be acquiring a very high detail for 3D information - comparable in accuracy to a direct relief on site. Describing topographical surfaces with very high resolution and accuracy can also improve hydro-morphologic processes analyses: terrain morphologic characteristics have strong impact on hydro-geological and geomorphologic processes, due to erosion and defluxion phenomena. In this context, Lombardy air basins constitute a significant example of 3D dynamic scenario modeling, even if design happened some years ago. Indeed, due to region topography, a cartographic representation of basins would not fit basin description at all. In order to achieve the best possible result, elevation was split in three levels (river canyons, central geographic zones and tops of mountains), fitting different regions and their peculiar characteristics. A global archive provided the base for a small scale digital elevation model (DEM) that required some refining with new information: therefore, a remote sensing image was acquired, geo-referenced and suitably displayed on the DEM. Then, texture mapping of the geo-referenced image on the small scale DEM further improved quality of data base, providing 3D dynamic scenarios of Lombardy air basins displayed in 3D regions. Then, in order to study their dynamic behavior and geographical distribution, an integrated approach to spatial-temporal modelling was applied, performing a treatment mixing deterministic and stochastic methodologies and procedures. Polynomial and spline interpolation were performed, in order to remove general trends and local variations, then collocation method was applied, using covariance estimation, in order to refine phenomena description. There is now a chance to evaluate results, thinking about fundamentals of applied methodologies and procedures. Therefore, a description of general mechanisms for abstraction of 3D reality and its conceptual modelling has to be pointed out. In this case, topology has the strongest part about conceptual model definition. As a consequence, linear approximation was used before performing graph theory algorithms, whilst only a limited case selection was effective in recognizing analogous numbers between topological relations and groups of symmetry. Spatial - temporal modelling follows basically a three-level procedure:

- firstly, low level polynomial interpolation removes the general trend;
- then finite element method catches and matches local variations;
- finally, assuming topography as the realization of a continuous, normal, stationary and isotropic stochastic process, it is possible to apply a filtering technique, based on covariance estimation and collocation method.

Therefore, the three levels can be computed together: indeed, integrated geodesy approach states a simultaneous solution of a unique global single adjustment. Furthermore, an interesting approach comes from taking into account boundary problems regarding linguistics and its contributions to pattern recognition (where geomatics meets human sciences). Indeed, regarding pattern recognition techniques, parsing shows some ambiguities, i.e. different rewriting rules of a grammar or language may be involved in the derivation of strings. Thus, stochastic languages can be used for pattern description, considering formal grammar ambiguity as for natural languages.

P2-20 Poster Lucchesi, Stefania

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APPLICATIONS OF HIGH-RESOLUTION DEMS FOR GEOMORPHOLOGICAL MAPPING AND ANALYSIS OF HIGH-ALTITUDE MOUNTAIN AREAS (AOSTA VALLEY) AND PLAINS (PIEDMONT, ITALY).

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Key terms: Geomorphology; Geomatics; Geomorphological mapping; Quaternary; North-Western Italy

During geomorphological studies conducted in the Aosta Valley and in Piedmont (NW-Italy), high spatial resolution Digital Elevation Models

(DEMs) have been tested as support elements for collecting and analyzing data. In particular, detailed analysis of DEMs have been fundamental for: 1) creating geomorphological hazard maps of high-altitude mountains areas (Aosta Valley), and 2) supporting the reconstruction of Quaternary evolutionary stages of river network in the central Piedmont (Asti and Turin Provinces).

In the first case, geomorphological mapping of high-altitude mountain areas (Gran Paradiso and Gran San Bernardo massifs) has been performed, by integrating photogrammetry and remote sensing. Different kinds of images and digital products have been overlapped and compared in a GIS environment: aerial photographs, digital orthophotos and high-resolution DEMs. Detailed stereoscopic aerial photointerpretation (approximately 1:3000 to 1:5000 in scale) has been coupled with airborne DEM LiDAR analysis (resolution 2m). Integration allowed single landforms individualization; then, comparison with other geo-environmental features allowed genetic interpretation of geomorphological processes (fluvial, glacial, gravitational dynamics, etc.); finally, the interpreted landforms have been used to define the areal distribution of related deposits, in order to estimate extent and distribution of unstable debris and other hazard-prone areas.

Integrated DEM LiDAR methodology demonstrated very useful for geomorphological analysis and mapping, because it allows to:

- describe in details high-altitude, often inaccessible areas;
- identify landforms masked by vegetation or others not easily distinguishable in the field;
- quickly change scale factor of digital images, from overview of the total area to details of a single landform;
- easily map the areal, linear and punctual elements in a GIS system, obtaining detailed cartographic documents associated to geodatabase.

In the second case, the geomatics enhancing in the topographical analysis of the middle River Tanaro basin (Central Piedmont) allowed to collect new elements for the interpretation of Quaternary evolutionary stages of the hydrographic network.

DEM sections derived from orto-photogrammetrical data of the Regional Technical Map have been elaborated into properly-defined altitudinal belts. The process highlighted flat surfaces at equal elevations, scarps and alignments at the top of reliefs, as well as topographic anomalies (slope breaks, isolated reliefs, abrupt changes in the fluvial incisions). Among fluvial landforms it has also been possible to identify those related to the present-day drainage network and those relics of ancient ones, being uplifted and/or deformed. All these elements were recorded, analyzed and then compared with data of different nature, as to reconstruct the ancient drainage network.

In conclusion, besides the already mentioned enhancements of geomorphological results by application of high-resolution DEMs, we emphasize the relative rapidity of their use and the reduced costs of data acquisition. These advantages should not obscure that the lack of a direct comparison requires field verification of the hypotheses arising from the interpretation of digital models; as an example, field data are still essential for interpreting composition of the deposits whose morphological expression have been individualized; moreover, dating elements (alteration rate of sediments, presence of soils, etc.) are needed for chronological reconstructions of evolutionary stages of landforms. As a consequence, from our case-studies, it can be asserted that high-resolution DEMs are important and complementary working tools, and that the indications coming from their analysis is useful for enhancing direct field surveys, optimizing research times and the dedicated resources.

P2-21 Poster De Luca, Alberto

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A LIDAR BASED ANALYSIS OF HYDRAULIC HAZARD MAPPING

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Key terms: LiDAR; topography; hazard mapping

Mapping hydraulic hazard is a ticklish procedure as it involves technical and socio-economic aspects. On the one hand no dangerous areas should be excluded, on the other hand it is important not to exceed, beyond the necessary, with the surface assigned to some use limitations-. The availability of a high resolution topographic survey allows nowadays to face this task with innovative procedures, both in the planning (mapping) and in the map validation phases. The latter is the object of the present work.

It should be stressed that the described procedure is proposed purely as a preliminary analysis based on topography only, and therefore does not intend in any way to replace more sophisticated analysis methods requiring based on hydraulic modelling.

The reference elevation model is a combination of the digital terrain model and the digital building model (DTM+DBM). The option of using the standard surface model (DSM) is not viable, as the DSM represents the vegetation canopy as a solid volume. This has the consequence of unrealistically considering the vegetation as a geometric obstacle to water flow. In some cases the topographic model construction requires the identification and digitization of the principal breaklines, such as river banks, ditches and similar natural or artificial structures.

The geometrical and topological procedure for the validation of the hydraulic hazard maps is made of two steps. In the first step the whole area is subdivided into fluvial segments, with length chosen as a reasonable trade-off between the need to keep the hydrographical unit as complete as possible, and the need to separate sections of the river bed with significantly different morphology. Each of these segments is made of a single elongated polygon, whose shape can be quite complex, especially for meandering river sections, where the flow direction (i.e. the potential energy gradient associated to the talweg) is often inverted.

In the second step the segments are analysed one by one. Therefore, each segment was split into many reaches, so that within any of them the slope of the piezometric line can be approximated to zero. As a consequence, the hydraulic profile (open channel flow) in every reach is assumed horizontal both downslope and on the cross-section. Each reach can be seen as a polygon, delimited laterally by the hazard mapping boundaries and longitudinally by two successive cross sections, usually orthogonal to the talweg line. Simulating the progressive increase of the river stage, with a horizontal piezometric line, allow the definition of the stage-area and stage-volume relationships. Such relationships are obtained exclusively by the geometric information as provided by the high resolution elevation model.

The maximum flooded area resulting from the simulation is finally compared to the potentially floodable area described by the hazard maps, to give a flooding index for every reach. Index values lower than 100% show that the mapped hazard area exceeds the maximum floodable area. Very low index values identify spots where there is a significant incongruity between the hazard map and the topography, and where a specific verification is probably needed. The procedure was successfully used for the validation of many hazard maps across Italy.

P2-22 Poster Mion, Elena

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A SEMI-AUTOMATIC DERIVATION OF CHANNEL NETWORK FROM HIGH-RESOLUTION DTMS: THE EXAMPLE OF AN ITALIAN ALPINE REGION.

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Key terms: hydrographic network; LiDAR; HR-DTM; geomorphometric indexes

High-resolution digital terrain models (HR-DTMs) of regional coverage open interesting scenarios for the analysis of landscape, including derivation and analysis of channel network.

In this study, we present our experience in the derivation of the channel network from a HR-DTM of the Autonomous Province of Trento. This region (about 6200 km²) has a complex orography, with a high variety of lithotypes and different types of land use (forests, bare ground at the highest elevation, rocky outcrops and debris, mountain grasslands and agricultural areas mostly located in valley floors).

A preliminary automatic extraction of the raw channel network was conducted using a curvature-based morphological algorithm (Tarboton and Ames, 2001) applied to a 2 m resolution DTM derived from an airborne LiDAR survey carried out in 2006.

This algorithm shows a good performance in terms of drainage density and channel heads location when preliminarily compared to available cartography.

The raw channel network automatically extracted from the HR-DTM needs a supervised control to check the spatial pattern of the channels and to classify every reach of the hydrographic network.

This analysis was carried out by means of different informative layers grouped into three main classes: i) geomorphometric indexes derived from HR-DTM encompassing 2 m resolution shaded relief map, openness (Yokoyama *et al.*, 2002), local anomalies, and plan curvature; ii) high-resolution orthophoto imagery (panchromatic and near-infrared); iii) technical cartography (1:10000, 1:25000 scale).

The result is an accurate and scale independent channel network definition of the study area that therefore needs to be complemented and corrected via field surveys and expert supervision, especially in urban areas. Summary statistics are presented to relate the drainage density to different topological and geomorphological parameters.

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P2-23 Poster Vianello, Alessandro

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LiDAR AND FIELD SURVEYS FOR CHANNEL NETWORK MORPHOLOGICAL ANALYSIS

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Key terms: channel width; local slope; LiDAR; DTM

The study analyses the variation of headwater channel geometry under bankfull conditions, and the relations between morpho-geometric variables of the channel network in two headwater basins of the Eastern Italian Alps. The two study basins cover areas of 5 and 7 km², and are characterized by a network of ephemeral colluvial incisions; the main alluvial channels are dominated by rapids and step-pool morphologies. Field surveys were carried out on channel heads and on selected colluvial incisions, as well as along the alluvial channels, with the aim to quantify geometric and morphometric parameters. Airborne LiDAR data, with a vertical accuracy of 0.2 m, made it possible to obtain a high resolution DTM (1 m grid size) of the two basins and to derive, through the use of GIS techniques, morphometric indicators suitable for the characterisation of channel morphologies. A comparison between field and DTM derived morphological data permitted to verify their overlapping degree. The research focuses on the relationships between channel width at bankfull stage, local slope and contributing area. The hydrological variables were derived from high resolution DTM. The relationships between the considered variables were investigated both for the whole hydrographic network, and considering separately the various channel bed morphologies (colluvial channels, step-pools and rapid reaches of the main alluvial stream). The relationships have been firstly investigated in the channel reaches surveyed in the field, and then extended to the whole channel network on the basis of field and DTM derived data comparison. The integration of field surveys carried out on the channel network with the analysis of high resolution LiDAR-derived DTMs is a promising approach for improving the knowledge of morphodynamic relationships in mountainous basins. In particular, LiDAR surveys give the possibility of deriving DTMs with grid size close to the width of the narrowest elements of the channel network and smaller than the width of the main alluvial channels, thus opening new prospects for the analysis of slope-area and width-area relations in headwater basins, as well as for the recognition of channel-bed morphologies.

P2-24 Poster Ciulli, Alice

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ANALYSIS OF DEM BY THE UPSLOPE POSITION INDEX (UPI) AND

CORRELATION WITH GEOTHEMATIC DATA FROM SELECTED CATCHMENTS IN TUSCANY (ITALY)

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Key terms: Upslope Position Index; Digital Elevation Model; geothematic data

In this paper we present a topographic index (Upslope Position Index - UPI) as a tool for quantitative analysis of Digital Elevation Model (DEM) and identification of relationships with spatial distribution of geological-geotechnical parameters.

The study areas are selected catchments in Tuscany (Italy) where a DEM with a cell size of 10 m is used as input datum.

We first implement the flow length GIS function in order to calculate the downstream and upstream weighted distances along a flow path from each cell to, respectively, either the valley bottom or the watershed divide. By normalizing the upstream flow length in respect to the flow path, we then obtain the UPI.

The UPI allows us to make spatial comparisons among catchments with both different size and geographic locations. In this study area we obtain "normalized" watershed profiles which highlight different shapes of catchments, as well as sub-catchments pertaining to the same first-order catchment.

Based on the above results we search for correlation among normalized profiles and geological-geotechnical parameters, like substratum-superficial geological units, lithological units, and landslides spatial distribution. We extract these geothematic datasets from the so-called "continuum geologico", the new geothematic cartographic dataset at the scale of 1:10,000 of the Regione Toscana.

Finally, we search for correlation among the above normalised profiles and spot geotechnical data obtained by sampling and analyzing the superficial formations of selected second-order catchments.

P2-25 Poster Calligaris, Chiara

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FIRST STEPS INTO THE LANDSLIDE INVENTORY OF THE KARAKORUM NATIONAL PARK USING A NEW GENERATION OF HIGH QUALITY DTM

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Key terms: landslide; DTM; GIS

The northeastern part of Pakistan is known to be a region of extremes, where the highest reliefs of the world are and where the geology can be considered young from an orogeny point of view. In this environment, a big multidisciplinary project, named SEED (Social, Economic and Environmental Development in the CKNP Region Project), is taken by Ev-K2-CNR project. SEED is made by several different projects, each one focused on a different theme (e.g. glaciology, meteorology, land cover) that permit to characterize, from different points of view, the new Central Karakorum National Park. One of it is focused on a better knowledge of the territory through the analysis of the hazardous areas, important instrument for a future rational planning. The geostatic evidences, better known as landslides, will be firstly identified using a new generation of high quality DTM (Digital Terrain Model) at a spatial resolution better than the one obtained through traditional techniques. These high quality data permit to individuate different slope morphologies and to recognize possible geostatic phenomena. The methodology will permit to identify the geostatic phenomena that will be secondarily identified on the field, only in sample areas in order to validate the tool. This permit to create the first, upgradable in real time, landslide inventory for the area of the Central Karakorum National Park.

P2-26 Poster Lancianese, Valerio

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ENVIRONMENTAL GEOCHEMISTRY MAPS OF TUSCAN- EMILIAN APENNINES: DEVELOPMENT OF A MODEL BASED ON CATCHMENT BASIN.

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Key terms: geochemistry MAPS; stream sediment sampling; catchment basin; landscape patch; open source GIS applications

The environmental geochemical mapping is a valid tool for land monitoring. The knowledge of the distribution, diffusion and concentration of chemical elements provides important information about economic and/or environmental problems concerning agriculture, discovery of mineral resources and their exploitation, waste disposal, water supply, irrigation, animal health, soil utilization, epidemiological surveys, industrial pollution. Geochemical maps regarding the distribution of chemical elements, background values and anomalous signature are produced by means of statistic methods (i. e. Multifractal IDW, Kriging) that sometimes can lead to significant inaccuracies because of data are obtained by irregular sampling grid. The construction of a geochemical mapping therefore requires new criteria in the sampling site selection. Regarding the sampling of Tuscan-Emilian Apennines, this analysis employs catchment basin extraction of landscape patches using open source GIS applications. The best sampling is represented by stream sediment and may be performed on rivers into each catchment basin. A background geochemical map integrated with catchment basin map allows both an immediate interpretation of geochemical data and a more certain estimation of the elements concentration regarding the areas for which sampling data were not available. In this way the distribution of chemical elements depends on soil, geological and physical characteristics of the patches. This study compares deterministic approaches to probabilistic analysis, showing the higher reliability of the first methodology in order to produce maps based on more certain techniques.

SESSIONE Q3

Cambiamenti climatici ed evoluzione delle spiagge (dalle regioni artiche a quelle subtropicali)

Q3-1 Orale Martini, I. Peter

10.1474/Epitome.04.0939.Geoitalia2011

QUATERNARY ARCTIC COASTAL LANDSCAPE, SEDIMENTS AND LANDUSE OF FOXE BASIN, CANADA - HIGHLIGHTS

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Key terms: *Foxe Basin; Arctic coasts; Periglacial features; Landuse*

Foxe Basin is a downfaulted Arctic basin in northeastern Canada floored by Paleozoic carbonates and mostly surrounded by crystalline Precambrian terrains. During the Pleistocene the area was covered by a thick glacier dome, and then inundated by an early sea as the glacier melted. Exposed Quaternary deposits record the events of the last glaciation and subsequent sea cover and the emergence. The deposits consist of a surficial veneer of glacial drift and frost-shattered clasts, locally reworked by sea waves during isostatic emergence (approximately 70 cm/century at present). This paper deals mainly with three major types of coasts of Foxe Basin: (1) 'Low hilly coasts' developed on metamorphic/igneous terrains: they are jagged, steep and rocky, with pebbly pocket beaches and some bouldery ice-push ridges in coves; (2) 'Lowland gravelly coasts' formed over a carbonate substrate, characterized by well developed beach ridges; and (3) 'Lowland muddy coasts' developed on relatively wide low-energy carbonate platforms (coastal plains) and/or in sheltered tidal embayments. Although strong storms develop during ice-free times, the shallow mesotidal sea is covered by ice for 10 months of the year and this ensures that the overall energy of the coasts is low. Cold climate processes active since postglacial emersion of the land have led to frost heaving of bedrock blocks, solifluction lobes on slopes, frost boils in sedimentary deposits of flatter areas, frost shattering and solution of surficial carbonate pebbles, and formation of shallow soils best developed in the top 1 m thick 'active layer' above the permafrost table. Foxe Basin is a remote region. Its coastal areas are used as breeding grounds by numerous species of migratory birds. A very large colony of migratory geese exists in the southeastern coastal Koukdjuak Plain (Dewey Soper Migratory Bird Sanctuary). Caribou herds and other land mammals visit the mainland coasts each year. The sea, particularly to the northwest, is very productive, including fish and migratory sea mammals. Because of this, the coasts have been inhabited by Inuit since antiquity. Two small permanent Inuit villages (Hall Beach and Igloolik) are now thriving with people still following some of the old customs, but increasingly becoming accustomed to modern facilities such as communications, transport, hunting tools, foodstuff, health care, education and work practices. An incipient tourist industry is emerging as well. The people there are very protective of the environment and this has led recently to a moratorium for hunting-tourism to avoid depletion of the decreasing sea-mammal stocks. Similarly, concerns have been expressed about the proposed shipping of iron ore from a Baffin mine through a nearby inlet because the use of freighters may affect the floating ice used by sea mammals, hence interfere with their population that is vital for the Inuit sustenance-hunting.

Q3-2 Orale Zanchetta, Giovanni

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RELATIVE SEA LEVEL CHANGES DURING THE HOLOCENE IN THE ATLANTIC PATAGONIAN COAST: NEW DATA

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Key terms: *relative sea level; Holocene; Patagonia; Radiocarbon dating*

Despite the Atlantic coast of south America has supplied a significant number of information for the variation of the relative sea level during the Holocene, the Patagonian coast was considered an area with data not particularly accurate (e.g. Milne et al., 2005). Recently, Schellmann and Radtke (e.g. 2010) have significantly reduced this gap of knowledge, but the accuracy of the data proposed is strongly affected by the difficulties to use depositional sea level markers in an area characterised by stormy and macrotidal conditions. In the last two years, careful field work on selected coastal areas between Cabo Raso and Puerto Deseado has improved the reconstruction of the relative sea level for this area, but has also highlighted the main limits of the current sea level markers used for the area (e.g. Ribolini et al., 2011). Indeed, new data seem to suggest that, locally, Middle Holocene highstand was ca 2-3 m above high tide level, lower than previously reported (Ribolini et al., 2011; Zanchetta et al., 2011a). Therefore, it is not still clear if there are significant differences on sea level curve in different sector of coastal Patagonia, or a comparable pattern exist. It is worth of note that the updated radiocarbon age dataset for the area points to a discontinuous depositional records, claiming for strong erosion phases affecting the coast and/or a short relative sea level low stand between ca 5000 and 4000 yr BP (e.g. Zanchetta et al., 2011ab).

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Q3-3 Orale Longhitano, Sergio

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THE BOSCO PANTANO DI POLICORO BEACH (BASILICATA, SOUTHERN ITALY): AN EXAMPLE OF A SYSTEM QUICKLY ADAPTED TO THE PRESENT-DAY SEA LEVEL RISE

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Key terms: *Coastal systems; sea-level changes; Basilicata; anthropogenic activities*

Coastal systems are very sensitive in recording quick sea-level changes and many are the ancient analogues that recorded such important variations in their depositional architectures or facies tracts. The present-day sea-level rise is seriously damaging shorelines in many coastal areas of the world, generally producing severe problems of beach erosion, destruction of coastal environments and consequent shoreline retreating.

The Bosco Pantano di Policoro represents the southernmost segment of a wider shoreline facing the Ionian Sea in Basilicata, southern Italy. The Ionian coastline is a microtidal, wave-dominated 40 km long shoreline, which was intensely characterized by anthropogenic activities and a heavy touristic development during the last 30 years. The studied coastal segment represents an exception along this human-influenced coastline, because the total absence of social activities and the presence of primary coastal environments. Such a rare circumstance allowed us to evaluate the 'natural' response of a coastal system to the pressure induced from the recent sea level rise.

The results of the ProviDune Euro-project carried out along the Bosco Pantano di Policoro beach document a strong coastal retreating during in the last 15 years, that has recently increased through the back-stepped migration of the foreshore which has replaced the backshore facies developed during the previous stage of shore accretion.

This important change has been revealed by specific sedimentary facies occurring in the back area of a natural/artificial dunefield. These facies consist of sparse accumulations of detrital matter admixed to coarse-grained sediments deriving from the suspended load of repeated storm waves.

This process is producing substantial modifications in the dynamic equilibrium of the studied beach system which can be considered as a good case study to observe how a beach system does react to the effects of a rapid sea-level rise.

Q3-4 Orale Sanna, Laura

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SEDIMENTS WITHIN CUEVA C3 GYPSUM CAVE (SORBAS, SE SPAIN)

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Key terms: *Cave sediment; Gypsum karst; Palaeoclimate; Palaeoenvironment; Cueva C3 (Sorbas, Spain)*

The arid zone of Sorbas (Almería, SE Spain) is one of the most important evaporitic karsts of the world. Karst develops in Messinian gypsum plateau that comprises continuous strata of very pure selenite overlying upper Tortonian marl units and covered by Mio-Pliocene-Quaternary siliciclastic sands and conglomerates.

In the last decades the well-exposed sedimentary strata of the Neogene intramontane basin of Sorbas have been exhaustively studied from genetic and chronologic points of view on the basis of their stratigraphic position in the overall formation. Most researches have focused on the recent alluvial fan conglomerate and braided fluvial systems deposits and have tried to define the palaeoenvironments associated with changes in the base level of the basin over the past 200k years.

However, no research has taken into account the Quaternary sediments deposited within the caves of Sorbas and their palaeoclimate implications. These clastic sediments consist of fluvio-karstic deposits, dominated by a poorly organized fluvial system possibly related to intense rainfall patterns extremely different from today's. In many cases they have been covered by subsequent carbonate flowstones.

The detailed analysis of this kind of karstic infill may allow to define, with high resolution, the sedimentary phases that occurred within underground galleries of the Sorbas karst. The mechanisms leading to the deposition of detrital materials within the cavities are strictly dependent on climatic processes. However, each type of sediment should be considered individually, because associated with a single different phase. For better understanding the no linear palaeoclimatic behaviour, field works, lab experiments, petrographic, isotopic and radiometric analyses are indispensable. They permit to determine the specific constraints controlling sedimentation in different environments.

With the aim to provide a past climate record referred to the present one, the clastic sediments of the gypsum caves of Sorbas have been examined. Samples were taken from various sedimentary environments in different stratigraphic positions. The preliminary results involve a sampling of three different levels of medium-fine sandy materials, alternate with pebbles-bearing debris flow lens and pelitic levels, in the Cueva C3 cave, a part of the Covadura karst system. After a first speleogenetic stage that led at the cave conduits formation, the sediments were carried into the system in fluvial conditions, filling entirely the cave passages, as testified by sediments stucked on the wall and ceiling of the cave. During a further phase, these deposits were partially eroded due to the lowering of the water table. Future OSL analysis will give rise to the chronology of these

previous humid periods and will allow the reconstruction of the palaeoenvironment conditions occurred before the establishment of the current arid climate condition.

Q3-5 Orale Vacchi, Matteo

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FUTURE SEA LEVEL RISE AS POTENTIAL THREAT FOR THE MEDITERRANEAN POSIDONIA OCEANICA MEADOWS. CONSIDERATIONS FROM THE HYDRODYNAMIC POINT OF VIEW.

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Key terms: Posidonia oceanica; sea level rise; Mediterranean sea; morphodynamic profile; Brunn role

In the face of a global rise in sea level, understanding the response of the nearshore zone to changes in sea level is a critical scientific goal. Seagrasses represent key ecosystem influencing the nearshore zone in many seas all over the world and their loss results both from direct human impacts and natural causes. Among the latter, effects of climate change represent a crucial topic. The possible effects of a changing global climate on natural and agricultural terrestrial plant communities have already received attention. On the contrary, relatively little importance has been given to the possible effects of global climate change on aquatic plant ecosystems, including seagrasses. The characteristics of sea level rise include both elevation in the mean level of the ocean surface and increase in the tidal variation around that mean. The consequent effects on available light, local hydrodynamics, current velocities, depth, and salinity distribution, are all factors that control the distribution and development of seagrasses. Therefore, sea level rise has important implications for seagrass populations and the habitats they create.

Aim of this contribution is to consider if the future sea level changes could represent a major threat for the Posidonia oceanica meadows, the most important seagrass of the Mediterranean sea. Starting point of these considerations is represented by some recent studies which individuated significant hydrodynamic influence of both upper (landward) and lower (seaward) limits of the P. oceanica meadows. In particular, upper limit of the meadow is controlled by the breaking depth (i.e. the depth where the wave breaks whereas the lower limit is controlled both by near shore zone extent and light availability).

Several data from tectonic and non-tectonic areas are consistent with a global eustatic near stability of the Mediterranean Sea during the last 6000 years, challenging the assertions recently proposed by isostatic modellers of a significant additional melting of the Antarctic ice sheet after 6000 years BP. However recent studies, based on satellite and tidal gauge data, reported a mean sea level rise of approximately 7 mm/year in the Mediterranean Sea. Its spatial distribution is not uniform and, for instance, while the Levantine basin is rising at a rate of 25-30 mm/year, the Ionian Sea is falling by 15-20 mm/year.

In tectonically stable areas, elevation of the mean sea level will cause a landward shifting of the shoreline and so an adaptation of the hydrodynamic zones along the beach profile. This will modify the location of the meadows limits until reaching a new hydrodynamic equilibrium. In this study the P. oceanica meadows response in relation to hydrodynamic characteristics variations due to the sea level rise was analyzed. In particular three Liguria beaches with different morphodynamic conditions (dissipative, intermediate, reflective profiles) were studied.

Obtained results showed a different response to sea level rise in relation to beach morphodynamic characteristics most of all on the meadow higher limit that is more affected by the new hydrodynamic conditions.

Q3-6 Orale Cantalamessa, Gino

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MONITORING OF THE LITTORAL STRETCH BETWEEN THE HARBOR OF GIULIANOVA AND TRONTO RIVER (NORTHERN ABRUZZO REGION).

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Key terms: littoral monitoring; Gavrilovic model; river sediment transport; sedimentological and morphological analysis; northern Abruzzo

Italy is the European country with the longest shoreline; approximately 40% of it presently is under erosion because of the reduced contribution of fluvial sediments caused by extraction of gravels from river beds, construction of dams and hydraulic works, stabilization of hillslopes, widespread cementification, abandonment of agriculture, destruction of coastal dunes etc.

In many physiographic units, the progradational trend of shores, which since the end of the Roman Empire has been remarkable and brought to the creation of extended coastal plains, starting from the end of the XIX century reversed, generating permanent alarm for many activities and facilities which have been built up there.

Surveying and analysis of historical, cartographic, geomorphologic and geologic data have been carried out along the coast stretching between the Tronto river and the harbor of Giulianova (ca. 15 km long) in order to improve knowledge of the marine dynamic and to highlight anthropic and natural modifications which happened during the last century.

In this physiographic unit, limited marine trasgressions took place from the beginning of the XX century due to the end of the small glacial era. This, in addition to the above-mentioned causes, assumed particularly severe rates at the Tronto river mouth (the biggest sediment tank of the area, estimated in over 1'000'000 cubic m and since a long time absolutely exhausted); there, in fact, from the half of XIX century up to today the retreat has been evaluated to be about 600 m.

At the north end of the area, at the the southern side of the Tronto river mouth a long groin has been build around 1930, stretching in the sea for hundreds of metres thus blocking the (few) sediments within the physiographic unit. To the south, the harbor of Giulianova with its long breakwaters, whose construction began in 1913, prevents the natural sediment feeding coming from Tordino river (once more reduced, due to excavation along the river bed and hydraulic protection works). The potential sedimentary contributions useful for the nourishment of the shores, coming from the inner torrents of the unit (Salinello and Vibrata) have been quantified using the Gavrilovic's model, suited for torrential

river basins. They turned out to be approximately 50.000 cubic m per year, while the esteem of the sediment losses toward the sea and caused by wind has been evaluated to be more than 70.000 cubic m per year. The average annual deficit therefore exceeds 20'000 cubic m of sediments. Neglecting local effects due to the building of cross-sectional and longitudinal structures for the control of waves, this shortage of debris has produced in the first stretch of the shore (Alba Adriatica, still lacking artificial protection works) a recession of about 90 m in the 1970-2004 timespan. Taking into consideration the protection works to the north too (cross-sectional and longitudinal breakwaters), the recession is exceeds 100 m.

Sedimentologic and morphologic analyses carried out on several transects uniformly distributed along the whole physiographic unit evidenced that the stretches in erosion are characterized by larger average grain size of the beach sediments, steeper slopes and deeper sea bottom. On both sides of the protection works, finer debris and remarkable advances of the shoreline have been recorded, in contrast with huge recessions at distances ranging from a few hundred metres and about 1 Km. These latter testify both the remarkable influence of artificial barriers on the sediment circulation along the shore and a typical bidirectionality of waves in this area.

Q3-7 Orale Cantalamessa, Gino

10.1474/Epitome.04.0945.Geoitalia2011

EVOLUTIONARY ANALYSIS OF THE MARCHE COAST BETWEEN THE CONERO MOUNT AND THE TRONTO RIVER MOUTH FROM THE ROMAN AGE UNTIL TODAY

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Key terms: littoral evolution; DSAS; spatial analysis of shoreline; southern Marche; evolution of coastal defense work

An analysis of the southern portion of the Marche coast has been carried out taking into account both natural and anthropic effect intervening from the Roman Age until today.

The study area, stretching between the harbor of Numana and the Tronto River mouth, faces the central Adriatic Sea and has a length of ca. 74 km. It is characterized by gravelly-sandy beaches, fading without breaks into alluvial plains; locally, narrow beaches are backed by fossil wave cut cliffs running in parallel with the present shoreline. The Sirocco (from SE) is the prevailing wave direction, while the Bora (from NE) and the Levant (from E) play a secondary even though relevant role in the evolution of the shoreline.

The study took advantage of modern techniques of acquisition, treatment and elaboration of data and aimed to quantitatively estimate the mobility of the shoreline. It has been based on the finding, co-georeferencing and analysis of maps, both raster and vectorial, surveyed during a long timespan. Using ESRI ArcGis 9.2 software, different cartographic bases have been imported and co-georeferenced in order to digitise rivers and shorelines. Processing carried out using techniques of spatial analysis, allowed to evaluate changes in shoreline position for each time interval (1835-1874, 1874-1894, 1894-1944/45, 1944/45-1953/55, 1953/55-1978, 1978-1984, 1984-1988, 1988-2000, 2000-2006). Variations and relative rates (meters/year) of the shoreline for each time interval have been calculated following regularly spaced (100 m) transects perpendicular to the shoreline.

Basing on the results of the above analyses, a study has been carried out to determine the climatic, natural and anthropic factors which have influenced the evolution of the area.

The decrease of river solid load is considered the primary cause of the regressions of Italian beaches together with the building of coastal defence works. Data reveal that the shoreline in the Roman age was much more inland than today (1200 m at the Tronto mouth, 700 m at the Tesino mouth, 650 meters at the Chienti mouth and 300 metres at the Potenza mouth); successively, from the Middle Age to the XIX century, various factors generated an increase of the river solid load which allowed the development and the advancement (up to some hundred metres) of the shoreline. In this period, evolved the deltas of the biggest Marche rivers. The first regressions started at the end of the XIX century along fluvial mouths and then in the nearby shores. After the Second World War, an enormous urban development of the coastal areas and of related infrastructures brought to widespread extraction of debris from river beds that has been paralleled by a dramatic decrease of the river solid load which induced severe regression of shorelines.

The request of wider beaches due to the increase of touristic demands induced local administrations to start to build coastal defence works. Therefore, during the last fifty years the evolution to the Marche coast has been essentially regulated by many different anthropic works lacking planning and forecasts of local alteration of coastal dynamics. Erosive phenomena concentrated downstream to the structures while huge advancements affected the upstream side; above all, anyhow, it has been underlined that lacks of sediment balance generated by protection works have been generally solved building up other structures, with a domino effect that brought to a nearly uninterrupted line of defence artifacts along the whole investigated coast.

Q3-8 Orale Corradi, Nicola

10.1474/Epitome.04.0946.Geoitalia2011

LIGURIA POCKET BEACHES: BONASSOLA CASE STUDY (LA SPEZIA, ITALY)

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Key terms: Pocket Beach; Morphodynamics; Sedimentology; Liguria

Physiographic features of Liguria coasts are mostly ascribed to Neogene - Quaternary geodynamic processes impacting on Liguria and North-Tyrrhenian margins, that substantially determined the region's geologic and geomorphologic evolution. 2/3 of the coast length (around 320 km) are in fact made of cliffs with jutting headlands, broken up by variously sized beaches. Therefore, apart from a few interdeltic beaches (Roja, Centa, Entella Magra), most Liguria beaches are pocket beaches, even if they can be very different, and their size must be interrelated more to structural influences than to progradational sedimentation

processes.

Liguria pocket beaches can be divided into two main categories:
 ° small pocket beaches, often with a high embayment rate, nourished by rocky cliffs instability, mainly composed of gravel sediments;
 ° beaches nourished by rivers, whose drainage basins may vary in relevance and slope, and whose size depends on the seafloor of small coastal plains. In this case, sediments are a mixture of gravel and sand, according to sediment loads characteristics and to wave motion exposure. Bonassola beach (SP), in its homonym bay, lies to the West of the Cinque Terre Park, in an area worldily renowned for its nature and its landscape. The beach is located between two headlands, Punta Levante (to the East) and Punta della Madonna (to the West), marking off the small stride, around 410 m wide, with no defense works around it. The beach, as well as the small plain of the Bonassola village, is nourished by S. Giorgio and Rossola streams, draining basins which are respectively 3.3 and 1.7 km² wide. At the beginning of 1960s it was fundamentally made of pebbly sediments. With time, the beach underwent obvious changes in its size as well as in its grain size characteristics. This was a consequence of the pouring of material coming from tunnel excavations for the laying of a second track (during the 1960s). Wave motion exposure conditions suggest that sediment transport processes on emerged beach and mobile seafloor are more forceful cross-shore. Seafloors are mainly made of sand; in the rocky parts of the headlands there are small meadows of *Posidonia Oceanica*. According to the analysis of aerial photographs provided by Liguria Region (1973, 1983, 1993, 2003) and to the regional geodatabase "SICoast", the beach is relatively stable, characterized by little advance and in particular by shoreline rotation. In 2006, after erosion had taken place (1999, 2000), the Bonassola municipality carried out a nourishment including about 13,000 m³ of local quarry material. Following this operation, single and multi-beam bathymetric surveys were carried out (2007, 2009, 2010), together with a campaign for seafloor samples collection which aimed at highlighting seafloor evolution trends. The first results show that, on the whole, seafloors remained substantially stable. Bathymetric data chiefly underline the accretion of a longitudinal bar, at a depth between 6 and 7 meters, and the effects on the seafloor of rip currents triggered by the predominant cross-shore transport.

Q3-9 Orale Schiaffino, Chiara Francesca

10.1474/Epitome.04.0947.Geoitalia2011

BEACH NOURISHMENT ON MIXED SAND AND GRAVEL BEACHES USING BIMODAL STREAM SEDIMENTS. THE CASE OF OSPEDALETTI (LIGURIA, MEDITERRANEAN SEA).

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Key terms: mixed beach; beach nourishment; stream sediment; bimodal sediment; Liguria

Nowadays erosive phenomena are one of the most important problems affecting beach areas due both to natural causes like storm events or sea level rise, and anthropic causes as indiscriminate exploitation of beaches. One of the methods put to use to curb this tendency and to defend coastal environment is nourishment. During the last decades replenishment has become the most common practice for beach maintenance due to its low environmental impact. In fact, in comparison with other methods, it produces faster results, it allows to maintain or increase beach width for storm protection, it is carried out without disturbing recreational activities and it is less expensive than structural defences.

Beach nourishment projects involve the placement of predefined quantities of fill material (sand or gravel) into the nearshore system. Clearly the fill material modifies the beach profile causing a perturbation in the natural shore system and the as-built beach profile is equilibrated throughout its natural dispersion and diffusion both in cross-shore and longshore directions. There is a correlation between as-built profiles and fill grain size. Coarse sediments create a strong beach steepness, thus obtaining a greater increase of the nourished area for equivalent volume of discharged material and therefore a drier beach per cubic metre of placed fill. Finer sediments move across-shore more than coarser ones, therefore offshore loss increases as size decreases.

In this study the performance of a recharge scheme using overbank stream sediment (bimodal mixed sediment) was analysed together with its efficacy on the creation of cross-shore morphodynamic equilibrium for the beach profile.

The study area is Ospedaletti Beach, located in the western Liguria region. The beach is 250 m long. This is a typical mixed sand and gravel beach: in fact it is characterized by gravel on submerged and emerged beach until the breaking zone and by medium and fine sand on the submerged beach beyond the breaking zone. During the nourishment carried out in 2008-2009, 65000 m³ of overbank stream sediment coming from the Argentina stream were filled. The borrow sediment was made up of almost 80% of gravel and 20 % of sand, with mean grain size varying between a

minimum of 0.5 ϕ for the sand fraction and a maximum of -5 ϕ for gravel. The nourishment analysis was performed comparing pre- and post-recharge beach behaviour from a morpho-sedimentologic point of view.

In Dean and Van der Meer profiles, calculated for the finest and coarsest fractions of the grain size curve, it is highlighted that while the coarsest fraction stays on the dry beach, the finest fraction is dispersed on the submerged zone beyond the breaking zone maintaining the distinctive slope break noticed here before the nourishment. Survey data confirm the creation of a slope break on the cross-shore profile.

In the present study it can be noticed that the use of bimodal stream sediments leads to the creation of two different slope break of beach cross-shore profile, related to the two main grain sizes of the fill sediment. Up until the breaking zone, the beach is made up of gravel sediments, and its intermediate morphodynamic profile (0.93), even if leading to plunging breaks, is able to counter and absorb wave energy within a short distance, due to increased clast size. On the other hand, beach nourishment on the submerged beach part between breaking zone and closing depth was performed with sand fraction, thus improving its morphodynamic profile. Therefore, the use of bimodal sediments essentially allowed the recreation of a morphodynamic profile similar to the pre-existing profile before beach nourishment.

Q3-10 Orale Pascucci, Vincenzo

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HOW STRONG IS THE HUMAN IMPACT ON MODERN BEACHES? COMPARISON WITH LAST INTERGLACIAL AND MODERN BEACHES

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Key terms: Beaches; Late Quaternary; MIS5; Climate Change; Human impact

Most of the modern beaches present around the Mediterranean Sea are suffering severe erosion. Main causes are indeed the strong human pressure on them and their high exploitation during touristic season. However, some natural effects cannot be ruled out and in some cases these can accelerate (or slow down) the human induced processes. Climate changes are seen as the principal trigger of coastal erosion, although the high urbanisation of Mediterranean coasts can amplify a lot this natural phenomenon.

It is widely accepted that the Holocene is an interglacial time and that since 6 ka years sea level did not changed much. However, it is not clear if we are at the apex of an interglacial high stand or if we are moving toward higher sea levels.

According to the record of the last 400 ka, after a glacial time sea level rises continuously without major still stands. Once the sea water has reached a maximum high, it stands for about 10 ka before to fall toward a relative low stand.

The last interglacial (MIS 5, 130-75 ka) may be considered the best analogue to be compared with the present one. Several studies have indicated that it could be split in five intervals (a, b, c, d, e) where a-c-e are the relative sea-level highs and b-d the lows. A general agreement exists considering that during MIS5e sea level was at about 5-6 meters above the present and that Mediterranean climate was about 5 °C warmer and tropical fauna developed in this warm sea. Less agreement occurs, instead, on the sea-level high during MIS5c and MIS5a. Recently, studies on MIS5 have been conducted in Sardinia. This because the island has been and can, thus, provide valuable information about sea-level variation in relation to climatic changes of the late Quaternary. Systematic studies conducted in north-west Sardinia on late Quaternary deposits have indicated that during MIS5c sea level was at about 1 m above the present and climate comparable to the present one. The objective of this presentation is to compare the main features of the MIS5c beaches with modern equivalents to unravel the question: how strong is the human impact on modern beaches.

MIS5c beaches were mainly sandy with a well developed coastal dune system in their backshore. In few places mixed sandy-gravelly beaches have been found as well. Sand is composed of siliciclastic and bioclastic grains. These last are normally up 40% of the grain population. Bioclastic grains derived from organisms living in the *Posidonia oceanica* seagrass meadows, well developed just few meters offshore. Similar modern beaches composed by 60 to 90 % bioclastic grains occur in protected areas where human influence is negligible (Maddalena and Asinara National Parks). They show an equilibrium profile and are not interested by erosive processes. On the contrary most of other heavily used (mainly for tourism) beaches of north-west Sardinia, such as Alghero, Stintino and Palatamona, suffer considerable erosion. Most of them are slanted for artificial nourishment to be able to sustain touristic activities.

This example indicates that uncontrolled, intense human activity leads to deterioration of the coastal environment. The obliteration of the coastal dunes, for example, that are the temporary storage of sand during storms, disrupts the natural cycle of the natural re-nourishment of the beach during fair-weather conditions. Beside depleting of the quality of the environments and of the natural vegetation and fauna, this will entail a considerable increase in expenditures to maintain the setting acceptable for the activity intended.

SESSIONE R1

[+D12] Geologia marina, ambiente fisico e habitat naturali: nuove prospettive emerse dal progetto CARG

R1-1 Orale Fiorentino, Andrea

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FORESEEING THE GEOLOGICAL CARTOGRAPHY OF SUBMERGED AREAS FROM THE EXPERIENCE OF THE CARG PROJECT

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Key terms: geological map; marine geology; geodatabase

Geological cartography of submerged areas so far produced within the CARG Project has allowed to establish direct connections between marine and land deposits. Criteria of representation evolved from basic texture of sediments to different categories of deposits subdivided according to their depositional environment and in the frame of unconformity bounded stratigraphic units, applying sequence stratigraphy methods.

The great diversity of geo-morphological settings of Italian Seas requested to take into account several parameters in order to be able to represent every attribute of each environment. All features have subsequently been represented according to standards homogeneous over the entire national territory.

The characteristics of the areas surveyed vary from a high rate of sedimentation to starvation, from carbonate sedimentation to volcanic deposits, from tectonically active shelves to lagoons. Such variety highlighted specific aspects of the seafloor which entangle other issues as the reconstruction of past climatic cycles, changes of coastline, assessment of risk levels in submerged areas, identification of areas of environmental interest, spread of pollution, marine resources. It has become clear that a multidisciplinary approach is needed in carrying on any kind of research in marine environments. The Geological Map of Italy (including submerged areas) could profitably be integrated with other data. The geodatabase, which constitutes a fundamental achievement of its realization, may well work as the connecting tool to interface with different disciplines.

In the future it might be desirable that, while planning a survey for any specific task, every aspects would be taken into account in order to collect in one shot all relevant data. This would lead to a better understanding of the environments surveyed and to a more detailed characterization of the issues to be studied, since there are no parameters which are not

connected to others. Sediment texture does not depend only on geological and morphological factors, but also relies on the biogenic component produced by organisms; biocoenoses do not depend only on temperature and nutrients, but also on the geological composition of the substrate; physical parameters are also influenced by living assemblages.

R1-2 Orale Putignano, Maria Luisa

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GEOLOGICAL SURVEY OF THE PERI-COASTAL SEA-BOTTOM IN CAMPANIA REGION (SOUTHERN ITALY) AT 1:10,000 SCALE: METHODOLOGICAL APPROACH, RESULTS AND FUTURE PERSPECTIVES

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Key terms: Campania Region; Cartography; sea level change

The Campania Region has participated in the National Project CARG confirming its institutional and financial presence with the aim of improve the geological knowledge in the region.

In particular, the CARG project of the Campania Region aims to make available a new national geological mapping at scale 1:50,000 and 1:25,000. At the same time, this project provides to local and regional communities a series of maps at 1:10,000 scale, produced following the CARG criteria specific for coastal areas. For this reason, the Campania Region has fully funded the implementation of geological mapping of the emerged and submarine coastal zones.

The regional CARG project has planned the geological survey of the submarine areas, from the coastline down to -200 m depth; the geological surveys have been carried out at 1:10,000 scale in order to make a significant contribution to knowledge, so allowing to define the evolutionary trends, which are very useful for the planning and managing processes of the coastal zones.

The selected scale corresponds to that required by ISPRA for the emerged landscape.

Three specific geological environments have been analysed:

- 1) the emerged area;
- 2) the submarine coastal zone (from 0 down to -30 m depth);
- 3) the marine zone (from -30 m down to -200 m depth),

and the results were summarized in a single final map. Of particular importance as well as innovative was the underwater geological survey of the submarine coastal zone (from 0 down to -30 m depth). The peri-coastal sea-bottoms were investigated at scale of 1:10,000 through underwater surveys with scuba diving techniques, by geologists with proven expertise in underwater CARG Project. These surveys have enabled the production of thematic and basic geological maps which were produced using the same standard criteria established for the maps of the contiguous emerged areas.

The cartography of the submerged coastal zone obtained by direct observations (divers) was also based on other types of geophysical seabed investigations (Multibeam, Side Scan Sonar, Sub-Bottom Profiler). These geophysical surveys are an useful support for the complete mapping of the outcropping geological units as well as for the spatial distribution and depiction of the geomorphological and biocenotic aspects.

The reconstruction of the seabed physiography through precise bathymetric surveys highlighted the geomorphological elements (i.e., erosion and deposition marine terraces, paleo-cliffs, etc.) which represent indicators of ancient sea-level stands and changes. At the same time, dives have identified further evidences of paleo sea-levels (i.e., sea-notches, sea caves, small abrasion platforms, bands of littoral deposits, beachrocks, etc.) which, because of their small size, can not be identified with geophysical methods, particularly when they are located along steep underwater cliffs or buried by limited marine vegetation covers.

The results have been reported in official maps at 1:25,000 scale according to the ISPRA standards, after a suitable generalization for the adopted reference scale, while are widely expressed in the regional geological maps at 1:10,000 scale. In particular, all the islands of the Gulf of Naples (islands of Ischia, Procida and Capri, and Isle of Vivara), characterized by numerous witnesses due to sea level changes, show a rather complex evolutionary scenario especially during the Quaternary.

R1-3 Orale Polizzi, Sabrina

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SEDIMENTARY DYNAMICS OF THE MARETTIMO CONTINENTAL SHELF AND MARETTIMO CHANNEL (EGADI ISLANDS - WESTERN MEDITERRANEAN): ANALYSIS OF DEPOSITIONAL AND EROSIONAL FEATURES.

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Key terms: Sedimentary dynamics; Marine geomorphology; Marine bedforms; Egadi Islands

Sedimentary dynamics of the Marettimo continental shelf and Marettimo Channel (Egadi Island - Western Mediterranean), have been unveiled based on the erosive and depositional features observed at the seafloor. Different morphologic features were recognized through side scan sonar, multibeam and high-resolution seismics, acquired in the framework of national Research Projects (CARG, GebecSud, MaGIC) carried out by the Department of Earth and Marine Science (former Department of Geology and Geodesy) of the University of Palermo. Sediment samples have been also collected and analyzed.

The Egadi Islands are part of the NW Sicilian offshore, and belong to the mountain chain that connects the Sicilian chain to the Maghrebides one. The Marettimo Island represents an isolated portion of the Egadi continental shelf and is separated from the rest of the archipelago by the Marettimo Channel.

Previous studies allowed to recognize different kind of sedimentary

structures along the seafloor. Lo Iacono and Guillén (2008) described extensive field of subaqueous dunes (Ashley, 1990) along the Marettimo inner shelf, forming on gravelly and pebbly sediments and related to strong storm events (H:5.5 m, T: 12 s). Larger dunes have been observed in the north-western sector of the inner shelf with wavelengths ranging from 1 to 2.5 m, heights between 15 cm and 30 cm and extending laterally for hundreds of meters. Moreover in the north-eastern sector of the inner shelf, sorted bedforms have been detected at a depth of 40 m: they are characterized by a width varying between 15 m and 50 m and a length that reaches hundreds of meters.

In the south-eastern sector of the Marettimo outer shelf, Colantoni et al. (1993) map two groups of sedimentary structures. In the same area, Lo Iacono (2004) recognized two-dimensional and three-dimensional subaqueous dunes. 2D dunes are found at depths between 60 and 90 m and show a wavelength variable between 15 and 50 m. 3D dunes, which are found at a depth of 80 m, are characterized by a wavelength of 30 m and a lateral extent of 50 m.

Morphological evidences of a strong hydrodynamic regime come also from the morphobathymetric analysis of the Marettimo Channel, that is a 24 km long submarine valley oriented NNW-SSE, with a depth ranging from a minimum of 180 m to a maximum of 370 m and a width from 2 km to 14 km. Inside the channel, south of its narrowest point, a 180 m deep bathymetric threshold separates two areas, which deepens towards opposite directions: north-west and south. The flanks of the sector that deepens towards the NW are affected by mass-wasting features (Lo Iacono et al., 2007). The western flank of the channel, which delimits the Marettimo continental shelf, is carved by gullies, making the shelf-edge very uneven. Gullies develop to a maximum depth of 280 m and have a length of 250 m and a width of 50 m. At the bottom of the channel a linear incision 20 m deep, 400 m wide and almost 3 km long, is probably generated by erosive bottom currents.

On the whole, the morpho-sedimentary structures here described reveal a strong hydrodynamic regime. The morphological and textural features of the bedforms observed on the Marettimo inner continental shelf suggest the occurrence of sporadic medium to strong storm events coming from western sectors. The morphological characteristics of the Marettimo Channel reveal the occurrence of strong bottom currents probably related to the severe interchange of water masses between the Tyrrhenian Sea and the Sicily Channel.

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R1-4 Orale Violante, Crescenzo

10.1474/Epitome.04.0952.Geoitalia2011

MARINE LANDSCAPES AND HABITATS OFF THE CAMPANIA REGION (EASTERN TYRRHENIAN SEA)

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Key terms: Marine Landscape; Habitat; Campania; Geodiversity; Geosite

Marine landscapes off Campania region are dominated by geologically young structures and by sedimentary processes. This mid-latitude sea area is composed of three main basins namely Voltorno Bay, Naples Bay and Salerno Bay and by a number of minor basins. It develops along the eastern margin of the Tyrrhenian sea across the boundary between the Apennine chain and the Tyrrhenian extensional area where Quaternary tectonics deeply controlled the physiographic setting. Sedimentary processes related to dynamics of Voltorno and Sele rivers contributed to shape the seascape off the Voltorno and Sele plains respectively. In the Naples Bay the occurrence of some of the most active volcanoes, namely Phlegrean Fields and Somma-Vesuvius, significantly influenced marine and coastal habitats and landscapes.

The Marine Landscape concept aims to describe the marine environment with respect to its main geophysical features, in terms of both the seabed and water column. It focuses also on the formation and consequences of spatial heterogeneity and dynamics in natural and human dominated environments and how spatial pattern controls ecological processes. Moreover, the strong ecological relationship between the physical environment and the character of biological communities allows the use of Marine Landscapes as surrogates for marine communities.

Whilst the habitat mapping approach is most suited to detailed (fine-scale) classification of the seabed, marine landscapes allow classification of the marine environment at an ecological relevant scale. The two approaches are hierarchical related to each other even if many habitat types can occur in several landscape types.

Currently the Marine Landscape concept is applied for management purposes both in Europe and USA. The general deterioration of the marine environment have resulted in the wide recognition that an ecosystem based approach to the management of marine environment is necessary for promoting a future sustainable development. There are various initiatives and legal requirements, such as the implementation of EU directives (EC Habitats Directive, EU Water Framework Directive, EU INSPIRE Directive and the EU Marine Strategy Directive), the identification of marine protected areas (MPAs) and the assessment of the ecological coherence and representativity of existing MPA networks, e.g. the Natura 2000, that endorse the current needs for broad-scale information. In particular the Regione Campania (Southern Italy) has issued "Standards and strategic directions for the protection, management and development of the regional geodiversity and places of special geological interest (GEOSITES)". Such legislation apply to marine environment with the identification of submerged geosites and recognizes the need to protect the various geologic and physiographic attributes as important entities shaping marine landscapes.

Based on such regional directive we started to classify seabed off the Campania Region using available bathymetric, backscatter and sedimentologic data that allowed to identify topography and bedform features. The interpretative process led to a first individuation of submerged Geosites occurring on the continental shelf area.

R1-5 Orale Innangi, Sara

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APPLICATION OF ACOUSTIC METHODS FOR MARINE HABITAT MAPPING AND CLASSIFICATION IN THE MARATEA COAST (BASILICATA, ITALY)

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Key terms: Multibeam; Backscatter; Acoustic facies; GIS; Habitat mapping

Habitat mapping and classification is recognised as a central topic in the definition of the quality of marine environment in the framework of the EU Marine Strategy. Acoustic methods for seafloor mapping have been widely developed over the last decades. In particular, the development of swath bathymetry has enabled the creation of detailed maps of seabed topography and acoustic backscatter data; these data have been used to predict sediment and habitat types.

The Institute for Coastal Marine Environment (Istituto per l'Ambiente Marino Costiero - IAMC) of CNR of Naples carried out a multidisciplinary study focused on the construction of subsurface sedimentological and bionomic maps along the Maratea coast (Basilicata region, south Tyrrhenian sea) which represent the raw data for the definition of marine protect area. For this purpose acoustic swath bathymetric data were collected, together with sediment sampling and direct scuba investigation on benthic communities.

In September 2007 the whole margin of the Basilicata Tyrrhenian coast was mapped using the Multibeam Seabat 8125 which, thus producing very high resolution digital terrain models. Furthermore backscatter data by Multibeam were acquired in order to distinguish the different habitat types based on their acoustic response. The backscatter is based on the acoustic signal detected by the Multibeam's receivers, and it works as the receivers of standard sidescan sonar by recording the acoustic response of the seabed, in relation to the morphology, composition and fine scale roughness of the beds. The main difference between standard sidescan and the "multibeam backscatter" is that the first may be brought to the towing vessel to the wanted depth, while the "multibeam backscatter" is mounted to the pole and its resolution decreases with increasing depth. Nevertheless the high-resolution data of acoustic swath mapping with Seabat 8125 allowed creating a 20 cm per pixel backscatter mosaic until to ~50 m depth. Furthermore the differences between the acoustic signals derived from different facies, in terms of pixel intensity of the sidescan image, have been tested using statistical methods.

The boundaries of the recognized acoustic facies were subsequently digitalized with software GIS Geomedia Professional to obtain a first habitat mapping. On the basis of acoustic facies recognized, forty-five sediment samples along the coast (~10 to ~30 meters) were collected by grab Van Veen and analyzed for sediment grain size. Ground truth data were also collected with scuba diving investigation in order to attribute the different acoustic facies to a specific habitat. Finally bionomic and sedimentological maps were obtained and used to characterize the marine environment of Maratea coast.

R1-6 Poster Romeo, Roberto

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DEEP-WATER CORAL COMMUNITIES IN THE OTRANTO CHANNEL REVEALED BY ACOUSTIC METHODS AND GRAVITY CORES DURING A 2011 R/V OGS EXPLORA SURVEY.

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Key terms: Deep-water corals; Otranto Channel; acoustic methods; gravity cores

Deep-water coral communities were imaged and sampled in the Otranto Channel (southern Adriatic Sea) during the BIOS submarine fibre optic cable system survey performed by the R/V OGS Explora in February 2011. The presence of coral bodies have been observed by both Side Scan Sonar and Sub-bottom profiler on the top part of carbonate mounds and confirmed by corings.

The evidence of these coral colonies were previously supposed by geophysical analysis of a vintage MS multichannel seismic line and a more recent high resolution acoustic dataset (Sub-bottom profiler and Multibeam echosounder) by Geletti (2008) and Del Ben et al. (2008). This discovery of "white coral" communities adds to findings made in surrounding areas on the Apulian Plateau in the Ionian Sea (Tursi et al., 2004; Taviani et al., 2005a; Fusi et al., 2006; Taviani, 2008) and on the Gondola Slide, Bari Canyon, Jabuka Trough in the Adriatic (Zupanovic, 1969; Bombace e Frogliola, 1972; Trincardi et al., 2007; Freiwald et al., 2009).

Acknowledgements

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SESSIONE R2

Movimenti verticali della costa e variazioni del livello del mare

R2-1 Orale Anzidei, Marco

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SEA LEVEL CHANGES AND VERTICAL MOVEMENTS OF THE LAND IN THE MEDITERRANEAN

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Key terms: Mediterranean; sea level; archeology; geodesy; geophysics

Coastal settlements and maritime installations built in antiquity along the coasts of the Mediterranean sea provide important insights into relative sea-level changes and vertical motion of the land during past millennia.

We present and discuss field data from more than 150 sites of valid coastal archaeological sites dated back to 1.6-2.5 ka BP. Particular attention was given to the elevation of the significant architectural features related with the sea level and we introduced the concept of "functional elevation". Field measurements were performed by invar rod, optical or electronic methods, during calm sea with null wave action. Elevations are related to the sea-level position at that moment. Data accuracy with their uncertainties for age and elevation at each site, are estimated on the basis of the type of indicator used and of the historical literature, based on the artifacts or on the architectural features. Observations of geomorphological indicators, such as beachrocks and solution notches, are used to integrate and reinforce the archaeological interpretations as in Antonioli et al. (2007).

The analysis was performed during four different steps: 1) the elevation of the valid sites were measured with respect to the sea level at the time of surveys; 2) measurements were reduced to mean sea level of the site itself, applying tidal corrections at the surveyed sites, using the data of the nearby tide gauges (www.idromare.it; www.pmsl.ac.uk). 3) finally, we examined the predicted and observed sea levels, by comparing the current elevations of the markers with the sea-level elevation predicted by the proposed glacio-hydro-isostatic model for each location. We hypothesize tectonic stability at the sites where the elevations of the markers are in agreement with the predicted sea-level curve. Conversely, we hypothesize that the area has experienced tectonic or volcanic subsidence or uplift when the elevations of the markers are below or above that of the predicted sea-level curve, respectively. We use the calibrated model results to separate out the tectonic contribution, widely diffused in the Mediterranean, from the vertical movements related to the glacio-hydro-isostatic changes. Our analysis are consistent with model predictions as well as trends inferred from seismic strain analysis of earthquakes occurred during the last 30-40 years and tide gauge data for the last ~100 yr. This indicates that besides the glacio-hydro-isostatic effect, also the tectonic contribution can affect the relative sea level changes along the coastlines of the Mediterranean, since the last ~2.5 ka.

R2-2 Orale Biolchi, Sara

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NEW DATA ON LATE HOLOCENE RELATIVE SEA LEVEL CHANGE IN SOUTHERN MALTA

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Key terms: Sea level change; geoarchaeology; Malta

Until now, few archaeological or geomorphological data have been considered to evaluate late Holocene sea level changes along the Maltese coast, although both the geomorphological evolution and the development of coastal settlements could provide useful information on the active tectonics.

We aim at providing new data on coastal archaeological remains collected along the southern coast of Malta and at discussing the relative late Holocene sea level changes.

Malta lies in the Sicily Channel, about 200 km south of the convergent segment of the Europe-Africa plate boundary. The Sicily Channel has been

affected, during Neogene-Quaternary, by continental rifting which produced extensive structures, controlled by NW-directed sub-vertical normal faults. The Maltese graben system is characterized by two intersecting fault trends.

The studied sites are located on lower Miocene limestones, belonging to the Globigerina Limestone Formation. We studied three archaeological structures, the first at St. George's Bay, at Birzebugia, the second at Marsaxlokk and the latter next to Manoel Island, at the Valletta Harbour. The Birzebugia archaeological site provides remains of activities related to the coastal zone, during the Bronze Age. It provides two types of archaeological remains. The first type are Bronze Age pits (3500-2900 BP), located close to the shoreline on a Globigerina Limestone platform, which are partially submerged. They were dated using pottery discovered in an archaeological site close to the coast. The altitude of the lowest pits is -0.9 m and it represents the upper limit of sea level in the studied period, considering that they had to stay surely always above the sea. The altitude of the lowest pit is -0.9 m. The second type are prehistoric cart tracks, completely submerged.

At Marsaxlokk two Roman age piers have been found out and measured: they are slightly inclined off-shore, are about 12 m long and their top ranges from -0.6 and -0.9 m m.s.l. The bottom of the sea is at about -1.15 m. Considering the functionality of the structure, they could be used as very small docking structures.

At Manoel Island, submerged tanks, maybe Roman in age have been surveyed: their altitude ranges between -1.20 m at the bottom and -0.7 m at the top of the walls. They could be used to produce garum or purpura.

On the island, archeological structures directly carved on rocky outcrops are very common, because of their high rock erodibility. The soft Globigerina Limestones outcrop along the Southern and Eastern sector of the island. Archeological remains have been surveyed just along these coasts. Anyway, observations carried out along the Maltese coast recorded the presence of a number of nineteenth-century (Victorian-age) swimming pools, usually architecturally well-defined. Their position and their relative bad conservation can easily cause misunderstandings, inasmuch as they can be confused with coastal archaeological remains.

Considering the submerged tanks at Manoel Island, despite their complex attribution, concerning both the age and the function, they seem to suggest that sea level was some tens of centimeters lower than the structure, that is about -1.0 m lower than nowadays. Even Roman age piers at Marsaxlokk seem to indicate the same relative sea level change. On the contrary, the altitude of the lowest Bronze Age pit represents the upper limit of sea level in the studied period, considering that they had to stay surely always above the sea.

No presence of MIS 5.5 deposits have been surveyed due to the exposition of the island, that prevents the conservation of rocks and deposits, or to the slightly submerged position of the Tyrrhenian deposits which deleted them.

Even if, at the moment, few data are available and better interpretations are required, the comparison of surveyed data and Lambeck predicted curve, slight late-Holocene vertical displacement seem to be occurred.

R2-3 Orale Lo Presti, Valeria

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SPATIAL EXTENT OF RECENT VERTICAL TECTONIC MOTIONS MISURED IN NE SICILY COASTAL AREA. INSIGHTS FROM MARINE GEOLOGY AND COASTAL GEOMORPHOLOGY STUDIES.

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Key terms: Coastal geomorphology; Tectonic uplift; North-eastern Sicily; Marine geology

Vertical position of sea-level, pointed out by related deposits and morphologies, provide useful markers to estimate tectonic uplift rates. For the Holocene very high uplift rates are measured in the northeast Sicily coast (Antonoli et al., 2009). This study compare vertical tectonic movements and marine geology data in the coastal sector between Capo d'Orlando and Brolo (NE Sicily); tectonic lineaments show different trends both onland (Nigro & Sulli, 1995) and offshore (Nicolich et al., 1982) and also the morphological response follow closely this difference. The geomorphologic survey provided data on Holocene uplift rates. We studied an archaeological ancient quarry of grinding wheels for oil that has been found in the Capo d'Orlando inshore (Scicchitano et al., 2011). They present semi submerged circular holes in Stilo-Capo d'Orlando deposits (Carbone et al., 1998). The tectonic uplift was evaluated as the difference between the observed local paleo-sea level position and the predicted sea-level curve for the same locality (Lambeck et al., 2011). The resulting uplift rates is 0.36 mm/yr (Scicchitano et al., 2011). In this area we studied also the Brolo stack. It is a metamorphic rocks emerging at 450 m from the coastline. The study led to discovery a fossils-bearing conglomerate in protected trays at 3.5 m a.s.l.. Radiocarbon analysis on a gastropod, gave us an age of 4965 years \pm 70 cal BP. If we compare this data with the predicted local sea level curves (Lambeck et al., 2011), we obtain an uplift rate about 1.5 mm/yr (Lo Presti et al., 2010), which is higher than that calculated in the study of archaeological rest. A detailed study of Brolo sector show us different morphological coastline position of Brolo plain. A picture of the year 1847 shows the coastline about 200 m landward. In Brolo coastal plain we have also found a Spondylus at -6 m b.s.l. We wait for the radiocarbon dating which allows us to have a new uplift rate data.

The analysis of marine geology data (Multibeam) evidenced structures connected to different faults systems, such as the submarine canyons that are the continuation of river beds. Multibeam data evidenced also tilted NE-ward submerged surfaces, indicating existing structural movements, interesting only restricted areas. So, very different uplift rates in the Holocene in very close areas distant only about 10 kilometers: both 0.36 mm/yr (Scicchitano et al. 2011) and 1.5 mm/yr (Lo Presti et al. 2010), and morphobathymetric data (tilted surfaces), evidence the important role of active tectonic lineaments. Seismic reflection profiles support this assumption, showing the metamorphic basement strongly dissected by high-angle faults, which at place determines the occurrence of emergent rock bodies (e.g. the Brolo stack). All this suggesting the occurrence of "restricted regions" in the coastal-marine sector with different geological behavior as response to prominent tectonic releasing bands, determining their horizontal and vertical movements.

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R2-4 Orale Anzidei, Marco

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RELATIVE SEA LEVEL CHANGES ALONG THE MEDITERRANEAN COASTS FROM ARCHAEOLOGICAL MARKERS

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Key terms: Mediterranean; sea level; archaeology

Coastal settlements and maritime installations built in antiquity provide important insights into sea-level changes during past millennia, and reconstructions of historical sea-level change using archaeological coastal sites are particularly effective in the Mediterranean sea, whose coastlines still preserve remnants of human activity since the last glacial maximum. The first pioneering results on sea level changes from archaeological indicators in the Mediterranean were published during the '70s, but new and more detailed results arise for the Mediterranean during the last decade.

Unfortunately, despite the large number of archaeological remains in the Mediterranean, only a part of them can be used to obtain reliable information on their former relationship to sea level. Limitations arise as a result of their uncertain use, poor preservation, or because they were built in geologically unstable areas which produce local disturbances. Particularly valuable are the roman age coastal sites. Fish tanks, piers and harbors constructions, generally dated between the 1st century BC and the 1st century AD, are very precise indicators. Quarries carved along the coastlines and located nearby fish tanks and harbors or villas of similar age, can provide additional data on past water level, as well as information on their elevation above sea level, although these alone are less precise indicators.

In this work we indicate the guidelines on how the coastal archaeological sites can be used to measure the intervening relative sea level changes since their construction. Particular attention was given to the elevation of the significant architectural features related with the sea level. We defined the "functional elevation" as the elevation of specific architectural parts of an archaeological structure with respect to the local mean sea level at that location and at the time of its construction. It depends on the type of structure, its use and the local tide amplitudes. The minimum elevation of particular structures above the local highest tides can also be defined. Finally, structures from different ages can provide a relative sea level curve for that specific site.

SESSIONE R3

Il progetto IODP (Integrated Ocean Drilling Program) e l'esplorazione degli oceani: contributi italiani alla ricostruzione della storia e della struttura del sistema Terra

R3-1 Orale Erba, Elisabetta

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IODP-ITALIA: PRESENT AND FUTURE.

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Key terms: IODP; Italian participation; state of the art; perspective

Italian Earth scientists have been involved in DSDP, ODP and IODP, writing proposals, participating as co-chiefs, shipboard and shorebased scientists, serving in the science advisory structure, (co)organizing and participating to conferences, workshops and summer schools. Italy also hosts one of the International Micropaleontological Reference Centers in Parma, where DSDP, ODP and IODP material has been used for research and training.

The talk is intended as an update of the financial and organizational situation of IODP-Italia as well as a report of IODP-related activities organized and/or performed by Italian researchers during FY 2010 and FY2011.

Information about possible post-2011 scenarios will be presented in order to increase interests of the Italian Earth Science community and consciousness about the role that individual researchers can play.

R3-2 Invitato Tartarotti, Paola

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ON-AXIS VS OFF-AXIS ACCRETION OF SUPERFAST SPREAD CRUST IN THE PACIFIC OCEAN (EAST PACIFIC RISE, 6°44.2' N)

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Key terms: oceanic crust; crustal accretion; fast spreading ridge; Pacific Ocean; lava flow

Crustal accretion at mid-ocean ridges occurs by a combination of magmatic and tectonic processes. Along fast and superfast-spreading ridges magmatic activity is the dominant process. Fast spread ocean crust is believed to be less variable than crust formed at slower spreading rates and closer to the ideal "Penrose" pseudostratigraphy developed from ophiolites (Anonymous, 1972). For this reason, ocean crust created at superfast East Pacific Rise was selected by Integrated Ocean Drilling Program with the main purpose of sampling a complete in situ section of ocean crust far from transform faults. IODP Hole 1256 (6°44N, 91°56W) lies in 3635 m of water in the Guatemala Basin on Cocos plate crust formed ca. 15 my ago on the eastern flank of the East Pacific Rise. Three IODP Expeditions (ODP Leg 206, IODP Exp. 309 and 312) have been devoted to drill Hole 1256D, and in these days (April-June 2011) a fourth cruise, IODP Expedition 335, is in progress for deepening the hole. The uppermost crust at Site 1256 comprises a ca. 100 m thick sequence of lava dominated by a single massive lava flow up to 75 m thick. The lavas immediately below include sheet and mas-sive flows, along with minor pillow flows. The extrusive section occurs down to 1004 mbsf before a lithologic transition marked by subvertical intrusive contacts and mineralized breccias. Below 1061 mbsf, subvertical intrusive contacts are numerous, indicating the beginning of a ca. 350 m thick sheeted dike complex dominated by massive basalts. The contact with underlying gabbros at 1407 mbsf is not sharp but characterized by cm-sized gabbroic and trondhjemite intrusions within recrystallized granoblastic dikes, marking the top of the plutonic complex. Two major bodies of gabbro were penetrated beneath this contact, with the 52 m thick upper gabbro separated from the 24 m thick lower gabbro by a 24 m screen of granoblastic dikes. The stratigraphy of the superfast spread ocean crust at IODP Site 1256 differs from that of other drilled fast and intermediate spread crust (e.g., ODP Hole 504B) for the relatively thin sheeted dike complex and occurrence of a thick lava flow (lava field) on the top. The lava field is of probable off-axis origin, although it may have originated at the ridge axis before flowing onto the ridge flanks, as is observed for very large lava flows on the modern ocean floor. However, structural investigations on cores and thin sections, integrated by geophysical log data confirm the inference of an off-axis origin for the lava field. It is much less fractured than the deeper lavas and shows higher values of electrical resistivity and compressional wave velocity. The frequent occurrence of channelized lava flows in fast spreading ridges have been documented by high-resolution side-scan sonar surveys. Spreading rate is an important parameter controlling crustal accretion. In fast spreading ridges, however, volcanic material is not only added at centrally located ridge axis, but it is also delivered off-axis. The resulting stratigraphy is thus affected by accretion modality referable to both on-axis and off-axis settings.

R3-3 Invitato Bottini, Cinzia

10.1474/Epitome.04.0961.Geoitalia2011

CO₂ REGULATION BY VOLCANISM AND WEATHERING DURING THE EARLY APTIAN OCEANIC ANOXIC EVENT 1ABOTTINI Cinzia¹, COHEN S. Anthony², ERBA Elisabetta¹, JENKYN S. C. Hugh³, COE L. Angela²¹ - Dipartimento di Scienze della Terra "Ardito Desio", Università degli Studi di Milano, Italia² - Department of Earth Sciences, The Open University, Milton Keynes, UK³ - Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, UK

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Key terms: Oceanic Anoxic Event 1a; Osmium isotope; Volcanism; Weathering

In the early Aptian, the ocean experienced a global phenomenon of widespread deposition of organic carbon-rich sediments under oxygen-poor conditions: the Oceanic Anoxic Event 1a (OAE 1a or Selli Event: ~120 Ma). Triggering mechanisms for OAE 1a are thought to be an exceptional episode of submarine volcanism, namely the emplacement of the Ontong Java Plateau (OJP), associated with global warming and enhanced primary productivity. Osmium- isotope ratios are used as a high-resolution geochemical proxy because they potentially offer information on the timing, duration and proportion of globally significant volcanic/hydrothermal activity versus continental weathering. Here, we consider new Os-isotope and Carbon stable-isotope analyses produced from two sections: DSDP Site 463 (Mid-Pacific Mountains, situated relatively close to the Ontong-Java province at the time of its emplacement; and the Cison core (Southern Alps, N. Italy) that accumulated in the margins of the Tethyan Ocean. Both sections are well dated through bio-, magneto-, chemo-, and cyclostratigraphy, providing high-resolution time control and correlation; moreover, micropaleontological and geochemical proxies contribute to the characterization of the OAE 1a.

Variations in the 187Os/188Os ratios are suggestive of both massive magmatic pulses and accelerated continental weathering. The Ontong Java emplacement started before and then persisted very intensely for most of OAE 1a (as conventionally defined). The dominant feature is a ~880 kyr-long unradiogenic Os-isotope interval, requiring a large contribution from a mantle source, and implying a homogenous Os-isotope composition of seawater. A short-lived (~100 kyrs) radiogenic Os-isotope spike has been detected in the early phase of OAE 1a. These high-resolution records also show how volcanism and the associated marine anoxia were related to changes in marine biota that took place before and during the interval of global anoxia.

R3-4 Orale Soldan, Dario Marcello

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PHYLOGENETIC RELATIONSHIPS IGORINA AND EVOLUTIONARY HISTORY OF THE PALEOGENE GENUS IGORINA THROUGH PARSIMONY ANALYSISSOLDAN Dario Marcello¹, PETRIZZO Maria Rose¹, PREMOLI SILVA Isabella¹, CAU Andrea²¹ - Dipartimento di Scienze della Terra "A. Desio", Università degli Studi di Milano² - Museo Geologico "Giovanni Capellini", Bologna

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Key terms: Planktic foraminifera; Paleogene; Biostratigraphy; Phylogeny; Ocean Drilling Program

The evolution of planktonic foraminifera in the Paleocene-Eocene time interval is characterized by a high rate of diversification after the major extinction event observed at the Cretaceous/Paleogene boundary. The accelerated speciation rate resulted in the appearance of several new genera (i.e., Igorina and Acarinina among others) each of them identified on the basis of distinctive wall texture of the shell. Phylogenetic relationships within many genera are still poor understood including the origin and phylogeny of the genus Igorina. This group, characterized by a thick, nonpinose and incrustated wall, appears in Subzone P3a (early late Paleocene) and disappears in Zone E9 (middle Eocene). To date, nine species have been assigned to the genus Igorina (I. pusilla, I. trichotrocha, I. tadjikistanensis, I. convexa, I. albeari, I. laevigata, I. lodoensis, I. broedermanni and I. anapetes) based on both wall texture and morphologic similarities.

This study is aimed to reconstruct the phylogeny and evolution of the igorinid species with cladistic analysis by applying the method of parsimony. To perform the study, two hundred samples have been analysed from Ocean Drilling Program (ODP) Leg 198 Hole 1209B (Shatsky Rise, Central Pacific Ocean), Leg 143 Hole 865B (Allison Guyot, Central Pacific Ocean), Leg 15 Sites 151 and 152 (Caribbean Sea) and Leg 113 Hole 690B. The biostratigraphic analysis of sub-tropical localities revealed some problems in applying the previous biostratigraphic scheme (Berggren and Pearson, 2005) mainly because some marker species 1) have been misinterpreted and/or misidentified several times in previous studies, 2) show a delayed appearance with respect to what reported from other localities, and 3) are very rare or absent in the studied samples. Species identification was mainly performed through comparison with the original descriptions and illustrations and partially follows Subbotina (1953), Blow (1979), Olsson and others (1999), Pearson and others (2006). Phylogenetic relationships of the species assigned to Igorina are determined through stratocladistic analysis by using a data matrix of 23 taxa (including key species of Acarinina), 31 morphological characters (unordered), and a stratigraphic character (ordered) mapping the first occurrence of the taxa under investigation. The morphological characters included in this analysis are based on morphometric measurements such as the angle of chambers, maximum diameter of the inner whorls, angle of peripheral margin, among others.

Some morphotypes of uncertain taxonomic identification but showing consistent morphological and wall texture features have been coded and analysed separately as morphotypes A, B, C, D, E and F to determine their ancestor-descendant relationships and evaluate their validity as discrete species. The software PAUP* (Swofford 2002) has been used to process the data and to obtain a numerical matrix with codified the selected characters, then the matrix has been processed using the heuristic search option to discover the most parsimonious trees.

Results suggest that Igorina pusilla is the first representatives of the Igorina lineage and is subsequently followed by I. laevigata, I. albeari, and I. tadjikistanensis in agreement with their stratigraphic distribution. Morphotypes (C, E, F) have been included in Igorina parapsiralis (Soldan and others, 2011) while Igorina morphotype A represents a single species (Igorina praecarinata Soldan and others, 2011). Morphotypes B and D fall in the variability of well-know species. Moreover, the analysis provides evidence that I. lodoensis, I. broedermanni and I. anapetes are more closely related to genus Acarinina than Igorina and clearly belong to a different lineage. A preliminary analysis of the wall texture architectures of the broedermanni group has been performed to assess their ancestor-descendant relationships and to evaluate the possibility to place them in a discrete new genus.

R3-5 Orale Bordiga, Manuela

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CARBONATE PRESERVATION AND PRIMARY PRODUCTIVITY INFERRED BY CALCAREOUS NANNOFOSSILS: AN EXAMPLE FROM THE MIDDLE-LATE PLEISTOCENE SEDIMENTS OF THE NORTH WEST PACIFIC OCEAN (ODP198-1209B, SHATSKY RISE)BORDIGA Manuela¹, LUPI Claudia¹, COBIANCHI Miriam¹¹ - Pavia University, Department of Earth Sciences and Environment

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Key terms: Calcareous nannofossil; Primary productivity; Preservation; Middle-Late Pleistocene; ODP198-1209B

Calcareous nannoplankton is one of the major producers of pelagic carbonates and contributes significantly to the primary productivity influencing the global climate. To better understand the complex interactions between phytoplankton and climate system, the relationship among preservation of fossil assemblages, paleoproductivity and glacial-interglacial cycles is intensively studied. This work, based on a quantitative micropaleontological approach, aims to evaluate the calcareous nannofossil preservation and the primary productivity in the North West Pacific Ocean during the Middle-Late Pleistocene. The studied material was recovered from the site ODP198-1209B located in the southern margin of the Shatsky Rise, an oceanic plateau east to Japan. The Pleistocene calcareous nannofossil content is here studied in detail for the first time. A total of 109 samples were collected from the top of the core to 11 mbsf (meter below sea floor) with a sampling rate of 10 cm and analysed in their nannofossil content under a polarized light microscope at 1000X magnification. The studied interval records the last 0.785 Ma, inferred from magneto-biostratigraphic data, with an estimated time averaging of about 7 kyr. Additional Scanning Electron Microscope (SEM) analyses were carried out on random samples in order to check the absolute abundance of some proxy species (like Emiliaia huxleyi and Florisphaera profunda). The nannofossil associations are abundant, well preserved and diversified. The nannofossil dissolution is evaluated using several indices proposed in literature that take into account the ratio between dissolution-resistant and more delicate taxa. These indices are: the dissolution curve of Calcidiscus leptoporus (Matsuoka 1990), the NDI index (Marino et al 2009), the CEX index (Dittert et al 1999) and the CEX' index (Boeckel and Baumann 2004). The Fragmentation Index (FI) from planktic foraminifera, is also evaluated only for 4 meters of the record. The C. leptoporus curve, the NDI and the FI suggest good preservation throughout the succession, confirming the qualitative observations made during the counting and their usefulness for the dissolution evaluation. The C. leptoporus curve and the NDI show a correlation value of 0.97 and both, in turn, correlate for a value of about -0.68 the FI. The CEX and CEX' show low correlation values with the other indices maybe for an underestimation of the small specimens of E. huxleyi to the light microscope, suggesting a probable major usefulness for SEM collected data-base. The primary productivity, evaluated through the N' (Lopez-Otalvaro et al 2008) and the PP (Beaufort et al 1997) indices both

based on the relative abundance of *F. profunda*, records several fluctuations throughout the core also remaining rather high. The PP index appears to be fairly positive correlated with the absolute abundance curve of calcareous nannofossils and negatively with the abundance curve of *F. profunda*, which proliferates during low nutrient intervals. Calcareous nannofossils appear, therefore, to be a major component of the primary producers. Comparing these data with the benthic oxygen isotope curve for the Middle-Late Pleistocene and therefore to the glacial-interglacial cycles, it is possible to observe carbonate dissolution maxima mainly during deglaciations, whereas the maximum efficiency of the biological pump and the nannofossil abundance maxima are recorded in the glacial phases. In conclusion, during the glacial phases the CO₂ sink is driven mostly by the shallow biological pump, partly buffered by the CO₂-producing carbonate pump. On the contrary, during deglaciations the main mechanism of CO₂ sink is the carbonate dissolution in the deep waters. It must be noted, however, that the oceans' capacity to absorb atmospheric CO₂ is further complicated by other parameters such as temperature, water dynamics, deep ocean carbonate chemistry and climate.

R3-6 Poster Agnini, Claudia

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CARBONATE EXPORT PRODUCTIVITY OF CALCAREOUS NANNOFOSSIL ASSEMBLAGES DURING THE PALEOCENE - EOCENE TRANSITION

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Key terms: IODP; Calcareous nannofossils; paleoceanography

The extraordinary high abundance of calcareous nannoplankton in the sea-surface marine waters makes them the main primary producers at the base of the marine food-chain. They are a fundamental part of the global biogeochemical carbon cycle, because of the role they play both in producing organic carbon and carbonate. Their first geological appearance in marine sediments has been recorded at about 230 Ma, so that they are thought to be a useful tool for Mesozoic and Cenozoic paleoceanographic reconstructions. From the 80ies till today, volume calculation of extant calcareous nannoplankton has been performed in order to convert coccolith fluxes data into carbonate export productivity. Here, we present volume evaluations of the most abundant Paleocene calcareous nannofossils, our data are eventually used first of all to make a quantitative estimation of the calcareous nannofossil carbonate production but also with the aim to calculate the ratio between the carbonate secreted by calcareous nannofossils and the total carbonate production. To obtain a more global perspective, our dataset comes from several DSDP/ODP Sites located at different latitudes both in the Atlantic (DSDP 401 and ODP 690, 1051, 1260, 1263 Sites) and Pacific (ODP Site 1209). The volume calculation of the most common early Paleocene calcareous nannofossil taxa were applied to a specific case history, the Paleocene Eocene Thermal Maximum, in order to investigate the absolute abundance of coccolith, the coccolith carbonate mass per species and the total calcareous nannofossil contribution to carbonate production before, during and after this prominent episode of global warming. Preliminary data show that a dramatic decrease both in the number of specimens/mm² and

carbonate production starts well before the onset of $\delta^{13}C$ negative shift suggesting a modification of pre-event conditions and a very perturbed paleo-environment during the main phase of the event.

R3-7 Poster Balestra, Barbara

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CALCAREOUS NANNOFOSSIL AND BENTHIC FORAMINIFERA BIOTIC RESPONSE TO THE EARLY EOCENE X-EVENT (ETM3) ON WALVIS RIDGE.

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Key terms: calcareous nannofossils; benthic foraminifera; early Eocene X-Event (ETM3); biotic response

The early Eocene Greenhouse World was punctuated by multiple transient global warming events, or hyperthermals, the most prominent of which was the Paleocene-Eocene Thermal Maximum (PETM). Additional Eocene Thermal Maxima (ETMs) exhibit a negative carbon isotope excursion (CIE), carbonate dissolution and biotic perturbations, and include the Elmo horizon (ETM-2, ~1.8 Myr after the PETM) and 'X' event (ETM-3, ~3.1 Myr after the PETM). We document the marine biotic response to the climatic and carbon cycle changes during the latter event (planktic foraminifer Zone P7, calcareous nannofossil Zone CP10; CIE ~0.9‰; warming ~2.5°C) through a study of stable isotopes combined with coccolith and benthic foraminiferal abundances at ODP sites drilled on Walvis Ridge (SE Atlantic), with paleodepths of ~1500m (Site1263) and ~3600 m (Site 1262). We analyzed samples spaced at 1-2 cm across the prominent clay layer. It is difficult to deconvolve effects of dissolution and changes in trophic state because the oligotrophic indicator species detected, also tend to be solution-resistant. We observed an increase in relative abundance of such species (*Discoaster* spp., *Sphenolithus* spp) during the CIE at Site 1263, while *Toweius* spp., (mesotrophic) decreased slightly, but species in the 'HS group' (eutrophic indicators) increased sharply. At the deeper Site 1262 assemblage changes were similar but more muted than at the shallower site, and the HS group doesn't vary significantly. Benthic foraminiferal assemblages decreased in diversity during the CIE at both sites, relative abundance of cylindrical species decreased, that of abyssaminids increased. At Site 1262 *Quadriformina profunda* increased in abundance, but it had its uppermost occurrence at shallower Site 1263. Benthic foraminiferal accumulation rates (BFAR), an indicator of food supply to the sea floor, remained even at Site 1262, while declining sharply at Site 1263, where *Nuttallides truempyi*, a low-food indicator, increased in abundance at both sites but more sharply at 1263.

We do not yet fully understand the environmental effects of the X-event but overall our records suggest that surface primary productivity may have increased at the shallower Site 1263 which was also closer to the coast (possibly due to increased nutrient inputs), while increased stratification due to warming caused increased remineralization of organic matter and declining food supply to the sea floor. The records were affected by increased dissolution, but the more extreme changes at the shallower site suggest that dissolution does not explain the records by itself. The biotic response to the X-event was less intense than that to the more severe Elmo and PETM hyperthermals at the same location, suggesting that the intensity of the biotic response reflects the severity of the environmental disturbance.

R3-8 Poster Fioroni, Chiara

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REVISED MIDDLE EOCENE-UPPER OLIGOCENE CALCAREOUS NANNOFOSSIL BIOZONATION FOR THE SOUTHERN OCEAN

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Key terms: Nannofossils; Biostratigraphy; Eocene; Oligocene; Southern Ocean

ODP pioneer drilling projects in the Southern Ocean (ODP Legs 113, 119, 120) have provided excellent stratigraphic sections for high-resolution biostratigraphic and paleoceanographic studies and are still relevant today as source of further information. However, it was evident that the widely used Eocene-Oligocene zonations of Martini (1971) and of Okada and Bukry (1980) were not applicable in high southern latitudes where some warm and temperate-water markers were rare or absent. Edwards (1971) first established a nannofossil zonation for the sub-antarctic Paleogene of New Zealand and later Wise (1983) proposed a Cenozoic zonation for the Falkland Plateau. The first detailed nannofossil zonal scheme for the Eocene and the Oligocene for the Southern Ocean (SO) was developed by Wei and Wise (1990) using well-preserved nannofossil assemblages from ODP Leg 113. These studies provided a large database on species stratigraphic distribution and revealed the importance of nannofossil assemblage studies in the SO for high-latitude biostratigraphic correlations.

However, despite the most recent SO Paleogene coring (e.g. ODP Leg 183), some significant problems regarding biostratigraphy have remained unresolved and recent updates on the Eocene-Oligocene biostratigraphy at SO sites have pointed out the need for revision of the existing zonations. This revision is also based on the refinement of nannofossil taxonomy and the recognition of several stratigraphic discrepancies in taxa distribution at southern latitudes. The biostratigraphic data discussed here are derived from the analysis of species distribution and from their correlation between ODP Sites 738, 748, and 744 (Kerguelen Plateau), ODP Sites 689 and 690 (Maud Rise), ODP Site 1172 (Tasman Plateau), and ODP Site 702 (Islas Orcadas Rise).

Eleven zones and six subzones are described, together with a number of additional biohorizons, intended to provide a high-resolution subdivision for the Eocene-Oligocene of the SO. Our approach was to follow as much as possible the Wei and Wise (1990) Zonation, tending to not altering the name of the zones. Nevertheless, ten zone and subzone boundaries are redefined, and six additional bioevents are introduced.

We propose 21 bioevents for the time interval from ~43 to 25 Ma. The proposed zonal scheme offers an average biostratigraphic resolution of ~800 ky over a ~18 Ma time interval, which significantly improves previous subdivisions.

The nannofossil bioevents were calibrated by using available magnetostratigraphic records, providing an improved biochronologic framework. Some of the Paleogene biostratigraphic datums used here show more restricted or expanded stratigraphic ranges at high latitudes compared to low and middle latitudes. In particular, the ranges of *Chiasmolithus solitus* and *Chiasmolithus oamaruensis* are more extended at high latitudes, and those of *Discoaster* spp. and *Ericsonia formosa* appear reduced, in response to different paleoclimatic conditions. Thus, the long cooling trend following the Middle Eocene Climatic Optimum event (~40Ma) is considered responsible for the early exclusion of warm-water taxa (*Discoaster* and *Ericsonia formosa*) from the southern high latitudes as well as for their time-transgressive behaviour between low and high latitudes.

The proposed scheme clarifies some long discussed enigmas (e.g., the *D. saipanensis* Zone), improving the correlation between high and low-mid latitude nannofossil biostratigraphy. Furthermore the new biostratigraphic scheme will allow more reliable paleoecological interpretations of nannofossil Eocene and Oligocene assemblages, which in turn are used for paleoceanographic and paleoclimatic reconstructions of this crucial time interval. The new zonal scheme is intended to better constrain in time the paleogeographic changes and to add contributions to the debate about the timing of the opening of ocean gateways surrounding Antarctica.

R3-9 Poster Luciani, Valeria

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THE RECORD OF MURICATE SYMBIOT-BEARING PLANKTONIC FORAMINIFERA FROM THE SUBTROPICAL ODP SITE 1051 A (ATLANTIC OCEAN) ACROSS THE EARLY EOCENE CLIMATIC OPTIMUM (EEO)

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Key terms: PLANKTONIC FORAMINIFERA; EARLY EOCENE CLIMATIC OPTIMUM; MOROZOVELLIDS

Within an extended interval of greenhouse-climate regime punctuated by at least two major transient hyperthermal events (< 200 kyr), the Earth reached the peak of Cenozoic warmth during longer lasting warming of the Early Eocene Climatic Optimum (EEO, ca 50-52 Ma) subsequently followed by a general long-term cooling trend culminating in the Eocene-Oligocene glaciation (e.g., Zachos et al. 2001 Science; 2008 Nature). This long term cooling has been mostly attributed to decrease in atmospheric carbon-dioxide pressure and its feedbacks within the climate system (e.g., Pagani et al. 2005 Science). A number of critical issues concerning the EEO event still need to be addressed albeit several data

has been recently acquired from both land and ODP (Ocean Drilling Program) Legs dedicated to Early Paleogene climate evolution. One of the most fascinating aspects of the investigation on early Paleogene climate is to evaluate the potential role of climate on the biotic evolution. On land, dramatic plant and mammal faunal turnover appears related to the EECO, thus supporting a direct primary climatic evolutionary control (e. g., Woodbourne et al. 2009 PNAS). In the marine realm, new evolutionary trends linked to the EECO give course to modern structure in calcareous nannofossil communities (Agnini et al. EPSL 2006). Recent studies on the planktonic foraminiferal response to the EECO event have been carried out on the classical early Paleogene section of Possagno (Venetians Pre-Alps, NE Italy). Results show that the EECO produced a permanent impact on the planktonic foraminiferal assemblages beside the transient modification related to the climatically-induced environmental perturbations. Specifically, the specialized muricate, symbiont-bearing surface-water morozovellids, that dominated together with the acarininids the low-latitude early Paleogene oceans, markedly decline in abundance just following the EECO and never recover. This reduction is coupled with the gradual disappearances of a number of morozovellid species, giving only in part reason for the decrease in abundance. During the EECO the Eocene pelagic ecosystems reached its maximum warmth and afterwards it passes from the greenhouse to the doubt-house/icehouse regime. The consequent modification in the water column structure and the reduced carbon-dioxide pressure might have negatively affected the ecological niches of the highly specialized muricate forms and biased the complicated mechanism of the morozovellid symbiosis processes. The short-term or permanent loss or inhibition of photosymbionts (bleaching) has recently been reported in many modern organisms including corals and benthic foraminifera in response to environmental stress. Bleaching events in the planktonic foraminiferal fossil record are still relatively unknown. They have been associated both to transient marked increase of SSTs, response to surface-water pH decrease (Middle Eocene Climatic Optimum, Edgar et al 2011 CBEP Abstr.) or to an extreme though detrimental reaction to an unfavourable environment (latest middle Eocene Morozovelloides extinction, Wade et al. 2008 Evol. Ecol.). It is therefore crucial to extend the analyses to diverse paleoceanographic settings and different time-slices. The superb documentation across the EECO of the pelagic calcareous plankton record archived in the deep-sea sediments of the subtropical ODP Site 1051A (Black Nose, Atlantic Ocean), provides the exceptional opportunity to evaluating the potential transient/permanent modifications within the planktonic foraminiferal muricate forms. Preliminary data reveal that a significant decrease in abundance of the muricate forms follows the EECO at the ODP 1051A site as observed for the Tethyan Possagno section although the initial proportions are different due to the diverse paleogeographic settings. A close interaction between global climate and biological evolution appears therefore supported by the ODP Site 1051A record.

R3-10 Poster Toffanin, Federica

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CALCAREOUS NANNOFOSSIL RESPONSE TO THE MIDDLE EOCENE CLIMATIC OPTIMUM: CLUES FROM DIFFERENT DEPOSITIONAL SETTINGS.

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Key terms: calcareous nannofossils; Middle Eocene Climatic Optimum; paleoecology; paleoclimate

Calcareous nannofossil assemblages show specific paleoecological affinities and thus can be utilized for palenviromental reconstructions. We investigated the response of calcareous nannofossil assemblages to the Middle Eocene Climatic Optimum (MECO) a significant temporary reversal in the middle-late Eocene long-term cooling trend. This warming event is characterized by a prominent perturbation both in oxygen and carbon stable isotopes occurred at Chron C18r-C18n transition (ca. 40 Ma) and lasting ca. 500-600 kyr (Bohaty et al., 2009). Our main aim is to point out if biotic response to the MECO is global and unique over wide areas and depositional settings or is more related to local conditions. To this purpose we are currently comparing calcareous nannofossils modifications at three sites. At Alano, a bathial section (NE Italy), our data indicate that the MECO interval seems to coincide with significant changes in calcareous nannofossil assemblages. Eutrophic/cold taxa and reworked specimens show an overall increase in abundance during the warming event. Conversely, oligotrophic/warm taxa are characterized by a peculiar anticovariant trend with respect to meso-eutrophic taxa, decreasing significantly during the MECO and post-MECO intervals. These results are interpreted as a transient enrichment in dissolved nutrients in warmer sea surface waters and suggests that the enhanced availability of nutrient in the water column overrides other environmental factors in the make-up of calcareous nannofossil assemblage. Moreover, the increase in reworking is consistent with an augment in terrigenous input, likely due to accelerated chemical weathering triggered by the enhanced hydrological cycle. Our results from ODP Exp. 320-321 (U1333C) in the Pacific Equatorial Ocean, show dramatic changes in preservation state, with the number of specimens counted on a specific area (1 mm²) virtually collapsing during the event. We observed changes in calcareous nannofossil assemblages that are consistent with strong dissolution, corresponding to the MECO. A strong decrease of specimens/mm² is clear, but if we considered the relative abundance (%) of the most resistant genus, Discoaster, there is a remarkable increase, as it is expected if the pristine assemblages were altered/biased by preferential dissolution. The last site we are considering is ODP Site 1051, in NW Atlantic Ocean, our preliminary results seem to show changes in calcareous nannofora assemblage during this transient episode of global warming, but a more detailed analysis of relative and semiquantitative data is needed, in order to obtain a more global perspective on nanoplankton response to the MECO.

Bohaty, S. M. et al. (2009), *Paleoceanography*, 24, PA2207.

R3-11 Poster Vannucchi, Paola

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IODP EXP. 334 CRISP A: THE FIRST STEP TOWARD DRILLING THE SEISMOGENIC ZONE IN CENTRAL AMERICA

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Key terms: IODP; Subduction; Seismogenesis

The Costa Rica Seismogenesis Project (CRISP) is designed to understand the processes that control nucleation and seismic rupture of large earthquakes at erosional subduction zones.

CRISP targets the only known erosional end-member of convergent margins within reach of scientific drilling. With a relatively thin sediment cover, fast convergence rate, abundant seismicity, subduction erosion, and change in subducting plate relief along strike, the Costa Rica margin in the CRISP area offers excellent opportunities to learn the causes of earthquake nucleation and rupture propagation.

This project complements other deep-fault drilling (San Andreas Fault Observatory at Depth and Nankai Trough Seismogenic Zone Experiment) and investigates the first-order seismogenic processes common to most faults and those unique to erosional margins.

Integrated Ocean Drilling Program Expedition 334 was the first of several planned expeditions to reach the seismogenic zone. The primary goals of Expedition 334 were:

1. Characterization of lithological, physical, and frictional properties of upper plate material;
2. Estimation of subduction channel thickness and the rate of subsidence caused by subduction erosion;
3. Characterization of the fluid flow system and thermal structure of the erosive margin;
4. Determination of the change in the stress field across the updip limit of the seismogenic zone
5. Explore the Cocos Ridge-volcanic arc gap-Cordillera de Talamanca relationship.

In order to accomplish these objectives, coring was conducted at three slope sites (Sites U1378 and U1380 on the middle slope and Site U1379 on the upper slope) and at one site on the Cocos plate (Site U1381). Both slope sites might serve as pilot holes for a potential future riser drilling project. Sites U1378 and U1379 were first characterized by logging while drilling (LWD) to document in situ physical properties, stratigraphic and structural features, and stress state, in addition to continuous core sampling to the target depth. Cores at both sites were taken to examine slope sediments and the underlying upper plate basement. The coupling of LWD data with data from sediment and basement samples provides important information about tectonic, hydrologic, and seismic features along this erosive convergent margin.

R3-12 Poster Villa, Giuliana

10.1474/Epitome.04.0970.Geoitalia2011

MIocene-Eocene NANNOFOSSIL RECORD OBTAINED DURING IODP EXPEDITION 317- CANTERBURY BASIN SEA LEVEL (NEW ZEALAND)- GLOBAL AND LOCAL CONTROLS ON CONTINENTAL MARGIN STRATIGRAPHY

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Key terms: IODP Expedition 317; CALCAREOUS NANNOFOSSIL; SEA LEVEL

Expedition 317 aimed to understand the relative importance of eustatic variations, local tectonic and sedimentary processes in determining depositional cyclicity on continental margins (Fulthorpe et al., 2011).

The goals of this Expedition were: 1) date clinoform sequence boundaries and study the facies variations associated to them; 2) date the Marshall Paraconformity; 3) understand the erosion history of the Southern Alps; 4) determine sediment drift depositional history and paleoceanographic record.

Three shelf sites (U1351, U1353 and U1354) and one slope site (U1352) were drilled along a transect perpendicular to the margin. Nineteen regional middle Miocene to Pleistocene sequence-bounding unconformities were identified from sequence stratigraphy on the prism of the Canterbury Basin.

For the age-control of the drilled sequences, all core-catcher samples were analyzed onboard using calcareous nannofossil, planktonic and benthic foraminifera biostratigraphy. During Exp. 317 Holocene to Eocene sediments were recovered. Calcareous nannofossil assemblages showed strong variations in abundance, preservation and composition associated with different lithologies.

Here we present calcareous nannofossil preliminary records for the Eocene-Miocene part of the drilled sediments. The calcareous nannofossil zonal scheme of Martini (1971) was used, together with the marker species of Okada & Bukry (1980) and de Kaenel and Villa (1996). Calcareous nannofossil assemblage analysis provided a good age control of the successions and the dating of the sequence boundaries.

The Miocene/Pliocene boundary was drilled at shelf Sites U1351 and U1353 and at slope Site U1352. Reworked calcareous nannofossils are abundant in Miocene assemblages. Abundance and composition analysis of reworked material will be one of the foci of post-cruise research.

A major hiatus (~12 m.y.), associated with the Marshall Paraconformity (MP), separates the early Miocene (18-19 Ma) from the early Oligocene (30.1-32 Ma). The MP likely represents intensified current erosion related to the inception of the Protoantarctic Circumpolar Current. At Site U1352 Oligocene and Eocene sediments were also drilled. The Eocene/Oligocene boundary falls within a hiatus lasting from the late Eocene (35.2-36.0 Ma) to the early Oligocene (32.5-32.9 Ma). The deepest sample taken during Exp. 317 was dated at 35.2-36.0 Ma (late Eocene).

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SESSIONE S1

Geoscienze e Tecnologia dell'Informazione

S1-1 Orale De Donatis, Mauro

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MAPPING GEOLOGY OF A SECTOR OF UPPER MARECCHIA VALLEY (ROMAGNAN APENNINES) FROM REAL FIELD TO 3D MODELLING.

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Key terms: Val Marecchia; Northern Apennines; digital field mapping; GIS; 3D modelling

Field digital mapping, GIS, multidimensional modelling are in the last years one of the new way of producing an innovative geological cartography (Bonham -Carter, 1994; McCaffrey et al., 2005; Wawrzyniec et al., 2007). Since the use of portable hardware in the field (Tablet PC, PDA and now also smartphone and iPad) allows to more accurately georeference (GPS receivers) and digitally store (database) data, informations, hypotheses and interpretations. The disponibility of these ones in digital format has led to new way of analysis and final map elaboration. Moreover this usage of information technology helps quite a lot private companies and public agencies to lower time and money consuming and more, to get uncertainties reduction (Jones et al., 2004) and a better knowledges management (Bond et al., 2007). Therefore many research groups worked on finding their own ways from field work to map elaboration (Briner et al., 1999; Walker & Black, 2000; Akciz et al., 2002; Howard, 2002; Brodaric, 2004; De Donatis et al., 2005). The academic research could be much more free to explore new methods and tools, from out-of-the-shelf products (ex. ArcPad) to home-made systems (ex. BeeGIS).

phase

1st

Starting in the lab, planning the field project development, base cartography, forms and data base were designed in the way we thought was the best for collecting and store data in order of producing a digital n-dimensional map. Bedding attitudes, outcrops sketches and description, stratigraphic logs, structural features and other informations were collected and organised in a structured database using rugged tablet PC, GPS receiver, digital cameras and later also an Android smatphone with some survey apps in-house developed.

A

new mobile GIS (BeeGIS) was developed starting from an open source GIS (uDig): a number of tools like GPS connection, pen drawing annotations, geonotes, fieldbook, photo synchronization and geotagging were originally designed.

phase

2nd

After some month of digital field work, all the informations were elaborated for drawing a geologic map in GIS environment. For that we use both commercial (ArcGIS) and open source (gvSig, QGIS, uDig) without big technical problems.

phase

3rd

When we get to the step of building a 3D model (using 3D Move), passing through the assisted drawing of cross-sections (2D Move), we discovered a number of problems in the interpretation of geological structures (thrusts, normal faults) and more in the interpretation of stratigraphic thicknesses and boundaries and their relationships with topography.

phase

4th

Before an "on-armchair" redrawing of map, we decide to go back to the field and check directly what was wrong. Two main vantages came from this: (1) the mistakes we found could be reinterpreted and corrected directly in the field having all digital tools we need; (2) previous interpretations could be stored in GIS layers keeping memory of the previous work (also mistakes).

phase

5th

A 3D model built with 3D Move is already almost self-consistent in showing the structural features of the study area. The work was not so strightforward, but the result is more then satisfying, even if some limitations were not solved (i.e. visualisation of bedding attitudes). Geological maps are fundamental for knowledge transfer among experts but, if combined with the innovative digital methods from survey to 3D model, this knowledges could reach a much larger number of people, allowing a cultural growth and the establishment of a larger awareness of the Earth and Environment.

S1-2 Orale Trevisani, Sebastiano

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SURFACE TEXTURE ANALYSIS OF AN ALPINE BASIN WITH

COMPLEX MORPHOLOGY AND POTENTIALITIES FOR GEO-ENGINEERING

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Key terms: engineering geology; high resolution DTM; geomorphometry; geostatistics; surface texture

In this presentation the results of a geomorphometric analysis of an alpine basin are presented with a special focus on their relevance in the applicative context. The complex morphology of the studied basin makes challenging the geomorphometric analysis of fine-scale topography. Moreover, the studied basin is representative of the geological, geomorphological and vegetation conditions frequently found in the Dolomites. The analysis of the surface morphology was performed on a high-resolution digital elevation model (cell size 2 m), derived from an airborne LiDAR survey. A set of spatial-statistical indexes were calculated locally and used as signature of the local surface morphology. Subsequently, these indexes were used in a fuzzy k-means classification that permitted to segment the basin into different spatial subdomains characterized by a specific surface texture. The results of the classification are compared with the actual surface morphology using high-resolution orthophotos, aerial photos and by conducting field surveys. The surveys were carried out with the aid of a GIS system mounted on a tablet rugged PC with GPS capabilities. This procedure permitted to pair the geomorphometric analysis results and other thematic layers with field evidences.

The analysis performed proved to offer a valuable interpretative tool of the complex surface morphology of the studied alpine basin. This kind of analysis seems exploitable in different contexts, among which: 1) speed up of field surveys; 2) comparative studies; 3) landslide susceptibility mapping; 4) ecological modeling.

S1-3 Orale Nappi, Rosa

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MULTIPARAMETRIC DATA ANALYSIS IN GIS ENVIRONMENT FOR IDENTIFICATION OF SEISMIC SOURCES IN CAMPANIAN AREA

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Key terms: G.I.S.; seismotectonics; Campanian plain

This paper deals with an interdisciplinary research that has been carried out for investigating the neotectonic activity of the Campanian plain and surrounding carbonate massifs (Southern Apennines). The analysis of the available seismic, tectonic and gravimetric data of the area has been carried out through the Geographic Information System (GIS) which has provided the capability for storing and managing large amount of spatial data from different sources.

The implementation of the GIS system (software ArcGIS 9.3) has been affected by both completeness of information, and quality of geographic data; for this reason special attention has been dedicated in our system to collect all the existing relevant data together with the updated territorial information about the Campanian area.

Three thematic Datasets have been generated for this area, the fault, earthquake and gravimetric datasets. In particular, the database creation has consisted of these main steps: (a) collection and acquisition of digitalized aerial photos, numeric cartography, Digital Terrain Model data (DTM), geophysical data; (b) generation of the vector cartographic database and alpha-numerical data; (c) image processing and features classification; (d) cartographic restitution and multi-layers representation. The UTM-WGS84 reference system has been used for geocoding the whole dataset.

The fault Dataset has been compiled by examining the available structural maps, and many recent geological and geophysical papers of literature, since the active fault systems of the Campanian area are not completely known and not comprehensively reported in up-to-date and reliable neotectonic maps.

The earthquake Dataset has been implemented collecting seismic data by various available historical and instrumental Catalogues; new precise earthquake locations have been carried out for some clusters of events, for better constraining existence and activity of some outcropping and buried tectonic structures. Seismic data have been standardized in the same format into the GIS and merged in a final catalogue.

For the gravimetric Dataset, the Multiscale Derivative Analysis (MDA) of the gravity field of the area has been performed, relying on the good resolution properties of the Enhanced Horizontal Derivative (EHD). MDA of gravity data has allowed localization of several linear and close trends, identifying anomaly sources whose presence was not previously detected. The main results of our integrated analysis show a strong correlation among the new hypocentral location of seismic clusters matching some fault systems bordering the Campanian Plain, and MDA lineaments from gravity data relative to the same tectonic structures.

S1-4 Orale Cipolloni, Carlo

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THE GEOLOGICAL DATA AND WEB SERVICES OF THE GEOLOGICAL SURVEY OF ITALY

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Key terms: geologic; standard; metadata; geoportale; web service

The geoportal of the Geological Survey of Italy, which is available at the URL (<http://sgi.isprambiente.it/geoportal>), is been re-designed to allow easy access to the digital informations contents of all the database and projects. This system is built as integrated architecture composed by an OGC/INSPIRE standard Metadata catalogue service (CSW 2.0.2.). According to the national law and to the INSPIRE European Directive we use a multi-profile standard. In the metadata catalogue all the services associated to web map services are archived as ISO-Core and as INSPIRE metadata, while the dataset metadata are directly archived in a special

profile that satisfies both the Italian standard RNDT (National Inventory of the Territorial Data - DigitPA) and the INSPIRE Implementing Rule. Therefore specific test are performed using the validation tool (i.e. INSPIRE Geoportal website and RNDT website) on the XML format export files.

The web services are publishing with ArcGIS Server technologies in several format to be available to the users a suite of web services that are in the same time interoperable with the OGC Standard (WMS/WFS/WCS/KML) and able to fulfil an high cartographic standard in the geological symbols representation (i.e. ArcGIS). The portal, at the moment, allows the consultation in the same framework of a set of standard vocabulary using standard ontology (OWL and/or SKOS) for implementing in the next future the terms definition in the same content of the data visualization.

Specific section related to the projects or to the standard are been created, and a direct access is available in the left side menu. Thanks to the new available technologies (flex and JavaScript) allow us to produce a gallery of the viewer application, where different user's typology could be access easily to the geological contents and to the natural hazard events. In particular we maintain daily updating, a list of javascript viewer using google-map images as base-map with landslide and geological bedrock information drape on, are been created to common user and presented as highlights object on the home-page. The Geoportal presents moreover an OGC/INSPIRE section that gives to the user a direct access to standard web services.

The real use of the Geoportal is as Geological search engine for the metadata, data and view services. This tool is realised to integrate in both direction viewer and metadata catalogue for discovering in the catalogues, add and view directly the available web services and, when it adopted the rule in this regard, to download data too. The Portal of the Geological Survey of Italy would be a focal point to search and fund the geological data at national and international level, in fact is also possible make query on the international standard metadata catalogue relate to the geological data (i.e. OneGeology, USGS, etc.).

S1-5 Orale Pantaloni, Marco

10.1474/Epitome.04.0975.Geoitalia2011

ONEGEOLOGY-EUROPE: A HARMONIZED GEOLOGICAL SPATIAL DATA INFRASTRUCTURE IN EU

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Key terms: OneGeology; Europe; geological map; spatial data infrastructure; harmonization

OneGeology-Europe is an ambitious project, started in September 2008 and finished in September 2010, aimed to make basic geological data, held by the Geological Surveys of 24 European countries, most popular and accessible, developing an integrated data system.

The project's aim was to create dynamic digital geological map data for Europe at 1:1M scale, working to allows different types of data and formats to be made available and accessible by anyone using the web. This objective has been reached through the implementation of a web mapping portal (<http://onegeology-europe.brgm.fr/GeoPortal/viewer.jsp>), realized using the latest computing technology, GeoSciML.

During the two years of the OneGeology-Europe project has been addressed issues relating to data licensing, multilingual aspects, sharing of geological knowledge, geological data harmonization and demonstration of best practices in provide and use of spatial geological data in the public and private sectors.

The project idea was born from the awareness of the presence of a wealth of spatial geological data often accessible only to specialists; this amount of data, unfortunately, is often hard to find and poorly accessible, almost never shared or, when shared, decipherable only through adequate knowledge and appropriate reading keys. These data, mostly owned by the Geological Surveys of different countries, are sometimes "locally" standardized and then absolutely not homogeneous between them.

The project has been divided into 10 Work Packages (WP), composed of experts and professionals from various Organizations with considerable experience in their field. Many of the Organizations work together in existing multi-national groups and projects and have achieved excellent results.

Work Package 3 (WP3) worked on essential basis for the OneGeology-Europe project: a specification for geological spatial data and an interoperable 1:1M scale dataset for the whole of Europe. This includes vocabularies to describe lithology, age and genesis of the rocks, tectonic structures, term definitions and relations. Based on the specification it identified the generic and specific geometric and semantic harmonisation issues.

Afterward WP3 "amended" existing national datasets to make significant "progress towards harmonization", a crucial step on the way to INSPIRE objectives. The standards, architecture and framework developed in OneGeology-Europe project can be "reorganized" to more detailed levels and deployed for higher resolution geological data. This work of the OneGeology-Europe Data Specification WP provide a solid base for the description of geology of each European Union country in the future. The architecture developed in the project is service oriented and OGC standards-based; the pan-European geological map produced is not stored in a centralized database but it is composed through various web services, each supported by the Geological Survey of the country involved in the project. Map data served to the Internet as part of OneGeology will remain in the ownership of the originating Geological Survey, and ideally be available at no cost. The format of the "web mapping and feature services" allow registry and technical references.

These procedure and architecture constitute a significant contribution to the development of INSPIRE, by developing systems and protocols for sharing, finding, viewing and downloading of geological European spatial data.

OneGeology-Europe consisted of a consortium of Geological Surveys of many European countries and representatives of user communities; therefore it was absolutely a multilateral and multinational programme. The project allows Europe to play a leading role into the OneGeology-global initiative, that follows the indications given by United Nations General Assembly in 1997 (the so called "Agenda 21") that asks nations to reduce the gap in the availability, quality, standardization and accessibility of data between world countries.

S1-6 Poster Balestro, Gianni

10.1474/Epitome.04.0976.Geoitalia2011

SHARING DATA AND INTERPRETATION OF GEOLOGICAL MAPS ON THE WEB

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Key terms: metadata; GIS databases; geological mapping

Web sharing of geological data is ever-increasing and geoscientists are now involved in the development and in the maintenance of IT (Information Technology) applications (Spatial Data Infrastructures, Geoportals, Web-GIS,...). Spreading of geo-referenced information is driven by different organizations (e.g. the Open Geospatial Consortium) and initiatives (e.g. the INSPIRE European Directive) that give useful standards and suggest common methods for storing actually sharable data. The Web Map Service (WMS) protocol for map images and the ISO19115 for geospatial metadata, are two examples of standards that increasingly characterize the management of geo-scientific information on the web. The aim is both supporting the interoperability of services and meeting different needs related to clearness and quality of web disseminated knowledge.

In the frame of the realization and sharing of geological maps, a better understanding of information is particularly needed. Maps and related geological datasets are stored in large and complex databases that suffer from incompleteness that is the lack of knowledge about interpretations that lie behind data. The datasets of geological maps do not always correspond to prompt information for data-users and are actually usable if they contain information about the knowledge-paths followed by data makers, with their generalizations and uncertainties. IT allows facing these problems through homogeneous meta-description of the digital processing of data (from the field to the map to the web), and by user-friendly tools that allow querying of maps gathered by different expertise, in different context and with different methods.

An example of an easy infrastructure (the CNR-IGG-TO Geoportal) for spreading on the web datasets of geological maps is given. In this geoportal maps are retrieved by the WMS protocol and managed through a catalog service of metadata, compiled according to the ISO19115 standard. The metadata descriptive classes (e.g. the "Identification" class or the "Data-quality" class), besides giving different information about where, when and how data were captured, allow bringing out in an explicit format the processing steps (e.g. "Lineage" class) performed from original field data to map generalization.

S1-7 Poster Tallone, Sergio

10.1474/Epitome.04.0977.Geoitalia2011

THE GEOPORTAL OF THE TORINO UNIT OF THE INSTITUTE OF GEOSCIENCES AND EARTH RESOURCES (CNR - ITALY)

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Key terms: WebMapService technology; Metadata; Knowledge sharing

The Torino operative unit of the Institute of Geosciences and Earth Resources - CNR IGG Torino - (<http://www.csg.to.cnr.it/>) recently set up a geoportal, where geological information are described referring to GeoSciML semantics, ISO19115 MetaData standard and shared through WebMapService technology.

(<http://server21.to.cnr.it/geonetwerk/srv/en/main.home>). The CNR IGG TO Server contains field data and related geological maps mainly in the frame of the CARG project (1:50000 Geological Map of Italy) and other field geological research programs such as the Geological Map of Piemonte region at 1:250.000 scale, the map of the Ligurian-Maritime Alps boundary and many others. Not only geological maps are stored, but all several kinds of geo-referenced geological data set are intended to be represented and shared through the geoportal.

The CNR IGG purpose is to get this information conceptually described, using the Geographic MD international standard for the geological context, in order to give geological interpretations in an explicit format. These "geological metadata" have been compiled mainly as regard the

"Identification" and the "Data Quality" classes. The Abstract element (Identification class) explains the criteria on which data are interpreted and the meaning of them, giving the peculiarities of interpreted features.

The Resource Locator element (Identification class) allows to link datasets with conceptual supplemental information (conceptual schemas), where concepts and methods adopted in the acquisition of knowledge are given. The Lineage element (Data Quality class) gives the different process steps performed on data, specifying the provenance of interpreted features and making them traceable.

The development of the CNR IGGTO geoportal was also carried out in the frame of the EU MEDOCC IDE-Univers project (<http://www.geoportal-idec.net/ideunivers/>) and the CNR GIIDA (<http://www.dta.cnr.it/content/view/2735/2735/lang, it/>) project (an initiative to implement the Spatial Information Infrastructure of CNR for Environmental and Earth Observation data).

S1-8 Poster Battaglini, Loredana

10.1474/Epitome.04.0978.Geoitalia2011

EXPERIMENTAL METHOD FOR AUTOMATED APPLYING OF STANDARD STYLES TO DATABASE OF THE CARG PROJECT IN ARCMAP GIS ENVIRONMENT

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Key terms: CARG PROJECT; GEOLOGICAL DATABASE; GIS STYLES

This work describes an experimental method for the automation assigning colors and symbols in a GIS software client to vector data from CARG Project Geological database, using official standards defined in the Guideline - "Linee guida per l'allestimento e per l'alimentazione per la stampa dalla banca dati (Quaderno Serie III Volumi 6-12 Carta Geologica d'Italia - scala 1:50,000)".

The process of revision and correction of CARG Geological Database, which involves also the field "COLORE" containing color codes assigned to each geological map on the basis of codes published on SGI's Chromatic

Handbook, carried out the possibility to use these codes to obtain a better visualization of geological CARG Database elements, similar to the printed map, and in the future also through web services. For this purpose, official CMYK color codes used for printed geological maps, has been converted into RGB triplets and assigned to corresponding features through a VBA script.

The work has been done using ESRI software but can be simply ported on other platforms, web included.

S1-9 Poster Carta, Roberta

10.1474/Epitome.04.0979.Geoitalia2011

OPTIMIZATION AND STANDARDIZATION PROCEEDINGS OF THE CARG GEOLOGICAL DATABASES TO PERFORMS THE USABILITY THROUGH THE PORTAL OF THE GEOLOGICAL SURVEY OF ITALY

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Key terms: GEOLOGICAL DATABASE; CARG PROJECT; PORTAL OF GEOLOGICAL SURVEY OF ITALY

The aims of CARG Project, funded since 1988, is to realize the new Geological Map of Italy at 1:50,000 scale: the first phase is almost concluded with the production of the 255 geological sheets (corresponding to 40% of the entire Italian territory).

The Project is carried out through the continuous collaboration between the Geological Survey of Italy (SGI) and Regions, Autonomous Provinces, CNR, University Departments and Institutes. The SGI coordinate the achievement of geological sheets and, by the expertise of its technical staff and the "Coordinating Committees for homogeneous geological areas" support, guarantees the quality of geological sheets with technical and scientific testing.

In order to attain a homogeneous and organized project, the SGI, with the effective collaboration of experts, published the Guidelines which define the content and the standards for survey, data storage, print process and "Explanatory Notes" of the official geological and geothematic maps at scale 1:50,000. In particular the Guideline - "Linee guida per l'informatizzazione e per l'allestimento per la stampa dalla banca dati (Quaderno Serie III Volumi 6-12 Carta Geologica d'Italia - scala 1:50,000)" - were established to define database geological model and ensure uniformity of data supply.

The database of the single sheet, compliant with legislation through technical tests, are now 130 of which 117 have been published on the website of SGI.

The loading phase of the database of individual sheets in the general Geodatabase is a further test of conformity with the requirements of standardized dataset, since only during this operation emerge the unevenness between adjacent sheets and sometimes within the same. Detailed analysis of information content of databases, both for individual sheets and for wider geographical areas, it was necessary to establish the criteria and the procedure to be followed in order to standardize the information stored in general Geodatabase.

Therefore the correction process must relate to the content referable substantially to geological units present in sheet that sometimes in adjacent sheets may include information not homogeneous.

On the basis of this analysis, the abbreviations of geological units contained in the field related to the code of the litho-stratigraphic units have been aligned.

A second phase involves the work of cleaning and standardization and in some cases the integration of tabular data for compliance and completeness of the information as stated in the Guidelines referred to above.

For this purpose it was decided to work in particular on:

- the correction of codes present in the tables relating to geological units sometimes incorrectly completed or imprecise
- the integration and review of the content of field 'LEGENDA'
- the inclusion of the missing information in some required fields
- the revision and integration of the data in the field "COLORE" on the basis of codes published on SGI's Chromatic Handbook
- the inclusion of new fields necessary to clarify the meaning of some coded information.

The process of revision and correction, which involves a considerable amount of data, aims to improve the current archive with more correct and homogeneous information and provides, as most immediate result, a better representation of the information contained in it, through the publication on the Portal of the Geological Survey of Italy.

S1-10 Poster Torchio, Silvia

10.1474/Epitome.04.0980.Geoitalia2011

FILLING THE GAP BETWEEN CARTOGRAPHIC-QUALITY MAPS AND GIS DATA

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Key terms: GIS; vector-based drawing software; geological map; high-quality cartography

We are carrying on a geological map project, financed by Regione Liguria, that covers an area of about 160 km² straddling the Savona and Genova provinces in central Liguria. We perform the field mapping at 1:10,000 scale, for a final rendering at 1:25,000 and 1:50,000 scale.

The aim of the project is twofold: to produce a high cartographic-quality map and to create a geological database. The only way to link these two elements is to use a vector drawing software with GIS capabilities. During fieldwork we collect different kind of information and to manage these data we have to use 4 types of GIS features:

- georeferenced raster images (Coordinate System: Monte Mario - Italy, Zone 1),
- polygons,
- straight lines,
- points.

Polygons represent the outcrops of different lithologies, and they have a specific graphic style (reported in the legend), defined by fill (colors and textures) and stroke (weight, color, dash pattern).

Lines represent faults and are characterized by a specific stroke and color. We show as points two different kinds of information: sampling locations that are represented as a non-oriented symbol and attitude data that are

represented on the map as oriented symbols (e.g. arrows) in order to express the real orientation of planes (e.g. schistosity, bedding, faults, fractures) and lines (e.g. fold axes, lineations).

To each vector datum we associate a database made of both numerical, alphanumeric and boolean attributes.

To handle this map project, we need:

- high-resolution raster images to display topography,
- advanced graphic tools (able) to draw smooth curved lines,
- layer-based graphic project to control the overlapping order of different items.

Both high-resolution raster images and smooth lines are necessary to draw a high-quality geological map; the possibility of changing the layers overlapping order is useful to correctly display the superposition of different geological objects (e.g. bedrock - sedimentary covers - geomorphological elements). We moreover need to link the geological database to graphical objects (either polygons or lines or points), to make queries (both spatial or attribute-based) and eventually analyse the selected data in external applications, and to link external objects (e.g. photographs, graphics, etc.) to graphical objects.

To exchange and integrate data with other research groups, we have to read files from other graphical (such as Macromedia Freehand®, Bentley Microstation® and Autodesk AutoCad®) and GIS software (e.g. ESRI ArcGIS®) and to export our project both as shape files and text files. Finally, since we use a GPS device during fieldwork to precisely locate outcrops, the software we use must be able to download gps data.

In order to manage this map project we chose Avenza MAPublisher® 8.3.3 for Adobe Illustrator® CS4. Developed as a suite of plug-ins for Adobe Illustrator, MAPublisher is the bridge between the graphics capabilities of this vector-based drawing software and the GIS potentiality, to produce high-quality maps. This software is able to manage simultaneously both georeferenced data and simple graphical and text elements, and, unlike the most part of GIS programs, it can manage text data as a feature instead of a mere object label: this means that MAPublisher allows you to create an attribute schema linked to a text object.

Future development could be the use of a portable device, with an integrated GPS device and display adequate for use in the field.

Here we show the preliminary output of this graphical-GIS map, compared to a simple GIS project, and the potential of spatial and attribute-based queries on the databases associated to different features.

S1-11 Poster Zamparutti, Paolo

10.1474/Epitome.04.0981.Geoitalia2011

GEOMATICS AND GIS FOR DATA ANALYSIS, MONITORING, AND COUNTRY PLANNING IN ALPINE ENVIRONMENT: CASE STUDY IN VALLE D'AOSTA AND PIEMONTE (ITALY)

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Key terms: GIS; Pocket PC; Planning; Cartography; GNSS

Analysis and country-planning procedures need precision and quickness, not only during field survey operation, but also in post processing data. With the digital systems spreading there's a necessity of testing innovative instruments for field data collection. The purpose is to collect "digital" data directly suitable for database and subsequently analysis.

In the last years several projects have been set up involving Regional Administration, National parks, Italian and foreign Universities and the Geosilab, Dipartimento di Scienze della Terra Università degli Studi di Torino. The result of a pre feasibility study directs our choice on a methodology that use a pocket pc for data collection, possibly with a GNSS capabilities and integrated camera. The use of a pocket pc as an instrument of survey represents the innovative side of this test, as an alternative to this, many other organizations of research and control of the environment suggest the use of a tablet pc. The instrumentation put on trial during several tests is thus composed by a pocket pc, to gather data through a GNSS connection, to collect and filing information, to access georeferenced maps, take pictures and associate them to the observed data.

The choice done for data collection was a Portable GIS devoted software (in this case ArcPad of the American ESRI) which allows to carry on the field whatever kind of georeferenced image used as base map (from Technical Map at 1:10.000 passing through geological map at 1:50.000, to thematic map and to digital orthophotos).

To this base equipment has been added the possibility to record the observations in a fast and reliable way, using a standardized format that can improve the precision of collected information and lower the possibility of errors and data omission. In this sense, specific forms have been developed for gathering different thematic data (geologic/geomorphologic, faunal and floristic, path system...etc.) For what concerning the path system, beside information about physical and morphological characteristics, the hiking difficulty and practicability could be collected points of interest, signs and degradation factors. The cartography obtained from the field work allowed to arrange maps useful for many purposes from country-planning to promulgation

S1-12 Poster Ghiraldi, Luca

10.1474/Epitome.04.0982.Geoitalia2011

GEOMATICS APPLICATIONS FOR EVALUATION AND MANAGEMENT OF PIEMONTE GEOHERITAGE (PROGEO-PIEMONTE, INTERDISCIPLINARY RESEARCH TEAM "A")

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Key terms: geological heritage; geomatics; inventory; evaluation; Piemonte

The multidisciplinary research project "PROGEOPIEMONTE" aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region. The goal is to develop

techniques for recognizing and managing its rich geodiversity at the local and regional scale. After a systematic review of inventoried geosites, 9 strategic geothematic areas will be investigated to represent the geodiversity of Piemonte. Each one characterized by high potential for scientific studies, enhancement of public understanding of science and recreation activities and for economic support to local communities. Geological history, climate and environmental changes, natural hazards, soil processes and georesources will be popularized not only with geosites but also with museum collections, evidences of mining activity and quarrying, science exhibits and nature trails. The recognition of the economic value of geodiversity will lead to the production of regional guidelines for Geoconservation integrated quality management system, suitable for tourism and sustainable development strategies. In order to collect scattered information concerning the geological heritage of the Piemonte region, cooperation between the University of Torino (Earth Science Department) and the Natural Science Museum of Torino was performed. The aim of this cooperation is to identify possible ways of acquiring knowledge and allowing enjoyment of the Region's geological heritage. This can be achieved not only by means of inventory and assessment processes of the most important sites of geological interest, but also by programs of usage and popularization. In order to define the state of the art in geosites studies and to identify the geoconservation projects developed by public or private institutions, a bibliographic research joined with field data collection was performed. The information are highly heterogeneous in quality and quantity, hence the need to develop a common methodology to performing the collection and the management of data. From the analysis and comparison of different methods already in use by public institution and research institutes, a new tool was developed for inventorying and evaluating geosites. The PROGEO-Piemonte form takes into account the specific regional needs derived from the state of the art, and follows the guidelines proposed by ISPRA for the project "National Census of Geosites". The form has been structured in two parts: 1) inventory and 2) evaluation.

- In the first part there are several sections requiring mandatory information, in order to get a holistic point of view on a geological site.
- The second part of the form concerns the evaluation process, in order to determine the value of geosites. It is divided into seven sections, where a series of predetermined parameters allow to assign a numerical value to each of the aspects taken into account.

At the end of the evaluation process, every geosite gets a score from each of the considered aspects. Depending on the final purpose of the evaluation process, geosites with higher score will be taken into account. The electronic image of the inventory and evaluation form has been placed into a database, so, the data can be retrieved and visualized from Internet.

In order to facilitate field data collection, the inventory form has been inserted as customized extension into a mobile-GIS software and adapted for use on pocket PC.

The whole information can also be used for the dissemination and promotion of geological heritage, so a map interface has been developed to make it accessible on Internet. The web-mapping tool used (Google Maps API with extension GoogleEarth) allows to enhance an interface of intuitive navigation for various additional features offered by advanced Internet Mapping.

S1-13 Poster Martinelli, Giovanni

10.1474/Epitome.04.0983.Geoitalia2011

GOOGLE MAPS MASH-UP FOR PETROGRAPHY, MINERALOGY AND PALAEONTOLOGY

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Key terms: mash-up; GIS; geographic data; image management; javascript

Google maps is a very popular WEB 2.0 application for mapping geographic data. Mash-up is a javascript-html programming language for the customization and data integration of the Google maps frameset. Google maps mash-ups, developed initially only for G.I.S. (Geographic Information Systems) applications have since been utilized for scientific image management. The need to superimpose geo-referenced raster images on Google Maps has prompted some developers to produce specific free applications to generate tiled image pyramids for these pictures e.g. Maptiler, GMap Image Cutter and Mapcruncher. This made it possible to give each image two new features: the option to zoom to max. resolution of the picture and to associate each pixel with a pair of coordinates as in a geographic map. Initially these packages were used only for G.I.S purposes but they have recently been applied to different images such as photos of paintings (The Kremer Collection of art/) and big photo collages and panoramas (see webworks of Marcus Dressen, Kalle Hagman, Blaubo Design) with the possibility of sharing over the web. Recently Google realized the potential of this approach, promoting the Art project: a virtual tour of some of the world's most important museums (but only from an artistic viewpoint and without explicit use of coordinates) and new dedicated packages are soon to be distributed to web users (e.g. Iipimage) for the new Google map V3 standard. These functions were previously available with a technology named Zoomify which permitted pyramid tiling of images but not coordinate attribution (at least in the free software version). Like the art images, scientific ones too such as T.E.M., S.E.M. images, microfossil photos and pictures of petrographic thin sections can be shared on the web in G.I.S modality with a Google Mash-up adopting the above-mentioned procedure. Results appear interesting both for didactic and scientific purposes in the field of Earth Sciences. In particular, image data, previously not really accessible, and now complete with detailed and localized information, can be made visible over the WEB. This can represent a new resource for the scientific community and a new cultural platform for sharing scientific information. Some examples developed with Google Map V2 scripts can be downloaded at the web address http://sciuto.yolasite.com/dwnld_4_v2.php

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S1-14 Poster Ferretti, Paolo

10.1474/Epitome.04.0984.Geoitalia2011

PROPOSAL FOR A GEOREFERENCED DATABASE OF MINING AND MINERALOGICAL SITES IN THE TRENTO PROVINCE

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Key terms: mining sites; mineralogical sites; Trento Province; georeferenced database; cultural heritage

The Provincia Autonoma di Trento owns an important heritage both of mining sites (that can be traced back to the prehistoric period) and of mineralogical sites (hanged out by scholars and mineral searchers since the end of 18th century).

Geodiversity is documented by over 200 mineralogical species, 5 of which have their type locality in the Province: pectolite, dachiardite-Na, chabazite-Ca, gehlenite and celadonite.

The mining activity in Trentino can be studied both by means of documentary and archaeological sources.

The first European mining law, the Liber de postis Montis Arzentarie, was drawn up by the Prince-Bishop Federico Wanga in his Codex Wangianus: it governed the extraction of the argentiferous galena in the Monte Calisio plateau, north-east of Trento, in the early XIII century.

Some evidences of metallurgical activities of the Copper Age, indirectly testify that the mineralogical deposits of the Province were exploited since the prehistoric period; the material traces of the mining activities performed during medieval times are also impressed in the landscape, where drifts and pits can be studied also by remote sensing (e.g., LIDAR survey).

More recent exploitations are clearly evident and well documented, for example in the archives of the mining societies that operated in the region until the 60s-70s and in some cases even beyond (the last mine was definitely closed in 2009 - in Darzo, Valle del Chiese).

The end of the modern extractive activity, the security measures implemented in open galleries and pits and the vegetation recapture of the working sites, produced a rapid loss of the material traces and of the historical memory of this important chapter in the socio-economic history of the Trento province.

This progressive disappearance of the mining activities and the reduced presence of mineral searchers in these particular sites, makes the creation of a dedicated archive relevant.

For this reason the Museo Tridentino di Scienze Naturali have launched a specific project with the aim of collecting all the disposable data concerning mineralogical and mining sites in the Province, focusing on geology, historical and technical aspects, and to the private and public collections of objects pertaining the extractive activity. The latter (from minerals to mining tools) in particular deserve great attention because of the increasing rarity of this kind of data.

The plan is to create a specific 3D georeferenced database taking into account both mining and mineralogical sites but also ore processing sites, museums and private collections and archaeological or architectural evidences that can be linked to the mining sites both geographically or chronologically. To each record a bibliographic, cartographic (maps and historical reliefs) and photographic documentation will be attached, both newly acquired or found in existing archives (museum collections, bibliographic catalogues, websites, public archives).

During this early stage the database is employed only for researches focused on single localities or on specific geological and historical subjects. Afterwards it will be part of the Museo delle Scienze del Trentino (MUSE - Science Museum of Trentino) public activities and, in the online version, will be accessible by external users.

The database might also be relevant in touristic and cultural valorization, providing a new tool to evaluate the scientific, historical and ethnoanthropological relevance of the sites.

SESSIONE S2

Geomatica: il suo apporto alle scienze della Terra

S2-1 Orale Roggero, Marco

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SINGLE FREQUENCY GPS MONITORING OF GLACIAL DISPLACEMENTS: THE CASE OF GRANDES JORASSES GLACIER

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Key terms: GNSS; deformation monitoring; glacier

Short baseline single frequency GPS positioning has been successfully applied in deformation monitoring networks. The reason to use L1 observables instead of L1+L2, it is the lower noise when the differential effect of ionospheric refraction can be neglected, that is the case of very short baselines (few kilometers length). For monitoring purposes also low cost receivers can be used in a dangerous environment, and the proposed technique has been applied since 2008 by Fondazione Montagna Sicura in the monitoring system of the Grandes Jorasses's serac. It is an unbalanced hanging glacier standing above Ferret Valley. The glacier is subject to periodic icefalls which (especially in winter) can trigger snow and ice avalanches.

The current monitoring system consists of poles with prisms placed on the surface of the serac and an automatic total station sited on the valley floor. The major drawback of this system is that fog or bad weather could impair its operation, thus causing loss of information about the serac movement.

For this reason low cost GPS receivers have been installed on the serac, transmitting data with a wireless network and gain high accuracy exploiting permanent GNSS stations. The system is characterized by low

cost (throwaway sensors due to the environment), high precision (mean velocity is about 5 cm/day) self recovery and stand-alone electric supply. The developed network is composed by three slave nodes (GNSS receiver plus PCB) one relay station and one receiving station. The receiving station logs the data in RINEX format closing one hourly file for each GNSS station. The high accuracy is than obtained by means of differential computation using local permanent GNSS stations and Bernese 5.0 software. The slave nodes have been installed on a pole with a prism on its top, in order to compare the GNSS log with the total station measurements.

S2-2 Orale Salvini, Riccardo

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TERRESTRIAL LASER SCANNING IN THE APUAN ALPS MARBLE DISTRICT (ITALY): MULTITEMPORAL MORPHOMETRIC ANALYSIS OF A QUARRY

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Key terms: Terrestrial Laser Scanning; Digital Terrestrial Photogrammetry; Multitemporal Analysis; GIS; Map Algebra

The paper describes the results obtained from the processing of multitemporal topographical data acquired by Laser Scanner, Total Station, DGPS, and photogrammetric surveys, useful for the identification of rock fall phenomena inside a marble quarry in the Apuan Alps (Italy). The assessment of the stability in mining rocky slopes is essential both to ensure safety in the workplace and to evaluate the feasibility of cultivation plan in accordance with regulations.

The study area is characterized by 100 meters high quarry wall dominated by a natural slope and historical dump deposits, locally called "ravanetti". Two underground tunnel portals are present; boundaries among dry-stone wall, marble outcrops and reinforced concrete, which stabilize the portals, represent areas where differential failures could be generated.

Laser scanning permits to get accurate information about the slopes also in inaccessible areas; multitemporal surveys allow to point out zones characterized by rocks and debris accumulation or by fall.

During fieldwork some optical targets were positioned to represent benchmarks needed in the registration process of multitemporal laser scanner points clouds and, together with some evident morphological elements of both anthropic and natural origin, in the orientation of digital images captured for photogrammetric processing. The coordinates of benchmarks and ground control points, relative and absolute, were acquired by Laser Total Station and differential GPS measurements. Five multitemporal laser scanner surveys were done with a time interval of about 2 months one from the other. Laboratory activities concerned multitemporal points clouds processing: the first phase of the work was the editing of the five points clouds in order to eliminate data representing areas out of interest (i.e. anthropic features) and to build the DDSM (Digital Dense Surface Model).

GIS analyses and Map Algebra techniques were applied to compute the spatial difference among the multitemporal DDSM and to evaluate the changes occurred in the study area. In order to overcome the unreliability of the interpolation process in the DDSM creation, strictly connected to shadows in the points clouds, the multitemporal comparison was done only for spatial positions corresponding to effective points of laser scanner clouds.

Afterwards, difference values were classified according to their statistic distribution but also considering both the registration error, the instrument accuracy and the topographic error related to the GPS and Total Station surveys.

High difference values achieved in some areas have well highlighted rock falls occurred during the analyzed period. In different zones, where the multitemporal photogrammetric analysis have not shown any variations, the high difference can be connected to high values of front slope and to the misalignment between different points clouds caused by slightly diverse positioning of the instrument during the surveys. Then, the compared analysis between difference rates and slope values was done in order to verify the effective weight of the points misalignment in the difference calculation. Results confirm that the highest difference values correspond to the most dipping areas or zones where the morphology changes suddenly its direction (quite often considering the artificial origin of the marble quarry front).

Zones characterized by low values of slope have presented differences included in the error range while only a reduced number of isolated points, without a outstanding spatial distribution, have shown a multitemporal difference greater than the threshold: they are due, thanks to the interpretation of the produced multitemporal orthophotos, to the spontaneous vegetation growth.

S2-3 Orale Allasia, Paolo

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INTEGRATED USE OF ROBOTIZED TOTAL STATION AND LASER SCANNER FOR LANDSLIDE MONITORING

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Key terms: Landslide monitoring; Robotized Total Stations; Laser scanner

In the last decades, Robotized Total Stations (RTS) have been widely considered to monitor the evolution of surface displacements due to landslide phenomena. RTS are frequently preferred to other monitoring methodologies due to their relatively simple installation, straightforward operational use and data processing, as well as their limited costs. One of the main disadvantages in the use of RTS is the need to install a network of artificial targets (prisms) directly on the surface of the monitored site. In many landslide phenomena this operation might be very difficult for different reasons: (i) limited access to the landslide area; (ii) problems in defining the landslide boundaries due to poor a-priori information; (iii) large extensions of the instable area. Moreover, when the morphological variations are relatively fast, the prisms may easily go outside the suitable range of the instrument or even fall down. Thus, the retrieved displacement time series might be often not well representative of the landslide evolution. In these cases, new generation RTS allowing a monitoring in modality "laser scanner" (thus without the installation of

prisms) can be very helpful. In this work, we present a case-study where the RTS Topcon IS has been installed to monitor the headwall sectors of the Montaguto landslide, a large earthflow located in Campania, southern Italy. We used the Topcon IS to monitor continuously a network of prisms with sampling rates of about 2 hours. Moreover, since this instrument can work also in "reflectorless mode", we use periodically its laser scanner facilities to generate multi-temporal DTMs. Our first results show the effectiveness of considering of an integrate analysis of surface displacement data provided at points in zones where their installation is possible and over areas where the installation of targets is difficult and/or even precluded.

S2-4 Orale Lanteri, Luca

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BEEGIS: SOME NEW FEATURES FOR FIELD MAPPING DEVELOPED IN RISKINAT PROJECT

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Key terms: Tablet PC; field survey; digital mapping; open source; GIS

One of the main goals of the Geological Department of Arpa Piemonte (the Regional Agency for Environmental Protection) is to set and to update the framework about the hydrogeological instability in the Piemonte region. In order to constantly maintain an efficient and up-to-date inventory the field survey work is a matter of utmost importance. Particularly, when a heavy-rain event occurs, the surveyors must collect a great amount of data, often scattered in a wide areas, in as short a time as possible. New GIS technology coupled with the improved performance of the next generation of portable hardware allows to have effective tools that aid to simplify and speed-up the field work.

As result of a early testing phase of the different available hardware products (mainly PDA vs tablet PC) rugged tablet PC results as the most efficient tools for this specific work. In this first step also different commercial software was tested. As a consequence of the limitations due to the commercial license, and following the indication of Regional Law n. 9 of 26 march 2009, that recommend to privilege the use of open-source software, ARPA had choose to join the BeeGIS community.

BeeGIS is an open source GIS software for field mapping conceived for pen computer working with any common operating system (Windows XP, Vista and 7, Mac OS, Linux). This software is developed mainly by Hydrologis, an environmental engineering company with extensive experience in Java-based GIS, in collaboration with LINEE (Laboratory of Information Technology for Earth and Environmental Sciences of Urbino University).

BeeGIS is a plugin of Udig, an open source (LGPL) desktop application framework, built with Eclipse Rich Client (RCP) technology. Several new tools were designed ad hoc in order to create an efficient and user friendly tool for professionals who may have a limited knowledge of GIS and who want to minimize the learning time for new technologies.

A particular attention was made to preserve the traditional methods for mapping, while replacing the pencil and the paper (map and field book) with a digital stylus and touch-screen. All conventional GIS features can be used directly during survey, as using different topographic maps and orthophoto and overlapping several different data layers. In addition the surveyors have at their disposal some tools who drastically simplify the field work, such as: a real time GPS positioning, the geonote to catch georeferenced note and sketch, a fieldbook to organize and search the geonotes and the annotation tool who allow to draw over the map as in the paper-based cartography.

Currently the developing of some new features and the improving of the existing ones is included into RISKINAT, a strategic Italian-French Interreg European Project. Particularly a new feature, named form editor, allow anyone with few knowledge of digital work to create and to manage their own survey forms. This tool is particularly useful for project that needs a prearranged forms to store data with standard structure, especially when there are more than a single surveyor. Moreover a new style editor that support SLD (the OpenGIS Styled Layer Descriptor format) has been developed, a complete library of geological and technical symbol is going to be created coupled with an exhaustive user guide. Also a lot of minor improvements and bug fixing are done.

Thanks to the LGPL license, BeeGIS can be distributed without limitation both to all project partners and others users. Therefore one's contribution can be shared to all scientific community.

S2-5 Orale Oggioni, Alessandro

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SOS IN ACTION: VARIOUS FIELDS OF APPLICATION

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Key terms: Sensor Web Enablement; Spatial Data Infrastructure; sensors

The Sensor Web Enablement has indicated a set of rules that allow the integration of sensors and the observations they detect within a Spatial Data Infrastructure. The SWE services have changed the way of expose and share data collected by distributed sensors, as at the moment they constitute the only actual opportunity for a standardized and interoperable spread of observations. In fact sensors of various types (fixed, mobile, in-situ and not in-situ) can be registered, observations on time series or representatives of bi- and three-dimensional domains can be shared, and finally access selected by either geographical, or time instance or time range, and concerning one or more Properties or Procedures can be performed by getObservation operations.

In this work are presented some experiments concerning the possibility to use the Sensor Web Service in different sectors (meteo-hydrology, biology/ecology, physics, chemistry and remote

sensing), introducing the possibility of using requests like RegisterSensor, InsertObservation and GetObservation, assessing the critical aspects, gaps or points of force, and finally test the interoperability within different clients.

S2-6 Orale Cipolloni, Carlo

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HARMONIZATION AND INTEROPERABILITY OF THE GEOLOGICAL SURVEY OF ITALY DATABASES

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Key terms: OneGeology; GeoSciML; Standard; Geological Map; CARG

The Geological Survey of Italy has applied the Geoscience standards (GeoSciML 3.0) to some national cases deriving from the experience developed during the realization of the OneGeology-Europe project and in the use of GeoSciML as member of the Interoperability Working Group of IUGS-CGI.

Geological information are achieved from several databases, such as the one derived from the Geological Map of Italy at 1:1,000,000 scale (GeoIMDB, Cipolloni et alii, 2009) based on its explanatory legend, where each feature is related to the geologic units information (i.e. lithology, chronostratigraphy, orogenetic phase, geologic event, tectonic event, tectonic structure, depositional environment, petrography, metamorphic grade, metamorphic phase).

A further database is the deep borehole DB in which the available geological information consists of lithology, formation description, chronostratigraphy, biostratigraphy, etc.

Another specific application of the data model has been pointed out on the Italian Geological Cartography Project (CARG project) database; these data are more detailed and plentiful; we decide their use for testing the detail case model and/or in other part of the GeoSciML model that aren't evaluated in the lower scale data.

Following the semantic structure defined by the "1:1M pan-European Scientific Data Specification, Identification and Sourcing" realized by the specific working package (WP3) of the OneGeology-Europe project, we are working to harmonize the GeoIMDB, particularly on definitions (lithology - chronostratigraphy) and structure of the surface geology.

The data model is mainly developed on the GeoSciML schema version 2.1.1 that represent the geologic schema used into OneGeology-Europe project that, probably, will represent the model for INSPIRE Data Specification - Annex II. In this model each feature require terms and definitions, referred to existing definitions and standards. A major basis for the Data Specification work come from the GeoSciML scheme and the CGI/GeoSciML vocabularies.

In order to match the local terminology versus the harmonised vocabulary we have created some bridge tables where all the local information are reconfigured to international ontology. An important challenge is represented by a new testbed that use the geologic data integration model made by ESRI that easily re-create a compliant model.

The access to geological datasets is settled as web map service (WMS) and web feature service (WFS) using a specific Java-connector, developed by BRGM for the OneGeology-Europe project; this connector allow us to configure a OGC standard WMS (1.3) and WFS (1.1.0) to INSPIRE data sharing service in multiple-language and in GeoSciML response.

At the moment our web map service is available in different format to spread the user's accessibility; the metadata of data and services are stored in multilingual format, according to INSPIRE rules, in two different metadata catalogues, accessible from the OneGeology-Europe portal (<http://www.onegeology-europe.eu>) and the Geological Survey of Italy portal (<http://sgl.isprambiente.it/geoportal>).

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S2-7 Invitato Bovolenta, Rossella

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A 3D MODEL IN GIS FOR THE ANALYSIS OF A KINEMATIC PHENOMENON IN LIGURIA (ITALY)

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Key terms: LANDSLIDE; GIS; MODELING

The present paper deals with a 3D model in GIS, realised in order to study a diffused and continuous kinematic phenomenon in Santo Stefano d'Aveto (Liguria - Italy).

The extensive area of interest (almost five square kilometers) is sited on a top-valley gentle slope (mean angle 11°), which downgrades directly from the south-side faces of the Northern Apennines summits locally arriving at 1800 meters a.s.l. From the geological and morphological points of view, the entire area was formed by a pliocenic glacial till and its body of widely assorted sediments had been reckoned as a large relict landslide.

The loose-soil thickness spans from few meters up to 90, before of reaching the bedrock formations. The seasonal rain/snow falls on the watershed represent the main trigger actions on the soil body's behavior. In consequence of the widespread and locally differential movements at ground level, many buildings and structures exhibit such damages that most of them are in constant need of repair.

Since the wide landslide is influenced by the interaction between water and soil, the creation of a 3D model, integrating the digital terrain model (DTM), the water table and the bedrock, is particularly effective for the stability analyses. The model has been implemented in GIS, which is an useful tool for the integration and analysis of georeferenced information for the territory monitoring, management and planning, also in support of risk analyses. GRASS (Geographic Resources Analysis Support System) has been chosen. It is a free and open source GIS, whose main feature is to allow the usage of existing algorithms and procedures, as well as the integration of additional features that can be returned to the community with the same characteristics of reusability.

In the work, all of the relevant data, yet available for the site under study, have been collected and examined. They are represented by the geotechnical - geophysical characterizations and monitoring, the topographical - GPS surveys and the results of a satellitar interferometry analysis. A full georeferenced integration of the raster, vector and spot

informations have been obtained, making possible the study of their intercorrelations. More than that, this first phase of implementation has been of great help into choosing the on-site positions where additional investigations have to be carried out, in order to obtain a proper dataset cover on the whole area.

The results attained by this research, which is still in progress, are represented by the 3D modeling of the phreatic surface and the loose soils' thickness for the overall area. This has been obtained by rather simple correlation techniques and interpolation procedures, applied on specific geophysical and hydrological measures collected on-site for these very purposes.

Great advantages are established by such an integrated working platform. In fact, the final objective lies into make possible to easily conduct classical, but widespread, 2D slope stability analyses, or better, apply non-standard 3D simulations on this micro-territorial complexity. A yet planned further development is to simulate the evolutions of the phreatic level by modeling the whole sediments' body as a charging-discharging subsurface reservoir, feeded from selected rainfall histories. To carry out this capacity, a proper description of the site rainfall-runoff response capacity is needed, and this may be attained using an overall Curve Numbers' grid, whose values may be scored, mostly, from the observation of the site's georeferenced satellitar images on the GIS interface.

The presented results are promising, because it seems that a challenging 3D physical modeling is today possible by GIS integration. It shall allow both a more proper land use planning and the correct placement/design of accurate rehabilitation measures.

S2-8 Invitato Cosso, Tiziano

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THE GEOGRAPHIC INFORMATION SYSTEM OF THE PROVINCE OF LA SPEZIA FOR THE MANAGEMENT OF THE PATH NETWORK

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Key terms: path network; WebGIS; Open Source

The Province of La Spezia, in the activities of informatization of the PA, has organized the implementation of a provincial information system of footpaths;

object of analysis is therefore complementary and alternative road network for hiking and civil defence.

According to what is already tested in terms of cadastre roads ex Legislative Decree 285/92 and Road Information System, information on the entire system of footpaths provincial ((CAI, REL, other paths mapped etc.) will be usable in the logic of paths information system, that is thematic, yet fully integrated into the provincial DataWarehouse designed to collect and make available all the resources available to the provincial S.I.T.I. Web community.

This helps to make accessible and connectable information to different ownership in an integrated organizational context in which each operator is the supplier of information produced by himself and user of the information generated by others, with the possibility of deriving more, by free combination and intersection.

The system shall be based on G-PASTRO (Gter - Path System Accessibility Outliner Tracks) which is the engine of the GRASS GIS environment and GisClient platform for the management of Web interfaces that can be created ad-hoc to interact and update the system; to store the data will be used PostgreSQL and PostGIS spatial extension.

In particular, GIS is used for proper and efficient planning and management of maintenance activities of mountain environments, besides as a support for any rescue operation.

The implemented features allow you to:

obtain elevation profiles and travel time along any stretch of the path network;

obtain elevation profiles and travel time along a path that is not included in the path network (useful for planning and managing research missing, often in areas not covered by paths);

automatically evaluate how the current trail network covers the territory, being able to identify where and by what route to create new sections of trail by the criterion of minimum energy;

store and update in a single DB all information relating to the conservation status of both trails and shelters, to plan and manage maintenance;

integrate information on the network footpaths with other data related to morphology of the land and the sources of risk (landslide areas, river network,) burned areas to assess when and where specific interventions of maintenance and possibly changes to current network;

integration with access points that can be used by emergency vehicles (jeep, helicopter,....).

The application is developed open source environment and can therefore be adapted to meet specific needs. In particular, it is already designed an interface for manipulating individual parameters to calculate the travel time, so you can easily and quickly adapt to different types of people (young / old man / man / woman,.... ..).

S2-9 Orale Molinari, Monia Elisa

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GIS-BASED CALIBRATION OF THE LANDSLIDE MODEL MASSMOV2D

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Key terms: landslide; model; calibration; GIS

MassMov2D (Begueria et al., 2009) is a numerical model for simulating run-out and deposition of landslide phenomena over a complex topography; the software, based on Saint-Venant equations (Navier-Stokes equations under shallow water assumption) with the integration of rheological models for the flow behavior control, is implemented within the free GIS PCRaster; currently the porting of the code into GRASS GIS with GPL license is under development.

During this research the model has been applied to the case study of the "C" instability: a complex landslide located on the left slope of the Canaria stream. In case of failure the mass accumulation would probably generate a natural dam that, if collapsing, would consequentially produce a flash flood. This may severely damage the population and the transport infrastructures (highway, main road and railway) of North-South axis of San Gottardo, with consequent high economic losses.

In agreement with the exposed scenario, a partial failure involving a volume of 350000 m³ happened in 2009; fortunately in this case the damages were limited. Thanks to a monitoring program performed with traditional survey techniques and terrestrial laser scanning, high resolution (1m) digital elevation model of the area before and after the collapse was available.

This research improved the MassMov2D code introducing the Nash-Sutcliffe model efficiency coefficient calculation in order to enable the semi-automatic sensitivity analysis and calibration that may replace the inefficient 'trial and error' approach that has been used for this model.

Here the authors want to illustrate (i) the mathematical model foundations, (ii) the sensitivity and calibration process with the obtained results and (iii) the hazard assessment analysis results. Moreover, the porting of the model to the GRASS GIS will be illustrated and presented. It has to be noted that the hazard analysis has been performed by applying the calibrated model to different future expected failures scenarios; all the analyses steps, with exception of the modeling, have been performed taking advantage of the GRASS GIS processing features.

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S2-10 Orale Marzocchi, Roberto

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SIMULATION OF DAM BREAK WITHIN THE GIS GRASS

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Key terms: dam break; flood hazard delineation; risk assessment; GIS

A Dam failure is a technological disaster of particular concern. In fact it could happen for several causes (overtopping of embankment, faults in construction methods, geological problems of foundations, landslides and earthquakes, etc.) and it has the potential to cause more death and destruction than the failure of any other man-made structure.

One of the main phases of the dam break risk management is constituted by the flood hazard delineation. To this purpose, we have developed a new numerical model for the solution of the two-dimensional dam break. It solves the conservative form of the 2D Shallow Water Equations (SWE) using a Finite Volume Method (FVM); the inter-cell flux is computed by one-side upwind conservative scheme extended to a two-dimensional problem.

We have implemented it in the GRASS GIS as a GIS embedded module (r.damflood), in order to taking advantages of the GIS features for risk assessment and emergency planning.

Aim of this work is to verify the model implemented in GRASS (Marzocchi & Cannata, 2009) and enhance the algorithms by adding controls and auto-calibration procedure able to guarantee numerical stability of the solutions. A new case study has been applied to verify the sensibility of the model to different grid spatial resolutions. Latest enhancements and results regarding the r.damflood model are here presented.

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S2-11 Poster Bacenetti, Marco

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GEOMATIC TECHNIQUES CONTRIBUTING TO UNDERSTANDING GEO-MORPHO-STRUCTURAL ASSESSMENT OF VENEY VALLEY (COURMAYEUR, AO)

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Key terms: pocket - PC; LiDAR; Coltop 3D; Close range photogrammetry; Geomorphology

The present work is orientated at the comprehension of the geomorphologic processes of periglacial environment past and on going of Veneý valley (Courmayeur, AO) and their interaction with the morpho-structural setting through geomatic techniques. Previously studied sectors within the project area with large quantities of data were integrated and compared by detailed research within sectors of scarce pre-existing field data.

First, the field data were collected using pocket-PC and integrated GPS in order to create an ESRI-GIS based geodatabase. Considering that the area was setting in an alpine context, stereoscopic models from the '97 and '03 flights with a 4 m precision were built to map geomorphological features in unaccessible area. Contemporaneously, to support these data, LiDAR '08 images were processed to include hillshade, slope, and aspect maps. Two areas of keen geomatic interest were individuated: the potential failure surfaces of the Mont Rouge de Peuterey and the Miage glacial basin. Using the Coltop 3D software, kinematic analysis of the data were performed using the Markland test. The software allowed also, through back-analysis, the determination of main areas of potential gravitational instabilities. MIVIS '99 images analysis allowed to classify the debris cover of Ghiacciaio del Miage and detected the potential rock instability using the Principal Component Analysis (PCA). On the same slopes close range photogrammetry was performed to measure joint sets setting.

Data interpretation yielded to obtain three geomatics layer: a) geomorphologic, within mapped landforms b) morpho-structural, concerning the structural evolution c) debris cover of Miage glacier, for the multitemporal analysis.

The remote sensing technologies, applied in this project, showed to be

more affordable than the usual field-based approaches, in the prespective of a safe analysis of stability conditions in mountainous areas.

S2-12 Poster Damiano, Elisa

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INTEGRATION OF FIELD SURVEYS AND GEOMATICS METHODOLOGIES FOR THE ANALYSIS OF SAN MARTINO SULLA MARRUCINA LANDSLIDE (CENTRAL ITALY).

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Key terms: Landslide; geomatics; multitemporal analysis

The purpose of this study is to achieve an understanding of the failure mechanism which caused a large landslide in San Martino Sulla Marrucina (SM) municipality (Chieti Province, central Italy).

The gravitative event occurred during the spring 2001 and it quickly affected many buildings and infrastructures of the urban center and is located nearby the main road connecting all villages in the valley. The landslide evolution has been characterized by a continuous activity (from 2001 to 2004), which caused the formation of a main crown 20 meters high and 1.5 km long. After this phase, the surface displacements have been less prominent, and nowadays the landslide is considered almost quiescent.

In this work, we aimed at investigating not only the structure of the landslide but also its potential triggering mechanisms. We considered several techniques, ranging from field surveys to surface displacement monitoring (GPS and airborne LiDAR), traditional stereoscopy and advanced geomatics methods (GIS spatial analysis, Digital cross-correlation techniques). Besides, thanks to Geographic Information System (GIS), a multitemporal approach has been carried out to reconstruct the main geomorphologic and topographical changes, occurred on the slope during the last eighty years.

The results achieved with this integrated study suggest that the SM landslide is actually a local reactivation of a wider quiescent landslide and that doubtless, his morphological evolution is characterized by a retrogressive trend. Furthermore, it has been inferred a preliminary geodynamic model based on a deep kinematic conditioning. This data will allow investigating the landslide susceptibility of the whole municipality territory and will represent the base for future risk evaluations.

S2-13 Poster Giuliani, Andrea

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TRIDIMENSIONAL DIGITAL MODELING OF THE PESTARENA GOLD MINE (PIEDMONT - NORTH ITALY)

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Key terms: Gold mine; 3D modeling method; Reopened dismissed site

Introduction

Among all conventional metals subject to a progressive increase in value in the international market, gold has jumped powerfully into the spotlight during all economic crises, which affect both developed and emerging Countries.

This contingency has led to reconsider the dismissal process for some Italian mining sites, occurred in last decades for many metalliferous mines, among which a very particular situation is the case of the gold mine Pestarena.

This mine site, placed in the north of Piedmont (Macugnaga - VB), is developed on an area of 4 square kilometers through about 40 km of tunnels.

From a mining point of view, the ore-body in Pestarena is characterized by the presence of significant gold-bearing grades in the mineralized rocks, but that is organized in filonian rock structures of small dimensions and complex geometry, not so easy to reconstruct from the surface.

This aspect makes very difficult to assume a profitable method of exploitation without a whole prospection of the ore-body, pursuing the goals of safety and sustainability of the yards.

Working method

In order to better understand the geometric relationships that link the different levels of the Pestarena mine, it was necessary to digitalize the only still existing mining plan, updating at the end of 1960; the operation has proved difficult due to the physical size of the document.

The digitization of the available data has been divided into different steps:

1. Reproduction in electronic form of paper mine plan (three meters long) through a professional scanner and its post-processing elaboration with a computer graphic software in order to zip the achieved files;
2. Ortorectifying and georeferencing on the UTM-WGS84 coordinate system of the cartographic base obtained with a specific software (ArcGIS 9.2 - ArcMAP), in order to place all the mining yards in the correct position in relationship with actual topographic maps;
3. Digitalization point by point of the main excavation voids in Pestarena mine (Morghen, Adit-Acquavite, Calpini, Tredici e research levels) by means of the creation of a point shapefile for each level and each descendency reported on the map (30.000 points in total);
4. Semi-automatic quotation of progressive altitude values for each beated point and realization of TIN for the foot-wall of each mining levels;
5. Plot of all TINs in tridimensional view thanks to a dedicated software (ArcGIS 9.2 - ArcScene), with the visualization of foot-wall, roof and walls for each tunnel.

The whole process led to the creation of a digital map of the Pestarena mine, with its three-dimensional model of all mapped levels. This tool has proven to be necessary for the understanding of spatial relationships between the surface topography above and the mine elements, also thanks to the redefinition of the nomenclature of the 34 levels that in some areas were difficult to detect because of repeated overlapping.

Conclusion

The help furnished to the Company that held the mining concession, allowed to plan the terrain surveys based on new criteria that represent a more deep geo-mining grade of knowledge planning only some technical operations environmental-friendly.

The research work has covered a valency of potential interest for the

manufacturing sector and, in any case, for a type of mineralization widely studied, but not well known from the practical point of view, also because it was possible to find only extraction yards conducted in the past with limited equipments by men guided by instinct instead of science knowledge.

S2-14 Poster Perotti, Luigi

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MULTITEMPORAL STUDIES OF ORCO VALLEY GLACIERS USING GPS AND PHOTOGRAMMETRIC TECHNIQUES APPLIED TO GEOMORPHOLOGICAL HAZARD ASSESSMENT

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Key terms: Glaciers; Geomatics; Hazard; Multitemporal

The alpine glacial and periglacial areas are difficult to be studied because they are impervious and they often lack of data. The dynamics of that areas need appropriate techniques for the collection, elaboration and representation of information.

The purpose of this work is the multitemporal analysis (last fifty years) of the evolution of some glaciers of the Western Alps, set in the Orco Valley, using suitable geomatic techniques applied both to remote sensed and to field data. The interest for reconstructing changes in glacial and periglacial areas is the high velocity of change of the geomorphological landforms and glacial mass extent in the valley: as a consequence, critical situations can arise where anthropic activities are located close to glacial and periglacial areas (dams, winter and summer touristic attractions, small towns).

The multitemporal assessment of variations of glaciers area and volume is performed by field work and by the application of digital photogrammetric techniques. The field work is carried out through a pocket pc with integrated GPS: this tool allows a precise contouring of glaciers and a precise positioning of the snout. Longitudinal and vertical profiles of glaciers and proglacial areas are obtained through a GPS campaign.

Using geomatic applications, stereo couples of aerial photographs from different years, have been digitalized and elaborated by mean of a photogrammetric system. A multitemporal aerial triangulation minimizes errors from the model, as photographs of different periods are put all together in one block. Ground control points have been implemented thanks to the GPS campaign in the field. As output, different cartographic products, as Digital Elevation Models, orthophotos and longitudinal and vertical glaciers profiles, are obtained.

The creation of Digital Elevation Models to calculate variations of elevation on glacial surfaces, permitted to notice significant variations of glacial masses and a thickness reduction of several meters from 1954 to 2000, in agreement with field observations reported on annals of the Italian Glaciological Committee. Moreover, graphical elaborations of topographic data, such as slope and hillshade maps, allow to identify factors which are associated to instability prone areas.

The present work is carried out in the framework of CNR-IRPI activities for the Alcotra 2007-2013 project N. 056 "GLARISKALP".

S2-15 Poster Salvini, Riccardo

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TOPOGRAPHIC AND GEOLOGICAL MAPPING OF USAKLI HOYUK (TURKEY) HITTITE SITE

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Key terms: High Resolution Remote Sensing; Stereoscopy; Topography; Geology; Spectral Signatures

Usakli Hoyuk, in Central Anatolia, is a Hittite site that was the focus of archaeological surveys by the University of Florence since 2008, after hittitologist O.R. Gurney identified it, in 1995, with the old sacred Hittite city of Zippalanda, cultural centre of the Storm God. The evidence came by epigraphic sources and its importance was based on some considerations obtained during the survey carried out by the Turkish METU University relatively to the close Kerkenes Project.

In order to aid the archaeological researches, a geological survey was carried out with the goal of producing the new geological map at the scale of 1:10,000.

A fieldwork was done to define the chronological development of the region and to recognize the geological and geomorphological structures useful to rebuild the ancient landscape controlling the archaeological settlements. The analysis of the geological setting was also functional to the identification of raw materials exploitation sites and path routes, cited in some ancient sources, which connected the Hittite capital of Hattusha to all the cultural cities of the surrounding areas.

The study area constitutes a perfect area to apply remote sensing techniques: since the region was unoccupied from a longtime, it is still unexcavated and the close connection with other important cultural sites in the vicinity can be well pointed out.

A GeoEye stereopair was properly acquired for the project in a way to have a multispectral image covering an area of about 100 km² with a spatial resolution of 0.5 m. GPS measurement of rock outcrops, morphological features and ancient sites was the core of preliminary fieldwork activities. The acquisition of topographic GCPs (Ground Control Points) and the processing of their tridimensional coordinates allowed, together with Rational Polynomial Coefficients, the external orientation of the stereopair.

Afterwards, digital satellite photogrammetry techniques permitted the stereorestitution of the topographic map at the scale of 1:10,000, the production of the DEM (Digital Elevation Model) and the orthophoto.

The DEM was helpful also for the interpretation of relevant geomorphological data related to the present landscape, to probable ancient scenarios and to site connecting paths.

During fieldwork, more than 100 geological and geomorphologic ground truths were surveyed and almost 100 rock samples collected for petrographic and micropaleontological analyses.

The new topographic map was used as reference cartography. All the geological outcrops surveyed were photographed, described and their

position coordinates recorded by a GPS.

In the southern part of the study area mainly granitic stones, belonging to the Yozgat Batholith, outcrop. The granitoids are overlaid by volcanic, clastic and calcareous Eocene deposits. To the North, the Neogene clastic sediments, mainly constituted by sandstones, marls, conglomerates and breccias, represent, together with limited Quaternary alluvium, the youngest rocks outcropping in the zone.

The archaeological site is located within Eocene rocks near the fluvial deposits of a small stream tributary of one of the main rivers of the area WNW- ESE trending.

On the southern side of the Tell which identify the site, an area of about 800 m² was surveyed using the FieldSpec 3 Full Range[®] Analytical Spectral Device in order to collect spectral signatures of land cover.

Superficial spectral signatures are being compared with results achieved by the automatic extraction of linear features and by the stereointerpretation of the satellite imagery in a way to recognize possible ancient buried remains. The position of the surveyed sites on the Tell was chosen in accordance with results from contemporary and previous geophysics studies.

Moreover, around the Tell area, spectral signatures of stones were recorded with the aim to create a geodatabase to be compared with spectral signatures of rocks coming from surrounding areas source of ancient quarries.

S2-16 Poster Vassena, Giorgio Paolo Maria

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AN AUTOMATIC APPROACH FOR 3D VOLUMES EXTRACTION BY TLS

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Key terms: volumes evaluation; laser scanner; reconstructor

The paper deals with an automatic system able to extract volumes from deposits of material. The system is composed by a TLS (Terrestrial Laser Scanner), protected by a climate box and remotely controlled by internet. The system is able to monitor automatically the volumes and the variations of volumes in the time.

The TLS is controlled thanks to the software JRC 3D Reconstructor, and the volumes evaluated thanks to an algorithm that creates from the scans a 2.5 D mesh and DTM.

The system is realised so to manage, in the same time, up to 4-5 TLS. The laser scanners acquisitions are automatically registered, and the 2.5D model is automatically extract. The system presented is one of the first systems, using TLS, where the information needed (the volume of the stockpiles) can be obtain automatically by the end user, without the support of an expert surveyor.

S2-17 Poster D'Eramo, Luca

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HIGH RESOLUTION SATELLITE IMAGERY AND FIELD SURVEYS TO MONITOR CHESTNUT INK DISEASE

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Key terms: IKONOS; NDVI; Supervised Classification; Phitophthora cambivora; Castanea sativa Mill

Chestnut ink disease, caused by Phitophthora cambivora, is one of the most dangerous and deadly pathologies afflicting chestnut trees. During the last decade, an outbreak of this phytopathology was recognized in southern Piedmont. This pathology causes considerable economic losses and prevent the development of new chestnut groves (Castanea sativa Mill.).

To monitor the disease extension inside the area of Comunità Montana delle Alpi del Mare (Cuneo province) was adopted a methodology combining high resolution satellite imagery and field works. We used the municipality of Robilante as test site. After a preliminary survey to identify some sample areas within ill/healthy plants, a second field work was done to acquire plant positions using a total station and a double frequency GPS. The global accuracy of data acquired has been estimated around 5 cm. Subsequently, the points collected have been reprojected onto a IKONOS image. Launched in 2000, IKONOS satellite is composed by one panchromatic band and 4 spectral channels (red, green, blue, near infrared), with a geometric resolution of 1 m and 4 m at nadir, respectively.

As known, the photosynthetic activity of plants is better observed within the red and the near infrared bands, using the Normalized Difference Vegetation Index (NDVI). After the radiometric calibration, from digital number to reflectance, an atmospheric correction was applied on image (dark subtraction). The area covered by chestnut groves were extracted from a NDVI mask, using ancillary information coming from the chestnut database realized by the agency cited above. The collected field samples were split into two groups. Using one of these sample, we test the efficiency of three different supervised classifications i.e., minimum-distance, parallelepiped, and maximum likelihood, to evaluate the best method able to highlight the spread of disease. During the first attempt, the sample used was estimated too less representative and meaningful. Thus, more chestnut areas, extrapolated from database, were introduced into classification process. After several tries, maximum likelihood algorithm was estimated as the best classificatory method.

Thus, the maximum likelihood classification has been applied on second sample, using confusion matrices to validate the procedure. The overall accuracy of methodology was confirmed by 85,4 % of properly classified plants (ill/healthy trees). Concluding, we can say that the methodology proposed can be very helpful to monitor the spread of this pathology. The high geometrical resolution of IKONOS images permits to check the health status of each plant over time, if a multitemporal monitoring is carried out. The main disadvantages are related to high acquisition costs of IKONOS imagery, and long time needed in acquiring a representative sample suitable for classification. In the future, it is planned to apply a topographical correction to IKONOS data, in order to reduce classification errors induced by different lighting conditions, and test the capabilities of other satellite such as SPOT or ASTER, which may represent a good compromise between data quality and acquisition costs.

S2-18 Poster Zamparutti, Paolo

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THE MIAGE GLACIER: GEOMORPHOLOGICAL MAP AND STUDY OF THE DEBRIS COVER USING DIGITAL PHOTOGRAMMETRIC TECHNIQUES AND REMOTE SENSING

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Key terms: Miage Glacier; Remote sensing; Photogrammetry; MIVIS; Debris cover

The aim of this work is the geomorphological study of the Miage Glacier (Aosta Valley, NW-Italy) by means of fieldwork, photogrammetric and remote sensing techniques. The fieldwork campaign was done during 2008-2009 summers using a pocket-PC with GPS. Using orthophotos and LIDAR DEM as a support to the cartography, a geomorphological map of the whole Miage basin and a glacier-cover map, both at the scale 1:10000, were created. The photogrammetric analysis was conducted on two flight series: RAVA 1997 and Ghiacciaio 2003, stereoscopic models were built with a 4m precision. The displacements of 18 large rock-blocks were evaluated for years 1997-2003-2006-2008 intervals, data for 2006 and 2008 were taken respectively from orthophotos of Ministero dell'Ambiente and LIDAR DEM. An estimation of the velocities for the glacial mass was performed for the interval '97-'06, giving ~50m/y for the upper part and ~10m/y close to the glacial fronts. The areal size deformation of the debris-cover units due to the ice mass flow has been evaluated. Short and strong climatic-induced variations on bédère and ice-cliff were also noticed. MIVIS images analysis allowed to classify the debris cover of Ghiacciaio del Miage using the Principal Component Analysis (PCA). An interpretative map of the whole basin, comparable with that by Deline (2002), but larger, was then created. Integration of all collected data inside a geographic information system allowed to understand that the origin of the debris cover is localized where glacial dynamic, tectonics, geographical settings and local climate strongly interact each others for producing rock material. While on the glacier surface the material is subjected to extensive translational, longitudinal, lateral and vertical processes due to the ice mass dynamics. The use of new technologies supported the integration of the data collected and their geomorphologic interpretation.

SESSIONE T1

Geologia Medica

T1-1 Orale Grendene, Francesca

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CHEMICAL BASIS OF THE HAZARD DUE TO OCCUPATIONAL EXPOSURE TO CRYSTALLINE SILICA.

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Key terms: Crystalline silica; Pathogenicity; Silicosis; Surface reactivity; Free radical

Crystalline silica polymorphs are highly pathogenic mineral dusts. Prolonged inhalation of most crystalline silica particles causes lung inflammation and development of the acute and chronic granulomatous and fibrogenic lung disease, known as silicosis. Silica is also associated with the development of lung cancer. The International Agency for Research on Cancer has recently confirmed the carcinogenicity of some crystalline silica polymorphs (IARC 2010) although the carcinogenicity was not observed in all workplace circumstances.

The mechanisms of pathogenicity of crystalline silica are still partially obscure at the molecular level. It is generally accepted that "the variability of quartz hazard" is due to the involvement of several properties at the same time and different steps of the multistage process which occurs when the silica particles gets in contact with cells within the lungs. Several studies have suggested that the variability in surface properties may arise from the origin, the mechanical history of the dusts and from a different level of contaminants, associated with the original mineral or acquired during the industrial processes.

In that regard the Italian agency INAIL (Piedmont division) has funded a Ph. D fellowship in order to evaluate which productive division have higher silica exposure hazard, and which cases of silicosis and cancer compensated by the INAIL agency were associated to the exposure to crystalline silica.

This study was focussed on the identification of physico-chemical properties which may be related to the development of silica related diseases in order to better understand the mechanism of silica pathogenicity.

On the bases of the results discussed by Maria Gullo in "The hazard due to occupational exposure to crystalline silica in Piedmont" the samples chosen are: i) clays from the stones division, ii) diorite from the bricks division, iii) silica sand from the glass division and iv) different firebricks from the metallurgical division.

The samples have been characterized by means of different techniques: X-ray diffractometry (XRD) for identification of silica crystalline polymorphs, X-ray fluorescence spectroscopy (XRF) for elemental analysis, scanning electron microscopy (SEM) to evaluate micromorphology and particle sizes. All samples were tested also by means of the spin trapping technique both for their potential to generate HO[•] radicals, via Fenton-like reaction, and COO radicals, through the cleavage a C-H bond of organic molecules.

The results obtained showed that all samples exhibits the typical XRD spectrum of the quartz overlapped to other crystalline phases, probably due to the impurities of the silica samples, as shown by elemental analysis (XRF spectroscopy).

All samples contain particle with irregular shapes, very sharp edges and acute spikes, a morphology characteristic of quartz obtained by grinding, and have a similar, very heterogeneous, distribution of particle size.

All samples show a remarkable activity in free radicals generation. Metallurgical division samples are the most reactive. These findings, although preliminary, are in agreement with the data reported in INAIL database discussed by Maria Gullo, that show a higher number of silicosis in the metallurgical division a possible role of particle-free radical generation in pathogenicity of crystalline silica. Further cellular studies will be necessary to confirm this hypothesis.

T1-2 Orale Gullo, Maria

10.1474/Epitome.04.1004.Geoitalia2011

THE HAZARD ASSOCIATED TO OCCUPATIONAL EXPOSURE TO CRYSTALLINE SILICA IN PIEDMONT

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Key terms: Crystalline silica; Silicosis; productive division

Occupational exposure to some crystalline silica polymorphs causes health damage which are well known in the scientific community. In particular silicosis, the most ancient occupational disease, requires a close attention because of their invalidating consequences for a large number of workers and for a great number of benefits paid by the Italian government agency for the insurance against work-related injuries (INAIL). The International Agency for Research on Cancer has recently confirmed the carcinogenicity of some crystalline silica polymorphs (IARC 2010) although the carcinogenicity was not observed in all workplace circumstances. Numerous studies on several quartz specimens derived from different sources, revealed a high variability in quartz hazard. The origin, the mechanical history of the dust and the different levels of contaminants, either associated with the original mineral or acquired during the industrial processes, have been recognized as important factors in determining its harmful effect.

The consequences of the IARC update was a decrease of Threshold Limit Value (TLV) by the American Conference of Governmental Industrial Hygienists (ACGIH) and the necessity of further studies on the silica hazard raised by the Institutions involved in the healthcare and human safety.

In that regard, the Italian agency INAIL (Piedmont division) has funded a Ph. D fellowship in order to evaluate those cases of silicosis and cancer compensated by the agency which were associated to the exposure to crystalline silica. Main results of this project will be discussed by Francesca Grendene in "Chemical basis of the hazard due to occupational exposure to crystalline silica"

This study was focussed to the identification of the most hazardous productive division in order to identify which division have higher silica exposure hazard, type of silica dusts used and the mechanisms of pathogenicity.

837 known cases of silicosis have been recognized between 1980 and 2007. They are representative of a phenomenon which is in strong decrease thanks to the elimination of silica by several industrial cycles and mitigation of exposure hazard for workers. 444 cases have been analyzed in detail.

The results obtained showed that 43% of the cases occurred in metallurgical activities (foundries and steelworks), 26% to mineral processing, 15% to construction and 10% in other activities.

Among each productive division some activities were the most hazardous, e.g. trimmer, founder, shaper and caster for metallurgical division, stone mason, miner and quarryman for mineral processing and bricklayer, cementer, hodman and packer for the construction compartment. Among all cases of silicosis examined 24 are associated with lung cancer in the most hazardous productive divisions (12 in metallurgical division, 7 Bricks division, 4 stones division and 1 electrical division).

Silicosis affects mainly men, indeed only 1.8% of cases analyzed were women, probably because some activities are typically masculine. All data reported highlight on the one hand the most hazardous productive divisions, where further preventive actions are needed, and on the other hand a limited carcinogenic hazard for metallurgical workers where other factors (e.g. asbestos and mineral oils) contribute or exacerbate the carcinogenic hazard.

T1-3 Orale Moroni, Beatrice

10.1474/Epitome.04.1005.Geoitalia2011

MICRO/NANOSTRUCTURES, CHEMISTRY, BIOACCESSIBILITY AND TOXIC POTENTIAL OF AEROSOL PARTICLES FROM CAST IRON FOUNDRIES

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Key terms: magnetite; quartz; carbon soot; SEM/TEM; metal solubility

Foundry operations of cast iron production involve numerous sources of potentially harmful particles including metal particles, crystalline silica and carbonaceous compounds. Studies assessing the health risk associated with iron founding tend to consider the risk factors separately with few or no account to possible synergistic effects resulting from concomitant exposure to different types of particles in the same working environment. In this work, we have investigated the airborne dusts from foundry plants by combining single particle and bulk chemical analyses in order to make some inferences on the toxic potential on cellular media.

Fifteen aerosol dust samples from different working stations and three samples of moulding quartz sand raw material were analyzed by scanning and transmission electron microscopy (SEM and TEM, respectively), coupled with image analysis and energy dispersive spectrometry (EDS) microanalysis. Quartz sand raw materials were also analyzed by cathodoluminescence spectroscopy. The concentration and the solubility of Fe and other metals of potential health effect (Mn, Zn, and Pb) in the bulk samples were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES).

Aerosol particles mostly consist of magnetite nanocrystals typically 5 to 50 nm in size. Measured d-hkl spacings of magnetite are slightly larger than those of the reference phase, due to frequent replacement of Fe by other cations such as Si, Mn, Zn, and Pb. The presence of well-known toxic elements (i.e., Mn and Pb) especially in nanoparticles, points to increasing toxic potential of the metal particles as a function of decreasing particle

size. Results from solubility tests reveal Fe and Pb as the most abundant, least soluble elements, while Mn and Zn are the most soluble elements in the aerosols. Due to this fact, and to the small size of particles, direct diffusion into the cell and chemical release of toxic elements into the cytosol may be assumed for moderately soluble particles, while the soluble transition metals may be directly involved in cellular DNA damage. Variable amounts of quartz particles are present in the aerosol samples. Cathodoluminescence analyses on quartz grains evidence significant amounts of defective crystals of possible pathogenic effect even in the raw materials. This fact points to the impact of the inherent physico-chemical characteristics of raw materials in influencing the toxic potential of quartz. A second aspect which is to be taken into account when considering the presence of quartz in the iron foundry aerosols is the evolution of the chemical and physical properties of quartz grains when passing from raw material to the airborne dust. The main points at this stage are size reduction and increasing complexity of morphology. When considering any possible effect of treatment (such as heating and crushing of quartz in the melting and moulding working activities, respectively), and of contamination of quartz grains by metal particles, the impact of coexisting inhalable metal and silica particles on pathogenicity should not be ruled out.

The final question which arises when approaching the risk factor related to iron foundry aerosols is the remarkable presence of inorganic C particles. High-resolution TEM images show that they consist of multiwall graphite nano-onions variable in size from 20 to 100 nm, typically close to 30-50 nm, similar to those observed in carbon soot. Graphite lattice fringes are often overlapped to Fe-rich particles, suggesting the metal particles be embedded in a poorly crystalline graphitic matrix. Considering the cytotoxic mechanisms of carbon soot, and the redox-dependent responses of macrophages in the presence of iron and carbon species, the possible synergistic effects of metal and carbon particles in the airborne dusts should be studied and considered in detail.

T1-4 Orale Pugnali, Armanda

10.1474/Epitome.04.1006.Geoitalia2011

EVALUATION OF THE TOXICITY RELATED TO NATURAL AND SYNTHETIC TREMOLITE ASBESTOS EXPOSURE IN VITRO.

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Key terms: natural tremolite asbestos; synthetic tremolite asbestos; XRPD, SEM-EDS, TEM-EDS characterization; A549 cells, citotoxicity, immunohistochemistry.

Two different samples of asbestos tremolite have been investigated to improve the comprehension of their toxicity. Natural asbestos tremolite (NAT) from Brachiello (Val d'Ala, Piemonte Region, NW Italy), and synthetic asbestos tremolite (SAT) were mineralogical characterized by X-ray powder diffractometry (XRPD), transmission and scanning electron microscopy (TEM, SEM) with annexed energy dispersive spectrometry (EDS).

NAT fibres are very long and rigid with diameters ranging from 1 µm to 1.5 µm; several thicker crystals range in diameter from 15 µm to 20 µm. They have an high crystallinity and absence of structural defects; at the TEM observation scale thin talc lamellae develop from some fibre border. SAT fibres are highly crystalline too but in general thinner than NAT ones: the width ranges from 0.04 to 0.68 µm. Some structural defects are present and they consist in different distances of the same structural planes. Traces of quartz have been detected. Dimensions for both NAT and SAT fibres are included in the respirability criterion.

The crystallochemical formula of NAT and SAT is respectively: Ca_{1.71}Mg_{5.24}Si_{8.01}O₂₂(OH)₂ and

Ca_{1.66}(Mg_{4.62}Fe₂+0.27Al_{0.18}Mn_{0.02})₅.09Si_{8.00}O₂₂(OH)₂. The SAT was synthesized on purpose iron free.

As pathogenetic mechanisms of asbestos are not entirely understood, we evaluated their morphological, immuno-histochemical, and functional effects in alveolar epithelial A549 cells representing the first target of inhaled micro-environmental contaminants.

Effects at 50 µg/ml resulted in functional and structural damages evidenced by viability, motility, and morphological investigations. Phalloidin labelling showed irregular distribution of cytoskeletal F-actin. Immunohistochemical investigations evidenced abnormal expression of

VEGF, Cdc42 and β-catenin, considered risks indicators for cancer development.

Results at 24 h better reflect the different action of both fibres: NAT effects result in survival of compromised cells highly expressing VEGF while SAT fibres exert a direct cytotoxic effect and can be considered as standard samples in several investigations. The potential health hazard of NAT fibres in vivo corresponds with their iron content and ROS generation capacity providing the opportunity to elucidate the effect of asbestos on cancer induction.

SESSIONE T2

Micro e nano-particelle minerali in ambienti atmosferici, idrici, biologici

T2-1 Invitato Sacco, Milena

10.1474/Epitome.04.1007.Geoitalia2011

ULTRAFINE PARTICLES NUMBER MONITORING IN TURIN METROPOLITAN AREA - YEAR 2010 RESULTS

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Key terms: ultrafine; particles; particulate; monitoring; air

Like all large urban areas of Po Valley, Turin metropolitan area is very critical with respect to particulate concentrations in ambient air. The measures which are carried out by Environmental Protection Agencies concerning institutional purposes are focused on mass concentration, which is the indicator provided for by law. In recent years, however, concern for number concentration measures is greatly increased, due to its importance for the evaluation of particulate toxic effects, in particular in respect of ultrafine fraction. The need for a deeper knowledge in this field was explicitly highlighted in the results of European Commission Programme CAFE (Clean Air For Europe).

In this context a research project was promoted in order to collect ultrafine particles data in the Turin metropolitan area through long-term measures carried out both at ground level and at an altitude comparable to winter planetary boundary layer height. A specific instrumentation was acquired (UFP Monitor 3031-TSI Incorporated), specifically designed for routine use within air quality monitoring networks.

This instrument was installed at the beginning of October 2009 in the first monitoring site which is located on the fifteenth floor of Province of Turin headquarters in the city centre at an altitude of about 50 meters.

The UFP operates continuously and provides both the size distribution and the number concentration of particles between 20 and 1000 nm. The set up channels of size resolution are six (20-30 nm, 30-50 nm, 50-70 nm, 70-100 nm, 100-200 nm, 200 -1000 nm).

The average number concentration in the year 2010 is approximately 7200 particles/cm³. The calculation was carried out on the basis of hourly average concentrations of particles whose size is between 20 and 200 nm. About 70% of the particles measured in the range 20-200 nm have a diameter between 20 and 50 nm, and the higher concentrations are recorded in the class 20-30 nm.

The data were correlated with other pollutants monitored at two traffic stations placed at ground level in the city centre (Torino Consolata and Torino-Rivoli) and at the background station of Torino-Lingotto. The comparison shows a good correlation with the concentrations of nitrogen monoxide, PM₁₀ and PM_{2.5}. The lowest correlation coefficients were found for nitrogen dioxide and benzene. The mean variability during the day for classes 20-30 nm and 30-50 nm is relatively high, whereas other classes have a more constant trend.

Monthly averages trend shows a relative maximum in July which does not seem to be explainable just on the basis of the weather situation and will require further investigation.

The analysis of critical events during cold weather shows that the concentration of ultrafine particles is related to the inversion layer height.

T2-2 Orale Bernini, Diego

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CHARACTERIZATION OF THE MINERALOGICAL COMPONENT OF MILAN PM10

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Key terms: PM10; electron microscopy; characterization

Samples of summer and winter (2010-2011) atmospheric particulate (PM10) of Milan urban area were collected and characterized for some classes of components with health impact. Moreover, the PM chemical characterization of the main components (i.e. inorganic compounds, organic compounds, and elemental carbon) was performed by XRF and ICP-MS. Toxicity test on pulmonary immortalized cell lines showed different effects produced by summer and winter samples. Indeed, the summer PM10 fraction has a more pronounced inflammatory effect, due to the presence of endotoxins. Nevertheless, their inhibition did not completely vanish the inflammatory effect, which may be related also to both silicic materials of crustal source and transition metals. The quantity of such materials is significantly higher in the summer PM10. The morphology and chemistry of this fraction components were characterized by scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX). Further SEM and EDX analysis will enable to a better characterization of this particulate. Moreover, the analysis at transmission electron microscopy (TEM) will allow to discriminate the mineralogical phases that contribute to the PM10 silicon and transition elements.

T2-3 Orale Moroni, Beatrice

10.1474/Epitome.04.1009.Geoitalia2011

ORIGIN, SOURCES AND DYNAMICS OF DISPERSION OF PARTICULATE POLLUTANTS IN A HEAVILY INDUSTRIALIZED BASIN VALLEY: THE CASE OF TERNI (CENTRAL ITALY)

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Key terms: Atmospheric particulate matter; multivariate source apportionment (PCA/APCS); SEM/EDS; image analysis; vertical profiles

In this paper combined PCA/APCS factor analysis on bulk chemical analyses and individual particle analyses by SEM/EDS have been applied to the characterization of airborne particulate matter sampled at urban and regional background sites near Terni, Central Italy, in order to discriminate local sources from long range dust intrusions of both natural and anthropogenic particulate pollutants. The distinctive morpho-chemical features of particulate matter of various origins (industrial, anthropogenic, long-range transport) have been characterized by a year long extensive sampling campaign at urban and remote background sites. These data were integrated by a 15-day long wintertime campaign exploiting a

tethered balloon equipped with real time instrumentations, able to continuously sample the lower troposphere from ground up to 600 m height.

Five distinct PM sources were identified, namely crustal/road dust, industrial (steel plant), traffic direct, oil combustion/incineration and secondary aerosol, and the contribution of each source to the particle size ranges modelled accordingly. Results show direct vehicular and industrial metallurgical activities be the main sources for PM in the fine fraction, and soil/road dust as the main contribution to the coarse fraction. Individual particle analyses revealed six different classes of particles in the aerosols, namely silicates, carbonates, carbonaceous and metal particles, sulphates and Ca-phosphates. They were included in the statistical analysis leading to three main clusters of crustal, secondary/transport and direct combustion/industrial sources. Except for silicates and carbonates, the rest of particles are from urban and industrial anthropogenic sources. Metal particles, in particular, result from a mix of sources from ground (car exhaust) to upper level (steel plant smokestacks) in the troposphere. A general tendency towards increasing size and size heterogeneity is observed when passing from atmospheric stability to convective conditions.

Multivariate source apportionment turned out to be a powerful tool in discriminating natural from anthropogenic sources of particle pollutants, but failed to distinguish local from long range transported soil dust. At this point discrimination between local and long range soil sources was focused on the correlation between individual particle analyses and bulk chemical composition of the coarse fraction in the aerosols. Based on the mineral chemistry of the constituent particles, corroborated by back-trajectory calculations and atmospheric vertical profile analyses, it was also possible to estimate the extent of the contribution of local and Saharan dust to the soil source.

The presence of local and mid- to long range anthropogenic sources of particulate pollutants has been put in evidence in this study. With regards to short range anthropogenic particles, those coming from automotive exhausts tend to be confined within the lower level in the atmosphere, whereas those coming from industrial emissions tend to permeate at higher levels in the atmosphere. On the other hand, long range anthropogenic sources of secondary aerosol from NE-Europe have been found to explain the observed increasing amounts of gypsum for increasing altitude upon Terni. Vertical dispersion of particle pollutants appears to be highly influenced by topography (which protects from ventilation), and also by thermal inversion within the mixing layer.

T2-4 Orale Musa, Maya

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MICRO-RAMAN SPECTROSCOPY AND VP-SEM/EDS TECHNIQUE APPLIED TO THE CHARACTERIZATION OF INORGANIC PARTICLES OR FIBRES IN LUNG AND PLEURAL TISSUES FROM PATIENTS AFFECTED BY RESPIRATORY DISEASES

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Key terms: Micro-Raman Spectroscopy; VP-SEM/EDS; Malignant Pleural Mesothelioma; Asbestos; Mineral Particles

During the XX century Italy was a big producer and importer of asbestos until 1992 when asbestos was banned: for this reason it results still now affected by a lot of asbestos-related diseases, as proved by the data published by ReNaM (Registro Nazionale dei Mesoteliomi).

The correlation between inhaled fibrous materials and diseases of the respiratory system - asbestosis, mesothelioma, pulmonary carcinoma - is demonstrated by a large scientific literature.

These pathologies are typically characterized by a long latency time, i. e. the time interval between exposure and the disease onset, therefore the effects on the human health of asbestos exposures occurred in the past appear decades later. Scientific studies indicate, despite the ban of these materials, an occurrence peak of asbestos-related diseases in the next decade.

Moreover, not only occupational and/or family exposure, but also the environmental one may today represent a cause of asbestos-related pathologies onset.

Previous works carried out in our laboratories proved that micro-Raman spectroscopy is a technique able to recognize mineral phases on untreated samples. In particular recently micro-Raman spectroscopy, using 632.8 nm laser beam as excitation source, has been coupled with VP-SEM/EDS - Variable Pressure Scanning Electron Microscopy with annexed Energy Dispersive Spectroscopy - to characterize, without digestion of the biological matrix, particles/fibres directly in the histological sections used for the medical diagnoses. In particular a methodology allowing the characterization of the same particle/fibre under the two techniques, on thin sections of lung and pleural tissues from patients affected by Malignant Pleural Mesothelioma, due to past professional exposures, have been studied. All the inorganic phases, fibrous or not, have been characterized on their spectroscopic and chemical aspects. The results obtained on all the analysed sections indicate on the silicate particles/fibres inhaled and detected in the respiratory system an interaction cell-particle/fibre affecting the crystalline structure.

Also the "asbestos bodies", where the inhaled fibre is coated by an iron rich protein material, have been characterized. The laser beam was addressed either on the material coating the fibre either on the portion more free from the coating. By this way identification about the mineral phase corresponding to the fibre in the core can be achieved.

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T2-5 Orale Colonna, Massimiliano

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STUDY ON THE POTENTIAL TOXICITY OF NATURAL CHRYSOTILE NANOFIBERS: PREPARATION OF PROPER SAMPLES AND PRELIMINARY CELLULAR AND CELL-FREE TESTS

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Key terms: Asbestos; Nanofibers; Toxicity; Ultrasonic Treatment

Inhalation of asbestos fibers causes asbestosis, lung cancer and pleural mesothelioma. Fiber length, biopersistence and surface reactivity are involved in the development of the respiratory diseases. The fiber length was the first parameter correlated with asbestos toxicity. In vivo studies on rodents showed that long (> 8 µm) and thin fibers have the highest potential to induce mesothelioma. Nevertheless, a large number of fibers in the mesothelial tissues of exposed workers has diameter < 0.2 µm and length of few µm. Nanofibers (NFs) have also been recovered in subjects only exposed to environmental pollution. NFs could result from the splitting up in the lung of long fibers - mainly of chrysotile asbestos - in sub-micrometric fibrils, or might be inhaled already in nanometric size. In the past NFs, were released from several products, e.g. brake pads, following mechanical stress. They are also detectable in the natural environment, e.g. in turbulent waters from mountain streams that flow through serpentinite outcrops.

The pathogenic potential of the asbestos NFs is still unclear. Therefore the main goal of the present work are a) to develop a size selective procedure for preparation of short (<5 µm) and thin (< 200 nm) chrysotile NFs and b) to compare their potential toxicity by respect to long fibers.

We investigated the effect of ultrasonic treatments on size, shape and structure on a pure sample of chrysotile asbestos from the Italian Central Alps widely characterized in previous investigations, in order to identify the best conditions to produce a homogenous batch of short asbestos fibers. Ultrasonic treatments were carried in water for different time periods (from 3 to 24 h) and the final products were subjected to morphological analysis to verify change in shape and size distribution (Scanning Electron Microscopy) and to crystallographic (XRD, micro-Raman spectroscopy) and elemental analysis (X-Ray Fluorescence) to detect any change in structure/composition. The preparation of asbestos NFs was performed also on a commercial chrysotile sample (from the Balangero mine, Italy) and the potential toxicity of the two samples was compared with the well known toxicity of the original asbestos. First we examined the surface properties considered relevant to pathogenicity then some cellular responses in human epithelial cells.

Among the most relevant surface properties involved in asbestos toxicity we examined the potential to cause oxidative injury within the lung by measuring free radical generation and depletion of antioxidant defenses. The potential of NFs to generate hydroxyl and carboxyl radicals when in contact with biological fluids has been investigated by means of the spin trapping technique. The potential to consume the antioxidant defenses has been evaluated by monitoring the depletion of cysteine and ascorbic acid, during the incubation of the sample over time. The amount of bio-available iron on the sample surface was also evaluated by mobilization of ferric and ferrous ions using specific chelators. In all cases NFs showed a lower reactivity than the long fibers. Cellular responses were measured as leakage of lactate dehydrogenase (LDH) into the extracellular medium, ROS and nitric oxide (NO) production, and lipid peroxidation.

The data of the cell test showed a different toxicity of the fibers correlated to their length. Nanofibers are less toxic than the long fiber of the same asbestos source.

T2-6 Poster Musa, Maya

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CHARACTERIZATION BY VP-SEM/EDS OF PARTICULATE MATTER IN AREAS WITH DIFFERENT ENVIRONMENTAL IMPACT: RELATIONSHIPS WITH EMISSION SOURCES

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Key terms: VP-SEM/EDS; Particulate Matter; Emission Sources; Methodology; Characterization

The increase of air pollution is one of the most important issues due to its effect on the human health and the European laws require a steady monitoring of suspended Particulate Matter (PM)₁₀. Deep investigation of the different components into the PM₁₀ (particles with aerodynamic

diameter less than 10 µm) is essential to obtain information about their chemical/physical properties, including how they interact with other aerosol species and gases in the atmosphere, and their effects on the human health. PM₁₀ is usually monitored by high volume device, collecting the suspended material onto specific membranes, made either in fused silica (commercially "quartz") or in glass fibres and measuring the concentration of the suspended PM₁₀ by the gravimetric method, defined as the total mass of the PM₁₀ per cubic meter of air within 24 hours. This type of analyses provides only the weight of suspended materials without information on their chemical composition. Moreover, the European Community is recently showing an increasing interest in assessing the chemical characterization of the different components occurring in the PM.

By our research group a quickly and not expensive methodology to characterize the PM starting from the filters routinely collected by the environmental protection agencies to determine the air quality - has been elaborated. A procedure for removing the solid components of the PM from the sampling filters and deposit them onto polycarbonate supports, more suitable for the VP-SEM/EDS, instrument used for the characterization study. The developed procedure proves able to:

- distinguish easily particles/fibres of the original support from those composing the PM;
- detect the inorganic/mineral phases on the basis of the EDS analyses;
- propose an apportionment to different sources, natural or anthropogenic, in the different analyzed samples and in each sample to define the percent weight of each of them;
- notice the presence of fibrous phases, in particular those ascribed to the minerals defined "asbestos" by the law.

The results obtained in different environmental situations: urban, rural and outskirts areas, localities characterized by various anthropogenic sources of pollution will be presented.

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T2-7 Poster Gianfagna, Antonio

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MINERALOGICAL METHODS FOR THE CHARACTERIZATION OF 2.5 PARTICULATE MATTER IN THE URBAN AREA OF ROME, ITALY.

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Key terms: Particulate Matter 2.5; Mineralogical Characterization; Analytical Methods; Environmental and health issue

The characterization of the airborne particulate represents a real issue. Many studies have examined the effects of the particulate matter on human health suggesting that the small particles represent a severe problem.

In the present work chemical and mineralogical investigations on the particulate matter of the city of Rome were carried out. The particulate samples (PM_{2.5}) were collected in Rome since April 2010. Polycarbonate filters were used to trap and recover airborne particles according to a standard procedure, and then utilized for different analytical techniques. Preliminary investigations on PM_{2.5} filters (SEM-EDS, X-ray and DTA) provided information about the inorganic compound. High iron content was highlighted as oxides, hydro-oxides, and sulphates. In particular, the presence of melanterite FeSO₄·7(H₂O)[1] was evidenced. Ca-sulphates and clays were also found. Moreover, innovative methodologies, such as Atomic Force Microscopy (AFM), resulted useful for morphological and dimensional investigations of the micro and nano-particles[2]. Hygroscopic properties of mixed urban aerosol can be monitored by FT-IR. Furthermore a complete functional group characterization of PM_{2.5} phases in the 4000-400 cm⁻¹ spectral range, with a procedure based on diffuse reflectance (DRIFT), is in progress.

The association in the atmospheric dust particles of amorphous phases and heavy metals is known to increase the release of these dangerous chemical elements. To obtain the bulk chemical composition of the particulate material the Regional Protection Agency usually utilize ion mass spectrometry (ICP-MS) on a little amount of particulate matter (2 mg; D.M. 60/2002). In this work ICP-MS analyses were performed on a high content of material (35 mg). The high amount was here used to investigate the presence of heavy metals and their release in biological environment. Data on PM_{2.5} samples was fully comparable with those typically observed by Regional Protection Agencies (ARPA). Test of release were executed in physiological solution (PH 7.4, 37 °C, 30 days). Release evidence were obtained for Fe, V, Pb, As and Cr. These results confirm that the release of heavy metals in the biological environments already occurs from the first hours. In vitro experiments are in progress to assess the relation between the fine and ultrafine particles and the health effects.

T2-8 Poster Belluso, Elena

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NATURAL AND ARTIFICIAL INORGANIC FIBERS IN LUNGS OF UNGULATES LIVED IN THE REGIONAL PARK OF "LA MANDRIA" (PIEMONTE REGION, NW ITALY)

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Key terms: natural and artificial inorganic fibers; biological samples; Animal Sentinel System; SEM-EDS

It has long been established that occupational exposure (high dose) to certain fibrous minerals is harmful to human health. The effects of environmental exposure (low doses) is still rather difficult to determine.

Recent publications show the advantage in using animal population called Animal Sentinel System (ASS), in alternative to the human ones, as indicator of environmental contaminants.

The aim of this work has been to assess the presence of fibers in general and asbestos in particular (breathable fibrous inorganic fraction: bfrif) airborne in the Regional Park of "La Mandria" (entrance of the Lanzo Valley, Torino) monitoring their presence in samples of lung tissue of ASS lived in that area with a natural environmental exposure (continuative and at low doses).

In the Regional Park of "La Mandria", in fact, some fibrous minerals are present both in the composition of the lithologies naturally present end in the debris come from the ex-mine of Balangero, used in the past to cover the footpaths.

Samples of lung tissue from 15 ungulates were been examined. The investigations were carried out by using the scanning electron microscope (SEM) equipped with an energy dispersive spectrometer (EDS) and have allowed us to obtain qualitative and quantitative data on breathed "bfrif" and in particular on asbestos.

The fibers found in the lung tissue of ungulates are chemically related to 2 main groups: silicate and non-silicate fibers. The different types of the detected silicate fibers are listed in decreasing order of abundance: artificial silicate with Na and possibly Mg, Al, Ca, K, chrysotile/antigorite; illite/smectite/montmorillonite, hornblende, tremolite asbestos, micas, phyllosilicates not better identified, vermiculite, crocidolite, Na-Ca feldspar, chlorite, edenite, pyrophyllite, kaolinite, diopside, zeolite. The two different types of the found out non-silicate fibers are listed below in decreasing abundance order: titanium dioxide, gypsum or anhydrite. Both crocidolite and tremolite asbestos and chrysotile/antigorite fibers were found in 40 % of the samples. Globally, these three groups were present in 47 % of the samples.

The antigorite fibers are released from both outcropping local serpentinitic rocks (natural source) and the debris from the ex-mine of Balangero (natural source), while those of chrysotile can come both from the local rocks (natural source) and the asbestos-containing materials (anthropogenic sources) such as the roofs of buildings.

The tremolite asbestos come from serpentinitic rocks (natural source) and not from the debris of the ex-mine of Balangero because this species has not been detected in the rocks of that area.

Crocidolite come exclusively from the asbestos-containing materials (anthropogenic source, such as the roofs of buildings) because this type of asbestos isn't naturally present in Italian lithologies.

Although it is not possible to establish from which of the two sources (natural and anthropogenic) the chrysotile/antigorite fibers come, as regards tremolite asbestos and crocidolite the ASS represent a good model for assessing environmental exposure in relation to topographic features, geological and human environment in which they lived.

T2-9 Poster Bardelli, Fabrizio

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HIGH RESOLUTION ELEMENTAL MAPPING OF FERRUGINOUS BODIES FROM LUNG TISSUE USING SYNCHROTRON RADIATION

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Key terms: ferruginous bodies; asbestos; synchrotron radiation; XAS; XRF

It was not until the late 1950s that asbestos was recognized as a human carcinogen and exposure to fibers started to be associated with several different lung injuries, including respiratory diseases, asbestosis, mesotheliomas, and lung cancer. Since that time, the mechanism by which asbestos causes cancer has been intensively studied, but, however, it is still not well-understood. Ferruginous Bodies (FB) consist of a coating of inorganic fibers (usually asbestos fibers, but not only) composed of inorganic and organic material. If the core of these bodies consists of asbestos, FB are known as Asbestos Bodies (AB), and their count is one of the most valuable tools for establishing if a subject underwent professional exposition to asbestos, or to estimate the degree of asbestos exposure among the general population [1]. It was generally accepted that the coating of embedded fibers to form AB is a protective mechanism produced by macrophages trying to segregate the cytotoxic fibers from the organic tissues [2]. However, more recently, other authors suggested that the coating material may enhance the cytotoxic properties of the asbestos fibers by increasing the production of free radicals [3]. Therefore, the exact knowledge of the composition of the AB, and of FB in general, is of fundamental interest. Accordingly, iron on the surface of AB was shown to be catalytically active [4] and capable of inducing the formation of single strand breaks in phiX174 RFI DNA [5]. Earlier studies, exploiting Transmission Electron Microscopy and X-ray diffraction on split AB, showed that the coating contained crystalline particles of the same order of size quoted for the inorganic iron core of the ferritin molecule [6]. More recently, synchrotron radiation soft x-rays imaging and fluorescence microscopy revealed novel properties on the composition of FB [7]. In this work, samples of human lung tissue rich in FB, due to professional exposure, were collected from three subjects died of lung cancer. Tissues were digested using NaClO to produce a suspension of inorganic material that was filtered on porous membranes. The membranes were preliminarily characterized by optical microscopy and Scanning Electron Microscopy, in order to estimate the number of the filtered particles. The samples were brought to the European Synchrotron Radiation Facility in Grenoble (France), a high brilliance x-ray source. Exploiting the high spatial resolution provided by the micro-focused x-ray beam (down to 0.5 microns), 100 x 100 microns² fluorescence maps of selected bodies were acquired. The fluorescence maps revealed that, except for bodies containing the asbestos fibers (which also contain Si, Mg, and Al), the FB are mainly composed of Fe, Cu, Zn, As, and, for certain subjects only, Ge and Ba. X-ray Absorption Spectroscopy at the Fe K-edge was also performed on selected FB in order to unravel the speciation of iron. The near edge part of the absorption spectra (XANES) revealed features that are in excellent agreement with the ferritine standard.

The results obtained will help solving a long time debate and lead to a better understanding of the toxicological mechanism of a large class of air pollutant particles that, nowadays, constitutes a serious risk for human health.

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SESSIONE U1

Geoetica e cultura geologica, il contributo delle Scienze della Terra ad un rinnovamento culturale della società

U1-2 Invitato Valensise, Gianluca

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GEOLOGICAL RISKS AND PUBLIC SENTIMENT: HANDLE WITH CARE

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Key terms: Geoethics; Societal implications; Sustainability

Unlike most other professionals, geologists are often confronted with technical issues that also bear significant societal implications, and that for this reason are also the object of public debates and political standings. The geologist's process towards acquiring the necessary knowledge and forming the requested assessment or opinion is often fraught with elements that have nothing to do with the technical merit of the question at hand.

Why is it so? Is it normal for that geologist to be biased by his/her own perception of issues such as the acceptability of a given risk level, the sustainability of natural resource exploitation, the environmental downsides of economic growth? Or should consideration of these issues be part of the good practice of any informed professional? And why does this happen to geologists more than to other professionals? Perhaps because they lie somehow in between exact science and social science?

The recent history of the Italian Earth Science community offers many of such cases and of the associated dilemmas, which together represent a perfect example of what Geoethics is about. We will recount some of them, attempt to find common causes and circumstances, and discuss possible remedies and recommended practice.

U1-3 Orale Nikitina, Nataliya

10.1474/Epitome.04.1017.Geoitalia2011

ETHICAL PRINCIPLES AND THE VALUABLE APPROACH FOR PRESERVATION OF GEODIVERSITY

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Key terms: geodiversity; value; principles; approach

The natural diversity is a fundamental feature, the property of the nature. It reflects the set of the structural functional characteristics of nature organization which have been implemented during the evolution and which provide now sustainable development of a planetary life, bio- and the geospheres, supporting ecological balance, ecological stability and at the sometime allow to develop inherent in the nature potential.

Having been adopted as geological equivalent of the term "biodiversity" the geodiversity is the natural range of geological processes, rocks, minerals, fossils, geomorphological processes and land forms, characteristics of subsoils and organic soil.

While endogenous and exogenous geological processes have a leading role in formation, preservation and destruction of a variety of subsoil, surface and landscapes of the Earth because of their exceeding power and duration, which is non-comparable with the duration of the existence of the human species.

Now human impacts on the Earth as on a geological body mentions only the lithosphere and affects in following basic directions: geological survey, exploration and a mining, construction and operation of underground facilities, formation of lithospheric technical zones under territories of city and industrial development; a dumping of household and industrial wastes, lithospheric (geological) weapon.

There is six types of values of the geodiversity: internal or intrinsic value, cultural (geomythological, archaeological and historical) value; aesthetic value; economic value; functional value; scientific and educational value. Our relation to the lifeless nature should be based on the fact that the Earth, its subsoil, geological objects on a planet surface have the primary right to exist, independently from advantage for the person, and owing to their internal value.

Any processes of degradation and decrease in level of a geodiversity as parts of the natural diversity are caused, first of all, by underestimation of their real economic value. Any offered variants of preservation of geodiversity will constantly lose competition to the mining industry as state budget revenues of this sector of economy are clear and tangible. All arguments about possible own utility of a geodiversity are easily eliminated by cost value of implementing conservation measures.

Value of the geodiversity is defined also by the reason that without its preservation it is impossible to keep a biological diversity of plants, animal, microorganisms, functioning of terrestrial biosphere in which the mankind lives.

U1-4 Orale De Amicis, Mattia Giovanni

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RISK MANAGEMENT: A PROPOSAL FOR COMMUNICATION STRATEGIES

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Key terms: civil protection; risk management; communication strategies

The increment of disasters related to natural hazards observed during the last decades, sometimes associated to the low perceived risk in the population involved, shows the need of non structural risk prevention and mitigation measures that contribute to improve people's safety towards natural hazards. Among the usually most effective non structural measures that serve to improve the preparedness of the population, is the development of locally adapted communication campaigns that actively involve the population. Three different strategies can be developed. A basic educational project addressed mainly to the schools; a collaborative work developed with an alpine institute to improve the scientific quality of the educational material, and a large communication campaign was designed in collaboration with several colleagues.

The content of the communication campaign was defined by combining the indications of the "Direttiva Regionale per la pianificazione di emergenza degli Enti locali" of Lombardy Region with the results of the survey applied in the CM Valtellina di Tirano. In addition, the operative procedure was inspired in advertising strategies. A widespread campaign to try to reach every family was preferred over great events that, even if have greater visibility, at the same time do not have enough long time impact. Therefore, was selected a horizontal communication strategy, that could be carried out by the local authorities (whom are the natural references in case of emergency), and that, at the same time, could become a normal part of everybody daily life.

The choice, of focusing on the daily life, has two reasons: first because is not yet possible to define the precise moment in which a catastrophe can take place. Therefore, the idea is not to generate fear in people with sudden announcements of imminent disasters, but to help the citizens to recognize that, on a particular territory, specific risks exist, and that with risk awareness and a correct territorial management the risk can be soundly reduced. Second, a daily familiar communication has greater penetration and can be more effective in influencing people reaction.

The communication campaign is composed of four phases. First, the dispatch, to all 10.000 resident families, of a brochure with the four symbols previously described. Afterwards, an umbrella with the symbols printed, will be sent to all families. Later, a public posting campaign will be developed in every municipality explaining the specific content of each symbol, the communication strategy in case of an emergency, the emergency routes and the safe meeting places in every municipality, and for every possible scenario. Parallel to the previous phases, a website has been designed, and will be possibly hosted in the website of the Comunità Montana authorities, with the aim of assuring the continuity of the education. The website contain the designed iconic symbols which will serve as links to several types of information and files, including the Emergency Plan, scientific results about risks in the study area, emergency procedures, contact details in case of emergency, etc. Thus, this communication path starts with an institutional communication, pass through a common object that is kept by the people, and conclude with a local institutional communication, but remains thanks to the possibility to constantly access the website.

At the end of the third phase, the public posting campaign, several public meetings will be performed in different public places of the study site. The aim of the meetings is not only to inform and educate about the local hazards and emergency plan, but also to stimulate the participation of the community in risk reduction strategies. By promoting the participation in the meetings is expected to receive feedbacks from the population which may collaborate to improve the quality of decisions made in the process of planning the warning system and all risk management.

U1-5 Orale Di Capua, Giuseppe

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ETHICS, SCIENTIFIC RESEARCH AND GOALS OF PUBLIC USEFULNESS

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Key terms: geoethics; scientific research; society; popularization; natural hazards

In the research activity, often the necessary fulfillment of administrative and bureaucratic practices can lead to neglecting the transfer of scientific results to the community, with the effect of a loss in terms of cultural growth for society itself, which has indirectly financed the products of that research and at the end risks not to have advantage by using them.

In a research project, it is necessary to find the right balance between the scientific-technical work and the financial and administrative management, and to assess time needed to develop the project in all its components, including the space for the dissemination and popularization of results respectively to professionals and citizens: the former could not be able to use achieved scientific advances for their application on the territory, the latter could remain passive people in decisions regarding the environment they inhabit, without the possibility for accessing to accurate information on natural hazards from which they must and can defend themselves.

The authors will show how the different modalities of financing and managing of two research projects have influenced the achievement and the usability of the results, with diverse consequences in the social contexts where these results would find their suitable application. In addition, through the two experiences, they will highlights the importance of collaboration between research and professional world for pursuing goals of public usefulness.

U1-6 Orale Crescimbene, Massimo

10.1474/Epitome.04.1020.Geoitalia2011

THE SCIENCE OF RUMORS

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Key terms: rumors; hoax; social psychology

This work, with a soft scientific cut, talks about rumors, hoaxes and urban legends.

Social psychology, more elegantly, uses the latin word rumor (rumour in British English) which means sound, voice, gossip.

Rumors, in social, economical, political, cultural and scientific communication, indicate a news, presumably true, that circulates without being confirmed or made evident.

The scientific history of rumors is briefly described starting from Ancient Rome period, throughout the Second World War and the Internet era, up

to today.

We will try to answer some questions that can be useful to scientists today. What are rumors? How are they born? How do they spread? By which laws are they regulated? How to fight them?

A final question regards the collocation of rumors into modern science. Science today is divided into hard and soft science (that lacks generally a basic mathematical structure), these terms, respectively, indicate natural sciences, which investigate nature, and social/human sciences, that investigate man in all his facets. Maybe rumors can be imagined as a bridge suspended between two banks: "scientific truth" and "human truth".

U1-7 Orale Georgiadis, Teodoro

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THE COMMUNICATION OF SCIENCE AS A ETHICAL ISSUE: THE CASE OF RAFFAELE BENDANDI

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Key terms: communication in geosciences; public expectations; public needs

The case of Raffaele Bendandi should be considered a paradigmatic example of the importance of the communication of geosciences and of the ethical importance covered by such issues in terms of public expectations. Nowadays the social perception of threats deeply changed from the past. Furthermore, the communication advancements allow everybody of being informed in real-time. Consequently a proper information leads to an increasing confidence about the future, while a millenarian approach, often proposed via web, should strongly affect the benefit trusted in science. At the edge of year 2012, where speculation and prophecies are disseminated by media, the case of the the Italian scientist Raffaele Bendandi (died November first 1979) clearly represents a case study to be more deeply investigated by the scientific geo-community.

U1-8 Orale Amato, Alessandro

10.1474/Epitome.04.1022.Geoitalia2011

HOW TO TURN THE RUMOR OF THE MAY 11, 2011 EARTHQUAKE IN ROME (ITALY) IN TO A DAY OF INFORMATION ON EARTHQUAKES: THE OPEN DAY AT INGV

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Key terms: Earthquake information; Seismic Risk reduction; Rumors; Science education

A devastating earthquake has been predicted for May 11, 2011 in Rome. This prediction was erroneously ascribed to Raffaele Bendandi an Italian self-taught natural scientist of the last century. During the previous months, the INGV has been overwhelmed with requests for information about this presumed prediction by Roman inhabitants and tourists. Given the considerable mediatic impact of this expected earthquake, the INGV decided to organize an Open Day of its headquarters in Rome devoted to the public who wanted to learn more about the Italian seismicity and the earthquake as natural phenomenon. The Open Day was preceded by a press conference two days before, with the purpose to present the Open Day and to have a scientific discussion with the journalists about the earthquake prediction and Italian seismic risk assessment.

About 40 journalists from newspapers, local and national tv's, press agencies and web news attended the Press Conference and hundreds of articles appeared the following days, advertising the 11 May Open Day. The INGV opened to the public all day long with the following program:

- ° meetings with INGV researchers to answer scientific questions
- ° visiting to the room of seismic monitoring, open 24h/7 all year
- ° guided tours through interactive exhibitions on earthquakes and Earth's magnetic field
- ° 5 afternoon conferences on general topics from the social impact of rumors to seismic risk reduction
- ° 13 new short videos on YouTube / INGVterremoti to explain the earthquake process and updates on various aspects of seismic monitoring room
- ° distribution of books and brochures.

Surprisingly, we had about 3000 visitors up to 9 p.m.: families, school classes with and without teachers, civil protection groups, journalists. The initiative, built up in few weeks, had a very large feedback, also thanks to the media highlighting the presumed prediction. We thank all the INGV colleagues who have made this initiative possible, in particular the Press Office, the educational and Outreach laboratory, the Graphics Laboratory and SissaMedialab.

U1-9 Orale Amato, Alessandro

10.1474/Epitome.04.1023.Geoitalia2011

THE INGVTERREMOTI CHANNEL ON YOUTUBE

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Key terms: Earthquakes; Science communication; Preparedness; Seismic hazard

On February 2010 we launched an experimental video channel on YouTube (youtube.com/INGVterremoti) in order to improve our communication strategy on earthquake risk and preparedness. The main goals of this initiative are to inform people about the ongoing seismic activity in Italy and in the world, to communicate the results of scientific research in various seismological fields, and to increase people's knowledge on seismic hazard.

In the first 15 months of activity, we published 43 original videos, thanks to the collaboration of many INGV seismologists. The videos are organized in 8 play lists: a) earthquakes in Italy; b) earthquakes worldwide; c) the 2009 L'Aquila earthquake; d) ongoing seismic activity; e) tsunami; f)

earthquake prediction; g) seismic hazard; h) 11 May 2011 (major earthquake predicted in Rome). To date, the total number of views is about 360,000, with two peaks of more than 20,000/day after the Japan earthquake and before the presumed prediction of a major earthquake in Rome on May 11, 2011. The most popular videos (6) have been viewed more than 20,000 times.

We think that this initiative has increased people's knowledge and awareness on seismic risk, although at the moment only on a specific target of citizens (but growing). In the future we will improve the technical aspects of our video-communication and broaden our audience. We learned that specific events, when the attention is high (either real earthquakes or unfounded news) are the best moments to move forward an improved risk communication strategy.

U1-10 Poster Spagna, Valerio

10.1474/Epitome.04.1024.Geoitalia2011

50 YEARS AGO: THE VAIONT NIGHT.

SPAGNA Valerio¹

1 - Self employed

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Key terms: Vaiont disaster; landslide; flood; first aid men

A geologist at the beginning of his career in the early 60s is a teacher of Mineralogy and Geology at the Agordo "Follador" Mining Institute, in the Dolomites area.

It was 50 years ago when he observed the building of the Vaiont dam and now tells us the night of October 9, 1963 when he rushed to the Piave Valley, together with the first aid teams, in front of the Longarone remains.

Did the dam collapse? Everybody thinks so but the moon wasn't shining enough to understand what had happened.

Only the first faint light of dawn revealed that the dam was still standing: it only edged the water, shaping the tremendous wave that was raised by the Mount Toc landslide entering the basin at one hundred kilometers per hour. The dam edge contributed to project the wave on the opposite versant where the water mass, once released from the narrow Vaiont canyon, raised compact in the air grazing the Casso village and precipitated as a massive block on the Longarone area.

Everybody, with hate and despair, looked upwards at the residual water streamlets overflowing along the dam concrete wall. Over the white bare esplanade people appeared extremely small. Pitiiful people gathered around the bodies wrenched from the devastated houses, denudated and buried in the mud.

SESSIONE U1

Geotica e cultura geologica, il contributo delle Scienze della Terra ad un rinnovamento culturale della società

U1-2 Orale Roda, Cesare

10.1474/Epitome.04.1025.Geoitalia2011

GEO-ETHICS AND MAJOR CIVIL WORKS

RODA Cesare¹

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Key terms: Geo-ethics; Underground vaste storage; Major civil works

The design of works that considerably involve ground and underground, as the ones intended for the nuclear waste depository, preliminarily needs geological and geophysics surveys to be carried out, with elaboration and interpretation of the acquired data.

The breadth of such investigations, the dimension of the temporal and financial effort, the interpretation difficulties and the range of indeterminateness that usually persists even after the most accurate surveys, increase more than linearly with the work relevance. The purposely planned investigations constitute a research activity.

Singling out the validation procedure of the results coming out from the survey activity propaedeutical for major civil works' design (mostly those that get even with environment, life quality or merely the collective imagination) is a relevant question.

The validity of the scientific surveys' results may be ascertained only by the scientific community, whose competences and knowledge allow to attest the research adequacy compared with the state of the art.

Geologists that perform surveys for the project of major works must publish on scientific reviews the results of their investigation.: this may become a relevant geo-ethic rule.

U1-3 Orale Solarino, Stefano

10.1474/Epitome.04.1026.Geoitalia2011

IMPACT FACTOR, H-INDEX, CITATION INDEX, PRODUCTIVITY INDEX: ARE RESEARCHERS STILL FREE TO CHOOSE WHERE AND HOW TO PUBLISH THEIR RESULTS ?

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Key terms: Evaluation index; Citation; Impact factor

During the last few years many tools to quantify the scientific importance of a research have been proposed and developed. They are based on the public output of the research, that is on its publication, and the most acknowledged probably are the Impact factor, the H-index and the citation index.

The impact factor is a number attributed to each scientific journal and consists in the average number of citations per published article. It is updated every year with the citations received in the two previous years and may significantly vary from time to time. The citation index is the number of citations of a single scientific article; it increases from the first appearance of the paper every time it gets quoted on a JCR journal, and has no upper limit. The H-index is a rather complex index which reflects both the number of publications and the number of citations per publication. In particular, it identifies the H papers have been cited at

least H times.

These tools apparently fulfil the motivated need to evaluate, in an objective way, the level of innovation, originality and continuity of the single researcher and may be used to compare the performances of different research agencies within the same scientific fields. However, it is clearly evident that the evaluation provided by these instruments not always corresponds to the real impact of the research, like it happens, as an example, for those publications that are frequently cited because they contain errors possibly not pointed out in the peer-review process. Moreover, the evaluation provided by these tools is sometimes used in contexts which are way different from their original field of application, like the distribution of financial supports or the attribution of duties to researchers. Finally, the same index may be computed using similar criteria on different databases, leading to confusion and contradictions. In this contribution are described the principal anomalies, problems and failures of the evaluation schemes, the most evident being the difficulties in evaluating the role of a single researcher in "pool" projects and papers and the need to find a way to recognize similar topics and studies published by the same researchers on more journals. It is then discussed the "selecting" effect that the evaluation indexes may have on the research. In fact, in the attempt of getting the highest possible score, there is a tendency to avoid studies that deal with small areas, scientific problems that have less peculiar characteristics or provide very practical results. In all the cases mentioned above the article describing the study will likely appear on "minor journals" (with low impact factor), will have, as a consequence, a low citation index, will not significantly contribute to the H-index and/or will only be published on reports.

Moreover, a discussion on the role that these evaluation indexes may have in the world of research is presented. Particular attention is paid to the consequences in the field of the geothetics, where scientific, technological, methodological and social-cultural aspects in a order different then what expected in pure meritocracy have to be considered. A few suggestions on how to render the usage of evaluation indexes if not more effective at least more adherent to real importance of the research are finally proposed.

U1-4 Orale Lucchesi, Stefania

10.1474/Epitome.04.1027.Geoitalia2011

THE ROLE OF GEOLOGISTS IN CULTURAL AND HUMAN PROGRESS.

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Key terms: Geoethics; Environment; Sustainability; Scientific communication

Geology, like any science, has a key role in the development and progress of human culture and society. In this context, scientists, professionals and practitioners of Earth Sciences must inevitably confront themselves with the purposes, methods and results of their works, concerning relationships between man and environment, that is dealing with ethic questions.

In this paper, we want to underline how geologists should not be dedicated only to environmental conservation, georesources prospection and civil protection activities. Nor they should merely put in place what today stated by international laws, in accordance to basic principles as "subsidiarity" (Maastricht, 1992), "precaution" (UNCED, Rio de Janeiro, 1992), and "responsibility" (Jonas, 1990).

An essential basis of any geo-environmental action is the enhancement of beauty and goodness inherent in nature. For this reason it is fundamental the role of geologists: their studies may let people know and then discover the beauty and goodness dimensions of the Kosmos. To give meaning to any operational choice, it is necessary, especially among younger generations, to encourage an "affective" dimension toward Nature, along with a capability to be amazed by it. An aid to this purpose can be found in some cultures, generally those from less developed countries than ours. Those populations have a greater awareness of the close relationship between humankind and Earth (e.g. Mother Earth), man not being seen as "other" than the environment, but part of it, together with the all community of living beings.

In the recent MuseoTorino project, a web-based and multimedia product by the Turin Municipality for the 150th anniversary of the Unification of Italy, a new scientific divulgation mode of the "history of a city" was used to communicate the constant relationship between the history of the Earth and of the humans, in a dimension of unity and continuum of space-time-life.

Therefore, the work of geologists is not limited to a merely pragmatic vision, which aims to provide a service, but as a harmonious collaboration between man and nature, between living and nonliving. In this relationship and inter-dependence, typical of a complex system like our planet Earth, man rediscovers his dignity and his role. He is a subject capable of safeguarding and responsibly managing the assets of his home-Earth for a progress aimed at improving the conditions of life and human dignity.

Geologists may also promote respect for "human rights" through appropriate educational and training actions in the knowledge that the Earth and its resources are a common heritage that must be shared among the community of living beings. For example, an erroneous policy of the international exploitation of gold deposits in Mendoza (Argentina), which would compromise the water quality of a vast inhabited area, was thwarted thanks to a widespread information and awareness on the problem.

In a society where a poor distribution of resources is often cause of conflicts between nations, geologists may also play an important role in promoting justice and peace, through a good management of resources. Furthermore, as the safeguard of the Earth, home of all peoples, is a common target of different cultures, geologists can take a significant role in multi-ethnic and multi-cultural dialogue, encouraging opportunities of meeting on environmental issues among people of different backgrounds and cultures.

Last but not least, is the vision of the Earth system that geoscientists can, more or less consciously, convey by means of their scientific communication and/or popular publications. In fact, they can lead to different ideologies (catastrophism, fatalism, mythologizing...) or myths such as "urban legend" that often affect people from a psychological and sociological point of view. For this reason geologists can play an important role in "service of truth".

U1-5 Orale Borgomeo, Edoardo

10.1474/Epitome.04.1028.Geoitalia2011

WHY I STUDY EARTH SCIENCES

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Key terms: environment; students; ethical responsibility

In my presentation I will explain the reasons why I chose to pursue a university degree in Earth Sciences. Although this topic might seem unrelated to geoethics, it is somehow connected to it. I will show how my decision to study Earth Science was indeed influenced by "geoethical" reflections even though I did not consider them as such when I made my decision. I will start the discussion with the word "environment" because, although much abused and quite vague, it is the word that focused my attention on the Earth Sciences. That is, I came to appreciate the importance of the Earth Sciences after I became aware of the extent to which human activities are changing our environment. I will explain how, without any visionary ambitions, I felt the ethical responsibility to explore the nature of the Earth to understand the role of humans on it. I will then discuss what contributions young people can give to the study of the Earth, especially in relation to the pressing issue of environmental change.

U1-7 Invitato Graziano, Gian Vito

10.1474/Epitome.04.1029.Geoitalia2011

THE GEOLOGIST'S ETHICS PROFESSIONAL: COMPETENCE, CODE OF ETHICS AND LEGALITY.

GRAZIANO Gian Vito¹

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Key terms: code of ethics; management of the territory; normative

The greatest sensibility and attention to the geoenvironmental problematic underline the urgency to face, with new awareness and responsibility, some matters, like the management of the territory, the exploitation of the georesources, the energetic problem list, the defense from the natural risks. Civil community asks ready and exhaustive answers. The technical-scientific competences of the geologist, conjugate with practical shared deontologiche in the respect of the normative in force, can give back trust to the citizens, support to the political decisions, safety and raising of our professionalism. The Italian territory is a great economic, social and cultural resource, that must be defended and valorized with the contribution of the geologist. New strategies are needed, aspired of action and operational tools. The CNG is working in this direction.

U1-8 Orale Ryzhova, Ludminla

10.1474/Epitome.04.1030.Geoitalia2011

GEOETHICS IN ORGANIZING A SYSTEMIC APPROACH TO EXPLOITATION OF THE NATURE

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Key terms: geoethics; geosphere; trend-technologies; environmental disasters; natural resources

Under the conditions of worsening environmental situation and complicated problems of exploiting the nature, geoethics as a novel scientific direction attains a special importance. As an individual scientific direction proposed by the scientists from the Czech Republic (V.Nemec, L.Nemcova), geoethics had been formed in 1992 at the International Mining Pribram Symposium (Czech Republic). The development of geoethics follows the way of differentiation of directions: the theoretic one (V.Nemec, M.Komarov, G.Gold, A.Trembetsky), the applied one (V.Ryzhov, L.Ryzhova, A.Krasavin, M.Kuz'min et al.), the social-economic one (V.Gur, N.Grigor'ev, G.Senatskaya V.Yusim et al.). According to the definition in the Encyclopaedic Dictionary "The Globalistics", GEOETHICS is a combination of moral-legal norms and rules of the multilevel system in the development of the GEOSPHERE such as geopolitical, social-economic, informational-technological ones. The whole material system of the natural environment components, of the natural resources (atmosphere, water, soil etc.) developing as a part of the whole complex, possesses a certain stability, homeostasis, and capability of self-restoration in exposure to external factors including human activity.

Optimal utilization of the main resources i.e. mineral deposits, time (non-replenishable resources), personnel, information, capital (own and attracted funds, credits and investments), is the factor of efficacy enhancement of resources' utilization, exploration, and development of mineral deposits.

The efficacy of resources' utilization is determined by the level of applied technologies (in production, management and information) to maintain high rates of economic growth and creation of a competitive price of the final product in solving the following express-problems:

- needed enhancement of natural-resource prognosis;
- the development of standards, regulations, technical-environmental-social risks;
- introduction of novel trend-technologies;
- analysis, prognosis of international markets of raw materials;
- Prevention of environmental disasters

Natural resources and first of all mineral ones make up the basis of wellbeing of countries and determine the future of the world civilization. Taking into consideration impossible replenishment of natural resources, formation of the need in mineral raw materials is determine by the reasonable sufficiency principle.

U1-9 Orale Di Loreto, Eugenio

10.1474/Epitome.04.1031.Geoitalia2011

GEOLOGISTS AS PUBLIC EMPLOYEES AND GEOETHICS

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Key terms: professional ethics; norms; public employees

In Italy there are 14.500 geologists, regularly enrolled in the professional register. Two thousands of them work as public employees in central Institutions (ISPRA, INAIL, ANAS, etc.) and local administrations (Regions, Provinces, Municipalities, Basin Authority, etc.).

These public geologists perform activities related to the territorial planning

and to the control of the pursuance of norms, provided in the specific competence area of the public body for which they work. In these contexts, they have to interact with political decision makers, private citizens and external professional figures, for making technical evaluations and studies related to feasible projects. For playing their role in the best way, they must have the following requirements: a specific basic training and ability to give appropriate answers to the questions submitted, but in any cases they must ensure professional ethics. The importance of the ethical aspects in their work appears especially when they must assess the technical-geological-environmental compatibility of human activities on the territory (construction of buildings, roads, tunnels, dams, railroad, polluting industries, etc.) in relation with the correct use of geo-resources (rocks, water, minerals). The author exposes his own work experience of thirty years in the local administration on these topics.

U1-10 Orale Peppoloni, Silvia

10.1474/Epitome.04.1032.Geoitalia2011

PROPOSALS FOR DEVELOPING GEOETHICS IN ITALY

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Key terms: Geoethics; dissemination; scientific community; society

In recent years among geoscientists there is a growing awareness that their scientific and technical choices in each sector of activity (public, professional, industrial, research or teaching) can have significant repercussions on the territory and on the citizens that inhabit it and therefore that it is opportune to accompany these choices with appropriate reflections.

Starting from the necessity to reconsider the way of man's relationship to the planet Earth, the geoscientists are wondering about the role played in the social context in which they operate, about their responsibilities in taking decisions on the use of natural resources, on the exploitation and protection of the Geosphere, when they are required to give correct information on hazards, to support the emergency management or to make society aware about the value of own territory as a common heritage to share.

Up to 2007 in Italy, many researchers and practitioners have dealt with these issues, but the debate never took place in a coordinated and organized way. In addition, the occasions where to develop these themes were dedicated in wider sense to philosophical, epistemological and social aspects related to the Geosciences.

The need to develop a debate on Geoethics with better coordination has been confirmed by the success of the session entirely devoted to Geoethics, hosted for the first time in Italy within the VII Forum of Earth Sciences (Rimini, 2009). The significant number of intervened speakers and discussed topics showed the desire and the importance of going ahead in this cultural path in our country. In any case, it became evident the necessity to organize more effectively those who want to devote to these issues, improving their coordination, expanding the network of contacts and creating more opportunities for the debate.

To this end, some ideas are proposed, that aim to create a common space of reflection on Geoethics issues, offering a convenient time for the research and the discussion, a place for organizing and setting the activities, which represents a starting point for the dissemination of these issues within the national and international scientific community and civil society.

U1-11 Invitato Lanzinger, Michele

10.1474/Epitome.04.1033.Geoitalia2011

GEOETHICS AMONG THE DEEP CONCEPTS OF THE EXHIBITION PATH OF MUSE - MUSEO DELLE SCIENZE - TRENTO

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Key terms: international museology; science and society; sustainability

In the spring of 2013 the MUSE - Museum of the Sciences will be opened in Trento, Italy. This new structure inherits the experience of the previous Tridentine Museum of Natural Sciences in relation to the naturalistic research on the local environment and proposes a cultural program focused on the themes of sustainability in the relationship among nature, science and society. Geosciences play an important role in the interpretation of factors that require humanity to pay attention to the impact on the biosphere and geosphere and this is one of the most relevant and deep issues of the new project. Muse is currently under construction within an urban requalification project of Trento city and is realized through the efforts and the financing of the Autonomous Province of Trento.

U1-12 Orale Piacente, Sandra

10.1474/Epitome.04.1034.Geoitalia2011

THE STUDY OF LANDSCAPE: FROM HOLISTIC APPROACH TO SOCIAL CONCEPTION OF KNOWLEDGE

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Key terms: Transdisciplinary approach; Topological identity; Sustainable reevaluation

We present three examples of study and improvement of the landscape, in which the transdisciplinary approach is not implemented using a simple juxtaposition, but through a conscious integration between different areas. This new approach give a new and more correct interpretative key which unites, while it makes distinctions, replacing the "disjunctive thought". Our society is complex and in a state of constant change. Rapid movement and transitions make distances seem to vanish, and the link with our own territory, the place where we belong, might be expected to disappear. On the contrary, the more familiar a place is, and the more it is overshadowed by exotic or faraway places, the more this link become

stronger, as if we were researching for our own topological identity. And it is really this identity that should emerge: it is important to underline that through history, life, social structure, religion, culture in general, it has always been possible to find the roots and the more immediate fundamental expressions in the physical landscape, in the geological forms and aspects, in the rock material and in their aesthetical and functional characteristics, exalting and conferring them deep meanings and values.

By these premises, a correct communication to the public becomes the fundamental complement of the scientific research: for the scientists, it is an essential aspect of their work, for the citizens it is an orientation of life. Naturally, it will be possible to integrate cognitive tools in the territory, suitable and accessible to all (informative and educational materials, information panels, brochures, guided tours), without exaggerating with an over-dose of equipments, above all logistics and structures ones. This attitude would be able "to denaturalize" and to make "artificial" the landscape, because of the luck of the characteristics that had suggested the improvement of it.

1° Example. Sustainable tourism and understanding of the relationships man-landscape in the Ecomuseum of Hill and Wine of Castello di Serravalle (Bologna). Studying the landscape of Castello di Serravalle, hilly zone of wines DOP and DCOG production, it is still possible to observe the signs of the mutual and continuous interaction among man and environment, which persists here since over 2.000 years. This was at the origin of the Ecomuseo: an effective tool both for a sustainable tourist exploitation and for spreading knowledge and awareness of the local cultural patrimony among the residents.

2° Example. The Lago Bracciano of Montese (Modena): reevaluation of a marginal Apennine area among archaeology, landscape and history. Using good archaeological and document data (Etruscan-Italic finds, nineteenth-century news on a lake now disappeared, local legends) partly known but never correlated, integrated by geologic and geognostic data, and chemical and geochemical analysis, it was possible to trace essential elements for the reconstruction of the landscape in areas historically frequented and used by the local communities. In this way, the premises for a tourist exploitation of a marginal and seemingly insignificant area created, giving again a cultural and historical value to a site that deserves.

3° Example. Geological signs and poetic textures in the Frignano Park. The project of a geological-literary itinerary starts from the hypothesis that there is a poetic and cultural specificity in the Modena Apennines, linked to more markedly morphological and geological features of the territory. The landscape is seen as the main space of thought; the possible itineraries that from real ones become symbolic ones and vice versa; Geology and Literature as a viaticum, for a new knowledge's pilgrim. And the poetry, with his words, creates a more articulated, complex and fascinating geographical map to discover, than the topographical one.

U1-13 Orale Ferrari, Graziano

10.1474/Epitome.04.1035.Geoitalia2011

THE MALLET PROJECT: FROM AN EARTHQUAKE LABORATORY TO LABORATORIES ON THE TERRITORY

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Key terms: Natural hazard; Education; Environmental laboratory

On 16th December 1857 an earthquake devastated a vast area of Basilicata and part of Campania (Southern Italy): more than 180 villages, over an area of more than 20,000 km², suffered very serious damage to the buildings, to the extent that most of the houses had to be abandoned. Whole towns and villages spread out across an area of 3,150 km² were razed to the ground. Altogether over 6,000 houses collapsed or became uninhabitable and about 11,000 people died.

The Irish engineer Robert Mallet was a witness and an extraordinary "scientific chronicler" of this earthquake's effects. In the months of February and March 1858 he undertook a scientific mission to the area most badly hit by the earthquake, drafting an extraordinary diary in the process, in which his technical-scientific observations are not separated from the descriptive and literary ones. Upon his return to England, Mallet put down his observations in a weighty opus, which he published in London in 1862 with the title: The Great Neapolitan Earthquake, The First Principles of Observational Seismology.

With this title Mallet gave a name to the nascent science of earthquakes: Seismology.

The report by Mallet on the 1857 earthquake also represents, from different standpoints, a unique "observatory" on the landscape and the various social, economic and cultural aspects of the area worst hit by the earthquake.

The part of the territory of the provinces of Salerno and Potenza hit by the earthquake is one of the few areas of the Mediterranean that has been capable of keeping its natural and cultural legacy intact and integrated in the economic and social structure.

As a result of this ancient "harmony" this area offered the unique opportunity to create a privileged "observatory" over its natural environment as well as its historic and present-day anthropology, finalised to fostering a conscious participation of the area's inhabitants in the territorial context.

Within the framework of the idea of a "Mallet Laboratory" project there has been the opportunity to set up a network of study centres in the territory of the two provinces (Salerno and Potenza), capable of promoting research characterised by a great national as well as international breadth, starting with the world of schools and local communities. The publication of the work entitled Viaggio nelle aree del terremoto del 16 dicembre 1857. L'opera di Robert Mallet nel contesto scientifico e ambientale attuale del Vallo di Diano e della Val d'Agri (6 vols. and 3 DVDROM), was published during the period 2004-2009.

This edition is part of a project officially started one year earlier in 2003, a concrete sign that strategies promoting research and environmental education have been achieved. These aspects are indeed of great importance in the drafting and the enforcement of plans for safeguarding the territory, in which the regional administrations of the Italian State, first and foremost the Regions and the Province, are increasingly called upon to operate. Objectives, the results and perspective of the Project Mallet Laboratory will be presented.

U1-14 Orale Sibi, Patrizia

10.1474/Epitome.04.1036.Geoitalia2011

THE PER (PARK OF RENEWABLE ENERGY) GEO-ETHICAL PROJECT: A LARGE WIDESPREAD COMMUNITY OF RENEWABLE ENERGY

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Key terms: sustainable community; renewable energy; energy producers; social participation

We cannot separate the human being from his life environment and therefore we cannot change one without changing the other, transform the world without changing ourselves (G. Bateson, 2000)

If today changing the world means, first of all, to build sustainable communities in which the lifestyle is in harmony with the natural vital processes, this goal requires us to modify our conceptions and world relations. In the first place it is necessary to change our bad habit to think and act exclusively in terms of aim and usefulness, that is in anti-ecological terms. We have to gather the transformation strength of every action instead, and learn to accept the uncertainty, the unforeseen event, the fate as factors of innovation and creation. The geo-sciences describe us the complex natural systems and their constant evolution. At the same time, they reveal us the organizational and conservative principles regulating these systems.

So these scientific knowledge show us the ethical direction of our social actions: to cooperate with nature's ability to sustain life and the natural resources essential to preserve life itself. This purpose has oriented the proposals of P.E.R. (Park of the Renewable Energies) for a few years. The P.E.R. was born thanks to few people with a strong environmental awareness currently living inside the park. The P.E.R. is located in the province of Terni, between Todi and Amelia, in the territory of Guardaia, at 575 meters above sea level. It is a rural area, far from factories and from areas with industrial agriculture, inside a Community Interest Site (SIC), in 6000 hectares of wood.

It is an environmental technology park with innovative integrated systems for the production of renewable energy. These systems are utilized for both farm activities and educational experiences with the visitors of the Centre. The buildings, including an eco-hotel, are equipped with solar panels, photovoltaic panels, wind generators, geothermal engines and sophisticated systems for gray water recovery and for recycling of organic waste. The site is totally independent from any supply network, including water supply; this makes it an interesting example of eco-sustainability. Recently, the park has launched a public invite: to become part of a great widespread community for the production of renewable energy, to promote energy conservation and sustainable lifestyles. This empowerment process that transforms consumers into energy producers - but also in those ones who spread the culture of sustainability - could, over time, give life to a community that really lives according to the geo-ethical principles of bio-sustainability.

The route for the identification and dissemination of the PER Community is an interesting example of the generative process in which actors, rather than doggedly pursuing a predetermined objective, a model to be implemented, "look for directions and values that are inherent in the means available" (Bateson, 2000), including communication networks and methodologies of social participation.

In this perspective, the experience brought by the PER deserves to become an interesting object of observation and reflection for its green ethics. The components of the new community focus their attention on the effects of actions and relationships rather than on ways to reach a predefined goal. This ecological approach promises unexpected new creations: there is a chance we will see the birth of a sustainable form of social organization adapted to the human community at last!

U1-15 Orale Matteucci, Ruggero

10.1474/Epitome.04.1037.Geoitalia2011

A HIPPOCRATIC OATH FOR GEOLOGISTS?MATTEUCCI Ruggero¹, GOSSO Guido², PEPOLONI Silvia³, PIACENTE Sandra⁴, WASOWSKI Janusz⁵

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Key terms: Hippocratic Oath; Geologists; Geoethics

The Oath of Hippocrates is the first and the most popular moral code for the physicians. Throughout varying historical fortunes, from its almost complete oblivion in the Middle Age to its rediscovery and high recognition in the Renaissance, the Oath, written in the second half of the fifth century B.C., continues today to be pledged in many Faculties and Schools of Medicine and in many professional associations throughout the world, both keeping to the original text or one of the modernized versions. It is widely regarded as a cornerstone of the medical approach. Historically, the Oath of Hippocrates marks the first sharp changeover to a rational approach to the illness and to the human health; for this reason it is reserved only to people who is able to operate because of their scientific knowledge of medicine. Human health and defence against the illness always are seen as one of the basic goods of Mankind; so, the Oath enforces the ethical duty of a rational and positive use of the power possessed by the individuals because of their capability to apply scientific knowledge on the other men, becoming patients. Every oath entails a personal moral engagement. But, the public Hippocratic Oath sworn by the physicians over the world has marked through the centuries the awareness of an assignment of universal value, that goes well beyond the professional duty, becoming a mission that calls for the total willingness to operate in art and consciousness where and when need arises.

The awareness of the sacred value of the Human life is profoundly rooted in every man. The awareness of the value of our planet as the unique and often not renewable resource for Human life has emerged rather recently and not yet on a worldwide scale. Also the understanding of the planet as a living system, with its natural and unavoidable processes, including those (geo-hazards) with dangerous effects for man, is anything but widespread and well established. And, only now governments are reaching a greater appreciation of the guiding role of the scientific approach for the management of our planet, of its health and for the defense against dangerous events.

From that derives the special responsibility of those who possess the knowledge of the geological processes and the power arising from (or,

better, which ought to arise from) it; this responsibility goes beyond a merely correct professional conduct.

Geologist is like a physician. He or she are ethically involved; he or she must be fully and consciously engaged, wherever and whenever geological knowledge can provide a contribution to solving problems linked to the sustainable use/management of land and the Earth's resources. This means to be ready to go beyond geologist's professional duty and economic convenience, willing to counter any political, industrial and social interests conflicting with the health of the planet; being conscious that the latter, in the short or long time, represents the real interest of the society; aiming to assure a harmonic interaction between geologists, governments and population, in considering the cost-benefit ratio, the technological capabilities, and the public media. For these reasons, the authors, who are members of the recently set up Commission of Geoethics of the FIST (Italian Federation of Earth Sciences), consider it useful to submit to the Italian geological community the proposal for the introduction of a voluntary Hippocratic Oath for geologists, through which they would solemnly and publicly declare their consciousness to be the repository of the geological knowledge and of its entailed ethical duty.

U1-16 Orale Viale, Michela

10.1474/Epitome.04.1038.Geoitalia2011

SPREAD OF ENDEMIC DISEASE AND GLOBAL CHANGES: PROPOSITION OF RELATIONSHIPS DEVELOPED IN A TWIN PARTNERSHIPVIALE Michela¹, FERRERO Elena¹

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Key terms: Twin partnership; Dengue fever; Education to Sustainability; Global changes; Cape Verde

A project of twinning between schools of the Piedmont Region (Italy) and the Republic of Cape Verde, explored in the first stage the geomorphological aspects of the territory, developed in the next stage an investigation on pupils and students' conceptions about the geological risks in the area. A further educational research on students' perception of waste and its dangers has highlighted the connection between the physical characteristics of the territory, the different ways of managing waste and the correlation with socio-economic problems, showing many similarities between the two partners.

A sudden event such as the spread of Dengue fever, which appeared for the first time in Cape Verde in 2009, revealed that the inappropriate management of waste can be considered a major cause of the spread of this disease. Dengue Fever, also known as break-bone fever, is an infectious tropical disease caused by the Dengue virus. Its vector, the *Aedes aegypti* mosquito, has found an optimal environment for its life cycle in the context of Cape Verde, with the persistence of water in abandoned waste objects.

How can we connect topics of Earth Sciences with the spread of this disease? The link is not obvious, but it has been explored and illustrated in this stage of the partnership. Activities with pupils and students provided an opportunity to investigate how some global phenomena like climate changes (with an increase in local rainfall and higher temperatures) are related to local events, such as the spread of Dengue fever.

Both twin partners have been involved in this process of understanding, with the support of didactic tools that proved to be valuable aids. The Cape Verdean students presented their preventive strategies, according to the instructions given by the Cape Verde Ministry of Health; the Italians students were involved in developing and reinforcing the emotional and empathetic value of the partnership both in terms of knowledge and friendship.

Some methods used to struggle with the mosquito vector's diffusion may interfere adversely with primary natural resources (air, water, soil): is it possible to fight this disease in a sustainable way?

Preventive strategies are conditioned by the geomorphology of the territory and the by the complex relationships that connect geosphere and biosphere. For this reason, it is important to be aware of the risk of breaking those delicate balances activating unexpected consequences. The strategies proposed by the Cape Verdean students demonstrate awareness of these risks, since they are involved in a clear example of a sustainable campaign against Dengue fever.

The roles played by both partners have linked knowledge about the natural dynamics of our planet with the development of appropriate behavior, thus contributing to the formation of responsible citizenship to preserve and protect the environment. The partnership also encouraged students to develop sustainable management strategies against the disease, and consequently against waste, actively involving them at school, at home and in their community.

U1-17 Orale Ferrero, Elena

10.1474/Epitome.04.1039.Geoitalia2011

GEODIVERSITY ACTION PLANS FOR DISSEMINATION ACTIVITIES OF PROGEOPiEMONTE PROJECTBELLUSO Elena¹, FERRERO Elena², GIARDINO Marco³, LOZAR Francesca³, PEROTTI Luigi²

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Key terms: Geological heritage; Piemonte; Science exhibits; Nature trails; Didactic tools

The multidisciplinary research project "PROGEOpiemonte" ("PROactive management of GEOlogical heritage in the PIEMONTE region: innovative methods and functional guidelines for promoting geodiversity knowledge and supporting geoconservation activities ("PROGEO-Piemonte"; coord. M. Giardino) aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region by means of the development of techniques for recognizing and managing its rich geodiversity at the local and regional scale. After a systematic review of inventoried geosites, 9 strategic geothematic areas will be investigated to represent the geodiversity of Piemonte, each characterized by high potential for scientific studies, enhancement of public understanding of science, recreation activities and for economic support to local communities. Geological history, climate and environmental changes, natural hazards, soil processes and georesources will be popularized not only with geosites but also with museum collections, evidences of mining

activity and quarrying, science exhibits and nature trails. The recognition of the economic value of geodiversity will lead to the production of regional guidelines for Geoconservation integrated quality management system, suitable for tourism and sustainable development strategies. An international advisory board will evaluate yearly project advancements, proposed strategies and products.

One of the main target of the project is to improve public awareness on major earth science challenges, both from the hard and applied Earth Sciences point of view. Since the general public, both the young and adults, have a sort of illiteracy with respect to Earth Sciences, we plan to get them involved in an easy but complete way in to the subject. We experienced in the last few years two approaches to disseminate and share geodiversity and geoheritage contents in Piemonte; the first one involved local partners, such as primary and secondary schools (proposing specific research-action curricular activities) or science museum (both at the local and regional level), for the design of scientific exhibits focused on specific subjects related to the impact of dramatic geologic events (vulcanos, earthquakes, floods, coastal hazards, etc) on human presence and activity; the second one was focused on road exhibits (European researcher's night, ESOF-European Science Open Forum- science in the city) where several scientific experiments, dealing with multi-faceted geological subjects, were developed such as the following: plate tectonics experiments; models of slope instabilities; the discovery of the fossil record and the reconstruction of past climate changes; the exploration of the decorative stones of Torino's historical buildings; awareness of fibrous mineral (asbestos) and mineral particles impacts on health; classification of mineral collection by using the five senses. These live experiments or games are the ideal start for the present project, and we plan to improve both their scientific content and the general organization. From these past experiences we will focus on new outcomes of the project, that will include didactic tools for educators, schools and public in general, together with more traditional museum exhibits, real and virtual geological tracks, interactive websites and training courses for geonaturalistic guides. The produced material will be shared with teachers for local school projects and natural science museums of Piemonte. Moreover, long-term objectives and short-term targets for geodiffusion actions will meet the requirements of local communities in the geothematic areas. Local partners will offer human and financial resources for the achievement of the geodiffusion objectives.

Last but not least, geological literacy of children, young persons and adults will thus have a positive deep impact on every day life and on our future.

U1-18 Orale D'Addezio, Giuliana

10.1474/Epitome.04.1040.Geitalia2011

RESEARCH AND EDUCATIONAL OUTREACH

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Key terms: natural hazard; research; education

The Istituto Nazionale di Geofisica e Vulcanologia (INGV) is one of principal Italian institution dealing with Earth Sciences research. INGV is also in charge of the real-time seismic and volcanic surveillance, and of the early warning and forecast activities. Italy is a seismic and volcanic country and it is therefore important the social role of a correct information on natural hazards and its implication on social and cultural aspects. The Laboratorio Didattica e Divulgazione Scientifica of the INGV organizes intense educational and outreach activities in the consciousness that preparedness is the best way to live with and to mitigate natural hazards.

These activities partially respond to a significant demand from the Society; one question is which are the most effective and authoritative approaches to be developed to fulfill this demand. The *Annuario Scienza e Società 2011*, even if outlines a scarce level of scientific knowledge among citizens, highlights a growing demand for information on science and technology. For the majority of people the main source of scientific notions are newspapers, where the exposition of science-related news is constantly increasing. On the other hand, public Conferences that allow a direct relationship with researcher represent the most reliable scientific informative contest, as well as the Web sites of scientific institutions and the researchers blogs. These data emphasize the importance of the social role of science institutions and the need of an active and responsible involvement of research in educational outreach. This represents one of the aim of our educational activity. This talk give an overview of our activities with regards to research-community interactions.

U1-19 Orale Magagna, Alessandra

10.1474/Epitome.04.1041.Geitalia2011

INTERACTIVE ACTIVITIES TO STIMULATE DEBATE AND CRITICAL THINKING ABOUT ISSUES RELATED TO EARTH SCIENCES AND SUSTAINABLE DEVELOPMENT

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Key terms: Earth Science education; Sustainable Development; Exhibition; Action-research

During the International Year of Planet Earth (2007-2009), the Department of Earth Sciences (University of Turin) and the Museum Craveri of Natural History (Bra, Cuneo) promoted the project "Understanding how the Earth works: from local situations to global processes". In this context, two geothematic exhibitions about Cape Verde were designed, both accompanied by guided tours and practical laboratories addressed to students of different ages (from nursery to secondary school), as well as workshops dedicated to in-service teachers. The exhibition "Knowing the volcano in order to live together with it" (February - April 2008) was the subject of an action-research carried out as part of a master's degree course in Natural Sciences. The research concerned the design of interactive activities related to the exhibition, the collection and analysis of data on the performance of these activities during the guided tours conducted with the students.

The aims of the interactive activities were to generate emotional involvement, to stimulate interest and curiosity, to develop debates among visitors, to widen view points on topics of relevant scientific and social value: volcanism, hazards and sustainable development. The activities included discussions about questions with many possible answers, in order to trigger a process of discovery driven by the rise of

multiple viewpoints. During the tours the museum guides (people involved in the action-research) moderated the discussions, helping both students and teachers in debate as well as in personal reflection.

The action-research project undertaken enabled us to assess the effectiveness of this teaching strategy, in order to establish possible modifications on activities during their execution as well as in view of future events.

To achieve this goal the research followed different ways: a quantitative analysis was completed on the worksheets elaborated by students during these activities, as well as the satisfaction questionnaires filled by students and teachers. From the qualitative point of view, the level of interest and participation of pupils and teachers were monitored during tours and, in some cases, it was possible to have a feed-back concerning the implications in the following classroom work.

In this research, the qualitative aspects were crucial: despite the quantitative data analysis allowed to study the mental representations on socially relevant themes in students of different ages and to collect multiple points of view in this regard, the interpersonal relationships that occurred with students and teachers during and after the guided tours provided the best evidence of the value of interactive teaching strategies adopted. For example, the guided tours stimulated interest for the topics discussed: this was demonstrated both during the visits, through questions and observations, both in the classrooms, through the request for further details. Some special cases allowed to investigate these aspects. The exhibition was subsequently staged at other institutions, where the activities were offered again, with positive feedback. In conclusion, the effectiveness of the interactive activities and of the teaching strategies proposed was proved, as well as the possibility to re-propose them outside the context of the museum for which they were conceived.

U1-20 Orale La Longa, Federica

10.1474/Epitome.04.1042.Geitalia2011

STRATEGIES FOR SEISMIC RISK REDUCTION: OUTREACHING SCIENTIFIC KNOWLEDGE OR PROMOTING AWARENESS, TO EDUCATE?

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Key terms: risk education; outreach; science teaching; awareness

This work develops a critical reflection on the activities for information, training and education conducted by a group of researchers of the INGV in recent years.

In particular, our analysis, from an epistemological point of view, is between:

- science outreach, the link between science and the school;
- science teaching and its role of contact between science and school;
- risk education, imaged as a process able to develop a culture of risk in relation to the territory in which we live.

These issues are critically analyzed on the basis of experience gained since 1995.

The educational methodologies tested in "peacetime", out of seismic events, with the EDURISK Project are compared with those experienced during the emergency in Abruzzo.

Increasingly today, we refer to prevention as a primary strategy of defense against risk.

But very often the responsibility of making prevention falls on the others as government, institutions, local authorities and the citizen perceive themselves as powerless against the inevitability of natural events and refer to the rulers for the implementation of effective prevention policies.

As researchers, what are the most effective actions we can take to influence the risk reduction and motivate the choices of people? Before an event occurs, how can we influence the views and choices that people do or not do to reduce the risk?

The effectiveness of our interventions must be based on scientific information, on a specific training, or must be reached to develop values, actions, awareness?

Our interventions must be oriented and developed to inform, to train or to educate?

U1-21 Orale Manni, Riccardo

10.1474/Epitome.04.1043.Geitalia2011

THE PALAEOLOGICAL MUSEUM IN AN APPROACH GEOETHIC

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Key terms: palaeontology; museum; fossils; mystification

The protection of scientific data with respect to incorrect interpretations or misrepresentation has ethical significance, especially when it depends on the information to the public. Striking were the cases of Man of Plitdown and the Indian researcher Vishwa Jit Gupta. Man of Plitdown was a sensational case in which one or more researchers deliberately altered the fossils found causing serious damage to image both the academic world and the scientific theories. The event organized by Gupta was equally sensational, because mystifying the paleontological data, he put the crisis in different palaeogeographic and palaeoclimatic models well established. But the mystification and alteration of scientific data can be made even in a more insidious way, because they often inconspicuous, where the fossils are preserved, that is in the Museum of Palaeontology. In fact, when a specimen is badly restored or is assembled incorrectly, the information given is altered and distorted.

The Paleontological Museum, frequently have fossils that are perfect at first sight. Only a closer look it turns out that often have been largely restored. There are parts rebuilt and then colored so well that at first you do not always notice it. The information of what is artificial reconstruction and what is original material must be immediate and clearly perceptible. It is always necessary to specify when a cast replaces an original finding. Other times you see skeletons assembled in questionable positions, as if the still image of a slow-motion. It is frequently the case of dinosaur skeletons that seem ... fly. More frequently, the skeletons are assembled according to theories no longer in vogue, partly because the replacement is often costly and difficult. Just think of the bipedal dinosaurs: until a few years ago it was believed that they had the same posture of "kangaroo". It is now believed, after detailed analysis of functional morphology, bipedal dinosaurs have tail and neck more or less parallel to the ground. However, many museums display their dinosaur skeletons still with

posture of kangaroo and the visitor is convinced that their posture is exactly that of the kangaroos.

It is clear that all these cases stem from an incorrect and more widespread understanding of the role of the paleontological museum and its exhibitions. At the end a fossil must be beautiful regardless. A vision that should not be accepted because the representation of the fossil, as evidence of past life, is sacrificed in this case in favor of aesthetics and an imaginative approach and unreal. It would be appropriate to better define a code of behaviour for the restoration and for the display of the paleontological material so that the visitor has a representation of what is exposed more possible near to reality.

U1-22 Orale Pannaccione Apa, Maria Ilaria

10.1474/Epitome.04.1044.Geoitalia2011

ETHICAL APPROACH TO SOCIO-ECONOMIC INFORMATION SOURCES IN PRESENT VULNERABILITY AND RESILIENCE STUDIES: THE MT. CAMEROON CASE (MIA-VITA PROJECT [FP7-ENV-2007-1])

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Key terms: Vulnerability; Social recovery; Resilience; Mt. Cameroon volcano; FP7 MIA-VITA project

The study of the vulnerability facing natural and man-made hazards with the related resilient answers belongs to the complex and articulate field of social sciences called Disaster Anthropology. Vulnerability is generally defined as the weak point facing an aggressive event difficult to manage. Resilience is the subsequent capacity for self-repair after a sustained stress (natural or anthropogenic).

Consequently, the theoretical model of economic resilience is the ability to restore an economic background able to support the gradual recovery of social benefits since the disaster.

Moreover, the presence in the territory of different systems of production (natural ecosystems and / or technical) should suppose multi-resilient communities.

The mathematical nature of these economic theorems makes difficult their practical application inside an ethno-anthropological contest and can easily conflict with the cultural traditions of those potentially resilient societies or with the inability to apply a practical recovery system due to socio-structural causes.

An example is given by some urban and rural family structures settled around the Mt Cameroon volcano, in which the general psychological pressure increases both for the constant exposure to natural hazards and the vulnerability arising from its social environment (e.g. castes, forced housing allocation, cultural estrangement to local chiefdom, etc.). The rational and carefully weighing choice of the heuristic model to be adopted in the study of social vulnerability is therefore an extremely complex task with many interpretive obstacles.

In 2009, within FP7-MIA-VITA (Assess and Mitigate risk from volcanic impact on terrain and Human Activities), was launched the 1st fieldwork mission for the study of socio-economic development of communities living around Mt Cameroon, completing 108 interviews at several social groups of different ethnicity and religion. The resulting information will be re-tested and verified during the 2nd fieldwork mission 2011 for completion of the study area.

The major attention and sincerity in answers observed in social groups with a common cultural background, as for the chiefdom, seems to confirm as the above suggested.

U1-23 Orale Piccione, Caterina

10.1474/Epitome.04.1045.Geoitalia2011

MEMORIES OF THE PAST CONTRIBUTE TO PREVENTION PHOTOGRAPHY CAN BE A DIRECT MEANS FOR THE PUBLIC UNDERSTANDING OF SCIENCE

PICCIONE Caterina¹
1 - INGV

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Key terms: prevention; memories of the past; photography

There are thousands of ways to achieve a sustainable future for our Planet: some of them follow high-value scientific research activities, others simply aim at increasing people's awareness of what can and should be done to improve our and our children's quality of life. The easiest way to develop this specific kind of "spread culture" consists in bringing back to life what was preserved of the history of a population and of a territory, by representing it with a renewed form and by making it a "food for thought".

The National Institute of Geophysics and Volcanology (INGV), followed this approach and decided to publish two volumes whose objective was to make people more aware of the geological and volcanic risks in some specific areas of our country. The immediacy of photography was used to tell the stories of volcanoes and earthquakes, to represent past events becoming "memories" and to use them as a basis to build a better future. "Terre di Fuoco" (Lands of fire) and "Terremoto Calabro-Messinese, 1908-2008" (Earthquake in the Calabria and Messina areas, 1908-2008) are the two photographic books published by INGV in cooperation with Alinari, the oldest firm in the world working in the field of photography and image communication. The pictures selected to be included in the two books had a double significance: on one side they had to convey to the reader the immediacy of emotions that other persons had felt and lived; on the other side they had to make people understand the importance of prevention.

The fascination of history, the importance of memories of the past and the extraordinary strength of images help the reader build a link between past, present and future, where the lesson learnt from the past centuries and from the study of the earth and its energy helps understanding which steps should be taken to achieve a "sustainable" future.

U1-24 Orale Pirro, Mario

10.1474/Epitome.04.1046.Geoitalia2011

A WAY OF MAKING GEOETHICS IN THE CONTEXT OF HIGH SCHOOL THROUGH SPECIFIC "EDUCATIONAL PROJECTS"

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Key terms: didactics; ethics; outreach

With no doubt the work of the geologist, both as a public employee and as a freelancer, is to be carried out through actions in line with the ethical rules that directly affect the problems involved.

In this regard, the recent reform of High School in Italy provides for a new organ, called "scientific committee", as part of its structural reorganization. It has the aim of proposing to the students of each institution some educational activities, targeted to the deepening of the disciplines tackled during the studies and to the inclusion of young people into employment.

In this context, the geologist can certainly give a scientific contribution based on his geo-environmental knowledge and his direct experience acquired over time. This could allow him to develop "educational projects", carried out over a three-years period, so that the students are able to acquire important knowledge about various topics related to Earth Sciences (e.g., on environmental hazards, etc.).

In this session we will present the geo-didactic project started at the ITSG E. Fermi in Tivoli (Rome), centred on the rediscovery of the "Lapis tiburtinus", from its formation to its use throughout history.

SESSIONE U2

Scienze della Terra e didattica: verticalità, didattica laboratoriale e contesto di senso

U2-1 Orale Occhipinti, Susanna

10.1474/Epitome.04.1047.Geoitalia2011

EARTH SCIENCES AD SCHOOL: "VERTICAL" CURRICULA, , "HANDS ON" PRACTICES AND CONTEXT OF MEANING

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Key terms: "vertical" curricula; "hands on" practices; context of meaning

The teaching-learning process of Earth science needs to be strongly supported by different tools. Teachers' community must give a greater attention to scientific curricula, passing by a careful choice of knowledge, a graduated vertical develop of levels and of scientific languages, a planned use of tools and methods.

Earth science curricula are characterized by a lack of identity and are often overshadowed by the life and physical sciences; Earth science topics are spear into geography, history, and even biology. It is necessary to give them more coordination and relevance: not only Plate tectonics but also meteorology, cartography, hydrology, Earth history and evolution, even pollution and energy, and Environmental education are related subjects.

Then it is possible to develop a curriculum where levels and standards are well organised and structured, where the necessary, progressive and growing knowledge is proposed at each level of education, in a not repetitive and constructivist way, with the main goal to understand the complexity of Earth system. To obtain this result we need good materials and tools and to teach in a more effectively way. Each subject needs appropriate instruments to be teach and learned. It is well known, and widely demonstrated, that these instruments are nowadays oriented on teaching methods based on hands-on experience on the inquiry (Inquiry-Based Science Education) and the use of the problems (Problem-Based Learning). A collection of Inquiry based instrument for Earth sciences, either with rough materials or with specialised instruments, with already known protocols or, if possible, by new ones. The goal is to find out the more effective experimentations, discoveries, protocols, approaching methods to teach knowledge, to promote students' abilities and to build competences and scientific literacy. It can be interesting also to propose good instruments to evaluation and to certificate acquired skills, for all level of education, to prepare to university skills: the impacts on student learning must be adequately evaluated.

A network of teachers with a Earth science formation, who are, for their cultural shape, well oriented in a "scientific working method", in a "scientific habits of the mind," and "inquiring from evidence" could work together to supports a dissemination of good practice-teaching and to improve a sensibility, even a "passion" in students towards Earth sciences subjects: a stone is not only a rock samples, but also a document of physics and chemical evolution, a mineral is a "living" object, rich of charm and of tales; a mountain is alive and changing exactly like animals and plants living on "her".

The goal is to establish strong connections between schools and the territory, in order to use the existing facilities for curricular activities, as a spread laboratory. Earth sciences have the big chance that is the most visual of all disciplines and that everyone is interested in the natural world with which we interact every day. The goal is to establish a strong connection between the school and the scientific community. For too long, research has been a priority in this community, who has spent most of its time communicating with other scientists in a language that only scientists understand.

Scientists have neglected the need to communicate with people other than themselves and first with the education system. It is essential that broader public understand the Earth science and its significance: education is the only route to achieving this goal. The challenge for scientists is to build educational opportunities that take advantage of this public interest without losing the priority of the science. We could work, in this way, to change the common idea of a complex and difficult science, up to date only in the occasion of big natural disasters, while on the contrary "it is basic to know our past, to face our future".

U2-2 Orale Greco, Roberto

10.1474/Epitome.04.1048.Geoitalia2011

EARTH SCIENCE CURRICULA IN PRIMARY AND LOWER SECONDARY

SCHOOL IN ITALYGRECO Roberto¹

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Key terms: Primary school; Earth Science; Education; Lower secondary school

In this presentation we will introduce the Italian curricula in primary and lower secondary school in Earth Science. We analyze the relation with geography and others subject and the way that the teachers are prepared and trained. There will even a comparative analysis with some other european curricula. There will be presented some successful experience in the teaching of this subject.

U2-3 Orale Benciolini, Luca

10.1474/Epitome.04.1049.Geoitalia2011

HOW CHILDREN OBSERVE, DRAW, THINK ROCKS: A DIDACTIC LABORATORY AT ELEMENTARY SCHOOLBENCIOLINI Luca¹, ROBAZZA Monica¹, ZORZENON Marco¹, MUSCIOGiuseppe², SIMONETTO Luca³, CODUTTI Daniela³, TAVANO Maura³

1 - Università di Udine

2 - Museo Friulano di Storia Naturale (Ud)

3 - Scuola Elementare di Martignacco (Ud)

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Key terms: elementary school; conceptual changes; petrographic description

In order to investigate how children think of rock samples, what are their spontaneous ideas and their conceptual changes during qualitative description of geological materials, the Museo Friulano di Storia Naturale in collaboration with the Università di Udine submitted two classrooms of fifth grade-students to a specific test. Fortyseven students without a specific background in Earth Science but with a curriculum in object description were asked to give I) a written description of a rock sample; II) a drawing of the sample; III) a written short story about the sample.

Main results are:

A) The shape of rock piece received many attention, and careful description. Samples were identified for their external form as expressly stated in a short story: "the stone slipped and broke thus forming a new stone type";

B) Fossils or clasts in a conglomerate were considered as attached to the sample, not as the sample components;

C) Similarities were evaluated revealing in turn fabulous or interpretative intentions. As an example, in the first case sentences like "this stone is like a mouse", "it has a flavor of licorice" were reported. Interpretative sentences are: "this stone is like a mountain" "it seems a dinosaur" "it smells like a cave";

D) Geological objects as foliations, strata, laminations were reduced to a one-dimensional description and were consequently identified as "lines, strips, petroglifs";

E) Minerals correspond to any specific color seen in the rock, but any difference was recognized between color of the mineral and color of the altered sample surface;

F) About 50% of the works did not demonstrate specific correspondence between the drawing and the written description. Drawing was often more detailed than the written description. Drawing often reflected the actual sample complexity and heterogeneity. Obvious heterogeneities such as magmatic contacts were correctly represented by drawing, but they were not worth of any attention in the written description. On the contrary, written works sometimes contain careful descriptions of the clastic sedimentary process but these criteria were applied to a travertine, without any relation with observed characters.

G) Short stories were often concerning adventures in a gemstone research or catastrophic geological events (earthquake, floods, landslides and so on). All students talked about stones having human properties and skills (movement, words, feelings and so on).

According to previous researches on misconceptions in geoscience, we consider that: results A) and B) reveal how difficult is thinking of a heterogeneous object as a complex system; result D) attests the problem of a three-dimensional thinking; stories reporting catastrophic events and "human" stones (G) suggest how difficult is thinking of long and continuous evolution-events that are out of the human experience, or more in general they reveal difficulties in thinking of geological times. We suggest that drawing activities could represent useful strategies for stimulating specific skills in observing reality, comparing with previous ideas and emerging conceptual changes. Finally, drawing geological objects could introduce pupils to a holistic perspective. We also suggest that most of these misconceptions mainly depend on the lack of field and laboratory experience. By standing in front of an outcrop, drawing it, and sampling it with a hammer, the rock surface should suddenly become representative of an interior essence, not only of an external side.

U2-4 Orale Bianchi, Cristiana

10.1474/Epitome.04.1050.Geoitalia2011

FOSTERING COMPETENCES THROUGH EARTH SCIENCE EDUCATIONBIANCHI Cristiana¹

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Key terms: competences; Earth System Science; learning

This paper will show the links between Earth Science and the competences reference grid that teachers are learning to use as a guideline for their curricula. Specifically, concerning the "Cultural Axes" provisions (Muir 2007) and the European guidelines on Lifelong Learning Key Competences (December 18th 2006), Earth Science helps develop competences related both to the observation, description and analysis of natural and man-made phenomena as well as to gaining an understanding of the concepts of "system" and "complexity". This discipline helps develop data collection skills through direct observation of natural phenomena; the data are then organized and represented appropriately, so they can be interpreted using models. This can be achieved by adopting laboratory - based teaching methods or at least active teaching methods, and by using experimental tools and approaches that help to understand phenomena and their interactions. Earth Science must be approached using cross sectional knowledge, but traditional disciplines shouldn't be ignored, as they play a key role in gaining understanding of complex interactions: the challenge teachers must face is to provide learning scenarios that bring both these aspects

into focus.

The recent introduction of a discipline called "Integrated Science" (see the Guidelines for New High Schools - 2009) in school curricula could prove useful to this goal.

U2-5 Orale Murelli, Valentina

10.1474/Epitome.04.1051.Geoitalia2011

MEDIA COMMUNICATION IN SUPPORT OF EARTH SCIENCE EDUCATIONMURELLI Valentina¹, CATTADORI Matteo²

1 - Linx - Pearson Italia

2 - Museo Tridentino di Scienze di Trento

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Key terms: citizenship; media; general communication

Out of school all citizens, both adults and the younger, more inexperienced, find in the media - tv, newspapers, the web - a source of scientific information. Over the past two years many issues related to Earth science have made the news and have caught the attention of the public by appearing on the most popular media: the earthquake in Haiti and the one in Japan, which was followed by a devastating seaquake, the scare story about the earthquake that assumedly should have hit Rome on May 11th 2011, the eruption of the Eyjafjallajökull volcano in Iceland, the catastrophe theories about 2012. This concentration of events provides a unique opportunity for all science communicators, science teachers included, to consider the amount of space dedicated to Earth science in large - scale media science communication and think about the role that this could play in Earth science education.

The aim of this paper is to offer a critical study, on a qualitative rather than on a quantitative scale, of Earth science media coverage. We believe that this could provide useful elements that, by catching students' attention and by raising their curiosity, would support educational projects which encourage scientific citizenship. A set of questions regarding both areas of communication and education, followed by a critical comparison between the two, guide the study.

U2-6 Orale Papini, Paola

10.1474/Epitome.04.1052.Geoitalia2011

THE MINERALSPAPINI Paola¹

1 - Istituto Comprensivo "Primo Levi" di Impruneta

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Key terms: vertical Science Curriculum; crystalline habitus; amorphous state; natural processes; physical properties

This is a study based on Minerals and the active involvement of Lower Secondary school pupils, developed along a vertical Science Curriculum, where the teaching-learning of Earth Science is effectively and significantly performed through laboratory practice.

The choice of minerals, and especially crystals, is also due to their beauty: their regular shapes, their colours and transparencies are aspects that capture the students' curiosity and attention. Any crystal, no matter big or small, retains its nature and can tell its story; it's up to us learning to understand it. Last but not least, crystals are natural solids which are suitable to being studied without the claim of becoming mineralogists; pupils can work on them both in their purely geometric and chemical-physical aspects, working in contest and being actively involved in their learning process.

Due to the cross-disciplinary teaching content and all the skills involved, the path can be successfully linked to other subjects such as Technology, Geometry, Art and History.

The activities within the project called The Minerals have been shared and experienced by all Science teachers of our school who are involved on the vertical curriculum of our institution.

The purpose of this course of study is that students are aware that minerals:

- are natural substances, solid and consistent
- are the result of a natural process
- can be studied and classified according to some physical characteristics
- have influenced human history.

U2-7 Orale Cattadori, Matteo

10.1474/Epitome.04.1053.Geoitalia2011

THE I-CLEEN PROJECT (INQUIRING ON CLIMATE & ENERGY). ENHANCING AN ENQUIRY-BASED APPROACH TO EARTH SYSTEM SCIENCE IN ITALIAN CLASSROOMSCATTADORI Matteo¹, BIANCHI Cristiana², LIONELLO Paola³, MACARIOMaddalena⁴, SCAPELLATO Barbara⁴

1 - Museo Tridentino di Scienze Naturali

2 - Centro Formazione degli Insegnanti di Rovereto (Trento)

3 - Scuola Media "Nuova Europa" I.C. Dro (Trento)

4 - Università degli Studi di Camerino

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Key terms: Cooperation; Liferay; Open Educational Resources; Climate; Energy

In the last years, the world of Italian school underwent some slow but deep transformation processes. One of the negative consequences - documented by specific studies - was the further weakening of the use of inquiring educational practices (or kinds of lessons) by science teachers. This occurred in a scholastic framework already traditionally little inclined to those.

The I-CLEEN project (Inquiring on CLimate & Energy, www.icleen.museum) was born in 2008 with the intent to react to (and contrast) this process (trend) by initiative of a staff of science teachers from different regions, all with many years' experience, coordinated and supported by the local museum, the Natural Science Museum of Trento - Trento, Italy.

I-CLEEN is a free instrument of cooperation for Italian teachers, aimed to support and enhance the practice of the inquiring education in explaining themes in range of Climate and Energy and generally about Earth System Sciences. This project is a consequence of what has been experienced and done in Italy by its creators within the Educational and Outreach program of ANDRILL (ANtartic geological DRILLing).

The core of the project is a database of resources potentially useful to a teacher preparing an inquiring lesson. These are selected by a staff

following a specific selection policy. There are also lessons ready to be used in the classrooms, prepared according to a specific editorial standard. These are composed by a paper for the teacher and a paper for the student.

The database is technically an information gateway and it is constantly enriched thanks to a job of critical research in the teachers' practices or the worthiest international educational web projects. These are published in Italian or in bilingual format (Italian-English), always through explicit authorization by the authors and under a Creative Commons license when possible.

This contribution illustrates details about this service which is on-line since December 2009 and is characterized by a peculiar use of the informatics technologies. Indeed, both the parts composing the project (site, resources database, publishers, and users) and their respective activities (editing, publishing, cataloguing, administration of web contents and users) are fully dealt by one open source web platform called LifeRay, purposely implemented for this project.

Also the undertaking and the study of international projects and reference standards were accurate and broad, both in designing and developing the service (DESIRE project - Development of a European Service for Information on Research and Education) and creating the metadata (DCMI standard - Dublin Core Metadata Initiative - and LOM standard - Learning Object Metadata, IEEE 1484.12.1 2002).

The i-CLEEN Project was recently awarded with the GOLD AWARD in the section Mathematics, Science and Technology of the new E-Learning Award 2010 contest. The competition was organized by European Schoolnet, the institution belonging to the EC and the Education Ministries of the member states, which promotes the use of the ICT in schools.

U2-8 Orale Macario, Maddalena

10.1474/Epitome.04.1054.Geoitalia2011

POTENTIALITIES AND LIMITS OF THE INTERACTIVE WHITEBOARD (IWB OR LIM) IN THE INQUIRY BASED LEARNING OF EARTH SCIENCES.

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Key terms: Interactive Whiteboard; teaching tools; Earth Sciences; Inquiry Based Learning

In the last few years a new multimedia device is taking place in the Italian School, as well as in other European countries. This is the Interactive Whiteboard (IWB or LIM in Italian), a powerful innovative teaching tool which is a whiteboard and at the same times also a beamer and a computer. Using the IWB, the Earth Sciences teacher of every kind of school can perform engaging lessons integrated with lab activities, in order to plan a complete inquiry-based curriculum. The multimedia resources, which are easily available in the web, are very useful in this approach. For example there are a lot of animations, applets and flash videos that can help the students in understanding some of the most difficult topics, like plate tectonics, faults origins and so on. Another very important resource is the multimedia material which is furnished by the Publishers as attachment of the textbooks in use. However, we stress the fact that the imagination and the ability of the teacher, but also his knowledge skills and expertise, are the essential elements that let the IWB become a dynamic, versatile teaching tool, which is able to help the teacher in leading effective and solid lessons. Every session can be saved, and then it can be recovered and expanded in the future. It is also possible to share the lesson with the students by mailing list, in order to perform remedial or revision activities. Moreover, this will be of great help for the students with handicap problems, like dyslexia or dyscalculia. Nevertheless, like every informatics technology the IWB has some limits. Giving the students a lot of passive information is the main risk, in fact most part of inputs are visual aid. As a consequence, possible loss of mind elaboration, abstraction power, and thinking skills might occur. This is a problem that every teacher must be ready to face. The teacher communities, which are growing in connection with the websites of the IWB proprietary brands, provide a huge quantity of prepared lessons, ready to be downloaded and to be implemented. In the same websites there are also e-learning courses and tutorials about the basic use of the instrument. In this way, the IWB may become a solid alternative partner of the well-known teaching tools of the trade, as chalk-cleaner-blackboard.

U2-9 Orale Giardino, Marco

10.1474/Epitome.04.1055.Geoitalia2011

THE "GEONATHAZ" PROJECT AND THE ENHANCEMENT OF AN INTERNATIONAL EARTH SCIENCE COMPETENCE ON NATURAL HAZARDS

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Key terms: Natural Hazards; cross-cultural understanding; internationalization of natural hazards curricula

Organizational frameworks for didactic activities and student mobility between didactic institutions are considered as critical solutions for enhancing student education and for strengthening international competence in natural hazards research. Particularly, geoscience partnerships among schools, university, government and private-sector institutions may offer expertise and material support for the integration of traditional field-based activities and Geomatics techniques. In this perspective, the "geoNatHaz" project develops a Transatlantic Exchange Partnership (TEP 2009-2012) in the framework of the EU-Canada program for co-operation in higher education, training and youth. The project aims to improve knowledge and skills required for assessment and management of natural hazards in mountain regions. It facilitates exchanges between a consortium of universities from European Countries and Canadian Provinces, to enhance international competence in natural hazard research.

The project promotes cross-cultural understanding and internationalization of natural hazards curricula through common lectures, laboratory exercises, and field activities. Six field courses are in program over the three-year period of the project - three in Europe and three in Canada. The course topics are: (1) impacts of climate change on natural hazards in

high mountains, (2) deep-seated rock-slope rock-slope deformation, (3) mitigation of landslide hazards in mountain valleys, (4) applications of new technologies in natural hazard research, (5) frequency-magnitude relations and risk assessment, (6) earthquake hazards and risk in mountain regions.

For development of transferable technical skills and cultural competence on Natural Hazards, a serie of supporting organizations provided their high technical value and live connections to the territories of NW-Italy and Western Canada where field activities have been performed. The GIS and Geomatic Laboratory (Geosilab) of the University of Turin and the Geotechnics and Photogrammetry laboratory at Simon Fraser University, trained participants in mapping and digital representation of natural hazards. Thanks to some "lucky circumstances", the distinction between hazard and risk and the environmental differences between Canada and Europe have been "lively" analyzed during the summer schools, without suffering harmful consequences of active instabilities. Participants in the Mount Meager area, an uninhabited sector of the Coast Mountains of British Columbia have experienced the effects of a high-magnitude hazard. Here, the second largest rock avalanche ever occurred in Canada happened just one week before the geoNatHaz field trip, leaving an available, open-air laboratory for large-slope instabilities. In contrast, geoNatHaz students could cross-examine the high-risk area of Mount Blanc: either in the upper glacial part of the mountain or at the lower elevations of Courmayeur, where natural hazards have a higher probability to cause injury to inhabitants and tourists, or damage to infrastructures.

Outcomes of the geoNatHaz project has been disseminated through the electronic and print media, results being of considerable interest not only to academics or professionals, but also to school teachers and students. Geological hazards literacy of children, young persons and adults has a deep impact on every day life and on our future. Didactic materials have been prepared for science exhibits (e.g. European Researcher's Night), where geoNatHaz results have been presented to visitors through interactive demonstrations, such as the web-GIS exploration of natural hazards in the NW-Alps and the Canadian Cordillera. The produced material could be shared with teachers for local school projects and natural science museums. Moreover, outcomes of the project could be useful to develop didactic tools for training educators and schools teachers.

U2-10 Orale Grillo, Barbara

10.1474/Epitome.04.1056.Geoitalia2011

EXAMPLE OF A COMPLEX MULTIMEDIA LABORATORY ON LIBYAN WATERS

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Key terms: multimedia; water; chemical analysis; laboratory; Natural Sciences

A video of 25 minutes long presents a workshop held on the study of chemical and physical characterization of salt water taken in Libya. The first 10 minutes the samples resume in Libya, the second 10 minutes the school tests and the latest advice from a geologist expert in groundwater at the University of Trieste, which confirms what the students have found. The objective was to understand the existence of different water in the world and how to do basic analysis. Four classes were involved in a Scientific Liceo, two first and two seconds, with very satisfactory results. Each has returned results in classical relations and Power Point presentations. The aim was to engage students in a complex laboratory using innovative way to develop the concept of water during the course of Chemistry and Natural Sciences, as well as to assess the ability of the boys to organise themselves in the group and their learning with multimedia techniques. All activity has been taken with the camera, which remains as a reminder to boys and the school as a promoting educational tools.

U2-11 Orale Ugolini, Francesca

10.1474/Epitome.04.1057.Geoitalia2011

BOSSOLETO: EXTREME ENVIRONMENT AS DIDACTIC LABORATORY FOR SECONDARY SCHOOLS

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Key terms: greenhouse effect; extreme environment; didactic laboratory; school

Bossoleto is a small doline located in the Siena-Radicofani basin (Tuscany, Italy). The area is characterized by high hydrothermal circulation with several thermal sites of water rich in carbonate. Close to Rapolano Terme, Bossoleto has the peculiarity to be an undisturbed biotope, where the high concentrations of carbon dioxide in atmosphere have been modifying the biotic communities and affecting the environment. Atmospheric CO₂ changes over the year and the day, however over 800 ppm during daylight and reaching in certain conditions nighttime concentrations of almost 70%. So far, Bossoleto is considered a worthy site for microbiology, geology, plant physiology research investigations. The Institute of Biometeorology has a long experience on ecophysiological research in that site and counts several collaborations with foreign institutions. Moreover, years ago, it started to carry on didactic activities with local schools due to the appreciated characteristics. Bossoleto might be considered a natural didactic laboratory to understand greenhouse effect and observe the effects of high concentrations of CO₂ on the environment with a multidisciplinary scientific approach. Geology, meteorology, ecology, botany, plant physiology, chemistry, physics are the matters linked to its features and a multiplicity of activities can be performed: scientists deepening seminars and explanations, experiments in loco or hands-on activities of longer duration. In the past didactic activities for instance, pupils run experiments on CO₂ chemical and physical properties, measured the real greenhouse effect due to the higher concentration of the greenhouse gas at the bottom of the doline, monitored the differences in growth and allocation of organic matter in plants exposed to high CO₂, compared to ambient concentration (pupils planted barley seeds in pots, they exposed half of them to high CO₂ in Bossoleto and half at school at ambient concentration), saw the effects of

high concentrations of CO₂ on plant and species distribution inside Bossoleto and on animals. To conclude, visiting Bossoleto, pupils approach to real scientific results but also get knowledge through observation, experimentation and by doing.

U2-12 Orale Solarino, Stefano

10.1474/Epitome.04.1058.Geoitalia2011

NATURAL HAZARDS IN THE SCHOOL OF THE VERTICAL CURRICULUM: IS THERE A LINK WITH THE WORLD OF RESEARCH ?

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Key terms: Natural hazards; Vertical curriculum; School network; Research

Many subjects are naturally tuned to the vertical curriculum. The humanities are characterized by evolutionary steps similar to those of the individual. In history, for example, the elementary knowledge of the events of ancient history must be substituted or at least supported by the capability to critically interpret the most recent historical occurrences, developing in a vertical succession the knowledge, ability, competence, skill and control. One important exception is that of civics: it is not likely to form a well educated citizen in steps. It is possible to add details and information, for example regarding the right, in successive close examinations but since the first, preliminary approach the students must learn the rules, statutes and regulations that guide the civilian living. Earth Science is similar to civics: the future citizen must understand and take consciousness of the most probable hazards of the own territory as soon as possible, no matter if it is earthquake, volcano, chemistry or hydrogeology. The sooner he or she gets acquainted with the risk the sooner he or she will learn how to behave to protect and survive. This is the main argument against a vertical evolution of the teaching hazards in Earth Science: in fact taking of consciousness is, generally speaking, the result of a long route while in this case is the starting point, followed then by the scientific aspects and close descriptions. Since the language and level of technical details must be in accordance with the age of the students, repetition of concepts is inevitable and this is the second element against the realization of a vertical curriculum. The third element is the fact that the peculiarity and characteristics of each territory makes difficult to build up a national curriculum. It is in fact not reasonable to teach in deep details hazards that are not present in an area, but if more than one is present any risk deserve attention despite the time to devote to other scientific issues.

In the teaching of Earth Science the presence of an "expert", that is of a researcher dealing with the arguments mentioned above, can thus significantly contribute to the formation. A scientist is naturally growing by goals more than cycles, as exactly foreseen in the vertical curriculum. To transfer the research method to the school can effectively contribute to the evolution from learning student to informed citizen. In fact, in the first approach and by using a proper language, the researcher can inform and form responsible students without any real interaction with and impediment to the standard school courses, and the classes given by the researcher with remain as a standalone experience. In a second step of the educative progress, the researcher can contribute not only to a close knowledge but also to the correct mood of approaching the scientific questions by sharing the "scientific habitus" that leads any research activity.

However, the educational duty is not the main one for a researcher and it is not plausible to hypothesize the presence of a researcher at school as constant or even repeatable. Specific tools and approaches are then needed to ensure a large cooperation between research and school worlds.

In the last decade, many programs and projects have been carried out to reach this aim; these attempts have produced many books, multimedia, manuals or have consisted in innovative approaches like lending to schools semi-professional instruments or letting the students do some very basic research in order to understand the problems that researcher are daily supposed to solve.

In this presentation the details of some of these projects, already ended or under way, are discussed together with the description of how they contribute to the establishment of a network among schools.

U2-13 Orale Queirolo, Cristiano

10.1474/Epitome.04.1059.Geoitalia2011

EDUCATIONAL TOOLBOX AND CONNECTED EXPERIENCES IN BEIGUA EUROPEAN & GLOBAL GEOPARK (NORTH WEST ITALY)

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Key terms: Beigua Geopark; educational toolbox; European & Global Geopark Network; geological laboratory; geological cartoon end comic

From 2004 Beigua Park - Geopark, proposed in the catalog of educational offerings for schools, programs devoted to Earth science. The experience in the European Geoparks Network has allowed a fruitful exchange of good practices and activities that led to an expansion of supply. Over the years there have been several collaborations with geological teaching Italian protected areas are members of CAPO (Coordinamento Aree Protette Ofiolitiche).

In particular we have developed educational tools and structures to understand the dynamics of the Earth: educational exhibits for recognition of rocks and minerals at the Information Point "Bruno Bacoccoli" near to Cogoleto, paleontology lab inside the "Visitor Center Palazzo Gervino", dedicated to the heritage paleontology of the Oligocene. There have been several publications for students: the "notebook of Rock Detective" and the comic story "Aldo's basalt". Many kits for experiments were designed and made to understand the hydrogeological process, to recognize copy without spoiling, minerals and fossils through various techniques of cast.

U2-14 Orale Marsili, Antonella

10.1474/Epitome.04.1060.Geoitalia2011

EDUCATION FOR SCIENCE: THE INGV EDUCATIONAL LABORATORY FOR SEISMOLOGY

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Key terms: HANDS ON; SKILLS; SEISMOLOGISTS

Teaching often favors scientific content rather than scientific methodology in order to approach specific problems and students are confused and demoralized by science teaching because they do not understand the reasons why they have to study boring and difficult scientific issues. Students believe that science teaching is far from reality, away from their interests and attractions.

Nevertheless it is very important to develop process abilities to perform investigations and to achieve conclusions.

Educators and experts assert that students learn best when they are motivated to identify a sense in the educational proposed activities.

There are many teaching methods for science: some teachers underline the importance of testing, others prefer planning, others think that is important for student to have a direct contact with researchers.

The educators' community agree to use educational laboratory activities like the experiences named "hands on" to learn science; this approach is also included in the indications provided by the Italian Educational Ministry (MIUR). Students have to simultaneously work with "their minds and hands", becoming authors of the development of their scientific experience.

The aim of this work is to discuss the INGV educational laboratory experience highlighting the educational dimension dedicated to the promotion of scientific method and robust skills to approach seismology and successively seismic hazard.

The INGV educational proposal adopts the laboratorial dimension and it is addressed to high school students. This experience enables students to build experimental abilities, to develop a critical thinking and, in particular, to use their skills. During the educational laboratory activities, small working groups of students make the necessary operations to calculate the earthquake epicenter following the same working methodology used by seismologists before the computer advent. Students work with real data collected from Italian earthquakes. They also use their own mathematical knowledge transforming them in seismological skills. Within the working groups the students use the same instruments: compasses, set square, ruler and mathematical knowledge that the seismologists used long time ago. Being "seismologists for a day" means to understand how to work in rational and scientific way, which are the problems and the related solutions, what is an acceptable error. In this framework, the goal of the INGV educational laboratory is to provide a working methodology to transform knowledge into specific skills rather than a set of notions.

U2-15 Orale Rossetto, Rudy

10.1474/Epitome.04.1061.Geoitalia2011

TRANSATLANTIC DIFFUSION OF SUSTAINABILITY THROUGH ENVIRONMENTAL SCIENCES AND ENGINEERING PROGRAMS

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Key terms: Environmental sustainability; student mobility; transatlantic cooperation

The project aims to train 60 scientist/engineers with emerging sustainable engineering and science principles and technical tools, and at the same time to foster cooperation and collaboration among 3 Canadian and 4 European universities.

Students will come from 3 different countries and will follow technically rich international curricula in a transatlantic exchange symbiotic experience. Planned activities include: research and industrial projects, learning emerging engineering disciplines and advanced technologies, language learning and cultural broadening.

The EU-CANADA Programme "Cooperation in higher education, training and youth" Transatlantic Exchange Partnerships finances the activities, which started on October 30th 2009 and will end on September 30th 2012. The project is wholly student-focussed and the funding requested is used almost in its entirety to fund mobility of students.

The EU partners are Dublin City University and Trinity College (Dublin, Ireland), Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento and Università degli Studi di Pisa (Pisa, Italy), while the Canadian partners are Laval University (Laval, Quebec), University of Ottawa, (Ottawa, Ontario) and the University of British Columbia (Vancouver, British Columbia).

The project will assist students becoming technically and socially skilled when studying, monitoring and solving environmental problems worldwide. Interactive communication tools for long distance learning are also being developed.

With respect to student's technical and academic development the objectives may be summarised as follows:

- to validate institutionally and professionally international exchanges;
- to create a strong self-sustainable network of university partners by solidifying existing links and approaching universities with organisms where students can apply acquired knowledge;
- to increase, among young people, the awareness of global environmental problems;
- to provide high-level quality teaching on sustainable concepts, methods and technologies;
- to offer students new professional skills: the ability to work in pluri-disciplinary fields to treat and solve problems with holistic, integrated approaches, to be able to communicate with different levels of societal stakeholders.

With respect to student social development the objectives are:

- to promote better understanding of foreign institutions, culture and language;
- to improve the quality of transatlantic student mobility with respect to variety and quality of supervision and social interactions.

All mobility is transatlantic involving 10 students/university during 2nd and 3rd year of the project. The targeted students are undergraduates and graduates from the following backgrounds: engineering (chemical, civil, geological, agricultural and mining); sciences (biological, hydrological, geological - earth, agricultural and chemical). The trainings takes the following forms: (i) academic enrolment (ii) industrial training (iii) research training (iv) laboratory work. The organisational activities to be undertaken by the partner institutions include:

- review of courses offered and courses contents;
- harmonization of course contents, updates and integration in a global curricula;
- courses credit equivalencies among participating universities;
- network communication mechanisms;
- preparation of students before travelling;
- student mobility (for undergraduate and masters students 10 students/university);
- registration on courses 4 months duration;
- industrial/research co-supervised training (for master's students);
- gathering of academics once per year.

Expected outcomes are also to compare, improve and reach integrated teaching contents and training activities in the area of Environmental Sciences and Engineering.

U2-16 Poster Ossola, Carlo

10.1474/Epitome.04.1062.Geoitalia2011

ANDRILL IN ITALY: WHEN A POLAR RESEARCH INSPIRES NEW APPROACHES IN FORMAL SCIENCE EDUCATION

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Key terms: FORMAL SCIENCE EDUCATION; OUTREACH AND EDUCATION; POLAR SCIENCE; EARTH SCIENCE

ANDRILL (Antarctic geological DRILLing) is an international and integrated research project involving the USA, New Zealand, Germany and Italy. The core concept of its Educational and Public Outreach Program was to embed a group of international science teachers in the midst of the research allowing them to participate in every phase of the mission. Their primary goal was to develop effective and innovative educational approaches for the explanation of the scientific and technical aspects of the drilling program.

ANDRILL, as inaugural 2006 and 2007 drilling seasons resulted in two high-quality and nearly continuous 2400 meters of sediment cores. The Educational and Outreach, E/O program, thanks to a comprehensive cooperation between participants (teachers and scientists), spawned a list of educational projects that is still growing strong after 5 years. In Italy, this experience triggered the creation of a network of subjects and institutions, lead by the National Museum of Antarctica, who's focus is the development of a more effective and inspired approach to climate education. The main activities carried out were: (1) *progettosmilla.it*, a gem project (online/classroom) involving over 2000 students across the Italian territory; (2) the Italian version of "Flexhibit", another ANDRILL-related educational US-made project; (3) the organization for the 2011 and 2012, of a Polar Summer School for science teachers to help them to incorporate polar research in the formal education. The School will be held in Genoa from July 18-22, 2011 and free for 12 science Italian teachers. The School will select one teacher that will take part in the Italian Antarctic Expedition (2011 - 2012).

U2-17 Poster Pace, Bruno

10.1474/Epitome.04.1063.Geoitalia2011

EARTHQUAKE FOR KIDS - I TERREMOTI SPIEGATI AI RAGAZZI

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Key terms: L'Aquila earthquake; Earth Science; Education; Awareness campaign

The idea of the project born from the desire to (re)build trust in science and, in particular, in Earth sciences among the young people of Abruzzo, who have recently experienced in first hand the tragedy of the earthquake of 6 April 2009. As often unfortunately happens, the earthquake has caused loss of lives and destruction. But this time the rage, bafflement and indignation for what happened have had recipients details: scientists, who, in an attempt to repeat the unpredictability of the earthquake, have, and this is the accusation, reassured the citizens of L'Aquila said that there was nothing to worry about.

So the confusion that exists for the common people respect to these topics, together added at a communication error by specialists, has meant that it generated a tremendous mistake. The result is that now it more difficult, in this context, speaking in scientific terms of earthquakes.

Objectives of the project are therefore the diffusion of knowledge of Earth science among young people, particularly those affected by the earthquake of L'Aquila 2009, and restoring their trust in science and experimenting with new methods of non-formal education.

It intends to achieve these objectives through the realization of a path that includes three different actions:

Junior Conference

The Conference will take place in L'Aquila, intended for Abruzzo's guys between 11 and 18 years, and will be managed with the methodology of the simulation game. The aim is to create an opportunity to compare the ideas and knowledge involved in managing an emergency situation, like the seismic phenomenon.

A team of research and science popularize will prepare a game scenario in which will describe the characterization of an area subject to frequent seismic activity, and through which it will offer at the students a variety of input on the genesis of earthquakes, the actions monitoring, on the geology of the area, the types of prevention and the procedures of risk management.

Then the simulation will be developed through game dynamics, in which the guys, followed by some specialized operators, will make personal decisions, typical of the stages of seismic prevention and emergency management.

The final phase of the simulation require that the "actors" in the game have to prepare and share a "Plan of risk management and emergency" and propose a program for communicating to the citizens.

2) Touring Exhibition

All secondary schools of the L'Aquila's "crater" will be invited to participate at the realization of a traveling photographic exhibition that will illustrate the effects of the earthquake. Schools may send photos and / or text, which will be organized together and prepared for a traveling show that will be sent to schools and to science museums or who request it. In this way the exhibition will continue to be used even after the conclusion of the project.

3) Earthquakes for Kids Webpage

To bring in a simple and funny way the kids to the theme of earthquakes and the prevention will be created and developed a dedicated portal, combining scientific rigor clearly disclosed to explain in a simple and addictive earthquakes to children.

The main result from the project is to be able to attract young people to the Earth Sciences, and both the methodologies and the tool. But also scientific thought necessary to understand and gain knowledge in relation the natural world in which we ourselves live.

So bring the experience, even dramatic, of young people, like the case of L'Aquila earthquake victims, at the work of scientific research and making them participate in establishing a collaboration, exchange and dialogue between the world of science, sometimes very far from the new generations, and the school, often with too many difficulties to be open outside.

U2-18 Poster Occhipinti, Susanna

10.1474/Epitome.04.1064.Geoitalia2011

UNICAM_EARTH : A RESEARCH GROUP ON TEACHING EARTH SCIENCES IN THE ITALIAN SCHOOLS

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Key terms: Inquiry based method investigation; vertical curricula; schools and museums

The Geology group of the University of Camerino (School of Science and Technology) has recently formed a research group whose aim is to address the teaching of Earth Sciences in the Italian schools (elementary, middle and high schools) also in the light of the recent changes of the law. The group, unique in Italy, is composed of high school teachers in Science, now PhD students in the curriculum Earth Sciences, as well as Geology researchers and the curators of Unicam Museum of Natural Sciences.

The purpose of this research group - named UNICAMearth - is to produce and experiment new activities and resources for the schools by using the Inquiry Based Science Education (IBSE) teaching approach. This approach follows the recommendations of the Rocard Report of the European Commission (2007)

The UNICAMearth group is focus to become a reference point for the Earth Sciences teachers in the Marche region and in Italy. The PhD projects in particular will concentrate on the relationship between school and research, with the aim to help the teachers to use the IBSE method and to promote active collaboration between school, museum and university. As a service for the school and the territory, the UNICAMearth group will promote seminars and working groups, stages and training courses, museum and laboratory activities in order to create a network of sharing best practices.

A mailing list will be available to the teachers and everyone is interested in joining the UNICAMearth group and the Geology web site (www.unicam.it/geologia/unicamearth) will contain all the information and the resources produced.

U2-19 Poster Colli, Angela

10.1474/Epitome.04.1065.Geoitalia2011

MOTHERSHIP EARTH

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Key terms: cooperation; Global World; energy sources; teaching-learning style; WebQuest

To ensure the preservation of life on earth we must recognize that 'we are all on the same boat' (with no distinction between different areas and countries): for this reason we must identify the problems and aim to solve them through far-reaching policies and shared goals. C.R.E.A. (Reference Centre for Environmental Education), sponsored by Lombardy District (Italy), represents a reference point for planning and implementing activities about environmental education. Different projects and activities are offered to the citizens of Pavia: the aim is to share good practices to promote a better lifestyle. CREA has worked for many years together with teachers and with schools of all levels located in the Municipality of Pavia. During the Academic year 2010-2011 CREA planned and realized "MOTHERSHIP EARTH": a project in cooperation with the ANISN section of Pavia in the first two classes of a high school and in the third of a middle school of the town:

Objectives:

° Develop knowledge and skills necessary to live in a Global World. Promote changes in attitudes and behaviour, both at individual and collective level.

° Spread the awareness that major issues currently affecting mankind can be tackled and solved through close cooperation not only between countries but also between various disciplines and cultures. Working arrangements and themes.

Since the 1980s, science has changed its approach in dealing with environmental phenomena, from a linear logic, based on Aristotelian-Galilean paradigms, to a systems theory, which is associated with the complexity theory. Edgar Morin defined ecology as 'the first new science able to tackle the relationship between life and death, science and conscience and between mankind and nature, above and beyond the simplifying thought that hid vital issues from us for such a long time' (E.Morin, 1990).

With the new generations of "digital natives" we need to overcome the traditional way of teaching. We should be aware that our students may use their brain in different ways and have a range of learning styles: by using a variety of presentation, activity and assignment we can appeal to

this diversity.

In our project we adopted an "active" research-based teaching-learning style to bring young people to reflect and act on issues of vital importance for the future, including protection of the territory and sustainable development. We looked for information together with students in a critical way to design and implement daily activities. The themes were chosen along with the classes participating to the project and focused on problems relatives to different energy sources' uses and to their impact on the territory. After the accident occurred in Fukushima students interest focused especially on "nuclear energy".

Every class realized a WebQuest: an inquiry-oriented lesson format in which most or all the information that learners work with comes from the web. Students critically evaluated information they found about the subject they had chosen and designed actions using information gathered. Times.

° 1 hour: meeting with teachers to present the project and to choose the theme for the webquest to realize with the students;

° 1 hour: meeting for presentation and setting of the class;

° 2 hour meeting in the school computer laboratory to develop the WebQuest;

° final event (conference, event) for public presentation of the products realized by the students.

Results

WebQuest influenced students' learning performance positively. For the future we will implement the project, proposing the realization of outdoor WebQuest: in real situations, students could acquire much more knowledge and experiences, with the aim to improve their lifestyle for the health of our MOTHERSHIP EARTH.

SESSIONE U3

Comunicare le scienze della Terra: iniziative ed esperienze per educare ad una cittadinanza responsabile

U3-1/2 Invitato Tozzi, Mario

10.1474/Epitome.04.1066.Geoitalia2011

DIVULGAZIONE VS TELEVISIONE

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Key terms: divulgazione scientifica; televisione; audience

Quanti si fermerebbero a leggere di faglie o di fotosintesi clorofilliana o di funghi in genere, se non venissero confezionati all'interno di una storia? Questa considerazione sembra basilare per qualsivoglia intervento scritto o parlato che si prefeggia lo scopo di divulgare le scienze della natura: altrimenti quale pubblico si interesserebbe perfino a decaloghi per un miglioramento ambientale futuro, se non ci fossero storie da raccontare? Sono storie ben note a chi si occupa di scienze della natura, ma mentre di alcune si può ricordare lo spunto o l'autore, altre si perdono a tal punto in quel patrimonio collettivo di sapienza e coscienza da nascondere definitivamente la fonte. Di tutto questo geologi e naturalisti possono e debbono essere i raccoglitori e i divulgatori.

Ci si può domandare se filtrare "scienza" attraverso i mezzi di comunicazione di massa perché arrivi a un pubblico a essa generalmente estraneo comporti un costo accettabile in termini di rigore scientifico oppure no. Il rischio c'è --ovviamente-- ed è grosso: con l'abbandono progressivo dell'intento pedagogico il *senso scientifico* tende a collimare sempre più facilmente con il *senso comune*, come dimostra il contemporaneo abbandono --per esempio in televisione-- dell'esperto-conduttore a favore del conduttore di provenienza extra-scientifica. In contesti di questo tipo c'è il pericolo di un "ripiegamento" negativo della scienza su se stessa, una chiusura che non permetta un accrescimento delle conoscenze e che, d'altro canto, non induca neppure una maggiore spendibilità quotidiana delle informazioni scientifiche.

Saremmo cioè alle solite: la divulgazione che diventa intrattenimento televisivo a discapito dei suoi stessi scopi (ma sono mai stati ben definiti e/o ha un senso farlo?) non incrementa la cultura scientifica --in questo paese cronicamente latitante-- e, anzi, si traduce nel sacrificio della scienza sull'altare del dio barbaro dell'*audience* a ogni costo. Ma, d'altra parte, è giusto lasciare lo spettatore senza quei dubbi, quei veri e propri errori che stanno alle spalle di molte affermazioni scientifiche, legandolo ai meccanismi di causalità lineari in grado di attrarre maggiore interesse dei problemi di fondo? La versione cinematografica del Giurassico crichtoniano, con le annessi ricadute televisive, ha portato comunque vantaggi in termini di divulgazione, al di là del richiamo spettacolare e della rappresentazione drammatica e largamente inesatta dell'estinzione dei dinosauri. D'altra parte il pubblico delle trasmissioni scientifiche televisive è composito, fatto anche di giovani colti, o almeno curiosi, di esperti di settori affini (o distanti), di potenziali lettori di libri a carattere scientifico non necessariamente divulgativo, pubblico che non dovrebbe essere privato neanche di quelle spiegazioni circostanziate che meritano certe eccezioni alla "regola" difficili da spiegare anche per gli stessi scienziati.

Potrebbe però esistere una terza via fra l'eccessiva semplificazione che produce deterioramento del patrimonio di conoscenza scientifica e la divulgazione astrusa che serve solo a comunicare fra esperti, non aumenta la base di pubblico e di interesse e non produce nessuno sviluppo culturale diffuso. Si può recuperare l'eguaglianza informazione-intrattenimento che, si dimostra nel libro, produce i risultati migliori in termini di divulgazione, allargamento della fascia di pubblico interessata e gradimento. Non mettere in difficoltà chi ascolta la scienza divulgata e insieme esprimere il *senso comune* può essere fatto anche senza quell'arrocamento della scienza, a cui pure tante volte si è assistito. Soprattutto quando l'obiettivo non è quello di formare degli esperti scienziati, ma quello --peraltro non meno difficile-- di fornire chiavi di accesso ai principi-base, aggiornare le conoscenze e suscitare un interesse anche in chi, a quella data fascia oraria, avrebbe guardato *telenovelas* o *chat-shows*.

U3-5 Orale Curzel, Elisabetta

10.1474/Epitome.04.1067.Geoitalia2011

SCIENCE COMMUNICATION AND THE WEB 2.0: A NEW OPPORTUNITY.

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Key terms: communication; web 2.0; social network; internet

Is there any place for science in the participatory web? Social networks - an instrument of entertainment, sharing, and information that engages millions of people all around the world - have been pushing scientific communicators to ask themselves this and other questions, such as: how is it possible to handle scientific information in the Internet? How can we make it recognizable? How can we create a reputation of trustworthiness? Several institutions have recently signed up to create "profiles", i.e. virtual identities, on some of the most used social networks such as Facebook, Twitter or YouTube. Followed by thousands of fans, they can be conceived and managed as channels of broadcasting, complementary to the traditional press offices, or as platforms of discussion and dialogue. Handled with care and accuracy, the web 2.0 can be a precious instrument, in the service of scientific culture: a source to question to better know the territory, its characteristics and its risks; a virtual place for intelligent and informative entertainment; a way to ease the access to specialized or generalist websites devoted to science communication.

U3-6 Orale Landini, Walter

10.1474/Epitome.04.1068.Geoitalia2011

HOW TO COMMUNICATE PALEONTOLOGY - THREE DIFFERENT INTERACTIVE EXHIBITIONS AT THE NATURAL HISTORY MUSEUM OF THE PISA UNIVERSITY

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Key terms: PALEONTOLOGY; NATURAL HISTORY MUSEUM; INTERACTIVE EXHIBITIONS; VISUALLY IMPAIRED ACCESSIBILITY

In the past few years the Natural History Museum of the Pisa University widely renewed its own paleontological exhibitions thanks to a CIPE grant, obtained in 2002. In just eight years three new permanent exhibitions have been opened: "Back to the Past - a 500-million-year trip to Monti Pisani" in 2006; "Dinosaurs in the Charterhouse" in 2008 and "Archaeocetes - Cetaceans of Land and Sea" in 2010.

These three exhibition paths, although different from one another, are joined by the search for new ways of Museum communication, aimed to transmit the scientific contents thought directed involvement, interactivity and multisensoriality.

The first exhibit, in order of opening, explores the geo-paleontological evolution of the Monti Pisani and its founding idea is the full-immersion of the visitor in the topic dealt, through the novelistic tool of the "trip in the time" materialized in a steel and glass footbridge. This time path passes through three rooms completely transformed in scenarios of a far past: three open dioramas dedicated respectively to the Monti Pisani in the Permo-Carboniferous, in the Triassic and in the Pliocene succeed one another in a sequence, both physical and temporal, encircling the visitor first in a tropical rainforest, than in a wide coastal desert and finally in an underwater landscape populated of giant sharks, seals and dolphins now extinct.

The reconstructions speaks by themselves, just helped by some few original specimens and by a touch screen monitor available to provide additional information and generating the background sounds of the different environments.

In the exhibition dedicated to the dinosaurs from Patagonia, on the contrary, more classical models, as the large skeletons of *Amargasaurus* and *Carnotaurus* exposed in the external courtyard, have been melted with elements that recall the temporal narration of the Monti Pisani exposure, as the large window that opens on a past of 80 million years ago. But it is interactivity to represent the main topic of this exhibit. In fact in the central part of this path the story of a fossil has been physically reconstructed from the moment of its discovery in the field to its exhibition in the museum, through all the various phases of excavation, restoration and duplication. This last sequence is shown in the real paleontological laboratory of the Museum, through windows that, when a technician is working in the lab may be completely opened, deleting any barrier between the truth of the exposed action and the visitor.

The exhibit dedicated to the archaeocetes differs from the others because projected according to some concepts of the universal design. This makes it suitable to visually impaired people but also winning for all the other categories of visitors, allowing an access to the information not only visual but above all tactile and sonorous. In this exhibition all the elements are disposed along a linear path, placed close at hand on a raised platform bordered by a guide leading the visitor and evidencing, through tactile marks, the presence of objects to be touched or buttons to be pushed to activate the audio sources.

Besides the search for new exposure modalities, another element joining these three exhibits is their being place of didactic workshops. The Natural History Museum of Pisa, in fact, follows the modern theory according which its rooms should be places where "to stay interacting" more than "to cross just watching". In particular the exposures dedicated to dinosaurs and archaeocetes have been equipped with didactic spaces dedicated to children 3 to 7 years old where the information to be learned becomes game experience through both activities and didactic supports especially realized for this purpose and also using the elements of the exhibit that, in this way, becomes more comprehensible and communicative.

U3-7 Orale Lanzinger, Michele

10.1474/Epitome.04.1069.Geoitalia2011

THE NEW SCIENCE MUSEUM OF TRENTO REGION: GEOSCIENCES AND SUSTAINABILITY IN THE MUSE PROJECT

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Key terms: International museology; Science and society; Lifelong learning; Geoscience communication; Planetary sustainability

In 2013 in Trento a science museum of latest concept, one that integrates nature, science and technologies, with attentive eye on ethical and social issues, will open to the public. The museum will tell the natural history of the Dolomite region and gradually wide to reach a planetary scale, linking the local natural heritage and research expertise to the most important achievements of science.

The MUSE (Museum of Science) will thus be a combination of natural history museum, science museum and science centre. The building, designed by Renzo Piano, will rise in a former industrial area, within a context of urban re-qualification, promoted by the Municipality of Trento. The MUSE represents the result of the Museo Tridentino di Scienze Naturali development which yielded, in the last 18 years, many successful cultural and educational initiatives and remarkable results in the naturalistic research of alpine ecosystems, Earth Sciences and Prehistory. The basic idea of the new museum is the relationship between the alpine natural environment and the planetary sustainability, through a "glocal" approach. The sustainability and the topics related (energy, resources, climate, water, nature conservation, natural hazards, transport...) play a special role and also inspire the architectural plan of the museum. The MUSE building displays a mountain skyline profile and the exhibition area is made up of two portions: the taller is dedicated to Alpine themes, on a journey from glaciers to the valleys floors, and to the mountain land modifications produced by the human action; the wider area, on the lower floors, deals with the global relations between Science and Society. The topic of Geosciences and its relation with sustainability are present in different exhibition floors. On the 4th floor peaks and glaciers of alpine landscapes are encountered. This section shows the state of health of glaciers and its importance both for the mountain's people and for the global climatic system: they are susceptible to climatic variations, a fundamental fresh water resource and contribute to the production of hydroelectric energy. The 2nd floor is almost entirely occupied by Alpine geology and Dolomites are paid of special attention. The Quaternary glaciers let to describe climate change in the past and how it modified the Alpine landscape and ecosystems. Then the natural geomorphologic evolution of this territory, increased by several anthropological factors, introduces the theme of geological risk and landscape's vulnerability and protection in Trentino, focusing on some processes, like landslides, floods, avalanches and earthquakes. Moreover the specificity of some minerals and rocks of this area introduces the theme of the thousand-year relationship between Man and Earth's resources. The 1st floor presents the ancient human settlers in the Alps. The land use and the anthropic impact on the alpine environment from the late glacial to the present is also exposed. The use of land to yield goods and services is infact the most substantial human alteration of the Earth system. In this way the concept of sustainability, green footprint, natural system resilience are introduced, linking the historical perspective to the contemporary and global overview presented in the following gallery. At last the basement hosts an exhibition on the story of Planet Earth, starting from its origin within the Solar System. It focuses on evolution of animal and plant life on Earth, through their fossil evidences. All the concepts above will give life to an exhibition made up of natural objects, multimedia, hands-on exhibits and also of scientific laboratories open to the public, where visitors can meet researchers. A museum designed around its visitors, for various reasons: to have a wide appeal on citizens and tourists, to families in particular; to be a major partner in support of school education; and finally to be renown for its benefits in terms of lifelong learning.

U3-8 Orale Pratesi, Giovanni

10.1474/Epitome.04.1070.Geoitalia2011

FOR AN AESTHETICS OF SCIENCE: NEW EDUCATIONAL FORMULAS IN THE EXPERIENCE OF THE NATURAL HISTORY MUSEUM OF THE UNIVERSITY OF FIRENZE

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Key terms: Aesthetics; Science; Mineralogy; Museum; Exhibition

Historians of science have not given much attention to the role of passion in science. As a matter of fact, there has been an implicit acceptance of a sharp dichotomy between the two cultures of reason and passion. Starting from such dichotomies - and going through the Goethe's fascination with the mineral kingdom - we will analyze the experience of the Museum of Natural History of the University of Firenze where the promotion of the mineralogical collections is passed through a comprehensive and thorough renovation of the exhibition, solutions museological and educational proposals. At the same time was made an innovative exhibition, in which there are specimens belonging to the Collection Adalberto Giazzotto, which complement the scientific and didactic proposals with a merely aesthetic proposal. The mineral collection of the Natural History Museum of the University of Firenze - containing over 50000 specimens - ranks among the world's finest due to its very broad representation of rare species and large number of specimens described in the scientific literature. Furthermore, the presence of holotypes, Island of Elba collection and pegmatite minerals from Brasil make known this Museum to all collector. In order to give a greater visibility at the about 800 mineral specimens on public view, the Mineralogical Section deserved a new exhibition which has been projected by Arch. Piero Roberto Papi. At the entrance, the visitors are welcomed with an amazing view of the best specimens from the Ponis collection and an exciting display of back-lighted thin slices of agate and liddicoatite. Showcases on meteorites, lithology, crystal growth, polymorphism, pseudomorphism, crystal chemistry, crystallography, physical properties, mineral deposits and use of minerals and rocks add to the educational and visual experience. Finally the systematic collection shows over 200 beautiful specimens, from all over the world, arranged according to their structural and chemical properties. On the other hand, thanks to the sponsorship of the "Ente Cassa di Risparmio di Firenze", the notable Giazzotto collection - including about 550 specimens of large crystallized minerals collected and selected for their exceptional aesthetic quality - has been transferred to the Natural History Museum as the "Cristalli" exhibition. The layout, the showcases (projected by Arch. Guido Spezza e Giancarlo CATALDI), the lighting system and the organization of the specimens enhance the spectacular quality of the specimens and the emotional impact of their wonderful array of shapes and colors. The exhibition includes a sequence of four halls: the first, named "The Treasury", is the largest and cannot fail to impress the visitor with its beautiful arrangement of specimens of all shapes and colors; the second, "The Italian collection", shows remarkable specimens from some of the most famous Italian localities; in the third and in the fourth halls, respectively "Masterpieces 1" and "Masterpieces 2", exceptional specimens are exhibited in individual glass cases. The rearrangement of the Giazzotto collection is very important from the point of view of the conservation of natural heritage. Large perfect crystals

are absolute rarities that must be preserved for the future generations both for their beauty and for their scientific interest. The show in the end, means to open a reflection on the concept of "subsurface ecology". Most of the crystals in the show, actually come from exhausted mines. It is quite evident how the growing demand of the world economy for energy and raw materials, is driving to a rapid and generalized exhaustion of layers and mineral resources.

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U3-9 Orale Ossola, Carlo

10.1474/Epitome.04.1071.Geoitalia2011

TRAVELLING EXHIBITION, A WAY TO DISSEMINATE THE KNOWLEDGE ON POLAR SCIENCE

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Key terms: OUTREACH AND EDUCATION; POLAR SCIENCE; EARTH SCIENCE

The Italian Antarctic Museum (MNA) has organised 2 travelling exhibitions to attract the interest of public, media and mainly students and make them awareness of the role that Polar Regions play for our Planet. This purpose was coherent with the mission of MNA of training a new generation of researchers and technicians specialised in polar science. The first exhibition was mainly scientific; the main goals were to show to the public the Italian and International research in Antarctica and to describe how interesting is, by a scientific point of view, the most remote and wild land in the Earth. Posters, interactive exhibits, clips, geological and biological materials collected in Antarctica, helped visitors to learn about the main biological, geological and physical features of the continent.

The second exhibition was an outdoor photographic exhibition that carried the visitor through Antarctica's spectacular landscapes. The project was curated by Carlo Ossola and Lucia Simion, photographer and science writer. 40 breathtaking images told a story about the different kind of ice, on the life over and under the sea, on the living and working conditions. Both exhibitions were made in order to be easily transported, quickly assembled and dismantled and with low costs for the institutions (museums, schools, Municipalities, etc.) interested in host them. The scientific exhibitions had been hosted in many cities in Italy (Palermo, Rome, Rovereto, Bergamo, Piacenza, Forlì, Rieti) but also in Warsaw, Budapest, Alexandria in Egypt.

In each venue Museum's curators trained local guides so that they were able to explain to visiting students the main features of Antarctica and the scientific topics. In some venues Museum organised conferences with antarctic researchers or videoconference with Italian Antarctica's research stations.

In the last venue located at S. Agata di Militello - Sicily, we tried another way to speak to classrooms. The Museum with the collaboration of local Institutions such as Rotary International, Municipalities, Schools, organised meetings with teachers from the Provincia di Messina in order to show them topics and aims of the exhibition, give them instruments and educational materials. In this way, they explained students about the main features of Antarctica and the Italian research and prepared them to the visit.

Afterwards we trained about 30 students from some scientific departments of the University of Messina so that they could work as guides during the classroom visits at the exhibition.

And it has been really a success! More than 3000 students visited the exhibition during 20 days.

U3-10 Orale Celi, Monica

10.1474/Epitome.04.1072.Geoitalia2011

AWARENESS RAISING AND EDUCATION IN THE FRAME OF THE EUROPEAN LANDSCAPE CONVENTION: THE ROLE OF MUSEUMS

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Key terms: European Landscape Convention; Education on landscape; Museum

The European Landscape Convention (proposed by the Council of Europe and open for signature in Florence, on 20th October 2000) represents nowadays an international reference point for research, action and education on landscape. Landscape is defined as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors"; the Convention aims to safeguard, management and planning of all landscapes in Europe (not only the exceptional ones), through the implementation of policies and the involvement and of local communities, subjects of rights and responsibilities. The first specific measures (art. 6, a and b) provide awareness raising and education of a large public, in order to increase people's knowledge of landscape dynamics and their attitude towards landscape values.

Starting from some experiences of education on landscape in school contexts - at different levels - the authors present its main targets and features. Education on landscape concerns all these three aspects: intellectual education (knowledge oriented), emotional education (finding out about the feelings and values) and motorative education (knowing about doing, how to practice) (Pedroli and Van Mansvelt, 2006), in the perspective of education on sustainable development. From a methodological point of view, landscape literacy is firstly aimed to achieve the ability of reading the landscape as a basic step in an interdisciplinary approach. Different levels of deepening knowledge on some landscape aspects (natural as well as human ones) can be then proposed.

Theoretical and practical suggestions and recommendations are available in the guidelines "Education on landscape for children", edited by the Council of Europe.

The project 3KCL - Karstic Cultural Landscapes carried on in 2004-05 by the Museums of Natural History and Archeology of Montebelluna, in the frame of the Culture2000 program, represents a best practice in education on landscape. It was aimed to deep knowledge on karst landscapes and to

disseminate this knowledge to a large public, through a strong involvement of school children. The Museum played a very important role in this project as a cultural mediator among research world, school world and the wide public.

In general, museums can play an important role concerning education on landscape. They conserve the natural, historical, ethnological, artistic etc. elements of an area and of its landscape; moreover they co-operate directly in the research with university and other research agencies, to study the collections and the landscape itself; finally, museums use this achieved knowledge and information in formal and informal educational contexts.

The museums are indeed strategic and fundamental places for the educational processes; billions of people, adults and children, young and old people, students and families, visit exhibitions, participate to conferences, experiment in laboratories, study in museums' libraries. Museums can therefore play an important role in promoting positive cultural dynamics, particularly proposing debates and discussions about our history and future. All museum's activities (research, conservation, education, exhibitions and communication) can help in achieving these aims, in raising awareness and in promoting the change of attitudes. Museums are special places to discover and interpret the yesterday's and today's landscapes and to design with awareness the future.

U3-11 Orale Bertolini, Maria

10.1474/Epitome.04.1073.Geoitalia2011

EARTH SCIENCES EDUCATIONAL EXPERIENCES: OBJECTIVES, APPROACHES AND EVALUATION AT THE SCIENCE MUSEUM OF TRENTO.

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Key terms: geosciences education; museum education; pedagogical approaches; evaluation

The Museo delle Scienze is actively working in the education area for about 18 years, involving an yearly through its activities and educational projects almost 62,000 people coming mainly from the schools of the Province of Trento and the nearby regions. The number of educational activities in the field of earth sciences are about 40 and pick up each year about 5,000 users (8% of total users). The types of activities are diversified in subject, length of time, location: they range from educational workshops, excursions in the natural environment, the projects, the thematic visits to the permanent and temporary exhibitions, lecture and talk and training courses for teachers.

The project aims to make a digression on the educational proposals in the field of earth sciences, illustrate the types of proposals, the cognitive, affective and operative objectives, tools, exhibits and materials used, methods and educational approach adopted. It will reflect on the strengths and weaknesses identified during twenty years. Will present the general data, the trend, evaluation made through the questionnaires of satisfaction to teachers and referents of the participating groups. Finally, we will focus on the educational work of Explainers: the selection and training procedures adopted by the museum to further develop their professional, communication, educational and relational skills. The data and information collected over time allowed to define some guidelines to be adopted in the design and implementation of educational proposals, and identifying the duties and skills required as a basis for educational work in museums.

U3-12 Orale Paganoni, Anna

10.1474/Epitome.04.1074.Geoitalia2011

ACCADUEORO -TO KNOW THE MOST PRECIOUS NATURAL GOOD

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Key terms: didactics; water; kits; music

The researchers of the Institute of Geology of Bergamo Museum realized coordinated activities to support the International Year of Planet Earth. Some experimental laboratories into a museum open to all visitors and attended by more than one hundred people, the production of a music DVD connected with water, the realization of regional meetings, were steps of this project but the main effort was in the school. It was designed, distributed of a handy kit in primary schools. It was very appreciated and used mainly in schools without laboratories or educational collections.

The minilab was produced in the form of an easily transportable box with tools and instructions that allows 20 experiences directly in the classroom to understand the significance of physical and chemical water. The kit has been designed and implemented on an experimental basis by the researchers of the Museum, in charge of the educational activities. These experts have introduced hands-on approach that leads students accompanied by teachers to learn through experimentation making direct observations and experiences

Thanks to the help of Soroptimist International 132 kits were gift to all primary schools in Bergamo and it's Province.

The case contains the cans, pipettes, test tubes, deionized water, salt and sand, a thermometer (-20C +100C) and many others tools.

U3-13 Orale Grossi, Francesco

10.1474/Epitome.04.1075.Geoitalia2011

AN "OUTDOORS LABORATORY" IN THE EARTH SCIENCE DIDACTICS AND EDUCATION: THE EXAMPLE OF THE "ARDITO DESIO" GEOPALEONTOLOGICAL MUSEUM OF ROCCA DI CAVE (PRENESTINI MOUNTAINS, LATIUM)

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Key terms: Apennines; Upper Cretacic; museum; geosite; didactics

The "Ardito Desio" Civic Geopaleontological Museum of Rocca di Cave (Rome) is located at the southern Preneptini Mountains, and its geopaleontological collections are strongly connected to the territory. The Rocca di Cave area has a great paleoenvironmental and paleogeographic

significance since it stands out as the westernmost end of Upper Cretacic neritic "laziale-abruzzese" shelf facies. Furthermore, it is the almost unique witness for the presence of a Cenomanian-Santonian edge in the western part of the shelf, whose fossil reefs were characterized by typical associations with dominant bivalves (rudists and others), gastropods, corals, sponges and rare sea urchins.

The safeguard and the enhancement of the Rocca di Cave geopaleontological heritage is implemented by several initiatives and structures linked to the "Ardito Desio" Museum, dedicated both to the younger visitors and to general public. For school classes, in the Museum there is an oral presentation together with direct, reaching a higher involvement and pointing to a much wider interactivity. Last year, more than 4000 visitors (mostly school classes) have crowd museum's rooms, in a tour designed as an imaginary travel back in time through subsequent jumps, from recent to Pangea supercontinent age, with detail to the Upper Cretacic. The integrated approach is powered by the presence of 3D-reconstructions and palaeogeographic globes, adding to the theoretical multimedia lessons and several posters. The direct observation of the territory and its morphology is enhanced by the 360°-view obtained from the Rock's tower: that allows visitors, not only the little ones, to correlate the observed landscape to the morphologies and, with the next step, to the geological meaning. Apennine reliefs, Albani Hills volcanic district's deposits, Campagna Romana, all the visible landscape elements, accompanied by most relevant toponyms, are reported in a strip placed on all the terrace perimeter.

The guided tour doesn't stop inside the museum, it continues along a series of geopaleontological paths evidenced by signs, all of them around Rocca di Cave. A real outdoors interactive laboratory, where visitors can touch rocks and fossils: the children were driven to an active participation and to a full involvement. This goal is facilitated by the materials given to the visitors that also include drawings, explanatory notes referable to the paths; a part of the graphic products is dedicated to elementary school and based on comics: representing fossils as protagonists of funny episodes allows children to approach an unknown world with elements which they growing up every day together. In the near future, it's planned to improve both the didactic material dedicated to the outcrops, and the number of paths. Among the new projects there is the first issue of the scientific journal linked to the Museum, "I Quaderni del Museo", intended for distribution in schools and for a general audience. The journal provides insights on topics closely correlated to the Rocca di Cave geology, a further interpretative key of the natural environment, besides divulgation columns and general geological interest topics. Again, particular attention is directed to younger readers, with a central double page full of games, cartoons and comics.

The geosites conservation and the knowledge organization in museums should be flanked by the growing attempt to approach both adult citizens and younger one to the Italian natural heritage, thus to educate citizenship much more responsible, mature and careful to environmental respect and to its history.

U3-14 Orale Todesco, Rossana

10.1474/Epitome.04.1076.Geoitalia2011

THE REDISCOVERED GEOLOGY. COMMUNICATION GEOSCIENCES FOR VISUAL AND HEARING IMPAIRMENT THROUGH EDUCATIONAL PATH OF MUSEO DELLE SCIENZE OF TRENTO

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Key terms: earth science divulgation; educational path; visual and hearing impairment

For many years Museo delle Scienze has been investing on scientific communication experimenting new divulgation way to create a dialogue among nature, research and society. Reaching more categories of visitors and give them a chance to understand and thus appreciate the geological treasures of the Dolomites, broadly speaking means to approach them to the Earth sciences, to build a dialogue on the basis of purely scientific matter close to everyday life and to face issues of strategic importance as land management and exploitation of resources. Starting from this year the Museo delle Scienze wants to approach in a constructive way also to the disability world with the purpose of involving people with difficulties in the sphere of communication such as the blind, visually impaired and the deaf. This is to facilitate the integration into the cultural fabric of a marginal band, but not negligible, of the population through the vehicle of culture. Thanks to a sponsorship from the Fondazione Cassa di Risparmio di Trento e Rovereto has began the project "Museum routes, enhancement and enjoyment of the geological heritage of the Autonomous Province of Trento for people with a visual and aural impairment" coordinated by Museo delle Scienze, which uses a network of partnerships with organizations working in the disability field (National Deaf and Italian Blind Union), in the technology research (Fondazione Bruno Kessler) and in design of natural pathways (Forest Service of the Municipality of Trento and Nature Conservation Service and Environmental Improvement of the Autonomous Province of Trento) in order to identify the most effective techniques to be adopted to communicate to disabled people geological and environmental notions. The project aims to create a permanent open-air museum tool addressed to all the target audience but also appropriate for users with disabilities, supported by educational activities in place, which will be proposed again in the Museo delle Scienze exposition area. The area identified for development of the project is located adjacent to the Alpine Botanical Garden of Viotte (Monte Bondone, Trento), satellite site of Museo delle Scienze. This is an educational path with the aim to highlight the geological peculiarities of the province of Trento and the Dolomites area.

The bases of the project had already been laid during the summer of 2010 by putting in place several rock blocks, also of enormous dimension, taken from the quarries and from yards of the Autonomous Province of Trento. The monoliths create a simplified geological map of Trentino, where block groups represent different geological lithology of the province main massifs mountain. The phases of the project trail have been launched following the directions of Museo delle Scienze regarding the choice of the most significant geological objects and instructions of disabled people with regard to the methods and techniques of mediation, and the development of technological support.

In support to the path have been planned hands-on type workshop

activities, so as to facilitate visitor in understanding the relationship between geologic objects and their geological area of origin. The path opening by the end of summer 2012. We are currently contextualize the arguments concerning the geological evolution of the Trentino region in a spatial level, intervening in order to adjust the path with facilities for the visually impaired people (gravel and guide ropes). The next phase will be focused on scientific mediation dedicated to sensorial disabled people and to the identification of rests for that purpose. It means absolutely to support the traditional teaching materials (panels, paper guides, maps, etc.) with new interactive tools, in line with the modern techniques of sciences divulgation. The very last phase, that go before the opening one, will focus on the testing of the structure and on the managing of the teaching activities and workshops.

U3-15 Orale Pescollderungg, Margherita

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THE DOLOMITES. HERE'S HOW THEY WERE BORN! A PROJECT FOR SMALL PUBLISHING SCIENTIFIC CURIOUS READERS WHO WANT TO HAVE ANSWERS TO ALL THEIR "WHY?"

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Key terms: publishing; geoscience education; Dolomites; awareness of nature; environment

The Dolomites. Here's how they were born! it was inspired by a request from the primary schools to create scientific material arising awareness and education of the territory.

The publishing house "fuoricittà editions" along with "Tati & Tate Illustration World" has chosen to explore an area particularly close to them, the Dolomites mountains, declared UNESCO World Heritage in the year 2009. The foundation Dolomites UNESCO has sponsored this project with their logo on the cover.

The books are thought as educational material dedicated to children of 5+ y.o. their parents, schools, museums etc.

There are several considerations about the development of this project, i.e. the importance to communicate to children values such respect and conservation of the Earth and related resources. There is a need to reinforce the intelligence and the critical attitude of children because at this age, they are extremely open to neurobiological stimulation.

The books are part of a series, designed with the intention of explaining complex concepts through simple texts and valuable hand-drawn illustrations, all scientifically sound, close to the child view.

Yet they offer interesting scientific ideas that intrigue the young reader who, together with parents, relatives or teachers can then deepen the topics at school, visiting museums or just discuss it at home

Young readers of these books have the opportunity to personalize, making drawings and collages on dedicated pages. Indeed the graphic project has a playful approach so children have the opportunity to develop drawings capabilities and different learning processes. Thus stimulating children to learn and get answers they are eager to get about scientific topics (...why this, why that? ...).

On the Internet portal of the publishing house will be available the scientific information of the specific theme of the book, with more texts, pictures and videos. In addition there will be curiosity for young readers, and other designs to download.

This project has been created with the scientific support of the Science Museum of Trento and in particular of geologist and paleontologist Marco Avanzini.

The protagonist of the publishing project "The Dolomites" is Dò a white kitten with a particular alive hat that remember the ornaments of transhumance and traditional costumes of the Dolomites. In his adventures is accompanied by wild animals (marmots, chamois etc.) or by characters even recalling personalities really existed (eg. Leopold von Buch).

First book: The Dolomites. Here's how they were born! Dò meets Leopold (von Buch) who explains the evolution from the Triassic sea to the actual mountain peaks using the subject of a fossil fish. Dò learns the origin of the name "Dolomites".

Second book: The Dolomites. The flowers of the Dolomites. Dò, together with the magic marmot Mari, discovers the flowers growing at various altitudes. In the eyes of Dò, in this case small like an ant, the flowers appear to be real giants.

Third book: The Dolomites. Animals of the Dolomites. Dò and Mari venture into a daring descent along a river from its source to the valley, using a log as yacht. During their journey they take on board different animals to get together to celebrate at the farm.

Fourth book: The Dolomites. The fossils of the Dolomites. Dò is invited to a special banquet, to inaugurate the world's largest safe, along with fellow scientists and researchers. The food flow is presented in a particular way using fossils of different ages.

Follow publications will try to give all the answers to the various "why?".

U3-16 Poster Antognini, Marco

10.1474/Epitome.04.1078.Geoitalia2011

"MAGIE DI PIETRA": PHOTOGRAPHY AS A TOOL OF DIVULGATION OF THE GEOLOGICAL LANDSCAPES OF TICINO (SOUTHERN SWITZERLAND)

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Key terms: Photography; Divulgation; Geological landscapes

In the framework of the «International Year of Planet Earth» initiative, the Natural History Museum of Ticino in Lugano (southern Switzerland) published a book with high quality panoramic photographs of the most scenic geologic features of this region. The book is the result of a collaborative work between a professional photographer and a geologist. The aim was to stimulate interest in the Earth sciences within the general public bearing in mind that a photograph can reveal geologic stories in a spectacular way. It is a visual tour through the geology of the alpine scenery landscape of Ticino driven by the artistic point of view of a photographer. This approach will interest the amateur naturalist without any great knowledge of Geology.

In order to outline the complex geologic history of this part of the Alps, 18 sites have been selected belonging to the three major geologic provinces of Ticino: the Gotthard Massif, the Penninic and the Southern Alps. Some

among these are renowned localities such as the Gole della Breggia (first Swiss GeoPark) or the Monte San Giorgio (UNESCO site), whereas other ones are less known sites scattered through much of the mountainous landscape of this remarkable area. Each site is described by a short multilingual text (Italian, French, German) that highlight a general and prominent geological process displayed by rocks in the field (e.g. glacial erosion, complexly folded strata on a mountain cliff, sculptured turrets of dolomitic outcrops). The exemplary colour photographs, presented in landscape format (28 x 19 cm), are also supported by simplified geological maps and sections giving a concise account of the processes that shaped the bedrock of southern Switzerland. The technical terms likely to be unfamiliar to the general reader are explained in a glossary.

U3-17 Poster Celi, Monica

10.1474/Epitome.04.1079.Geoitalia2011

"GEOLOGICA" - THE NEW GEOLOGICAL SECTION OF MUSEO DI STORIA NATURALE E ARCHEOLOGIA DI MONTEBELLUNA (TREVISO, ITALY)

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1 - Museo di Storia Naturale ed Archeologia di Montebelluna (TV)
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Key terms: geology; science education; museum exhibition

The new exhibition is based on two assumptions: the role of geoscience in the educational plan for the future of society and the importance of the tools of scientific research in Earth science, to meet the challenges of sustainable development.

The exhibition is organized around the theme of geodiversity, who see the variety of geological environments the basis of the variety of life on Earth, and represents scientific, social, cultural values as substrate of unique geo-historical witness.

The layout incorporates four interpretations, already been developed in the Mineralogy section and Life Sciences section: morphology, classification, evolution and relationship with man.

Exhibition will cover two blocks: the first the earth's crust and the rock cycle and the second the local geology (pre-Alpine foothills, hills, plains and Montello).

With manipulable objects and locations through direct experimentation, we want to clarify and make more comprehensible complex abstract concepts (tectonic movements, stratigraphy, etc.) using the latest multimedia technology (interactive video, audio, touch screen) and in full compliance with the application of Kolb's learning styles.

U3-18 Poster Landini, Walter

10.1474/Epitome.04.1080.Geoitalia2011

HOW TO COMMUNICATE PALEONTOLOGY - INTEGRATION BETWEEN DIDACTIC WORKSHOPS AND EXHIBITIONS AT THE NATURAL HISTORY MUSEUM OF THE PISA UNIVERSITY

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Key terms: PALEONTOLOGY; NATURAL HISTORY MUSEUM; DIDACTICS FOR SCHOOLS; INTEGRATE WORKSHOPS; MULTISENSORIALITY

The recent inaugurations of three new permanent paleontological exhibitions stimulated the Natural History Museum of the Pisa University to renew and upgrade its own didactic offer to schools as regards Palaeontology and, above all, to modernize its organizational modalities. Fundamental under this aspect has been the experience matured during thematic events of great popular participation as the Festival of Science in Genoa (2005, 2006, 2007), the Mondadori Junior Festival in Verona (2007) and the Parma Science (2010), in addition to events of local interest as the Energy Forum in the St. Rossore park (Pisa, 2006) and the Pisa Book Festival (2008).

Three are the didactic models applied according to the age of the classes. The youngest students (3 to 7 years old) have special spaces, dedicated and purposely equipped, inside the exhibition rooms (dinosaurs and archaeocetes) where the contents are transmitted through game activities that all the children carry out personally (e.g. simulated digging, drawings, collages, puzzles and thematic games), punctuated by short explanations of the materials on exhibition (e.g. the reconstructions of archaeocetes).

Didactic workshops for students 8 to 13 years old are a balance of a first part in which learning realizes through explanations and practical experiences to be executed by some of the students using didactic supports (e.g. static and/or dynamic 3D models) purposely projected and realized; and a full immersion, not only visual but also sonorous and tactile, in the "lost world" narrated in the exhibits that become not just a place of passing though and passive observation but of interaction and active understanding.

Finally for the high school students, but also for adults, it is this last part to take the windward with a guided visit in which the single elements of the exhibition become occasion of observation, learning and of a deepening especially focused on the topics chosen by the teachers of each class who can select in advance, interacting with the didactic operators, the topics they want to be dealt more in detail.

In the last eight years, each time a new exhibit was inaugurated, one or more workshops were added to the didactic offer of the Museum: the opening of "Back to the Past - a 500-million-year trip to the Monti Pisani" in 2006 was followed by the introduction of two new workshops (one for students 8 to 13 years old and one for the high school); the inauguration of "Dinosaurs in the Charterhouse" in 2008 included the opening of three new didactic activities (respectively for 3 to 7 and 8 to 13 years old students and for the high school); finally the newest exhibit "Archaeocetes - Cetaceans of Land and Sea" in 2010 has been accompanied by the opening of two didactic workshops (for 3 to 7 and 8 to 13 years old students), moreover it enriched the already present workshop on the living cetaceans by including the exploration of real objects in the part on the evolutionary origin of whales and dolphins.

Teachers positively answered to these innovations and, since the school year 2006-07, the classes requesting workshops on Paleontological subjects have been almost 500. Significant is the case of the workshops on dinosaurs: even if they were included in the didactic offer since the participation of the Museum to the Science Festival of Genoa (school year 2005-06) their requests increased of the 27% (from 64 to 81 classes per year) in correspondence with the opening of the exhibition on the

dinosaurs from Patagonia.

Moreover, in addition to the regular workshops for schools, the practical experiences connected with the new exhibitions are presented to the larger public during several special events.

A recent example is the "Night of Dinosaurs" held on May 14th 2011: this nightly opening of the Museum recorded more than 1200 people participating to a thematic program including children workshops, practical experiences, movies and guided tours on the dinosaur subject.

U3-19 Poster Casarotto, Christian

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LET'S DISCOVER SNOW!

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Key terms: education; snow; avalanches; climate change

Affirmed centre of ideation, design and production of didactic projects with certified quality, the Museo Tridentino di Scienze Naturali directs its activities toward formative, up to date, and innovative proposals for pedagogic and communicative methodologies, meeting the constantly evolving requirements of school and society.

Didactic initiatives distinguish for innovative methodologies based on *hands-on* approach: during guided tours, laboratory activities, and field excursions students directly interact with naturalistic objects and laboratory equipment to experience the various phases of scientific research. Didactic proposals are based on student involvement and imply the use of materials which stimulate a direct interaction with the studied phenomena. Special attention has recently been given to Primary School teachers whose didactic programs were integrated with an *ad hoc* project, planned and led in cooperation, dedicated to the discovery of the **snow environment**.

The snow, decoration of the winter alpine landscape, represents a climatic and natural element - at times dangerous - and an economic support to the winter tourism. It is thus worth educate school-age children to nivology, with the aim to inform about and prevent from hazards and to exploit it commercially.

To such purpose the Museum and Primary Schools teachers have developed on the following contents: i) the snow: what it is and how it forms, ii) how snow can be studied, iii) the social value of snow, iv) snow ecological and touristic importance, v) stability of the snow blanket, vi) education to winter environments.

The project was organized in two meetings, in class and then in mountain environment, near the school. During the first meeting, with the aid of a power point presentation, the basic concepts of snow science have been passed through by means of a comic history. A snowman - the principal character - helped in adapting terminology and calibrating the scientific contents, and made easy technical concepts such as formation and metamorphism of snowflakes, their study and interpretation. Students have also been introduced to research instruments that, during the second meeting, were used to describe the properties of the snow blanket and to determine its degree of stability. These, in turn, helped to teach about the correct behaviour to be adopted in order to prevent avalanches.

In the second meeting students experienced the unusual winter environment where reciprocal cooperation and team spirit have been fundamental to solve problems.

Divided up in small teams, students performed meteorological observations, executed excavations, produced stratigraphic profiles of the snow blanket and studied form, dimension, density, and resistance of the snow crystals. An educated test of the snow blanket stability was then performed.

The main goals of these activities have to be found in the *Lisbon Strategy*, where the *lifelong learning* concept has been fixed as an inalienable target for the Society. The permanent learning strategy fit in the scheme of a European Union as a knowledge-based developed society, where sustainable economy, social cohesion together with environmental protection have to be pursued for present and next generations.

U3-20 Poster Ferretti, Paolo

10.1474/Epitome.04.1082.Geitalia2011

AN "HOME-MADE" GEOLOGICAL TRAIL: THE EXPERIENCE OF THE LICEO GALILEI (TRENTO) SCHOOL GARDEN

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Key terms: Liceo Galilei geological trail; Trento; Trentino geology; Dolomites; science communication

Since the last two decades, the Museo Tridentino di Scienze Naturali (MTSN), in line with its institutional mission, deals with the field of education and training in order to promote the cultural and social growth, and common education (scholastic and permanent) within the field of natural sciences and specifically of Earth sciences.

Through a wide range of information campaigns and educational activities carried out at the headquarter and in the numerous territorial seats, over time the MTSN has expanded and established a network of relationships with schools and society in general.

Some schools, from mere users of educational activities, are becoming partners and inspiring new projects. This is the case of the Liceo Galilei in Trento, where starting from an idea developed by a group of science teachers in May 2009, the MTSN, in cooperation with the "Nature preservation and environmental valorization Service" of the Provincia Autonoma di Trento, has inaugurated a peculiar geological trail on the hill behind the school.

The aim of this project was to artificially recreate a didactic trail that can be used in all seasons and accessible to students with disabilities, where the simplified stratigraphic succession of the Trentino province can be shown, with particular reference to the Dolomites, recently declared UNESCO World Heritage Site.

For some time the MTSN carries out didactic activities in the Dolomites area, mainly at the geological trail Dos Capel - the prototype of Italian geological trail - and at the Geopark Bletterbach. In this places, due the high altitude and for the summer closing of schools, only in the summer season the good fruition of the trail is allowed.

The Liceo Galilei geological trail was performed by putting in place 13

monoliths representing to the most important rock formations in Trentino and in the Dolomites. The blocks were selected and taken from quarries or from forest yards of the Provincia Autonoma di Trento.

The "Nature preservation and environmental valorization Service" of the Provincia Autonoma di Trento has been involved in designing and performing special steel supports fixed to a concrete base buried in the ground, to guarantee stability and good visibility of the blocks. For each monolith an explanatory panel quoting the name of the rock formation, age, composition, depositional environment and possible use of the rock was prepared.

The trail (length: 500 m; drop: 50 m) develops along paths with natural bottom, characterized by a slight slope. From the bottom, where the oldest rocks were positioned (Southern Alps metamorphic basement, Permian plutonic and volcanic rocks, Val Gardena Sandstones) one can climb running up toward younger rocks, represented by tertiary formations (limestones and volcanic rocks).

The tour ends at a panoramic point overlooking the Trento valley and Monte Bondone, allowing to complete the trail with the topics of orogenesis, here well represented by the Monte Bondone anticline, and morphogenesis, with a view of the Adige valley shaped by glacial exaration and of the Torrente Fersina alluvial fan on which the city of Trento rises.

The trail has been successfully tested in October 2008 in the occasion of the training courses, organized by the MTSN, for teachers of Primary and Secondary Schools.

It can be accessed by reservation at the Educational Services of MTSN that offer guided tours; for autonomous tours an agreement with the secretariat of the Liceo Galilei is needed.

Despite the organizational difficulties due to completion of work in some areas of the garden, during the first school year (2010-2011) MTSN has accompanied 11 classes, for a total of over 200 students. Over the next few years, when the project will be completed, a sharp increase in visits is expected, hoping to be opened to the public at least during the school opening hours.

U3-21 Poster Nave, Rosa

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RAISING AWARENESS TO NATURAL HAZARDS: THE RACCE EUROPEAN PROJECT

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2 - NATURAL HISTORY MUSEUM, UNIV. OF CRETA

3 - NATURAL HISTORY MUSEUM OF LESVOS PETRIFIED FOREST

4 - EARTHQUAKE PLANNING AND PROTECTION ORGANIZATION

5 - RESERVE GEOLOGIQUE HAUTE PROVENCE

6 - CENTRO STUDI E FORMAZIONE VILLA MONTESCA

7 - CENTRE FOR EDUCATIONAL INITIATIVES ASSOCIATION

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Key terms: natural hazard; earthquakes; volcanoes; education; preparedness

Promoting the geological heritage and educating people on natural phenomena can play key role in disseminating information and good practices to minimize the effect of possible disasters.

To put it into action in 2010 has been developed the project RACCE (Raising earthquake Awareness and Coping Children's Emotions), granted by European Commission, Civil Protection Instrument, which involves as partners: Vesuvius Observatory (Section of INGV), Natural History Museum of Lesvos Petrified Forest (Greece), Reserve Geologique de Haute Provence (France), Greek National Earthquake Planning and Protection Organization, Centro Studi e Formazione Villa Montesca (Italy), Center for Educational Initiatives Association (CEI -Bulgary) and as Coordinator the Natural History Museum of Crete (University of Crete - Greece).

The project's aim is to raise awareness, improving knowledge on natural hazardous phenomena, (mainly seismic and then volcanic hazard) and simultaneously, to educate relative groups (teachers, parents, civil protection volunteers, etc.) on the best practices to deal with seismic and volcanic risk and also on responses able to palliate the children emotional burden in case of a serious events.

The main objectives of the project are: to identify, share and implement best practices and methodologies gained from previous EU projects and partners' activities; to develop and realize innovative initiatives and actions aiming to raise awareness and increase knowledge of pupils on earthquake and volcanic hazards; to train teachers, parents or other relative groups also to be able to contribute to children palliation in case of seismic/volcanic hazard. Main deliverables of the project would be the elaboration of an innovative and mobile experiential Educational Project connected with school curricula and a Travelling Exhibition. Project is expected to contribute in sharing information in raising awareness and minimizing the impact of such disasters and finally, in the establishment of a voluntary network of operators and beneficiaries in the areas involved to constantly share, discuss and apply the outcomes.

U3-22 Poster Martelli, Mauro

10.1474/Epitome.04.1084.Geitalia2011

RESEARCH AT DIRECT CONTACT WITH SCHOOL: AN EXPERIENCE ABOUT EARTH SCIENCE

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Key terms: Earth Science; School; Divulgation

In the frame of the divulgation activities carried out by the Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Palermo (INGV-Pa), we have performed a stage for 100 students of a Secondary School of the same city. The first part has been theoretical and dealt with lessons about various aspects of Earth Sciences, open to numerous questions coming from the students. The dramatic events of Japan (March 2011), happened just few days before the lessons, have been the trigger to handle with the themes of volcanic and seismic risk, their natural origin and impact on our society. The second part has been developed in the laboratories of INGV-Pa, where all the students, shared in groups of 10, took actively part to experiments and experiences regarding the chemical and isotopic analyses of natural gases and waters. They have also learnt the

usefulness of these analyses for volcanic and seismic surveillance. Each student has been involved in 6 hours of theory and 6 of practise, while 10 among researchers and technicians of INGV-Pa participated as teachers. At the end of the stage, the students have done some oral talks at their school, resuming the experiences done. The students demonstrated great interest in the Earth Science problematics as well as in the laboratory experiments. In the next autumn, 10 students among those who participated to the stage, selected by their teachers, will spend a week at INGV-Pa beside researcher and technicians to live the real life of the scientific research.

U3-23 Poster Pignone, Maurizio

10.1474/Epitome.04.1085.Geoitalia2011

MAP OF 150 YEARS OF SEISMIC HISTORY IN ITALY

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Key terms: 150 years seismicity Italy; 150 years Italy; seismic history of Italy; map 150 years

This map shows the strong earthquakes of the last 150 years in Italy. From the unification of Italy to this day, our country was struck by 170 earthquakes strong, very strong or even catastrophic. Of these, 12 were destroyed (Maximum intensity of MCS [Mercalli-Sieberg-Cancani] IMax > X) and have caused a total of over 130 000 victims. The earthquake of 1908 (M 7.2, Imax X-XI) in Messina and Reggio Calabria was the strongest of the past 150 years with more than 80 000 victims and the almost total destruction of two cities. The most recent earthquake occurred in Abruzzo April 6, 2009 (M 6.3, Imax IX-X). This map has been designed and produced by the Laboratorio di Cartografia Digitale e Sistemi Informativi Geografici di Sede Iripinia of INGV. It's been used GIS technology (ESRI ArcGIS 10) for the organization of seismic data. The map is available at www.gm.ingv.it

U3-24 Poster Girone, Angela

10.1474/Epitome.04.1086.Geoitalia2011

THE GEO-PALEONTOLOGICAL SITE OF MONTALBANO JONICO SECTION (LOWER-MIDDLE PLEISTOCENE) WITHIN THE RISERVA NATURALE SPECIALE "I CALANCI DI MONTALBANO JONICO"

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Key terms: geosite; Montalbano Jonico section; Pleistocene; Ionian Stage

The lower-middle Pleistocene Montalbano Jonico composite section crops out in the southernmost part of the Southern Apennine Foredeep. It is a well-exposed and continuous succession, about 500m thick, consisting of muds and muddy silts with nine interbedded volcanoclastic layers (V1-V9) (Ciaranfi et al., 2001). The vertical distribution of both invertebrate fossil assemblages and teleostean otoliths points out changes in the primary environmental parameters, particularly bathymetry, sedimentation rate and oxygen concentration. The observations allowed the reconstruction of several deepening-shallowing cycles within a general regressive framework. Five "sapropel" layers have been identified by benthic foraminiferal assemblages (Stefanelli, 2004) and they have been correlated to insolation cycles i-112, i-104, i-102, i-90 and i-86 (Ciaranfi et al., 2010). Radiometric Ar/Ar ages of 801.2±19.5 ka (Maiorano et al., 2010) and of 719.5±12.6 ka (Ciaranfi et al., 2010) have been obtained for V3 and V5, respectively.

The developed astronomical tuning of the section recently proposed by Ciaranfi et al. (2010) revealed that the Montalbano Jonico section covers an interval from 1240 ka to 645 ka through Marine Oxygen Isotope Stage (MIS) 37 to MIS 17-16. The upper portion of the section contains MIS 19, which is known to occur close to the Matuyama/Brunhes reversal, and may represent a suitable horizon for the definition of the GSSP (Global Boundary Stratotype Section and Point) of the "Ionian" Stage at lower-middle Pleistocene boundary (Maiorano et al. 2010). Considering the important scientific and panoramic valences of the Montalbano Jonico area, the researchers of Bari University and the community of Montalbano Jonico village worked all together in order to popularize and preserve this significant geo-stratigraphical heritage. Indeed, in January 2011, the "Regione Basilicata" ratified a specific law (L.R. 3/11) with the aim to protect the Montalbano Jonico area, thus establishing the *Riserva Naturale Speciale "I calanchi di Montalbano Jonico"* for its peculiar geo-stratigraphical value.

We present a project for the realization of the geo-naturalistic routes in order to improve the accessibility of the area and promote the natural secrets of this spectacular badland and its scientific role. The geo-stratigraphical site of Montalbano Jonico represents an interesting didactics laboratory for all community components and a proper opportunity to improve environmental education.

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U3-25 Poster Perotti, Luigi

10.1474/Epitome.04.1087.Geoitalia2011

GEOLOGICAL MAPS AS TOOLS FOR POPULARIZING GEOCIENCE

CONTENTS. THE CASE STUDY OF MIDDLE TANARO VALLEY (PIEMONTE, NW ITALY)

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Key terms: Tanaro; Mapping; Cartography; Popularization; Educational

Over the last 15 years within the scientific community has raised the awareness of the importance of geological heritage. Several methodologies have been developed for the identification, classification, evaluation and conservation of sites with a specific interest for the Earth Sciences.

Recently, some working groups have focused their attention on the promotion and valorization of geological heritage, through the development of projects whose goal is to popularize the geo-scientific information in order to make easier for a generic public the comprehension of features and process proper of a certain area. Promotional activities are manifolds and concerning different popularization products, such as itineraries, educational panels, publications, etc. Maps are often employed as part of the cited products because they represent a medium for the interpretation of geo-scientific data and serves popularization purposes. This kinds of maps may be defined as "interpretative maps": "an educational activity which aims to reveal meanings and relationships through the use of original objects, by firsthand experience and by illustrative media, rather than simply to communicate factual information" or in a simple words "an attempt to reveal the truths that lie behind the appearances" (Tilden, 1957). The main goal is to translate and transferring on the map specialized information to a general audience in order to facilitate the understanding of phenomena and processes that transform and shape the landscape over time, using illustrations and explanatory text, where appropriate. On the basis of assumptions cited above the Torino's Natural Science Museum and the GeosITLab of the Department of Earth Sciences started a project whose aim is to develop a cartographic tool able to popularize geological and geomorphological information of the Middle Tanaro Valley (located in the South-East sector of the Cuneo Plain, Piemonte, NW Italy).

Key requirement for this kind of work is the knowledge of processes and natural phenomena that have changed and shaped the territory over time. Through the deep analysis of the geological, geomorphological and structural components, a process of decoding, together with appropriate simplifications, has been implemented in order to attempt a reconstruction of the morphological evolution of the Middle Tanaro Valley's landscape.

Before the map implementation, the mapmaker chooses the information that has to be communicated on the basis of what's going to be revealed with the map, the specific target audience and the map's purpose. Another important question concerns the visual representation of geo-scientific data. Specialist of geoscience tends to represent data using standard operating procedure that can be difficult to read by an audience not involved in Earth Science disciplines. Geoscientist involved in mapping project should, therefore, have knowledge concerning visual information transmission, and hold the necessary communication know-how with the chosen media. For this reason a graphic designer has been involved in the project that led to the realization of geo-didactic map of Middle Tanaro Valley.

The two-sided map developed, shows both the situation at the present day, where the main geomorphological features have been emphasized and represented with a simplified legend, and a chronological succession of landforms realized with six bird's eye view drawings supported by synthetic text explanations.

It is a product expressly set-up for educational purpose, whose aim is to provide a simple and effective way to explain the geological and geomorphological processes of one of the most interesting sectors of the whole Piemonte region.

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U3-26 Poster Vigano', Alfio

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THE TRENITINO SEISMIC AND ACCELEROMETRIC NETWORKS: PRINCIPAL TOOLS FOR SEISMOLOGICAL AND EARTHQUAKE HAZARD STUDIES

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Key terms: Seismic network; Accelerometric network; Trentino;

Seismology; Earthquake hazard

The Trentino seismic network was installed by the Provincia Autonoma di Trento (PAT) after the relevant Gemona del Friuli (6th May 1976, M. 6.2) and Riva del Garda (13th December 1976, M. 4.1) earthquakes. The seismic network, which has been active since 1981, is today composed of 7 seismic stations uniformly distributed on the region. Besides, an accelerometric network has been installed since 2005, after the national seismic code and seismic zonation approved during 2003, with stations mainly located in the Southern Trentino. Digital recordings, acquired at remote stations, are transferred to a central server (Geological Survey Laboratory) where they are archived to be processed.

Aim and scope of the seismic and accelerometric networks are the following: i) give automatic alerts, particularly for strong earthquakes, ii) register and localize the seismic events of Trentino, iii) provide data for territory planning (e.g., seismic microzonation), iv) collaborate with other national/international seismic networks within the project "Antelope" of the NE Alps.

The results from the elaboration of seismic and accelerometric data are made available through an Annual Seismic Bulletin, a dedicated Web page (www.protezionecivile.tn.it) and scientific publications. Moreover, the PAT Geological Survey is involved in events devoted to study natural hazards (in particular, earthquake and/or landslide hazards) and to show monitoring and prevention activities planned for the Trentino area. In the period 2009-2010, a specific experience was about a thematic exhibition hold in Trento (Museo Tridentino di Scienze Naturali) to show regional seismicity and its monitoring.

U3-27 Poster Torre, Rosario

10.1474/Epitome.04.1089.Geoitalia2011

GEOCULTURAL ITINERARIES IN THE MEDIEVAL HAMLET OF SANTA LUCIA DEL MELA (PELORITANI MTS. NE SICILY)TORRE Rosario¹, CARABETTA Maria Teresa¹, CIRINÀ Valentina¹, MACCARRONE Beatrice¹, MESSINA Antonia¹
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*Key terms: Peloritani Mts., Calabria-Peloritani Arc; Santa Lucia del Mela Medieval Hamlet (NE Peloritani Mts., Southern Italy); Geological, Geomorphological and Historical Heritage; Geocultural Itineraries*The Medieval Hamlet of Santa Lucia del Mela, with 4800 people, occupies a surface of about 83 km², which extends along the three hydrographic basins of the Mela, Floripotema and Muto Torrents.

The Mela Torrent, which is the most important, originates in the Pizzo Acqua Bianca (1211 m). Its name derives from the Greek "Melas" meaning "black, dark", due to the several eclogite bodies alternate to marbles and schists in the two hydrographic versants of the Valley and in the river bed alluvial deposits.

The complex geological history of this Territory is also responsible for its heterogeneous morphology. It belongs to the orogen Calabria-Peloritani Arc, and is made up of a pile of Alpine tectonic units, called, from top to bottom and from N to S, the Aspromonte, Mela, Piraino and Mandanici Units. Proterozoic high-grade metamorphic and plutonic rocks outcrop in the area which are affected by Variscan and, locally, also Alpine re-equilibrations up to low-grade rocks, and Palaeozoic medium- to low-grade metamorphic rocks. The first lithotypes belong to the Aspromonte Unit, where Variscan augengneisses prevail and the second to the other Units, where Variscan marbles, schists and phyllites prevail. In particular the Mela Unit extensively outcrops, with thick levels of Variscan marbles, schists, gneisses, and relicts of Eo-Variscan eclogites.

The area is also known for the abundance of metallic deposits, such as Pb, Zn, Cu, Fe, Ag, Au, W etc., which are still observable in the V.ne Pomara and in the Cerasiera Torrent, along the tectonic contacts. Preserved old mines are also present in V.ne Malonato and Pizzo Nevola.

The territory is characterized by widespread and significant epigeal and hypogean karst phenomena which developed within the thick Mela Unit marbles, such as the beautiful "Sautu i Lapa" cave and the spectacular canyons of Rocche Strette in the middle tract of the Floripotema Torrent, the V.ne Pomara, V.ne Ferrà and V.ne Monastri in the middle-low tract of the Mela Torrent, the "Ula Funna" in the middle tract of Muto Torrent. For scenic landscapes and spectacular geomorphological characteristics, the following sites are listed: Makkarruna Hill (370 m) on which stands the Hamlet of Santa Lucia del Mela, with the Arabian-Suevian-Aragonese Castle; Rocca Timogna (1127 m) the top of which shows the outline of a crouching lion; Rocca Vernava (1048 m), the top of which exhibits the characteristic profile of a human face; the remaining spectacular mountains of Pizzo Acqua Bianca, Pizzo Croce (1214 m), Pizzo Acqua Menta (1107 m) and Mt. Poverello (1279 m).

The numerous springs and waterfalls, e.g. the "Salto di Ferrà", the "Schicciu a Saitta", the "Ula Funna" have the same importance. The "Demanio Forestale Mela" and the "Affluenti del Torrente Mela Site of Community Importance" are also situated in this territory due to biotic aspects, where many endemic species of flora and fauna are preserved, such as the rare and giant Woodwardia radicans fern growing in both the "V.ne Mandrazza" and the "V.ne del Lacino".

The Santa Lucia del Mela municipality holds a very important historical heritage, including archaeological relics from the Hellenistic Age, Roman tombs, the Castle with three towers containing the preserved Madonna della Neve Sanctuary which dates from 1673, the Cathedral of 1094, the Churches of Santa Maria Annunziata and San Nicola (XV century), the Capuchin Church and Convent (XVII century), the Basile-Vasari Palace of 1599, the Bishop's Palace of 1608 and the San Giovanni medieval hamlet, sited along the Floripotema Torrent. Recently, the area has also been investigated as the site of the famous Artemis Phakelitis Temple.

The studied territory, although located in the "Milazzo-Valle del Mela Area of high environmental risk", exhibits a considerable cultural system promoter of innovative conservation and management models which also include thematic itineraries for a qualified fruition of its Geo-cultural Heritage.

U3-28 Poster Borghi, Alessandro

10.1474/Epitome.04.1090.Geoitalia2011

TURIN: THE FOUNDATION STONES OF GEOLOGICAL HERITAGE IN PIEMONTE REGION (PROGEO PIEMONTE, GEOTHEMATIC AREA 9)BORGI Alessandro¹, CASTELLI Daniele¹, COSTA Emanuele¹, D'ATRI Anna², FAVERO-LONGO Sergio³, FERRANDO Simona¹, FORNO M. Gabriella², GIANOTTI Franco², GROppo Chiara², MARTIRE Luca², PIERVITTORI Rossana³, ROLFO Franco¹, ROSSETTI Piergiorgio¹, VAGGELLI Gloria¹, et al.
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Key terms: applied petrography; ornamental stones; geological heritage; Piemonte

The multidisciplinary research project "PROGEO Piemonte" aims to achieve a new conceptual and operational discipline in the management of the geological heritage of the Piemonte Region by means of the development of techniques for recognizing and managing its rich geodiversity at the local and regional scale. Within the project, 9 strategic geothematic areas will be investigated to represent the geodiversity of Piemonte, each characterized by high potential for scientific studies, enhancement of public understanding of science, recreation activities and for economic support to local communities. The recognition of the economic value of geodiversity will lead to the production of regional guidelines for Geoconservation integrated quality management system, suitable for tourism and sustainable development strategies.

In Turin, the stone has always characterized the strong architectural identity of the city. From Roman times to the '700, marbles were the rocks used in construction of greater value. Starting from '800, granites and other silicate rocks were progressively used thanks to the development of technologies for their processing.

The great variety of ornamental and building stones found in Turin is certainly due to the highly composite geological nature of Piemonte region where very different geological domains crop out: the western portion of the metamorphic Alpine chain, the sedimentary basin of Langhe and

Monferrato and a small sector of the Northern Apennine.

In the framework of the "PROGEO Piemonte", the aim of geothematic area 9 is the compilation of a detailed list of the many historic and contemporary Piemonte stones, which over the centuries have been used in buildings and architecture.

The main ornamental stones used in Turin will be identified and characterized from petrographic and mineralogical point of view in order to identify the geological units of provenance as well as the quarry sites. For the minero-chemical characterization of the main rock types, different analytical techniques will be applied such as the scanning electron microscope, the electron microprobe, the micro-fluorescence, the cathodoluminescence and the confocal Raman. The main agents of deterioration, such as air pollution, human activity and (micro-)organisms, will also be studied. The role of different compositional and structural features of the bedrock in the biodeterioration process on the ornamental stones surface will be investigated in detail.

The creation of a comprehensive database for the Piemonte rocks used in buildings of historical and contemporary highlights of the city of Turin is expected as the final product of our research. The data base will include the full name of the rock (commercial and scientific), the location of the quarry site, the main applications in buildings and monuments of Turin, the macroscopic and microscopic description illustrated by extensive iconographic material.

Main emphasis will be given to the rock types used for external application as they are easily observed during touristic city tours. Moreover, some significant rock examples that decorate the inside of churches and buildings will be also identified and reported on the proposed database.

The project also includes the study of many ancient villas in the Northern slope of the Turin Hill, built on a succession of flat terraced surfaces, corresponding to relicts of Pleistocene alluvial plains involved in the hill uplift.

The research, finally, aims to disseminate the knowledge on stones both in science teaching and in cultural tourism, but the results will also be useful and available to people involved in territory planning and to operators involved in restoration activity.

U3-29 Poster Pennisi, Maddalena

10.1474/Epitome.04.1091.Geoitalia2011

LET'S FIND OUT THE SECRETS HIDDEN IN A GLASS OF WATERPENNISI Maddalena¹, ADORNI-BRACCESI Alessandra¹, DELL'OMODARME Daniela²

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Key terms: Middle school science project; Water; Front presentation; Experimental activity

CNR in Pisa is periodically open to the public and interested students who wish to learn about topics in computing, life and earth sciences. "Let's find out the secrets hidden in a glass of water" is a Middle School Science Project created in 2010 through the cooperation of the Istituto di Geoscienze e Georisorse and the teachers from the Scuola Media, San Frediano a Settimo, in Cascina, Pisa.

The purpose of the project is to:

- educate school age children on the importance of water as a precious resource to the community and the environment; and
- provide students with a laboratory experience not commonly provided in schools, to assist them to determine the characteristics of water as found in nature and from the tap.

The project involves a power point presentation (24 slides) that results in a discussion between teachers and students and is followed by an experimental activity (approx. 2 hours).

The power point presentation commences with basic concepts: the physical and chemical characteristics of water, its distribution on the surface of the earth, the water cycle, and the relationship between water and geology. The concepts of aquifers are introduced together with the relationships between rock and water chemistry. Potential toxic elements from geogenic sources and pollution are introduced and their effects on health discussed. The students are also shown the huge discrepancies in global water resource distribution. They are shown how to promote sustainable every day water usage and the relationship of water usage to the environment.

The second part of the project takes place in the chemical laboratory. During the experiment the students familiarise themselves with some of the materials commonly used in a laboratory - beakers, micropipettes, pH colour - fixed indicator sticks and flasks. The concepts of salinity, alkalinity and acidity are investigated. The children measure conductivity, pH and temperature from several water samples that included rain, tap and bottled water as well as commercially available liquids - cola, milk, juice. The values obtained are recorded on laboratory data sheets and then inserted in the final report compiled by each student.

The instruments used in the laboratory are pH-meters and temperature sensors linked to conductivity. NaCl solutions (with different molar concentrations) are used to measure the increase of salinity in rain, surface, ground and sea water, respectively. Other reagents such as methyl orange, weak ammonia solution, lemon and vinegar are used to change the pH of the solution. Measurements are taken of the change in pH.

The students are highly satisfied as shown by their active participation in both the theoretical and experimental parts of the project. The cost of running the project is moderate. If there is an interest from other middle schools, the power point presentation, list of chemical materials, and laboratory data sheets will be willingly provided upon request.

U3-30 Poster Murgia, Rosalba

10.1474/Epitome.04.1092.Geoitalia2011

"MARE NOSTRUM" - RESEARCHERS FOR ONE WEEKMURGIA Rosalba¹, MOSSONE P.¹, ANTOGNARELLI F.², CAMEDDA A.², COPPA S.², DE FALCO Gianni², DE LUCIA G.A.², FENZI G.², SATTA A.², SINERCHIA M.², PERILLI A.², et al.

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Key terms: scientific dissemination; educational project; coastal marine environment; evolution adaptation; biodiversity

In recent years, the number of students studying natural science has been

decreasing all over Europe. In particular in Italy, this decrease in environmental related topics enrolment is caused primarily by a reduced interest in scientific topics and secondarily by the lack of job opportunities in such field. The International Marine Centre (IMC) foundation and the Institute for Coastal Marine Environment, (IAMC-CNR) collaborated for several years in educational activities for the diffusion of marine science. During the last 10 years, more than 2000 students from primary and secondary schools were involved in different theoretical and practical didactic activities carried out by the marine researchers.

The project "Mare Nostrum" (8th May - 12th May 2010) promoted the dissemination of scientific culture bringing students, aged 16 to 17, closer to the "world of research". 45 students of the "Liceo Scientifico Galileo Galilei" of Civitavecchia had the chance to get closer to the world of marine research at the IAMC-CNR laboratories at Torregrande (Sardinia).

Students learned about the advantage of the applied research and how a researcher is carried out following different steps (hypothesis, field and lab work and data analysis) with the constant support of the senior IAMC-CNRIMC researchers.

The high environmental richness and variability of Western Sardinian coast (coasts, lagoons, beaches, open sea) is an ideal scenario to demonstrate how to use environments multidisciplinary approach in different situations.

The interactive theoretical lessons prepared the students to the practical activities in field related to the monitoring and management of coastal environments. Students were divided in small groups and each group had to choose one of the following topics: oceanography, sedimentology or ecology of lagoons and coastal marine systems. The educational project finished with a meeting with other Italian students (from the Oristano "Liceo Scientifico Mariano IV Arborea"), who had the same experience at the IAMC-CNR laboratories. Students from both schools discussed the obtained results and showed them in presentations, in order to compare the achieved scientific knowledge.

This experience gave students the opportunity to open their minds and to increase their scientific, cultural and social experiences. The practical activities have to be considered fundamental to show students how the world of marine science can be interesting.

Furthermore, this project aims at offering the Oristano students the opportunity to go to the University of Viterbo to live and work for one week as university researchers.

These activities contribute to implement the strategy network between students of different European regions for sharing knowledge and experiences.

SESSIONE U3

Comunicare le scienze della Terra: iniziative ed esperienze per educare ad una cittadinanza responsabile

U3-1 Orale Vaccari, Ezio

10.1474/Epitome.04.1093.Geoitalia2011

THE HISTORY OF GEOLOGY AS COMMUNICATIVE TOOL FOR SCIENTIFIC EDUCATION IN THE EARTH SCIENCES

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Key terms: history of geology; geological education; museums; geosites; itineraries

The aim of this paper is to introduce and evaluate the role of the history of geological sciences for the scientific communication and a sustainable education in the field of the Earth Sciences. Some possible example will be presented and discussed within the following topics: reassessment of historical collections in geological museums, as tools for approaching and understanding scientific debates; results of historical research-work on seismic, volcanological and hydrogeological events, as tools for achieving a correct knowledge of the real extent of the so called (by the media) "catastrophic events" or "irreversible changes"; the planning of historical routes of the geosciences (for example in mountain areas such as the Alps or the Apennines), in order to provide a new network of geotouristic itineraries with didactic and informative purposes.

U3-2 Orale Losi, Claudia

10.1474/Epitome.04.1094.Geoitalia2011

DRAWING UP ON TIPTOE: THE CONTACT BETWEEN ART AND SCIENCE

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Key terms: art; amazement; metaphor; landscape; experience

The close and complex relationship between art and science is certainly not a novelty. Much has been written and discussed on the matter (recently in Italy: Effetto Terra, edited by Maria Perosino, Johan & Levi, 2010).

While still a student, along with a couple of travelling companions (Matteo Meschiari and Francesco Benozzo), I began to reflect on how to translate some of our considerations on the relationship between man and earth in visual terms, leading us to run the Studio Italiano di Geopoetica from 1996 to around 2000, following in the footsteps of the multidisciplinary experience that the Scottish writer Kenneth White had undertaken years before with the Institut International de Géopoétique.

It was on this occasion that I decided to use needle and thread to reproduce the structure of the lichens photographed during my excursions (Tavole Vegetali, 1995). I consulted scientific handbooks to identify them, or to understand what kind of terrain they grew on and I walked on. Just as I do now, I shifted between the coring of real soil and ice and the metaphorical perforation of imaginary places. On my wanderings through the Dijon countryside, around Montbard and the birthplace of Georges-Louis Leclerc, Comte de Buffon, I took a dozen shots of some partially buried tanks belonging to a long-abandoned trout farm and, once printed, I sewed onto each one a stage of the drifting apart of the continents: ideally these continental plates would also return to the surface (Marmagne, 2001).

One of my first group works was the Arthur's Seat Project (1999-2001): I

asked six Serbian women and six Albanian women to sew 12 fragments of a drawing onto fabric showing the stylised shape of Arthur's Seat, the volcano near the centre of Edinburgh which has been dormant for thousands of years. In the 18th century, J. Hutton put forward his theories on the evolution of the earth's crust, partly on the basis of his observations of this highly particular place as a student (J. Repcheck, The Man who Found Time. James Hutton and the Discovery of the Earth's Antiquity, 2003).

And then the latest project which came to a close a few months ago: Balena Project, which consisted of a life-size fin whale that I constructed out of fabric, padding and air balloons. This was a very complex project which originated partly from walking through the sandy gullies of the Piacenza hills, where Pliocene fossils may still be found, and where - a few centuries ago - the bones of a number of cetaceans were uncovered beneath the vineyards after thousands and thousands of years.

As regards the relationship between science and art, I'm interested in the endless source of amazement represented by both cognitive and technological tools, but also the "sharp-edged" approach with which the sciences study the world around us. That world that makes us what we are. As Marina Wallace says, the artist today looks towards science as a source of visions, through a different language, one often metaphorical or metonymic.

I believe that for the artist it is a question of drawing up on tiptoe, of adopting a panoramic view through which to put together things which might or might not have anything to do with each other, and then create fruitful links between them. Thus the micro-landscape of a lichen growing on a rock has to do with the dilated view of a faraway era of the continental drift; the clay modelled into the shapes of aquatic animals by children, shapes which are then left to be washed away on a riverbank and which serve as a narrative motif for the passage of both practical and theoretical knowledge.

Hence, those who have no real grasp of the subject wantonly pick out pieces of the information provided by those who, instead, leave no stone unturned in their meticulous search for detail, and then elaborate them using an entirely different language. Clearly, the operation requires a certain degree of recklessness.

U3-3 Orale Fruguglietti, Salvatore

10.1474/Epitome.04.1095.Geoitalia2011

GEOLOGICAL SCIENCES IN LE NUVOLE

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Key terms: SCIENCE COMMUNICATION; THEATRE AND SCIENCE; SCIENCE IN SOCIETY- SCIENTIFIC CITIZENSHIP; KNOWLEDGE'S SOCIETY; PHILOSOPHY OF SCIENCE

Le Nuvole, Theatre of Innovation for Children in Naples, founded in 1985 and since 1996, following the happy encounter with IDIS - Città della Scienza (which since 2001 is the first Italian science center), deals with communication of science, so with educational activities for the public school that theatrical communication events for the public school and beyond.

The history of science communication of Le Nuvole begins with the management and conduct guided tours and educational activities.

The first development was the thinking that guided tours may be different performances. That is how the "show-visits, which are still valid experimental models of science communication. Not yet a show, but no more than a simple tour: it gives more attention to the gesture, the word, the mime, narration and animation. All this to intrigue and charm.

Following the visits show (VS) have been joined by the events of theatrical communication of science (TCS), a piece of theater scientific topic, which for the simple logistics and the possibility of staging in non-conventional areas are significantly appreciated by the local science.

Among the cases are related, directly or indirectly by the geological sciences Le Nuvole offer

Geoquiz - (VS) - 5 billion years in 18 questions. Geology becomes a quiz show on network structure on the basics of geology for primary schools. The formula takes advantage of the game between two teams, educational purposes, the innate spirit of emulation and competition for kids.

Two wires, one expert and a facilitator, directing a team game involving two groups of students, enabling dynamic knowledge of Geology. Called upon the students to choose topics and reflect on the themes: the permeability of soils, continental drift, the globe, the erosion, the internal structure. The winners who answered and have obtained the highest score will receive the applause and a symbolic diploma.

Naples, discover the city - (VS) A visit touring show in public areas of the Science Centre of Naples, using the Neapolitan traditions and beliefs, told the site. An intriguing way to use a place of science to describe the geology of the Campi Flegrei.

Lottery nuclear - (TCS) Risk communication and construction of citizenship scientifically aware -

Not only nuclear energy but also environmental protection and planning, assisted reproduction, GMOs, stem cells, high-speed trains: the more science and technology advancing rapidly, especially since society seems to resist. Such questions can not tolerate nor a "technocratic response" or an "ethical response." What is needed is rather a "policy response", because each technology incorporates a vision of man, nature, society, are indispensable sites, transparent and accountable institutions and procedures through which to reach a public choice between alternatives.

Biodiversity - (TCS) Entertainment was born from a co-production, even metaphorically, focuses on "work together" to build responsible citizenship. Among the topics dealt with environmental sustainability and protection of soils.

The European society is currently experiencing a situation of constant changes in political, social, cultural and technological developments and, especially, is experiencing a crisis in relations between citizens and scientific culture.

The theatrical communication of science can make science more accessible and understandable, encouraging the intermingling of two cultures (scientific and humanistic) that have long been uneasy relationship so much that it was believed, rightly, that it was dangerous to have two cultures that do not could or could not know to communicate.

U3-4 Orale Greco, Roberto

10.1474/Epitome.04.1096.Geoitalia2011

INTERNATIONAL EARTH SCIENCE OLYMPIAD - THE 1ST EDITION

IN EUROPE

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Key terms: International Earth Science Olympiad; Education; Earth Science

International Earth Science Olympiad - IESO is one of the 10 International Scientific Olympiad. This project was developed by International Geoscience Education Organization - IGEO.

IESO is an annual competition for secondary school students (students not older than 18 years in July 1st of the year of the Olympiad). The students have to test their skills in all major areas of Earth sciences, including geology, geophysics, meteorology, oceanography, terrestrial astronomy and environmental sciences. The theoretical examination includes problems which are developed to measure the participants knowledge and understanding in Earth science areas. The practical examination consists of task which are designed to assess participants' abilities to carry out scientific investigations in earth science inquiries. The examinations are prepared by specialist in Earth sciences and Earth science education, who also provide solutions and evaluation guidelines. Each delegation is made of 4 students (young than 18 years old the 1st July of the year of the Olympiad) and 2 mentors. Mentors must be specialists in Earth science and Earth science education and capable to serving as members of the International Jury. Official language of IESO is English, however the mentors could translate the written examinations and related materials from English to the participants' native language. The main aim of IESO is to raise student interest and public awareness of Earth science and even to enhance Earth science learning of students. With IESO the organizer hope to award talented and gifted students in Earth science and to promote the improvement of teaching Earth science in schools. Last but not least encourage friendly relationships among young learners from different countries and promoting international cooperation in exchanging ideas and materials about Earth science and Earth science education. IESO is the only International Olympiad that include an International Team Field Investigation - ITFI. Past International Team Field Investigation have included developing stratigraphic sequences, evaluating living on the Mt. Mayon volcano, and evaluating the fault escarpment of the Chi-Chi earthquake. In 2010 in Indonesia, the International Team Field Investigation focus on sustainability and the use of underground water.

The IESO is one of the last science Olympiads established. The first edition was held only in 2007 with the support of countries with a strong emphasis on Earth science in their national curriculum.

Republic of Korea guest the 1st IESO edition in 2007, then:
 208 2nd Philippine, theme: Cooption in Addressing Climate Change (the word "cooption" refers to a combination of competition and cooperation).
 2009 3rd Taiwan, theme: Human Environment
 2010 4th Indonesia, theme: The present is the key to the future.
 2011 5th Italy, theme: Earth science renaissance, science, environment and art

2012 6th Argentina
 2013 7th India

In 2011 for the first time IESO will be held outside Asia, in Europe. That could be a great occasion to involve more European country to participate in this competition and a great occasion for Earth science education expert to know each other and grow a European network.

U3-5 Orale Mundula, Matilde

10.1474/Epitome.04.1097.Geoitalia2011

EARTH SCIENCES FOR THE EDUCATION TO CITIZENSHIP. EXAMPLES OF PARTNERSHIP BETWEEN SCHOOLS

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Key terms: Earth Science education; International partnership; Developing countries; Water

The project involved pupils, students and teachers - belonging to different communities - in a meeting work which, through an inquiry dedicated to natural environment, will help everybody to become aware of its own role as "citizen" and to act consciously with equal dignity. The project, supported by the University of Turin (Earth Science Department) and the Piedmont Region, had the aim of starting an educational path in partnership with Developing Countries, and was based on the framework of the main guidelines of Geology (complexity, interaction, dynamism, fragility, cycles...).

One example, carried out in the school year 2009/2010, involved more than 250 students from Italian schools (Turin and Airasca) and a school of a deprived district in Salvador de Bahia (Brazil). The aim of the project is to improve the learning skills and the enthusiasm of students in troubles by means of an interactive didactic, based on field and laboratory work. Direct perception and observation of their environment, starting from the physical components, has the goal of introducing it to the twin partner, living in another continent, produces a highly motivational task.

The project extended to the area of Earth Sciences, focusing on the theme WATER. The activities included both individual tasks and team work, focusing the attention on the location of water on the territory and on its action of transformation, highlighting the risks that may occur. A tight correspondence took part between students and teachers belonging to the different schools and a lot of drawings, texts, teaching materials and pictures have been exchanged through the net.

A second path has been realized between the students of a technical school near Turin (Italy) and the students of Cape Verde. They were both involved in an inquiry about water management in the area in which they live (Prealpi di Piedmont for Italian students, Fogo Island for students of Cape Verde), and in general about the actions carried out by Municipalities in order to manage and to defend water from waste and damage and more widely to protect the natural environment.

The starting point has been the Charter of Earth. We introduced the students to its general themes and asked them to investigate which indications are actually realized by the local Municipality and how. This work has been completed by a workshop dedicated to the global climate change and to perceive clues showed in our countries. Each step required an active participation of the students in the

teaching-learning process (fieldwork, identification and choice of sources, self managed teamwork, sharing of final products and assessment, a new partnership with new friends), creating - as a consequence - an emotional involvement that has never failed during this experience.

U3-6 Orale D'Addezio, Giuliana

10.1474/Epitome.04.1098.Geoitalia2011

FROM RESEARCHERS TO COMMUNITY: EDUCATIONAL AND OUTREACH ACTIVITIES OF THE L'ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

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Key terms: outreach; research; awareness; information

The Istituto Nazionale di Geofisica e Vulcanologia (INGV) is currently the largest European scientific institution dealing with Earth Sciences research and real-time surveillance, early warning and forecast activities in geophysics and volcanology. The Laboratorio Didattica e Divulgazione Scientifica Group of the INGV organizes every year intense educational and outreach activities with schools of different grades and with general public to convey scientific knowledge and to promote research on science and nature. Since Italy is a place prone to seismic and volcanic activities our activity focalize in particular on causes of earthquakes and volcanic eruptions and how to behave properly during these events. This approach derived from the consciousness that preparedness is the best way to live with and to mitigate natural hazards.

We schematize our outreach activities in three main topics:

- 1) Schools at INGV; more than 40,000 students have visited our Center in Rome, and demands increase each year; the visit consists of a theoretical lesson in a conference hall supported by multimedia tools, and practical experiences based on exhibitions and hands-on experiments focused on earthquakes, plate tectonics and the inner structure of the Earth. A special experience is the visit to the control room of the INGV National Seismic Surveillance where the students can see in real time the seismic activity and how it is important its continuous monitoring 24-hours a day all year round.
- 2) Week of the Scientific Culture and The European Night of Researcher; every year our Institute is opened for special national and international events to the general public, in order to show our laboratories, to talk about new researches on Earth Sciences and to explain the Volcanic and Seismic risk and the related surveillance activities.
- 3) Expositions and Science Festivals; we can bring on the road, in concomitance with the Science Festival in Genoa, Italy, or in cooperation with Museum and Academies, a self-designed portable museum with experiments, models and instalments projected for teaching and learning plate tectonics, seismology, volcanology, seismic and volcanic hazard and geomagnetism.

In this talk we give an overview of these activities, showing also how enthusiastic the audience participation is and how Science Divulgate is necessary to stimulate the interest of the widest possible range of public and to justify the employment of Public Funds for Research and University.

U3-7 Orale Eva, Elena

10.1474/Epitome.04.1099.Geoitalia2011

GEOPHYSICAL INSTRUMENTS AS LEARNING TOOLS: PROS AND CONS

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Key terms: Geophysical instruments; School; Teaching; Educational projects

It is well acknowledged that the best way to learn is to practise. Learning a foreign language needs conversation, improving visual arts benefits from drawing, learning information technology would be impossible without training on a computer and so on. Nevertheless, in Italian schools, physics, biology and earth sciences laboratories are becoming poor and poor, so that for students to experience becomes very difficult if not impossible. This remark not only applies to experiments that are seldom applicable in everyday life, like watching a cell on a microscope, but also to phenomena which we experience several times in a life, like rain or wind or, fortunately not as frequent, earthquake. Apparently, thus, having the chance to watch, manage and use an instrument to measure some of these quantities can turn to be a valuable tool for a better learning.

In the last decade several projects, mainly financed by the European Community, were born with the aim to buy and lend to schools semi-professional instruments. The financial support has been granted to universities and research agencies with the aim to organize a network of interconnected schools sharing and exchanging data and activities. The results of these activities have been included in manuals or books, often after a comprehensive discussion held during meetings among teachers and researchers.

The idea behind these projects is that preparedness is an efficient (and certainly the most recommendable and cheap) way to face emergencies. Education and training are thus two ingredients to help the students, that is the future citizens, to perceive the scientific information formerly confined in the research laboratories, in particular in the domain of the environmental risk.

Within the projects the students were taught how to install, run, manage, fix (in case of minor failures) the instruments (weather and seismic stations, hydrological kits), to collect the recorded data and to organize them in databases. The schools were then proposed activities to be carried out with the dataset resulting from the recordings or let free to design their own experiences. Many activities were also aiming at designing and building home-made instruments or to assemble facilities to show the science behind natural phenomena.

In this presentation we try to make a thorough analysis of the advantages and disadvantages of these projects and especially of the related activities, with a particular attention to the importance of having an instrument available for teaching / learning. As a general comment, the availability of an instrument requires much more than the regular school time and, especially at the beginning of the experience, a much greater effort from researchers and teachers. An organization of duties and responsibilities among the students is needed for a correct management of the instruments and databases. All these aspects of course concur to a growth from students to citizens, from curiosity to responsibility, from spectator to protagonist.

Unfortunately, the initial thrill is substituted quite soon by a lack of interest, coinciding with the second phase of the projects, that is when the researcher let the student teams go ahead on their own. It turns out that the most negative aspect of these projects is the lack of spatial and temporal continuity: in fact projects have a limited duration (in general three years, rarely they are renewed) and often students do not transfer their knowledge and skills to the younger ones.

U3-8 Orale Lanza, Tiziana

10.1474/Epitome.04.1100.Geoitalia2011

AN ECOMUSEUM EXPERIENCE IN THE CASTELLI ROMANI AREA FOR DIDACTIC PURPOSES

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Key terms: Ecomuseum; Environment; Science Theatre; Earth education; Science Communication

Among the different methodologies to educate people to the planet sustainability, the Ecomuseum is one of the most innovative and advanced. It offers the opportunity of using different didactic modules such as drama and museography in order to obtain the full involvement of the people to be educated. In the Ecomuseum, visitors are not just the observers but also interactors and in a wide perspective even the watchmen of the territory where they live. In Italy already exist eighty Ecomuseums, two already established in the Lazio Region. One of those, the one in the Agro-pontino area, is already operating at a large scale and in a European context with great results. Following the same path, the Istituto Nazionale di Geofisica e Vulcanologia in Rome chose an area, the Albani Hills, to implement a pilot-project for the establishment of an Ecomuseum in one of the Lazio Region areas rich of natural landscapes and history. In collaboration with the Ente Parco dei Castelli Romani a program for Lyceum students was implemented during a year (2009-2010). The students of two classrooms of the Mancinelli and Falconi Institute in Velletri (III Classical Lyceum and III Socio-Pedagogical Lyceum), aged 16, chose an itinerary in the volcanic-origin area around the Nemi Lake to be developed in three items: the Roman Ships Museum; The lake itself; and the Diana Nemorensis Temple's ruins. The final goal was interpreting the territory with the help of scenic actions. It was a sort of opened-air theatre where history, legends and their historical figures - mainly Caligula and the Goddess Diana - described the area from the different points of view: geological, historical, naturalistic and even gastronomic. The project evaluation was assigned to a Socio-Pedagogical Lyceum, under the supervision of INGV Didactic Lab. Results are encouraging even if innovative way to gain students enthusiasm should be thought since only a small group of students participated actively to the project. For future experiences it is important to succeed in involving as many teachers as possible to have more hours at disposal to be dedicated also to the dramatization.

U3-9 Orale Stanchi, Silvia

10.1474/Epitome.04.1101.Geoitalia2011

THE EXPERIENCES OF DIVAPRA AND NATRISK IN SOIL EDUCATION AND AWARENESS RAISING: THE DI-VERTISUOLO

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Key terms: scientific communication; soil; laboratory; education; outreach

In the last years, scientific education has become more and more popular, as showed by many initiatives with different target audience, themes, and aims.

In the 18th World Congress of Soil Science (Philadelphia, 2006) the importance of scientific communication was underlined, and it's now evident that the future of soil science is strictly related to communication and education strategies, mainly for the young public. Also the European Union remarked the importance of soil awareness raising for the large public.

The NatRISK (Research Centre on Natural Risks in Mountain and Hill Environments), the DIVAPRA (Department of Reclamation and Valorization of Agro-forestry Resources) of the Faculty of Agriculture of Turin, the LNSA (High Altitude Alpine Soil and Snow Laboratory) ideated many activities focusing on soil awareness raising, and they have been carrying on outreach activities for almost a decade.

The main activity is the DI-VERTISUOLO, a soil lab created for schools, that registered a big success also among the general public.

The DI-VERTISUOLO is a portable lab for soil exploration, observation, and study that doesn't require any specific devices and lab instruments. It was presented in several events and places such as: World Soil Day (Fontainemore, AO, 2005); European Union Researchers' Night; ESOF-European Science Open Forum, Barcelona, 2008; Environment Day, Asti, 2009; expositions hosted by Mosso Scientific Institute - Col d'Olen and Savoia Alpine Hut - Oropa, <http://www.gboropa.it/Divertisuolo.htm>; Campus 2009; many schools.

Thousand people were already involved (students, teachers, trainers, large public).

The main objective is getting people familiar with soil themes and complexity, with an interactive funny approach. Teachers and trainers are involved in the experiments, that can be carried out at home or school with a simplified home-made lab-kit.

Some soil properties are presented and described: the main soil environmental functions; soil physical and chemical properties (color, structure, consistence); the role of water in soils...

All the activities are adapted to the age and background of the target audience.

U3-10 Orale Sibi, Patrizia

10.1474/Epitome.04.1102.Geoitalia2011

THE VISITOR CENTER OF THE VALLE DEL TREJA REGIONAL PARK (RM): A GATEWAY TO THE GENERATIVE NETWORK OF PARK ECOSYSTEM.

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Key terms: River-ecosystem; park management; ecological literacy; interactive room; ecological thought

The future challenge passes through the process of ecological literacy of the human communities. (F. Capra, 2004)

This ambitious, although necessary, goal involves the development of skills equally spread among the human communities: to be able to recognize the systemic nature of every phenomenon, to look for the networks of energy connections which determine the existence of biotic and a-biotic factors, to support the processes which make life on our planet possible.

In front of this cultural need expressed by all mankind, even if at different levels, every type of environmental communication and scientific spreading should become an ecological literacy opportunity. Everyone needs a lot of chances to train himself to the ecological thought, to the connecting thought, to experience the feeling to be part of the whole.

In the context of the communication activities promoted by the Valle del Treja Park organization, the authorities and the officials of the Park, in cooperation with the Environmental Educational Laboratory of the DECOS Department of Tuscia University, planned an interactive room for visitors. In the park visitor center, at the ground floor of the baronial palace in Calcata, everybody will be able to discover the secrets of the park through multimedia workstations. It will be possible to bring to light the mechanisms and the processes characterizing this specific ecosystem, to find out the evolutionary events which produced it, to discover how the park could become in the future in relationship to the behaviours of the community living there and to the park management effects.

The Valle del Treja Park is a little regional park established in 1982 by the Lazio Region. It cover 628 hectares in the municipalities of Mazzano Romano (RM) and Calcata (VT) along the Treja River course.

This is an area of geological and hydrogeological importance: the landscape is characterized by gorges carved by the waters in the soft tufa of the volcanic complex of Sabatini. So, these morphological and lithological features, along with the micro-climate of the groves, determine the particular landscape, vegetation, fauna and the whole ecosystem of the Park.

This natural area is particularly rich in biodiversity and cultural resources, but it is also particularly 'sensitive' to the effects of human activities and of tourist flow.

For these reasons we believe that the park can be a useful laboratory for ecological literacy. In the Valle del Treja Park every visitor, of any age, will be able to experience - by means of appropriate tools - the ecological approach to natural systems and to realize that and how even small actions done by man can change the balance of the park ecosystem.

U3-11 Invitato Lambert, Ian

10.1474/Epitome.04.1103.Geoitalia2011

STRATEGIC ROLES FOR THE GEOSCIENCES IN ADDRESSING MAJOR CHALLENGES OF THE 21ST CENTURY

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Key terms: multidisciplinary systems approaches; addressing challenges; digital age

There are many challenges in meeting the needs of societies while sustaining Earth systems. Difficult decisions have to be made and there is increasing scrutiny of their effectiveness and validity. With increasing levels of education, societies are more capable of questioning what they see as poor decisions and policies.

There are emerging opportunities for applications of the geosciences in multidisciplinary systems approaches to underpin important decisions and policies on issues such as mineral and energy resources, groundwaters, soils, competing land uses, geohazards and emergency management. Ongoing advances in web technologies and in data transfer standards are making geological and geospatial data and information much more accessible online and reusable for purposes beyond those they were originally collected for. In parallel, the rapid increases in available computing power and in open source processing algorithms are enabling geoscientists globally to analyse and model these data. In combination, these new developments are rendering multidisciplinary approaches much more effective and transparent.

Government geosurveys and research agencies need to play pivotal roles in ensuring that the geosciences are accepted as important components in integrated approaches to address issues relating to natural resources, land use and hazards, in particular. Universities also need to play vital roles in instilling the importance of high quality multidisciplinary systems science. This presentation will illustrate, at a high level, how geoscientists in Australia are involved in addressing a number of major challenges faced by the nation. It will link these examples to areas of focus within the scientific program for the 34th International Geological Congress to be held in Brisbane, Australia 5-10 August 2012 (www.34igc.org). While this large and prestigious meeting will cover the whole spectrum of the geosciences, it will feature a wide range of sessions on the influential roles the geosciences can play in the digital age.

U3-12 Orale Di Patti, Carolina

10.1474/Epitome.04.1104.Geoitalia2011

THE GEOLOGICAL RISK PREVENTION THROUGH THE DISSEMINATION IN SCHOOLS

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Key terms: Geological risk; environmental protection; educational activity

In Sicily the 80 % of the region is under seismic, volcanic, hydrogeological and geomorphological risks. All the 390 sicilian municipalities have been defined seismic from D.P.C.M. n.3274 and, among these, 29 are considered within the category 1 of the risk. Hydrogeological risk is the most common in Sicily, as evidenced by the high density of landslides

about 1 every 50 km².

Earthquakes, volcanic eruptions, tsunamis and floods are the expressions of the energy of the planet Earth. The man is unable to live in harmony with the Planet and he is often the reason of the huge disasters and the victim at the same time.

To save the planet Earth the man has to take a responsible behaviour. Local territory knowledge is essential in order to protect themselves from it. For this reason is necessary to develop the attention to the environmental protection with educational activity that guide people to conduct awareness.

The "G.G. Gemellaro" Museum has conducted two experimental courses to explain the geological risk in the region. The first was carried out with the teachers of primary school and the second with the pupils of the primary school. To understand the dynamics of the earth and the geological phenomena, the course was structured in three teaching units: Volcanic risk - The aim was to understand origin, dynamics and evolution of volcanism, with a focus on Italian territory. The methods of forecasting volcanic events and the possible preventive measures feasible have been shown.

Seismic Risk - This teaching unit was aimed at understanding the causes and distribution of earthquakes and the risks associated with them, starting from the structures of the Earth and the "plate tectonics". Preventive measures and forecasts, which could reduce the flow of destructive phenomenon, have been exposed.

Hydrogeological risk - Among the geological risk, this is the most dangerous for his high social-economical impact. This term refers to the risk of the occurrence of extreme weather events that lead to different types of instability and are closely intertwined to landslides and flooding. The course was divided into a theoretical and a practical parts.

The theoretical part was held in the classrooms, the practical part in the territory. To achieve these objectives were carried out lectures with the help of multimedia products, case studies, brainstorming and guided tours.

In the course for teachers were provided the tools of knowledge and expertise for future programming. In the pupils' course many laboratories have been carried out which have led to the creation of a model for the understanding of "plate tectonics" and a scale model of a volcano. A volcanic eruption has been simulated in order to understand the risk associated with the urbanization of volcanic areas heavily populated

U3-13 Orale Campo, Valentina

10.1474/Epitome.04.1105.Geoitalia2011

GEOSCIENCE AWARENESS: THE USE OF THE GEOGRAPHIC INFORMATION BY MEANS OF WEB VIEWERS

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Key terms: geoscience awareness; geology; web viewers

Geoscience organizations especially the national geological survey represents the geoscience community of a country. The Geological Survey of Italy - ISPRA - collects, documents, manages and interprets geological information, which is used by companies, authorities, organizations and others and has among its tasks to disseminate knowledge about geology and its applications: the primary goal is to make our geological information more accessible via web services such as map viewers. To do this the Geological Survey of Italy (SGI) has provided a geoport in which a viewer allows viewing the data collected in the form of maps. It's also possible to consult databases, reports, other publications, etc. The users, students, citizens, and technicians, using the geoport can find the data about geology of our area, soil depths, geophysics, natural hazard assessment, and other fields related to the earth sciences. Our aim is to develop human resources and to create awareness of the role of the earth sciences among the mass population of the country about geosciences and its contribution to our life and society to enhance and protect our quality of life. To plan as safe a society as possible, we need to take account both of the hazards that exist in nature and the ones we ourselves have created and geological information can be used to try to prevent and minimize the effects of different types of hazards, such as landslides and floods.

For publication the data must be documented to describe the methods or techniques used to collect, process, and analyze data, the structure of the output, description of accuracy and precision; standards for metadata. Metadata (information that characterizes and describes data, including how, when, and by whom the data were collected) are one tool used by the SGI to maximize information quality, utility, objectivity, and transparency of third-party data. Metadata plays a key role in describing the specific quality procedures that were followed, as well as documenting methods and techniques used in studies.

Our map viewers gallery is designed to offer easy access to some of the information available in our databases. Many of these applications also provide an overview of what additional information you can order from us. When using our map viewers, which are free of charge, you navigate via digital maps and select the geological information you are interested in. We realize own web map application with different technologies, also open source, to highlight or simplify the content in relation with the type of end-user.

U3-14 Orale Di Stefano, Rinalda

10.1474/Epitome.04.1106.Geoitalia2011

THE LESSON IS SELF-POWERED

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Key terms: geological maps; training events; digital learning; microscope

The adventure that brought us into contact with the children and the schools started as a joke around 2000 when a school district of Rome invited us to keep a lesson on fossils to primary school students. Then we have had the opportunity to open a new world to children, that of microfossils, but at the same time they have opened a new world for us, one of the schools, the wonder and excitement that takes the kids every time resting eyes on a microscope. Their enthusiasm was so contagious that led us to continue having these meetings with them even if we had absolutely no experience in teaching.

Excited and encouraged by the feedback we thought about the possibility of taking this activity a bit more seriously and, as a Geological Survey of

Italy - Department of Soil Protection we deal with the implementation of the Italian geological maps, we thought we could tell them what is our work and how to realize a geological map.

The opportunity has been offered by the participation in some events, both national and international, as the various editions of the "Conference of Environmental Agencies" that were held in several Italian regions; the 1st International Festival of Elements ground/air/water/ fire that took place in Parma; the Educational Project City of Rome; the 4th edition of the Geography Festival in SAY & DO event organized in Florence by the Tuscany Region; some lectures at primary schools "Giovanni XXIII" and "Edmondo De Amicis" in L'Aquila, finishing with the creation and development of a complete teaching plan agreed with professors of the "Renato Fucini" school of Rome.

The participation in training events incentive us to give more and to enrich our lesson with new arguments every time. Indeed, although at the beginning we have been concerned of fossils and paleontology for their ability to arouse curiosity and always stimulate the imagination of children, then we started telling the geological mapping and tried to explain them more engaging and accessible the basic concepts of geology. To make the principles, such as the graphical representation of a three-dimensional world, more appealing is not easy. To play down the concept of geology "lesson", the disclosure of geological mapping and awareness of different issues concerning the Earth sciences, in the 4th "Geography Festival" they have been addressed both through lectures, both with a quiz based on knowledge of geology, geography and geo-renowned scientists and with educational activities even with the aid of optical microscopes.

A very interesting experience was realized in cooperation with Telecom Italy during the Public Administration Forum based on the applications of digital learning, developed with the use of open source software Moodle, in science and in particular to those of Earth sciences.

In this case we have created a cycle of "experimental" lectures" as part of a public school digitization project. The digital platform allows the teachers to create online educational courses also having the ability to coordinate interactions with students.

The interest in children led us in the years to improve our "participation" seeing more and more active in finding different ways of communication depending on their interests and age. For example, we could experience among primary school children using the microscope to observe the associations of the various marine microfossils in the past, because it arouses as well as interest, curiosity and wonder. The high school prefer to be involved in competitive quiz game.

Over the years we have seen that working with children aged between eight and twelve years is very challenging and rewarding for us because we were often surprised with their questions almost never trivial and sometimes very complex.

U3-15 Orale Ghiara, Maria Rosaria

10.1474/Epitome.04.1107.Geoitalia2011

WHO TALK ABOUT SCIENCE?

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Key terms: scientific communication; informal education; professional training

Spreading of sciences still has great limits in our society. Conquering the stage on the occasion of discoveries which generate wait for the resolution of problems that trouble mankind, or, otherwise, on the occasion of dramatic and catastrophic events. Issues are often explained roughly and generally without any consideration of the general context, offering in this way an incomplete view of scientific problems, and what is more depreciable, aimed just to press human sensibility. 25 years are elapsed from the alarm launched by Royal Society with Bodmer report on Public Understanding of Science (1985) which warned against potential deterioration in relations between science and public opinion. Then the most logical solution seemed to be teaching scientists to "speak" to the public in an understandable way, in order that they could gain more and more accurate scientific knowledge. Someone tried to run for cover with the creation of CoPUS (Committee for the Public Understanding of Sciences) which carried out a program of public understanding of science but, back in the '90s was in crisis. A crisis increasingly evident, so much so that in 2000 the third report of the House of Lords entitled "Science and Technology", recognized the failure of the project because, not only the scientific literacy was not increased but the suspicion grew even aversion towards scientific research. Unfortunately, having pressed scientists to learn how to communicate with public has not delivered desired results. Science is not yet considered as a major factor in promoting national welfares. Most people, in fact, continues to feel scientific disciplines as not properly "cultural" and to be deaf to the right assertion that "no public communication of science means a not real democratic society of knowledge" (Greco & Pitrelli, 2009). Earth Sciences divulgation, in this respect, is certainly a particularly eloquent case. Because in most cases it deals with catastrophic natural events inevitably relating this kind of collective misfortune. Moreover not always the catastrophic event is adequately documented and proposed in the natural and complex evolution and geodynamics of the Earth. Earth Sciences need a much greater disclosure. In a nutshell, the communication on the issues concerning the earth sciences should be reserved to professionals who care not only to provide a global vision but also to detect and stress existing connections. It is essential therefore to train and educate rigorously scientific communicators, according to precise and shared criteria, to achieve the goal to establish an appropriate role for scientific cultural mediators (Tran & King, 2007; Tran, 2008; Rodari & Merzagora, 2009). On the other hand what does it mean to know or understand science? Maybe to know a lot of scientific facts? Many theories? Its methods? We understand that it is not possible to transform common people in small chemists, physicists or biologists. Neither one can reduce science to a mere technical knowledge or, on the other hand, to empty entertainment, renouncing its primary educational role (Israel, 2008). But we can, at least, try to get the public more aware of the influence that science exerts on society.

SESSIONE U5

La Geografia e la Geologia Militare: una nuova prospettiva per gli studi storico-militari

U5-1 Orale Laureti, Lamberto

10.1474/Epitome.04.1108.Geoitalia2011

THE MILITARY GEOGRAPHY AND GEOLOGY IN ITALY FROM THE NATIONAL UNITY TO THE SECOND WORLD WAR

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Key terms: military geology; military geography; applied geology

This paper will present a bibliographic review of the more significant works about the application of the geographical knowledges and earth sciences to the military operations. Besides the well known concepts referring to the importance and the role of the Geography (as remarked in the ancient times by the same Strabon, I, 1, 16), it is not useless to remember that the cartographic representations have always been an important tool in the terrain recognition, surveyed mainly in order to help the military operations. So it is possible to assert that the history of cartography follows strictly the development of the military technologies. In Italy, the studies about the application of the geographical knowledges to the war operations begins to develop about the half of the XIX century, on the wake of the ones issued in other european countries, as Prussia, Austria, France, etc. Among the more noteworthy italian works (normally written by high officers) we can draw attention toward some precursory ones (of Annibale da Saluzzo, 1845, Francesco Orsini, 1852) and the italian translation of the treatise of the french T. Lavallée (1852). After the national unity, in the last quarter of the XIX century, we must point out the works of Giovanni Sironi (1873), Giuseppe Perrucchetti (1874-1881, Giovanni Riva-Palazzi (1883-1885) and Carlo Porro (1898). Very numerous are also the contributors by the academic geologists, mainly during the operations of the First World War, as Enrico Fossa Mancini, Federico Sacco and others. Then, during the twenty years before the Second World War, the teaching of Geography and Geology become duty organized by the military academies and schools and based on the monumental set of the monographies of the brigadier general Delfino Deambrosio (1920-1935).

U5-2 Orale Francese, Roberto

10.1474/Epitome.04.1109.Geoitalia2011

THE FORTIFIED VENICE: THE LINE OF FORTIFICATIONS AROUND VENICE AND ITS RELATION WITH THE GEOMORPHOLOGY OF ITS LAGOON AND THE MAINLAND.

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Key terms: Military Geography; Geomorphology; Venice; Fortification

Starting from XVI Century and during the Austrian occupation of Venice, fortifications were built on many of the outlying islands of the lagoon and in the mainland. It is a fortified Venice that few are aware of. Today only a part of the city's huge and complex defensive system had survived. This valuable group of buildings for decades had been designated exclusively for military purposes and was little known. Now that the military authorities have ceded a good many of these forts, it has been possible to convert them into cultural sites and places of tourist interest. They are now part of the new historical naturalist itineraries between the lagoon and its hinterland, winding along a very estensive and most picturesque route. The main fort - of extraordinary architectural, naturalistic and archaeological interest - is Forte Marghera, the oldest and most imposing of those of the entrenchment around Mestre, occupying over 40 hectares. It was the first fortified work built for the defence of Venice against attacks from the land and is placed at the inner border of the lagoon, connected with the center of Mestre through the old "Fossa Gradengia", the present Canal Salso. Many other forts surround the city of Venice, from Forte Manin to Forte Bazzera, where we find the powder magazines, the last remaining ones of the whole system, and dating from the First World War. On the lagoon side, the defensive system used to extended to the Arsenale, the vast complex whose work-shop fitted out the powerful Venetian mercantile war fleets that so facilitated the city's rise to greatness. Between one island and another stands the strategically sited Forte Sant'Andrea at the entrance to the lagoon, the Forte San Felice at Chioggia, the Forte Ca' Roman on the littoral at Pellestrina. Then, typical octagonal forts defends the ports of the lagoon: the "Octagons" of Alberoni, Campana, Poveglia and Caroman. An historical map analyses was performed in order to identify the main defensive constructions. They were described and georeferenced. Each fortification has been linked with the topographical and geomorphological context in which it was built, considering its strategical significance.

U5-3 Orale Caruso, Vincenzo

10.1474/Epitome.04.1110.Geoitalia2011

THE ROYAL ARMY MILITARY ROAD AMONG THE FORTRESSES OF XIX CENTURY IN THE PELORITANI MTS. (NE SICILY, ITALY)

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Key terms: Peloritani Mts.; Calabria-Peloritani Arc; Military Roads; Geo-cultural Heritage; Fortresses and Milvestones

The present study focuses on the geo-historical reconstruction, evaluation and fruition of the Peloritani road network realized by the Military Genius in the late 1800s. These peculiar structures were traced with the intent of linking several spectacular Fortresses erected in the hills along the Sicilian and Calabrian coasts of the Messina Straits, as very important defence

structures against military attacks from the Tyrrhenian and Ionian Seas. The Peloritani Mts. extend from the extreme NE of Sicily to the Taormina-St. Agata di Militello tectonic Line, separated from the Italian Peninsula by the Straits of Messina and delimited to the north and east by the Tyrrhenian and Ionian Seas respectively, and to the south by the Alcantara Valley and Mount Etna.

Their very articulated morphology involves the Ionian and Tyrrhenian coasts and a scenic inland made up of hills and mountains belonging to the Calabria-Peloritani orogen and consisting of Proterozoic to Palaeozoic metamorphics and plutonics and of Mesozoic sedimentary covers, unconformably covered by Lower Miocene to Modern deposits. These relieves are cut by deep valleys, where an intersected fluvial network develops. The ridge, with an average altitude of 1.000 m, extends in a NE-SW direction, from Dinnammare (1.127 m) to Montagna Grande (1.374 m), defining the watershed, and continues with an E-W trend, up to the joint with the Nebrodi Mts.. The geological landscape is characterized by steep reliefs, very deep valleys, acute peaks and a hierarchical hydrography with torrent-like water courses. Marine and alluvial terraces are widespread at different sea levels. The Lagoon Systems of the Peloro Cape, with the Ganzirri and Faro Lakes situated on the Ionian and Tyrrhenian coasts respectively, are also present, located in the extreme NE of Sicily.

Due to their strategic geographical position, emphasized by the Messina Straits as the gate to the Sicily and Mediterranean Basin, the Peloritani mountains were the centre of civilizations and the scene of very important battles.

In spite of several natural and anthropic events which took place during approximately 130 years, elements of the defined military roads which have been preserved are still "legible" and due to which it is possible to reconstruct the history of the Peloritani "Regie trazzere" today with the aim of promoting environmental itineraries in a territory very rich in geological and morphological harmony, and where landscapes immortalize both the thick Mediterranean scrub and wonderful woods.

The defined "Royal Army Military Road" has a specific and characterizing identity. It is significant to note that, with its architectonic and artistic features, such as bridges, retaining walls, tunnels, arcades, milestones, pluvial water convey systems, cisterns, etc., it constitutes a monumental complexity, indicating among other aspects the technical construction and the natural materials used in an important architectonic project carried out by the Italian Military Genius of the late 1800s.

Today this road today represents an important and indispensable heritage for Messina and the surrounding communities and also for tourists, because it links several old picturesque villages and allows people to benefit from the luxurious vegetation and superb landscapes on the Ionian and Tyrrhenian coastlines.

"Knowing the history of a territory, of a site, of an object allows us to understand its very value". This is the spirit responsible for the present research carried out with the aim of reconstructing, documenting and illustrating the geo-cultural characteristics present along this Military Road.

U5-4 Orale Bondesan, Aldino

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THE HISTORICAL PARK OF THE EL ALAMEIN BATTLEFIELD (EGYPT, 1942)

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Key terms: MILITARY GEOLOGY; GEOPARK; DESERT GEOMORPHOLOGY; BATTLE OF EL ALAMEIN; SAHARA

In 1942, between the end of June and the beginning of November, a series of battles and war actions took place in the Egyptian Desert (namely, Western Desert), near the location known as El Alamein. The third, and final, El Alamein battle began at 20.40 on October 23rd when the awaited British offensive started. After 12 days of hard fighting Montgomery's VIII Army broke into Rommel's defenses, and the Axis troops began a long and difficult retreat which finally ended-up in Tunisia, in May 1943. During the El Alamein battle, which lasted until November 4th, and the next few days, about 30,000 Italian and German prisoners were captured, while, as a whole, the Axis had 9,000 men killed or missing and 15,000 wounded. On the British side, Montgomery's VIII Army losses accounted for 13,560 killed, missing, or wounded men. This study concentrates on the project of a historical-geological park at El Alamein which is under construction taking into account the geological-historical analysis of the reciprocal relationships between the terrain and the development of military operations. The area of interest encompasses the sites in the Egyptian sector of El Alamein (Western Desert), where three battles took place in 1942, in particular the southern front where the Folgore and Pavia divisions fought. Former investigations were performed according to a multidisciplinary approach, in tight collaboration with researchers having expertise varying from military history to archaeology, from geophysics to topography, from geopolitics to sociology, etc. A Geographical Information System was implemented in order to document and reconstruct the battlefield by means of remote sensing and geological-geomorphological field survey and mapping. The study was integrated by an historical analysis of the battle and of the North African Campaign. A comprehensive study of the battlefield has allowed analysis of the geological and geomorphological factors that influenced the military operations and the environmental consequences on the actions of war.

U5-5 Orale Avanzini, Marco

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SOLDIER TRACKS IN A FIRST WORLD WAR FORT (VALMORBIAWERK, TRENTO, ITALY)

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Key terms: footprints; First World War; Bergshue; dolomitic fortifications; Austro-Hungarian army

Traces have commonly been defined as evidences of the activity (or work) of organisms. In this perspective, human traces document a range of very

heterogeneous and diverse activities.

A research carried out by the Museo Tridentino Scienze Naturali in some bunker systems along the First World War Front in the Pasubio-Lavarone area (Trento) led the discovery of several soldier footprints and traces (Valmorbia, Luserna, Dosso Sommo, Sommo Alto, Cherle, Celva, Nagia Grom, Mt. Testò). Data coming from track analyses are used as a tool for better reconstructing everyday life activities and this follows in the steps of a modern perspective on human ichnology whereby it is considered an interdisciplinary science that interacts with different academic traditions such as various natural sciences as well as social sciences, archaeology and history.

The best preserved footprints are those preserved in the "Valmorbiawerk" Fort (Forte di Pozzaccio in Italian documents) located on the right hand side of the Vallarsa Valley, approximately 8 km from Rovereto in the Trentino-Alto Adige region (Northern Italy). The fort was meant to be housed entirely in a rocky promontory of the Jurassic Calcarei Grigi Group, within a thick (25-30 m) layer of compact oolitic limestones. The building would perfectly fit the rock morphology and due to its innovative features it can be considered a forerunner of the underground bunkers of World War II.

The battery would be situated in the central part of the fort, a long and narrow concrete body where two 10 cm howitzers contained in 30-cm-thick nickel steel swivel domes and one observatory would be located. Underneath, connected by a 15 m shaft, would lay the heart of the fortified system, which was divided into four main caves separated by 10-m-thick rocky walls. These caves would house the troops (3 officers and about 100 soldiers), engine rooms plus provision and ammunition depots.

According to the original plans, the fortification's caves were meant to be covered by brick walls, to have a raised floor, a metal cover and an advanced electric heating system. All the connecting tunnels and the artillery sites were meant to have an efficient system for collecting dripping water, which would then be carried to reservoirs and tanks by pipes and concrete channels.

When the building work was interrupted, only some of the above features were completed.

One of the caves, which were meant to be a storage room, has along its perimeter a 30 cm wide concrete curb that preserve 28 partial or complete boot tracks.

Basing on their morphology and the hobnail layout, the tracks are interpreted as impressed to the right and left boots of the same person. The layout and the shape of the tracks perfectly match the mountain footwear used by the Austro-Hungarian army ("Bergshue"). Using the average ratio of foot length/height of 15 % proposed by Topinard in the mid-1800s, and according to the most recent known data (foot length/stature ratios between 13.47% and 15.98%), the trackway indicate a trackmaker height ranging between 1.77 to 1.80 m. Basing on shoe wearing, the locomotor pattern displayed by the trail can be considered normal except for a slight lateral functional prevalence of the foot. This latter characteristic suggests a slender (from 70 to 80 kgs) and tall soldier with slightly varus knee as possible producer for the trail. The speed of the trackmaker varies between 1.67 and 1.80 m/s.

The curb ends in concrete stairs that lead to a site armed with mountain cannon. It is possible that the man wearing the boots was a soldier at the firing site or another one, perhaps delivering orders, who would have used the nearly solidified curb while the workers were busy in the central part of the cave.

These tracks represent an unusual record of life inside an Austro-Hungarian fortress of the First World War and they also raise the likelihood of other similar findings in dolomitic fortifications.

U5-6 Orale Visintin, Luca

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WWI AND WWII IMPACT IN THE NORTHERN SECTOR OF THE TRIESTE KARST

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Key terms: *Mount Hermada; geomorphology and war; Trieste Karst*

The Northern sector of the Trieste Karst was a significant area both during the WWI and the WWII, the former because it represented the battlefield of the military operations in the spring of 1917, the latter because the coastline of the Gulf of Trieste hosted a number of military artefacts built to defend the territory after the armistice on the 8th September.

We aim at studying the impact of these artefacts on the landscape after respectively 50 and 100 years from the events through a detailed mapping of the remains.

During the WWI, the area was theatre of the operations of the Royal Italian Army in the 1917. Its advance had to drastically stop after forcing Austrians troops from their protected positions, along the Isonzo River.

The Austrians were capable of pivoting on a lofty mountain system, consisting of various lines of high peaks, each of which was a dominating base connected with its neighbour; so that, taken together, they formed a formidable defensive line. On the Trieste Karst, the Third Army, commanded by the Duca D'Aosta, took the enemy's first line (Coren & Francese, 2009). A number of military fortifications, like trenches and barracks, have been built, mainly on the Mount Hermada, but also along the coast. Even the continuous gunshot blown-up on the Mount Hermada seems to have modified the general topography of the area, lowering the top of the hill up to 16 m.

During the WWII, military fortifications have been built mainly after the 8th September 1943, when the German command provided to defend the Trieste area forecasting a landing of allies in the Northern Adriatic Sea. A number of military observatories, trenches, Bunker, anti-aircraft guns were located along the coast between Sistiana and Duino. The remains are still visible, but usually are covered by vegetations. Moreover, a submarine base was located in the Bay of Sistiana (Furlani et al., 2009) and some military structures connected to the base are preserved.

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U5-7 Orale Bondesan, Aldino

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THE GEOMORPHOLOGICAL MAP OF THE SOUTHERN SECTOR OF THE EL ALAMEIN BATTLEFIELD (EGYPT)

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Key terms: *MILITARY GEOLOGY; GEOLOGICAL MAPPING; EL ALAMEIN BATTLEFIELD; EGYPT*

The desert between El Alamein and the El Qattara Depression hosted a series of battles and war actions that can be considered decisive for the North African Campaign. The four months between the end of June and the beginning of November 1942 mark the turning point of the WW2 and the end of the Axis dream to invade Egypt. The location of the battlefield was selected following the geographic features: this sector of the desert narrows to a passage of only 60 km and it is restricted by the Mediterranean Sea, to the North, and by the inaccessible Qattara Depression to the South.

The recent availability of high resolution satellite imagery of large portions of the Western Desert allowed to study the geological and geomorphological features of the El Alamein battlefield and to create two detailed maps. We analysed, in particular, the Southern sector since it was actually the main location of the El Alamein Project, which aims to study and recover the territory interested by the battles.

The geomorphological analysis was performed using some common tools of the GIS software applied to a DTM obtained by SRTM data, while geological limits were obtained mainly by the comparison of ASTER images following the results of a number of Authors in other desert areas. From a geomorphological point of view, the area is characterized by a limestone plateau at about 200 m a.s.l. (Naqb Rala). To the South, the Qattara Depression reaches -145 m a.s.l. The central part is a flat area, gently dipping to the North and incised by depressions, locally called Deir. The northern part is characterized by the presence of Pleistocene hills, called kurkar, which represent the old Nile delta.

From a geologic point of view, the southern part is the oldest one. The El Moghra Formation and the Marmarica Formation outcrops in the Naqb Rala and in the central part, while the Northern part is characterized by Pliocene and Pleistocene limestones, that are respectively the Hagif Formation and the Alexandria Formation.

The availability of these detailed maps will represent a useful instrument to study the war events connected to the three battles of El Alamein and to define their impact on the landscape (as, for example, the extensive minefields laid during the war).

U5-8 Orale Petti, Fabio Massimo

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UPPER JURASSIC AMMONITES FROM THE FIRST WORLD WAR FORT LUSERN (TRENTINO-ALTO ADIGE): THE LAKOM COLLECTION

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Key terms: *Military geology; First World War; Austro-Hungarian army; Ammonites; Upper Jurassic*

During management activities of the Museo Tridentino di Scienze Naturali (MTSN) palaeontological collections, a systematic review of the ammonite association collected from the Upper Jurassic of Cima Campo (Trentino-Alto Adige) was undertaken. Most of the specimens were collected during the First World War by the Captain of the General Staff of the Austro-Hungarian army Eduard Lakom. The ammonites, stored at the Museo Tridentino di Scienze Naturali, were originally part of a larger collection assembled by Lakom during the building of Fort Lusern between 1908 and 1912.

The Fort Lusern stands on the rise of Cima Campo (1549 m a.s.l.), just above the village of Luserna. The area was considered strategic by the Austro-Hungarian army because it dominates the Altopiano della Vezzena and the eastern sector of the Altipiani di Lavarone. The construction of the fortress, approved in 1905, began on July 15, 1908 and was completed on October 20, 1912, through the incessant work of hundreds of men. The Fort had a volume of 200,000 cubic meters and was composed of a main-building and two outposts: the Viaz (1507 sl.m. m) to the east, and the Oberwiesen (1517 m a.s.l.) to the west. Armament consisted of four tower howitzers positioned in armored revolving domes, four rapid-fire guns and 19 machine-guns M07/12.

The presence of the 'Lakom ammonites' within the palaeontological collection of the MTSN is due to the initiative of the Italian geologist Giovanni Battista Trener (1877-1954). During a geological survey commissioned by the k.k. Geologische Reichsanstalt, from 1900 to 1914 (Tomasi, 2004), Trener repeatedly studied the stratigraphy of the Altipiani di Lavarone and the Cima Campo areas (Trener, 1910, 1913a, 1913b). When Trener became acquainted with the Lakom collection, got in touch with the Austrian captain in order to study his fossil material which turned out to be of great interest both for the large number of samples and for their excellent preservation (some preserve their own shell). The Lakom collection included also brachiopods, bivalves, shark and Lepidotus teeth, and reptile bones (Trener, 1910).

The systematic review of the Cima Campo ammonites, allowed to identify 11 genera and 15 species attributed to middle Oxfordian-lower Kimmeridgian interval. All the ammonites were collected from the upper member of the Rosso Ammonitico Veronese Fm., mainly (57%) from the basal interval of the "upper member", attributed to the lower Kimmeridgian (from the Silenum Zone to the Herbichi Zone). A large number of ammonites belong to different species of the genera *Benacoceras* and *Trenerites* (Silenum Zone) whose type-locality, as reported from literature, is the Cima Campo outcrop (Sarti, 1993). Oxfordian and upper Kimmeridgian ammonites are relatively rare.

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U5-9 Orale Furlani, Stefano

10.1474/Epitome.04.1116.Geoitalia2011

THE SIEGE OF MALTA: GEOGRAPHY AND WAR

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Key terms: Geography and war; Second World War; Malta

During WWII, Malta was a significant military and naval fortress, because it was the only Allied base between Gibraltar and Alexandria. It became a very significant way station for Britain toward Egypt and the Suez Canal. It offered a safe haven for British shipping and it gave an excellent staging platform of offensive thrusts against naval, land, air and shipping targets in the central Mediterranean.

The opening of a new front in North Africa in 1940 increased the military value of the island, since British air and sea forces could attack Axis ships transporting supplies and reinforcements from Italy. In May 1941, Field Marshal Erwin Rommel warned that "Without Malta the Axis will end by losing control of North Africa". The Axis resolved to bomb by attacking its ports and towns, cities and Allied shipping supplying the island. Malta was one of the most intensively bombed areas during the war. The Luftwaffe and the Italian Regia Aeronautica flew a total of 3,000 bombing raids over a period of two years. A combined German-Italian amphibious landing (Operation Herkules) would probably have been successful in the occupancy of the island, but it was never carried out. In the end, Allied convoys were able to supply and reinforce Malta, while the RAF defended its airspace.

In November 1942, when the Axis had lost the Second Battle of El Alamein, attacks on Malta were rapidly reduced.

In this work, we have examined the position of the more than one-hundred anti-aircraft guns and other defensive structures on Malta to analyze their geographical distribution, geological substrate and their location for their significance in defending vulnerable geomorphologic areas such as harbours, bays, inlets and valleys with respect to the protection and the successful defence of the island during the war.

U5-10 Poster Delle Rose, Marco

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WAR STRATEGY, HISTORY WRITING AND KARST ABYSSES FEAR AS REGARDS THE "FOIBE TRAGEDY" DEBATE

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Key terms: mass killing; karst landscape; national monument

Inside the earth sciences community, the wide limestone plateau between Slovenia and Italy, named Kras in Slovenian and Carso in Italian, is known to have given the name to the "karst landscapes". As a consequence, it is also referred as the Classical Karst. Some other areas encompassed between Italy, Slovenia and Croatia belong to this type of territory. Dolinas, caverns, ponds, sinkholes and abysses are the main characteristic features of such landscapes. The aforementioned areas had been the "conflict theaters" of a number of II World War episodes, which the current hegemonic Italian historiography referred, as a whole, to the so called "foibe tragedy".

Usually the term "foiba" (pl. foibe, in Italian) is used to indicate deep natural sinkhole or doline. It may also refer to a chasm of a river at the place where it goes underground. Nevertheless, especially in Italy, "foiba" is commonly associated with the mass killings perpetrated by local and Yugoslav partisans, during and shortly after the II World War, against Italians and other real or perceived enemies of the incoming Tito communists. According to the Italian Minister of the Interior "thousands of soldiers and civilians, many of them still alive, were thrown into [the foibe]. The wave of blind violence and summary executions, which involved partisans (Italian anti-fascist partisan organizations), Germans, fascists and Tito's army, lasted until 1947" (www.interno.it). After the end of the Paris Conference, which resulted in the Peace Treaties signed on 10 February 1947, thousands of Istria, Fiume and Dalmatia residents became victims of a forced migration from their regions of settlement. However, during the Cold War and until the disintegration of Yugoslavia and Soviet Empire, the question of the "foibe tragedy" sinking into oblivion. To start from the '90, the history writing process of the above mentioned facts have been constantly accompanied by a political quarrel. At the same time, the Italian Government, by means of adequate laws, has designed the foibe of Basovizza and Monrupino as national monuments. Finally, to keep memory of foibe and of the post-1947 exiles, in 2005 the Italian Republic set aside a memorial day called "Giorno del Ricordo", a civil celebration held on 10th February every year.

By the point of view of the military history studies, it seems to be necessary to question about the "reasons" which could have determined the mass killing. Ethnic hatred and war revenges appear to be plausible causes, although Yugoslav army would have not had any "war usefulness" by such massacres. Moreover, in term of partisan "guerrilla economy", capture, deportation and killing by means of throw into abysses of many hundred of people could be unreal. Perhaps, just to clear such hurdle, some Italian scholars invoke an "ancient use" of the foibe to human killing by Slavonic populations. However, the approval of such disputable hypothesis could lever, for instance, on the ancestral fear to fall over abysses, and it will become "common sense". As a matter of fact, the "evocations of the 'Slav other' and of the terrors of the foibe made by state institutions, academics, amateur historians, journalists and the memorial landscape of everyday life [are] the backdrop to the post-war renegotiation of Italian national identity" (G. Sluga, 1999, Italian National Memory, National Identity and Fascism). More pertinent for the historiography is the analysis of each singular documented episodes of killing into foibe, especially in relation with the features of site and landscape. The case study here proposed regards an episode of throw into abyss with a presumed survivor, occurred on May 1943 probably at a foiba near Plomin (Croatia). Such abyss is now used as water well for a

thermoelectric power station (Pol Vice, La foiba dei miracoli, 2008). Several questions can be raised as regards the truthfulness of the episode and its possible contribution to historiographical process.

U5-11 Poster Francese, Roberto

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A GEOPHYSICAL RESEARCH FOR WW2 BURIAL SITES IN THE TOLMINO AREA (SLOVENIA)

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Key terms: MILITARY GEOLOGY; geophysical surveys; WW2

The Tolmino area was formerly in Italy and belongs now to Slovenia. It was one of the main battlefield during WW1 and today many are the remnants still preserved as fortifications, galleries and cemeteries. During WW2, after the end of the war, 79 Italian soldier were killed and buried in mass graves. The historical reconstruction through the attestation of survivals indicated some possible sites of burial. A geophysical investigation was performed to detect mass graves along the Tolminka River, in fluvial sediments, and at the foot of the karstic hills close to the town of Tolmino. Here, some of the ancient war galleries, hosting also guns, were probably used as site of burial.

The present work shows the result of the GPR and ERT prospection in different areas.

SESSIONE GEO1

Paleontologia e paleoecologia

GEO1-1 Orale Balini, Marco

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LATE CARNIAN-EARLY NORIAN AMMONOIDS FROM THE BERLIN-ICHTHYOSAUR STATE PARK AND WEST UNION CANYON (SHOSHONE RANGE, CENTRAL NEVADA, USA)

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Key terms: Carnian; Norian; Ammonoites; Biostratigraphy; Paleobiogeography

The Berlin-Ichthyosaur State Park (BISP) in central Nevada is a protected area known worldwide for its unusual record of the large-size ichthyosaur *Shonisaurus popularis*, consisting of 37 specimens collected from the Luning Formation by C. Camp, during excavation between the mid 1950's and 1960's. This site, however, is also of great interest for invertebrate paleontologists, because exposures of the Luning Formation in West Union Canyon, both inside the BISP and on adjacent U.S. Forest Service land, also yield very rich and very well preserved Upper Carnian and Lower Norian ammonoid faunas. These faunas, described by Silberling (1959), were crucial for the development of the North American Triassic standard scale (Silberling & Tozer, 1968), which up to now is still the most complete scale for the Triassic System. The latest two ammonoid zones of the Carnian stage of the North American standard scale, namely the *Klamathites schucherti* and *K. macrolobatus* chronozones, were defined at this site. Moreover, the sedimentary succession exposed at this site also provides a rich record of the earliest Norian *Stikinoceras kerri* chronozone, whose type locality is Brown Hill, on the Peace River in British Columbia (Canada). Despite its importance, no further investigations have been carried out at this site during in the last 50 years, but the relatively recent efforts to select a GSSP for the Norian Stage have necessitated the re-examination of this succession, since it is known to be one of the best Carnian/Norian boundary sections in the world.

Field work has been planned on the basis of a two year program. Detailed notes and measurements by N.J. Silberling have provided the groundwork for the first field survey, which included preliminary bed-by-bed sampling of the outcrops and identifying potential sites for trenching during the second year.

The initial field survey, carried out in October 2010 on both sides of West Union Canyon, concentrated on the upper part of the "shaly limestone member" of the Luning Formation and on the overlying "calcareous shale member".

The southern side of the canyon, within the BISP, provides the best record of the *K. macrolobatus* chronozone, which is represented by several beds yielding ammonoids of the *Tropites* group, namely *T. crassicastratus*, *T. nevadanus* and *Anatropites* div. sp. Higher in the section, the ammonoid fauna shows a sudden change and is dominated by *Tropites* species. The first occurrence of Norian ammonoids like *Guembelites jandianus* and *Stikinoceras* is recorded some tens of meters above, but exposures are generally poor.

The best exposure of the *S. kerri* chronozone is on the northern side of the West Union Canyon on Toiyabe National Forest land, but the *K. macrolobatus* chronozone is not exposed on this side. Ammonoids, dominated by *Guembelites* and *Stikinoceras* div. sp., have been collected from several fossil-bearing levels.

The collected ammonoids fit perfectly well with the faunas described by Silberling in 1959, but they differ somewhat from coeval faunas of the Tethys and Canada. The genus *Gonionotites*, very common in the Tethys and British Columbia, is for the moment unknown in Nevada. More in general, the Upper Carnian faunas are dominated by *Tropitidae*, while *Juvavitidae* are lacking.

Acknowledgments

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GEO1-2 Orale Levera, Marco

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HALOBIA SPECIES (BIVALVES) AS TOOLS OF CORRELATION BETWEEN LATE TRIASSIC (CARNIAN-NORIAN) SUCCESSIONS IN TETHYS AND PANTHALASSA

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Key terms: *Halobia*; Upper Triassic; Carnian/Norian boundary; world-wide correlations

Within the Triassic, four GSSPs remain to be established. Among these, the Carnian/Norian boundary interval has seen significant research activity over the last years, especially on the two GSSP candidate sections: the west-Tethyan Pizzo Mondello (Sicily, Italy) and the east Panthalassan Black Bear Ridge (B.C., Canada). Amongst the various possible markers, ammonoids, conodonts and halobiids seem to offer the best correlatability between the two sections, as well as with other section world-wide. Ammonoids are often considered as the primary tools for palaeo-bio-chronological studies and worldwide correlations, but they not always occur. In fact, both the Pizzo Mondello and Black Bear Ridge sections have a rich conodont record and a rich halobiid record, but are somewhat lacking in ammonoids.

The biochronologic significance and correlation potential of the Triassic flat

clams of the genus *Halobia* has been demonstrated at regional and global scales. In fact, many species are widely distributed and exhibit high speciation rates, with a resolution comparable with that of ammonoids in terms of duration of the biozones.

Sufficient data on key halobiid species have been collected through the comparison of the halobiid fossil record from the two GSSP candidate sections, as well as others from Tethys and Panthalassa. These allow precise correlation of more than one species within the C/N boundary interval between the west-Tethyan and eastern Panthalassic realms. At Pizzo Mondello, ten halobiid forms occur (from base to top): *Halobia carnica*, *H. lenticularis*, *H. simplex*, *H. superba*, *H. cf. rugosa*, *H. radiata*, *H. austriaca*, *H. styriaca*, *H. beyrichi* and *H. mediterranea*. Most, if not all, of these taxa and their succession are repeatable throughout much of the western Tethys, especially in Austria, Lucania, Greece and Montenegro. The halobiid sequence at Black Bear Ridge includes, from base to top, six species: *Halobia septentrionalis*, *H. ornaticissima*, *H. radiata*, *H. selwynii*, *H. austriaca*, and *H. cordillerana*. Likewise, most of these taxa provide strong correlations across eastern Panthalassa and especially throughout far-eastern Russia.

Within the C/N boundary interval, several species occurring at both sites offer good potential for global correlation and may provide potential markers for the Norian GSSP. The first is *H. radiata*, which spans from the latest Carnian (Tuvalian 3) to the basalmost Norian (first zone of the Lacián 1). *H. radiata* is indeed one of the most cosmopolitan halobiids from this time interval and has often been considered as a good marker for the upper part of the *Anatropites spinosus* Zone in the Tethys and the *Klamathites macrolobatus* Zone in North. At Pizzo Mondello, the first occurrences of *H. austriaca*, *H. styriaca*, and *H. beyrichi* closely follow one another. *H. styriaca* is common in the western Tethys (where it occurs in a well defined lithological interval that can be traced at least from Austria to Italy, Greece and Turkey), eastern Tethys and western Panthalassa, but it has yet to be reported in western North America. *H. beyrichi*, in its turn, is a relatively common species in the Tethys, while it is only known from a few occurrences in the terranes of North America and British Columbia, and it is not known to occur in craton-bound strata such as at Black Bear Ridge. On the other hand, *Halobia austriaca*, much like *H. radiata*, is a more wide-spread taxon, occurring in the tropical western and eastern Tethys, throughout Indonesia and the western Panthalassa, the Boreal of northeastern Russia and throughout the North American Cordillera. The succession of *H. radiata* and *H. austriaca* represents an interval which can be recognized at a global scale. Moreover, the first appearance datum of *H. austriaca* seems to be the best proxy of the base of the Norian Stage in world-wide correlations.

GEO1-3 Orale Tripodo, Angelo

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TAXONOMIC REVISION OF THE PINACOCERATIDAE (AMMONOIDEA, UPPER TRIASSIC) FROM SICILY

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Key terms: Upper Triassic; Sicily; Ammonoidea; Pinacoceratidae; taxonomic revision

The Triassic ammonoids studied by G.G. Gemmellaro are one of the most important collections housed in the homonymous museum of Palermo University. The collection was assembled by Gemmellaro or by his co-workers between the end of 1800 and the first years of 1900 and consists of 780 specimens. All the ammonoids have been described in the monograph "I cefalopodi del Trias Superiore della regione occidentale della Sicilia" (Gemmellaro, 1904) which provides the final report on the taxonomic and stratigraphic studies performed by Gemmellaro on the Triassic cephalopods. Gemmellaro described 49 genera, including 4 new for the science, further divided in 230 taxa, including 166 new species. The knowledge of the Triassic ammonoids has been notably improved since the beginning of the XX century, especially in the last 40 years, with several contributions on Tethyan and north American faunas.

Unfortunately the rather rich literature does not take into account the faunas from Sicily, whose knowledge is still based on the Gemmellaro monograph.

Three years ago we started a taxonomic revision of the Gemmellaro collection in the framework of a PhD thesis (Tripodo, 2011). Here we present the redescription and revision of the specimens belonging to the family Pinacoceratidae and their comparison with the Pinacoceratidae from northern Alps.

The genus *Pinacoceras*, type species *Pinacoceras metternichi* (Hauer, 1846), was established by Mojsisovics, 1873 on specimens from Hallstatt Limestone divided in 6 groups and 34 species. For some tens of years the genus *Pinacoceras* grew up as a "basket" including a wide variety of species sometimes rather different with respect to the type species. From the beginning of 1900 the genus *Pinacoceras* has been splitted by the separation of the most diverse species as new genera like *Eupinacoceras*, *Parapinacoceras* and *Placites*. No one of these revisions took the specimens from Sicily into consideration, then the Gemmellaro specimens are still referred to *Pinacoceras*.

Gemmellaro described 4 species but actually only 3 are stored in the Museum: *P. zitteli* Gemmellaro, 1904, *P. suessi* Gemmellaro, 1904, *P. haueri* Gemmellaro, 1904.

The Sicilian species show some differences with respect to *Pinacoceras* s.s. (type species *P. metternichi*) and the other genera of the family. In particular the Gemmellaro specimens differ from *P. metternichi* for the coiling, namely the Uw/D ratio, and the more simple suture line. The difference in the suture is of very great significance as the complex suture is one of the most typical features of *Pinacoceras*, that is well known to represent the highest complexity developed by Triassic ammonoids. Similar features have been found in *P. rex*, from the Carnian of northern Alps and suggest the separation of this species, together with *P. zitteli* and *P. haueri*, as a new genus. The new genus will be dedicated to the memory of Enzo Burgio (1946 - 2001), curator of the Geological Museum "G.G. Gemmellaro" of the Palermo University from 1995 to 2001.

The chronostratigraphic position and evolutionary relationships of the new genus with the classic lineages of *Pinacoceras* documented in the Hallstatt Limestone of the northern Alps are discussed. On the basis of the available data the new genus seems to be restricted to the Upper Carnian.

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GEO1-4 Orale Cusumano, Antonio

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NEW DATA ON THE BATHONIAN-KIMMERIDGIAN SECTION OF STRETTA ARANCIO AND THE HISTORICAL AMMONITES COLLECTIONS FROM THE TARDARA MOUNTAIN (SAMBUCA DI SICILIA, SOUTHERN SICILY).

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Key terms: *Jurassic; Ammonites; Sicily*

New data of Middle-Upper Jurassic sequence from the Tardara Mountain, near Sambuca di Sicilia (Agrigento Province) have been described in this paper. The deposits, constituting the succession of this area, are part of the Monte Magaggiaro-Pizzo Telegrafo Unit that belongs to a large tectonic unit located in the outer part of the Apennine-Magrebide chain. During the Mesozoic Era, this Unit was part of the Saccense Domain, an area palaeogeographically located along the southern margin of Tethys.

The Jurassic sequence of Stretta Arancio outcrops on the flank's top of the deep and narrow canyon formed by the Carboj River. The studied succession consists of about 7 m of pelagic limestones from Middle to Upper Jurassic, covered by Upper Cretaceous *Globotruncana* limestones of "Scaglia" type. The oldest deposits cropping out, paraconformably on the dolomitic limestone of Inici Fm. (Lower Jurassic), consist of 5,5 m of gray-pink *Bositra* packstone-wackestone referable to Bathonian-Callovian. These layers include specimens of *Homeoplanulites* Buckman and *Phylloceras kunthi* Neumayr. The Middle-Upper Jurassic boundary is marked by an hardground surface. Above this surface, 40 cm of gray packstone with Protoglobigerinids containing only rare *Sowerbicerias* and referable to Upper Jurassic (Oxfordian). The sequence follows up with about 50 cm of gray packstone including *Pictonia* cfr. *perornatula* Schneid wich support a Kimmeridgian age for these strata. The succession is overlain by 40 cm of milky-white micritic limestone with calponellids, Upper Tithonian-Lower Cretaceous in age. The sequence ends with whitish calcilutites with planktonic foraminifera of "Scaglia" type.

The revision of two historical collections, come from the Tardara Mountain and housed in the "Gaetano Giorgio Gemmellaro" Museum of the University of Palermo, have been useful for the present study.

The former and older of the two collections was studied by Mariano Gemmellaro (1919) and it is composed of 27 specimens, attributed to 5 genera. All the taxa studied by M. Gemmellaro were referred to the *Macrocephalites macrocephalus* Zone (early Callovian stage). The second collection, studied by Francesco Bruno (1954), consists of 46 specimens, attributed to 13 genera. In this work numerous taxa have been described. The species identified by Bruno were referred to a chronostratigraphic range spanning from Callovian to Tithonian.

After the revision, some of the original determinations were confirmed, many others, instead, have been taxonomically revised and attributed to different genera and species. The analysis of the collections studied has shown, for the M. Gemmellaro Collection, a prevalence of species and genera stratigraphically attributable to the Middle Jurassic (Bajocian-Callovian) while, in the Bruno Collection, genera and species are more related to the Upper Jurassic (Oxfordian)-Lower Cretaceous (Valanginian).

Biostratigraphic study of Tardara Mountain has allowed to recognize the chronostratigraphic age from Middle to Upper Jurassic and to assign the fossil assemblages to the Mediterranean Province.

The taxonomic study of collecting ammonites and the systematic review of the historical collections has led to identify the presence of some species reported for the first time in Sicily or in the Tardara area and to extend their original stratigraphic range. Furthermore, this study has allowed to increase knowledge on faunal associations of the area related to the pelagic carbonate platform system of Saccense Domain for the Middle Jurassic-Lower Cretaceous stratigraphic range.

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GEO1-5 Orale Manni, Riccardo

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SACCOCOMA: A BENTHIC OR PELAGIC CRINOID?

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Key terms: *Saccocoma; crinoids; Jurassic; benthic; pelagic*

The crinoids of the genus *Saccocoma* Agassiz, 1836 are characterized by certain characters that distinguish it from many others. In fact there is not stem, the cup consists of very thin radial plates, the ventral cavity is very wide, the proximal brachials have well developed lateral expansions, the distal brachials have long ventral processes.

All these characters have been studied by the scientific community and researchers have hypothesized different life styles.

Jaekel (1892) suggests that the lateral expansions of the proximal brachials are in reality used to swim (schwimmplatten). In practice Jaekel believes that *Saccocoma* used the arms as the birds use the wings and so doing *Saccocoma* was able to "swim".

Milson (1994) based on geological data, considers *Saccocoma* a benthic crinoid.

Manni, Nicosia & Tagliacozzo (1997), after taphonomic and functional morphology analyses, consider *Saccocoma* a benthic crinoid partially sunken inner the sediment of the sea bottom.

Hess (1999) proposes, based on direct observations of articulated specimens found at Solnhofen, the assumption of Jaekel.

Seilacher & Hauff (2004) propose a "snap-swimming model" based on anatomical and taphonomic observations. In practice according to these authors *Saccocoma* curled the distal parts of the arms and then unwind rapidly, so doing the crinoid would be able to "swim".

Brodacki (2006), based on anatomical studies, considers the classic model proposed by Jaekel as to be the most likely, but slightly modifying the angle of arm movement.

In summary, there are two proposed models, one purely pelagic and benthic another.

The pelagic model requires the movement of arms or as a kind of bird's wings (theory of Jaekel and of Hess), or the movement of the arms snap (theory of Seilacher & Hauff). Both assumptions, however, after the motion include a phase in which the crinoid "sail" in order to filter the water in peace. This soaring and parachute effect would have been favored by the expansion of its proximal brachials.

The benthic model (theory of Milson and of Manni, Nicosia & Tagliacozzo) simply requires that the crinoid remains sunken into the sediment to filter out. In this case the expansions were perhaps the function of protection from external agents (sediment, predators, etc.).

The pelagic model, however, is not without its critics and problems, such as on the other hand the same Brodacki (2006) recognizes. In fact, the expansions are too close to the cup and too stiff to move efficiently crinoid. In addition, the parachute effect is disturbed by the horizontality of the proximal brachials, especially the second primibrachial, which is the brachial type which has developed the lateral expansions exceedingly. All these assumptions on the life are based on *Saccocoma tenella*, that, because it is found articulated into the Solnhofen limestone, has been well studied. However, if we consider other *Saccocoma* species, we realize that there are several problems that undermine the pelagic model. For example *Saccocoma vernioryi* has thorns on the radials and a second set of expansions, transverse to the first, on proximal brachials. *Saccocoma longipinna* shows flat and very long expansions on proximal brachials. These additional expansions or disproportionately development could reduce the parachute effect because the crinoid is more weighty, although this may not necessarily be a handicap.

It is evident that the lifestyle of *Saccocoma* is far from been identified and that further studies are necessary.

GEO1-6 Orale Khaksar, Keyvan

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STUDIO PALEONTOLOGICO DEI BIVALVI E ECHINODERMI DELLA FORMAZIONE QOM IN TAKHTE CHAKAB (IRAN CENTRALE)

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Key terms: *Formazione Qom; Iran Centrale; Paleontologia; bivalvi; echinodermi*

La formazione marina dell'Oligo - Miocene di Qom è risultato dell'ultima trasgressione marina in Iran centrale e si divide in 5 membri differenti (A-E). Questa formazione, al meno nella parte centrale del bacino (intorno della città di Qom) è costruito per due cicli sedimentari (membro A-C2-D) che sono risultati, fondamentalmente di successivi movimenti verticali prodotti nel bacino sedimentario.

Dentro dei macrofossili più significativi della Formazione in Takhte Chakab (SW della città di Qom in Iran Centrale) si può incontrare numerosi generi d'echinodermi e bivalvi che hanno una grande importanza paleontologica. Inoltre i generi più frequenti di echinodermi e bivalvi riconosciuti (*Scutella*, *Clypeaster*, *Echinolampas*, *Spatangus*, *Kuphus*, *Ostrea* e ...) indicano il rapporto contemporaneo con il Mare Mediterraneo e Qceano Indiano.

In questo lavoro si fa un studio sistematico dei fossili ritrovati (presentazione di 15 spec di bivalvi e echinodermi) e in base del contenuto paleontologico e sedimentologico della Formazione si dimostra che questa Formazione è stato depositat in una clima tropicale a subtropicale.

GEO1-7 Orale Matteucci, Ruggero

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THE MIOCENE SPONGOLITIC OUTCROP OF ROCCA DI CAVE (PRENESTINI MOUNTAINS)

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Key terms: *Miocene; Siliceous Sponges; Paleoenvironment*

A thick Miocene depositional complex characterized by its high content in spicules of siliceous sponges (Guadagnolo Fm.) crops out widely along the margin of the shallow-water or emerged carbonate platform of the central Apennines. Skeletal bodies or fragments are also present, but not frequently. Panseri (1950) recognized for the first time the spiculitic content in the small outcrop of Rocca di Cave (Preneestini Mountains).

The Rocca di Cave site has been recently revisited and skeletal fragments were found. In spite of the poor preservation, skeletal remains have been recognized as pertaining to the Hexactinellids.

Aphrocallistes (Order Hexactinosida, Family Aphrocallistidae) is the most frequent genus, as in other Miocene deposits of the Apennines. Dictyonal eurentoid or/and farreoid skeletal framework and lynchiscid nodes (Order Lynchiscosida) are also frequent. No skeletal fragment referable to *Laocoetis* (Order Hexactinosida, Family Craticularidae), a frequent component in other Miocene successions of the Apennines, has been found. Spicules are very abundant, forming in some levels a dense framework within the rock. Their state of conservation is often poor, because of dissolution and fragmentation. Monaxons, triaxenes, desmas and polyaxons are the most frequent types; in addition, ornamented (annulate, tuberculate) spicules are present.

Aphrocallistes, and eurentoid and farreoid (mostly *Farrea*) groups are well represented today; *Aphrocallistes* and *Farrea* live today in all oceans, with an extremely wide bathymetric range. Representatives of these two genera, along with *Heterochone* (a genus of the Family Aphrocallistidae) constitute the main framework of the hexactinellid build-ups recently recognized along the Pacific Ocean coast of Canada, at depths between 200-300 metres.

The siliceous sponge assemblage of Rocca di Cave suggests some similarities with modern depositional environment which today favours the exceptional development of the *Aphrocallistes-Farrea-Heterochone*

community.

GEO1-8 Orale Tinelli, Chiara

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APPLICATION OF GROUND PENETRATING RADAR TO LOCATE SIRENIAN REMAINS FROM EARLY PLIOCENE OF ARCILLE (GROSSETO, ITALY)

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Key terms: *Mammalia; Pliocene; Sirenia; Ground Penetrating Radar*

We report the preliminary description of recent discoveries of Pliocene marine fauna from Arcille (Grosseto, Italy) and application of Ground Penetrating Radar to locate fossil vertebrate.

During the past years four partially articulated sirenian skeletons were found in shallow siliciclastic deposits exposed in the Arcille area. All these fossil remains can be referred to *Metaxytherium subapenninum*, an extinct species of haliteriine dugongid (Mammalia, Sirenia) spread along the northwestern coasts of Mediterranean Basin and became extinct in the upper part of the Pliocene because of the progressive climatic cooling occurred after 3.1 Ma (Sorbi et al., 2008).

Planktonic foraminiferal assemblages are consistent with an attribution of the sirenian specimens to the lower part of the Zanclean, in particular to the MP12 zone of Cita (1975) dated between 5.08 and 4.52 Ma (age after Lourens et al., 2004).

Three specimens were collected in a sand quarry and one of this is almost complete.

The fourth specimen, discovered in a sunflower field near the quarry, was collected as a consequence of a preliminary georadar prospection. This technique is a non destructive method based on propagation and reflection of electromagnetic (EM) waves and it is sensitive to variations of the EM parameters in the subsol, especially the dielectric constant and electric conductivity (Davis and Annan, 1989).

The GPR survey was performed using the Radar System device of IDS Company, equipped with a monostatic antenna of 200 MHz. Two adjacent areas have been mapped. Time slices at various depths indicated the presence of several reflective zones: one of this was located at the centre of the first area at 0.20 m from surface. The other zones were smaller and not persistent and rapidly changing in shape with depth. In the second area, two small zones were recorded.

We decided to verify the nature of this GPR signals through an excavation. In correspondence with the central reflective zone of the first area, some fossil bones emerged: in particular, the skull with tusks, the mandibles with teeth, some cervical and dorsal vertebrae and a considerable number of ribs. Other bones (humerus, radius and scapula) were found in correspondence with smaller reflective zones of the same area. In the second area, we discovered several caudal vertebrae in correspondence of one of the two reflective zones.

The results obtained from this study are very interesting, although further experimentations are required for a better refinement of this surveying method for paleontological research.

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GEO1-9 Orale Vertino, Agostina

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PLEISTOCENE COLD-WATER CORAL FACIES IN A TECTONICALLY ACTIVE SETTING: AN EXAMPLE FROM THE MARGINS OF THE MESSINA STRAITS (SOUTHERN ITALY)

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Key terms: *Cold-Water Corals; Pleistocene; Messina Straits; Facies; Bathyal*

Cold-water coral (CWC) ecosystems are widespread in modern oceans and have been the focus of intensive geo-biological and oceanographic research in the last decades. However, the internal structure of CWC mounds/banks and the driving forces behind their start-up, growth and demise are still little known.

The Pleistocene deposits cropping out along the margins of the Messina Straits represent a unique opportunity to investigate, in a tectonically active setting, carbonate facies related to CWC ecosystems and their modifications through time. The results presented herein pertain to four stratigraphic sections cropping out in the Scoppo - S. Corrado locality (Messina). Field observations combined with detailed litho-biofacies analyses show that clinostriated coral rudstones, interfingering with marls and sandy marls, are truncated by overlying matrix-supported polymict breccias. The Early Pleistocene (MNN19 b and 19 c biozones) coral rudstones (CR) overlie Messinian brecciate evaporitic limestones and are mostly made up of centimetre- to decimetre-sized fragments of the frame-building scleractinian corals *Lophelia pertusa*, *Madrepora oculata*, *Desmophyllum dianthus* and dendrophyllids (*Enallopsammia scillae* and *Dendrophyllia* spp.). These deposits contain also rather common isolated coripectid plates (*Scillaelepas carinata*, *Pachylasma giganteum*), brachiopods (e.g., *Gryphus vitreus*, *Terebratulina retusa*), molluscs (e.g., *Putzeysia wiseri*, *Spondylus gussonii*), echinoderms (mostly *Cidaris cidaris*) and, subordinately, bryozoans (e.g. *Tessaradoma boreale*, *Cabereia ligata*, *Palmicellaria elegans*, *Idmidronea* sp.), ostracods (*Pseudocythere caudata*, *Paradoxostoma simile* and *Sclerochilus contortus*) and serpulids

(*Metavermlia multicristata*, *Semivermlia pomatostegoides* and *Neovermlia falcigera*). The coeval marls, depleted in scleractinian fragments and enriched in coripectid plates, locally include layers with abundant octocorals, brachiopods and echinoids. Both coral rudstones and marls show typical species of bathyal or deep circalittoral-to-bathyal environments. The matrix-supported breccias which overlie and truncate the CR-marl deposits are characterized by abundant bioclasts (mostly *Lophelia*, *Madrepora* and *Enallopsammia* fragments) and polymict lithoclasts which include the CR-marl themselves.

Due to their geometry, sedimentary structures, composition and texture the Scoppo-S. Corrado CR can be interpreted as the fossil counterparts of modern CWC rubble ("on reef" facies), presumably accumulated along the slopes of topographic and/or structural highs. The interfingering coripectid/octocoral/brachiopod marls and sandy marls can instead be compared to modern CWC "off-reef" facies, lateral to coral rubble, which are typically characterized by mud- and/or sand-dominated deposits. The polymict breccias, herein interpreted as debris flow deposits, together with evidence of synsedimentary faulting during coral rudstone deposition imply a highly unstable depositional environment.

GEO1-10 Orale Pezzetti, Claudia

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A NEW LATE TORINGIAN (LATE PLEISTOCENE) FAUNAL ASSEMBLAGE FROM MOLETO (OTTIGLIO MONFERRATO, AL).

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Key terms: *Small mammals; NW Italy; Late Toringian; Biochronology; Palaeoenvironment*

Late Pleistocene vertebrate fossil assemblages have recently been reported in the neighborhoods of Moletto (Ottiglio Monferrato, AL). This discovery is of particular interest as Late Pleistocene vertebrate assemblages are very rare in Piedmont, and so far limited to Moncucco Torinese (Alessio et al., 1992) and Roaschia (Zunino, 2002).

The fossils discovered in Moletto, relatively abundant and well-preserved, were extracted from three karst fissures (M0, M1, M2) carved in the Burdigalian-Langhian limestones known as "Pietra da Cantoni". The assemblages include mollusks, small and large mammals.

On a biochronological basis whole Moletto assemblages may be attributed to the late Toringian (Late Pleistocene). The lower limit of 135 ky is the same for the three assemblages (presence of *Arvicola amphibius* vel *scherman*), whereas the upper limit is 35 ky for M0 and M2 (due to the presence of *Stephanorhinus* sp.) and 11 ky for M1 (due to the absence of Holocene taxa as *Micromys*, *Mus*, *Rattus*).

The palaeoenvironmental framework provided by the study of small mammals, which indicates a forested environment and a relatively cool climate, may further restrict the chronological range of the Moletto assemblages to MIS 5b, 5d, 4, or to the last part of MIS 3.

GEO1-11 Poster Ronchi, Ausonio

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THE GIANT CASEID FROM THE PERMIAN CALA DEL VINO FORMATION (ALGERO, NW SARDINIA): THE STATE OF THE ART

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Key terms: *Pelycosauria; Caseidae; Permian; stratigraphy; taphonomy*

Some bones of a post-cranial skeleton of a huge caseid (Synapsida, stem-Eupelycosauria) were found in 2008 in the Permian Cala del Vino Formation (Alghero, NW Sardinia) during a field-camp organized by the Pavia University. The find, that represents to date the sole Pelycosaur remains from Italy, is very important also taking into account the extreme rarity of Paleozoic vertebrates (Reisz and Laurin, 2001). The information of the discovery was immediately released (Ronchi et al., 2008a, b) and an upgraded report on the state of the research has been communicated at 20ème Journée Thématique de l'Association des Géologues du Permien et du Trias (Sacchi et al., 2009).

The finding represents a significant biochronological constraint to better define the age of the Cala del Vino Formation in the studied area, where, according to M. Durand (pers. comm.) is the lower portion of the formation that crops out, paraconformably covered by the Early Triassic Conglomerato del Porticciolo. Up to now, The Cala del Vino Fm. had not a precise chronostratigraphic attribution and, also recently, it was dubitatively ascribed to Early Triassic times (e.g. Sciuinich, 2001) or to "undefined Late Permian (Tatarian) times" by Cassinis et al. (2003). The presence of a large caseid allows for the time being to lower the fossil bearing level to a stage not younger than lowermost Wordian.

Careful taphonomic analysis was performed on the well-preserved caseid remain. The extraordinary preservation of osteological material, found both still embedded or loose on the outcrop surface, allowed us to infer a parsimonious multiphase biostratigraphic process able to explain a complex set of observed phenomena. These include the discovery of bone embedded at different depth, some isolated and others in articulation, and the presence of still articulated proximal portions of fragile aeal arches along with bones broken before being buried (i. e. vertebrae, ulna, ribs etc.). The finding of foot distal portions is also peculiar taking into account that these bones are usually among the first that are displaced from the body during the decay processes. The identical kind of preservation, the non-repetitive nature of skeletal element and the non-random distribution of body parts allowed referring all the analyzed osteological material to the same individual. The certification of the unitary nature of the discovery allows us to proceed with the classification of the Sardinian caseid. The phylogenetic analysis is currently in an advanced state with the identification of several caseids synapomorphies and some autapomorphies features that suggest the attribution of the Sardinian specimen to a new genus and species.

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GEO1-12 Poster Cusumano, Antonio

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NEW DATA ON MIDDLE AND UPPER JURASSIC AMMONITE SUCCESIONS FROM THE SCIACCA AREA IN SOUTHERN SICILY.

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Key terms: Jurassic; Ammonites; Stratigraphy; Sicily

Contributions on the Middle-Upper Jurassic (Bathonian-Kimmeridgian) pelagic successions of Sicily have been numerous during the recent years. Most of the studies are focused on several historical sections known since Gemmellaro (1882) with the main purpose of setting a better definition of sedimentological features, ammonite associations and their taphonomic analyses, the presence and extension of discontinuity surfaces and their meaning in terms of sedimentary dynamics.

These studies have been developed on some key sections of the "Trapanese platform" in Western Sicily, and have provided a basic framework on the paleogeographic evolution of the carbonate platform to pelagic basin systems in this area.

In the so-called "Saccense Domain", southern Sicily, only the section of "Contrada Diesi" (CDS) has been studied with these methods and compared to the Trapanese ones. This section (Baldanza *et al.*, 2002, D'Arpa & Meléndez, 2006) consists of about 9 m of massive calcilutites (Buccheri Fm.) spanning from Bathonian to Oxfordian. They are covered by some 2,7 meter thick sequence of stromatolitic and calcarenitic limestones of Kimmeridgian age, which are in turn followed on top by Tithonian beds.

Differences between the Saccense and Trapanese successions are notorious: the thickness of the different chronostratigraphic units, the span of the middle Callovian-lower Oxfordian stratigraphic gap and the presence of Submediterranean ammonite taxa and the specific diversity. In particular the anomalous presence of representatives of the subfamily Perispinctinae (usually only occasional in the Mediterranean Province) and the presence of a wide "registratic" ammonite gap at the Lamberti-Mariae Zone (uppermost Callovian to lowermost Oxfordian) in the succession from CDS are particularly relevant.

In order to set a detail taxonomic and taphonomic analyses in the Jurassic of the Saccense Domain, a new section has been recorded some 8 km east of CDS, along an abandoned quarry named "Cava ex Capraria" (CCS) near the village of Sambuca di Sicilia (Agrigento Province). It comprises a 26 meter thick sequence of Middle-Upper Jurassic ammonite-rich limestones passing upwards into the upper Tithonian-Lower Cretaceous unit (marly limestones with calpionellids).

Preliminary data show that the Section of Cava ex Capraria spans the same stratigraphic range as that of Contrada Diesi. Also the extent of gaps (from Bathonian to Tithonian) is comparable although the recorded units are generally thicker in CCS than at CDS. Moreover the Kimmeridgian strata consist of pelagic calcilutites whilst in Contrada Diesi they are represented by stromatolitic limestones. Ammonites successions in both sections are generally comparable. However, in CCS the best represented intervals are close to the Oxfordian-Kimmeridgian boundary and in the Lower and Middle Kimmeridgian beds whilst in CDS the ammonites are more abundant in the Bathonian, Callovian and Oxfordian strata.

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GEO1-13 Poster Khaksar, Keyvan

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STUDY OF STRATIGRAPHY AND MICROFOSSILS OF QOM FORMATION, TAKHTE CHAKAB MOUNTAINS (CENTRAL IRAN)

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Key terms: Qom Formation; Central Iran; Takhtechakab; Stratigraphy; Foraminifer

The current research has been accomplished on Qom-Formation in Takhte chakab, in Central Iran. The studied section is equal to patterned Formation of Qom, at the age of Oligo-Miocene. The said section is 370 meter deep and it is composed of a range of Sandstone, thin to thick bedded Limestone, Marl, Gypsum and in some points it is made of

conglomerate. Qom-Formation, in this section with the same slope boundaries, is between the lower and upper red Formations. According to our research based on the existence of Foraminifera benthic, the age of this section is determined the lower Oligocene-Miocene. According to Stratigraphy studies, all introduced units in Qom-Formation include f, e, d, c4, c3, c2, c1, b, a was found in the said section. During desert operation, forty-nine 60 samples was extracted that the study on them based on Foraminifera leads to the recognition of 26 genus, 9 species and finally 3 biozones which are as follows:

- 1) Meandropsina iranica Assemblage Zone Henson 1950.
- 2) Miogypsina sp. Archaias sp. Vavulinid sp. Assemblage Zone
- 2a) Elphidium sp. Miogypsina sp. Assemblage Subzone
- 2b) Archaias angulatus Assemblage Zone.
- 3) Eulepidina dilatata, Nummulites intermedius, Nummulites vasculus Assemblage zone

GEO1-14 Poster Tinelli, Chiara

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METHODOLOGIES FOR PALEONTOLOGICAL FIELD RESEARCH: EARLY PLIOCENE SIRENIAN PALEOSITE IN SOUTHERN TUSCANY

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Key terms: Pliocene; Sirenia; Ground Penetrating Radar; 3D scanning

Like most of the paleontological discoveries, the new fossils recently identified in Tuscany were found almost by chance. We used the standard procedure for collecting large vertebrate fossils associated to two technological applications: georadar prospecting and in situ survey of the fossiliferous surface with 3D scanning instrument (Zscan, Menci) based on photogrammetric method.

In 2007 and 2010 four partially articulated sirenian fossil skeletons were found in Arcille (Grosseto, Italy). They are referred to *Metaxytherium subapenninum*, a sirenian species that lived in the Mediterranean and became extinct in the upper part of the Pliocene (Sorbi *et al.* 2008). Micropaleontological analysis based on planktonic foraminifera allowed us to date the specimens to the lower Zanclean.

Three specimens were found in a sand quarry in 2007, while the fourth was discovered in 2010 in a sunflower field near the quarry. The sirenians found in the quarry were suddenly recovered. First, all bones have been exposed on the surface and hardened with special chemicals, then, we isolated the skeletal remains from the surrounding rock by digging a trench around them. The remains were covered with a layer of wet paper towels and burlap strips soaked with plaster, applied one at a time on the covered bones. After the plaster has hardened the block was further undercut. We built a wood frame to protect the bones; the block was later transported with a grab truck.

The discovery of the fourth sirenian occurred through a preliminary georadar prospecting. Once having obtained the first results, in order to conduct the excavation we used GPR maps, that highlighted several reflective zones. Once ascertained the presence of bones in the subsoil, we compared GPR and paleontological data by using an excavation map. This was formed by a grid divided in squares where the position of each bones was recorded and then compared with the location of the reflective zones. We verified that most of the reflective zones corresponded to areas where fossil bones were discovered. Despite the good result of this application, more tests must be conducted in different geological and paleontological settings.

The other technology used was photogrammetry with a 3D scanning instrument (Zscan, Menci). This method, using a calibrated metric digital camera, collects triplets of overlapping images, from which it extracts a cloud of points and then, through specific software based on an innovative proprietary algorithm for multifocal image analysis, it constructs 3D model.

It is used in different application fields, like archaeology, engineering, but its use in paleontology is just beginning (Landini *et al.* 2010). It is possible to apply this technique both to fossil sites and remains. The advantages range from saving the original setting of the fossil site that could be damaged during the excavation, to making 3D imaging of fossil remains in order to take morphometric measures on virtual bones instead of original fossils, especially the holotypes.

We applied this method to the fourth sirenian found in the sunflower field. We placed a tripod, mounted under a slide bar and put the camera on a ruler. Then we did several 3 shots sequences ("triple") from different positions in order to entirely cover the site and the skeletal remains to be modeled.

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GEO1-15 Poster Petti, Fabio Massimo

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A SALAMANDRID FROM THE MIDDLE PLEISTOCENE OF NORTHERN LATIUM (FOSSO DI SAN MARTINO, ROME, ITALY)

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Key terms: Amphibia; Caudata; middle Pleistocene; diatomite basins

The industrial exploitation of Pleistocene diatomite deposits in the neighboring of Rome has provided scientists with a large amount of fossil flora and fauna, sometimes in a remarkable state of preservation. Extremely detailed palaeobotanical and palynological studies have been produced since the mid of the last century, which allowed researchers to outline a palaeoenvironmental reconstruction of this area during the middle and upper Pleistocene. Vertebrate macrofossils and especially large-bodied mammals have been recovered from diatomitic basins in the Riano area and a large sample of smaller faunal entities, such as invertebrates and small vertebrates (fishes, amphibians, reptiles, mammals) is known as well. Indeed, Caudata were limited so far to a couple of localities, with only two taxa, namely *Lissotriton vulgaris* cfr. ssp. *meridionalis* from the middle Pleistocene of Riano Flaminio (Rome) and a coeval *Triturus cristatus* from Baccano (Rome). The discovery of an almost complete salamandrid specimen is therefore relevant as it adds new data to the urodeles fossil record of the Italian peninsula.

The new specimen has been discovered at Fosso di San Martino locality, about 45 km North of Rome. The stratigraphic succession of the Fosso di San Martino crops out in the eastern sector of the Sabatini Volcanic District (SVD; Latium, central Italy; 0.8-0.1 Ma) and consists of a ca. 60m-thick sedimentary succession with alternating diatom-rich silts and sandy silts, plus diatomites. Several primary pyroclastic layers from the ultrapotassic Quaternary volcanism of the Roman Province interfinger with the diatomitic deposits. The fossiliferous diatomites rest on top of a pyroclastic flow deposit erupted during the ancient SVD volcanic activity (i.e., Tufo Giallo di Prima Porta unit, radiometric 39Ar/40Ar age 514±3 ka, Karner et al. 2001) and is overlain by a pyroclastic flow deposit from the early SVD volcanic activity (i.e., Tufo Rosso a Scorie Nere unit, radiometric 39Ar/40Ar age 449±1 ka).

Although the specimen may be considered as an almost complete one (total length 42 mm), the preservation of single bones differs depending on the sector of the body. The specimen mainly consists of a thin brownish organic layer, even though few portions of the skeleton are preserved tridimensionally, as for some sectors of the dental bone. The head is longer than wide, elongated along to the main axis of the body. The cranial roof is virtually lost, and neither dermal nor neural bones are recognizable. Dental bones bear a row of small conical teeth. The postcranial skeleton is made of a fairly complete vertebral column, a complete set of ribs, a portion of the front girdle, front and rear limbs, and an almost complete tail. Up to 14 vertebrae have been counted in the trunk. The phalangeal formula observed on the manus is 2-2-3-2, associated to the following pedal formula ?2.3.3.?

The taxonomic allocation of the new specimen was proven to be extremely difficult owing to a set of accompanying causes. The most relevant one is related to the anatomic features (skull bones, vertebrae), which are either deformed, lost or too badly preserved to give definite taxonomic clues. Additionally, the specimen is probably not fully grown in somatic terms. So far, preserved anatomic features made it possible to restrict the field of potential attributions to the Salamandridae family. The fossils is still under examination and a detailed study is in progress.

SESSIONE GEO2

Geologia stratigrafica e sedimentologica

GEO2-1 Orale Costamagna, Luca Giacomo

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THE "BUNTSANDSTEIN" GROUP OF SARDINIA: A COMPLEX OF HETEROGENEOUS UNITS DEPOSED UNDER DIFFERENT ENVIRONMENTAL, MORPHOTECTONIC AND CLIMATIC (?) CONDITIONS

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Key terms: Buntsandstein; Paleogeography; Sedimentology; Sardinia; Triassic

In Sardinia red bed "Buntsandstein" thin deposits are scattered: they are Early to early Middle Triassic in age and represent the start of the Alpine depositional cycle. The age of their base grows younger from W (late Early Triassic, Sardegna NW) to E (Middle Triassic, Sardegna SE).

Sedimentological and petrographical comparisons of the diverse outcrops suggest the "Buntsandstein" evolution, depositional environments, sediment sources, tectonics and even perhaps the dominating climate varied from place to place, as well as the landscape morphology behind. All the "Buntsandstein" successions pass finally to the "Muschelkalk" carbonates. In NW Sardinia the 30 m thick Verrucano Sardo Fm. (Early-Middle Triassic) conglomerate to sandy deposits are formed by conglomerates, sandstones and scarce pelites: they laid down in a continental-transitional braid-delta context rapidly evolving to a marine tidal flat environment. Those deposits are quartz-rich and very mature especially in the lower part of the unit: the conglomerates are usually rounded and quartzose (quartzrudites); sandstones are well-sorted sublitharenites passing upwards to moderately well-sorted litharenites. In SW Sardinia (Arborea) the 20 m thick Punta S'Arredelli Fm. (Late Anisian) is built of a fining-upward sequence of alternations of conglomerates, coarse sandstones and pelites. Channelized bodies are rare. Towards the top, rare calcareous thin layers and former evaporitic, now calcitized beds are interspaced. This unit deposited in a braided stream environment. The conglomerates are polygenic and angular to subrounded; the sandstones are moderately to well-sorted litharenites. Still in SW Sardinia (Iglesiente), the 25 m thick Riu Is Corras Fm. (Late Anisian) is formed by alternations of unchanneled conglomeratic debris flows alternated with calcrite beds whose former protilites were open-frame conglomerates or former (lacustrine?) limestones: rare, thin intercalations of bioturbated sandstones and siltites are also present. Here an alluvial fan delta developed. Conglomerates are polygenic and built of rounded pebbles and small cobbles; sandstones are well-sorted litharenites. In SE Sardinia, the 18 m thick Escalaplano Fm. (Latest Anisian) shows only a thin localized metre-thick basal conglomerate: upwards it passes to extremely regular, plane-bedded greenish, reddish and locally blackish siltites and clayey siltites containing scattered sandstone beds; bioturbation and mud-cracks

are rare. Rare shallow channels filled by sandy deposits have been found. Scattered pinkish evaporitic thin layers (mainly produced by diagenetic recirculation of former syndepositional levels) are also present. This setting suggests a smoothed landscape initially feeding low, cone-shaped, depositional bodies made of gravelly lobes built of few, thin sheet-floods: they rapidly were followed by a low energy mudflat playa-like environment crossed by rare channels. The scarce conglomerates and polygenic with angular to subrounded pebbles; the sandstones are well-sorted litharenites. All those "Buntsandstein" units, despite their similar age and stratigraphic position, display environmental and petrographic differences suggesting different ruling factors, as landscape morphology, tectonics and perhaps climate. As examples, in the Iglesias area the Riu Is Corras Fm. the coarse massive deposits showing no fining-upward trend suggest an articulated landscape and a coeval tectonic activity; these characters contrast with the Escalaplano Fm. quiet muddy environment of SE Sardinia featured mainly by a wide depositional flat. So the markedly diverse compositional maturity of the siliciclastics sampled in different Sardinia territories may suggest variable transport duration, different feeding areas, or even diverse local climates. So, considerations and analysis are ongoing to settle discrepancies in the Sardinian "Buntsandstein" setting.

GEO2-2 Orale Costamagna, Luca Giacomo

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THE MIDDLE JURASSIC "TETHYAN" UNCONFORMITY IN EASTERN SARDINIA (ITALY): EVIDENCES OF TECTONO-SEDIMENTARY CONTROL OVER THE BASEMENT ALTERATION PROFILES AND THE TRANSGRESSIVE DEPOSITS

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Key terms: Jurassic; Paleogeography; Sinesedimentary tectonics; Sedimentology; Sardinia

Sedimentological, stratigraphical and petrographic investigations were carried on both upper sedimentary and lower metamorphic rocks located on opposite sides of the "Tethyan" Middle Jurassic unconformity surface of Eastern Sardinia. They evidenced that sedimentation/alteration processes over the transgressed metamorphic Variscan basement have been ruled by different factors, in their turn influencing each other. The Variscan metamorphic basement located below the unconformity shows different alteration stages depending on the lasting of the emergence and on the lithologic type composition on which the surface rests. Thus the basement may be affected by alteration processes ranging from thin alteration halos coating the surfaces of unaltered rocks to well-developed and thick Fe-rich hot-humid paleosols. The unconformably overlapping Middle Jurassic Genna Selole Fm. (at most 50 m thick) was laid down by evolving fluvial to deltaic-lagoon-marine processes: it is formed by three lithofacies: 1: massive to crude-bedded, locally cross-bedded conglomerates to breccias and coarse to medium grain-sized, cross-bedded sandstones (monogenic quartzose to polygenic conglomerates and breccias; quartzarenites to sublitharenites) related to fluvial (longitudinal?) braid bars; 2: medium-grain sized to fine sandstones (quartzarenites to sublitharenites) and quartzsiltites lens and beds and thinly laminated black clays and silty clays linked to deposition in coastal marshes crossed by meandering channels; 3: fine to rare mid-grain-sized sandstones (quartzarenites), carbonates and thin levels of blackish carbonaceous clays with interspaced oxidized surfaces testifying emergence times and connected with the passage from the deltaic-lagoon transitional environment to the marine carbonate shelf. Comparing different sections, these lithofacies may A) be all represented or not; B) have variable thickness; C) be arranged in thick cycles suggesting rise and sink of independent basement sub-highs. A tidal influence on the lithofacies 2 and 3 is suspected but the coeval tectonic movements make it difficult to unravel. Sometimes the Genna Selole Fm. may be missing and the upper carbonate Dorgali Fm. rests directly over the Variscan basement. In this case metamorphic rock or quartz pebbles and cobbles may be scattered in carbonate deposits. The thickness of the Genna Selole Fm. and the alteration profiles underneath were controlled also by the paleomorphology of the Barbagia high, a rugged structural feature emerging in Eastern Sardinia during Middle Jurassic times for the opening of the Tethys Ocean eastward. The surfacing of this high under an aggressive climate triggered the erosion of thick early Mesozoic to Paleozoic successions. The whole Barbagia high was in its turn quite immediately split in diverse rising and sinking minor blocks by the Middle Jurassic extensional tectonics: the sinking ones were interested by depositional processes so the Genna Selole Fm. accumulated thickly and rapidly there and no alteration profiles developed on the basement below; conversely erosive processes kept going on the rising ones, thus the following marine transgression covered them directly through the Dorgali Fm. carbonate shelf deposits without any significant continental siliciclastics interposed: here alteration worked deeply on the basement. The petrographic composition of the siliciclastics of the Genna Selole Fm. shows variations according to the geographic and tectonic location: in the southernmost areas (Tacchi) quartz-rich deposits prevail largely, while northwards (Ogliastra, Baronia) litharenites and arkoses grow in importance. Moreover, while the siliciclastic feeding in the southernmost areas stops quite rapidly passing upwards to carbonate marine environments, in the north it shows up intermittently with abundant quartz grains in the carbonate succession so testifying the persisting presence of emerged surrounding basement highs.

GEO2-3 Orale Masetti, Daniele

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EARLY JURASSIC CARBON CYCLE ANOMALIES IN THE EASTERN SOUTHERN ALPS

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Key terms: Early Jurassic; Isotope stratigraphy; Southern Alps

A major reorganization of Early Jurassic Tethyan palaeogeography took place around Sinemurian-Pliensbachian boundary time with the drowning of many carbonate platforms. Detailed investigations of the Jurassic succession of the Trento Platform indicates that the upper

Sinemurian(?)-Pliensbachian Rotzo Formation of the Calcarei Grigi Group is missing in the northern and eastern sector where the pelagic lower Rosso Ammonitico (Bajocian-Bathonian) directly overlies the Hettangian-Sinemurian Monte Zugna Formation. A coeval depositional hiatus occurs also in most of the northern portion of the shallow-water Friuli Platform, suggesting that the Pliensbachian hiatus is ubiquitous in the easternmost outcropping sector of the Southern Alps.

An integrated stratigraphy is being developed across an E-W-oriented transect that crosses the entire Eastern Southern Alps from the western margin of the Trento Platform, through the Belluno Basin, to the Friuli Platform. In the Trento Platform four different sections have been selected: Madonna della Corona, Val Gola, Rotzo and Monte Grappa, corresponding to three different types of successions. The Madonna della Corona section represents the western margin of the Trento Platform, adjacent to the Lombardy Basin, where the marginal upper Sinemurian(?)-Pliensbachian oolitic body (Oolite di Massone) encircles the finer grained lagoonal *Lithotis*-bearing deposits of the Rotzo Formation that became more significant eastward. In the Val Gola section and Rotzo stratotype, the Rotzo Formation overlies the Calcare Oolitico di Loppio. In Monte Grappa, as well as in the whole eastern sector of the platform, the Rotzo Formation is replaced by cross-bedded crinoidal calcarenites (Encrinure di Fanes) accumulated on top of a plateau in its early post-platform drowning phase.

Chemostratigraphic investigation of bulk limestones from the Madonna della Corona, Val Gola and Rotzo sections indicates an abrupt and marked negative carbon-isotope shift located in the topmost portion of the Calcare Oolitico di Loppio, in close stratigraphic proximity to the FO of *Orbitopsella*.

This negative excursion is also recorded in skeletal calcite (belemnites) from the Sinemurian-Pliensbachian boundary in England, where black shales are locally developed. Taken together, these data are consistent with the hypothesis that a global disturbance in the carbon cycle was connected with modifications of the Early Jurassic Tethyan palaeogeography, particularly as regards platform drowning. This negative carbon-isotope excursion must record injection of isotopically light carbon, either as methane and/or carbon dioxide, into the ocean-atmosphere system. Whether this carbon derives from volcanogenic sources, from metamorphism of organic-rich sediments, or from dissociation of gas hydrates is currently unknown. The negative carbon-isotope excursion in sections from Madonna della Corona and Rotzo both correlate with similar excursions in oxygen-isotope ratios, which could either be an artefact of diagenesis or record increases in marine sea-surface temperature. Palaeoenvironmental changes, in concert with extensional tectonics, may have instigated drowning of certain Tethyan carbonate platforms around Sinemurian-Pliensbachian boundary time.

Taken together, these phenomena recall the well-known Toarcian Oceanic Anoxic Event, which may also have been instrumental in the drowning of those Tethyan carbonate platforms whose subsidence rates were relatively high.

GE02-4 Orale Gasparo Morticelli, Maurizio

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INTEGRATED ANALYSES OF SYN-TECTONIC BASIN FILL TO CONSTRAIN THE DEFORMATION EVOLUTION IN A FOLD AND THRUST BELT: FIELD EXAMPLES FROM THE SICILIAN CHAIN.

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Key terms: Sedimentary Basin; Synsedimentary tectonics; Sicily chain; Late Miocene Early Pliocene

The Late Tortonian to Early Pliocene structural and stratigraphic evolution of north-western sector of the Sicilian thrust belt (SFTB) is the subject of this paper.

As it has been widely demonstrated by many Authors, (Bally et al., 1966 with references among other) during the fold and thrust belt building the compressional deformation propagates "in sequence" from the internal to the external zone involving from the top to the bottom deeper and deeper structural levels. As a consequence, the effects induced by deformation that developed at different structural levels (multiple décollements) and ages, will be recognized on the field as an interference structure due to the superimposition of successive tectonic events. Therefore, in a fold and thrust belt two main compressional events can be commonly detected, that are respectively: 1) a former shallow-seated thrusting followed by 2) a later deep-seated transpressive deformation. A such tectonic evolution have been documented by the following Authors in the sicilian chain: Roure et al. (1990); Oldow et al (1990); Catalano et al. (2000).

We focus our attention on the relationships between tectonics and sedimentation of some syntectonic basins, developed above the Sicilian orogenic belt during the transition between the shallow-seated and the deep-seated-transpressional events, in order to better understand the geological processes occurred during this topic transitional phase. A set of new field-based data concerning sedimentologic, stratigraphic and structural analyses performed on the sedimentary fill of three syntectonic basins located in the inner sectors of the Sicilian thrust belt have been used for the paper aim. These basins are: (i) the Scillato Basin (SB, north-central Sicily); (ii) the Ciminna Basin (CB, north-western Sicily) and (iii) the Lascari Basin (LB, northern Sicily). Each of these basins is representative for a specific portion of the late Tortonian to early Pliocene geological record characterizing the study area. In particular, evidences for a syn-depositional tectonics have been recognized in the Late Tortonian clastics filling the Scillato Basin, in the Messinian evaporites filling the Ciminna Basins and in the Early Pliocene deep-water limestones filling the Lascari Basin.

Interpretation of our data allowed us to hypothesize that: 1) an almost continuous contractional to transpressional deformation (since Early-Middle Miocene to Late Pliocene time) can be outlined in this sector of the SFTB also according with what documented by Oldow et al. (1990) in western Sicily; 2) in the study sectors of the SFTB the transition between the shallow-seated event and the deep-seated-transpressional event occurred during the Middle-Late Tortonian time (reasonably after the Castellana Scula Fm. deposition). The deep-seated, transpressional structures were already active at least during the latest Tortonian (as documented in the SB) and continue during both the Messinian and Early Pliocene (as demonstrated in the CB and LB). The latter tectonic event goes on almost till the late Pliocene (Abate et al. 1991).

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GE02-5 Orale Zecchin, Massimo

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SHORELINE MIGRATION FROM INLAND CROTONE TO THE IONIAN CALABRIAN SHELF (SOUTHERN ITALY) DURING THE LAST 250 KYR

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Key terms: Shoreline; Marine terrace; Glacio-eustasy; Uplift; Crotone Basin

A reconstruction of the shoreline migration in the Crotone area from Middle Pleistocene onwards is here presented, based on facies analysis of marine terrace deposits, the uplift history, and submerged seabottom features observed on sub-bottom data (Chirp 2-7 kHz) along the present day shelf.

The Crotone Basin, located on the Ionian side of Calabria, began to open between Serravallian and Tortonian times. It is interpreted as a forearc basin of the Calabrian accretionary wedge. The uplift of the basin initiated in the Middle Pleistocene (ca. 0.4 Ma), with an average rate in the order of 1 m/ka. The interplay between regional uplift and glacio-eustasy since MIS 7.5 (ca. 230 ka B.P.), produced a staircase of marine terraces, located between 230 to 10 m above present sea-level.

Facies analysis of the marine terrace deposits, together with the reconstruction of inner edges at the base of uplifted palaeo-coastal cliffs, allowed the recognition of shoreline positions during peak interglacials corresponding to MIS 7.5, 7.1, 5.5, 5.3, 5.1 and 3.3. In addition, the LGM (MIS 2) shoreline position along the shelf margin, and another shoreline inferred to be related to the abandonment of a submerged palaeo-coastal cliff during melt-water pulse (MWP) 1A (14-14.3 ka B.P.), were recognized on sub-bottom data.

The scenario here presented suggests a stepped seaward (to the SE) migration of the shoreline from MIS 7.5 to 2, due to a long-term forced regression related to the uplift of the area, followed by a rapid retrogradation to the present day position, related to the post-LGM glacio-eustatic rise. MIS 7.5 and 7.1 shorelines formed in an area characterized by relatively flat topography, and thus favouring the local development of barrier islands and lagoon-estuarine systems. In contrast, MIS 5.5 to MIS 2 shorelines formed in high-gradient settings, at the base of coastal cliffs. This change from low- to high-gradient topography was probably linked to the continuous uplift of the area, producing prominent relief after MIS 7.1.

GE02-6 Poster Caggiati, Marcello

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NEW CORRELATIONS OF SEQUENCE STRATIGRAPHIC PATTERNS IN THE SOUTHERN ALPS ACROSS LADINIAN/CARNIAN BOUNDARY

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Key terms: Southern Alps; Triassic; Sequence stratigraphy; Carbonate Platforms

New on-field studies, focused in the Southern Alps, allowed for new insights on third-order depositional sequences on Upper Ladinian/Lower Carnian interval. In order to study the response of mixed carbonatic and siliciclastic systems to relative sea level variations, four areas have been investigated: Lozio area (BS), M. Sciliar and Denti di Terra Rossa groups (BZ), Braies and Sesto Dolomites (BZ), and the area between Val D'Aupa and Val Dogna (UD).

The sections were correlated through the identification of all sequence stratigraphic units and bounding surfaces of different system tracts, constrained by new bio-chronostratigraphical data supported also by radiometric dating close to the Ladinian/Carnian boundary. In all studied areas it was possible to identify a 3rd order depositional sequence, evolved between Upper Ladinian Regoledanus subzone and Lower Carnian Aon sbz, equivalent to La 3 in Gianolla et al. (1998). Falling Stage System Tract (FSST) is well recognizable in basins, thanks to deposition of high-density mainly siliciclastic to volcanoclastic turbidites of Wengen Fm., often with sharp erosive bases. Simultaneous collapses of the slope produced confined megabreccia wedges at the toe-of-slope. Subaerial exposures of carbonate platform top (Esino and Sciliar Fms.) are expressed by mature paleo-karst filled with bauxites (eg. Dogna Valley, Tre Scarperi Mt.).

The lowest system tract (LST) is characterized by terrigenous prograding complexes, often organized in thickening-upward patterns switching from fine sandstones, siltstones and marls to coarse sandstones and conglomerates. Locally, in the Dolomites region, low-angle carbonate prograding clinobeds interfingered with these terrigenous deposits can be observed, testifying the presence of fringing reefs and also renewed carbonate production in the platform interior. On the basis of ammonoids and conodonts findings, FSST and LST can be dated at the base of Regoledanus sbz.

The following transgressive system tract is characterized mainly by fining-upward sequences, with a decrease of carbonate input and a transition to marly and dark pelitic layers, clearly identifying the retreat both of terrigenous and carbonatic coastlines. In the Dolomites and Lombardy area, maximum flooding surface has been attributed to Regoledanus sbz by ammonoid findings.

Above these fine sediments, in all studied sections an increase in carbonate input and calcarenites, expresses a re-occurrence of optimal conditions for carbonate production due to the highstand position of relative sea-level. Strata stacking patterns show thickening-upward trends culminating in breccia layers underlying cinostratified bodies. Although some differences exist among platform margins and slopes carbonate factories in different regions of Southern Alps, i.e. microbial mounds and automicrite factories (subordinate corals) of Cassian Dolomite vs. coral-tubiphytes dominated and early marine cementation of Concarena slopes, timing of renewed carbonate input in basins seems almost simultaneous in all areas and can be confined from Canadensis to Aon sbz.

Identified system tracts and bounding surfaces are well defined in time framework and possible differences in depositional environments and conditions can be attributed to regional conditions, due both to tectonic and paleogeographical settings; for example, diversity in c.f. and type of prograding geometries can be linked to depth, oxygenation, nutrient amount, currents of the basins, that in turn can be linked to the paleogeography (barrier-effect of wide platforms, connections with more open seas, relative position of emerged lands, etc.). The same factors are probably responsible for the presence, confined only to some areas, of LST carbonate platforms.

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GEO2-7 Poster Interbartolo, Francesco

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PALEOENVIRONMENTAL AND TECTONIC EVOLUTION OF THE LIASSIC CARBONATE PLATFORM SUCCESSION OF MT. MARANFUSA (CENTRAL WESTERN SICILY)

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Key terms: Calcrete; Paleokarst; Neptunian dike; Injection dike

The upper part of the Liassic carbonate platform succession (Inici Fm., Hettangian-Sinemurian), outcropping at Mt. Maranfusa (central western Sicily) consists of a sequence of peritidal limestones, overlain by Jurassic to Cenozoic pelagic limestones and their siliciclastic Tertiary covers. The good exposure of this succession, pertaining to the trapanese domain, in the area between Palermo and Sciacca mountains, allowed to study in detail the facies sequences and structural features of the carbonate platform and of the sedimentary dikes, in order to improve knowledge on its paleoenvironmental and tectonic evolution. The Inici Fm. is constituted by subtidal cyclic sequences of wackestone-packstones with gastropods, megalodonts, oncolids, grain aggregates, dasycladacean algae and benthic foraminifers, followed by dismicrites with psolitic levels of intertidal environment, and at the top, when they are present, bioclastic calcarenites with birdseyes of supratidal environment.

At the top of the cycles we recognized often a peculiar type of layers constituted by:

- 1) dark gray, compact and well cemented limestones with blackish clasts. The microfacies analysis shows packstones consisting of carbonate grains and bioclasts coated with thin regular to highly irregular, laminae of brownish or yellowish micrite, creating small subspherical nodules, or irregular masses, named glaebole, often associated with pisoid.
- 2) millimetric reddish calcite laminae, locally deformed by elongated cavities, filled with greenish vadose silt, and bordered by radial fibrous cement. The crystals grow toward the inside of the cavity and crystallize at the expense of the silt fills.

We classified for the first time the levels 1 as calcrete, while levels 2 were indicated as paleokarst.

The facies sequences of the Inici Fm. are shallowing upward; the environment is attributed to a tidal flat and to the neighbour lagoon, pertaining to an inner carbonate ramp.

The recognized calcretes are of pedogenic origin and were classified as alpha and beta calcrete (Wright, 1994). The paleokarsts for their characteristics were classified as paleopeleoethems, which are important stratigraphic markers because they indicate periods of non-deposition and/or erosion during sea-level changes. Both the layers indicate phases of emersion during the deposition of carbonate platform succession. The study succession is crossed by three fault systems: NNW-SSE trending dextral transensional fault system, NNE-SSW trending sinistral transensional fault system, both late Lias-middle-late Miocene in age, often reactivating previous normal faults, and E-W trending transensional fault system (Miocene). The first two fault systems are cut by neptunian dikes (Fischer, 1964), filled by several generations of Toarcian-early Miocene pelagic sediments layers. Another system of dikes, parallel to the stratification, is created by planar slip in the carbonate rocks; they are filled by pelagic sediments (late Lias-Dogger in age). The neptunian dikes are of tectonic origin with evidence of reactivation of faults, while parallel dikes (injection dike, Castellarin, 1982) are interpreted as to be due to flexure of the platform during the Jurassic tectonic events.

So, in this paper we assert, for the first time, that the horizontal layers, previously described by many authors only as horizontal dikes, can be actually interpreted as: a) layers that are effectively horizontal dikes; b) pedogenic calcretes; c) paleopeleoethems.

As a consequence we identified some episodes of emersion in the evolution of the Trapanese carbonate platform during the Liassic.

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GEO2-8 Poster Ronchi, Ausonio

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THE LATE CRETACEOUS CONTINENTAL SUCCESSION OF THE NEUQUÉN BASIN (ARGENTINA): FACIES-ANALYSIS, PROVENANCE PATTERNS AND DETRITAL ZIRCON GEOCHRONOLOGY IN A BACK ARC-FORELAND BASIN AS A RESPONSE TO MAJOR GEODYNAMIC EVENTS

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Key terms: provenance; geochronology; foreland basin; subduction; Andes

During the Late Cretaceous, in the Neuquén basin (Patagonia, Argentina) the change from a retro-arc extensional setting to a foreland compressional one, is interpreted as the result of a decrease of the subduction dip of the Pacific Plate under the South American continental

margin, between 36 and 41° S latitude (Ramos & Kay, 2006; Tunik et al., 2010). This important geodynamic event is evidenced by the re-arrangement of the alluvial drainage pattern that filled the basin in the same time span.

Through an integrated study of depositional facies, sandstone provenance and detrital zircons geochronology, the presented work investigates how the Cretaceous surface evolution of this basin system is linked with the history of the Pacific subduction zone at depth.

The obtained results clearly show that the basin turning from extensional to compressional is registered by a regional scale unconformity in the depositional record, and is coupled with an abrupt switch of sandstone composition from continental block sandstones fed by the foreland (to the east) to magmatic arc sandstones fed by the Andean Cordillera (to the west), followed upsection by a progressive return toward continental-block compositions, though to be the result of the uplift of the peripheral bulge in the foreland, as a consequence of the Late Cretaceous thrust front migration.

These repeated changes of sandstone detrital provenance occurred in a basin having a persistent longitudinal distribution pattern in the depocentre region, where, conversely, repeated facies changes from higher energy river channel deposits to lower energy alluvial plain facies should reflect repeated variations of the base level.

Therefore, we infer that the Cretaceous evolution of the Neuquén Basin could provide a nice example of surface response to deep geodynamic processes, as well as of interference between tectonic and eustatic forcing into a tectonically active alluvial plain environment.

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GEO2-9 Poster Fabbi, Simone

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MIOCENE EXTENSION IN THE SIMBRUINI MTS. (CENTRAL APENNINES)

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Key terms: Miocene; Apennines; Submarine escarpments; syn-sedimentary tectonics

Evidence of pre-orogenic Tertiary deformation across the Simbruini Mts. (Latium-Abruzzi domain) is more common than previously believed. Several authors identified pre-orogenic tectonic phases both at regional and local scale. Active extension was inferred during the Cretaceous [1] [2], Paleogene [3] and the early Miocene [1]. Centamore & Rossi [4] hypothesized the continuous development of extensional structures during the Cretaceous to Miocene interval. New field data clearly indicate that in this area the early Messinian [3] compressive phase was predated by a middle-late Miocene extensional phase, as inferred by Compagnoni et alii [5] and by Bigi & Costa Pisani [6] in a neighbouring sector. This is evidenced by peculiar stratigraphic, structural, geometric and sedimentological features. In the north-eastern Simbruini Mts., the "Breccia della Renga" fm.(BDR), a ruditic unit made of chaotic boulder beds to well bedded breccias/arenites and associated pelites, rests unconformably on the Cretaceous to lower Miocene carbonate platform succession being partly lateral to the lower Messinian turbidites of the Roveto Valley. This unit has a late Tortonian-early Messinian age, based on calcareous nannoplankton biostratigraphy and on sedimentological and geometrical relationships with the turbidites. The BDR, which were sedimented under severe tectonic control, provide clue for identifying Miocene faults: 1. Faults producing up to ~0.5 km displacement in the substrate are sealed by unfaulted BDR; 2. Surfaces truncating bedding of the substrate with a high cut-off angle, also bearing diffuse phosphatic nodules and crusts, are covered unconformably by upper Tortonian Breccias and associated pelites; the phosphatization is interpreted as an evidence for submarine exposure during the Miocene. The surfaces themselves can be interpreted as normal fault paleoescarpments [7]. 3. The depocenter of the upper Tortonian BDR is located westward of a main alignment formed by the above mentioned paleoescarpments and by SW-dipping normal faults in the Cretaceous substrate, sealed by breccias. In the study area it is possible to identify at least two major extensional NW-SE trending lineages that controlled sedimentation and spatial distribution of the BDR. The main alignment (Villaromana-C.le La Fossa) is ~25 km long and represents the eastern margin of the principal depocenter of the Tortonian breccias. The second lineage (F.te Lubro-Campolungo), located westward, is ~10 km long and is subparallel to the main one with a spacing of ~3 km. It represents the external margin of a narrow elongated basin filled by Messinian breccias and pelites. This tectonic activity could be related with the initial flexuration of the foreland as a response to the advancing Apenninic chain.

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GEO2-10 Poster Barilaro, Federica

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SEDIMENTOLOGY AND PETROGRAPHY OF HOT-SPRING TRAVERTINE DEPOSITS IN THE ALBEGNA VALLEY, SOUTHERN TUSCANY (CENTRAL ITALY).BARILARO Federica¹, DELLA PORTA Giovanna¹, CAPEZZUOLI Enrico²

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Key terms: Hot-spring travertines; Albegna Valley; Tuscany

Travertines, non marine carbonates of calcium carbonate precipitation under thermal-hydrothermal condition are produced by CaCO₃ precipitation due to degassing and evaporation of the spring waters; nevertheless biological influence may also stimulate precipitation. Hot-spring travertine deposition in Central Italy is considered mainly to be related to the magmatic and hydrothermal activity linked to the Plio-Pleistocene extensional tectonics developed during the opening of the Tyrrhenian Sea. Central Italy has extensive travertine accumulations all younger than 400 kyrs that include present-day deposits.

In the Neogene Albegna Basin, southern Tuscany (central Italy), travertines are present in several deposits, distributed along faults and fractures. They were chiefly deposited as fans and wedges with terraced slopes and are located at different topographic heights (from about 25 up to 700 m a.s.l.).

The travertine body under study (Pleistocene- Holocene) is well exposed within an active quarry situated on the Manciano sector of the Albegna Valley.

Three meter-scale travertine units separated by two clay levels were identified in the "Saturmia Travertine Quarry" suggesting an intermittent accretion of the travertine body. These travertine units exhibit terraced slope, smooth slope depositional systems and filling topographic depressions. The terraced slope system (30-35 m thick) consists of terrace walls (several cm to 2 m high), pools (1-15 m wide), pool rims (few cm to 1 m high) and waterfalls (2-3 m high). The smooth slope consists of non-terraced and low-angle slope on which the terrace pools did not developed. More than thirteen carbonate fabrics at the cm-scale were distinguished in the field. These occur in different depositional environments (i.e., fast- vs. low-flowing water). Crystalline crusts (from cm to a few dm thick) are common of rims and walls, vertical surfaces of waterfalls of the terrace pools. These were also characteristic of smooth slope, where water supply and flow velocity are fast.

Shrubs, mm to cm arborescent structures that expand away from the substrate, are typical components of pools of terraced slope (relatively low energy areas).

In horizons of reduced topographic relief (ponds) and of low-angle dip of smooth slope systems, cm-scale alteration of different fabrics occurs including: shrubs (few mm to 20 cm), mm to cm elongated rafts, undulated sub-millimeter stromatolite-like structures, honeycomb, pisoids, micrite layers, rounded and elongated bubbles.

Petrographic analysis displays diversified microfabrics. Shrub structures usually consist of peloidal micrite. Crystal shrubs display a dendritic crystalline morphology and undulated extinctions. Calcite crystals (generally micritized) show a range of morphology from feather to ray crystals and dominate the crystalline crusts. Thin or crude laminated micrite/microspar forms stromatolite-like structures. Honeycomb like-structures consist of thin micrite/microspar laminae aggregated into packages with large subspherical/lenticular discontinuous cavities bulged up by large gas bubbles or insect larvae.

The microfabrics show 15-30% porosity, partially closed by spar calcite (likely of meteoric origin), micrite and microspar. The occurrence of biofilms in actively forming travertines at Bagni di Saturmia (12 km far from Saturmia Travertine quarry) confirms the hypothesis of the possible presence of an organic framework in some fabric of the studied fossil travertines.

The study of Albegna River Basin travertine provide fundamental information in terms of geometry and lateral and vertical evolution of the sedimentary bodies, depositional facies, carbonate fabrics their diagenesis and porosity that can have implications for comparable carbonate reservoirs in the subsurface.

GEO2-11 Poster Bizzarri, Roberto

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MULTIDISCIPLINARY ANALYSIS OF THE PLIO-PLEISTOCENE CLAY DEPOSITS IN UMBRIA (CENTRAL ITALY): PRELIMINARY REPORTBIZZARRI Roberto¹, BALDANZA Angela¹, CAMBI Costanza², SABATINO Giuseppe², VINTI Giuseppe¹

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Key terms: Clay deposits; Multidisciplinary approach; Stratigraphy; Quaternary; Central Italy

Marine and continental clay deposits, dating from Pliocene to Late Pleistocene, widely crop out in the Umbria territory (central Italy). They belong to several lithostratigraphic units, the identification of which is in some cases still debated. The available allow to define almost homogenous outcrop areas, both in marine and continental deposits (Ambrosetti et al., 1987, 1995; Basili, 1997; Coltorti & Pieruccini, 1997; Girotti & Mancini, 2003). Four main clay units are usually defined: the Fabro Unit and the Chiani-Tevere Unit, which accommodate the Pliocene and Pleistocene marine sedimentary cycles, respectively, and the F.so Bianco Unit and Fighille Unit, which hold the wider outcropping continental clays in south and north Tiber Valley. Subordinate clay intervals also characterize the other Lithostratigraphic Units. In fact, clay deposits have been often used in cartography, as well in the geological models, independently on their meaning in terms of sedimentological, biostratigraphic, mineralogical features, and of paleoenvironmental context. New sedimentological and stratigraphic data are now available, and the former scenery needs a deep revision (Baldanza et al., 2011, with references), at least for marine deposits. On the other hand, geotechnical and mineralogical features vary both with stratigraphic range and paleoenvironmental context (Candio et al., 1992). The results of an ongoing research project, based upon a multidisciplinary approach and aimed to a whole re-evaluation of Umbria clay sediments are here presented. Several sections have been sampled, both in marine and continental clay deposits and sedimentological, stratigraphical, geotechnical and mineralogical analyses have been carried out, aimed to a comprehensive characterization of clay Units. Analyses are focused on micropaleontology, grain-size, Atterberg's limits, XRD. The results of this multidisciplinary analysis will be useful in cartography, geotechnical

studies, industry of ceramic and lateritic, archeometry and territory planning. Finally, this multidisciplinary approach, based upon a stratigraphic redefinition, contributes to the paleoenvironmental restoration and geological modeling.

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GEO2-12 Poster Rellini, Ivano

10.1474/Epitome.04.1145.Geoitalia2011

PETROPLINTHITE FORMATION IN A QUATERNARY COMPLEX PALEOSOL ALONG NW ITALIAN COAST: GROUNDWATER AND SEDIMENTARY INPUT INTERACTION.RELLINI Ivano¹, TROMBINO Luca², CARBONE Cristina¹, FIRPO Marco¹

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Key terms: petroplinthite; paleosol; marine terrace; micromorphology

According to WRB a petroplinthic horizon is a continuous, fractured or broken layer of indurated material, in which Fe (and in cases also Mn) is an important cement and in which organic matter is either absent or present only in traces. Petroplinthic horizons are closely associated with plinthic horizons from which they develop on exposure to repeated wetting and drying. From a genetic viewpoint, plinthite forms by segregation of iron, in a horizon that is saturated with water for some time during the year. It normally forms in a horizon below base of a slope or in flat or gently undulating landscape. At the present time (petro)plinthite is commonly found in soils forming in subhumid tropical climates with distinct wet and dry seasons. The aim of this work is to document the evolution of costal complex paleosol developed in NW Italy during the Quaternary, and discuss the genesis of its associated petroplinthic horizon within the context of the environmental changes. These events affected the soil at different levels and most of the transformation has been recorded at the microscopic scale. The studied complex paleosol was observed close to the inner margin of marine terrace of Natta which has height of 75 m above sea level near Celle Ligure (SV, Northern Italy). On the terrace surface is possible to observe both marine and continental deposits that cover the Oligocene polygenic conglomerate bedrock. The Natta pedosedimentary section, more than 4 m thick, can be regarded as polycyclic pedocomplex which contains different paleosols. These paleosols have been truncated, reworked and have been supplied with an input of sediments during their development. The strong development of the pedosedimentary sequence is mainly due to superimposed pedogenetic phases (e.g. overlapping of illuvial horizons) in an accretional landscape. In particular the petroplinthic horizon represents the pedogenesis in response to seasonal fluctuation of the water table, the petroplinthite has no genetic link with the weathered bedrock. In this light, the plinthitisation/ferruginization derived from iron enrichment and accumulation from an external upslope source and mainly by post-depositional precipitation of neo-formed iron and alumina oxyhydroxides (hisingerite), deriving from the dissolution of pre-existing hematite in detrital laterite fragments. These probably derived by complete erosion of Pliocene lateritic soils (duricrust) in higher landscape positions. Therefore, each pedostratigraphic level reflects environmental changes resulted from complex interactions between rapid uplift and climate change controlled processes.

GEO2-13 Poster Saccà, Domenica

10.1474/Epitome.04.1146.Geoitalia2011

GRAIN-SIZE, CHEMICAL COMPOSITION AND FORAMINIFERAL FAUNAS OF SEDIMENTS IN THE TYRRHENIAN SEA (CALABRIA, SOUTHERN ITALY)SACCÀ Carmelo¹, SACCÀ Domenica¹, NUCERA Preziosa², DE FAZIO Anna¹, GIACOBBE Salvatore²

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Key terms: Tyrrhenian Sea; Calabria; grain-size; benthic Foraminifera; trace elements

This study examines the grain size, chemical composition and benthic foraminiferal assemblages in marine sediments collected along the Tyrrhenian coast of central-southern Calabria. The sampling has been carried out along sixteen transects (from Bagnara to Falerna), at depths ranging from 50 m to about 400 m. Sediments consist of mud (silt+clay) and sand. Most of the samples show a preponderant silt fraction (43.20 to 84.85%). Clay fraction oscillates between 4.05% at Briatico and 44.11% at Gulf of Sant'Eufemia. Its content increases with depth in almost all transects. Sand fraction is well represented in the area between Gioia Tauro and Bagnara (13.08%-45.47%). The percentage of sand is inversely proportional to clay content and is not a function of depth. According to Flemming's classification (2000), sediments can be divided

into two groups: the first, including samples collected in the south area of Gioia Tauro, shows a higher sand content and falls in the range "Very silty sandy mud"; the latter, including the most sediments collected in the north area of Gioia Tauro, is mainly composed of silt and clay fraction and includes samples which can be prevalently considered as "Very silty slightly sandy mud" and "Clayey silt".

Optical microscopy examination revealed that size fractions higher than 63 microns include both terrigenous and biogenic components (mostly Foraminifera).

The benthic foraminiferal assemblages reflect effects of bottom topography. The presence of a scarp in the south area of Gioia Tauro influences the benthic association of the deep samples which are characterized, as well as the shallow samples, by typical species of shallow waters. This effect is less evident in samples collected in the north area of Gioia Tauro. The most abundant species are *Uvigerina mediterranea*, *Elphidium crispum*, *Amphycorina scalaris* and *Præglobobulimina ovata*.

Fraction less than 2 microns was also analyzed for the composition of 37 elements including major, trace and rare earth elements. Mn has the highest values (437-3840 ppm), followed by Zn (213-1209 ppm), Cu (65.7-440.5 ppm), Sr (117-338 ppm), Ba (63-202 ppm), V (69-112 ppm), Ni (37.3-103 ppm), Cr (38-93 ppm) and Pb (37.2-80.8 ppm). Metals show a different trend: Cu, Th, V, Sc, La, Zn, Ni, Co, Au, Cr, Hg show a decreasing concentration gradient from the coast toward the open sea, except for La at Pietra Galera, Zn at Agliastro and Pellegrina, Ni, Co, Au, Cr and Hg from Briatico to Pellegrina; the Pb, Mn, As, Sr and Ca concentrations increase offshore, except for Pb at Falerna, for Mn and As at Pellegrina and for Se and Ca at Gioia Tauro.

SESSIONE GEO3

Geologia strutturale

GEO3-1 Orale Argnani, Andrea

10.1474/Epitome.04.1147.Geoitalia2011

ANALOGUE MODELLING OF MAGMA-POOR CONTINENTAL RIFTED MARGINS

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Key terms: analogue modelling; passive margin; lithospheric-scale extension; rifting

The crustal-scale structure of rifted passive margins represents an issue of relevant academic and commercial hydrocarbon-industry interest, and has been extensively investigated in the last decade, using both geophysical prospecting and numerical and analogue modelling.

In spite of the efforts, some basic questions are still open to debate, mostly concerning the amount and mode of crustal and lithospheric thinning, and the possible depth-dependency of lithospheric stretching. Although hampered by obvious limitations, sandbox analogue modelling has proven to be an effective way to investigate lithospheric-scale extension, and particularly to visualize the 3D modelling evolution. This contribution presents the results of a set of lithospheric-scale sandbox modelling experiments aimed at investigating the relationship between brittle faulting and ductile thinning in the crust and mantle.

Modelling has been performed in a sandbox using a 4-layers set-up, with alternating layers of sand and silicone putty, representing the brittle and ductile rheology, respectively, of crust and mantle. The reference lithosphere is "cold", i.e., it has a low geothermal gradient. The layer-cake has been set so as to float above a glucose solution, that represents the asthenosphere, and the density of modelling materials has been appropriately scaled, in order to reproduce crustal and mantle rocks of a realistic lithospheric structure. Lateral anisotropy in the viscosity of the lower crust has been introduced in some 3D models.

The sandboxes used are made of plexiglass and have a width of ca. 30 cm and a length ranging from 40 to 50 cm. One of the short walls of the sandbox is pulled using a computer-controlled motor to impose extension at a velocity of 1 to 3 cm/hour; this wall is attached to two moving side-walls that help pulling the sand/silicone layer-cake. Two end-member sets of models have been performed, based on the relative length of the two mobile side-walls: a) the two side-walls are of the same length and rifting is produced along a line parallel to the pulled wall, joining the tip of the side-walls; and b) the two side-walls have different lengths and, thus, an oblique rifting is produced. In the latter case, weak seeds in the brittle mantle are used to impose segmented boundaries. During extension loose sand has been poured at regular time intervals to simulate syn-rift sedimentation.

Laser scanning of the top surface has been performed at regular time intervals so as to monitor the surface faulting in the rift zone. At the end of extension (typically 12-20 cm), the models have been frozen and cut into vertical serial slices, so as to analyse the fault geometry in the volume unaffected by side-wall shearing, and to study the eventual 3D variations imposed in the model set-up.

The results show pure shear affecting the ductile mantle lithosphere, in the initial stages, which is subsequently followed by a necking of the ductile lithospheric mantle and lower crust that join together, following the sharp breakup of the brittle mantle. A simple shear deformation, typically dominated by one major extensional fault that soles out into the underlying ductile unit, characterizes the brittle upper layer. Typically, some degree of asymmetry in the fault system and in the sedimentary basin is observed in the brittle upper layer. Limited portions of weaker brittle mantle appear quite effective in localizing the main ductile mantle deformation, imposing the large-scale geometry of the rift system. Lateral heterogeneity in the viscosity of the lower crust, on the other hand, affects the faulting of the overlying brittle layer, and may promote some degree of asymmetry in the rift fault patterns.

GEO3-2 Orale Brozzetti, Francesco

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QUATERNARY LANF-DRIVEN EXTENSION IN NORTHERN CALABRIA:

THE CASE OF THE CRATI GRABEN

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Key terms: Calabrian Arc; Seismic lines interpretation; Extensional tectonics; Lanfs

During the last two decades, extensional systems driven by low angle normal faults (LANFs) have been progressively documented in the westerly part of the Italian peninsula (western Tuscany, Umbria and Campania-Lucania Apennines). In western Calabria (Ver-bicaro-San-Donato and Coastal Range areas), LANFs have been recently invoked by several authors to explain the omission of entire units from the orogenic pile; there is not agreement instead, about their attitude and time of activity. In this work we present the sur-face and deep geophysical evidence of an east-dipping LANF outcropping along the east side of the Calabria Coastal Range and bounding westward the Crati valley graben (CVB). This LANF, here named North Calabria Detachment Fault (NCDF), has as surface expression the NS-striking S. Fili - S.Marco Argentano fault and the NNE-SSW-striking S. Sosti-Saracena fault. Both these regional lineaments are well known in their outcrop features, the timing of activity and their kinematics. Nevertheless no literature data exist on their subsurface geometry and on the cross-cut relationships with the antithetical west-dipping faults dissecting the inner slope of the Sila massif.

We reconstructed the trajectory at depth of the NCDF and the geometry of the CVB through the interpretation of three commercial reflection lines (acquired by the Fiat RIMI - in the Esaro Permit) recently made public by the V.I.D.E.P.I. project (unmig.sviluppo-economico.gov.it/videpi). In particular, two WE-striking transversal lines and a longitudinal NS-striking line have been interpreted and depth-converted down to 3 sec TWT (corresponding to nearly 6 km depth). Our geological interpretation suggests that the NCDF is a regional east-dipping detachment fault characterized by a marked down-dip staircase trajectory. The NCDF outcrops at a dip-angle comprised between 30° and 40° which rapidly decrease to <15°. This shallow flat, 1 to 2 km depth, passes downward to a 40°-dipping ramp located just to the west of the present alluvial plain of the Crati river (2 to 4 km depth). The deepest detectable segment of the fault shows a dip-angle of nearly 25° which corresponds to the average value for the NCDF. The studied seismic sections clearly show that the CVB is a wide graben structure developed within the hanging wall of the NCDF and that it is split by a complex set of conjugate west-dipping and east-dipping high-angle normal faults, splaying from the basal detachment.

Some of these splays influenced the syntectonic sedimentation and caused growth and tilt-ing of the clastic fill. The analysis of these effects on the recognized seismostratigraphic units allow to define the order of nucleation of the major splay faults even if their accurate timing is hindered by the lack of calibration boreholes.

A detailed surface mapping and a comparison with other public and well calibrated seismic lines in the northern Crati Valley, have been performed to constrain our stratigraphic interpretation. Among the synthetic splays of the NCDF, the Torano-Roggiano-Firmo and the Mongrassano Scalo - Ferramonte faults show evidence of Late-Quaternary activity. The Bisignano-Luzzi antithetical fault shows also a great importance on the geometry of the CVB infill during the Calabrian.

A balanced geological section, elaborated through the Move Software (Midland Valley Package), allowed us to verify that our interpretation is restorable at the pre-extensional stage and that the minimum displacement occurred on the detachment during the Quaternary amounts to 4,5 km. The NCDF assumes the role of a first-order, probably active, ex-tensional feature of the southern Apennines and its recognition suggest new perspectives for a review of the geological and seismo-tectonic setting of the Calabrian arc.

GEO3-3 Orale Civile, Dario

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CRUSTAL ARCHITECTURE AND BASIN DEVELOPMENT ALONG THE SCOTIA-ANTARCTICA PLATE BOUNDARY

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Key terms: South Scotia Sea; Conjugate margins; Structural setting; Tectonic development

The Scotia-Antarctica plate boundary is a complex margin that juxtaposes thinned continental and transitional crust elements, separated by restricted oceanic basins and deep troughs, some of them representing pull-apart basins. The blocks, once adjacent each others, were part of the continental link between the southern South America and the Antarctic Peninsula, and are now distributed along the periphery of the Scotia Sea. They have been severely deformed and stretched during the tectonic processes responsible for the Scotia Sea formation, initiated in the late Oligocene. This was particularly relevant along the southern margin of the nascent Scotia Sea, where intense strike-slip tectonism was active since its early development. The E-W trending South Scotia Ridge hosts part of the plate boundary, and is composed by a series of submarine elevations (Terror Rise, Pirie Bank, Bruce Bank, Discovery Bank and Herdman Bank), some of them separated by small basins (Protector, Dove and Scan basins). East of the Discovery Bank, the boundary of the Scotia Sea is structurally much less constrained because of the paucity of geophysical and geological data, and its inherent complexity, as seen from satellite-derived bathymetric maps. Geophysical data have shown that before South America-Antarctic Peninsula break-up, the most probable candidate for the conjugate margin of Tierra del Fuego is the Terror Rise, an elevated topographic rise now located just to the north of the western part of the South Scotia Ridge, and possibly the Ona Rise, a morphological elevation that lies just to the west of the Terror Rise. The southern boundary of the Scotia Sea became the left-lateral Scotia-Antarctica plate boundary since the early development of the oceanic plate.

A compilation and reappraisal of available multichannel seismic profiles acquired along the southern margin of the Scotia Sea has allowed identifying and mapping the main morphological and structural features of this segment of the plate boundary. In general, data show that the complex style of deformation of the South Scotia Ridge was generated by the combination and superposition of several transcurent and compressional tectonic events. We propose here an evolutionary sketch for this margin, dominated since the Early Miocene by the northward

subduction of the Weddell Sea oceanic crust and by prevalent transcurrent motion between the two principal South America and Antarctic landmasses.

GEO3-4 Orale Ferranti, Luigi

10.1474/Epitome.04.1150.Geoitalia2011

ACTIVE SHORTENING IN THE SOUTHERN TARANTO GULF, SOUTHERN ITALY: RESULTS FROM THE TEATICOA_11 CRUISE.

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Key terms: Marine Geophysics; Active tectonics; Taranto Gulf

In this contribution we illustrate the preliminary results of the Teaticoa_11 cruise carried in the southern Taranto Gulf and aimed at investigation of recent faults. Within this sector of the Apennines, studies on-land documented recent and unsuspected transpression (Ferranti et al., 2009), but identification of active faults is difficult because most are located offshore. Although major transcurrent faults were previously recognized offshore (Del Ben et al., 2007), their recent tectonic history is yet obscure. The investigated area displays a ridge-basin pattern, characterized by the Amendolara bathymetric high, bordered on the south by a steep scarp and by the elongated Sibari basin.

High-resolution multibeam data allowed to locate with great confidence the major tectonic structures, and to scrutiny evidence of sea bottom ruptures and gravitational effects. Widely distributed mass-movements are represented both by large-sized scars along the major fault-line scarps, and by sediment collapse above gliding horizons located on tilted strata. Terraced surfaces were mapped on the summit of the bank, and can be correlated to glacial-stage position of the sea-level, the counterparts of the interglacial terraces exposed on-land. Preliminary evaluation of the inferred undersea terraces age indicate limited regional uplift, and deformation related to local active structures.

High-resolution sparker profiles across the mapped structures provided vital insights to unravel their recent history. The stratigraphic signature of deep fault activity is recorded by depositional sequences within satellite basins and on the flanks of submarine ridges, and is represented by debris flows, growth fans and forced shift of depoaxes. This activity interlaces with the effects of regional processes, expressed by the vertical stacking of highstand and lowstand system tracts and generated by the interplay between tectonic uplift and global sea-level fluctuations. The Late Quaternary depositional packages appear folded up to the recentmost one, including the basal unconformity of the last glacial sequence. In addition, thick landslide bodies (already evidenced in the study of Rebescio et al., 2008) were imaged in great detail. The distinctive structural and stratigraphic features imaged by the sparker profiles are corroborated by high-resolution CHIRP profiles, which have locally evidenced offset of the near-bottom reflectors.

The pattern emerging from the integrated data analysis supports the contention that the Amendolara ridge is a composite fault-propagation fold limited to the south by a major south-displacing transpressional system. The ~60 km long system is arranged in at least four segments limiting as many morpho-bathymetric highs. In the central part of the system, a fault scarp rupture is mapped at the sea-bottom. Appraisal of publicly available multi-channel seismic reflection profiles indicate that the mapped structures are the shallow-crustal expression of steep transpressional faults, which emanate from underneath the Apulian platform and cut the thin-skin Apennine belt. Based on the size of fault segments and the modeled depth of micro-seismicity, we argue that the Amendolara deformation belt may incorporate the source of moderate-sized historical earthquakes (e.g. 1836). Active seismogenic and/or creep faulting and fold growth controls the near-sea bottom slumping and creeping and possibly prehistoric catastrophic landsliding.

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GEO3-5 Orale Mosca, Pietro

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THE MAIN CENTRAL THRUST ZONE BETWEEN THE ROLWALING AND KHUMBU HIMAL (EAST-CENTRAL NEPAL)

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Key terms: Himalayas; Main Central Thrust Zone; shear zone

The Main Central Thrust Zone (MCTZ) is one of the most intriguing and long-time discussed geological features of the Himalayas (e.g. Searle et al. 2008, for a discussion). It is a crustal scale shear zone several km-thick, extending along strike all along the Himalayas and marking the juxtaposition of the high-grade Greater Himalayan Sequence (GHS) over the low- to medium-grade Lesser Himalaya Sequence (LHS). In the geologic literature, a common definition, location and kinematic interpretation of the MCTZ is still lacking.

During autumn 2010, in the framework of a collaboration with Ev-K2-CNR and the Nepal Academy of Science and Technology, new structural and petrographic data were collected, and field mapping was performed, in the MCTZ along an east-west trending cross section in the Rolwaling and Khumbu Himal (east-central Nepal) from the villages of Lukla to Jiri, in an area still poorly known from the geological point of view.

At a regional scale, the structural setting of the investigated area is

dominated by north-dipping composite foliations, parallel to the lithological contacts or the compositional banding. The MCTZ has been identified as a several km-thick shear zone characterized by mylonites, mesoscopic shear zones and tectonic slices. These slivers comprise a number of different lithologies: augen-gneiss, two-micas paragneiss and micaschist, slate, quartzite, pure and impure marble, Ca-silicate fels. No sharp structural breaks can be clearly mapped at the boundaries of the MCTZ. However, the upper portions of the MCTZ can be roughly envisaged in the Poyan area, about 5 km south of Lukla, where mylonitic biotitic orthogneiss occurs structurally below the garnet + K-feldspar + kyanite + sillimanite Barun gneiss of the GHS. The lower portions of the MCTZ are underlined by strongly deformed two-micas augen-gneiss outcropping in the Karikhola area, about 10 km south of Lukla, above biotite-bearing phyllites of the LHS; these peculiar gneiss are reported in the literature as the Paphlu augen-gneiss (Maruo & Kizaki, 1981). In the MCTZ, the abundant kinematic indicators record a consistent top-to-south sense of shear.

The results of this study can be usefully compared with additional data collected further eastward (e.g. Goscombe et al., 2006; Searle, 2008; Mosca et al., 2010) and discussed in the regional tectonic scenario of the central-eastern Himalaya.

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GEO3-6 Orale Iacopini, David

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SEISMIC DAMAGE ZONES AND THEIR IMPACT ON DEEPWATER STRUCTURE CHARACTERIZATION

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Key terms: fold-thrust structures;; 3-D seismic interpretation; deformation localization; seismic imaging

In recent years the advent of 3D seismic data as a research tool has been a major factor in our understanding thrust faults, normal fault propagation and linkage. Thanks to the new 3D migration algorithms, extreme advances on describing the real 3D geometry and relationship between thrust fault and folds associated with gravity driven deformation has been done. The well accepted classes of structures (eg. fault bent folds, trishear faults and detachment folds;) mainly based on cross sectional geometry either derived by exposed section or from 2D seismic profiles resulted unsatisfactory on describing the full 3D geometry and the three dimensional evolution of thrust related folds. Measurements of growth sequence and detailed fault plane geometry from 3D seismic data illustrate a great variability along strike of the internal geometry that cannot be fully represented by any of the existing models. A direct consequence of those new 3D models is a better characterization of the toe-thrust traps geometry and more complicated constrain into sequential restoration of 3D thrust structures. However there is still poor understanding of the internal architecture of the thrust and fault zones especially within deep water environment, that even where seismic data are excellent they still are conventionally and routinely defined by breaks and apparent offsets of seismic reflectors. As clearly indicated by outcrops and by detailed seismic image processing these descriptions are not satisfactory and they miss to identify position of thrusts, their associated splay and the zones of damaged wall rocks. The main reasons were partly due to the poor seismic resolution failing to detail objects within the resolution of these complexities but also to a simplified geometrical assumption by the interpreter during the migration process that do not take into account the complexity systematically observed in analogue outcrop studies. This is specifically true when we are dealing with exceptionally good seismic datasets where details can be analyzed at different scale and complex fault or thrust geometry can be visualized. In order to improve our understanding of such complexities and investigate the geological meaning of that low signal to noise zones in different context, various images processing workflow using combination of seismic attributes has been recently proposed. Those studies highlight and extract potential geological information from the systematic signal distortion around fault, thrust, and steep fold limb. This disturbed area has been called fault seismic distortion zones or more generally seismic damage zones. Part of those disturbed zones is clearly associated to deformation complexities associated with fault thrust and fold, other to imaging problem due to the presence of geometrical complication around the fault and folds. We stress and show that in various situations the two different sources can be reasonably distinguished by developing specific workflows or seismic imaging surgery. At a larger scale the main faults thrust and damage imaged clearly shows a branched and dendritic architecture, with interconnected double verging thrusts. In both the time-dip and coherence map the main fault structures appear as bands defined by a patchwork of small curvilinear discontinuities and non rotated but disrupted reflections. Concluding, seismic damaged zones store more information than simple reflector disruption or incoherent noise. In those specific cases obtaining detailed information on the real geometrical properties of fault systems developing post stack signal processing (or attributes generation) to fine tune the imaging of the main structural features can be critical for the geometry prediction within scenario of hydrocarbon exploration as well as for reconnaissance of seismogenetic structures in submarine seismically active margin.

GEO3-7 Orale Bonini, Lorenzo

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THE INVESTIGATION OF SEISMOGENIC SOURCES THROUGH ANALOGUE MODELING: INSIGHTS FROM THE 2009 L'AQUILA EARTHQUAKE (MW 6.3, ITALY)

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Key terms: Seismogenic fault; sandbox modeling; Central Apennines

The 6 April 2009, L'Aquila earthquake (Mw 6.3) represents one of the best documented normal faulting sequences worldwide as it allows seismological, interferometric and geological data to be analyzed jointly. Nevertheless, an apparent discrepancy exists between deep and surface data. Integration of available instrumental data showed that the earthquake rupture developed on a 45° SW-dipping normal fault extending from 9-10 to 2-3 km depth (e.g. Chiarabba et al., 2009). On the one hand, field surveys highlighted surface breaks (fractures and small faults) after the earthquake near Paganica, named the Paganica Fault System (Emergeo Working Group, 2009). On the other hand, the overall pattern of coseismic deformation revealed by InSAR analyses showed an asymmetric subsiding basin with maximum vertical displacement (19-28 cm; Atzori et al., 2009) falling halfway between the city of L'Aquila and the village of Fossa, 5 km from the Paganica Fault. In order to identify a faulting process compatible with all these data, in particular with the dynamic rupture cut-off at 2-3 km depth and with the surface breaks (InSAR data and surface ruptures), we tested two different hypotheses using the sandbox modeling technique: 1) a seismogenic fault that reaches the surface (direct fault propagation model); 2) a blind seismogenic source extending between 2-3 and 9-10 km that does not reach the surface (blind seismogenic source model).

We selected a modeling technique commonly employed to simulate upper crustal rocks. All models are scaled 1:100,000. We used a new apparatus designed to reproduce the deformation associated with an earthquake occurring in the uppermost crust, and that occurs specifically above the seismicity cut-off. In the first model the master fault was free to propagate towards the surface from its seismological tip point. The experiment showed that a synthetic fault propagated upward from the upper tip of the modeled seismogenic source with a dip of 70°. In this case, the associated subsiding basin was asymmetric, its depocenter being located along the emerging fault plane. We therefore obtained a typical basin-bounding normal fault. In the second model we prevented the fault from propagating upward by introducing an artificial barrier to simulate the buried top of the master fault. This allowed us to evaluate if and how rocks located above the dynamic rupture can experience secondary brittle deformation. The results showed the formation of secondary extensional faults located on the fold that develops above the upper tip of the master fault, where horizontal tensile stress is maximum. These faults are not directly connected with the deeper master fault, and in this case the depocenter of the basin is located about 5 cm (i.e. 5 km in nature) away from the surface faults.

A comparison of our results with geological observations shows that, even though the causative fault of the 2009 L'Aquila earthquake did not reach the surface, for instance because according to seismological data dynamic rupture stopped at 2-3 km, motion on the Paganica Fault System may indeed occur, either on a pre-existing fault reactivated for its favorable orientation, or on secondary structures related to the fold above the upper tip of the master fault, which is in turn coseismically deformed. These two observations are consistent with the InSAR-detected coseismic deformation.

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GEO3-8 Orale Zanferrari, Adriano

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PROPAGATION OF THE IDRİJA STRIKE-SLIP FAULT SYSTEM IN FRIULI (WESTERN JULIAN ALPS AND CARNIA REGION, NE ITALY): PRELIMINARY REPORT.ZANFERRARI Adriano¹; POLI Eliana¹

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Presenter e-mail: adriano.zanferrari@uniud.it**Key terms: Idrija fault system; strike-slips faulting; seismotectonics; eastern Southern Alps; NE Italy**

The NW-SE trending, dextral strike-slip Idrija fault system is a Neogene to Quaternary seismogenic structural network, extending from W-Slovenia to NE Italy. Its activation is linked to the N-directed motion of Africa vs. Europe, coupled with a counter-clockwise rotation of the Adria microplate. Structural characteristics, kinematics and seismogenic activity are well known in western Slovenia. On the contrary in the Friuli region the lack of updated geological and structural data, till now prevented a correct mapping of the fault trace. Detailed geological mapping (1:5,000) carried out in the framework of the 049 "Gemona del Friuli" geological sheet (Italian CARG Project), enabled to define the geometric and structural characteristics of the Idrija fault system in the Friuli-Carnia area too. The dextral strike-slip fault-system, (that here presents a WNW-ESE trending, and was mapped for about sixty kilometres), causes contractional and extensional bends, duplexes and positive and negative flowers. Both Paleogene Dinaric and Neogene-Quaternary Southalpine thrusts are cut by the Idrija strike-slip system. The neotectonic activity of the fault system is demonstrated by: 1) deformation of Pliocene to Middle Pleistocene continental successions; 2) morphotectonic evidence; 3) historical and instrumental seismicity that hit Carnia. Earthquakes recorded by the Friuli Venezia Giulia seismometric network, managed by the O.G.S.-Trieste (Seismological Research Dept.), show WNW-ESE dextral strike-slip focal mechanisms; 4) the coseismic deformations recorded by the topographic high precision survey performed after the M=6.4 and M=6.1, 1976 Friuli earthquakes, that may be now linked to the present activity of the Idrija fault system in the Tolmezzo-Venezzone area. On the basis of the new geological and structural mapping, and on the available morphotectonic data related to the surficial expressions of the active faults, we will afterwards try to define geometric and kinematic characteristics of the seismogenic faulting which affect this portion of the eastern Southern Alps, giving a new contribution for the definition of the seismic hazard of this region.

GEO3-9 Orale Pennino, Valentina

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RELATIONSHIP BETWEEN NEOTECTONICS AND FLUID ESCAPING IN THE NORTHERN SICILIAN CONTINENTAL MARGINPENNINO Valentina¹; SULLI Attilio¹

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Presenter e-mail: valentinapennino@unipa.it**Key terms: Neotectonics; Fluid escape; Pockmark; Mound; Seismicity**

New exploration in the marine environments has revealed that the fluid escape structures are often associated with neotectonic elements and are aligned along the same direction. Sometimes is observed the migration of fluid along fault planes to the sea floor as gas venting (Forrest et al., 2005).

This paper aims to recognize and to classify the different types of structures associated with fluid seepage, particularly those that develop along alignments coinciding with or parallel to the neotectonic lineaments, in order to assess the interactions between tectonics and fluid circulation. The study area extends, from west to east, from the Gulf of Castellammare to the Gulf of Termini (offshore northern Sicily), and belongs to the northern Sicily continental margin, in the transitional area between the Sicilian-Maghrebian Chain to the south and the southern Tyrrhenian Sea to the north.

Previous morphostructural studies identified a wide W-E trending right-lateral shear zone, mainly characterized by both a synthetic NW-SE/W-E trending, and antithetic left-lateral N-S/NE-SW fault systems, which affected the tectonic edifice, since the Pliocene (Giunta et al., 2009), while the current seismicity shows compressional focal mechanisms aligned to the NW-SE and ENE-WSW trends, in agreement with axis of maximum horizontal compression oriented NW-SE (Neri et al., 2003).

We used a dataset of seismic reflection profiles, both high and very high resolution single-channel and multi-channel profiles, acquired respectively with CHIRP, sparker and airgun sources, and high resolution morphobathymetric data acquired down to 2200 m, in relation to the MaGIC project (Marine Geohazards along the Italian Coasts).

The data allowed us to distinguish three different types of fluid escape structures by means of highly contrasting seismic and morphological signatures. In particular, mounds and buried mounds have been recognized in the continental shelf, while pockmarks occur in the continental slope; the latter are often found to be aligned in this area. Two fault systems have been recognized: a NW-SE trending extensional and/or transtensional system, which produces the recent articulation of the seabed, and an ENE-WSW trending compressive, which contributed to the formation of morphological relieves.

The seismicity of the area confirms the recent activity of both the systems, because the clusters of earthquakes of 1998, 2002 and the most recent until 2011 (<http://www.ingv.it>), are aligned with the recognized tectonic structures, and have focal mechanisms with major compression horizontal axis oriented NW-SE, compatible with the orientation of the tectonic lineaments.

The identification of fluid escape structures, aligned with the neotectonic lineaments and with the clusters of earthquakes, allows us to hypothesize the relationship between the circulation of fluids and faults, the latter being preferential pathways for the rapid ascent of the fluid towards the surface.

Moreover, the recent seismic activity indicates that the recognized neotectonic structures, respectively oriented NW-SE and ENE-WSW, are active and especially seismogenic structures.

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GEO3-10 Poster Carosi, Rodolfo

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TECTONIC DISCONTINUITIES IN THE GREATER HIMALAYAN SEQUENCE OF THE HIMALAYAN BELTCAROSI Rodolfo¹; MONTOMOLI Chiara¹; VISONÀ Dario²

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The Himalayan belt has a spectacular continuity for more than 2000 km. In spite of the fact that the main tectonic units building up the chain can be recognized all along the belt, detailed structural analyses performed during the last years (CAROSI ET AL., 2006, 2007, 2010) pointed out that the Greater Himalayan Sequence (GHS) presents important tectonic discontinuities at the regional scale.

These shear zones, mainly located in the core of the crystalline units, triggered exhumation of the crystalline rocks during the collisional phase. A high-temperature contractional shear zone with a top-to-the SW sense of shear affects the core of the Greater Himalayan Sequence (GHS) in western Nepal. The shear zone developed during the decompression (sillimanite stability field) of rocks that previously underwent relatively high-pressure metamorphism (kyanite stability field). PT conditions indicate that the footwall experienced higher pressure than the hanging wall and similar temperatures. This indicates that the shear zone developed during contractional tectonics, allowing the upward movement of the hanging wall whereas the footwall continued to be underthrust. Monazite growth constrains the initial activity of the shear zone at 25.8±0.3 Ma, before the onset of the Main Central Thrust zone. The late intrusion of a cross-cutting granitic dyke limits its final activity (17±0.2). Monazites in kyanite-bearing gneisses from the footwall record prograde metamorphism in the Greater Himalayan Sequence from ~43 to 33 Ma. These data suggest that exhumation of the GHS started earlier in western Nepal than in other portions of the belt and before the activity of both the South Tibetan Detachment System (BURCHFIEL ET AL., 1992; CAROSI ET AL., 1998, 2002) and Main Central Thrust zone (SEARLE ET AL., 2008 and references therein).

As a consequence, western Nepal represents a key area where channel flow driven mechanism of exhumation, which is active from Bhutan to central-eastern Nepal, does terminate. In this area, exhumation of crystalline units likely occurred by foreland propagation of ductile, and subsequently, brittle deformation.

Since the shear zone started to move during the underthrusting of the GHS it changed the fate of the hanging wall rocks that were the first to be exhumed: they inverted their displacement starting to move upward and southward. It is worth noting that by activation of the shear zone and before MCT movement, the footwall rocks continued to be underthrust

reaching higher pressures with respect to hanging wall rocks. This stage was followed by the overall exhumation of the GHS. As a consequence different P-T-t paths are obtained for footwall and hanging wall rocks, being the main difference the maximum pressure reached. Considering only the P-T-t paths, without the exact deformation path of the rocks or, at least, the geometry and kinematic indicators in mylonites, we could erroneously interpret the shear zone as a normal sense shear zone (in contrast to the movement indicated by kinematic indicators in the mylonites). A main consequence, from this case study, is that interpreting the sense of movement of tectonic structures having only the P-T-t paths may lead to erroneous interpretations.

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GEO3-11 Poster Federico, Laura

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TRANSCURRENT TECTONICS IN THE NORTH-WESTERN SECTOR OF THE VOLTRI MASSIF: INSIGHT FROM FAULT-SLIP ANALYSIS

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Key terms: fault-slip analysis; paleostress; fault zone; Voltri Massif; Western Alps

We studied the brittle structures occurring in the northwestern sector of the metaophiolitic Voltri Massif (Western Ligurian Alps), with the aim to characterise the kinematics and evolution of a poorly-known tectonic lineament, i.e. "Pra' Vallarino - Tiglieto" (Martinis & Pasquare, 1971) and its role in the tertiary evolution of the area.

This fault zone is largely developed inside HP serpentinite in its central-eastern part, whereas it represents the contact between bedrock and post-orogenic Oligocene deposits of the Tertiary Piedmont Basin (TPB) in its western part. Some of the studied faults crosscut basal deposits of the TPB, and therefore can be relatively dated to be post-Lower Oligocene. This study couples structural analysis of fault zones with analysis of tectonic lineaments from aerial photographs and paleostress determinations by means of inversion of fault-slip data.

Fieldwork revealed that this lineament is actually the sum of different fault segments, with a dominant transcurrent character but changing orientations. They are accompanied by the development of wide fault zones, (locally hundred meters wide) and huge amounts of fault rocks, (mostly crush breccia and cataclaste, according to Sibson, 1977). In the central part of the study area (between Pra' Vallarino and Acquabona) faults are dominantly E-W or WNW-ESE trending and steeply dipping, whereas they move to NE-SW trends at the western and eastern terminations (near the villages of Sassello and Tiglieto, respectively). According to field relationships, faults have been grouped into different Riedel systems (either left-hand or right-hand) that allow to obtain a first-order determination of orientation of paleostress axes. The reconstruction of paleostress tensors is then refined coupling field observations with different methods of inversion of fault-slip data and using different open-source computer programs (Faultkin 4.3.5 and Fsa), that calculate either P-B-T axes or resolved stress tensors. This approach is able to distinguish different superposed stress tensors and therefore is especially useful to unravel a polyphase deformation pattern like the one we studied.

We therefore identified strike-slip and oblique-slip stress tensors with σ_1 oriented either NW-SE or NE-SW, linked to left-hand or right-hand strike-slip systems.

Overprinting relationships between these two events are still under investigation, but regional studies (e.g. Capponi et al., 2009; Crispini et al., 2009) suggest a possible correlation of the stress field with

NE-SW-trending σ_1 with a Late Oligocene-Early Miocene tectonic phase, as defined by Mutti et al., 1995 ("Fase Ligure III") which displays NE-SW shortening.

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GEO3-12 Poster Mosca, Pietro

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THE "ÉCAILLES INTERMÉDIAIRES" OF THE RIO SECCO-CLARÉE VALLEY AND COL LONGET (WESTERN ALPS)

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Key terms: tectonic slices; Ultrabriançonnais; breccias

In the western Alps, a series of discontinuous tectonic slices reported in literature as "écaillies intermédiaires" (EI) locally outcrop along the contact between Piedmont and Briançonnais units. In general, these slices consist of pre-Tertiary basement rocks and/or thin Mesozoic cover sequences of Ultrabriançonnais (or Acegllo) affinity, showing then an almost complete erosion of Triassic platform carbonates by transgressive Upper Jurassic deposits (e.g. Lemoine, 1961).

This paper describes the structural-geological features of the EI outcropping in the Rio Secco-Clarée Valley (north of Montgenèvre, high Susa Valley) and Col Longet (high Ubaye Valley) areas. In the Rio Secco-Clarée Valley area, the Chaberton-Grand Hoche unit of Piedmont affinity is over a tectonic unit formed by a pre-Tertiary

basement and its Permo-Mesozoic cover along a major thrust plane, folded and cross-cut by N-S trending strike-slip faults. The basement consists of polymetamorphic quartz-micaschists, monometamorphic micaschists and orthogneisses showing a pervasive blueschist-greenschist facies metamorphic imprint of Alpine age. The lower portions of the metamorphic cover sequence are Permian to Lower Triassic quartzites with diffuse pink quartz pebbles and intercalated red shales (Pseudoverrucano facies), upward followed by Scythian quartzites and by rare platform carbonates considered Middle Triassic in age (Barfety et al., 1995). The upper portions of the cover sequence consist of heterogeneous detrital calcschists and marbles with intercalations of breccias, and a peculiar conglomeratic micaschist ("Permien reconstitué" of literature); clasts of these levels are made of Triassic carbonates, Permo-Triassic quartzites and basement rocks, and have sizes ranging from mm to cm. These chaotic deposits rest unconformably above both the basement rocks and the lower terms of the cover sequence and their age ranges from Late Jurassic to Cretaceous-Eocene? (Barfety et al., 1995).

In the investigated sectors near Col Longet, a few hundred meters-thick succession of megabreccias crops out between Piedmont and Briançonnais units. Breccias have sub-angular clasts and blocks up to dam-sized, made up of material dismantled from the adjacent Briançonnais units (micaschists, quartzites and carbonates) and deposited on marine environments (Lemoine, 1967). The megabreccias fade upwards into gray marbles, which are tentatively considered Late Cretaceous in age on the basis of regional correlations.

The most striking feature of the investigated tectonic units is therefore the occurrence of Upper Jurassic to Cretaceous levels dominated by huge breccias; the sub-angular aspect of clasts and blocks suggests rock fall processes with short distance transport. In addition, the EI exposed in the Rio Secco-Clarée Valley area show an almost complete erosion of Triassic platform deposits, conversely reaching several hundred-meters in the adjacent Briançonnais units. The tectono-depositional evolution of the investigated EI is presented and discussed within the regional tectonic scenario of the western Alps, pointing emphasis on the syn- and post-rift extension occurring along the continental margin.

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GEO3-13 Poster Toscani, Giovanni

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EARLY DATA FROM FIELD SURVEYING IN THE VENTIMIGLIA AREA: STRATIGRAPHIC AND TECTONIC CHARACTERS FROM RISKINAT INTERREG PROJECT.

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Key terms: Dauphinois; Thrust; Ventimiglia

Since 2010, an extensive field-work has been performed north of Ventimiglia (IM) by the Pavia University surveyors of the Dipartimento di Scienze della Terra e dell'Ambiente for the Riskinat-Interreg project (Pavia Unit Resp. Prof. S. Senò) in collaboration with Regione Liguria (Resp. Dott. G. Gorziglia). The investigated area is constituted by a thick Dauphinois succession of sedimentary rocks. The post-Cretaceous Dauphinois units near the boundary between Italy and France are formed by a well-known succession: the "Priabonian trilogy". It is formed by rocks that deposited in the Alpine underfilled peripheral foreland basin. A thick succession of Cretaceous marly limestones (Calcari e calcari marmosi di Trucco) forms the pre-Cenozoic basement, top-bound by a regional unconformity (mostly an angular unconformity with rarer paraconcordance evidences) sealing up late Cretaceous and Paleocene deposits. The following transgression caused the deposition of marine-continental transitional deposits (conglomerates, sandstones and marls of the Microcodium Formation) during the Early Eocene. The vertical evolution of these deposits in the developing Alpine foreland basin is represented by the nummulitic limestones and calcarenites of the Calcareniti di Capo member, belonging to a shallow platform environment (about few to a hundred meters depth). The deepening trend bring to the sedimentation of marls and pelites of Marne di Olivetta San Michele Formation and finally to the turbidite sandstones of the Ventimiglia Flysch (corresponding to the Italian sub-basin deposit of the Gres d'Annot turbidite system).

The field mapping of the study area evidenced the presence of a kilometric thrust (Abellio thrust) that juxtaposes two tectonic elements made up by the same, above described Cretaceous-Eocene succession. The units has been informally named "M. Terca unit" (the upper) and "Rojà unit" (the lower). The thrust is roughly NNE-SSW oriented; the amount of west-transport of the M. Terca unit is probably limited but significantly diminishes toward the South. This assumption is supported by observing the amplitude and geometry of the associated drag folds. The thrust is interrupted by a lateral ramp located northward near the M. Gouta area and reaches the coast near Ventimiglia toward the South. The geometry of the thrust has been also reconstructed through digital modelling in order to understand the real implications of its anticlockwise rotation. The Abellio thrust has been tentatively dated as Late Oligocene-Early Miocene, when the north-west Alpine compressive thrust fronts propagated in the Helvetic-Dauphinois zone. Interesting implications may come from its position, as the Abellio thrust could be considered the southernmost onland structure affecting the Dauphinois succession. Its transport was probably also influenced by the interactions between the complex geometry of dispersal blocks that followed the rifting of Greater Iberia (causing the anticlockwise rotation of the Corsica-Sardinia) and the Alpine-Apennine orogens.

GEO3-14 Poster Perrone, Gianluigi

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DIFFERENTIAL UPLIFT IN THE CENTRAL WESTERN ALPS (ITALY) AS DERIVED BY PERMANENT SCATTERERS (PS-INSAR™) DATA: A NEW CONSTRAINT FOR ITS CURRENT TECTONIC ACTIVITY

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Key terms: uplift; Western Alps; interferometry; faults; tectonic activity

In this work we integrated and compared structural geology, geomorphology, quaternary geology with Permanent Scatterers data, in order to constrain the current tectonic activity of the central Western Alps, where evidences of superficial deformation are scarce.

The study area is characterized by low deformation rate, as attested by the low magnitude of the instrumental seismicity (Eva et al., 1997; Perrone et al., 2010; in press) and by the GPS data (Calais et al., 2002). Nevertheless some moderate historical seismic events, like those of the 1808 seismic sequence, struck this area.

Continuous velocity surface maps (Iso-Kinematic Maps: IKM; Morelli et al., 2011) obtained from geo-statistical and spatial cluster techniques (Hot Spot analysis) of PS were compared with geological model.

The comparison of the IKM with the fault pattern shows a rough correspondence with some of the regional brittle tectonic features that dissect this part of the Alpine chain. In particular isokinematic boundaries show a correspondence with the Lis-Trana Deformation Zone (Balestro et al., 2009; Perrone et al., 2010) and the southern prolongation of the Canavese Line, in the innermost part of the chain, and with the Longitudinal Fault system (Sue and Tricart, 2003) in the external sector. The correspondence between the trace of the brittle tectonic features and the isokinematic boundaries may represent a further constrain for the current activity of the regional fault systems dissecting this sector of the western Alpine Chain.

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GEO3-15 Poster Vaselli, Luca

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AN INTEGRATED STRUCTURAL AND GRAVIMETRIC APPROACH FOR THE SUBSURFACE GEOLOGY DEFINITION OF THE MONSUMMANO-MONTECATINI AREA (TUSCANY, ITALY)

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Key terms: Northern Apennines; structural analysis; gravity interpretation; subsurface geological mapping

Commonly complex structural settings characterize transition zones between basin and belt areas. In this scenario a multidisciplinary approach is the most suitable to reconstruct subsurface geological structures.

The case study concerns the Monsummano-Montecatini area, located in north-central Tuscany, where part of the Northern Apennines structural stacking (Tuscan Nappe and Ligurian Units) crops out at the margin with the Montecarlo basin.

In this contribution we present the results of a multidisciplinary study targeted to the definition of the overall outcropping and subsurface structures of the Monsummano-Montecatini area. Data from structural-geological survey, aerial photo interpretation and analysis of brittle structures have been integrated with the results of a gravimetry survey used to map the subsurface distribution of rock density.

In particular a structural analysis aimed to the definition of geometry and kinematics of the occurring brittle structures (faults and joints) has been performed in several measurement stations especially located in the Tuscan Nappe carbonate succession of Monsummano-Montecatini area and Marliana area, about 5 km north of Montecatini. The elaboration of the collected data allowed the identification of two main populations of high-angle discontinuities oriented respectively roughly NE-SW and NW-SE. The kinematic analysis indicates that brittle tectonics is characterized by a polyphase evolution with the superposition of normal and/or oblique-normal movements on strike-slip movements.

The gravimetric survey has been carried out in a 25 km² area including Monsummano and Montecatini ridges as well as the Monsummano plain. The Bouguer anomaly map is characterized by the occurrence of a positive gradient, trending from NE-SW in the eastern sector to N-S in the western sector of the map. The horizontal gradient-gravity map allows to identify some discontinuities whose trends correspond to major faults evidenced by the structural-geological study.

Modelling of gravity anomalies along three selected profiles, crossing NE-SW, N-S and WNW-ESE the investigated area, fit with height main gravimetric bodies characterized by weak density differences.

On the basis of the results of the structural-geological study and the gravimetric modelling, three geological cross-sections have been realized, allowing the interpretation of the subsurface geological structure of Monsummano plain and Monsummano-Montecatini ridge up to a depth of about 1-1,5 km. These cross-sections have been also constrained with available well data and other geophysical information.

The main structural feature is represented by a complex fault system formed by main faults oriented respectively NE-SW and NW-SE. This fault system affected the E-verging antiforms which deformed the Tuscan Nappe carbonate succession outcropping in Monsummano, Montecatini and Marliana areas, as well as the other geological units including the Neogene-Quaternary deposits filling the Monsummano plain. In particular the NE-SW directed faults cutting along the Nievole Valley determined the interposition of less permeable formations (Ligurian Units and Macigno and Scaglia formations) inside the Mesozoic carbonate succession, assuming importance for the relations between the hydrothermal systems of Monsummano and Montecatini.

In conclusion, this study allow to highlight how the integration of a detailed structural-geological analysis with a gravity survey, a not invasive geophysical method, can provide a better definition and understanding of the subsurface structure prefiguring a 3D geological model. This new insight in the structure of the Monsummano-Montecatini area will be a very useful document for planning the hydrogeological research to be undertaken in this thermal area.

GEO3-16 Poster Cadoppi, Paola

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ANALYSIS OF THE FAULT PATTERN IN THE LOWER LANZO VALLEY (ITALIAN WESTERN ALPS): A MULTI-SCALE INTEGRATED APPROACH

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Key terms: Western Alps; fault pattern; structural analysis; Lanzo Valley

This work combines morpho-structural analysis, field mapping and detailed structural analysis for the study of the fault network in the Lower Lanzo valley (Italian Western Alps), where the Sesia-Lanzo Unit and the Lanzo Ultramafic Complex crop out. At the regional scale this area is bordered by two major post-Oligocene tectonic discontinuities: the Canavese Line and the Lis-Trana Deformation Zone (Balestro et al., 2009).

Morpho-structural analysis (carried out both on satellite, Landsat 5 TM and Aster, and aerial images) allows detecting three lineament systems: Ln1 (E-W), Ln2 (NE-SW), Ln3 (NW-SE).

Ln1 system is constituted by the longest lineaments (up to 2-3 kilometres long), usually arranged to form several, sub-parallel belts that cross the whole study area.

Ln2 system is widespread in the whole study area even if the highest density of distribution is mainly observed in the northern sector of the analysed area. These lineaments are characterized by a moderate variability in terms of strike and length. Ln2 lineaments often terminate against Ln1 lineaments or, in some cases, cut them.

Ln3 system is better shown on Aster image and it consists of fewer and shorter lineaments than the others, but is evident throughout the whole area. Its lineaments often define clusters of lineaments which form sub-parallel belts that can reach a multi-kilometre length (western sector).

Field mapping and structural analysis allowed distinguishing three main fault systems striking E-W, NE-SW and NW-SE.

The E-W fault system represents the major brittle structural feature and it is constituted by E-W striking steep faults, up to few kilometres long. Slip indicators show mostly right-lateral movements and rare normal movements; overprinting relations and the rheology of fault rocks indicate that strike-slip activity pre-date extensional ones. A dextral component of displacement is also suggested by the rotation of the main syn-metamorphic foliation and the lithological contacts in the correspondence of these faults.

The NE-SW fault system is constituted by few steep fault segments, ranging from the hectometre- to kilometre-scale, with right-lateral and reverse movements. At map-scale these faults tend to link the E-W major faults.

The NW-SE fault systems is constituted by rare steep fault segments, mostly concentrated in the western part of the area; these faults show right-lateral, left-lateral and extensional movements; overprinting relations between different striae generations show that strike-slip pre-date extensional ones.

On the basis of the geometry, the hierarchical relations between different fault systems, the rheology of fault rocks and the mineralisations on fault surfaces (mainly represented by antigorite and asbestos fibers), two main faulting stages were distinguished: the first one is related to the development of major E-W right-lateral faults, at times linked by minor NE-SW and NW-SE faults, whereas the second one could be related to the extensional reactivation of the pre-existing structures.

As the orientation, the geometry and the hierarchical relations of the lineaments are very similar to those of the geological discontinuities at different scales, it is then possible to attempt to extrapolate the structural model outlined in the mapped area to the adjoining sectors of the Lower Lanzo valley.

The right-lateral movements along E-W faults, consistent with a bulk NW-SE shortening direction with a NE-SW extension, do not seem to be consistent with the dextral activity along the adjoining Canavese Line and Lis-Trana Deformation Zone (see also Perrone et al., 2010). The occurrence of E-W dextral strike-slip faults in this area may therefore raise new questions about the post-Oligocene tectonic evolution of the innermost part of the chain.

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SESSIONE GEO5

Geologia applicata

GEO5-1 Orale Tedeschi, Fabio

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CHARACTERIZATION AND ENHANCEMENT OF HISTORIC AND RECENT QUARRY SITES IN PIETRA DI FINALE (WESTERN LIGURIA)

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Key terms: Georisorsa; Pietra di Finale; Beni Culturali

This article proposes the development of an integrated geological analysis methodology for characterizing and preserving the quarry sites of Pietra di

Finale, a sedimentary mass of long-standing importance for the production of dimensional stone, situated in an area of great cultural and natural value.

The rock mass of Pietra di Finale crops out near Finale Ligure in western Liguria and covers an area of about 20 km², in the hydrographic basins of the Pora, Aquila and Sciusa torrents and fronting the sea between Capo Noli and Caprazoppa. It had its genesis in a marine-shelf depositional environment that was then subjected to continental transgression.

Pietra di Finale is a miocenic biocalciuridite of medium compacted porosity that was used over the centuries as building material and for ornamentation, both in Italy and overseas, in all its diverse colors (Chiaro, Antico, Rosa and Verzezi), corresponding to its different facies. The preservation of such a rich and diverse cultural and archeological patrimony has been aided by the gradual diminution of mining activity in recent years, but this activity has left profound marks on the landscape as it adapted to the vagaries of commercial, industrial and financial oscillations over time.

The interdisciplinary approach proposed here provides for a census of all the quarry sites and the study of their state of preservation and current ore potential for the formulation of proposals for their possible use for environmental and tourist purposes, while furnishing information for the revival of mining activity, even if only from the point of view of its possible substitution and/or restoration.

A survey of the area under consideration has identified around thirty quarry sites that can be distinguished chronologically (historic and recent) and by the extraction technique used (underground and open-pit). The historic quarry sites have, for the most part, an optimal scenic setting and sufficient stability for their total exploitation, whereas the areas of more recent extraction have often interfered with sites of archeological interest (Rocca dell'Aquila quarry) or stability of the caric morphology, causing rock falls in open-citit quarries and instability and flooding in the underground rooms.

Even if these conditions do not pose an immediate risk for public safety, they highlight the need to carefully assess any risk in resuming mining activity at Pietra di Finale and preserving quarry areas no longer suitable for such activity for environmental and tourist use.

GE05-2 Orale Di Matteo, Lucio

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PHYSICAL PROPERTIES OF KAOLINITIC SOIL CONTAMINATED BY BIOETHANOL-GASOLINE BLENDS

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Key terms: Kaolinitic clay; Ethanol-gasoline blends; Soil contamination; Compression index; Liquid limit

Over the past four decades, a number of experimental studies have been carried out for relating engineering and hydrogeological properties of soils with pore fluid composition which can change as a consequence of chemical pollution. Special attention was paid on petrochemicals and hydrocarbon-based fluids, with particular regards to the effect of transport fuels (gasoline, diesel and kerosene), on Atterberg limit, compressibility and permeability of soils. Petrochemicals and transport fuel pollutants can alter the consolidation characteristics of clayey soil, increasing the total or differential settlements of the foundations of engineering structures resting on it, which may later undergo functional or structural failure. In the last years the energetic plans of many country in the world promote the using of gasoline added with bio-fuels, such as bio-ethanol, with the purpose to control air pollution emission. It is expected in the future for gasoline with high-ethanol content an increase of episodes of soil contamination, as occurred in the last decades for conventional transport fuels. The present work shows the results of different laboratory investigations (Atterberg limit and oedometer test) conducted on a remolded commercial kaolinitic clay contaminated by bioethanol-gasoline blends. Liquid limit was determined by using the fall cone test which is very simple to perform and it is less operator-dependent than the Casagrande percussion method. Some difficulties were encountered to perform oedometer tests with contaminated soils due to the high volatility of both gasoline and ethanol: to reduce the fluid evaporation during the test the entire consolidation cell was enclosed within a plastic bag. In addition to eliminate the micro and macro-cracks produced by ethanol-gasoline blends on the oedometer cell body, the perplex cylinder was replaced with a glass one. Samples were prepared mixing the kaolinitic soil with distilled water and with gasoline to which several fractions of bio-ethanol were added. Ethanol was added in the gasoline in weight fraction up to 85%: in order to prevent phase separation of the water and gasoline in the blend (de-mixing), anhydrous ethanol (high purity ethanol) was employed (water content is below 1%). Physicochemical properties of pore fluid influence the van der Waals attractive force of clay and its fabric. When water is used as pore fluid (dielectric constant of about 80), the structure of the kaolinite leads to a parallel-arrayed clay. On the contrary when bio-ethanol is added in the gasoline in weight fraction of 10% (E10, dielectric constant of about 2.8) the structure of the kaolinite leads to a more flocculated soil. These physicochemical effects influence both equivalent liquid limit and compression index values of soil which reach the highest values when E10 is used as pore fluid, respectively of 80% and 0.60. On the contrary when soil is mixed with water both properties decrease respectively of 28% and 43%. A relative minimum of compression index was observed for a dielectric constant between 6.2 and 15.7. The oedometer tests were also used to investigate indirectly changes in permeability during compression due to the different pore fluid composition. As observed for compressibility the presence of bioethanol and gasoline increases significantly the permeability. The results obtained may be useful to increase the knowledge on the modification of physical properties of low plasticity soils due to accidental contamination of bio-fuels.

GE05-3 Orale Pucci, Valerio

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ANALYSIS AND PLANNING OF THE GEOINDICATOR NETWORK IN LIGURIA: A RENEWED PERSPECTIVE IN ENVIRONMENTAL MONITORING

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Key terms: Geoindicators; environmental monitoring; sustainable development

Short time scale geologic changes have been suggested as efficient indicators of environmental evolution as they provide data over periods of 100 years or less. Geoindicators measure both catastrophic events and those that are more gradual but evident within a human lifespan (Berger & Iams 1996; Berger 2008). Moreover, some indicators can provide a record of natural events through time. In landscape, natural areas and environments in broad sense, they reflect both the development of intrinsic components and a passive or active lithosphere - anthroposphere interaction. The indicators measure parameters that can be used to assess changes in rates, frequencies, trends, and/or magnitudes in geological processes. Most indicators address non-biological components of the exogenous cycle as physical-chemical parameters of groundwater, erosion and deposition at different scale in different geological matrix and environments (e.g. coastline, slopes, river basins, caves). At present, the IUGS GEOIN checklist is actively applied in sensitive areas of the Earth planet in all continent such as Australia (<http://www.environment.gov.au/soe/2011/>), North America (United States in National Parks and Monuments, Canada), South America (Argentina, Brazil, Peru), Africa (Mozambique, Mauritania, Egypt, Zambia), Eastern Europe. Provided that geoinicator differs from the environmental monitoring of anomalies exceeding the threshold values or to catastrophic events, a preliminary study was addressed to verify and transfer the GEOIND checklist of 27 indicators to the Liguria territory. This choice intends to achieve a time - integrated acquisition of the environmental parameters beyond the observation needed to the "state of environment" report.

The following steps are carried out:

- 1) selection of sustainable indicators within the IUGS checklist. This list includes observation of: i) coral chemistry and their growth pattern ii) desert surface crust and fissures iii) dune morphology and activity iv) dust transport v) frozen ground activity vi) glacier fluctuation vii) groundwater quality viii) groundwater chemistry in the unsaturated zone ix) groundwater level x) karst activity xi) lake levels and salinity xii) landslides and avalanches xiii) relative sea level xiv) sediment sequence and composition xv) seismicity xvi) shoreline position xvii) soil and sediment erosion xviii) soil quality xix) stream channel morphology and position xx) streamflow xxi) stream sediment storage and load xii) subsurface temperature and regime xxiii) surface displacement xxiv) surface water quality xxv) volcanic unrest xxvii) wetland extent, structure and hydrology xxviii) wind erosion. Our selection was addressed to observation of significant features of the Liguria geology, both for environmental equilibria (coastal setting, slope equilibria, river basins) and for economic and social issues (water and soil resources).
- 2) analysis of the present monitoring network. The present geomonitoring in the region is in line with the national and EU normative (e.g., Italian D.Lgs. 152/06, Dir. 2000/60/CE, etc.). Excellence in high resolution and / or time integrated data acquisition is active along the Roja river; other advanced projects devoted to landslide monitoring and groundwater chemistry and levels cover most of the first rank occurrences.
- 3) elaboration from the present ARPAL, SIRAL and UNIGE databases.
- 4) selection of strategic sites, within regional parks, urban, karst areas and the coastline belt.
- 5) deployment of new recording tools
- 6) validation of acquired data
- 7) elaboration of new data in the perspective of global change and / or local triggers of geological processes.
- 8) design technical improvements to the present monitoring network. The GEOIN project is therefore i) a tool considered over a longer time scale than current State of the Environment (SOE) scale, and ii) environment monitoring beyond Civil Protection (emergencies) needs.

GE05-4 Orale Lazzari, Silvestro

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MODELLO DI RECUPERO AMBIENTALE DI DISCARICHE AD ALTO RISCHIO NELLA PROVINCIA DI SALTA (ARGENTINA)

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Key terms: Argentina; Discariche; Rischi; Recupero ambientale

In tutta la provincia di Salta i versanti collinari sono oggetto di depositi di R.S.U. in cave a cielo aperto abbandonate al termine della coltivazione senza alcuna copertura. Sono depositi, questi, che incidono fortemente sullo stato di inquinamento del sottosuolo nonché della falda freatica, in connessione con i corsi d'acqua superficiali da cui dipendono la tutela ambientale e lo sviluppo economico - sociale della Provincia. Attualmente più località, in provincia di Salta, hanno necessità di un recupero ambientale dovuto alla presenza di discariche di R.S.U. non protette e ad alto potenziale inquinante. Una di queste è ubicata nel municipio di Capital, a circa 3 km dalla città di Salta, nella depressione tettonica del Valle De Lerna, sul versante sinistro del tratto intermedio della pianura alluvionale del Rio Arias-Arenales. Quest'ultimo è altamente inquinato essendo il ricettore di una grande quantità di percolato. La discarica misura, in senso areale, 15.000 mq circa ed ha spessore dell'ordine di 15 m, ed è priva di compattazione e copertura. La stratigrafia locale è rappresentata da un orizzonte litologico composto da sabbia e limo in lenti interdigitate, relitto di una antica conoide Quaternaria. Lo spessore di questo deposito di superficie è di circa 20 m e poggia su argille caolimitiche della formazione Piquete di età terziaria. La permeabilità su tali argille è stata determinata con l'ausilio delle dissipazioni delle pressioni neutre registrate con la punta piezometrica C.P.T.U. e generate dall'infissione di un penetrometro dotato di cella di pressione. Le prove sono state effettuate in tre punti diversi (C.P.T.U. 1,2,3), sottostanti la discarica, a profondità compresa tra 22 m e 25 m dal suolo. La permeabilità dell'orizzonte argilloso caolimitico è piuttosto limitata e compresa tra 10-6 e 10-7 cm/s. Ne deriva che il substrato delle alluvioni si comporta come un sistema chiuso ed un livello impermeabile di protezione delle falde idriche profonde. Non è stato però considerato che la superficie di discontinuità è inclinata sia pure di pochi gradi (2°-3°) verso la pianura

alluvionale del Rio Arias-Arenales e pertanto funge da letto impermeabile del deflusso dei liquami della discarica.

L'impianto determina quindi vari effetti negativi tra cui:

a. contaminazione della falda freatica per infiltrazioni del percolato;
b. contaminazione delle acque fluviali da percolato e rifiuti solidi urbani (R.S.U.);

c. contaminazione dell'ecosistema circostante la discarica.

L'inquinamento si diffonde in luoghi piuttosto distanti dalla discarica per la migrazione sia del plume nel sottosuolo, che dei residui trasportati dalle acque fluviali.

Dopo un'analisi di rischio lo studio propone alcune possibili soluzioni al problema, attraverso due ipotesi di intervento.

La prima, economica ma non risolutiva, prevede un confinamento dei rifiuti con argille ben compatte e poco permeabili. La discarica sarà protetta mediante opere di difesa erosiva e lo smaltimento del percolato e dei gas prodotti dai rifiuti.

La seconda, costosa ma risolutiva, prevede il confinamento con materiali impermeabili artificiali di ultima generazione (geotessili) ed interventi a presidio dei R.S.U. e smaltimento dei gas.

In superficie la discarica sarà protetta con opere di recupero ambientale. Bibliografia essenziale

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GE05-5 Orale Dino, Giovanna Antonella

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SLUDGE MANAGEMENT IN PIEDMONT DIMENSIONAL STONES INDUSTRY: NEW EXAMPLES OF RESIDUAL SLUDGE "RENATURATION"

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Key terms: dimensional stone; residual sludge; bioremediation; secondary raw material; artificial loam

Residual sludge management is an aged problem, object of legislative changes and potential application developments. Such wastes (EWC code 010413) arise from the treatment of mud produced in dimensional stones working plants. The average production for the two largest quarry basins in Piedmont are: 70 Mt/Y for the VCO and 16 Mt/Y for Luserna Stone Basin. The main problems related to their management are: the size distribution (fine materials, potentially asphyxial), the presence of heavy metals (due to the treatment with gang saw with abrasive shot and diamond framsaw) and the presence of TPH (mainly due to losses of oil machines).

The residual sludge management, now considered according to the Legislative Decree 152/06, could have additional problems, related to the entry into force of L.13/09, which connotes them as "earth and rock removed (digging and mucking)" with unavoidable "interpretative" problems. They are used, as wastes, for environmental restoration (R10) or raw material for cement plants (R5). It is also possible to think about their systematic treatment in consortium plat for the production of secondary raw materials (filler, etc.) or "Products" (artificial loam). The paper will report the results of a recent experimentation, conducted at the plant of AFIB (Trino Vercellese), to recovery such wastes (composting of a mix of residual sludge, shredded green material, loam, compost and nutrients - specific microbial activators) for the production of "artificial loam" (Bioremediation treatments).

The components are designed to start up and accelerate the process of aerobic degradation, in order to transform the organic matter and obtain a structurally, chemically and biologically stable products. The final product acquires definite properties other than a mere blending of mineral and organic material (this is a loam with suitable characteristics to support a consortium vegetable, also once finished the organic fermentable components).

The individual materials were used in established quantities (see ACEA employment).

All materials were stored in lengthened piles, wet, mixed, homogenized using a wheel loader and arranged to form two stock piles, covered by semi-permeable sheets.

The trial lasted 8 weeks; during this period the piles were periodically turned (to aerate and mix the material and stimulate the growth of microbial colonies able to degrade and mineralize organic matter) and monitored (by means of systematic sampling and analysis: grain size distribution, moisture, pH, ash, total organic matter, N tot, C tot, index of humification, C/N, heavy metals, nutrients, TPH (C10-C40)).

In order to evaluate the quality of the loam, phytotoxicity tests were set up on different test plants.

It was also estimated the microbial load both on sludge as such and on produced artificial loam, to obtain an indication of the status of organic soils.

The results confirm that the developed protocol offers the chance of handling such a waste material to produce a loam potentially useful for land reclamation of industrial and residential areas. They also show a good performance of the process (reduction of the concentration of heavy metals and increasing of organic matter). The obtained loam respects the limits imposed by the D.Lgs 152/06 for commercial and industrial lands. In the experiments conducted at ACEA the obtained products were better (within the limits for residential land). That was because the material had a lower initial concentration of heavy metals. Lately, instead, the absence of turning machines, air insufflators and of closed hangars caused a decrease in the efficiency of the process. However, biological tests show that plant growth was excellent: 75% compared to the sand and peat witness, with microbial load improvement of about 3-4 orders of magnitude.

After all, it should be interesting to implement the experimentations of such applications, which are also interested by international patent (EU Patent No 1299265).

GE05-6 Orale Ponte, Maurizio

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DEFORMAZIONI GRAVITATIVE E GRANDI FRANE NELLA FASCIA DI TERRITORIO COMPRESA TRA PAOLA-SAN LUCIDO E RENDE-COSENZA (CALABRIA)

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Key terms: Catena Costiera Calabria; DGPV; Terremoto 1783; Rotture a forbice

La porzione centro-meridionale della Catena Costiera compresa tra i territori compresi tra Paola-San Lucido ad Ovest e Rende-Cosenza ad Est è coinvolta da deformazioni gravitative a varia scala, che vanno dalle vere e proprie DGPV, alle grandi frane ed alle frane p.d..

Nelle unità alpine di alto grado metamorfico, costituenti l'ossatura della Catena Costiera di quel territorio, predominano le DGPV, lungo le rotture delle quali si impostano i corsi d'acqua, che non presentano, quindi, un'origine da soli fenomeni di erosione lineare. Essi, con andamenti prevalenti a ferro di cavallo delimitano ed evidenziano le morfologie da rotture gravitative, tra le quali sono pure comprese alte scarpate, trenches, deformazioni a ginocchio e rigonfiamenti nelle zone di massima compressione. Questi ultimi aspetti prevalgono nel versante tirrenico del tratto di Catena Costiera esaminato.

L'area di San Lucido-Paola costituisce un chiaro esempio di "continuum" tra le rotture da neotettonica, le deformazioni gravitative profonde, le grandi frane e le frane p.d..

Nel versante ricadente nella Valle del Crati, invece, emergono comportamenti differenziabili nei movimenti gravitativi, che comprendono strutture ad enclon e grandi frane, in corrispondenza delle principali linee tettoniche, che coinvolgono sia le metamorfite del basamento che i terreni plastici del Terziario e del Quaternario.

Tutto il restante corpo metamorfico della Catena Costiera è coinvolto da deformazioni attribuibili a tettonica gravitativa a forbice, con parziali rotazioni delle masse in senso orario. Ai suddetti movimenti va attribuita la notevole espansione laterale verso Est, e cioè verso la Valle del Crati, delle stesse masse metamorfiche, con il conseguente spostamento, per fenomeni gravitativi, delle sovrastanti formazioni sedimentarie del Terziario e del Quaternario.

Infine, si evidenzia come, a causa della diffusa presenza di rotture tettoniche e gravitative nelle metamorfite del basamento e nelle formazioni sedimentarie mioceniche e plio-pleistoceniche, il territorio esaminato sia da considerare ad alto rischio sia da frane che da terremoti, come testimoniato dalle profonde deformazioni gravitative prodottesi in occorrenza del terremoto del 1783.

GE05-7 Orale Carrisi, Stefano

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USE OF THE METHYLENE BLUE STAIN TEST IN PRELIMINARY ANALYSES OF LIME-TREATED CLAYEY SOILS.

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Key terms: Lime stabilization; geotechnical; laboratory tests; clayey soils

The construction of road, railways and airport embankments requires the use of materials with good physical and mechanical properties, the supplying of which often requires the opening of quarries located far from the construction site; this makes arise evident problems both on the environmental and on the economical point of view. There is therefore a strong interest for the techniques able to improve soils characteristics and allowing to use materials which would otherwise be rejected, such as clayey soils. The most popular method to stabilize clayey soils is the lime stabilization, which is widely used due to its simplicity and cheapness. When lime is added to a clayey soil it first reacts by exchanging calcium ions with the interlayer cations of clay and inducing the formation of floccs; such a process is known as modification. The modification leads to a more open framework and reduces dry density and plasticity, making the soil more workable. Once the affinity for lime of the clayey part of a soil is satisfied, if a further amount of lime is available, and there are suitable conditions, the real stabilization occurs, improving the main geotechnical parameters of the soil and reducing compressibility and swelling phenomena. The reactions leading to stabilization are known as pozzolanic and the amount of lime necessary to induce them strongly depends on the cation exchange capacity of the treated soil.

Most of the methods normally used to estimate the amount of lime needed to pass from modification to stabilization are affected by uncertainty, since they establish such amount on the basis of the plasticity index, which is not always representative of cation exchange capacity. On the contrary a good estimation of the cation exchange capacity can be obtained by evaluating the specific surface. Thus, introducing in the preliminary analyses for lime treatment tests able to estimate the specific surface of clayey soils, can be useful to have a sound indication of the amount of lime necessary to pass from modification to stabilization. Furthermore, since the specific surface of clayey soils decreases with lime addition, the use of such tests can help in verifying the efficiency of modification. In this work the Methylene blue stain test was used to study the efficiency of lime treatment, in the field of modification, in soils with clayey fraction made by Kaolinite and Na-Montmorillonite, mixed in different proportions. The results have shown that this test is able to follow the evolution of clayey minerals in the lime-modification field, since it detects the gradual reduction of specific surface which takes place as lime is added, up to a lime weight% which satisfies the affinity of clayey minerals for lime, and which depends on the clay nature. The analysis showed that the higher the soil activity the higher the specific surface decrease and the higher the lime percentage above which specific surface does no longer reduces; such percentage corresponds to the lime quantity which separates the modification and stabilization fields. The Methylene blue test can therefore be used both to preliminary estimate how efficient is the modification process of a soil, and to define the lime quantity allowing to enter the stabilization field.

The mineralogical investigations (X-ray powder diffraction analysis of glycolated and untreated sample to evaluate the swelling properties evolution and thermal analysis) carried out on the soil more rich in montmorillonite strengthened the results obtained by the Methylene blue test. In this soil, the addition of about 4% of lime reduces interlayer distance, mass loss on ignition and swelling properties. Moreover this lime addition changes the microtexture of clay soils, increasing the pore index and the workability of the material, as evidenced from SEM analysis.

GEO5-8 Orale Donnarumma, Angelo

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STATISTICAL APPROACH IN LANDSLIDE SUSCEPTIBILITY ASSESSMENT OF SLOW-MOVING EARTH FLOW

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Key terms: Earth Flows; Probability of areal failure; Slope angle

Assessment of the landslide susceptibility and identification of potentially landslide-prone areas have experienced extensive advance in the scientific literature. A variety of methods have been developed including deterministic, probabilistic and statistical approaches. The statistical analysis is widely used mainly in large-scale provisional studies, as it allows for a better understanding of the relations between landslide phenomena and predisposing factors, guarantying a lower degree of subjectivity with respect to heuristic methods.

However, a key issue is represented by the definition of predictive models founded on rigorous statistical bases. The assumptions on which these models are based, are only partially satisfied when the statistical analysis deals with discrete variables such as for example the slope angle. In this case, methodologies adopted are usually based on the assumption that the landslide susceptibility monotonically increases with increasing slope angle. Nevertheless, even though in geomorphologic environments dominated by intermittent slow movements (such as earth flows) landslide evolution is mainly connected with the slope steepness, it has to be taken into account that high slope angles do not always produce earth flows. High gradients can be often due to the presence of stony layers within sequences, which influences the behavior of the masses.

Based on the above considerations, the paper introduces a methodology to estimate the susceptibility to develop intermittent earth flows, involving structurally and lithologically complex sequences and showing visco-plastic mechanisms of failure. In particular, a spatially distributed model to predict potential instable areas has been applied to a pilot area of the Benevento province in Southern Italy, with the aim to calculate the probability of areal failure.

The model applies statistical-mathematical algorithms to slope angle data obtained from a statistically significant landslide sample. Since the study area is characterized by a complex lithological setting, landslide distribution has been analyzed within four-groups of homogeneous litho-technical unities.

The analysis has shown an interval of slope angles ranging from 9° to 12° where the largest occurrence of landslides can be found. In addition, the low frequency of instabilities on steeper slopes can be explained by a deficit of susceptible and potentially involving materials, partially due to the presence of stony sequences. Consequently, the probability of areal failure has been calculated only on slope angle range already affected by existing landslide phenomena.

Results obtained show that the methodology applied is able to evaluate the landslide susceptibility of areas characterized by intermittent failure mechanisms. Moreover, since the methodology has been developed to analyze spatial domains which are homogeneous with respect to the set of variables that came into play, it could be applied in similar geomorphological environments.

GEO5-9 Orale Francani, Vincenzo

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HYDROGEOLOGICAL STUDY ABOUT THE CONSEQUENCES OF HYDROMETRIC FLUCTUATIONS ON THE RIVER BANKS

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Key terms: Morphological evolution; Critical gradient; Liquefaction; Piping

The morphologic evolution of river banks is conditioned by the erosion effects due to the flow and liquefaction and piping phenomena, already studied for others Italian application cases.

This study, applied on the Pioverna river, located in the Prealps area in Lombardy (Italy), follows previous researches presented in geological literature, and it examines the effects of hydraulic head fluctuations of river beds due to floods, both in flood growth and in its decrease. In this context, critical conditions for river banks stability could occur. They can often generate situations of geological instability.

It is underlined that, during floods, abnormal hydraulic gradients, could be generated. These situations can cause velocity increases in groundwater flow circulation, which can generate piping, and slope liquefaction, as identified in literature equations.

In this note, it is also studied geological instability due to flood in the Pioverna river. The flood can cause, in any zones, hydrometric level growth about 3 meters respect to the previous conditions, in different hydrogeological situations.

It is observed that critically conditions for river banks befall when:

- The bedrock emerges near to the river; in this case instability interests the alluvial deposits which separate riverbed from the bedrock;
- There are fluvial islands that create a wedge shaped aquifer;
- A high - permeability layer, constituted by silty and sandy sediments with less permeability, flanks the bank river.

A further objective of the study, it has been to examine the causes of anomalous water - bearing stratum gradients. They may be generated especially during flood decrease, when groundwater flow runs towards the river, and when hydrometric river head comes back to the previous levels briefly (called "flash floods").

The situations described before facilitate the permanence of higher groundwater levels not so far away by the river, whereas only a small groundwater part lies to the hydrometric river head.

For this reason, important piezometric fluctuations are generated in closed areas; these oscillations are the principal cause of observed criticalities. Known models, partially modified in order to describe as well as possible all critical situations, are used to analyze the behavior of hydraulic heads. It is also observed that, with a detailed mathematical description, it is possible to improve the knowledge of critical phenomena, even if there are not usually enough data about permeability and hydrogeological structures, in order to apply a valid mathematical model.

However, this approach allows to simply identify any hydrogeological layers subjected to the critical situations described before. This is possible

also knowing permeability distribution, the most simple data which can be collected during geological surveys.

GEO5-10 Orale Simeone, Vincenzo

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TERRITORIAL GRAVITATIONAL DEFORMATION ALONG CALABRIA IONIAN COAST AS HAZARD FACTOR FOR LARGE CIVIL ENGINEERING WORKS

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Key terms: Territorial gravitational deformation; Scaly clay; Tectonic and landslide; Large civil engineering works

Siderno area along the Ionian coast of Calabria region (Southern Italy) is affected by deep seated large geomorphological deformations and landslides, conditioned by the structural geological set up of the territory and by its ancient earthquake history. Pliocenic units rest transversely on the va-ricolored scaly clays, a geological unit strongly deformed in consequence of its tectonic history as gravitational thrust.

These deformations involve a so large area that can be qualified as "Territorial gravitational deformations".

The Pliocenic Unit (gravels, sands and clays) seems a huge block subject to a slow sliding movement toward the Ionian sea at ESE, at the contact between the below scaly clays that have a really low shear strength and stiffness. This large block is bordered by two wide torrents: fiumara Torbido at NE and fiumara Novito at SE. During this movement, in consequence of different mechanical behavior of the Pliocenic unit and the varicolored clays and of the severe seismic history of the study territory, the Plio-Pleistocenic units are dismembered in large blocks related to landslides. All these fractures have generated a lot of deep seated landslide and surficial landslides. The first one in consequence of the low shear strength of the varicolored clays, the second ones of the fractures in the Plio-Pleistocenic masses.

The evidence of all these fractures in the Plio-Pleistocenic unit are evident in a lot of scarps and in all the deformations and the anomalies of the stream network, that cannot be related to erosion phenomena, but mainly to large deep seated gravitation deformation. Also the curvature of the coastline just in front of Siderno Marina can be related to the movement of a large block, subject also to a counterclockwise deformation, of the block where Siderno itself is located. Such phenomena have been severely activated or reactivated during the disastrous earthquake of 1783, that destroyed large part of the Calabria Region and, at present, conditions the vulnerability and the risk of the whole territory.

On the bottom of large fractures, locally varicolored clays outcrop also in consequence of "camber valley" bulging phenomena. To recognize that all the morphological anomalies in the study area have to be related to these gravitative territorial deformations is really relevant for the hazard related to a large civil engineering work.

An earth dam, in fact, recently built up upstream to the town of Siderno Marina (RC), was founded on impermeable Pliocenic-Pleistocenic units, that are dismembered by large landslides. So the water can flow through clays toward the varicolored scaly clays favoring the plastic behavior and the loss of stiffness of this unit. So, it may be possible the generation of landslides and small earthquakes re-lated to water level variation. Therefore, in the management of water level in the dam it is necessary a particular attention and a monitoring system to limit risk connected to the reservoir.

GEO5-11 Orale Giuliani, Andrea

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GEO-ENGINEERING CRITERIA FOR A SUSTAINABLE ENHANCEMENT OF HISTORICAL DIMENSIONAL STONES

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Key terms: Dismissed quarry site; Geomechanical survey; Giacimentological quality; Cultural heritage; Historical dimensional stone

Inside the framework of the mineral resources, the dimensional stone materials derived generally from a unicum ore-body, whose cultivation has been not only an economic activity, but also an opportunity for social employment. In this context, the rediscovery of dismissed quarries still offers the opportunity to recover limited volumes of stone that could be precious for the necessary restoration of important monuments, like the SS. Shroud Chapel inside the Turin Cathedral. According to the three pillars of sustainability (Environment, Society and Economy), it is also possible to transform these sites from negative elements into environmental resources for the mankind, making the best use of the giacimentological capability of natural material. Therefore, it was developed a method for the classification of rock mass that are interesting for the exploitation of an ornamental stone. This study is connected to the increasing demands that the Offices of Superintendence of Cultural Heritage are asking to the researchers for recovering of suitable materials useful in extraordinary restorations (due to fires, wars, earthquakes etc.) of the architectural monuments of Italy.

The first aim of this study was to increase the giacimentological knowledge on the historical ornamental stone of the "Monregalese", a geographical area of Southern Piedmont, achieved by a bibliographic census of the dismissed mine sites and a geological surveys of the most representative ones.

These quarry sites are concentrated in some geological formations ("San Pietro dei Monti Dolostones", "Rio di Nava Limestones" and "Val Tanarello Limestone") linked to some tectonic units of the Brianzonese Ligure Domain ("Ormea Unit", "Caprauna Armetta Unit" and "Klippen of Deviglia Unit"). This work of prospection was supported by a giacimentological characterization of stone materials. All lithotypes were investigated with repeated tests of Point Load, according to current technical standard; the results of this test (Uniaxial compressive strength: 64 ÷ 135 MPa) have shown that the historical ornamental studied rock are within the reference range proposed in literature.

All involved quarry faces of historical excavations were surveyed with geomechanical analysis, following the ISRM recommendations. Because of the minimal difference between the results in the investigated

quarry sites, it was proposed an original methodological approach designed ad hoc, called F.A., that analyze the relative influence of joint and the orientation of the quarry-fronts on productivity, in order to obtain another geomechanical parameter for a possible classification of quarry sites investigated.

The method developed was tested in the mining basin of the "Pietra di Luserna" (Bagnolo Piemonte - CN) through the survey of two thousand meters of quarry-faces. On this basis, the comparison of the parameter Jv and the index F.A. made it possible to classify all the dismissed sites, identifying three classes of giacimentological quality.

The practical applicability of the study was reached with the translation of each classes in a real measurable parameter (cube meters). This aim was developed with the evaluation of the mining yield in a quarry site (Rio Sbornina, Frabosa Soprana - CN), re-opened for the reconstruction of the SS. Shroud Chapel of Turin Cathedral. The volumetric calculation of stone blocks was made possible thanks to 3D modelling software (SketchUp Pro) that has also allowed the measurement of irregular solids. It was possible to highlight how a lower quality site provided a very limited amount of stone material, even in very large blocks, useful to achieve monolithic elements with structural functions (e.g. columns); the same quarry also has provided for some standard blocks for a commercial activity.

The project produced a possible method based on the identification and the comparative classification of historical quarry sites that could be applicable in other quarrying situations.

GE05-12 Orale Martarelli, Lucio

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THE REALIZATION PROCESS OF THE HYDROGEOLOGICAL MAP OF THE CARG SHEET N.348 "ANTRODOCO" (CENTRAL ITALY)

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Key terms: Hydrogeology; Hydrogeological mapping; CARG Project; Antrodoco; Central Italy

The Geological Survey of Italy (now Land Resources and Soil Protection Dept. of ISPRA) is realizing the new Geological Map of Italy at 1:50,000 scale (CARG Project). In this framework, the "N.348 Antrodoco Sheet" Project started. This project foresees, besides the basic geologic mapping, the realization of different informative layers, concerning hydrogeology, applied geology, geomorphology and geo-anthropogenic activities. The realization of the hydrogeological thematic level was assigned to the Applied Geology and Hydrogeology Unit of ISPRA.

The N.348 "Antrodoco" sheet map is located between Lazio and Abruzzo regions (Central Italy) and is characterized by a very complex structural asset, due to the occurrence of structural units deeply involved in the Apennine Orogeny. The four main units cropping out in the sheet map area are the M.Sibillini (carbonatic shelf, slope and basin environment), the Gran Sasso-Cittareale (carbonatic shelf, slope, basin and foredeep environment), the M.Giano-M.Gabbia (carbonatic shelf and slope environment) and the Acquisanta-Montagna dei Fiori (foredeep environment) units.

Concerning the hydrogeological aspects, the study has included research activities about water sources (springs, wells), streams and waterways, in order to characterize the hydrogeological asset. In particular a detailed screening of the springs (about 200 water points collected) has been carried out and about 70 of them have constituted a control network aimed to the measurement and characterization of groundwater flow rates and of some physical-chemical in situ parameters (temperature, pH and electric conductivity). These data have been uploaded in a specific Geographical Information System (GIS) to perform the cartographic elaborations showed in this work. They consist in a preliminary hydrogeological cartography composed of a main map illustrating a hydrogeological complex classification on the basis of their relative hydraulic conductivity, distinguished as follows (from bottom to top): (i) Calcareous complex (Lower Jurassic-Upper Cretaceous), showing a high relative permeability degree and including Calcare Massiccio, Corniola, Marne del Monte Serrone, Calcari e Marne a Posidonia, Calcari Diasprigni and Maiolica formations; (ii) Calcareous-marly complex (Middle Cretaceous-Middle Eocene), intermediate relative permeability, including Marne a Fucoidi, Scaglia Bianca and Scaglia Rossa formations; (iii) Marly-calcareous and marly complex (Upper Eocene-Upper Miocene p.p.), low relative permeability, including Bisciario, Marne con Cerrogna, Marne ad Orbulina formations; (iv) Flysch complex (Upper Miocene p.p.), low relative permeability, including the Laga Formation; (v) Conglomeratic-sandy and detritic complex (Upper Pliocene-Pleistocene), intermediate to low relative permeability; (vi) Alluvial complex (Quaternary), low relative permeability.

Other significant hydrogeological elements have been also reported in the main map and concern: (i) surface hydrology (boundaries of hydrographical basin and sub-basin, stream gauging stations, meteo-climatic stations, streamwater-groundwater exchange processes); (ii) groundwater hydrology (boundaries of hydrostructure, spring flow rates, groundwater flow directions).

Furthermore, complementary smaller-scale sketches at the margin of the main map have been realized (e.g., hydrogeological structure map, hydrogeological complex map based on effective infiltration information, hydrogeological cross-sections).

The aspects regarding the cartographical criteria and the realization process adopted for the best cartographical representation of all the cited hydrogeological elements derived from field surveys have been discussed.

GE05-13 Orale Soriano, Marcella

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HAZARD SPATIAL ANALYSIS IN RELATION TO STORM TRIGGERED SHALLOW LANDSLIDES IN A SECTOR OF THE SANNIO APENNINES.

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Key terms: Gis; Shallows landslides; Storm-induced landslides; TRIGRS code

Storm-induced slope instability assumes a character which is recurrent both in time and space.

Therefore, for these phenomena hazard analysis must take into account

not only the morphological and mechanical-hydrological features of the slope, but also the multi-year storm regimes in the area.

Current spatial analysis of data, implemented in the GIS platform, provides reliable scenarios with regards to triggering susceptibility. Particularly, the TRIGRS code provides an infinite-slope analysis which can be associated with a simplified hydrological model based on Iversen's linearized solution of Richard's Equation. The forecasting model is water table time-dependent and acts in a rainfall-runoff system in relation to conditions of surface runoff in saturated soils.

The saturation condition suggests that the model is more suitable for hazard scenario analysis during previous storm periods in clay slopes. In a North-Eastern sector of the Sannio Apennines, the availability data on the outcropping lithology, landslide and rainfall history, has permitted a spatial stability analysis in relation to the alteration cover of the clayey Formation in hazard terms.

The DEM, regarding an area of about 500 Km², was obtained from a map with a 1:5000 scale. In addition, in this area, the storm history data, related to the village of San Giorgio La Molara, has permitted the definition of the time-dependent probability occurrence of storm-triggered landslides. In this regard, in relation to Gumbel's probabilistic regression method, the synthetic rain rate-time series were defined in order to define the hazard scenarios in different return probability periods of storms under an un-stationary pore pressure regime.

The results show a good correlation with past landslides that occurred under similar storm conditions. Hence, the method can be a useful tool-analysis in planning in landslide-prone areas.

GE05-14 Orale Mandaglio, Giuseppe

10.1474/Epitome.04.1176.Geoitalia2011

ROCK SLOPES: FROM THE ANALYSIS TO THE DEFINITION OF THE RISK MITIGATION WORKS. THE "SCILLA RUPE" CASE (RC, ITALY)

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Key terms: rock slope; landslide; vulnerability; risk mitigation.

The problem of the instabilities on the Scilla Rupe (RC, Italy), known for a long period, determines an hazard situation on the surrounding areas (existing historical buildings and downstream structures). The Rupe has been classified as a landslide risk area with from high to very high level inside the Hydrogeological Plan of the Calabria region (PAI, 2001) because several vulnerabilities, such as "Ruffo di Calabria" castle upstream and the homonymous strategic platform and the Chianalea village downstream, there are.

In order to analyze in detail the Rupe, a specific study on the safety measures and the risk mitigation by means of the structural works has been developed using a specific regional activity programming (OPCM 3734- General Plan of the works for the soil protection in Calabria, 2010). The applied methodology is based on detailed geological researches, on the geomorphologic and hydrogeological analyses, on the mineralogical and petrographic analyses, on physical-mechanical laboratory tests and on in situ investigations. In particular, laser scanning technologies have been used and a geostuctural relief has been performed in order to analyze spatially the geomechanics data.

The detailed study allowed to define a correct geological-technical model of slope and to define the likely evolution models in relation to intensity (in terms of size, velocity and type) of mass movements. The used multidisciplinary approach focused on the construction of geomechanical asset, at the mass scale, and on the individuation of the potentially unstable rock blocks. The proposed approach improves the traditional approaches based on the geometric reconstruction of the structural asset of rock slopes.

The developed investigations allowed to define a strongly diaclasato and fractured crystalline-metamorphic (especially granodioritic) rock mass. The larger litoclasti and fractures reduce strongly the spatial continuity of the rock along the Rupe. The safety measures, that will be performed, will aim to: reduce the detaching and shallow fall from the wall of the fissured rock blocks, stabilize the rock mass of bedrock (rock fall and rock slock slide), such as the large wedge retained by the barbacane- underpinning. In fact, in these cases, rock volumes can slope along preferential slip surfaces and further accelerations can be generated if earthquakes or water infiltrations occur.

Finally, the obtained data have been integrated with stability analyses of rock slopes, where the geological-technical model of slope has been divided in analytical failure models corresponding to the physical situation of the Rupe in order to demonstrate the effectiveness of the works (ante and post-operam analyses).

GE05-15 Orale Rapti, Dimitra

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HEAVY METAL CONTAMINATION OF THE SACCA DI GORO AND VALLI DI COMACCHIO LAGOON AREAS (PO RIVER DELTA, NORTHERN ITALY)

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Key terms: lagoon; heavy metal; water; sediments

The lagoon areas of the Sacca di Goro and Valli di Comacchio, within the Po River delta, are holds a major naturalistic interest as well as an economic one due to the aquaculture activities (mussels, clams and eels). In there lagoon systems, the quality of the sea-bottom sediments is crucial not only for the cultivated species, but also for the potential bio-accumulation problems in heavy metals. The definition of the qualitative status of the lagoon sediments is crucial for adopting the best management strategies and the protection of the environmental conditions.

We determined the concentration in SiO₂, TiO₂, Al₂O₃, Fe₂O₃, MgO, MnO, CaO, Na₂O, K₂O, P₂O₅, Ba, Ce, Co, Cr, La, Nb, Ni, Pb, Rb, Sr, Th, V, Y, Zn, Cu, Ga, Nd, S and Sr, of 70 samples homogeneously collected

over the lagoon areas. This large dataset allowed i) to define the environmental quality of the sediments, ii) to recognise the areas with the higher contamination risk; and iii) to emphasise the local occurrence of polluting phenomena associated to chromium, nickel, vanadium, cobalt, lead, zinc and copper.

GE05-16 Poster Dino, Giovanna Antonella

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ENVIRONMENTAL ISSUES AND QUARRY PRACTICES IN THE MANAGEMENT OF THE MUD COMING FROM SANDS AND GRAVELS WORKING PLANTS

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Key terms: aggregate quarry lake; washing process; mud; water exchanges; environment and water hazard

The topic of the research is the management of the mud coming from aggregates washing process, which are commonly put into the quarry lakes.

Before focusing on the mud disposal in quarry lake, it should be good to understand the origin of such "scraps", which come from the sands and gravels washing.

After the digging out of the raw material (a mix of sands, gravels, silt and clay) the tout venant is sent to the treatment plant in order to obtain the different aggregates products (washing process).

After the size selection in the dressing plants we obtain the main products for aggregates industry and mud, characterized by: fine size distribution (silt-clay dimension), high water content, and sometimes TPH (total petroleum hydrocarbon), brought about by the working plants operations. The practice of disposal the muddy slurries into the quarry lakes will improve the silts deposition phenomenon that progressively can wrap the bottom and the walls of the excavation.

Silts deposition can also lead to some problems about the water flux and piezometric surface and about the hydrochemical features, limiting the water exchange between the aquifer and the lake, thus increasing its trophic state and foreclosing potential reuse at the end of quarrying activity.

Production data, provided by a sample of Piemonte pit lakes, allowed to estimate the average amount of silts in lakes in approximately 1 m/y. The size distribution analysis allowed to classify such muddy slurries as weak clayey silt.

A modeling approach was chosen in order to define the piezometric variations related to these backfilling, while chemical analysis of water were carried out in order to define the hydrochemical relationships between lakes and groundwater.

Thanks to researches and field surveys it is possible to observe that silts deposition in quarry lakes involves changes in groundwater level, particularly the wrapping of the excavation walls, instead it does not determine substantial changes in the case of sedimentation on the bottom of basins. In any case, the calculated piezometric variations were modest. In the investigated situations there were not found very thick sediments of silt and clay on the walls, since the slopes (about 30° and more steep during the excavation activities), due to the presence of gravelly-sandy material, do not allow the accumulation of excessive thickness of silts. In the case of resulting material, composed mainly by silt, the hydraulic conductivity allows, even if reduced, water exchanges with the groundwater, supported by a good correlation between the chemical composition of waters of the quarry lakes and the shallow groundwater intercepted by the excavation. In this way it is generally guaranteed water exchange in the lake, thus promoting reuse at the end of the mining activity. It is of course to avoid an immoderate lake refilling by muddy slurries in order to let a sufficient thickness for lateral water exchange. At the moment the habits of putting the mud in the lakes does not seem to be dangerous for environment and water. Nevertheless it is useful to underline that mud coming from the working plants could be considered as "waste" (D.Lgs. 152/06; D.Lgs. 117/08; L. 13/09). In this case the material have not to be deposited into the quarry lakes. A possible change to reuse these recovered material is the production of "artificial loam" (after a bioremediation treatment).

Land farming application of "mud as such" appear not feasible due to size distribution and to the possible contamination of TPH (to verify). The now proposed technical system - studied for residual sludge from dimensional stones industry - concerns the composting of a mix (mud, shredded green material, natural loam, compost and nutrients) which is deposited in covered piles, periodically aerated and monitored. At the end of the process it is possible to obtain "artificial loam", to use for quarry rehabilitation, civil works, etc.

GE05-17 Poster Salemi, Enzo

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MONITORING AND MAPPING OF RESIDUAL NITROGEN IN LOWLANDS. THE CASE STUDY OF FERRARA PROVINCE.

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Key terms: soil nitrogen; groundwater; pollution; C/N ratio

After the growing seasons, the soil nitrogen that remains as inorganic phases (Nitrate and Ammonium), represents one of the most serious threat for cultivated land, determining eutrophication and groundwater nitrate contamination. This issue has recently become a priority within the European Community Framework Directive for water protection (WFD) which has established a list of measures and limitations to be applied in areas declared "vulnerable to nitrate from agricultural sources. The Ferrara Province (Northern Italy), is an intensively cultivated area since decades. The land is fertile and allows the cultivation of different crops, especially winter cereals, maize and energy plants which cover more than 65% of the land.

The Ferrara province is a flat area located on Po lowlands covering an area of 2.623 km². It is characterized by a flat topography and is fertilized by more than 91% with synthetic fertilizers, mainly urea. The minimal run-off and an homogeneous inorganic nitrogen load allow to simplify the

hydrological and nitrogen balance: excess nitrogen tend to move vertically through the unsaturated zone, becoming one of the most important causes of groundwater contamination.

A monitoring program was started in 2010, to estimate the readily available nitrogen before and after maize and wheat cropping cycles. 742 core samples (1 m long and 2.5 cm int. diam.) were taken in 67 different agricultural plots, fertilized in 2009 with synthetic urea, respectively with 240 kg/ha for plots cultivated with wheat and 160 kg/ha for plots cultivated with maize and with 700 - 900 kg/ha of chicken manure (only sandy soils along the coastal zone). Cores were splitted and analyzed into two halves, in order to investigate separately the upper soil layer stressed by tillage, roots growth and weathering (0 to 50 cm of depth) and the lower undisturbed one (50 to 100 cm of depth). Samples were colorimetrically analyzed for urea (CO(NH₂)₂), NH₄⁺, NO₂⁻ and NO₃⁻ using a double beam Jasco 550C spectrophotometer and a Technicon Autoanalyser II. C and N were obtained using an elemental analyzer Fisons Instruments.

Data were processed using Geographical Information System applications to obtain maps of the residual mineral nitrogen availability and C/N ratio, for each of considered soil. Results highlights the presence, at different concentration, of residual nitrogen as NH₄⁺ and NO₃⁻ mainly, in the whole territory. Distributions of NH₄⁺ and NO₃⁻ are correlated with C/N ratio values, which are prevalently dependent on the textural characteristics of soils and influenced by the type of fertilizer used. This information can be transferred to agro-technicians and farmers to accurately estimate the amount of fertilizer to be added in the next cropping season. The proposed procedure highlight the possibility to assess nitrogen needs in specific vulnerable zones and proceed with fertilization by avoiding to generate excess and risk of nitrate leaching to groundwater.

SESSIONE GE06

Mineralogia

GE06-1 Key Lecture Nazzareni, Sabrina

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LARGE SCALE FACILITIES HIGH-PRESSURE EXPERIMENTS: THE GYPSUM CASE HISTORY

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Key terms: gypsum; X-ray synchrotron diffraction; neutron diffraction; high pressure

Recently, strong developments and improvements of high-pressure (HP) experiments at large scale facilities (both synchrotron and neutron facilities) opened new scenarios on the accurate determination of physical properties of minerals at very deep conditions. High-pressure single-crystal X-ray diffraction (SCXRD) synchrotron experiments allow to determine small structural variations with pressure due to increase of the quality of data collection. In HP experiments the angular limitation access to the Ewald sphere, due to the diamond anvil cell, can be partially encompassed by the high intensity of the synchrotron X-ray beam using small samples and multiple mounting into the DAC. At the same time, HP neutron powder diffraction experiments could determine the hydrogen position (and hydrogen bonds evolution) directly both on deuterated and natural materials.

We performed high-pressure single-crystal synchrotron and neutron diffraction experiments on gypsum (CaSO₄ 2H₂O) to study the HP behavior of this sulphate including the hydrogen bonds. Literature data [1-4] suggested a polymorphic transition at 4 GPa and the structure of the new polymorph, gypsum-II, was recently solved [5]. SCXRD studies [4-5] suggested that water molecules play a key role on the phase transition. We combined the HP neutron data with single-crystal and powder synchrotron diffraction data measured on gypsum up to 13 GPa at ESRF (Grenoble, France - ID09 and ID27 beamlines). We performed HP neutron powder diffraction up to 10 GPa at ILL (Grenoble- D20 beamline), loading a Paris-Edinburgh cell with NaCl as pressure calibrant and deuterated Ethanol/methanol as pressure transmitting medium and the same sample used in previous papers. Powder diffractions were collected with a radio oscillator collimator and each data collection was measured from 3 to 6 hours as P increased. The lattice parameters of gypsum at increasing P were obtained by refining the powder pattern by using the Fullprof software.

In the pressure range investigated we recognised two discontinuities in the a and b lattice parameters and beta monoclinic angle corresponding to the first phase transition at 4 GPa (already suggested [4-5]) and a second phase transition at around 7 GPa not clearly defined previously. A very good agreement was found between our XRD data set (SC-XRD in house, synchrotron SC- and powder XRD at ESRF, Grenoble) and the lattice parameters measured by neutron diffraction at D20 (ILL- Grenoble). We used the synchrotron XRD data to constrain the neutron refinement and decrease the refined variables, thus to focus in the H coordinates and occupancies.

Single-crystal XRD data [4] showed that the gypsum interlayer, where the water molecules are located, strongly decreases its thickness up to 3.94 GPa. The water molecule shares an oxygen with the Ca-polyhedron and hydrogen atoms (H1 and H2) form, at ambient pressure, weak hydrogen bonds with the oxygens belonging to S- and Ca-polyhedra. Neutron diffraction data suggest that increasing pressure the two hydrogens configuration changes: the coordinates of H1 move slightly from its position at ambient pressure whereas the y/b coordinate of H2 decrease significantly explaining the different compressibility of the two hydrogen bonds [4].

These new hydrogen bond configurations confirm that in the gypsum structure there is an increasing shift of the calcium-sulphate layer along a axis that lead to the phase transition and allow to retain water molecules at high pressure, namely to prevent the free movement of water molecules and should affect the dehydration condition.

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GEO6-2 Orale Biagioni, Cristian

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TOBERMORITE 11 Å: ONE MINERAL SPECIES, SEVERAL THERMAL BEHAVIORSBIAGIONI Cristian¹, BONACCORSI Elena¹, MERLINO Stefano¹¹ - Università di Pisa, Dipartimento di Scienze della Terra

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Key terms: tobermorite 11 Å; tobermorite 10 Å; tobermorite 9 Å; thermal behavior

Tobermorite 11 Å, $\text{Ca}_{4-x}\text{Si}_6\text{O}_{15-2x}(\text{OH})_{2-2x}\cdot 5\text{H}_2\text{O}$, with $0 < x < 1$, is a calcium silicate hydrate characterized by a variable content of "zeolitic" calcium cations. Its crystal structure is formed by calcium polyhedra layers, continuous in the plane (001), connected to wollastonite-like chains on both sides. These structural elements form the so-called "complex module", common to all the phases of the tobermorite group. This module is C-centered, with cell parameter a 11.2, b 7.3, and width c_0 11.2 Å. Two kinds of complex module exist, due to the two different ways of placing the "bridging" tetrahedron with respect to the "paired" tetrahedra in wollastonite-like chains on the two sides of the calcium layer. The stacking of these two different complex modules forms clinotobbermorite and tobermorite 11 Å, with monoclinic and orthorhombic subcells, respectively [1]. The 11 Å phases, both monoclinic or orthorhombic, are characterized by double silicate chains, and their polyhedral framework shows cavities that may host "zeolitic" cations and water molecules.

Three kinds of thermal behavior were distinguished at 300°C [2]: "normal" (tobermorite 11 Å shrinks to a 9 Å phase at 300°C), "anomalous" (the 11 Å phase does not shrink at 300°C), and "mixed" (both the 11 and 9 Å phase coexist at 300°C). However, further investigations [3] indicated that the thermal behavior of tobermorites is more complex than that depicted by the previous authors.

In order to understand the involved processes during dehydration, several natural tobermorites were studied through a multi-technique approach. Tobermorites from N'Chwaning II mine (South Africa) and San Vito di Leguzzano (Italy) showed an "anomalous" behavior at 300°C but the former, shrunk to a 10 Å phase at 420°C, whereas the latter preserves its 11 Å basal spacing. TG curves showed different weight loss patterns; in particular, tobermorite from N'Chwaning II mine lost 10 wt.% at 300°C, corresponding to 4 water molecules, whereas the sample from San Vito Leguzzano showed a weight loss of 8 wt.% (3 H₂O pfu). Chemically, the only difference between the two specimens is related to the presence of 0.5 Al pfu in the Italian tobermorite; the introduction of Al in tobermorite

is possible through the substitution $\text{Si}^{4+} + \text{O}^{2-} \rightarrow \text{Al}^{3+} + \text{OH}^-$. The different amount of OH groups in the two studied specimens may give rise to different hydrogen bond schemes; the important role of "zeolitic" water molecules in stabilizing the position of H₂O and OH bonded to the calcium layers was hypothesized by [4]. The occurrence of additional hydrogen bonds, related to the introduction of Al in tobermorite, may contribute to the stabilization of the 11 Å phase. On the contrary, their absence may result in structural changes upon dehydration that can lead to the shrinking to 10 Å. The 10 Å phase was characterized through SC-XRD, ²⁹Si NMR and micro-Raman spectroscopies. It shows a orthorhombic (or pseudo-orthorhombic) subcell with a 11.2, b 3.67, c 20.4 Å; spectroscopic data point to the maintenance of double wollastonite-like chains. It is interesting to note that a clinotobbermorite-like phase appeared during the transition from the 11 to the 10 Å phase. "Normal" tobermorite from Montalto di Castro (Italy) was studied through in situ X-ray powder diffraction. At 300°C, tobermorite 9 Å appears. Also in this case, the diffraction patterns suggest the occurrence of a clinotobbermorite-like phase as an intermediate product between the 11 and the 9 Å phases.

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GEO6-3 Orale Ballirano, Paolo

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THERMAL BEHAVIOR OF AFGHANITE, AN EIGHT-LAYERS MEMBER OF THE CANCRINITE GROUPBALLIRANO Paolo¹, BOSI Ferdinando¹¹ - Dip.to Scienze della Terra, Sapienza Università di Roma

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Key terms: Afghanite; Cancrinite group; HT X-ray powder diffraction; Rietveld method

Thermal behaviour of afghanite, $(\text{Na}_{15}\text{K}_5\text{Ca}_{11})\Sigma_{21}[\text{Si}_{12}\text{Al}_{24}\text{O}_{96}](\text{SO}_4)_6\text{Cl}_6$, s.g. P 31c, $a = 12.7961(7)$ Å, $c = 21.4094(13)$ Å, an eight-layers member of the cancrinite group, has been investigated by combined electron microprobe analysis, X-ray single-crystal diffraction, and high-temperature X-ray powder diffraction. Non-ambient data were collected in the 323-1223 K thermal range on a specimen from Case Collina, Latium, Italy. RT structural data, from single-crystal work, provided improved details on cation partition with respect to reference data. The framework consists of columns of cancrinite cages ($[4^6\bar{1}]$ polyhedra following the IUPAC nomenclature) stacked along $[0\ 0\ z]$, and regularly alternating liottite ($[4^6\bar{6}^{17}]$ polyhedra) and cancrinite cages piled along $[2/3\ 1/3\ z]$ and $[1/3\ 2/3\ z]$. It has been observed that the cancrinite cages alternating with the liottite cages are more compressed along z than the remaining ones. As result the chlorine atom, located at the centre of the cages, is driven off-axis in order to obtain a favorable coordination with the neighboring calcium atoms. Repeated heating-RT-cooling cycles led to the partial afghanite structure disruption and the partial conversion, via an intermediate disordered phase, to hayingne. Thermal expansion shows a discontinuity at 448 K for both a and c cell parameters, a feature previously reported for other cancrinite-like minerals. In fact, up to 448 K the c cell parameter expands significantly and more than the a cell parameter. Above the discontinuity temperature T_d , the thermal expansion is reverted becoming greater for the a cell parameter. Afghanite shows a significant microstrain at RT that increases up to ca. 700 K and subsequently decreases as a function of T . Cooling to RT permits a significant release of ϵ microstrain and this process is coupled with a significant expansion of the c cell parameter as compared to the starting RT data. The expansion of the c axis has been prevalently attributed to the full expansion of the cancrinite cages alternating with the liottite cages. Upon reheating at 1173 K, the microstrain increases back to

approximately the same value calculated for the first heating process. Repeated heating/cooling cycles did not modify the ϵ values both at RT and at HT.

GEO6-4 Orale Bellatreccia, Fabio

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MINERALOGICAL APPLICATION OF NANOINDENTATION TESTINGBELLATRECCIA Fabio¹, SEBASTIANI Marco¹, DE FELICIS Daniele²¹ - Dipartimento Scienze Geologiche, Università Roma Tre² - Dipartimento di Ingegneria Meccanica e Industriale, Università Roma Tre

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Key terms: Nanoindentation; Elasticity; Elastic modulus; Hardness; Minerals

The study of elastic properties of rocks and minerals had a significant development because these data are crucial for the interpretation of the propagation of seismic waves on which all models of Earth's internal structure are based. In addition, these properties are essential for determining the equation of state of geological materials [1,2]. Other physical properties related to elasticity, such as hardness, fracture toughness, contact stiffness, creep resistance, can be used to understand the mechanisms of ductile deformation of rocks at the level of the mantle or deep crust, and of the brittle behaviour of rocks at the level of upper crust. Finally, since the elastic properties are closely related to the crystal-chemistry of minerals, they can be used to probe the structural deformations induced by phase transitions and/or ionic substitutions [3,4]. The measurement of the elastic properties of minerals is essentially based on three methods: 1) direct mechanical methods; 2) sound wave velocity measurements and 3) electromagnetic wave scattering methods (Brillouin, inelastic X-ray/neutron). All of these methods are now well established, mature and widely used however they have an inherent limitation: they do not allow the measurement of elastic properties of materials at micro to nano scale [5].

Nanoindentation testing (introduced by Oliver and Pharr in 1992 [6]) has been widely adopted in the last two decades for the surface mechanical characterization of bulk materials and coatings. The method involves the controlled penetration of a diamond pyramidal indenter into the material: by measuring the load and displacement during the loading and unloading parts of the test, hardness (i.e. resistance to plastic deformation) and elastic modulus can be calculated [6-7]. In this way, a very accurate characterisation of the elastic properties at material's surface can be achieved, with a depth resolution and a lateral spatial resolution of the order of few nanometres. Three factors motivate the use of nanoindentation for the study of the mechanical properties of minerals. Firstly, in such tests the load and displacement of the indenter tip, are continuously monitored thus the method is ideal for probing local gradients and heterogeneities in samples. Second, no extensive sample preparation is required prior to mechanical testing. Third, most nanoindentation instruments provide experimental control that allows for a variety of different deformation modes. The data so far published are scarce and cover a limited number of minerals (some phyllosilicate, kyanite, K-feldspar, periclase, garnet, quartz and the first nine minerals of the Mohs scale) [8,9,10,11]. However, the results show the possibility of very interesting developments in the field of mineralogy, applied mineralogy and gemmology.

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GEO6-5 Orale Adamo, Iliaria

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TRACE ELEMENT AND REE BEHAVIOR OF GEM-QUALITY GREEN ANDRADITE FROM VARIOUS LOCALITIESADAMO Iliaria¹, BOCCHIO Rosangela¹, DIELLA Valeria²¹ - Dipartimento di Scienze della Terra, Università degli Studi di Milano² - CNR, Istituto per la Dinamica dei Processi Ambientali, Milano

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Key terms: andradite; major-element composition; trace-element composition; REE profile

Andradite, of ideal composition $\text{Ca}_3\text{Fe}_2\text{Si}_3\text{O}_{12}$ and space group Ia3d, is a rock-forming garnet typically found in metamorphic rocks (i.e. serpentinites and skarns). The structure consists of a framework of alternating SiO_4 tetrahedra and FeO_6 octahedra, with cavities containing Ca cations in eightfold coordination (Novak and Gibbs, 1971). Because relatively few studies are devoted to the trace-element composition, including REE profiles, of Ca-Fe^{3+} garnets (Gaspar et al., 2008), we have undertaken a study of andradite, in particular focusing on gem-quality green-colored crystals (variety "demantoid"). A suite of 28 andradite samples, occurring both in serpentinites and skarns, coming from the most notable localities worldwide (Italy, Russia, Iran, Pakistan, Madagascar, Namibia, and Romania) has been investigated by means of EMPA and LA-ICP-MS. More details about geology and garnet formation are reported by Bocchio et al. (2010) and Pezzotta et al. (2011). Our work aims to provide a chemical characterization of these stones and so contribute to a quantitative evaluation of the crystal chemistry of andradite.

The analyzed crystals cover a restricted range of composition, from almost pure andradite ($\text{Adr} \geq 98$ mol%) to members of andradite-uvarovite ($\text{Adr}_{81-96}\text{-Uv}_{3-18}$) or andradite-grossular ($\text{Adr}_{76-94}\text{-Gr}_{5-12}$) solid-solution series. They are homogeneous, with the only exception of a sample from the skarn deposit of Namibia, showing a composition varying from pure andradite up to almost pure grossular ($\text{Grs}_{89}\text{Adr}_{11}$), which frequently occurs

in garnets from skarn (Smith et al., 2004; Gaspar et al., 2008). The chondrite-normalized diagrams of selected trace elements (Sc, Ti, Cr, Co, Ni, Zn, Sr, Y, Zr) indicated that all the examined garnets, both associated with serpentinites and skarn deposits, display a comparable pattern of distribution. However, the garnets occurring in the skarn rocks (*i.e.* samples from Madagascar, Namibia, and Romania) contain minor amounts of the chromophore elements, in particular of chromium, which is almost absent. The chromium contents detected in specimens from serpentinites are instead very variable, ranging from a few ppm up to 1 wt%. With regard to the profile of REE, we observed that (i) all the samples showing a composition close to pure andradite, both associated with serpentinites and skarns, exhibit LREE-enriched and HREE-depleted patterns with a strong positive Eu anomaly, whereas (ii) the uvarovite-enriched samples show flatter patterns with a small positive Eu anomaly, and (iii) grossular rich samples are LREE-depleted with no Eu anomaly or negative one. These results indicate that the incorporation of REE in andradite is mainly controlled by the crystal chemistry. In particular, the substitution of Fe³⁺ (and Cr³⁺) for Al expands the framework and consequently favors the incorporation of the larger LREE. However, also the bulk composition of the host rocks and the physicochemical conditions occurring during the growth may contribute to the REE incorporation (Whitney and Olmsted, 1998; Smith et al., 2004; Gaspar et al., 2008).

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GEO6-6 Orale Carbone, Cristina

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SECONDARY MINERALS FORMED IN ACID MINE DRAINAGE ENVIRONMENT: THE CASE OF LIBIOLA MINE

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Key terms: secondary minerals; acid sulphate waters; mine-waste; Libiola

The sulphide-ore of the Libiola mine (Sestri Levante, eastern Liguria, Italy) occurs as massive-, stockwork- and disseminated-mineralizations within pillow and brecciated basalts of the northern Apennine ophiolites [1]. They mainly consist of pyrite-chalcopyrite mineralizations with minor sphalerite and pyrrhotite. Gangue minerals are mainly represented by quartz with minor chlorite, magnetite, hematite, carbonate, and serpentine minerals. The Libiola mine represent one of the most important Italian exploited sulphide-ore, already known in the Bronze Age [2]. Nowadays, the mining area is completely abandoned. Underground and superficial waters are mostly Acid Sulfate Waters [3, 4], due to active Acid Mine Drainage processes triggered by oxidation of pyrite-chalcopyrite mineralizations. Mine wastes are acid generating because they contain a high amounts of partially altered sulphide-rich mineralizations [5]. Secondary minerals directly formed within dumps, streams, and outcropping mineralized bodies through precipitation from contaminated solutions. They are within stream sediments of the creek and stream of the area or on and within waste-rock dumps. In this last setting, they occur as cement waste-rock fragments and as coating on rock surfaces or between the mineralized clasts, where they partially or completely replace both ore and gangue minerals. They are mainly represented by iron oxyhydroxides and oxyhydroxysulphate (such as goethite, ferrihydrites, lepidocrocite, hematite, and schwertmannite), sulphates (such as jarosite, brochantite, gypsum, epsomite, bieberite, bonattite, siderotil, halotrichite, chalcantite, pickeringite, melanterite, copiapite, hydroxoodwardite, and basaluminite) and Cu-carbonates (such as malachite and azurite). Locally, native copper, chrysocolla, and alunogen are abundant as fracture fillings or as coating and occur in both superficial and underground settings. The presence of these minerals and the evaluation of their stability fields are of environmental concerns because they can play an important role in attenuating the contaminant load of mine effluents [6, 7]. The goal of this study is a comprehensive overview of the mineralogy and geochemistry of secondary minerals that formed in the Libiola mine, owing to acquire a detailed mineralogical knowledge about the genesis and the evolution of the authigenic secondary phases. The knowledge about the types of mineral phases allow to understand the short and long-term fate of the ecotoxic metals. All these information are paramount parameters for any predictive models and also to define effective remediation strategies.

GEO6-7 Orale Prencipe, Mauro

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COMPRESSIBILITY OF PYROXENES AND ITS TEMPERATURE DEPENDENCE: THE CASES OF DIOPSIDE, JADEITE AND THE ORDERED OMPHACITE, INVESTIGATED AT THE AB INITIO LEVEL, THROUGH QUANTUM-MECHANICAL CALCULATIONS

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Key terms: Pyroxenes; Thermo-elastic properties; Ab initio Calculations

Recent developments of (i) sophisticated codes for quantum-mechanical calculations on crystalline materials [1]; (ii) effective hybrid HF/DFT Hamiltonians [2]; (iii) algorithms from the calculation of thermo-elastic properties of crystals [3] starting from ab initio calculated static equations of state (no zero point and thermal effect included) and frequencies of the vibrational mode, together with the increased availability of computational resources at a relatively low cost, allows for the determination of compressibility of minerals with accuracies and reliabilities which parallels those reachable experimentally, at room temperature. At high temperatures, in general, while the accuracy of the experimentally measured compressibility decreases dramatically, that of the ab initio calculation remains high, so that the theoretical approach can reliably be used to produce data which are crucial for the development of models of

the Earth's interior.

Examples of applications of the whole first principle procedure will be shown with reference to pyroxenes (in particular diopside, jadeite and ordered omphacite). In the case of diopside, the calculated bulk modulus (K_0) and its first pressure derivative, at room temperature, are 106 GPa and 5.5 respectively, to be compared with the correspondent experimental values of 107(1) GPa and 5.8 [4]. The calculated dK/dT is -0.011 GPa/K, and the thermal expansion coefficient at 300K is 2.12×10^{-6} K⁻¹.

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GEO6-8 Orale Scanavino, Isacco

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AB-INITIO STUDY OF THE EFFECTS OF IRON IN PERICLASE ON THERMODYNAMIC PROPERTIES

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Key terms: Periclase; Ferropericlase; Lower mantle; ab-initio calculations; thermodynamic properties

The thermodynamic properties of periclase and ferropericlase, at pressures and temperatures typical of the Earth's lower mantle, have been studied through ab-initio calculations carried out at the hybrid HF/DFT level. The correlated thermodynamic properties were calculated by following a standard statistical-thermodynamics approach, within the limit of the quasi-harmonic approximation. The dependence of the calculated parameters by temperature/pressure/composition in iron has been shown, paying particular attention to the effects on bulk modulus and on thermal expansion. About the former, at environmental conditions an adding of 3% of iron in the chemical composition increases the bulk modulus from 160.14 GPa to 167.41 GPa; the same percentage at the P/T deepest lower mantle conditions (135.8 GPa and 4000 K) reduces the bulk modulus from 563 GPa to 558 GPa. About the thermal expansion, the same percentage in iron at environmental conditions reduces this parameter from 2.79E-05 1/K to 2.60E-05 1/K; at the deepest lower mantle conditions the decrease is less pronounced and the coefficient goes from 1.191E-05 1/K to 1.186E-05 1/K.

GEO6-9 Orale Zucchini, Azzurra

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ABOUT CATION DISTRIBUTION IN DOLOMITE STRUCTURE BY THEORY AND EXPERIMENTS

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Key terms: Dolomite; Order/disorder; Twinning; Quantum-mechanical calculations; Piston Cylinder

Features and evolution of many geological processes, such as fluid-rock interaction, CO₂ sequestration, fault weakening and dolomite stability under subduction conditions, significantly depend on the physical-chemical properties of dolomite. Our attention was focused on the study of cation distribution over crystallographic sites since it is one of the main factor impacting physics and thermodynamic properties of the mineral. *In-situ* [1] and *ex-situ* [2] experiments attributed a T range of about 1200-1400K to the intra-layered-type disordering where Ca and Mg are randomly distributed over cationic sites. Such structures, however, have not been found in nature probably due to the non-quenchability of thermally treated systems [2]. However, there is a possibility of domain disorder that could be stable at lower temperatures and is not investigated in sufficient detail. In order to study various types of disorder in dolomite as well as the thermodynamic stability of disordered dolomite structures, we have used both theoretical and experimental approaches. First principle total-energy calculations were performed at the hybrid Hartree-Fock/Density-Functional-Theory level [3] using a development version of CRYSTAL software [4]. Calculations were carried out by using the WC1LYP Hamiltonian [5], which includes a non local exact Hartree-Fock exchange contribution. Different stoichiometric disordered dolomite structures were simulated and they appeared to be due to both intra- and inter-layered-type defects. Starting from theoretically calculated energies, a quantum-statistical calculation approach was used in order to obtain the probability of specific disordered configurations at a given temperature. A very low degree of disorder was observed for temperatures below 750K. As T increases, a disordered configuration becomes gradually the most stable one. Such observations allowed us to preliminarily state that disorder in the cation distribution in dolomite seems energetically stable at lower temperatures than expected from previous results. In the experimental part, dolomite crystals were thermally treated by using a piston cylinder apparatus under P of 3GPa and T of about 1270K, 1370K and 1470K. Products were studied by using powder and single crystal X-ray diffraction. The former analysis evidenced an increase of the intensity ratio of 006/015 reflections by increasing T as a marker for disordering [6]. Moreover, data refinement showed mixed Ca and Mg cationic site occupancies. It shows that the disorder is produced by the heat treatment. On the contrary, three dimensional refinement by using single crystal X-ray diffraction analysis showed evidences of twinned structures, following the {11-20} twin law, consisting of twin domains with a high internal crystallographic order. So even if the theoretical modelling suggests the intra-layered-type disordering as the main mechanism affecting Ca-Mg distribution in dolomite during heat treatment also at relative low T, single crystal X-ray

diffraction suggests presence of highly ordered domains at all temperatures and a localisation of disorder to twin boundaries and defects in the structure. We can speculate that the twinning could be driven by either a dis-ordering process during thermal treatment or a re-ordering process during the quench. *In-situ* single crystal X-ray diffraction analysis under HT and HP conditions are in progress at the ESRF synchrotron facility (Grenoble) in order to clarify the kinetic effects.

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GEO6-10 Poster Barrese, Eugenio

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ASBESTOS AND OTHER FIBROUS MINERALS CONTAINED IN THE GIMIGLIANO-MOUNT REVENTINO UNIT (CALABRIA, S-ITALY)

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Key terms: *serpentinite; metabasite; asbestos minerals; characterization*

The study concerns the investigation of asbestos and other fibrous minerals carrying out on 32 natural rock samples collected in the metabasite sequence belonging to the Gimigliano-Mount Reventino Unit (GMRU).

The GMRU consists of serpentinites, metabasalts, metagabbros/metadolerites with a sedimentary cover made up of marble alternating with calceschists and quartzites. Opicalcites are found in close association with serpentinites and show brecciated fabric. Owing to possible presence of asbestos and other fibrous minerals in these kinds of lithologies, the aim of this investigation is to evaluate their presence and in detail to characterize them. Previous studies are not detailed and above all referred to quarries, because some of these lithologies are quarrying for using as building and ornamental stones and road bed. Besides in these rocks, road yards have often opened.

The univocal distinction among asbestos and other fibrous minerals is very important in so-called "green rocks" as regulated by the Italian law (DM 14/06/1996) which demands the asbestos presence identification and quantification. Besides the Italian law (DM 18/03/2003) established to make a map of the asbestos presence in Italian outcropping rocks.

Moreover, the interaction between natural water and serpentinitic rocks can also cause in former an enrichment in heavy metals in particular Cr which is potentially dangerous for human health.

To reach the target a detailed characterization of the main lithologies (serpentinites, metabasites) are being conducting by MOLP, XRPD, SEM/EDS, TEM/EDS, TG/DSC, XRF and micro-Raman investigations.

The most abundant minerals in serpentinitic rocks are serpentine minerals, chlorite and clay minerals. Serpentinites show pseudomorph mesh texture and bastite replacing olivine and pyroxene respectively with some rare relicts of these silicates. Intergrowths of fibrous chrysotile with bastite are frequently recovered. TEM/EDS investigations show that serpentine minerals are represented by chrysotile, asbestiform and massive antigorite, fibrous polygonal serpentine, fibrous proto-chrysotile, asbestos tremolite-actinolite and lizardite as main phases. Metabasites consist of amphiboles (dominated by asbestos tremolite-actinolite), epidote, albite, muscovite, chlorite, titanite, calcite, magnetite and nimite.

These new knowledges could be used i) as markers of specific environmental conditions during asbestos mineral formation, ii) to identify eventually health hazard areas owing to asbestos fiber presence, iii) to provide data for compulsory Italian mapping.

GEO6-11 Poster Biagioni, Cristian

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MONTE ARSICCIO MINE: THE FIRST THALLIUM ORE IN APUAN ALPS

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Key terms: *thallium; sulfosalts; Monte Arsiccio mine; Apuan Alps; Tuscany*

Together with the magmatic hydrothermal system of La Fossa Crater (Vulcano, Eolie Islands, Sicily, Italy; Camprostrini *et al.*, 2011), the Monte Arsiccio mine is the second Italian locality showing the presence of thallium-bearing mineral assemblages. In particular, it is an interesting locality for the study of thallium sulfosalts in metamorphic environment. Notwithstanding over two centuries of mineralogical studies on the Apuan Alps ores, only recently the first thallium mineral, chabournéite, was identified from the Monte Arsiccio mine (Bonaccorsi *et al.*, 2010); at the same time, Moëlo *et al.* (in press) detected the presence of minor Tl in Sb-rich sterrite from Pollone mine, confirming the geochemical complexity of the hydrothermal paragenesis of the ore deposits from Apuan Alps. Successively, boscardinite and routhierite were also discovered. These minerals have been identified by X-ray diffraction and chemical analyses. These sulfosalts are associated with baryte, calcite, cymrite, dolomite, pyrite, quartz, realgar, sphalerite, stibnite, and zinkenite in Triassic dolostones of the Sant'Olga level.

Chabournéite occurs as black metallic veins; chemically, it agrees with the general formula $Tl_{5-2x}Pb_{2x}(Sb,As)_{2-2x}S_{3+2x}$, with x in the range 1.2 and 1.5 in the two analyzed samples. Therefore it is one of the Pb-richest chabournéites ever described; in addition, this new occurrence shows the lowest As contents, with $As/(As+Sb)$ equal to 0.20 and 0.10 in the two samples. The crystal structure of chabournéite from Monte Arsiccio has been determined in the space group $P-1$; it confirms the general features given by Nagl (1979) but on the basis of a simpler and more symmetrical unit cell, without any visible superstructure, that may be due to the higher Sb contents of

chabournéite from Monte Arsiccio.

This mine is the type locality of boscardinite (IMA 2010-079), a recently approved new mineral that occurs as lead-grey masses in quartz veins or in dolostones. Its simplified chemical formula is $TlPb_2(Sb,As)_2S_{11}$; minor Ag is also present. Boscardinite is the Tl-Sb homeotype of baumhauserite. Its crystal structure was determined and refined to $R = 4.5\%$ for 4319 observed reflections, in a cell with a 8.0929(4), b 8.7610(5), c

22.4497(11) Å, α 90.868(4), β 97.247(4), γ 90.793(4)°, space group $P-1$. The crystal structure of boscardinite can be described in the sartorite homologous series, as formed by the 1:1 alternation of sartorite type and dufrénoysite type layers.

Finally, routhierite was identified on the basis of X-ray powder diffraction and qualitative chemical analysis. It occurs strictly associated with chabournéite, boscardinite, and stibnite, as small cinnabar red anhedral crystals, up to 1 mm. A full characterization of this new occurrence is planned.

The occurrence of a thallium-rich sulfide ore in the Apuan Alps constitutes a very interesting topic according to two points of view. First, it is a new field of exploration of the crystal chemistry of thallium sulfosalts, whose occurrences are extremely rare in the world. Secondly, the geochemistry of this ore, with (Sb,As, Pb, Zn, Tl, Cu, Hg)-sulfides and sulfosalts associated with pyrite is very similar to that described at Jas Roux (French Alps - Johan & Mantiene, 1974), and may be related to the same type of metallogenic process related to Alpine orogeny.

Ref.: Bonaccorsi *et al.* (2010): 20th General Meeting IMA 6, 714; Camprostrini *et al.* (2011). AMI, 344 pp; Johan & Mantiene (1974) *Bull. BRGM Sect. II*, 1-75; Moëlo *et al.* (2011): *Can. Min.* 49, in press; Nagl (1979): *Z. Kristallogr.* 150, 85-106.

GEO6-12 Poster Bindi, Luca

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MENCHETTIITE, A NEW AG-PB-MN-SULFOSALT FROM UCHUCCHACUA POLYMETALLIC DEPOSIT, LIMA DEPARTMENT, PERU, BELONGING TO THE LILLIANITE SERIES

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Key terms: *sulfosalt; new minerals; chemical composition; crystal structure; Peru*

Menchettiite was found at the Nivel 890, Uchucchacua polymetallic deposit, Oyon district, Catajumbo, Lima Department, Peru, that is the same type locality for three other Mn-bearing sulfosalts, uchucchacuaite, $Pb_2AgMnSb_2S_{12}$ [1], benavidesite, $Pb_2MnSb_2S_{12}$ [2], and the newly approved manganoadratite, $AgMnAsS_3$ [3]. The new mineral has been named after Silvio Menchetti, full professor in mineralogy and crystallography at the University of Florence.

Menchettiite occurs in a calcite matrix associated with orpiment, minerals of the tennantite-tetrahedrite series, and other, still unnamed, minerals of the system $Pb-Ag-Sb-Mn-As-S$. Electron microprobe analyses carried out on the same crystal used for the structural investigation led to the following empirical chemical formula: $[Pb_{4.81}Mn_{3.20}Ag_{1.95}Cu_{0.01}Fe_{0.02}Zn_{0.01}Sb_{6.09}As_{3.94}Bi_{0.01}]_{\Sigma=28.04}[S_{23.95}Se_{0.01}]_{\Sigma=24.96}$.

Menchettiite is monoclinic, space group $P2_1/n$, with $a = 19.233(2)$, $b =$

$12.633(3)$, $c = 8.476(2)$ Å, $\beta = 90.08(2)^\circ$ and $V = 2059.4(8)$ Å³; and it is ubiquitously twinned on $\{100\}$. Its crystal structure [$R = 0.0903$ for 2365

reflections with $F_o > 4\sigma(F_o)$] is based on Pb-S like slabs of four-octahedra thickness and appears topologically identical to that of ramdohrite, $Pb_2Sb_{11}Ag_2S_{24}$ [4]. The main difference is related to the atomic species occupying the different structural sites. In detail, in menchettiite: (i) the M1 site appears occupied by a mixture of Pb and Mn whereas it is fully occupied by Sb in ramdohrite; (ii) the M5 site is dominated by Sb whereas it is fully occupied by Pb in ramdohrite; (iii) M9 is fully occupied by Mn whereas it is $Sb_{0.50}Ag_{0.50}$ in ramdohrite; and (iv) variable amounts of As are hosted in M2, M7 and M10 which are fully occupied by Sb in ramdohrite. The geometrical parameters of the coordination polyhedra change accordingly. Menchettiite can be classified among the Sb-rich members of the lillianite homeotypic series which are described with the general formula $Ag.Pb_{3-2x}Sb_{2+5x}Se$ [5]. Besides the heterovalent substitution $2Pb^{2+} \rightarrow Ag^+ + Sb^{3+}$ taken into consideration by the above formula, however, two isovalent substitutions relate menchettiite to the others lillianite homeotypes, i.e.

$Mn^{2+} \rightarrow Pb^{2+}$ (also working in uchucchacuaite [1]) and $As^{3+} \rightarrow Sb^{3+}$. Thus, the general formula of menchettiite can be written as follows: $Ag.Pb_{3-2x-y}Mn_xSb_{2+5x-z}As_ySe$ with $x = 0.5$, $y = 0.8$ and $z = 1.0$. This formalism makes evident the close similarity of the new mineral with uchucchacuaite ($x = 0.5$, $y = 0.5$, $z = 0.0$), the only member of the series to have the same ratio between metallic and semi-metallic elements. In its appearance and physical properties menchettiite is indeed quite similar to uchucchacuaite; as expected on the basis of its higher Mn/Pb and As/Sb ratios, however, menchettiite exhibits a reflectivity lower than that of uchucchacuaite.

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GEO6-13 Poster Bonaccorsi, Elena

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IN SITU STUDY OF THE THERMAL BEHAVIOR OF PLOMBIÈRITE

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Key terms: *tobermorite group; plombièrite; thermal behavior*

Plombièrite is the most hydrated phase belonging to the tobermorite group; it is characterized by a basal spacing of 14 Å. The structure solution and refinement by Bonaccorsi *et al.* (2005) indicated that the

chemical formula of plombièrite is $\text{Ca}_2(\text{Si}_2\text{O}_7)(\text{OH})_2 \cdot 9\text{H}_2\text{O}$. Similarly to other members of the tobermorite group, its structure is composed by the stacking along *c* of a complex module, which is formed by a calcium layer, decorated on both sides by wollastonite-like single silicate chains. The modules are shifted each other of *b*/2 and are separated by a layer of additional calcium cations and H_2O molecules.

The thermal behavior of plombièrite is apparently simple: at 110°C plombièrite shrinks to a 11 Å phase, which transforms into tobermorite 9 Å upon heating up to 300°C. However, some authors (Farmer *et al.*, 1966; Mitsuda & Taylor, 1978) describe a more complex behavior, with the appearance of a new phase at higher temperature, with basal distance of ≈ 10 Å. Another matter of discussion is represented by the polymerization of the silicate chains in the 11 Å tobermorite formed through the dehydration of plombièrite: all the so far studied samples of natural tobermorite 11 Å show double wollastonite-like chains, whereas the 11 Å phase obtained upon heating might show single chains (Wieker *et al.*, 1982; Yu & Kirkpatrick, 1999).

Specimens of plombièrite from Crestmore (California, USA) and Zeilberg (Bavaria, Germany) were studied *in situ* through the experimental apparatus described by Meneghini *et al.* (2001) at the GILDA beamline of ESRF (Grenoble, France). The results obtained by the two specimens confirmed that at 110°C plombièrite shrinks to a 11 Å phase; the refinement of the cell parameters showed clearly the decreasing of the *c* parameter, whereas *a* and *b* maintain their values. These data pointed to the approaching along *c* of unmodified complex modules.

At the beginning, the so-formed 11 Å phase presented a basal spacing of nearly 11.7 Å, in accordance with the results of a previous study by Yu & Kirkpatrick (1999); this value progressively decreased down to 11.3 Å at about 250°C. At 300°C, the 11 Å phase is replaced by a 9 Å phase. As already observed by previous authors, the higher the temperature, the longer is the basal spacing of the 9 Å phase, which shifts toward 10 Å. To investigate the condensation degree of the silicate chains in the 11 Å phase formed by dehydration of plombièrite, either double or single, we collected the micro-Raman spectra of the heating product of plombièrite from Crestmore, and compare them with those of other phases with known structure. Our results point to the occurrence of single silicate chains, in agreement with that reported by Yu & Kirkpatrick (1999). In principle, it is possible to hypothesize that 11 Å phases characterized by single chains occur also in nature, due to the possible dehydration of plombièrite under mild metamorphic conditions. However, up to now this kind of phase was not yet discovered in natural samples.

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GEO6-14 Poster Bonazzi, Paola

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MANGANOQUADRATITE, AGMNASS₃, A NEW MANGANESE BEARING SULFOSALT FROM UCHUCACHACUA POLYMETALLIC DEPOSIT, LIMA DEPARTMENT, PERU

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Key terms: sulfosalt; new mineral; chemical composition; crystal structure; Peru

A new manganese bearing sulfosalt was found at the Nivel 890, Uchucachaca polymetallic deposit, Lima Department, Peru, that is the same type locality for three other Mn-bearing sulfosalts, i.e. uchucachacuite [1], benavidesite [2], and the just approved menchettiite, Pb-Mn-Ag-Sb-As-S₂ [3]. Associated minerals are Mn-rich calcite, alabandite, Mn-rich sphalerite, proustite, pyrite, argentotennantite, stannite and other unnamed minerals of the system Pb-Ag-Sb-Mn-As-S. Electron microprobe data, lead to the following empirical formula: $(\text{Ag}_{0.95}\text{Cu}_{0.05})(\text{Mn}_{0.95}\text{Pb}_{0.05})(\text{As}_{0.87}\text{Sb}_{0.13})\text{S}_{2.99}$. Single-crystal X-ray data were collected with a CCD diffractometer, using MoK α radiation. Unit-cell parameters (*a* = *a* = 5.4496(5), *c* = 32.949(1) Å; $\alpha = \beta = \gamma = 90^\circ$) and analysis of intensity data indicated the Laue group *4/mmm* and E-statistic strongly indicated the structure to be centrosymmetric. However, systematic absences gave contradictory information and first attempts to solve the structure by a standard way (Patterson and direct methods) were unsuccessful.

Due to the strong subcell *a*_{sub} = *a*, *c*_{sub} = 1/3 *c*, a first model of the average structure was obtained by refining a chalcopyrite-like model (I4-2*d*). The obtained atom coordinates were then transformed for a 3-fold unit-cell and the model slowly achieved convergence in the P1 space group (*R*1 = 0.093 for 1622 *F*_o > 4 σ (*F*_o) and 0.15 for all 2939 data). At this stage, an analysis of the structure with the ADDSYM routine of the PLATON program [4] revealed the real symmetry to be P4-22; in this space group the structure was refined up *R*1 = 0.086 for 907 reflections with *F*_o > 4 σ (*F*_o) and 0.14 for all 1532 independent data). The structure consists of a stacking sequence along [001] of square-net layers of O atoms (O-O = 2^{1/2}*a*/2 = 3.85 Å) each one shifted of 1/2*a* with respect to the adjacent one, with the cations located in the center of the O₄ squared nets. In the sequence, one Mn-S₂ layer is stacked by two AsAgS₂ layers, thus determining the 3-fold translation along [001]. The layers containing Mn²⁺, located at *z* = 1/8, 3/8, 5/8 and 7/8, are the most regular. Layers containing As³⁺ and Ag⁺ are more irregular, mostly due to the lone-pair bearing As³⁺ cation which is asymmetrically located within the O₄ squared nets. Couples of AsAgS₂ layers are interconnected to each other by both As³⁺-S and Ag-S bonds which complete the coordination polyhedra forming AS₂ and AgS₂ pyramids, respectively. In turn, the sulfur atoms of the AsAgS₂ layers complete the octahedral coordination of Mn²⁺.

Due to the analogy of the chemical formula and the unit cell parameters with those of quadratite (AgCdAs₂, *a* = 5.499(5), *c* = 33.91(4) Å; [5]) the new mineral here described was supposed to be the Mn-analogue of quadratite and therefore named manganoquadratite. The crystal structure of quadratite (supposed to crystallize in the I4₁/amd space group) however, is still unknown and whether these two minerals are strictly isostructural or not remain to be ascertained.

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GEO6-15 Poster Camara, Fernando

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KAZANSKYITE, BA Na₃Ti₂Nb (Si₂O₇)₂O₂(OH)₂(H₂O)₄, A NEW TITANIUM DISILICATE MINERAL WITH THE TS BLOCK FROM KIROVSKII MINE, KOLA PENINSULA, RUSSIA.

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Key terms: new mineral; titanium disilicate; crystal structure; Kola Peninsula

Kazanskyite, ideally BaNa₃Ti₂Nb(Si₂O₇)₂O₂(OH)₂(H₂O)₄, triclinic:

a 5.4260(9), *b* 7.135(1), *c* 25.514(4) Å, α 98.172(4), β 90.916(4), γ 89.964(3)°, *V* 977.61(5) Å³, *Z* = 2, is a new representative of titanium disilicate minerals with the TS (titanium silicate) block[1]. It occurs at Kirovskii mine, Mt. Kukisvumchorr, the Khibiny alkaline massif, Kola Peninsula (Russia), associated to natrolite, barytolamprophyllite, nechelyustovite, hydroxylapatite, belovite-(La), belovite-(Ce), gaidonnayite, nenadkevichite, epididymite, apophyllite-(KF), sphalerite. The crystal structure of kazanskyite is a new structure type and does not have any analogues. It is a combination of a TS block and an I (intermediate) block. The TS block consists of HOH sheets (H = heteropolyhedral, O = octahedral).

The TS block exhibits linkage and stereochemistry typical for Group III (Ti-Nb = 3 a.p.f.u.) of the Ti-disilicate minerals: two H sheets connect to the O sheet such that two (Si₂O₇) groups link to the trans edges of a Ti octahedron of the O sheet [1]. In the O sheet, there are four M² sites. The M²(1) and M²(2), M²(3), M²(4) sites are occupied by Ti_{0.74}Mn_{0.26} and Na, Na_{0.77}Mn_{0.15}Ca_{0.07}Fe²⁺_{0.01}, Na_{0.77}Mn_{0.15}Ca_{0.07}Fe²⁺_{0.01}, respectively. The cation composition of the O sheet is ideally Na₃Ti₂p.f.u. (per formula unit). The TS block has two H sheets, H1 and H2, which differ in coordination number and dominant cation at the M² site, [6]-coordinated Nb and [5]-coordinated Ti, respectively. In the H sheets, there are four Si sites occupied solely by Si and tetrahedrally coordinated by O atoms, with <Si-O> = 1.62 Å. In the H sheet, (Si₂O₇) groups link to M² polyhedra. The chemical formulae of the H sheets is ideally NbTi(Si₂O₇)(H₂O) and of the TS block is Na₃Ti₂Nb(Si₂O₇)₂O₂(OH)₂(H₂O). There are two peripheral sites, A¹

(1) and A²(2), occupied by Ba_{0.91}Sr_{0.28}K_{0.21} and Ba_{0.19}^{0.81}, respectively.

There are two I blocks: the I1 block is a layer of A¹(1) atoms with ideal composition Ba a.p.f.u.; the I2 block consists of A²(2) atoms and H₂O groups, ideally (H₂O)₂. TS blocks and I blocks alternate along [001]. We write the chemical formula of kazanskyite as two TS and two I blocks divided by two: Na₃Ti₂Nb(Si₂O₇)₂O₂(OH)₂(H₂O) + Ba + (H₂O)₂ = BaNa₃Ti₂Nb(Si₂O₇)₂O₂(OH)₂(H₂O)₄, *Z* = 2. The I1 and I2 blocks of kazanskyite are topologically and chemically identical to the I1 and I2 blocks in nechelyustovite [2]. The layer of Ba atoms (I1 block) also occurs in barytolamprophyllite [3] and bornemanite [4].

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GEO6-16 Poster Kaneva, Ekaterina

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IMPROVEMENT OF THE CRYSTAL STRUCTURAL MODEL OF TINAKSITE

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Key terms: Tinaksite; crystal structure refinement; structural disorder

Tinaksite from ultralkaline apgaitic Murun massif (Russia) has been investigated. The name reflects its composition: titanium (Ti), sodium (Na), potassium (K) and silicon (Si). Its structure was reported for the first time in 1971 by Petrunina [1]. To the best of author's knowledge,

tinaksite is the only silicate based on {**hb**, 2 **oo**} [Si₂O₇(SiO₂)] hybrid anion [2]. The structural model of Tinaksite proposed by Petrunina [1] was validated and improved by von Bissert [3] in 1980, who observed a more regular tetrahedra conformation. The tinaksite investigated by von Bissert [3] is triclinic with chemical composition: Na₂Ca₂Ti₂[Si₂O₇](OH). The compound here investigated has chemistry more complex, ((Na_{0.855}K_{1.993}Ca_{2.008}Ti_{0.792}Mg_{0.083}Fe³⁺_{0.096}Mn_{0.106}Zr_{0.027}Sr_{0.012}Zr_{0.027}Zr_{0.008}Ni_{0.007}Cr_{0.005})[Si₂O₇](OH), compared with Petrunina's [1] and von Bissert's [3] ones. It has been refined in P1, using the following lattice parameters: *a* = 7.0565(1) Å, *b* =

10.3750(1) Å, *c* = 12.1885(2) Å, $\alpha = 92.802(1)^\circ$, $\beta = 90.763(1)^\circ$, $\gamma = 99.241(1)^\circ$.

In this work, the cation partition derived from SCXRD and EPMA data, is presented. The structure has been anisotropically refined up to a *R*(*F*) = 0.025 (for 5238 observed reflections with *F*_o > σ (*F*_o)). Tinaksite exhibits straight channels parallel to [001] direction, formed by double chains of silicate. The channels are stretched approximately along [110] direction, with maximum dimension 10.972(2) Å.

The highest peak in the Fourier difference map is related to some structural disorder inside the Ti octahedron. This disorder likely can be ascribed to the entrance of the large K substituting the six-fold coordinated Na atom. As a matter of fact, the replacing of Na for K changes the coordination number of the polyhedron from 6 to 7, which seems to influence the neighbouring Ti atom position.

Another point concerns the K1 and K2 atoms located inside the channels. According to von Bissert [3], the higher K1 thermal parameter with respect to the K2 one indicates the site filled by K1 is disorder. The

structural refinement shows that K1 atom is located over at least three different positions. A charge distribution analysis, performed by means of the Chardi-It software [4], has returned an EON number [5] of 11 and 9 for the K1 and K2, respectively. The bond distances for the three K atoms, related to K1, show these atoms are not always bonded to the same oxygens. Indeed, K1 can move inside a cage formed by 14 oxygen atoms with a volume of about 90 Å³. This volume results to be much larger even than the one of the ideal twelve-fold coordinated K atom (~18 Å³).

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GEO6-17 Poster Lenaz, Davide

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CRYSTALCHEMISTRY OF CR-SPINELS FROM THE SHETLAND OPHIOLITE COMPLEX (SCOTLAND)

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Key terms: crystal chemistry; Cr-spinel; ophiolites; Shetland Island

Cr-spinels are typical accessory minerals in a wide variety of ultrabasic rocks such as dunites, harzburgites and lherzolites, occurring in various geological settings and belonging to different depth-zone facies. In the present study, ten Cr-spinel crystals from four localities in the ~492 Ma Shetland ophiolite (NW Scotland) have been studied using single-crystal XRD to assess their petrogenesis and cooling history. The mantle section of the Shetland Ophiolite dominantly outcrops on the Isle of Unst and preserves a heavily serpentinized, two kilometre-thick section of layered dunites and harzburgites (Spray and Dunning, 1991; Flinn, 2001). Numerous podiform chromitites (defined as >60% vol. Cr-spinel) enclosed in dunite lenses are frequently found close to the petrological Moho (Flinn, 2001). Cr-spinel seams are between 10 cm-1 m in thickness and laterally discontinuous over the scale of several meters. Previous work reveals that the Cr# [Cr/(Cr+Al)] of the seams vary in different chromitite locations; 0.63-0.81, 0.60-0.67, 0.60-0.65, and 0.65-0.67 respectively (Derbyshire et al., unpublished data).

In the study of spinels the most important structural parameters are cell edge and oxygen coordinate. These parameters are influenced both by chemistry and the cooling history inferred by the host rocks. In particular, oxygen coordinate is sensitive of this last "condition" being influenced by the cation-exchange between T and M sites. For single-crystal XRD analyses, synthetic spinels were mounted on an automated KUMA-KM4 (K-geometry) diffractometer, using MoK α radiation monochromatized by a flat graphite crystal. The unit cell (a0) was determined by 24 equivalent reflections of (12 8 4) or (8 4 4) (about 90° and 50° of 2theta), according to the size of the crystal accurately centred at both sides of 2theta. Data collection was made according to Della Giusta et al. (1996) up to 2theta = 55°. The analyzed Cr-spinels show cell edges and oxygen coordinate parameters ranging from 8.2580 (6) to 8.3134 (6) Å and 0.2623 (1) to 0.2631 (1), respectively.

One of the most peculiar features of the analysed Cr-spinels is that, despite their occurrence in ophiolitic samples, their structural parameters resemble those of Cr-spinels occurring in layered mafic complexes such as the Bushveld (Lenaz et al. 2007) and Stillwater (Lenaz et al. 2011) intrusions, rather than those of Cr-spinels in typical ophiolitic samples (cf. Bosi et al. 2004). In fact, the spinels from ophiolitic complexes usually show similar cell edges, but very different u parameters ranging between 0.2616 (1) and 0.26267 (8), where low values derived by cation vacancies due to Fe²⁺ oxidation to Fe³⁺.

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GEO6-18 Poster Mattias, Pierpaolo

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BENTONITES AND BENTONITIZED ROCKS OF MARCHE REGION (CENTRAL, ITALY) (UMBRO - MARCHEAN APENNINES)

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Key terms: Bentonites; Bentonitic Earth; Mines; Underground; Marche Region (Italy)

The presence of bentonites and bentonitized rocks inside the sedimentary sequences of the Umbro - Marche Apennines (Central Italy) is poorly known, even though several careful studies have been devoted to these rocks owing to their industrial importance. The above rocks form beds, levels or lenses, spanning from Cretaceous to Miocene in age. They are found inside terrains belonging to several lithostratigraphic units, from the Bisciaro Fm until the Laga Fm. Complex lying of bentonitic deposits is the result of several and successive dislocations caused by orogenic pulses. In the Pesaro-Urbino province (northern Marche), under particularly favourable conditions, bentonite levels and / or lenses, 40 to 200 cm - thick, originated between marine sediments such as marly limestones and marls. In the past, bentonitic materials have long been known and used as pietra saponaria (soap stones), argille da bianca (fuller's earth), or argille

smettiche (smectitic clays). In the late century, from the end of 30's to the whole 70's, these rocks have been the object of several researches also of regional extent. Afterwards, national and foreign chemical industries provided to open some mines in the most promising sites. Purity of such bentonitic materials, as well as their excellent suitability for technological uses, pushed excavation further down until a 275-m depth was reached, corresponding to a digging level of the 9th order, in the Lama - Mondaino mine.

Other important mines were located in the Montefotogno - I Pianacci area (where an exploitation of small extent is still carried on), at Montefabbi (Talacchio - Colbordolo), S. Martino (Case Cecchini - Belvedere Fogliense), and S. Maria (Val di Loto - Sassocorvaro), plus minor occurrences. Mineralogical analyses revealed that the smectitic term is composed mainly by montmorillonite, montmorillonite - beidellite, and rarely by nontronite. Negligible amounts of calcite, quartz, illite, kaolinite, and dolomite are recognized. The genesis of bentonitic rocks has been widely discussed in the past. Nowadays, it is linked to emplacement of volcanic ashes coming from westerly volcanoes. The age, and mainly the chemistry, of such volcanic materials allow to ascribing them to huge eruptive cycles of the Western Sardinia volcanic district. At the moment, all the bentonite mines are covered by a natural vegetation, which obliterated them almost completely.

GEO6-19 Poster Pasero, Marco

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DOES HOLLANDITE CONTAIN WATER? PHASE TRANSITIONS IN HOLLANDITE INDUCED BY TEMPERATURE

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Key terms: hollandite; thermal behavior; phase transitions

As a part of an ongoing study on the crystal-chemistry of the so-called "tunnel oxides", we aimed at clarifying the possible presence of water in hollandite and in the other minerals of the cryptomelane group, whose general formula is $(A^+, A^{2+}_{0.5})(M^{2+}_{x-1}M^{3+})O_{16}$ ($x \approx 2$). Due to the microporous nature of these minerals, it cannot be excluded that the tunnels may host water molecules, together with the A exchangeable cations (K⁺, Na⁺, Ba²⁺, Pb²⁺, Sr²⁺). So far specimens of Fe-rich hollandite from Vagli were studied.

Their chemical formula can be expressed as $(Ba_{0.79}Sr_{0.22}Na_{0.02}K_{0.01})_{\Sigma=1.04}(Mn^{4+}_{5.70}Ti_{0.32}Fe^{3+}_{1.05}Mn^{2+}_{0.79}Al_{0.13})_{\Sigma=7.99}O_{16}$. As almost all members of the cryptomelane (all but manganite), hollandite is nominally anhydrous. The ideal topological symmetry of hollandite is tetragonal, space group $I4/m$, with $a \approx 10$, $c \approx 2.9$ Å. A single-crystal X-ray diffraction study of hollandite from Vagli carried out with a conventional Siemens P4 four-circle diffractometer proved that its c axis is doubled and the actual symmetry is monoclinic. The observed cell parameters are a 10.152(4), b

9.938(4), c 5.828(2) Å, β 90.71(3)°, space group $P2_1/n$. The doubling of the c parameter has been related to the ordering of Ba cations between two split positions within the tunnels. The crystal structure of anhydrous hollandite has been refined to $R = 5.01\%$ for 1641 observed reflections. Assuming an actual electron density equal to $[Ba_{0.8}Sr_{0.2}]$, as indicated by EPMA data, we tried to include water molecules, alternating with Ba along the tunnels. This would result in a better coordination of barium and would avoid unlikely Ba...Ba interactions between neighbor cations. Notwithstanding the difficulty in accurately refining the occupancy of water molecules sharing the same sites with heavy cations (also because of the high mobility of both), a plausible and self-consistent crystal-chemical model has been depicted; in addition, the refinement converged to $R = 4.97\%$.

In order to confirm the presence of water in hollandite, TG/DSC runs have been carried out with powdered samples (ca. 25 mg), using a Netzsch STA 449C equipment in N₂ atmosphere, from room temperature up to 1200°C, with a thermal gradient of 10°C/min. After each run, the products were identified through powder X-ray diffraction using a Philips PW1050/25 diffractometer. The collected data suggest the presence of three steps of weight loss: i) at T \approx 730°C, a small endothermic hump related to a weight loss of 1.2 wt.%, maybe due to molecular water loss; ii) at T \approx 895°C, a broad endothermic peak, probably related to the appearance of bixbyite and minor hausmannite in the heated products, as indicated by PXRD pattern; finally, iii) at T \approx 950°C, a marked endothermic peak is observed. The final product consists of hausmannite and, maybe, of a new-formed Ba-bearing Mn phase. The total final weight loss is approximately 9 wt.%.

Further thermo-gravimetric data on other specimens of hollandite from different localities are planned to verify the extent of the weight loss observed for the sample from Vagli. Preliminary data seems to confirm the above-described trend.

GEO6-20 Poster Pastoro, Linda

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MORPHOLOGICAL CHANGE OF CALCITE CRYSTALS GROWN FROM AQUEOUS SOLUTION IN THE PRESENCE OF L- AND D/L-ASPARTIC ACID

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Key terms: adsorption; epitaxy; enantioselectivity; calcite; surfaces

The mechanisms of biologically driven crystal growth are usually limited to the stereochemistry of the adsorption of biologically interesting molecules. Hence, the theoretical approach is confined to the study of the interaction between specific sites of crystal surfaces (substrate) and the isolated molecule (adsorbate). This is, of course, a necessary step to evaluate the adsorption energy of an isolated molecule on a given substrate. Nevertheless, more information is needed to understand the "cooperative effect" when the adsorbate is not made by a randomly distributed molecular population but is localized either in 2D nuclei or in monolayers making epitaxy with the substrate.

The results of the researches we carried out in the last decade clearly show that several morphological changes, already attributed to the random adsorption of impurity on specific crystal surfaces, can be correctly interpreted in the light of 2D epitaxially adsorbed phases. This is the case of the 2D epitaxies of: i) - Li₂CO₃ on Calcite growing from Li-doped

solutions [1]; ii)- SiO₂ (α-quartz) on Witherite growing from Na-metasilicate doped solutions [2]; iii)- formamide on NaCl crystals growing from aqueous solutions [3]. Moreover, it has been shown, in i) and iii), that the 2D adsorption is a preliminary step for selective adsorption in the growing substrates followed by the formation of "anomalous mixed crystals" in the sense of Johnsen [4]. In this work, we deal with the changes induced in the morphology of calcite crystals when variable amounts of L- and D/L- Aspartic Acid are added to the growth solution. It is worth remembering that the mother solution, supersaturated with respect to calcite, is unsaturated with respect to both the impurities we used, in order to verify:

-the occurrence of 2D adsorbed phase on the crystal surfaces
-the enantioselectivity of the calcite {21.4} scalenohedron surfaces with respect to the L- enantiomer and to the racemic phase of the Aspartic Acid.

Concerning the theoretical aspects, the Hartman-Perdok analysis [5] on the <441> zone of calcite has been carried out and the calculation of the surface (γ_{hkl}) and attachment energies was performed, on both unrelaxed and relaxed surfaces. The flat (F) character of the {10.4} and {11.0} forms and the stepped (S) one of the {01.8} and {21.4} forms contradicts the observed occurrence frequency of natural crystals:

{21.4} > {01.8} > {10.4} > {11.0}. A minor reduction of the relaxed γ_{hkl} values of both {01.8} and {21.4} forms, could be sufficient to make the theoretical equilibrium shape of the crystal composed by the {10.4}, {01.2}, {10.0}, {00.1}, {01.8} and {21.4} forms, which explains the richness of the growth morphology of calcite, even if water adsorption is not considered. Our analysis is focused on the {21.4} scalenohedron. Epitaxy models are described: i)- between D and L {21.4} surfaces and the adsorbed 2D layers of polar {010} and {0-10} L-Aspartic acid; ii) - between the {10.4} surface and the adsorbed 1D rows and 2D Aspartic layers. Hence, the adsorption enantiospecificity is better explained through a "cooperative molecular" approach, instead of searching for the best interaction of a single molecule on specific surface sites.

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GEO6-21 Poster Ventruti, Gennaro

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IN SITU, HIGH-T FTIR SPECTROSCOPY OF SIDERONATRITE: Na-Fe³⁺(SO₄)₂(OH)³(H₂O)

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Key terms: Ferric sulphate hydrates; sideronatrite; HT-FTIR spectroscopy; phase transition

Sideronatrite - Na-Fe³⁺(SO₄)₂(OH)³(H₂O) - is a secondary iron-bearing, hydrous sulfate formed during oxidation of pre-existing sulfides. It is a typical sedimentary product in some soils and evaporitic deposits. Sideronatrite is formed in acid, sulfate-rich environments, and plays an important role in the acid drainage mobilization of metals and in the monitoring of water quality. The dehydration behavior of sideronatrite from Sierra Gorda (Chile) was investigated by *in situ* high-T FTIR spectroscopy. The structural variations induced by thermal treatment were monitored by FTIR using the bending mode of the water molecule around 1650 cm⁻¹, the stretching modes around 3500 cm⁻¹, and the corresponding combinations modes in the wavenumber region 4000-6000 cm⁻¹. A succession of three structural phase transitions have been observed in the range RT - 400°C. In the first and second phase transition (sideronatrite

→ metasideronatrite I, [Na-Fe³⁺(SO₄)₂(OH)³(H₂O)] [1] and

metasideronatrite I → metasideronatrite II, [Na₂Fe³⁺(SO₄)₂(OH)]² and one interstitial water molecules, coordinated by the Na atoms, are lost respectively, while the backbone of the structure present in sideronatrite, i.e. the [Fe³⁺(SO₄)₂(OH)]³ chain, keeps unchanged. The loss of OH-group corner-sharing between two adjacent Fe³⁺-octahedra in sideronatrite chain, involves the break down of the [Fe³⁺(SO₄)₂(OH)]³ chain and the subsequent formation of an intermediate amorphous transition phase from which the Na-Fe(SO₄)₂ compound [2] will form later. Thermogravimetry combined with mass spectroscopy of evolved gases confirm furtherly the dehydration and dehydroxylation processes observed.

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GEO6-22 Poster Pratesi, Giovanni

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THE DUAL BEHAVIOUR OF THE β-AS₂S₃ ALTERED BY LIGHT

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Key terms: beta-As₂S₃; realgar; pararealgar; alacranite; light

The mineral realgar (alpha-As₂S₃), and the polymorph of high temperature, beta-As₂S₃ (stable over 252 °C) undergo a peculiar process of alteration induced by light. Both the phases alter to pararealgar (Bonazzi et al., 1995), as a result of the exposure to natural or artificial light (Douglass et al., 1992; Bonazzi et al., 1996) and this causes an anisotropic increase of the unit-cell volume (up to 2.6%) of both the polymorphs. During the process of alteration, starting from both realgar or the beta-phase, arsenolite occurs along with a metastable phase, named

chi-phase, which is the precursor of pararealgar. As Bonazzi et al. (2006) shown remarkable work has been done to understand the nature of the transformation and the authors relate the unit-cell expansion to the substitution of As₂S₃ units by As₂S₂ uzonite-type molecules according to

the reaction 5As₂S₃ + 3O₂ → 4As₂S₂ + 2As₂O₃ and the following removal of the additional sulfur atom to produce the molecule of pararealgar. Thus, the untied S atom would be ready to enter another realgar molecule and continue the cyclic mechanism. To better understand the role of the oxygen and if the unit-cell expansion of the beta-phase is really due to the presence of uzonite-type molecules, some powdered beta-phase has been altered by the light with and without the presence of the air, XRPD data were collected in transmission geometry, and structural refinements along with quantitative phase analysis were carried out using the Rietveld method. The alteration induced with the presence of the air caused the formation of pararealgar, arsenolite and an amorphous phase, while from the powder not in contact with the air only pararealgar was obtained. The second part of the experiment was aimed to detect if the two types of pararealgar, so obtained, could transform into the beta-phase through the action of the heat in a closed environment, and within the stability field of realgar. The powder made by pararealgar, arsenolite and amorphous phase yielded crystalline arsenolite and alacranite. Differently, the powder made of only pararealgar turned into the chi-phase, and slowly into the beta-phase only, the unit cell exhibiting a contraction. This points out that the beta-phase altered by the light shows a dual behaviour whether or not that occurs with the presence of the air, that is the oxygen. In the first case the transformation is not reversible and follows a mechanism above mentioned, while in the second case the transformation is reversible. With these evidences it is difficult to make the hypothesis that some As₂S₂ molecules form during the alteration under the light, since neither arsenolite nor amorphous phase occurs, and the whole material turns into pararealgar. It is also difficult to invoke the proposed mechanism to explain both the expansion of the unit cell of the beta-phase and the contraction of the unit cell of the chi-phase. In this case the transformation must be due to a different mechanism, such for instance the direct transformation of the As₂S₃ molecule, of alpha and beta polymorphs, to that of pararealgar with the simple breaking of the As-As and AsS bonds and the sudden reconstruction.

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GEO6-23 Poster Carati, Mariano

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GRUPPO MINERALOGICO GEOLOGICO NAPOLETANO AND THE MINERALOGY OF SOMMA-VESUVIUS AND CAMPI FLEGREI: THIRTY YEARS OF CONTRIBUTIONS

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Key terms: Gruppo Mineralogico Geologico Napoletano; Minerals of Somma-Vesuvius; Minerals of Campi Flegrei; Discovery Minerals; Collaboration with Institute of Research

Gruppo Mineralogico Geologico Napoletano (GMGN) is a non-profit organization founded in Naples in 1980 by three mineralogy fan: Massimo Russo, Giovanni Coslovich and Claudio Lombardo (the latter two left the group over time).

Over the years GMGN has built up a remarkable experience in the field, so that it has substantially contributed to a better knowledge of the mineralogy of the Neapolitan area, especially Somma-Vesuvius and Campi Flegrei areas.

Over the years it has enjoyed the collaboration of several major national and foreign research institutes: universities of Bari, Napoli, Milano, Pisa, Roma, the British Museum of London, and the Muséum National d'Histoire Naturelle of Paris. At the present GMGN cooperates with Istituto Nazionale di Geofisica e Vulcanologia sezione di Napoli | Osservatorio Vesuviano, Dipartimento di Chimica Strutturale e Stereochimica Inorganica, University of Milano and Associazione Micromineralogica Italiana.

The research carried out by GMGN has led to the discovery of 34 species new to Somma-Vesuvius (one Type Locality: fluoro-potassichrichterite), two now discredited (one Type Locality: caratite now pyrite), two to be reviewed according to the new IMA definitions: pyroclorite and betafite, and two in which GMGN has contributed to a better knowledge of the species: euchlorine and quadridavvne. Similarly, for Campi Flegrei GMGN has contributed with 13 species new to the area and one be reviewed according to the new IMA definitions: pyroclorite.

In these thirty years of activity GMGN has published a significant number of scientific and specialized articles in the following bulletins: Notiziario del GMGN, GMGN Notizie, GMGN News, Rivista Mineralogica Italiana, MICRO, and on the web. The collaboration with the Associazione Micromineralogica Italiana led to the realization of a book very popular among scientists and collectors: Russo, M. and Punzo, I. (2004): I Minerali del Somma-Vesuvio, edited by Associazione Micromineralogica Italiana.

The GMGN meets regularly to discuss topics related to the Campania territory, to organize geological and mineralogical excursions and lectures and to give specialized advices about Campania minerals. More information: www.gmgcn.it.

GEO6-24 Poster Stara, Paolo

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CONTRIBUTION TO THE STANDARDIZATION IN THE ASSESSMENT OF MINERAL COLLECTIONS

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Key terms: mineral collections; assessment; standardization

The recovery of the mineralogical heritage by public institutions, with a

view to increasing musealization, can lead to the purchase of entire private collections or any part of them.

However, in the practice, the evaluation is influenced by factors and "interests" that are not always clearly defined. Instead, the increasing transparency of public administrative acts, requires the adequacy of evaluations, whose methods need to be more reproducible and less attackable.

In this work the authors focus on a series of reproducible parameters, which, starting from the values prevailing in the period, tend to make a final assessment more transparent.

SESSIONE GEO7

Petrologia e petrografia

GEO7-1 Key Lecture Ferrari, Marco

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MINERALOGICAL TRANSFORMATIONS IN SERPENTINITES FROM THE MT. CAPANNE THERMOMETAMORPHIC AUREOLE (ELBA ISLAND, ITALY)

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Key terms: serpentinite; olivine; thermal metamorphism; reaction mechanism; TEM

The Mt. Capanne intrusion (Elba Island, Italy) induced thermal metamorphic reactions within pseudomorphic lizardite (liz) + chrysotile (chr) serpentinites, giving rise to prograde minerals crystallization. This research is aimed at characterizing the thermally induced mineralogical and micro/nanostructural transformations in serpentinites, showing four main prograde reactions.

The first prograde reaction takes place both in bastites and mesh cores and leads to the formation of antigorite. Antigorite grows in the form of lamellae, longer than 50 µm, with random orientation; it develops at the expense of low-crystallinity liz + chr serpentine. The TEM study showed that antigorite has a highly defective structure with variable superperiodicity, modulation dislocations and polysynthetic twinings. The second prograde reaction leads to a fine intergrowth of talc and chlorite starting from the low-crystallinity liz + chr serpentine of the bastites. TEM images show that talc within bastites grows in the form of very long and rather thin lamellae (typical thickness of 30 - 60 nm), which are finely intercalated to low-crystallinity serpentine. Talc is always associated with lesser amount of chlorite. The lamellae of chlorite show a rather variable width, but they are always wider than the talc lamellae. High-resolution images and SAED patterns showed that also chlorite is often affected by structural defects, generally concentrated in specific crystal portions rather than homogeneously distributed.

The third prograde reaction causes the formation of anthophyllite and/or tremolite amphiboles. Prograde amphiboles can nucleate both in bastites and mesh textures. Within bastite, they may grow as tiny acicular crystals with size around 100 µm in length, developing in random orientation, and evolving to a fine-grained interpenetrating felt. Alternatively, they may progressively replace the bastitic serpentine from the outer toward the inner portions, producing a large pseudomorphic single crystal. In mesh textures, amphiboles typically occur as elongated crystals, with an acicular-fibrous habit in random orientation. In some cases anthophyllite and tremolite coexist within meshes. High-resolution TEM images and SAED patterns showed that anthophyllite is typically affected by polytypic disorder with random stacking of anthophyllite, protoanthophyllite and cummingtonite; conversely, tremolite is very ordered and defect-free. The fourth prograde reaction leads to the formation of forsteritic olivine, replacing mesh serpentine and never occurring within bastites. TEM observations suggest that all prograde transformations take place through amorphization and subsequent recrystallization processes; low crystallinity sites tend to react easily evolving to higher temperature paragenesis, while high crystallinity sites tend to persist in samples of higher metamorphic grade.

In most cases, the retrograde association (lizardite + chrysotile) tends to transform directly into prograde associations (talc + chlorite, amphibole and olivine). The formation of prograde antigorite in interpenetrating textures, found in a single outcrop, may have been favored by an intense deformation.

Serpentinite outcrops show a variable metamorphic grade. It could be due to the complex sequence of the intrusion emplacement, to a non-uniform movement of hydrothermal fluids and to a variable deformation induced by pluton on the wall rocks.

GEO7-2 Orale Ferrando, Simona

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MG-METASOMATISM OF METAGRANITOIDS FROM THE ALPS: GENESIS AND POSSIBLE TECTONIC SCENARIOS

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Key terms: metasomatism; ultramafic rocks; seawater

The genetic process and the possible tectonic scenarios responsible for the origin of continental Mg-metasomatic rocks in the Alps are proposed by integration of field, petrological, geochemical (bulk-rock chemistry and stable isotope compositions) and fluid inclusion data previously reported for Mg-metasomatic rocks derived from post-Variscan granitoids (e.g., whiteschists, leucophyllites).

Despite the heterogeneous data, the large range of peak metamorphic conditions (from the lowermost greenschists-facies to the ultrahigh-pressure medium-temperature eclogite facies) and the distinct time of metasomatism (from rifting to exhumation), some common features have been recognized in all of the continental Mg-metasomatic rocks belonging to the palaeogeographic realms of both Europe and Adria: i) they occur along shear zones within the metagranitoids; ii) they display a simple MgO-Al₂O₃-SiO₂-H₂O±K₂O-silicate mineralogy; iii) based on major-

and trace-element compositions, they can be grouped in four homogeneous Classes, representative for a progressive increase in Mg-metasomatism from the host rock to the centre of the shear zone; iv) from Class 0 (protolith) to Class 3 (Mg-richer rocks) the lithologies show an increase in Mg, Ni, H₂O, Fe, Cr, and a decrease in Na, Ca, Sr, P, K, Rb, Si; v) fluid inclusion data, coupled with bulk-rock chemical compositions, indicate that the metasomatic fluid was a Ni-Mg-rich brine, containing also

Fe and Cr, and possibly undersaturated in Si; vi) δ¹⁸O and δD data are indicative for seawater, locally mixed with meteoric water, as source of the metasomatic fluid.

All the data indicate that the genetic process responsible for the Mg-metasomatic rocks is most likely the same all along the entire range of the Alps. The proposed process assumes highly channelized fluids (derived from ultramafics that has previously interacted with seawater) that infiltrated the continental crust along high strain zones and produced chromatographic fractionation of major and trace elements. Distinct petrological data and timing of metasomatism from each locality suggest at least three possible tectonic scenarios for this genetic process: rift-related ocean-continent transition, oceanic-continent subduction, and continent-continent collision.

GEO7-3 Orale Di Rocco, Tommaso

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TEMPERATURE DEPENDENCE OF YTTRIUM PARTITIONING BETWEEN GARNET AND XENOTIME: AN EXPERIMENTAL STUDY

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Key terms: garnet; xenotime; yttrium

Yttrium is a notable trace element particularly compatible with garnet. Lanzitrotti (1995) provided evidences that, among major metapelite minerals, yttrium preferentially partitions into garnet and that the mode of major metapelite phases besides garnet have little effect on its fractionation. On the contrary trace elements are extremely sensitive to changes in accessory mineral assemblage (e.g. Ganguly, 2010). Xenotime (YPO₄) is a common accessory mineral in metapelites and arguments for garnet growth in equilibrium with xenotime are presented in several papers (e.g. Martin, 2009). Pyle & Spear (1999) described a relevant temperature control on the solubility of yttrium in garnet in xenotime-bearing metapelites from New England (USA). On the basis of a strong negative correlation between Y concentration and temperature they derived an empirical calibration to be used as geothermometer. However, no experimental studies do exist to date on the temperature dependence of Y partitioning between garnet and xenotime. In order to unravel this relation, high pressure (up to 2.0 GPa) xenotime - saturated synthesis of garnet have been performed in an end-loaded piston cylinder. The simple model system MgO-FeO-Al₂O₃-SiO₂ has been investigated at temperature between 800 and 1000°C with running compositions falling along the join almandine-pyrope + 5 wt% YPO₄. Gels have been prepared as starting materials using tetraethylorthosilicate (TEOS) as silica source, pure Mg-, Al-, Ca-, Y-nitric solutions, ferric benzoate and ammonium dihydrogen phosphate (NH₄H₂PO₄) digested in deionised water. Gels were fired in a gas-mixing furnace at fO₂ conditions approaching the IW (iron-wustite) buffer at 1 atm for 3 hours. The powder was tightly packed into a gold capsule with an internal graphite sleeve to keep the oxygen fugacity low. Run products were preliminary identified by X-ray powder diffraction, carefully inspected on back-scattered electron images and by X ray element maps, and analysed by electron microprobe and particle-induced X-ray emission (micro-PIXE). The use of the proton microprobe stems from its higher spatial resolution and lower X-ray background with respect to electron microprobe. This allows to measure trace element

concentrations down to levels of ~ 1 ppm on a 1 µm beam spot (Fraser, 1990). Preliminary results will be discussed.

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GEO7-4 Orale Groppo, Chiara

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IRON OXIDATION STATE IN GARNET (MONVISO META-OPHILITE, WESTERN ALPS) AS A MONITOR OF DEHYDRATION-REDOX REACTIONS DURING SUBDUCTION: A MICRO-XANES AND ELECTRON MICROPROBE ("FLANK METHOD") COMPARATIVE STUDY

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Key terms: Fe3+/sum(Fe) ratio; garnet; dehydration-redox reactions; micro-XANES; flank method

Although it is accepted that the mantle wedge above subduction zones is oxidized, the exact processes of relative oxidation are still controversial

(e.g. Parkinson & Arculus, 1999). It is widely recognized that oxidized components are transferred to the overlying mantle wedge by fluid phases coming from the subducting slab (e.g. Parkinson & Arculus, 1999; Peslier et al., 2002; Malaspina et al., 2009; Rowe et al., 2009; Hirschmann, 2009); however, the study of the redox reactions occurring at the interface between the subducting slab and the mantle wedge, is often hampered by the difficulties in accurately determining the oxidation state of phase assemblages involved in these redox reactions.

In this contribution we report the results of a micro-XANES study (performed at ESRF ID22) on strongly-zoned garnet crystals from an eclogitic FeTi-oxide gabbro (Monviso meta-ophiolites, western Alps), aimed to the determination of the $Fe^{3+}/\Sigma Fe$ variation across the crystals. The studied sample extraordinarily well preserves evidence of its prograde evolution during subduction down to a depth of ca. 80 km (Gropo &

Castelli, 2010). Because in the studied garnet the $Fe^{3+}/\Sigma Fe$ variations are small and occur on a micrometric scale, the challenge of this study was twofold: (i) the spatial resolution must be of the order of microns, and (ii) the spectral resolution must be as small as possible in order to appreciate the differences in the oxidation state of garnet. The results of the XANES

spectra, acquired with a spatial resolution of $1.7 \mu m \times 5.3 \mu m$, show that the $Fe^{3+}/\Sigma Fe$ ratio decreases from a maximum of 0.14 in the garnet core to a minimum of 0.00 in the garnet rim.

These results are in excellent agreement with those previously obtained using the "flank method" at the electron microprobe. Comparing the results obtained with the two techniques, it can be concluded that

micro-XANES can be successfully used to estimate $Fe^{3+}/\Sigma Fe$ variations in

natural garnets at a high spatial resolution ($< 5 \mu m$), provided that the differences in $Fe^{3+}/\Sigma Fe$ are higher than ca. 5%. The "flank method" is the only method which has demonstrated, so far, to be sensitive to smaller variations (i.e. $< 5\%$) of the $Fe^{3+}/\Sigma Fe$ ratio in garnet, for $\Sigma Fe > 8 \text{ wt}\%$.

The measured $Fe^{3+}/\Sigma Fe$ zoning in garnet, combined with the already estimated P-T conditions of its growth, provides qualitative information about the redox equilibria occurring during subduction of the studied FeTi-oxide metagabbro. Dehydration-redox equilibria involving the breakdown of lawsonite and chlorite (i.e. $Qtz + Lws + Chl + Omp1 + Grt1 = Grt2 + Omp2 + H_2O + O_2$) are responsible for a significant chemical re-equilibration of garnet (and omphacite), resulting in a progressive

decrease of its $Fe^{3+}/\Sigma Fe$ ratio toward the rim and, consequently, in the release of oxygen. Dehydration-redox reactions of this type, occurring at least locally during subduction of the oceanic crust, may be likely involved in the oxidation of the mantle wedge.

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GEO7-5 Orale Malaspina, Nadia

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FE3+ DISTRIBUTION BETWEEN GARNET AND PYROXENES IN METASOMATISED MANTLE WEDGE GARNET PERIDOTITES

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Key terms: *Fe3+ partitioning; clinopyroxene; oxygen fugacity; mantle wedge; subduction zone*

The determination of the oxidation state of most metasomatized garnet peridotites is a demanding task because a large number of phases incorporate both ferric and ferrous iron (e.g. garnet and clinopyroxene), and may show zonations. Oxygen fugacity in high pressure peridotites is traditionally determined from the Fe^{2+} and Fe^{3+} contents of garnet in equilibrium with olivine and orthopyroxene. However, the low Fe^{3+} contents in orthopyroxene as well as the Fe^{3+} partitioning into further peridotite mineral phases are often neglected. Previous studies demonstrated that the increase of Fe^{3+} in garnet with increasing temperature does not depend on the whole-rock Fe_2O_3 , but is rather the consequence of the redistribution of Fe^{3+} from clinopyroxene into garnet. This implies that the Fe^{3+} content of all the mineral phases and their possible Fe^{3+} zonations must be considered to obtain reliable quantifications of the oxidation state of the whole rock.

This study presents new measurements of Fe^{3+} in garnet, olivine, clinopyroxene and orthopyroxene of a mantle-derived garnet peridotite from Donghai County, the southeastern end of the Sulu ultrahigh pressure terrane. These rocks correspond to a slice of supra-subduction lithospheric mantle wedge, tectonically emplaced into the crust. They record a multistage metasomatism by an alkali-rich silicate melt at high temperature, and a subsequent influx of a slab-derived incompatible element and silicate-rich fluid during the Triassic UHP metamorphism. We employed two

"unconventional" techniques to measure the $Fe^{3+}/\Sigma Fe$ content of mineral phases with high spatial resolution: (i) the Flank Method electron microprobe analyses for garnet, performing for the first time quantitative Fe_2O_3 map analyses on zoned garnets at the University of Milano, and (ii) the electron energy loss spectroscopy (EELS) for garnet, olivine and pyroxenes, at the Bayerisches Geoinstitut.

The results indicate that the pyrope-rich metasomatic garnets present a chemical zoning, with the complementary decrease in Al_2O_3 from ~26 to ~21 wt%, relative to the increase of Fe_2O_3 from ~0.8 to ~2.5 wt%. Such a trend is likely related to the Fe^{3+} -Al substitution in the garnet octahedral site, which is sensitive to the garnet oxidation state.

Clinopyroxenes are diopside in composition, whereas olivine and orthopyroxene have ~92 mol% of forsterite and enstatite, respectively. The EELS measurements show that clinopyroxene contains relatively high

$Fe^{3+}/\Sigma Fe$ ratios and Na contents, ranging from 0.48 to 0.51 and from 0.13 to 0.17 a.p.f.u., respectively. Interestingly, also orthopyroxene may

contain $Fe^{3+}/\Sigma Fe$ up to 0.10 (± 0.05), a percentage comparable to that of garnet, with important consequences in the study of redox processes in mantle rocks and in the application of many geothermometers.

Garnet/clinopyroxene and orthopyroxene/clinopyroxene qualitative partitioning indicates a minimum partitioning of Fe^{3+} from clinopyroxene to garnet. The enrichment in Fe^{3+} of Ca-clinopyroxene requires the incorporation of a $NaFe_3Si_2O_6$ (aegerine) component, particularly in garnet peridotites where the Al content of clinopyroxene is buffered by its coexistence with garnet. The coupled Na- Fe^{3+} enrichment of our clinopyroxene likely suggests a corresponding enrichment in the whole rock. The Fe^{3+} substitution mechanism into clinopyroxene as aegerine component could be therefore favoured by the influx of alkali-rich metasomatic fluid phases. This suggests that a possible net bulk oxidation and the redistribution of Fe^{3+} between garnet and pyroxenes could depend on additional variables besides temperature and pressure. Such mechanisms open new possibilities to unravel the redox processes occurring in the portion of mantle wedge interfacing the subducting slab, which is a key location where the mantle redox reactions likely occur.

GEO7-6 Orale Tumiati, Simone

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SUBSOLIDUS PHASE RELATIONS IN K-BEARING PERIDOTITE SATURATED WITH COH FLUIDS

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Key terms: *COH fluids; carbonates; high pressure; experimental petrology*

The mantle wedge overlying a subducting slab in the sub-arc region is fluxed by aqueous fluids originating from the dehydration of the downgoing oceanic lithosphere, previously hydrated, and its sedimentary cover. These fluids, enriched in large ion lithophile, can promote the crystallization of hydrous minerals in mantle-wedge peridotite, especially amphibole and phlogopite. Several authors stressed the importance of carbon, released from the subducting slab (e.g., carbonate-bearing sediments, ophiocarbonates), which can modify the composition of the slab-related fluid and thus its capability of transferring masses to the mantle wedge. In particular, COH fluids obviously influence the coexistence of hydrous minerals, carbonates and elemental carbon (graphite/diamond) in the mantle wedge. However, experimental data concerning relatively complex peridotite compositions are restricted to date to the two studies of Olafsson & Eggler (1983) and Wallace & Green (1988), who described subsolidus phase relations that are profoundly mismatched.

We carried out experiments in the system KNCMAS+COH at $P=1.6-3.2 \text{ GPa}$, $T=900-1050^\circ\text{C}$, $fO_2=NNO$, under fluid saturated conditions. The starting bulk composition is that of a spinel lherzolite -30% olivine (ol) + 5% phlogopite (phl) (cf. Konzett & Ulmer, 1999), which represents a metasomatized peridotite. Seeded gels were loaded in a piston-cylinder apparatus using conventional double capsule technique. GCOH fluids have been generated by addition of 10 wt.% oxalic acid dihydrate and excess graphite. Following thermodynamic modeling, we expect binary H₂O-CO₂ fluids characterized by intermediate XCO₂ and X(O).

Phlogopite is ubiquitous. The stable carbonates are dolomite (dol) at low P (1.6 GPa at 950°C), magnesite (mag) at high-P conditions (2.6 GPa at 900°C). We observe in between a region where both mag and dol are stable. In this region, an increase in T up to 1060°C at 2.6 GPa induces the melting of the system, producing magnesite-carbonates. Carbonate-out occurs for $P < 1.8 \text{ GPa}$ and T around 1000°C, leaving an assemblage composed of ol + orthopyroxene (opx) + clinopyroxene (cpx) + garnet (grt) + amphibole (amph) + phl. In this region, melting occurs at 1075°C producing trachyandesite.

Amph stability field extends up to 3 GPa at 900°C and 2.6 GPa at 1040°C. By increasing P, mass-balance calculations suggest that amph-breakdown reaction produces cpx and grt. Despite amph breakdown, the COH fluid phase decreases its abundance with increasing P, because fluid at fh2 NNO changes its composition from XCO₂=0.65 at 1.6 GPa, 1000°C to XCO₂=0.1 at 3.2 GPa, 900°C.

Cpx does not occur in equilibrium with amph+dol for $P < 2.3$. Chemographic analysis suggests that the absence of cpx in dol-bearing, low-P lherzolite is expected at COH-fluid saturation, i.e. at fluid-present conditions. In mag-bearing, high-P lherzolites, ol can be consumed entirely by COH fluids, through the reaction $ol + CO_2 = en + mag$, leaving an assemblage composed of opx + mag + cpx + amph + grt + phl. Indeed, we observe a marked decrease in ol abundance, especially in experiments where both dol + mag occur.

In conclusion, the presented experimental data constrain the mineral assemblages expected at different P-T conditions in mantle-wedge lherzolites fluxed by K-bearing H₂O-CO₂ fluids. From the slab at around 100 km depth upwards the inner mantle wedge at about 50 km depth, we expect first mag+amph, followed by mag+dol+amph, then dol+amph and finally fluid+amph assemblages

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GEO7-7 Orale Borghini, Giulio

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SMALL SCALE HETEROGENEITIES IN MORB MANTLE: INSIGHTS ON PYROXENITE-PERIDOTITE ASSOCIATION FROM EXTERNAL LIGURIDE OPHIOLITES (ITALY)

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Key terms: *mantle peridotites; MORB mantle heterogeneity; pyroxenites; isotope geochemistry; melt-peridotite interaction*

The occurrence of mafic layers in peridotites constitutes an important compositional heterogeneity in the mantle, and their role in mantle melting and basalt generation is currently debated (e.g. Hirschmann &

Stolper, 1996; Salters & Dick, 2002). Pyroxene-rich lithologies are commonly documented in subcontinental lithospheric mantle, from both tectonically-emplaced ultramafic massifs and mantle xenoliths (e.g. Downes, 2007), and rarely sampled in abyssal peridotites (e.g. Warren et al., 2009). They are mostly interpreted as high-pressure magmatic products and rarely as remnants of recycled oceanic crust. However, the origin and composition of such lithologies, and their potential role in creating small-scale heterogeneities in the MORB mantle remain still poorly constrained. In this study, we present field, chemical and isotopic data on pyroxenites and host peridotites from some peridotite massifs of the External Liguride ophiolitic Units (Northern Apennines, Italy) with the aim to widen the knowledge on the origin of pyroxenites in MORB-type settings and discuss the occurrence and extent of chemical and isotopic heterogeneities in the MORB mantle related to the pyroxenitic component. At this latter purpose, pyroxenites and host peridotites have been accurately sampled from single dm-scale profiles, in order to test whether the existence of lithologic heterogeneities in the mantle in turn reflects the occurrence of isotopic contrasts at the small scale. Pyroxenites occur as cm-thick bands (up to 12 cm) parallel to the tectonite mantle foliation and vary from spinel-bearing websterite to clinopyroxenite. As the host peridotites, they are partially recrystallized at plagioclase-facies conditions. The occurrence of orthopyroxene-rich rim between pyroxenite and peridotite and large poikilitic orthopyroxene in the wall-rock peridotites indicate that host peridotites have interacted with melts related to pyroxenite intrusion. These latter display very heterogeneous whole-rock chemistry, almost covering the entire compositional range defined by worldwide lithospheric pyroxenites ($X_{\text{Mg}} = 74-88$, $\text{Al}_2\text{O}_3 = 10-17$ wt%, $\text{CaO} = 7-20$ wt%). The pyroxenite chemistry reflects high-pressure magma segregation of tholeiitic melts dominated by clinopyroxene crystallization. Both mineral and bulk-rock compositions from peridotite-pyroxenite traverses reveal that the host peridotites have been significantly modified in terms of major (e.g. X_{Mg} , Al_2O_3 , CaO) and trace element (e.g. the LREE) composition by the interaction with pyroxenite component. A multi-step, sequential leaching procedure on clinopyroxene separates enables us to remove partial contamination and provides reliable Sr isotope data. The Sr and Nd compositions of clinopyroxenes from pyroxenites and peridotites fall in the typical range of normal MORB ($^{87}\text{Sr}/^{86}\text{Sr} = 0.7023-0.7029$; $^{143}\text{Nd}/^{142}\text{Nd} = 0.5134-0.5128$). Internal Sm-Nd isochrons based on plagioclase, clinopyroxene and whole-rock from several pyroxenite samples yield ages ranging from 174 to 183 Ma (with errors between $\pm 11-25$) for the low-P mantle exhumation. On a slightly larger spatial scale, isotopic profiles through the pyroxenite-peridotite boundaries indicate cm-scale modification of the wall-rock peridotite, presumably related to emplacement of the pyroxenites. This suggests that deep melt intrusion can locally modify the host peridotites and introduce small scale compositional heterogeneity in a MORB mantle.

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GEO7-8 Orale Najafzadeh, Alireza

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EVIDENCES OF MELT-ROCK INTERACTION ON THE PETROGENESIS OF WEHLITES FROM SORKHBAND ULTRAMAFIC COMPLEX, SOUTHERN KERMAN, IRAN: CONSTRAINTS ON MINERAL AND WHOLE ROCK CHEMISTRY

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Key terms: petrogenesis; wehrlites; melt-rock interaction; Sorkhband ultramafic complex; Iran

The Ordovician Sorkhband ultramafic complex lies in the southern Kerman Province of Iran. The wedge shape complex covers an area of more than 100 km² and is divided into lower and upper parts. The former comprises of dunite, podiform chromitite deposits (Faryab mine, largest in Iran), massive and dyke like olivine clinopyroxenite, wehrlite (as bands with width of 0.5-5m and a few meters long) and olivine websterite dykes. The upper part consist of foliated porphyroclastic diopside harzburgite with subordinate lenses and dykes of dunite, massive and dyke like olivine clinopyroxenite and minor orthopyroxenite dykes with no significant chromitite mineralization.

According to petrographical studies, wehrlites show granular textures with variable modal composition which consist mainly of 40-70% olivine (Fo90-91), 20-50% diopside clinopyroxene, 1-10% bronzitic orthopyroxene and <1% chromite (Cr# = 65-67, Mg# = 44-46). Some olivine minerals show evidences of recrystallization as triple junction with other minerals, deformation lamellae along its slip planes, mini kinking and irregular extinction band configurations, whereas clinopyroxene minerals are deformed and often exhibit exsolution lamellae of orthopyroxene.

Mineral chemistry of olivine, clinopyroxene, orthopyroxene, and chromites in wehrlites are similar to olivine clinopyroxenites and reveal a mantle origin for the Sorkhband ultramafic complex. Moreover, chondrite normalized rare-earth element (REE) patterns of wehrlites show flat medium REE (MREE) and heavy REE (HREE) patterns, [(Gd/Yb)N ~ 1], and highly light REE (LREE) depletions similar to olivine clinopyroxenite patterns. Furthermore, platinum group element (PGE) show highly differentiated pattern in wehrlites with a positive slope (similar to olivine clinopyroxenites) and high Pd/Ir ratio (36-59).

According to Nicolas and Prinzhofer (1983), wehrlite may be formed by the passage of a melt through dunite bodies where by the process of impregnation and melt-rock interaction clinopyroxene crystallize in dunite. Such impregnated clinopyroxenes are allotriomorphic and interstitially filled between olivine crystals and due to poikilitic crystallization may contain spinel and olivine inclusions. Other evidences of melt-rock interaction in the Sorkhband ultramafic complex have been reported before (Najafzadeh et al., 2009, 2010).

So, regarding the mineral chemistry; REE, PGE and transition elements (TE) patterns similarity in between wehrlites and olivine clinopyroxenites in the Sorkhband ultramafic complex it can be concluded that wehrlites are most likely formed by interaction of pyroxenite melt with dunites as a result of impregnation and melt-rock interaction.

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GEO7-9 Orale Zanetti, Alberto

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SEGREGATION OF IGNEOUS SAPPHIRINE IN GABBROIC VEINS CUTTING THE FINERO MANTLE SEQUENCE (SOUTHERN ALPS): PETROLOGY, GEOCHEMISTRY AND GEODYNAMIC CONTEXT

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Key terms: Melt-peridotite reaction; Igneous sapphirine; Finero complex

Sapphirine is generally interpreted to be of metamorphic origin in high Mg-Al rocks. Igneous sapphirine, i.e. sapphirine crystallized from melt, is very rare. We examined sapphirine-bearing rocks in the Finero Phlogopite-Peridotite Massif, Western Italian Alps, to investigate a possible igneous origin for sapphirine in a melt modified via melt-peridotite interaction. Sapphirine locally occurs in a melanocratic zone between a leucogabbroic vein and the host peridotite. The leucogabbroic vein cuts the foliation and lithologic layering of the peridotite massif, which is defined by alternating phlogopite-rich harzburgites and pyroxenites, indicating that its emplacement occurred after the main metasomatic events in the massif. Melanocratic seams are observed on both sides of the leucogabbroic vein. These mainly consist of orthopyroxene and amphibole, and show a marked zoning in modal compositions: an orthopyroxene-rich zone overgrown on the host peridotite side (OPX zone), whereas an amphibole-rich zone occurs on the leucogabbroic vein side (AMPH zone). Sapphirine precipitated in the AMPH zone as independent interstitial grains (up to 3 mm long), as independent grains within large amphibole grains or as overgrowth on spinel. The amphiboles with sapphirine inclusions can also enclose spinel crystals that do not have sapphirine envelopes. Amphibole in the sapphirine-free melanocratic zone is more abundant in incompatible elements, such as TiO₂ and K₂O, than that in the gabbroic veins and the OPX zone, excluding the development of diffusion-controlled subsolidus reaction. A pronounced enrichment in Al₂O₃ of the parent hydrous melts is indicated by the composition of the amphiboles and phlogopites of this study that show higher Al₂O₃ than those crystallized by basaltic melts. Mineral assemblages and chemistry in both the melanocratic zone and the host peridotite can be explained by melt-peridotite interactions, which resulted in replacement of peridotite olivine by secondary orthopyroxene in the OPX zone, and by Al₂O₃, TiO₂, FeO enrichments in the host peridotite beyond the recrystallization front. Interactions between peridotite and a hydrous, high Al₂O₃, orthopyroxene-oversaturated, mafic melt related to the formation of the leucogabbroic vein caused the formation of orthopyroxene at the expense of peridotite olivine. This resulted in high MgO/FeO and high Al₂O₃/SiO₂ ratios in a modified melt, allowing for precipitation of igneous sapphirine.

GEO7-10 Poster Fedoryshyn, Oleksandr

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ESTIMATION OF OVERPRESSURE IN ASTHENOSPHERE BASED ON THE THEORY OF THERMOELASTICITY OF SOLIDS

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Key terms: thermo-elasticity; fluctuations of strains; partial melting

The substance of the Earth mantle is inhomogeneous. It consists of a lot of components with various properties. Mathematical modelling of such medium is difficult and in order to obtain a complete solution we should be restricted by simple mathematical models. Abnormal properties of mantle substance in the depths of 60-100 km, where asthenosphere is located, are explained by presence of partial melt in it. This work deals with investigation of thermo-elastic properties of a two-phase material of the Earth mantle. Presence of the internal strains caused by partial melting is shown.

The two-phase statistically inhomogeneous thermoelastic medium consisting of a solid phase and melt is considered. Effective thermoelastic constants for such medium can be found by averaging of the common system of the equations of movement and balance of warm [Shermergor T.D. 1977]. For any mediums the resolving of such problem is impossible, therefore it is necessary to be limited to correlation approach, that is to accept that physical parameters of phases not so strongly differ among themselves. Formulas for effective modules of elasticity, temperature factor of strains and heat conductivity can be defined. We know that when there is no external loading and at uniform heating of the homogeneous medium there is no strain. In this case average strains in the heterogeneous medium equals to zero. However, fluctuations of strains will not be equal to zero, because the thermal stress coefficients in phases are various. That is why it is interesting to find the mean-square fluctuations of deformations and strains. These fluctuations will be equal

$$\langle \sigma'^2 \rangle = 9K^2 \langle \epsilon'^2 \rangle; \langle \epsilon'^2 \rangle = M_\beta (T - T_0)^2.$$

Here σ' and ϵ' are fluctuations of strains and deformations accordingly, K is the effective bulk module, M is average quadratic fluctuation of thermal expansions coefficient, T_0 is the initial temperature. Angular brackets indicate averaging on ensemble.

The substance of the Earth's mantle does not have a definite temperature of melting. According to the experimental data there is a region of melting. At T_{sol} temperature it starts melting (solidus), and at T_{liq} temperature it melts completely (liquidus). Temperatures of solidus and

liquidus are not constants and depend on pressure and thus on depth too (Magnitskiy V. A. 1965). We shall accept for simplicity linear dependence of quantity of the melted material on temperature, that is $c_m = (T - T_{m0}) / (T_{m1} - T_{m0})$, $c_{li} = (T - T_{m0}) / (T_{m1} - T_{m0})$, c_{cr} and c_{sol} are volumetric concentrations of liquid and solid phase in partial melt ($c_{cr} + c_{sol} = 1$). Melt is a phase transform of the first sort. At phase transforms of the first sort the first derivative of internal energy varies step-like. Thus, process of melting can be modelled as step-like variation of the elasticity modules and the heat expansion coefficient caused by temperature changes. Now we can define strains which result in partial melt by means of resulted above formulas. In order to analyse the dependence of magmatism on deformations it is of interest to estimate the appearance of internal strains as a result of partial melting. Dependence of internal strain on temperature will be in the following form

$$\langle \sigma \rangle = 3K \sqrt{M\beta} (T - T_0).$$

As we can see the rise of temperature of the medium by a few degrees leads to appearance of additional strain which is comparable to geostatic pressure.

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GEO7-11 Poster Ferrando, Simona

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APPLICATION OF CATHODOLUMINESCENCE TO THE STUDY OF METAMORPHIC TEXTURES IN UHP CALCITE-DOLOMITE MARBLES OF THE DORA-MAIRA MASSIF

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Key terms: cathodoluminescence; UHP; impure marbles; SEM-EDS; microraman

Impure calcite-dolomite marbles from the ultra-high pressure (UHP) Brossasco-Isasca Unit (BIU) of the Dora-Maira Massif (Western Alps) are studied under cathodoluminescence (CL), petrographic microscope, and SEM-EDS. Most of the polymetamorphic (Variscan and Alpine) evolution of these marbles has been already reconstructed mainly by silicate minerals, whereas the local variability in microstructure and mineral assemblages of carbonate minerals are still unconstrained.

Under petrographic microscope, the studied impure calcite-dolomite marbles are medium- to coarse-grained, locally with a weak foliation defined by: i) phengite or Mg-chlorite wrapping around both porphyroclastic dolomite and clinopyroxene; ii) alignment of neoblastic clinopyroxene and garnet; iii) silicate-rich layers. Different relative amounts, kinds and compositions of silicate minerals are present. Early mineral assemblages include garnet, clinopyroxene, phengite, olivine, talc, and rutile, and late mineral assemblages include epidote s.l., Ca-amphibole, phlogopite, chlorite, serpentine, talc and titanite. Rare quartz and accessory zircon are also observed.

Dolomite is strongly zoned under CL and SEM, mainly because of variations in Ca, Mg and Fe contents. The locally zoned dolomite core is most likely a Variscan relic which may include garnet, diopside and rare ilmenite. The locally zoned dolomite rim, which partly corrodes the pre-Alpine core, is interpreted as a product of the Alpine metamorphism. In some samples, the outermost rim locally includes Ca-amphibole, phlogopite and titanite. In one sample, late dolomite, in equilibrium with serpentine, partly overgrows olivine.

The rock matrix is constituted by weakly-deformed medium-grained Mg-calcite that partly corrodes dolomite. In rare samples, exsolved dolomite is present within Mg-calcite. CL observations reveal that Mg-calcite is usually zoned with a rim composition variable from sample to sample. Rare, undeformed and fine-grained (Mg)-calcite is locally present at the grain boundaries.

In conclusion, microstructures in carbonates from the BIU marbles are complex such as that shown in the associated silicate minerals. Because in impure marbles both carbonate and silicate minerals record the same growth history under CL, this is a simple but powerful tool to correlate the evolution of the two groups of minerals. Therefore, the use of CL in studies on metacarbonate rocks allows to better constrain their PTX metamorphic conditions because it is suitable for a more detailed evaluation of the equilibrium mineral assemblages.

GEO7-12 Poster Castelli, Daniele

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BORON ISOTOPE STUDY OF MAGMATIC-HYDROTHERMAL TOURMALINES FROM BIELLA AND TRAVERSSELLA PLUTONIC COMPLEXES (PERIADRIATIC IGNEOUS PROVINCE, WESTERN ITALIAN ALPS)

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Key terms: Boron isotopes; Tourmaline; Periadriatic Igneous Province; Western Alps

The Biella pluton is part of an Oligocene volcano-plutonic complex emplaced at shallow crustal levels within the eclogite-facies rocks of the Austroalpine Sesia-Lanzo Zone. It is a composite stock of calc-alkaline to shoshonitic affinity ranging in composition from monzogranite-granodiorite to syenite and monzonite. Volcanic to volcanoclastic sequences coeval to the Biella stock occur as a steeply dipping belt truncated, to the southeast, by the Insubric Lineament; they range in composition from basaltic andesite and andesite of high-K calc-alkaline affinity to trachyandesite and trachydacite of shoshonitic affinity. Palaeomagnetic, geological and petrological data show that both the Oligocene igneous rocks and the Sesia-Lanzo country-rocks suffered a clockwise (towards southeast) tilting, along a NE-SW trending subhorizontal axis, during late Tertiary; as a consequence, along both the Cervo and Sessera valleys

crustal sections, from deeper (to the NW) to shallower (to the SE) levels are exposed (Bernardelli et al., 2000; Callegari et al., 2004; with refs.). The Traversella stock, coeval with the Biella complex, is also intruded in the Sesia-Lanzo Zone and is mostly composed of diorite to quartz-diorite and monzonite of high-K calc-alkaline affinity, with some mafic cumulates showing shoshonitic affinity (Vander Auwera & Andre, 1991, with refs.). Both plutons record a complex history of magmatic-related fluid circulation that often involves boron-rich fluids as shown by the occurrence of abundant tourmaline.

Within and around the Biella pluton tourmaline occurs (Bernardelli et al., 2000; Rossetti et al., 2007):

- as a late-magmatic phase in aplitic dykes in the monzosyenite and as Pl + Qtz + Tr + Tur orbicules in satellite magmatic bodies;
- in early Kfs + Qtz + Tur hydrothermal veins;
- as Tur ± Qtz ± Ru clasts, locally surrounded by Qtz + Tur, embedded by Qtz ± carbonate matrix in brecciated veins and breccias;
- as very fine-grained tourmalinite (Tur ± Qtz ± Py) clasts in a Qtz + Py + Cpy hydrothermal matrix in brecciated veins;
- as radial aggregates of cm-long, acicular crystals in the matrix of a large hydrothermal breccia body at roof of the pluton;
- as a product of metasomatic replacement of phengite and garnet in metapelites from the Sesia-Lanzo Zone in hydrothermal breccias close to the pluton contact.

At Traversella, the occurrence of dolomite marble lenses in the host rock favored the development of complex skarn bodies (mined for magnetite: Vander Auwera & Andre, 1991, with refs.). Tourmaline occurs:

- as a late-magmatic phase in aplitic dykes crosscutting quartz-diorite;
- within the skarn bodies (which locally contain abundant boron-bearing phases other than tourmaline: e.g., ludwigite, szaibelyite and low-T, secondary phases, like canavesite).

Boron isotopes represent a powerful systematic in tracing the origin of volatile elements in magmatic-hydrothermal systems and the extent of water/rock interactions occurred (e.g. Palmer & Swihart, 1996). In this study, boron isotope compositions of tourmaline from magmatic to hydrothermal/metasomatic settings have been determined. The new boron isotope data coupled with chemical features of tourmalines (Rossetti et al., 2007) provide new constraints on the evolution of fluid chemistry during the magmatic-hydrothermal transition at the interface between pluton and host rocks. Availability of couples of minerals from similar settings in Biella and Traversella intrusions as well as the occurrence of different boron-bearing minerals (tourmaline and ludwigite) allow the discussion of boron isotope fractionation behaviour in a high temperature setting.

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GEO7-13 Poster Giacometti, Fabio

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PETROGRAPHY OF KAOLINIZED RHYOLITES FROM ROCCASTRADA - CENTRAL APENNINES

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Key terms: rhyolite; hydrothermal weathering; kaolin deposit; Roccastrada

Roccastrada rhyolites are pliocene volcanic weathering of crustal anatectic origin; they represent the most acid product of the Toscan Magmatic Province. A kaolin deposit, derived from hydrothermal weathering of the Roccastrada rhyolites, formed near Piloni di Torriella (GR, southern Tuscany). The raw material is currently mined for the ceramic industry. Hydrothermal fluids caused significant changes of the mineralogical and textural properties of the primary rock as well as changes of the bulk rock composition. The deposit is heterogeneous due to different weathering extents of the rhyolites so that lithologies ranging from poorly weathered to strongly weathered rhyolites and kaolin outcrop in the mining area. The aim of this work is to classify the different materials outcropping in the deposit and to show their location on a map. Samples have been analyzed by XRF, polarised light optical microscope and SEM-EDS techniques so that field observations can be sustained and correlated with laboratory test, in order to show the effects of different extents of weathering on rhyolites at both macroscopic and microscopic scale. XRF tests show that different lithologies have different bulk rock compositions: as a consequence of kaolinization, Al₂O₃ contents and LOI values (wt.%) increase with the weathering extent, while SiO₂, K₂O, CaO and Na₂O (Wt.%) decrease, often giving rise to nearly pure kaolinitic materials of great interest for exploitation. Locally, high S concentration are found, especially in strongly weathered rocks: S is unwelcome in ceramics and the definition of the location of S-enriched materials in the deposit is fundamental during exploitation.

Investigations by optical and electronic microscope show how weathering affects both the texture and the mineralogy of the primary rocks and allows the reconstruction of a weathering sequence: primary plagioclase is substituted by kaolinitic aggregates, amorphous silica and, locally, alunite in poorly weathered rhyolites. In weathered and strongly weathered rocks also glass and alkali-feldspar are substituted by these pseudomorphic assemblages. Biotite can occur either preserved or totally substituted by pseudomorphic aggregates similar to those described above. Weathering of biotite consists of progressive leaching of Fe, Mg and Ti which, due to low mobility in water solutions, form hydroxides and oxides in the neighbouring groundmass.

The extent of weathering and the amount of kaolinite and alunite are extremely variable all over the deposit: hydrothermal fluids with different compositions circulated through the deposit, causing different weathering products to form.

GEO7-14 Poster Muschitiello, Annalisa

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GEOCHEMICAL FEATURES OF TWO ROCK TYPES IN THE LOWER BASIC CRUST OF THE SERRE (CALABRIA): A PRELIMINARY

STUDY.

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Key terms: Calabria; basic rocks; lower crust; geochemistry

In the Serre massif (southern Calabria, Italy) a Variscan crust section crops out consisting of: i) a middle- to low-grade metamorphic rocks in the upper segment, ii) an about 13 km thick "layer" of granitoids and iii) 7-8 km thick lower crust. The deep crust forms the lower part of the section and includes from the bottom to the top: a) layered metagabbros including meta-peridotites; b) felsic and mafic granulites with interleaved metapelites; c) migmatitic metapelites with interleaved metabasites, rare marbles and felsic orthogneisses.

The aim of this study is to characterize the geochemistry and the evolution of the Neoproterozoic to Early Cambrian basic magmatism represented by metagabbros and metabasites.

The reconstruction of the geodynamic setting in which the basic magmas were emplacement could allow a better understanding of the tectonic evolution of the peri-Gondwana terranes having memory of the West African craton.

The effects of the Hercynian metamorphism have modified the mineralogical assemblage and, in some case, have induced partial melting modifying the original compositions.

Petrographic and geochemical (major and trace elements) analyses have been performed on ~20 samples collected at the base of the deep crust in the gabbroic portion. Two groups of basic rocks have been defined on the basis of the petrographic features. The first group characterized by coarse grained and isotropic texture, consists of gabbros and Qtz-gabbro containing Pl+Opx+Cpx+Amph±Qtz±Grt, rare crystals of biotite can be also present. Frequently, amphibolites with green or brown hornblende form thick layers. On the other hand leucocratic portions showing trondhjemitic composition are interspersed within the main gabbroic body. The second group is characterized by a medium grained and anisotropic texture formed by Pl+Opx+Bt+k-feld±Cpx±Qtz±Grt. Peculiar characteristics of this rock-type are the abundance of biotite and the presence of pockets of granitic melts having eutectic composition. In both groups, few porphyroblastic garnet crystals occur including amphibole, pyroxene, plagioclase, ± biotite and ± quartz. Frequently, garnet crystals are rimmed by Opx+Pl+Amph or Amph+Pl symplectitic corona in biotite free-rock types or by Bt+Pl±Qtz symplectitic corona in biotite bearing-rock types.

The two groups of rocks have variable chemical compositions owing to the variability of their components. The former are subalkaline rocks (Na₂O+K₂O=1.17-4.84%) with a content of K₂O around 0.47%, whereas the latter are alkaline rocks (Na₂O+K₂O=4.88-6.77%) with a content of K₂O around 3.9%.

The metagabbros show lower Rb, Sr and Nb contents (Rb=0-12 ppm; Sr=68-592 ppm; Nb=0.5-13 ppm) than the Bt-bearing metabasites (Rb=10-210 ppm; Sr=389-1044 ppm; Nb=8-25 ppm).

The contents of the other major elements are quite similar despite varying in a large range (SiO₂=41.53-60.38% vs. 45.75-51.16%; Al₂O₃=14.71-20.75% vs. 14.72-19.48%; FeO=6.29-13.99% vs. 8.13-12.54%; MgO= 2.59-9.84% vs. 4.72-7.99%; CaO=6.82-15.49% vs. 5.73-8.96%) for the presence of cumulitic portions and of differentiated rock type, in addition the Variscan partial melting events complicate the chemical variability. The first data (ACF and A'KF diagrams) indicate a common origin from basic magmas for the two rock types so the alkali enrichment for biotite bearing-rocks can be connected with host rock interaction or due to permeation of melts derived from wall rocks in Variscan times.

Different hypotheses about the origin and evolution of metabasic rocks of the Serre, can be proposed.

GEO7-15 Poster Daif, Menana

10.1474/Epitome.04.1218.Geoitalia2011

PETROLOGY OF MIOCENE ANDESITES FROM ANNABA AREA (NORTHEAST ALGERIA)

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Key terms: Algeria; Miocene; Petrology; genesis

Miocene andesites are part of an igneous series that outcrops in the Northeast of Algeria and that belongs to Maghreb's magmatic margin belt. This series includes volcanic, subvolcanic and plutonic rocks. On the basis of their nature and their field relationship, rocks have been divided into four main groups: andesites, microgranites, rhyolites and diorites.

Andesitic-group covers around 25 Km² and presents a wide range of colour, texture and structure. Four facies are distinguished: andesites (stricto-sensu), dacites, discrete amounts of rhyolites and strongly rare basalts. Pyroclastic andesites are widespread and characterized by their poor sorting producing various breccias. Massive andesites are essentially composed of flow, and some pillow-lavas. In spite of this huge heterogeneity, andesites are intimately related to each other in time, space, mineralogy and chemical nature. They have a constant and particular paragenesis: olivine is lacking, orthopyroxene is restricted to basic andesites which are less common whereas plagioclases, clinopyroxenes and hydrous minerals are abundant; titanomagnetite, ilmenite and sphene are also present in small quantities.

The salient geochemical characteristics of these rocks are high SiO₂, K₂O, Rb and low FeO, MgO, CaO, Ba and Sr. They also show enrichment in light Rare Earth Elements (REE) and depletion in heavy REE. Whole rock 87Sr/86Sr ratios are high and unequal (from 0.707 to 0.710). All these characteristics testify that investigated andesites are mostly acid, medium to strongly potassic and are typical of calc-alkaline suites of continental margins.

The genesis of this series, previously considered as complex because difficult to explain according to an usual subduction process, has been partly resolved late years by some models as that proposed by Maury et al. (2000). The main purpose of this contribution is to point out particular geological features dealing with this genesis.

SESSIONE GEO8**Geochimica e vulcanologia****GEO8-1 Key Lecture Macedonio, Giovanni**

10.1474/Epitome.04.1219.Geoitalia2011

MODELING VOLCANIC ASH TRANSPORT AND DEPOSITION

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Key terms: volcanic ash fallout; numerical modeling; volcanic hazard

Volcanic ash fallout can be responsible for severe damages to buildings, infrastructures, viability, agriculture, livestock and air traffic. Numerical models are available for the simulation of transport and deposition of volcanic ash emitted during explosive eruptions, allowing short-term forecasts. Actual models are able to capture the main processes related to the transport of volcanic plumes, including advection by the wind, spreading due to atmospheric turbulence, particles settling and aggregation. Moreover, statistical analysis based on meteorological records, field observations and modeling allows the estimation of the probability of occurrence of different fallout scenarios in a given area, to be used for long-term analysis.

In this talk, both methods for forecasting the evolution of volcanic plumes and for producing hazard maps for ash fallout are presented. In the former case, the forecast wind field and other meteorological parameters, coupled with observations and measurements of the volcanic plume or pre-defined eruption scenarios, are used for forecasting the evolution of the concentration of ash in the atmosphere and the thickness of the deposit. In the latter, a large dataset of daily wind velocity averages (typically 10-50 years) is used to simulate the ash dispersal under different wind and volcanic conditions. The obtained maps show different frequencies of occurrence of ash deposition in different zones and allow the estimation of the probability maps (hazard maps) for volcanic ash fallout. Typically, these procedures start with the reconstruction of the eruption parameters able to reproduce past deposits (total mass, grain size distribution, column height, wind velocity, etc.). This task is performed through a best fit of the model parameters with field measurements and leads to the definition of one or more eruption scenarios. This procedure needs the simulation of the ash fall deposit under different input and environmental conditions and is typically very time consuming. For this, simplified ash dispersal models were used in the past for best-fits and statistical analysis. The use of powerful computers may circumvent this difficulty.

GEO8-2 Orale Fiorani, Luca

10.1474/Epitome.04.1220.Geoitalia2011

LIDAR MONITORING OF VOLCANIC CLOUDS

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Key terms: laser remote sensing; environmental monitoring; backscattering lidar; volcanic ashes; air transportation

The threat to air transportation represented by volcanic ashes has been recognized after the dramatic events of British Airways Flight 9 on 24 June 1982. More recently, the Eyjafjallajökull's eruption caused substantial disruption to air traffic across Europe. This problem is also present in Italy where the Catania airport undergoes frequent stops due to Etna's plume.

In the last decade the Diagnostics and Metrology Laboratory (UTAPRAD-DIM) of the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) developed the Agile Tuner Lidar for Atmospheric Sensing (ATLAS), mounted on the Environmental Laboratory (ENVILAB) hosted in a small truck. ATLAS can be decomposed in four subsystems: transmitter, receiver, detector and ADC (Analog-to-Digital Converter). The main parts of the transmitter are a tunable TEA (Transverse Excited Atmospheric) CO₂ laser and an off-axis reflective beam expander consisting of two OFHC (Oxygen-Free High Conductivity) copper mirrors manufactured in our laboratory. The laser is tunable thanks to the agile tuner consisting of a diffraction grating and a scanning mirror actuated by a computer-controlled galvo motor. The receiver is based on a Newton telescope. A liquid-nitrogen-cooled mercury-cadmium-telluride photodiode, coupled with a pre-amplifier designed to complement it, has been chosen as detector. The ADC is embedded in a PCI (Peripheral Component Interconnect) card mounted in the personal computer that controls the experiment.

In this paper, the monitoring capabilities of ATLAS in the frame of air safety will be discussed. ATLAS already characterized the Etna and Stromboli volcanic plumes. At Etna, the extinction coefficient inside the volcanic plume was retrieved, while at Stromboli also water vapor concentration in cross sections of the plume and wind speed at the crater were measured. Water vapor concentration and wind speed were retrieved by differential absorption lidar and correlation technique, respectively. Lidar returns were obtained up to a range of 5 km. The spatial resolution was 15 m and the temporal resolution was 20 s. By combining these measurements, the water vapor flux in the Stromboli volcano plume was found. To our knowledge, it is the first time that a CO₂ laser-based lidar is used to profile a volcanic plume and a lidar retrieves water vapor concentrations in a volcanic plume.

GEO8-3 Orale Tuccimei, Paola

10.1474/Epitome.04.1221.Geoitalia2011

UNRAVELLING RADON EMISSION FROM ROCK DAMAGE MECHANISMS: NEW LABORATORY INSIGHTS

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Key terms: radon emission; toron; rock deformation; seismic surveillance; laboratory experiments

Positive radon anomalies are commonly used as a tool to predict dynamic failure in the crust, as stated by the widely-used dilatancy model for earthquake prediction. The model foresees that the formation and propagation of cracks prior to rupture will serve to create new surface area and hence increase radon emanation. However, this simplified picture is not only occasionally contradicted by negative radon anomalies, but sometimes negative anomalies are measured at the seismic source, whilst contemporaneous positive anomalies are recorded at monitoring stations located hundreds of kilometres away. Mysteriously, alternating increases and decreases or no significant variations have also been recorded. Hence, despite early promise, radon emanation does not appear to be a very compelling warning signal and many questions remain unresolved. Although numerous studies have investigated field radon emanation from rocks under natural stress conditions, only few have attempted to experimentally relate rock deformation with radon change. Here we present, for the first time to our knowledge, an original experimental set-up consisting of a new accumulation chamber made of a drypack material, a polyester-aluminum-polyethylene bag, containing the rock specimen and connected in a closed-loop configuration to the RAD 7. The drypack-chamber is loaded under a uniaxial press, without being damaged during rock deformation. Radon gas concentration emitted from the samples is simultaneously and continuously monitored by the system; therefore, the originality of the experiments consists in a real time monitoring of radon emission changes during the whole process of rock deformation. Additionally, the drypack-chamber is surrounded by a heating belt that allows us to investigate the effect of high temperature conditions (up to 90 °C) on radon emission. It needs to be stressed that the radonometer is alpha-spectrometry based and is able to measure simultaneously ²²²Rn (radon) and ²²⁰Rn (thoron) activity concentrations. The great advantage of determining thoron is the possibility of recording any activity change in the closed system within the length of a single run cycle (30 minutes), due to the short half-life of ²²⁰Rn (55.6 seconds) that reaches any new equilibrium conditions in about 5 minutes. Results demonstrate that radon exhalation from the rock specimen drastically increases with increasing the experimental temperature. This finding allows us to discriminate low variations in radon emissions when rock samples are uniaxially loaded under the press. Uniaxial compressive tests performed on highly porous (47 %) volcanic tuff from Vico Volcanic District (central Italy) shows that the radon emission decreases with increasing load. Such a variation is proportional to a reduction of porosity associated with the compaction of the tuff sample. When the specimen fails, a drastic increase of emission is verified. Moreover, long-term experiments (in the order of weeks) performed by maintaining a constant load on the tuff specimen show that the deformation increases with time. The radon signal coherently continues to decrease up to the complete closure of pores. At that point, a further increase of load does not induce any additional compaction and any radon emission change, with a constant exhalation up to the failure. This has strong implications in the field of radon anomalies prior to earthquakes, showing that the seismic event can be preceded by no significant radon anomalies, as already documented in literature. Our experimental investigation sheds light on several apparently contradictory signals recorded by radon monitoring stations near active faults and volcanoes. Results demonstrate that emanation rate is governed by the prevalent deformation mechanism. In terms of seismic and volcanic hazard, the deformation mechanism of rocks under stresses should be carefully considered to properly interpret data from geochemical field monitoring.

GE08-4 Orale Zanchetta, Giovanni

10.1474/Epitome.04.1222.Geoitalia2011

MIS 5/6 TRANSITION AND LAST INTERGLACIAL MULTIPROXY ANALYSES FROM ANTRO DEL CORCHIA SPELEOTHEMS (ALPI APAUANE, CENTRAL ITALY).

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Key terms: Last Interglacial; Speleothems; Stable isotopes; Paleoclimatology; U/Th dating

The last interglacial is the most obvious analogue for understanding the climate variability of interglacial conditions when human impact was virtually absent (even if orbital configuration was not exactly that of the current interglacial). However, few well radiometrically dated records exist for this period (e.g. Bar-Matthews et al., 2000) worldwide. Corchia cave (Apuan Alps, Central Italy) shows a continuous phase of speleothem growth during the period between ca 140 to 90 ka allowing a systematic replication of proxy records from several stalagmites. Stable isotopes (carbon and oxygen) on speleothems calcite from 3 different speleothems obtained with high resolution show very consistent variations and the time series (anchored by more than 100 U/Th dates on exceptionally pure calcite, allowing a mean resolution of less than 50 yr) replicate in detail the most obvious climatic phases recorded in GNIP ice core and marine records (Drysdale et al., 2006, 2009), with the main advantage of an independent, radiometrically-supported chronology. U and Mg trace element records show a consistent anti-correlation, with variation

substantially in phase with the 180 time series, supporting the interpretation that changes in oxygen isotopic composition were mostly driven by changes in the amount of precipitation and trace element variations were driven by prior calcite precipitation linked to changes in residence time of the water within the fractures, as also supported by the geochemical data obtained from different water monitored in different parts of the cave (Piccini et al., 2008). Speleothem growth was severely reduced for most of the late marine isotope stage 5 (MIS5) and MIS3 and 2 (as also supported by several drill cores on flowstone), with significant resumption of speleothem growth at ca 12-13 ka. We suggest that this phase of discontinuous and extremely reduced growth was due to glaciated conditions in the catchment of Corchia cave.

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GE08-5 Poster Schiavi, Federica

10.1474/Epitome.04.1223.Geoitalia2011

ADSORPTION OF HCL GAS ONTO VOLCANIC ASH

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Key terms: HCl; adsorption; experimental approach; volcanic ash; volcanic eruption

During volcanic activity large quantities of gases and ashes are injected into the troposphere and, in case of major explosive eruptions, into the stratosphere. The injections of considerable amounts of gases (e.g., SO₂ and HCl) into the stratosphere may disturb its chemical equilibrium and affect Earth's climate. In particular, chlorine free radicals, which form by breakdown of gaseous HCl molecules via heterogeneous chemical reactions and photolysis, contributes to the destruction of the ozone layer. However, before reaching the stratosphere a significant fraction of gases may be removed from the eruption column by adsorption onto volcanic ash surface. Thus, experimental investigations of the adsorption process of volcanic gases on ashes at conditions relevant for volcanic plumes become important to estimate the removal of HCl from the atmosphere during eruptive events.

We performed adsorption experiments on a synthetic glass with rhyolitic composition and on natural obsidian collected on Vulcano island (Aeolian Islands, southern Italy). Both synthetic and natural glasses were ground to sub-micrometer sized particles using a planetary mill under dry conditions. The glass powder was stored in a simple volumetric vacuum device, which was purged with pure HCl gas to a desired pressure. Pressure dropping caused by adsorption was recorded by a vacuum gauge until an equilibrium pressure was reached within hours or days. The pressure was increased in six steps from 32 to 932 mbar and from 87 to 957 mbar in the experiments on rhyolitic and obsidian glasses, respectively. The amount of HCl adsorbed on ash surface during each step was then calculated from the recorded pressure drop applying both the ideal gas law and the van-der-Waals equation.

Preliminary results from two experimental runs performed at room temperature on rhyolitic and obsidian glasses, respectively, indicate that adsorption on the order of 1.4 mg/m² and 0.5 mg/m² occurs even at low partial pressures of HCl. The amount of adsorbed HCl appears to depend on the glass composition, and increases rapidly in the first two pressure steps (P ≤ 200 mbar) in both experimental runs. At higher pressures, HCl adsorption on obsidian ashes continues to increase but less rapidly, whereas the adsorption isotherm for the rhyolitic sample reaches a plateau and exhibits a very slight increase at the highest pressure. The forms of the adsorption isotherms provide evidence for both chemical and physical adsorption mechanisms. No significant desorption and a slight desorption are observed in the experiments on rhyolitic and obsidian ashes, respectively. This suggests that the adsorption process of HCl on ash particles is a partially irreversible mechanism that contributes to the removal of volcanic HCl from the atmosphere.

GE08-6 Poster Aiello, Gemma

10.1474/Epitome.04.1224.Geoitalia2011

NEW SEISMO-STRATIGRAPHIC DATA ON BURIED VOLCANIC STRUCTURES IN THE SOUTH-EASTERN OFFSHORE OF THE ISCHIA ISLAND (NAPLES BAY, SOUTHERN TYRRHENIAN SEA): IMPLICATIONS FOR THE CAMPANIA VOLCANISM

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Key terms: volcanic structures; seismic stratigraphy; Ischia island; Naples Bay; Tyrrhenian sea

Some new seismo-stratigraphic data on buried volcanic structures and Quaternary deposits in the south-eastern offshore of Ischia island (Naples Bay) are here presented. In particular, we focus our presentation on southern continental slope of Ischia island and eastern Ischia offshore, surveyed during the realization of geological maps at the scales 1:25.000 and 1:10.000 (Geological Map n. 464 "Ischia"; Aiello et al. 2009. Explanatory Notes to the Geological Map - Marine Geology, in press.). The geological bodies recognized through seismic interpretation are the volcanic seismic units, acoustically transparent, representing the rocky acoustic basement and the systems tracts of the Late Quaternary depositional sequence. The prevailing volcanic activity, which controlled the stratigraphic setting of the Naples Bay, has prevented the application of a classical stratigraphic approach, taking into account the associations of depositional systems and the interstratified volcanic bodies (volcanites and volcanoclastites). The sequence stratigraphic approach permits recognition and mapping of depositional bodies defined as three-dimensional objects, consequently to their relative stratigraphic position. Complementary stratigraphic information about the nature of the individuated depositional bodies and the geological processes controlling their deposition and preservation is furnished.

Volcanic deposits resulting from effusive and explosive eruptions extensively crop out in the Ischia Island, constructing volcanic edifices; some of them are still well preserved, other ones are completely dismantled or buried. The main geo-volcanologic event is represented by the eruption of the Green Tuff of the Epomeo Mt, conditioning a complex calderic resurgence. It allowed for the gradual uplift and emersion of the calderic rocks with a rate of about 800-1100 m. Corresponding volcanic products crop out along the southern coasts of the island at Mt. Vico, S.

Angelo and Scarrupata di Barano. In the Ischia island the occurrence of intrusions, volcanic domes and necks and tabular seismic units makes more complex the sequence stratigraphic approach in the geological interpretation of seismic profiles. The marine sedimentation includes both the contribution of siliciclastic sediments, alluvial or marine in origin and that of volcanites and volcanoclastites erupted by Ischia and Procida volcanic complexes. While the volcanic bodies are deaf to the acoustic energy, the pyroclastic edifices and/or deposits may be acoustically observed. As a consequence, the seismic stratigraphy offshore the Phlegrean Fields is more complex and difficult to interpret with respect to that one of the eastern sector of the Naples Bay, where sedimentary seismic units prevail, apart from the Dohrn canyon morpho-structural lineament. The sub-actual terrace of the Maronti offshore, coincident with a progradational wedge deposited during the last 5-6 ky should coincide, in terms of geological times, with the Holocene highstand wedge. This is not confirmed neither by the thickness of the Holocene sequence, anomalously high, due to the high sedimentary rates coming from the Serrara Fontana basin neither by its internal geometries. A geologic section has been constructed along the south-eastern Ischia offshore. It documents the stratigraphic relationships between the volcanic units of the acoustic basement and the Quaternary deposits. The section is located along the volcanic structure of the Ischia Bank through the Ischia Channel. Here it crosses the relic volcanic edifice "Il Pertuso" and arrives up to the continental shelf of Procida Island (Punta Solchiaro).

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GEO8-7 Poster De Rosa, Rosanna

10.1474/Epitome.04.1225.Geitalia2011

QUATERNARY VOLCANIC LAYERS IN THE PAOLA SLOPE BASIN: COMPOSITION AND PROVENANCE

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Key terms: LA-ICP-MS analyses; Aeolian Islands magmatism; Lipari-Vulcano magmatic system; volcanoclastic provenance

Paola Basin, in the Eastern Tyrrhenian margin, is an elongate trough bounded by the Calabrian Arc terranes to the east. Its western margin is represented by the Aeolian Volcanic Arc, which separates it from the Tyrrhenian bathyal plane. The shoreline of the basin is about 150 km long, from Cape Bonifati to Briatico. It represents the submerged part of the Calabrian Coastal range Province, consisting of Mesozoic ophiolites and Paleozoic basement nappes (phyllite, schist, gneiss and plutonics) thrust over the Triassic to Paleogene Apenninic sedimentary units (dolostone, limestone and clastics) [1, 2, 3]. It has been estimated that during Quaternary the uplift rates of the Calabrian Coastal Range have been of 1 +/- 0.1 mm/yr [4]; this quick uplift determined high sedimentation rates in the shelf area [5]. The Paola Basin filling sequence can be divided into two portions: the pre-12ka is characterized by sandy-turbidites and mass-failure deposits, while in the post 12ka pelagic and hemipelagic sediments dominated [6]. In the upper portion, at 20 cm of depth, a tephra layer attributed to the 79 AD eruption of Vesuvius [6] has been found. This tephra consists of pumices fragments with stretched and flattened vesicles containing abundant microphenocrysts of leucite and diopside and minor feldspar. Loose crystals of biotite are common. Glass composition is phonolitic with K₂O content higher than 7wt%. Compositional and textural studies of the lower sandy-turbidites at 372 cm of depth evidenced the occurrence of a second distinctive sandy-gray crystal-rich bed containing fragments of vesiculated glass and porphyritic, non vesiculated, volcanic clasts. Micromorphoscopic observation by SEM showed that glass fragments are characterized by rounded and sub-rounded outlines with stretched vesicles. Glass has a dacitic-rhyolitic composition and K₂O content around 5wt%.

The absence of non-volcanic detritus suggests that both tephra layers deposited sin-ruptively. A provenance of the post 12ka tephra layer from the 79 AD plinian eruption of Vesuvius seems to be confirmed whereas the calcalkaline affinity of the pre 12ka tephra layer suggests an origin from the Aeolian Arc volcanic system.

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GEO8-8 Poster Mattias, Pierpaolo

10.1474/Epitome.04.1226.Geitalia2011

THE MT. ARCI OBSIDIANS (SARDINIA IS.- ITALY)

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Key terms: Obsidians; Genesis; Mt. Arci; Sardinia; Italy

The Mt. Arci obsidian is an important, well known geo-resource, as it has been subjected to an intense exploitation since the Neolithic, i.e. 9,000 to 8,000 years ago.

The Mt. Arci volcanic relief lays in the central - western region of Sardinia, almost 16 - 18 Km SE of Oristano. The central part of the igneous body is

a N-S trending ridge, more than 25-30 Km long and less than 5-6 Km wide. The massif has a thick morphology, reaching 812 m above sea level at Punta Trebinalonga. The Mt. Arci is included in the sheet no 217 (Quadrants I and II) of the 1:100,000 IGM topographical map. It has to be noted that the massif has a strongly asymmetric shape, also due to intense faulting.

The succession of the eruptive events that built up the massif is particularly complex, as it covers wide chemical spectrum (salic and femic magmas coexist) and time span (from 18-15 My to 3.5-3 My). The later igneous activity is thought to have given origin to the obsidians. Field surveys found obsidian occurrences in the eastern sector, next to the Pau village (just renowned for the obsidian, and in the southern sector, mainly along the basal belt of the massif. Obsidians form numerous outcrops, twenty-nine of which were inferred to have a primary origin (Fanti and Lugliè, 2010). Some other occurrences, presently hidden by the morphological arrangement or by the vegetation cover, cannot be excluded.

Generally, obsidian outcrops at the Mt. Arci have little thickness.

Nevertheless, some of them (S. Maria Zuarbara-Marrubiu, Roia Cannas, Perdus Urias, Conca Su'Ollastu, Canale Perdara, Riu Solacera) underwent to extraction of perlite, in which obsidian is frequently included.

On the basis of their colors and textures, the obsidians can be subdivided in the following types: monochromatic black and "coda di pavone" (fan-like), reddish, brown, and gray; stratified; breached with heterogeneous polychromatic elements; "fiocco di neve" (snowflake-like); "cariate" (decayed) or crenulated.

In most of cases, the genesis of the Mt. Arci obsidians can be ascribed to assimilation of preexisting volcanic rocks, like tuffites, ignimbrites, volcanic breaches, by the high-temperature primary magma. The decayed and crenulated obsidians, in particular, were originated from marine deposits rich in remains of siliceous organisms (sponges, echinoderms, etc.), before the relief emerged of 380 - 400 m at least.

These studies allowed to classify the glassy products into four types: SA, SB1, SB2, and SC, respectively (cfr. mainly Tykot, 1992, 1996, after Puxeddu, 1958).

The whole Mt. Arci massif represents the area no 1 of the Parco Geominerario Storico-Ambientale della Sardegna (Geomineral Historic and Environmental Park of Sardinia), because of its morphological and petrological peculiarities. Moreover, it has been included in the World Heritage list of the UNESCO, owing to the cultural aspects connected with exploitation and use of the obsidian.

After all, the obsidian can be considered as the object of the first exploitation activity having a significant economical impact in the history of Europe.

GEO8-9 Poster Baneschi, Ilaria

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GEOCHEMISTRY AND STABLE ISOTOPES OF LATE QUATERNARY MARINE SHELL FROM GULF OF S. JORGE (ATLANTIC PATAGONIA): PALEOCEANOGRAPHIC IMPLICATIONS

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Key terms: geochemistry; Atlantic Patagonia; marine shell

Late Quaternary raised coarse-beaches from the Gulf of S. Jorge (Atlantic Patagonia, Argentina) preserve rich parautochthonous shell beds potentially useful for the paleoenvironmental reconstructions (Aguirre, 2003). Petrographic, XRD and geochemical analyses (in particular Mn and Fe content and Mn/Sr ratio) along with the comparison of living and fossil shells of the bivalves *Prototacha antiqua*, *Mytilus edulis* and *Aulacomya atra* indicate that fossil shells sufficiently preserved pristine structure. Also, Strontium radiogenic isotope data suggest a well-preserved state since the studied samples have retained their original seawater isotopic signatures. Therefore, their isotopic and geochemical composition can be used as proxy for the reconstruction of the past sea conditions (e.g. Dodd, 1965; Mook, 1971; Klein et al., 1996). The oxygen stable isotopes record suggest significant changes in the Gulf circulation and salinity, possibly related to the shift of the frontal position of the superficial Falkland (Malvinas) and Brazilian currents during time. Trace elements content (Mg, Ba, Sr, U) appears more difficult to be interpreted, particularly for the high variability observed in living specimens. However, high U content on some set of fossil shells is interpreted as evidence of subtle diagenesis and/or adsorption of this very mobile element making currently particularly arduous, as well known in literature (Kaufman et al., 1971; 1996), the application of the U/Th dating method.

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SESSIONE GEO9

Georisorse minerarie e applicazioni mineralogico-petrografiche per l'ambiente ed i beni culturali

GEO9-1 Orale Brundu, Antonio

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RELATIONSHIP BETWEEN EXCHANGEABLE LEAD AND TEMPERATURE TREATMENT IN A Pb-CLINOPTILOLITE

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Key terms: cation exchanges; clinoptilolite; lead; thermal treatments; zeolite

The technological characterization of a Pb-clinoptilolite can contribute to the evaluation of the problems presented by zeolite-based exchangers used to treat lead contaminated wastewaters, since the zeolite itself become a potential source of pollution. Thermal treatments could represent a way to achieve the inactivation of exhausted Pb-exchangers. Heating can affect the structure and, consequently, the properties of a zeolite, so a thorough study of the heating effects on Pb-clinoptilolite has been started. This work shows the relationship between temperature treatment and exchangeable lead in a Pb-clinoptilolite.

A Sardinian epicalcite, containing 66% of clinoptilolite (along with glass, feldspars, quartz, opal-CT and biotite), was processed through autogenous comminution followed by dry and wet sieving, obtaining a powder 125-64

µm in size with 87% of zeolite grade (Siemens D5000 diffractometer; Rietveld QXRPD, Topas 4.2 software). This material was split in two aliquots (BZ and CZ) conducted in Pb-form in different times. Initially, these were contacted with a 1 M NaCH₃COO solution (10 cycles, 2 h each; solid/liquid = 30 g/l; T = 65°C; continuous stirring). The Na-forms (BZ2 and CZ2) were then brought to Pb-forms (BZ3 and CZ3) by 3 further exchange cycles in a 0.5 M Pb(CH₃COO)₂ solution (2 h/cycle; solid/liquid = 30 g/l; T = 65°C; continuous stirring). Lead release from Pb-clinoptilolite was tested at 20°C in 0.5 M KCH₃COO (BZ3) and NaCH₃COO (CZ3) solutions (10 cycles, 2 h each; solid/liquid = 30 g/l; continuous stirring). The results were compared with the lead releases, measured in the same solutions and conditions, from different aliquots of BZ3 and CZ3 previously heated for 2 h at 200, 300, 400, 500, 600, 700, 800, and 900°C. White solutions and eluates resulting from all exchange processes were analyzed by AAS.

Chemical analyses showed that both BZ3 and CZ3 substantially contain Pb-clinoptilolite end-members. With respect to their initial Pb²⁺ contents, lead releases from unheated materials were incomplete: 47% in K- and 54% in Na-solution. Regardless of the solution used, heated powders presented the same decreasing relationship between percentage of lead released vs. temperature treatment. Heating up to 400°C brought to a weak decrease of exchanged Pb²⁺ (≈ 43% at 400°C), that became pronounced from 500 (≈ 35%) to 700°C (< 2%). Materials heated at temperature ≥ 800°C did not evidence lead release.

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GEO9-2 Orale Pedrotti, Maria

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EXTREME CHROMITE ALTERATION IN ANTANIMBARY CHROMITITES FROM THE MAEVATANANA BELT, TSARATANANA SHEET (NORTHERN MADAGASCAR)

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Key terms: chromite alteration; Antanimbary chromitites; ferritchromites; Madagascar

The Maevatanana Belt, located in the north-central Madagascar, is the westernmost of three belts (Andriamena, Beforona and Maevatanana) belonging to the Tsaratanana Sheet. This tectonic unit, individuated by Collins (2006), is composed of mafic gneisses, tonalites, chromite-bearing ultramafic rocks and meta-pelites, some of which were metamorphosed to ultra-high temperatures at 2.5 Ga (Goncalves et al., 2004).

Chromitites were found close to the village of Antanimbary in the northern part of Maevatanana Belt, but unlike nearby chromitites, hosted within ultramafic bodies of Andriamena belt, they have never been studied. Seven separate chromitite lenses, forming a 3 km long, NE to SW trending, alignment, outcrop close to the Ikopa river bank. They are included within a metamorphic unit, known in literature as orthoamphibolite, composed of sodic plagioclase, hornblende-like amphibole and minor biotite and quartz.

All chromitites are massive with more than 70 and up to 90 modal % chromite and have a cumulus texture where the cumulus phase is always chromite with intercumulus silicates. Chromite grains, completely altered in ferritchromite, ranging from 0.5 to 0.1 mm in size, are euhedral, with fractured cores and porous rims, and enclosed in an anhedral silicate gangue. The most common silicate mineral is chlorite, whose composition falls in the fields of sheridanite and clinochlore and shows detectable Cr₂O₃ contents (1-2 wt%), which are anyway low if compared to kammererite usually associated to ferritchromite. Tremolitic to actinolitic amphibole and orthopyroxene also occur, often in intergrowth. Serpentine and titanite are present as accessory silicate phases. Ilmenite, as tiny inclusions in chromite grains, is the most common non silicate gangue mineral, followed by rutile, monazite, magnetite and rarely pyrrhotite. Chromite crystals (isolated or in aggregates) preserve the original shape even if they are completely altered in ferritchromite. A slight core to rim zonation occurs with broken and porous ferritchromite cores surrounded by a more porous corona showing a stronger alteration. Grains never preserve composition of primary chromite. Generally ferritchromites are

very low in Cr₂O₃, never exceeding 43 Cr₂O₃ wt%. FeO is high, ranging between 29.23 and 32.81 wt%, calculated Fe₂O₃ is never below 6.60 wt% and reaches very high values, up to 28 wt%, in more altered ferritchromite grains. MgO is extremely low, systematically below 2.14 wt%. Al₂O₃ content is strongly variable, with the lowest and highest limits at 3.33 and 21.96 wt%.

Ferritchromite composition, plotted in XFe vs XCr and XFe vs XFe₃₊ "fried egg diagrams", shows a best fit with layered mafic-ultramafic intrusions (Barnes and Roeder, 2001), confirmed by composition of chromite alteration rims from Bird River Sill (Ohnenstetter et al., 1986). Quite constant high values of XFe, ranging between 0.89 and 0.94, together with variable XCr evidence that alteration of primary chromite is complete and occurred firstly at reducing conditions with a primary substitution of Fe²⁺ on Mg. Only after almost complete loss of Mg iron is oxidized to Fe³⁺ and substitutes for Al and Cr.

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GEO9-3 Orale Serra, Margherita

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MICRO-XRF TRACE ELEMENT QUANTIFICATION IN CALCITE: A CONTRIBUTION TO WHITE MARBLE PROVENANCE DETERMINATION

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Key terms: Micro X-ray Fluorescence Spectrometer; Mediterranean Marbles; Trace elements; Provenance determination; Archaeometry

In the last few decades marble provenance identification has represented a focal concern for archaeometric researches, leading to the creation of extensive databases based on the combined results of different geological and physico-chemical methods. Even though isotope geochemistry seemed to give the most discriminant results, the progressive increasing of the database and the consequent overlapping of the characteristic fields pointed out the need of developing multi-method strategies.

The methodological approach presented here combines petrographic and micro-XRF geochemical data acquired on a set of 320 reference samples from 20 different Mediterranean quarrying sites.

Main goal of the research was to evaluate the effective discriminant capability of a new micro-analytical approach based on trace element quantification with micro-XRF Eagle III-XPL (Röntgenanalytik Messtechnik GmbH, Germany) non-destructive instrument. Poly-capillary lenses (30 µm) were used to collimate the microbeam at the sample surface. Single spot analyses on calcite grains gave reproducible results and allowed overcoming the problem of the considerable variations of solution-based ICP-MS analyses.

Preliminary results on Alpine and Apuan Italian marbles encouraged the creation of a wider database which took advantage of the availability of different collections coming from the University of Turin, Genoa and Florence and from the Regional Museum of Natural Science of Turin. The whole set of samples led to the acquisition of original data and allowed quantitative testing the discriminant power of the chosen variables though different samples of the same quarry and in different quarries of the same district. Moreover, it contributed to the scientific valorization of valuable Cultural Heritage.

The choice of the varieties to be included in the database was determined by the historic and economic importance of each specific quarrying site over time. They correspond to the well-known Greek marbles from Aegean Islands and Attica, Turkish islands, Aegean coast and Western Anatolia. Spain was represented by Macael marble, while Italian Apuan varieties were analyzed together with some of the best known Alpine white marbles.

Calcite compositional data were acquired optimizing analytical conditions for different energetic intervals and the statistical error was evaluated by amorphous and crystalline standards (NIST SRM 610 - 612, Standard Carrara Marble M43). The referred averages for NIST SRM trace elements standards (SRM 610 - SRM612), were used for µ-XRF calibration. Applying 40kV, 1 mA, a Ti primary filter (25 µm thick), the statistical intensity error percentage from Mn to Nb was < 5% at 50 ppm nominal concentration (live time of 1000 s) and < 3% at 500 ppm (live time 1000 s). Mg concentration was acquired for 1000 s using 10 kV, 1 mA on unfiltered primary beam. Statistical intensity error, in this case, was below 2% at 500 ppm nominal concentration.

Calcite compositional data were cross-checked and critically compared to SEM-EDS, ICP-AES and ICP-MS independent analyses on the same samples.

Factor and principal component statistical analysis drove the selection of the experimental variables, taking into account petrographic and geochemical evidences. Continuous variables matched micro-XRF calcite composition, expressed as ppm of the most discriminant minor and trace elements: Mg, Mn, Fe, Zn and Sr. Petrographic parameters as maximum grain size, grain boundary shape, texture and shape of the crystals were considered as categorical variables.

Chemometric methods were used for data processing and development of proper grouping procedures. The final cross-validated models were successfully used in different case-studies, including byzantine ancient marble artifacts from Liguria and medieval coat of arms from the Raconigi (CN, Italy) residence of the Royal House of Savoy.

GEO9-4 Orale Kastrati, Shpetim

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MAGNETIC SEPARATION TESTS ON A BRAUNITE-RICH MANGANESE ORE, ESKISEHIR, TURKEY

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Key terms: manganese ore; braunite; metal recovery; Turkey

Turkey is an important manganese ore producer and exploration for new manganese deposits is ongoing. One of the prospected areas is the melange zone of the Eskisehir ophiolite. Some samples from the Tayclar deposits, located in the Eskisehir ophiolite melange, were used in this study to assess the feasibility of magnetic enrichment of manganese ore. The Eskisehir ophiolite is located in the western part of the Izmir-Ankara-Erzincan Suture Zone (IAESZ) that crosses Turkey from the west (Izmir area) to the east (border with Georgia) (Uysal et al., 2009). Manganese deposits within the IAESZ are classified by Ozturk (1997) as radiolarian chert-hosted deposits. They are related to Neo-Tethyan suture and form the epi-ophiolite sediment succession together with associated radiolarite, radiolarian chert, siliceous shale and brown claystone. The deposits show high Mn, Si variable and low Al contents. The most important of these deposits is the Cayirli Mn deposit in central Anatolia. The Tayclar deposit has never been mined and the local geology is not well known due to paucity of outcrops and absence of investigation. Mn-rich rocks are mainly strongly deformed braunite-rich quartzites, with NW-SE trend of layering. As a whole the Tayclar deposit belongs to the IAESZ Mn deposits but it is characterized by a strong metamorphic overprint that changed its mineralogy and texture.

Mineralogy and texture of the Tayclar deposit show conditions that can favour magnetic enrichment of ore at relatively fine grain size, providing the opportunity to produce a high grade final product. Magnetic properties of Mn ore have been assessed in magnetic prospecting (Bhimasankaram and Rao, 1957). Braunite shows a paramagnetic behaviour that is strongly affected by incorporation of elements, like Mg and Fe, substituting Mn. In addition the Tayclar deposit shows a metamorphic re-crystallization with grain size increase that allows good separation of Mn-rich phases and quartz at relatively fine grain size of crushed ore.

For the experiment samples, about 25 kg each, were taken from two outcrops (ESK1 and ESK2) and mixed in equal proportion. Ore was crushed at grain size < 4mm.

Magnetic separation tests were carried out with a Permroll dry magnetic separator at University of Eskisehir, using constant roll speed and magnetic field.

First test, on the whole sample, crushed at < 4 mm, shows that separation of a Mn-rich sand is possible with a high metal recovery. Efficiency is higher for the finest fraction (< 1 mm), with an MnO content increase from 15 to 30 wt% at a very high metal recovery of more than 96 wt%. For coarser grain sizes, without any change of setting, metal recovery decreases due to stronger effect of gravity (78 wt% at > 2 mm) but MnO enrichment increases up to 35 wt%.

A second test was carried out dividing beforehand the feeding sand in three grain size classes, in order to study the effect of sorting on separation. Results show that metal recovery does not change meaningfully and hence previous separation of feeding sand in different grain size classes is useless.

In conclusion tests show that braunite-rich metamorphic manganese deposits can be successfully enriched magnetically, with a metal recovery that is inversely correlated to grain size. Minimum grain size is hence chosen on the basis of crushing costs and market demand. Bhimasankaram V. L. S. and Rao B. S. R. Manganese ore of South-India and its magnetic properties. Geoph. Prosp. 1957, 6(1), 11-24. Ozturk H. Manganese deposits in Turkey: distribution, types and tectonic setting. Ore Geol. Rev. 1997, 12, 187-203.

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GEO9-5 Orale Scalera, Giancarlo

10.1474/Epitome.04.1232.Geoitalia2011

BIOGENIC AND ABIOTIC HYDROCARBONS AND OROGENIC BELTS

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Key terms: Hydrocarbons origin; Abiogenic hydrocarbons; Fold belts building; Expanding Earth

Oil and associated phenomena can be found preferentially along old fold-belts and margins. A fold belt building model proposed in preceding papers by SCALERA (2005, 2007, 2008) can be used to judge if the difficulties encountered by the different biogenic/abiogenic conceptions can be solved. The main characteristics of the model are:

- The tectonic overpressures (MANCKTELOW, 1995, 2008), and the higher temperatures at shallower depth in the model of SCALERA (2005, 2007, 2008), can bear a relation with the synthesis of biogenic and abiogenic hydrocarbons.
- Higher thermal gradients - produced by the isostatic uplift of very deep materials - together with uplifted contents of mantle metals (catalysts) and hydrogen, can favour the occurrence of the conditions leading to the development of the Fischer-Tropsch reaction.
- The underthrust carbonate slabs can interact at proper high temperature with hydrogen and catalytic metals.
- Pressure range can be very wide both because the nonlithostatic overpressures (MANCKTELOW, 1995, 2008) at the boundary between uplifting material and adjacent stable or underthrust lithosphere and occasionally because the inevitable occurrence of strong earthquakes during the thrust-fold belts building.
- Laboratory experiments (MARTINELLI & PLESCIA, 2005) have ascertained that calcareous-marly rocks to which friction is applied produce an emission of CO₂ and methane of inorganic origin.
- The compressional state of the gravity-driven nappes, together with the general rifting environment of the proposed model and the aperiodic activation of deep change of phase with extrusion of material below the fold belt, can be facilitating factors in HCs migration towards the surface and its accumulation under impermeable layers.

The lack of reducing conditions in the upper part of the upper mantle to be possible the Fischer-Tropsch reaction (GLASBY, 2006), is overcome in this model by the upward isostatic transport of the reducing under-lithospheric mantle environment. The criticism of Kenney that suitable TP conditions to produce HCs can be found only at depth greater than 100 km is overcome by the transport of such conditions toward the surface. In my framework a high-temperature reducing environment of undepleted mantle rises up and come in contact with the relatively cold oxidizing lithospheric environment. In the interposed region of thermal gradient, and of hydraulic gradient due to nonlithostatic overpressures - all at depths not overcoming few tens of km - a continuum of very different physicochemical conditions come in existence.

A number of chemical reaction are then favoured in this sort of tectonic oxidizing-reducing pile, leading to a multiple origin of hydrocarbons. In addition, near to the surface - in the first few tens of kilometres - a considerable amount of fluids (FYFE, 1978) and of organic biogenic material of various provenance is present in the underthrust sedimentary layers, which can participate in a passive way (contaminant) or active way (transmuting materials, kerogens) to the HCs forming.

In Italy, a comparison of the petroleum and gas fields (data from PIERI, 2001) with the maximum felt intensity (VIII, XI, X and XI MCS degrees; fig. 2) shows a good agreement between the model and the highest seismic energy release. The earthquakes enclose an elongated area of tectonic working in which hydrocarbons can be produced in the depths, and then expelled laterally toward the cold side of the region. The 'warm side' can be considered the region where the volcanic rocks are located. On this side oil cannot migrate without be decomposed. More deep geochemical investigations and analyses need in determining the real nature (biogenic or abiogenic or mixing of them) of the Italian hydrocarbons.

GEO9-6 Orale Andaloro, Eliana

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DIFFERENT FINE POTTERY CLASSES FROM THE ARCHAEOLOGICAL SITE OF "TIMPONE DELLA MOTTA" IN THE SIBARITIDE AREA (CS) - CALABRIA

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Key terms: Archaeometry; Fine pottery; Characterization; Provenance; Technology

In this work, we focus on the archaeometric characterisation of some pottery remains dated to the 8th and early 7th centuries BC. The examined sherds come from the excavations carried out by the Groningen Institute of Archaeology (GIA) on the acropolis of the Timpone della Motta archaeological site, located near the well-known Greek colony of Sybaris (Calabria, southern Italy).

We focus here on four ceramic classes frequently found in the sanctuary: a) matt-painted pottery ("Undulating band", "Fringe" and "Messapian" styles); b) Oinotrian-Euboean style; c) colonial ware (hydriskai); d) Sub-Thapsos pottery.

All the sherds were examined by means of an integrated analytical approach, including petrographic, mineralogical, chemical and micro-morphological investigations and also clay sediments from the area around Timpone della Motta, representing the potential raw materials used for local pottery production, were sampled for comparison with the pottery. To establish pottery firing temperatures, firing tests (950°C) on the collected clay samples and on each test thin section and diffractometric analysis were carried out.

The results demonstrated that the groups of Matt-painted ("Undulating band" and "Fringe" styles), Oinotrian-euboean, colonial-ware and Sub-Thapsos pottery from Timpone della Motta are characterised by similar features. Although they are very similar, thin-section observations and the chemical data (such as their higher Fe₂O₃ and MgO contents) did highlight some small differences only between the Colonial-ware and Sub-Thapsos group respect to the other two classes. The "Messapian" matt-painted pottery instead show very different characteristics, compared to the other ceramic groups.

The similarity between the chemical compositions of the matt-painted pottery (local styles) and Oinotrian-euboean ceramics could implies their production with the same raw materials. The local styles matt-painted and Oinotrian-Euboean groups, are compositionally similar to both the Pliocene and alluvial clay sediments outcropping near Timpone della Motta, but the comparison between the fine ceramics and the thin sections of firing tests showed the greater similarity with the Pliocene clay tests. The extensive outcrop of Pliocene clay sediments near the archaeological site may explain the large-scale production of pottery ware in this area testified by the great numbers of matt-painted and Oinotrian-Euboean specimens brought to light during excavations.

The composition of "Messapian" matt-painted pottery is completely different from the collected clayey materials, so very probably, they were not locally produced.

The chemical data for the hydriskoi and Sub-Thapsos showed some small differences with respect to the other two groups and to the local clays. This could suggest that this ceramic type was not locally produced or, alternatively, that Fe- and Mg-enriched clay layers, possibly occurring in Pliocene outcrops nearby the archaeological site, were used to produce this type of pottery; otherwise could be supposed that the amorphous nodules were intentionally added, therefore local production might also be hypothesised for this groups.

As regards technological features, the combined information of XRD data and micro-morphological observations by SEM indicated a rough estimate of firing temperatures. Temperatures higher than 850° C are inferred for almost all examined samples, instead observations allow to estimate a firing temperature higher than 1050°C for the over-fired hydriskai.

GEO9-7 Orale Cantisani, Emma

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INFLUENCE OF RAW MATERIALS ON THE QUALITY OF TRADITIONAL LIME BINDERS.

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Key terms: Traditional binders; Limestones; Quality of lime

This contribution presents the preliminary results of a research project named Calci DOC, included in the activities of Forum Italiano Calce. The aim of this project is to realise a database of the raw materials used in the Italian regions for the production of traditional lime. The project was born in Tuscany with the collection of different stones that from Middle Age up to the last century have been utilized for the production of lime and natural hydraulic lime. The project has two purposes: from one side to identify the carbonate rocks, usually outcropping in the neighbourhood of the furnaces, and to fit them into the geology of each region. On the other side we want to assess the relationship among the chemical, mineralogical and physical properties of these carbonate materials and the type and quality of lime that was produced.

Concerning Tuscany, pure Apuan calcitic marbles with different microstructures, pure limestones, marly limestones and other carbonate lithotypes have been utilised in the past centuries and were considered within this study. A standardised processing of the carbonatic stone materials was followed: burning temperature, burning time, slaking, aging of the lime putty, time of setting of the lime putty.

All samples were preliminarily characterised from the chemical (X ray fluorescence), mineralogical (X ray diffraction, thermogravimetric analyses TGA), petrographical and physical (optical microscopy and porosimetry techniques) point of view. The colorimetric coordinates expressed in CIELab system were measured with a Minolta colorimeter on the rock samples and on the hardened binder samples. After the setting of the lime putties, during carbonation, at time intervals, mineralogical controls (XRD) and SEM EDS morphological observations on polished and fractured surfaces were performed. The hardness of the binder samples was measured with a Drilling Resistance Measurement System (DRMS). The obtained drilling resistance was put in relation to the compressive strength of material.

In particular for the Alberese marly limestone, the stone used in the Florentine area for the production of lime, the role of structure, porosity and different amount of clay minerals in controlling the development of calcium silico aluminate, has been investigated. A comparison with the characteristics of the marly limestone from the Chartreuse Massif used in France for the production of the Roman cement (or Prompt Natural Cement) is proposed.

GEO9-8 Orale Arletti, Rossella

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ARCHAOMETRICAL ANALYSES OF EARLY EGYPTIAN GLASS

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Key terms: Glass; EMPA; XRD; Unguentaria

In this work a series of glass fragments of Egyptian unguentaria were characterized from the chemical and physical point of view. The studied samples were produced in the first period of the Egyptian glass production, during the new Kingdom of Egypt. The glass production in Egypt started under Thutmose III kingdom and reached its maximum during the kingdom of Amenhotep III (XVIII dynasty, 1390-1352 BC.) e Amenhotep IV/Akhenaton (XVIII dynasty, 1352-1338 BC). In this period, different glass shapes and typologies appeared with a large variety of decorations and colours. The aim of this work is to compare these samples, never analysed before, with the data relative to coeval Egyptian productions in order to identify a common origin.

The analysed fragments pertain to six vessels (amphoriskoi and krateriskoi) coming from Thebes area and stored at the Egyptian Museum of Turin (Italy) after the excavation carried out at the Valley of the Queens. All these vessels, are blue with yellow, white and turquoise decorations and produced with the core forming technique.

The chemical analyses of major and minor elements were performed by Electron Microprobe (EMPA). The nature of the opacifying and colouring agents was determined by X-ray powder diffraction. Since only micro volumes were sampled from the artefacts (less than 1 mm³), the diffraction experiments were carried out using a single crystal diffractometer equipped with a CCD camera.

The chemical data show that all the samples contain high levels of Na₂O. However, along with a number of glass containing rather high levels of both MgO and K₂O - thus classified as plant ash based glass - some show rather low levels of K₂O along with high MgO amount. Most of these low-potassium high-magnesium samples are Al-rich Co-bearing blue glass: this seems to indicate the possible coloration with Co-bearing alum. This is also consistent with the high level of MnO present in these samples.

These data suggest the use of two different kinds of flux for the production of these glass: an organic source (for the production of most of yellow, white and turquoise items and an inorganic one leading to lower levels of K and Mg-) used for the production of the Co-bearing samples. Yellow opaque decorations are rich in Pb and Sb, while only Sb is present in the white and light blue ones. This is consistent with the results of the X-ray powder diffraction analyses, that confirmed the presence of lead antimonates in the yellow decorations and of calcium antimonates in white and light blue ones. No crystalline phases were detected in dark blue, black and violet bulk glass.

GEO9-9 Orale De Bonis, Alberto

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RAW MATERIALS FOR ARCHAEOLOGICAL POTTERY FROM CAMPANIA REGION (ITALY): A PETROPHYSICAL CHARACTERIZATION

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Key terms: Clayey raw materials; Temper; Campania; Pottery; Ceramic

replicas

Campania is known as one of the Italian regions with the largest number of archaeological sites, and pottery was widespread in the whole region since prehistoric times, with many workshops operating in the territory. Aim of this research is to achieve new data on raw materials for ceramics (clay and additives) from Campania region (Italy), with particular attention to those most likely exploited for archaeological pottery. Samples were chosen taking into account their proximity to the ancient archaeological sites and to the ancient ways of communication; further information was gathered through the personal communication of potters that still today are using local clays.

Minero-petrological and physical investigations on ceramic raw materials are valuable tools to better define the provenance of pottery and the technological potential of clays.

Clayey raw materials from Campania region mainly consist of basinal sediments; the others are represented by alluvial sediments and strongly weathered pyroclastics.

From a chemical point of view basinal and alluvial sediments can be distinguished in calcareous (CaO > 6%) and non-calcareous (CaO < 6%); pyroclastics are only non-calcareous, a parameter strongly influencing the technological features of ceramic products. Because of their good thermal shock resistance, non-calcareous clays are more suitable for cooking ware, whereas calcareous clays are generally used to produce common ware or pottery for liquid storage, due to their higher sintering degree achieved at relatively low firing temperatures.

A moderate to high plasticity characterizes both basinal and alluvial sediments, due to the abundance of different clay mineral phases (e.g. illite-smectite, kaolinite, chlorite) and finer fraction; kaolinite/halloysite bearing weathered pyroclastics show worse plastic features and a higher abundance of coarser fraction.

Liquid and plastic limits as well as shrinkage are other physical features that strongly affect the technological attitude, such as moldability of clayey raw materials whereas grain size distribution influences the physical-mechanical properties of ceramic products. For this reason ancient potters used to modify the grain size of clays either depurating or adding temper. For example, temper improves the toughness of pottery, enhancing the thermal shock resistance of cooking wares or the impact resistance of amphorae.

Sands of the Bay of Naples coastline were analyzed for comparison with the additive observed in the ceramic findings of this area. Those tempers reflect the petrographic composition of the volcano-sedimentary neighboring lithologies, thus they can be used as provenance tracers for the Bay of Naples pottery.

Two different clayey samples from the Bay of Naples area were chosen to make ceramic replicas fired at different temperatures, in order to simulate the technological process as is assumed to be made originally. A calcareous clay from the Island of Ischia (historically known as production center and raw materials supplier) was mixed with different proportions of temper from Campi Flegrei to reproduce the main features of common wares (e.g., fine ware, table ware, amphorae, bricks); a non-calcareous weathered pyroclastic from Sorrento was used to simulate the characteristics of cooking ware.

Petrophysical investigation showed that higher strength and lower water absorptions were achieved at relatively low firing temperatures (850 °C) for the calcareous ceramics of Ischia. Temper addition improves the mechanical stress resistance, due to the formation of a secondary pore system (discontinuities at the ceramic matrix/temper grains interface), which dissipates the mechanical energy. Such a feature is particularly suitable for the production of objects such as amphorae. Pottery made with weathered pyroclastics show better refractory features, which make these materials appropriate for the production of cooking ware.

GEO9-10 Orale Colella, Abner

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THE VOLCANIC TUFFS IN HISTORICAL BUILDINGS: VULNERABILITY AND INTERPRETATION OF WEATHERING PHENOMENA

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Key terms: tuff; ignimbrite; building materials; ageing tests; weathering

The volcanoclastic rocks are undoubtedly an outstanding material widely employed in historic buildings of some relevant cities in southern Italy. In particular, the Neapolitan Yellow Tuff and Campanian Ignimbrite (the yellow facies, with prevailing zeolites and the gray facies, almost exclusively constituted by feldspars), have been extensively used in the architecture of the city of Naples and of Campania region, both as a building material and as ornamental stone when used facciavista.

These materials definitely represent an historical-cultural heritage which deserves appropriate protection; however, any conservative operation cannot disregard a deep knowledge of the lithotypes as well as the environment in which they are used as building material.

As a rule, the correct understanding of all the technical features (origin, formation mechanisms, mineralogical and chemical features, geomechanical properties, accurate interpretation of the weathering phenomena, etc.) represents a prerequisite necessary to plan the appropriate restoration and/or preservation interventions, including the use of consolidating and waterproofing products.

The present work aims at evaluating the influence of some parameters such as temperature, humidity and crystallization of soluble salts on some physical features of the stone.

On this account, some new parameters have been measured so far, such as the dimensional changes induced by increasing heating and by water saturation. Tests carried out on high zeolite-bearing rocks (TGN; ICgi), showed sensible shrinkages under increasing temperatures, likely due to dehydration of these hydrous phases, and a likewise significant volume increase after water immersion (swelling test). By contrast, feldspar-bearing rocks (ICgr) evidenced slight or no variation of these parameters under the same experimental conditions.

A possible explanation to this unusual behavior should be that the zeolitized rocks subjected to changes in temperature or humidity, undergo deformations that may lead to loss of cohesion of the constituent elements and thus to the decay of the physical properties of the rock; moreover, the combination of two effects such as water that penetrates the pores

and the dimensional changes upon heating may represent the main weathering agent (Weiss et al., 2004; Benavente et al., 2008). Artificial ageing tests (wet-dry and freeze-thaw) providing cyclic variations in temperature and humidity also highlighted the different behaviour of the two zeolite facies (TGN and ICg) if compared to the ICgr. To better understand the decay mechanisms of volcanoclastic materials, soluble salts crystallization tests were also carried out. Actually, salt crystallization definitely represents a major cause of physical deterioration of macroporous materials exposed to marine aerosol. This test enabled to appreciate the substantial different behavior of the investigated rocks. In particular, TGN quickly achieved a substantial deterioration (total disintegration) of the specimens already after few treatment cycles. Another relevant aspect of this research is that the changes of many petrophysical parameters (water absorption by capillarity or by total immersion, ultrasonic velocity, uniaxial compressive strength, etc.) induced by accelerated ageing tests are not to be linked to the absolute porosity values of the different materials (these values are almost similar for the three investigated lithotypes), but mainly to the different porous system and a different pore size distribution.

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GEO9-11 Orale Bonazza, Alessandra

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MONITORING OF COLOR CHANGE AT BUILDING SURFACES: POTENTIALITIES FOR EVALUATING POLLUTION IMPACT ON CULTURAL HERITAGE

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Key terms: Monitoring; Color; Cultural Heritage; Pollution Change; Impact

The majority of the monuments and archaeological sites constituting our cultural heritage is located in urban areas. Thus buildings and remains of cultural/artistic interest undergo the impact of different climate and pollution parameters, which act synergistically, but at the same time need to be addressed separately. It is important to consider local-scale variations of the urban environment, such as changes in pollutants, temperature and relative humidity cycles, wind field, urban heat island effect, etc. In conservation field, nowadays one of the most important challenge is to understand the impact caused by environmental changes on cultural heritage.

The available scenarios of multi-pollutants trends in Europe indicate a shift in modern urban atmospheres from and SO₂ dominated situation to a multi-pollutant situation, linked to the driven role played by traffic in determining the overall pollution in urban centres. In view of the proven overwhelming influence of mobile combustion sources in determining the future urban atmosphere, "modern" soiling on built heritage will be likely to contain primarily organic carbon (OC). This will imply a change in composition of damage layers, which will presumably assume a yellow-brown coloration.

The EC TeACH project (Technologies and tools to prioritize assessment and diagnosis of air pollution impact on immovable and movable cultural heritage) sets out to understand the different types of damage on cultural heritage that can be expected in the future, due to changes in pollutants, both in terms of typology and concentration.

To accomplish this goal, from the technological point of view the project aims to develop a non invasive device for the continuous monitoring of the damage caused on monuments located outdoor by changing pollution impact, based on the change of colour of the architectural surface. A prototype is currently under testing at 5 monuments located in urban sites in Europe and one in the Mediterranean area, characterized by different environmental and climate conditions: Cologne Cathedral (Germany), S. Maria del Fiore Cathedral in Florence (Italy), the National Gallery in Oslo (Norway), the Arriaga Theatre in Bilbao (Spain), the National Museum in Cracow (Poland), the historic walls of Salé (Morocco). At each target site samples of surface deposits and damage layers have been collected and analysed by:

° Ion chromatography to measure soluble ions, including water soluble organic anions (e.g. formate, acetate and oxalate).

° Chemical-thermal methodology for carbon fraction speciation and measurement, including organic and elemental carbon (OC and EC).

° Colorimetric analyses directly at the building surface for blackening/colour change characterisation using a portable spectrophotometer.

Results achieved within this still running project on the composition of damage layers will be presented and discussed. Elaboration of carbon fractions data will be liked in particular to colorimetric parameters (L*, a*, b*), with the aim of exploring the application of monitoring of color change of architectural surfaces as potential strategy for preventive conservation.

GEO9-12 Orale Benvenuti, Marco

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SILVER, LEAD AND COPPER METALLURGY IN THE COLLINE METALLIFERE DISTRICT (TUSCANY) IN THE MEDIEVAL PERIOD: PRELIMINARY RESULTS FROM AN ARCHAOMETALLURGICAL SURVEY IN THE MONTIERI AREA

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Key terms: silver, copper and lead; archaeometallurgy; Colline Metallifere; Montieri; Tuscany

Tuscany has been for centuries one of the most important mining regions of Italy. Among the many districts, the "Colline Metallifere" hosts a number of base and precious metal deposits which fed a long-lived mining and metallurgical industry, possibly dating back to the onset of the Etruscan domination (IX-VIII cent BC). The whole district is now included within the "Technological and Archaeological Park of the Colline Metallifere", established in 2002.

Base and precious metal deposits of the Colline Metallifere district are mostly constituted by Cu-Pb-Zn(Ag) vein bodies associated with late-Apenninic tectonic lineaments and emplaced by magmatic-meteoric hydrothermal fluids in the late stages of the Apenninic orogeny (Lattanzi et al., 1994). Ore mineralogy includes mainly chalcopyrite, galena, tetrahedrite, pyrite and sphalerite. The former three minerals are the most important silver-carriers, particularly the Ag-rich variety of tetrahedrite (Tanelli, 1983).

The ancient town of Montieri played a major role in the exploitation and metallurgical treatment of base and precious metal ores (mainly Pb, Ag and Cu) at least since the X-XI cent AD, when the castle of Montieri and its mines came into possession of the Bishop of Volterra (Bruttini & Grassi, 2010). According to some scholars, the first issues of the mint of Volterra, known as 'old Volterrani' and consisting of an imitation of coins ("lucenses") minted at Lucca in the 12th-13th century, were coined just at Montieri, possibly in the Palazzo delle Fonderie, a still-standing old edifice in the centre of the town.

In order to better ascertain type and evolution of smelting and metalworking industry at Montieri, a cooperation project was established between the Dip.to Scienze della Terra (Univ. of Florence) and the Dip.to di Archeologia e Storia delle Arti (Univ. of Siena). We started to analyze several kinds of archaeometallurgical material unearthed during recent excavations in the Palazzo delle Fonderie di Montieri (slags), at the nearby S. Niccolò Rectory (slags) and Montemassi Castle (coins).

The otherwise scanty traces of metallurgical activity found during excavations at Le Fonderie are referable to metalworking activity for lead, copper and iron; the employed ore charges were presumably constituted by sulfidic ore assemblages. Nothing can be said about the possibility that the edifice actually served as a mint in the Middle Age.

From the Montemassi Castle we analyzed for textural, chemical and Pb-isotope composition four coins ("denari"), two typical "lucenses" (minted at Lucca) and two showing somehow distinctive stylistic features, which could be ascribed to a different mint (i.e., "old Volterrani" coined at Montieri?). Based on their mineralogical, textural, chemical and Pb-isotope composition, the two pairs of currencies appeared similar to each other. All the coins are made of a Cu (85 wt%) - Ag (15 wt%) alloy and show evidence of intentional surface silvering through the blanching method. The similarity between the four coins does not necessarily imply, however, that all of them have been produced in the same mint. Pb-isotope compositions of all coins fall within the compositional field of polymetallic sulfide deposits of southern Tuscany and far apart from the corresponding field of the Apuane Alps district (cf. Lattanzi et al., 1997), another important base and precious metal district of northern Tuscany, very close to the town of Lucca. This seems to indicate that, independently from where coins were minted, metals for coinage came from southern Tuscany, and possibly from the Colline Metallifere.

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GEO9-13 Orale Vettori, Silvia

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AN APPLICATION OF PORTABLE HYPERSPECTRAL SENSOR TO CULTURAL HERITAGE

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Key terms: hyperspectral sensor; gypsum; cleaning procedure; marble surface

Hyperspectral image analysis (HIA) is a potential tool for obtaining many spectral information in the visible and near infrared region with a series of narrow and contiguous wavelength bands, permitting to discriminate materials on the basis of their different patterns of absorption at specific wavelengths. This technique, widely used for determining the characteristics and properties of soils, air and water in a rapid, simultaneous and non-destructive way, has been recently proposed as a non-invasive method for in situ analyses of artworks (Vettori et al 2008, Camaiti et al. in press).

A portable high-resolution spectroradiometer (a special kind of spectrometer that can measure radiant energy), ASD FieldSpec FR Pro, is a compact, field portable and precision instrument designed to acquire Visible and Near-Infrared (VNIR: 350-1000 nm) and Short-Wave Infrared (SWIR: 1000-2500 nm) punctual reflectance spectra with a rapid data collection time (about 0.1 s for each spectrum). The ASD-FieldSpec FR Pro spectroradiometer can acquire spectra using the contact reflectance probe employing an artificial internal light source with a spot analysis of about 1.5 cm².

Since the spectral fingerprints of a number of mineralogical phases fall within the spectral range covered by ASD-FieldSpec FR Pro, like calcite and gypsum.

In collaboration with Opificio delle Pietre Dure of Florence, the spectroradiometer has been employed for selecting the best cleaning procedure on a marble column belonging to the Loggia di Baccio D'Agnoletti of Florence Cathedral. The column was originally heavily affected by sulphation and the superficial gypsum layer showed a good adhesion to the underlying patina; in this situation a not controlled gypsum removal may cause the damage of the original surface (over cleaning). Our results on the marble column indicate differences in the cleaning efficacy depending on the methodology adopted.

These results point out that portable hyperspectral instruments may be powerful tools for characterizing historical surfaces in a non-destructive and non-invasive way.

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GEO9-14 Poster Belfiore, Cristina Maria

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TRANSPORT AMPHORAE FROM A REPUBLICAN SHIPWRECK DISCOVERED NEAR PONZA (PONTINE ISLANDS, ITALY): NEW PETROGRAPHIC AND CHEMICAL DATA TO TRACE THE TRADE ROUTE

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Key terms: Shipwreck; Dressel 1 amphorae; Volcanic inclusions; Production area; Trade routes

This work deals with the petrographic and chemical study of Dressel 1 amphorae from the cargo of a shipwreck discovered in the "Secca dei mattoni" shallows, between the islands of Ponza and Palmarola (Italy). The presence of this shipwreck has been firstly signalled in 1986 by some skin-divers of the Archaeological Superintendence of Latium. This was followed with an immediate inspection and some emergency recovery. The ship, resting on the sea bed at a depth of thirty metres, had two differentiated cargos made up of Brindisi amphorae, in the lower layer, and Dressel 1 and Lamboglia 2 types (the most frequent), in the upper layer. The entire cargo would seem to form a well determined typology, already known thanks to the discovery of other wrecks, above all along the Iberian Peninsula and the French coast of the Mediterranean. Everything seems to coincide with a very precise trade route along which wine and ceramics were carried from Southern Italy (probably with departure from the Apulian coasts, due to the layout of the cargo, with a stop over in Campania, probably at Pozzuoli, where she took on board the Dressel 1 and the Lamboglia 2 items) as far as Gaul or Spain, in the chronological period between the end of the 2nd century and the early part of the 1st century BC.

The research carried out on Dressel 1 amphorae aims to confirm or reject the hypothesis of a production of such a ceramic type in the Campanian area. With this aim, mineralogical-petrographic (POM and SEM-EDS) and geochemical investigations (XRF) have been performed. Microscopic observations highlighted homogeneous textural and compositional features for all examined Dressel 1 amphorae, thus suggesting a common provenance area. This hypothesis was also confirmed by XRF results, since the bulk chemical composition of all artefacts resulted to be quite similar. In addition, in order to obtain more precise information on their production area, punctual microchemical analyses have been performed on single crystals of clinopyroxene (largely represented among the volcanic temper occurring within the pastes), according to a volcanic inclusions based approach for provenance studies, recently proposed by Barone et al. (2010). The data obtained have been then compared with compositions of clinopyroxenes occurring within volcanic rocks from different South Italian magmatic provinces. The data are still being processed, even if the first observations seem to indicate a magmatic affinity between the ceramic clinopyroxenes and those from volcanic rocks of the Campanian area, thus confirming the provenance area hypothesized for the examined artefacts.

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GEO9-15 Poster Belfiore, Cristina Maria

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AN INTEGRATED APPROACH FOR THE CHEMICAL CHARACTERIZATION OF GLASS MOSAIC TESSERAE FROM THE ROMAN "VILLA DEI QUINTILI" (ROME, ITALY)

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Key terms: Glass mosaic tesserae; Rome; SEM-EDS; LA-ICP-MS

Variouly coloured vitreous mosaic tesserae have been brought to light during the numerous archaeological excavations of the Roman site "Villa dei Quintili" (Rome, Italy). The architectonic complex, dating back to the 2nd century AD, is considered to be one of the largest in the roman suburb, extending between the Appia Antica and the Appia Nuova. The mosaic tesserae studied here have been taken out from the thermal area of the villa, in the southwest wall of Calidarium, embedded in the bedding mortars.

A double analytical approach has been used in order to obtain a complete chemical characterization of all examined tesserae. Specifically, analyses by scanning electron microscopy coupled with energy dispersive x-ray spectrometry (SEM-EDS) have been carried out for the determination of major elements, whereas laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) for trace elements, including REE. Data obtained highlight that all tesserae mainly consist of SiO₂ (55-72 wt%), Na₂O (8-20 wt%) and CaO (5-7 wt%), and subordinate amounts of K₂O and MgO. For this, they can be defined as soda-lime-silica glasses. The concentration of alkali indicates that samples have been produced using natron as flux.

The high Sb₂O₃ content in all samples is imputable to the deliberate addition of antimony to the batch as a decolorant, while Cu and Cr, also present, were probably used as colorant substances.

GEO9-16 Poster Brundu, Antonio

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SANT'IMBENIA AMPHORAE FROM NURAGIC SANT'IMBENIA VILLAGE (ALGHERO, SS): ARCHAEOMETRIC INVESTIGATIONS AND COMPARISON WITH LOCAL RAW MATERIALS

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Key terms: local raw materials; Nuragic pottery; technology; Sant'Imbenia Amphorae; Sardinia

The Nuragic Village of Sant'Imbenia is located in North-West Sardinia (Alghero, SS). It was inhabited from approximately the XIV to VII century BC by natives and, during the last period of life, also by foreign people. It is obvious that as well as goods and raw materials they exchanged ideas, knowledge and technologies.

The aim of the work is identify the trades and contacts of this settlement through the provenance of clays and the technology of ceramic. Particularly, the study takes into account the results of the archaeometric analyses of the so-called Sant'Imbenia Amphorae found in the Village during the excavations carried out in 1990 and 2008. Sant'Imbenia Amphorae, in fact, are considered "an open question" by the archaeologists either for production area or chronology.

80 selected ceramic samples were studied by X-ray fluorescence, X-ray powder diffraction and optical microscopy to analyze their chemical, mineralogical and textural features and compare clays with local raw materials.

Analytical results reveal that the Amphorae are characterized by two different typologies. The first, more abundant, is compatible with a local production which results relevant and specialized, the second suggest an import from different sites.

GEO9-17 Poster Conz, Elisa

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TECHNOLOGICAL AND PROVENANCE STUDY OF RENAISSANCE EARTHENWARE FROM AOSTA (ITALY)

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Key terms: earthenware; technological features; Aosta Valley; polarized light optical microscope

Some archaeological investigations, promoted by Regione Autonoma Valle d'Aosta, Assessorato alla Cultura and Servizio Beni Archeologici, have been carried out in 2005, just in front of the Aosta Cathedral. The excavation revealed the workshop and the kiln where architectural earthenware, used for the Cathedral façade decoration, was produced and fired.

The construction of the new Cathedral façade was started in the second half of XV century and finished in 1526. The polychrome earthenware Renaissance Apostle statues are located in the arch entrance, which is decorated with flowers tiles.

Flower tile sherds, clay mixtures, raw clay bricks and firing scraps have been found in the excavation. These findings suggest that only the tiles for the Cathedral decoration were fired in the kiln, as scraps from the sculptures weren't excavated and the small size of the kiln suggests that the statues were made in another workshop. Evidence from the clay materials suggest two possible provenances: a local deposit, probably known by Romans, and/or a deposit in the Eorediese (Ivrea region).

In this work the manufacture process and the firing conditions are reconstructed through the petrographical and mineralogical study of the archaeological findings. Thin sections of tile sherds have been studied to determine their textures and components. Moreover firing tests have been run on mixtures obtained using the original clay materials from the excavation in order to locate the clay provenance area and to compare them with the actual tiles and to reconstruct the technological features of the craftsmen.

The observation under polarizing light optical microscope allows to correlate the clay mixtures with the scraps. The yellowish clay found in the excavation has been fired at 850°C and compared with three tiles fragments found in the same spot. The fired yellow clay mixture is texturally characterized by alternating bands consisting of layers, with a high temper percentage content, and layers with high percentage of matrix. The same texture is observed in the tile sherds from the excavation, supporting that tiles were produced using these raw materials. Future development of this work is the examination of the clays, tiles, scraps and mixture firing tests by Scanning Electron Microscopy (SEM) and X-Ray Fluorescence.

GEO9-18 Poster Cuccuru, Stefano

10.1474/Epitome.04.1245.Geoitalia2011

PRELIMINARY MINERO-PETROGRAPHICAL ANALYSES OF STONES AND MORTARS IN A ROMAN BRIDGE (THE "PONT'EUZZU" OF ILLORAI-SARDINIA)

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Key terms: roman bridge; ashlars; mortars; crusts

The preliminary results of archaeometrical investigations performed on the building materials of the Pont'Ezzu Roman Bridge of Illorai (Sardinia), with the aim of a future restoration, are reported.

The monument, built in Roman times is characterized by an original portion consisting of squared ashlars (about 70 x 30 x 30 cm) and a portion rebuilt in medieval times, located at the top of the bridge, which

consists of shapeless blocks of about 30 cm in diameter. Mineropetrographical analyses carried out in optical microscopy (OM) evidenced that the ashlar is made of a welded ignimbrite, rhyolitic in composition, with eutaxitic texture and xenoliths mainly of metamorphic origin. The irregular blocks instead are made with different lithotypes representative of several rocks outcropping nearby where, beyond tertiary ignimbrites, Silurian marble, granites and metavolcanic rocks are the most suitable for artifact building. Ashlar interstices are also filled with three different mortars, apparently of different ages.

In order to support restoration, a detailed evaluation of alteration processes has been carried out. Macroscopic analyses evidenced lichens, white crusts and, in some ashlar of the basal portion, alveolization and scaling (Normal 1 /88). As for the crusts, they are more evident on the arcades, particularly in the volts, where they completely coat the masonries. Such crusts are made of calcium carbonate and in places assume the consistence of true concretions reaching thicknesses of 2 cm. Taking into account their relevance, it is necessary to assume a source of calcium carbonate different from the pyroclastite ashlar. At the current state of observations, stones (e.g. marbles) employed in the restoration of the summital portion as well as lime mortars could be hypothesized as the principal source of calcium carbonate. Moreover, SEM observations on sampled crusts permitted to better appreciate the different coating films and EDS analyses do not evidenced the presence of nitrogen, typical of biological crusts (e.g. due to birds dropping). Finally, optical microscopy analysis of the mortars have shown different characteristics among the three different types. These concern the nature of the binder and aggregate as well the binder/aggregate relationships. From this characterization, that is in progress, the age and the composition of the mortars, as possible Ca source for the concretions, is expected.

GEO9-19 Poster De Francesco, Anna Maria

10.1474/Epitome.04.1246.Geoitalia2011

GEOCHEMICAL CHARACTERIZATION ON GLASS FROM PIAZZA BOVIO, NAPOLI (ITALY)

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Key terms: glass; archaeometry; chemical characterization; LA ICP MS

The archaeological excavation of Piazza Bovio in Naples, has yielded a large deposit, characterized by exceptional findings related to the production of a glass workshop built on site or nearby, around the mid to late sixth century AD.

The workshop features, coupled with the presence of numerous broken glass for recycling and glass scraps, lead to identify the area, as part of a secondary workshop.

Samples of residues of glass melting activities, selected finished objects and glass scraps, dated to VI century AD and IX-X century AD, were analysed by SEM/EDS associated to LA-ICP-MS analysis. The study aims to highlight the technological and compositional differences of the studied glass fragments and to verify the hypothesis of a secondary production in Naples, using raw materials from Levant area, which seems to continue until the eighth century in the southern Italy.

The composition of sixth century glass fragments of Piazza Bovio, indicates the use of natron-based glass and supports the hypothesis of the technological, cultural and commercial continuity in the glass production from the Roman to early medieval period.

The analysis carried out on the medieval finished vessels, dated to the IX-X century, demonstrate the widespread recourse of recycled soda-lime cullet and/or glass tesserae, rather than the direct use of sand and natron or plant ash. The plant ash technology that becomes apparent in glass compositions, in both the Islamic world and the West after the ninth century, probably in Naples was a limited process.

The comparison of the Piazza Bovio glass fragments with Medieval glass of the Italian area (Mirti et al., 2000 and Silvestri et al., 2005) revealed a compositional similarity that probably, confirms the existence of few workshops for primary glass production in the Mediterranean Area.

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GEO9-20 Poster Fichera, Giusj Valentina

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A MULTIANALYTICAL APPROACH FOR THE STUDY OF HISTORICAL MORTARS FROM THE ROMAN "VILLA DEI QUINTILI" (ROME, ITALY)

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Key terms: historical mortars; Rome; hydraulic properties; construction phases; provenance of materials

The present contribution focuses on the study of historical mortars taken from the Roman archaeological site "Villa dei Quintili", dating back to the 2nd century AD. It's one of the largest architectural complexes in the south-eastern part of Rome, extending between the Appia Antica and the Appia Nuova.

The complex was in use until the 6th century. After that, it gradually decayed and in 1986 became property of the State.

The study regarded several types of mortars, taken out from different edifices within the monumental complex, such as the thermal area (Calidarium and Frigidarium), the Viridarium, some residential areas and the Nymphaeum.

All samples underwent an integrated analytical program including: a) a mineralogical-petrographic characterization through polarizing optical microscopy (POM), which allowed to define the nature and grain size of

binder and aggregate and the ratio between the two components; b) the study of hydraulic properties through mineralogical investigations (XRD and FTIR), aiming to the identification of CSH phases, and microchemical analyses (SEM-EDS) in order to get compositional profiles along the reaction rims between binder and aggregate; c) punctual analyses by SEM-EDS and La-ICP-MS of lumps as well as of clinopyroxene crystals and pozzolana fragments, abundantly occurring among the aggregate fraction. Investigations have been carried out with the aim to discriminate diverse types of binder, to possibly identify different construction phases within the architectural complex and to restrict the source area of the raw materials used for the preparation of mortars. For the latter purpose, the obtained results have been also compared with literature data referring to the chemical composition of clinopyroxenes occurring within volcanic rocks from the Roman magmatic province and pozzolana samples from the Alban Hills area, thus allowing to better constrain the provenance area.

GEO9-21 Poster Miriello, Domenico

10.1474/Epitome.04.1248.Geoitalia2011

PROVENANCE OF VOLCANIC ROCKS FROM ARCHAEOLOGICAL AREA OF KYME (TURKEY)

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Key terms: andesites; archaeometry; provenance; Eolide; Kyme

The present study focuses on the provenance of volcanic stones (andesites) sampled in the archaeological site of Kyme (Turkey), the major city of the Aeolia was founded in the middle of the XI century BC by populations coming from the North of Greece. The work is part of a wider project aims to supply the first compositional data on the stone materials of Kyme. However, despite the archaeological importance of Kyme, there are few archaeometric studies on this city (Ciminale, 2003, Miriello et al., 2011). Previous and preliminary studies have suggested that the provenance of volcanic blocks could be from the Burunçuk quarry (La Marca, 2006) located near the ancient city of Larisa (a few kilometers from the archaeological site of Kyme). In this work were performed new and exhaustive compositional analysis, comparing the composition of the stones from the Burunçuk quarry with that of archaeological samples. The samples were studied by chemical (SEM-EDS, XRF), mineralogical (XRPD) and petrographic (polarised optical microscopy) analysis. The comparison between the archaeological samples and the quarry materials definitively confirmed the provenance from the Burunçuk quarry.

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GEO9-22 Poster Pecchioni, Elena

10.1474/Epitome.04.1249.Geoitalia2011

THE ROCK PAINTINGS FROM NYERO (UGANDA): MINERALOGICAL AND GEOCHEMICAL CHARACTERIZATION OF THE PIGMENTS.

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Key terms: pigments; rock paintings; Uganda; mineralogy; geochemistry

Rock painting samples from the archaeological sites of Nyero, Kakoro and Mukongoro (Teso District, Uganda) were collected in the framework of a collaboration between the Universities of Tuscia and Florence (Italy) and the National Museum of Uganda. The main goals of this project are those to provide a mineralogical and geochemical characterization of the pigments with which these rock paintings were made.

The Nyero rock-paintings sites are consisting of primitive drawings of unknown age, although they are commonly attributed to the Later Iron Age. These paintings are main set on the surfaces of large rounded blocks of Precambrian granites and granodiorites, the latter rising above the surrounding areas of about 30 to 50 m outlining a typical Inselberg landscape related to the long-lasting weathering of such acidic rocks.

The rock paintings mainly represent concentric circles, flowers, vegetables, ships and other figures not well defined. Two colors are dominating the Nyero paintings: white or reddish-orange.

The sampling collection was carried out in order to preserve the most significant drawings, consequently, only small flakes or fragments also containing the bedrock were removed. This has posed some difficulties in separating the drawing material and has allowed to collect only small quantities of the pigments. Thus, not destructive mineralogical and geochemical analyses were performed. In particular x-ray diffraction (XRD) and chemical analyses by FT-IR and micro-Raman spectroscopy were carried out.

Preliminary results indicate the presence of different pigments that were used to draw the rock: the reddish-orange color is certainly characterized by iron oxides, while for the white could assume the use of a mixture of kaolin based. Moreover, several organic compounds were recognized, e.g. calcium oxalates: whewellite [Ca(C2O4)·(H2O)] and weddellite [Ca(C2O4)2·(H2O)], in the pigment samples that were used to date the drawings by 14C radiometric method with the technique of accelerator mass spectrometry, at CEDAD (Centre of Dating and Diagnosis) of the University of Salento (Italy) and whose analysis is currently in progress.

GEO9-23 Poster Rovella, Natalia

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ARCHEOMETRIC INVESTIGATION OF RED-FIGURED VASES OF UNKNOWN PROVENANCE

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Key terms: red-figured vases; archeometry; provenance

Three red-figured vases, kindly provided by the Carabinieri Corps for Protection of Cultural Heritage, Cosenza Unit (Calabria, Italy), were subjected to archeometric investigation.

The primary fine of the study was to establish the definite origin and source area of archaeological artefacts. For this reason the samples were characterized from petrographical, morphological, mineralogical, and chemical viewpoints with the aim of identifying technological features and defining the nature of coatings.

The results obtained highlighted common technological features: fine texture of the ceramic body, and black gloss painted directly on it.

A study of their composition excluded the possibility that they are of Greek production. Inductively coupled plasma mass spectrometry (ICP-MS) data revealed that they come exclusively from the Locride area in Calabria, South Italy.

GEO9-24 Poster Rovella, Natalia

10.1474/Epitome.04.1251.Geoitalia2011

CHARACTERIZATION OF ARCHAEOLOGICAL MORTARS FROM ISOLA CAPO RIZZUTO CASTLE (CROTONE, ITALY) AND IDENTIFICATION OF CONSTRUCTION PHASES BY COMPOSITIONAL DATA ANALYSIS

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Key terms: Mortars; Isola Capo Rizzuto; Characterization

In this work different samples of mortars taken from Aragonese Castle, located in Isola Capo Rizzuto (Crotone, Italy) were analyzed.

It was built in 204 BC and represents one of the most important monuments of Calabria.

With the aim of finding a complete characterization of the used mortars, different and complementary analytical techniques were carried out on the samples.

In particular samples were studied by optical microscopy and analyzed by SEM-EDS, LA-ICP-MS and XRPD analysis.

The results obtained identified different construction phases involved in building the Aragonese Castle. Precisely, data provide information on several important technological aspects: ratio binder/aggregate, porosity, presence of lumps.

In addition, mineralogical and petrographic characteristics of the aggregate were determined and found to be compatible with local geological deposits from the Crotona area.

GEO9-25 Poster Scarpelli, Roberta

10.1474/Epitome.04.1252.Geoitalia2011

PRELIMINARY ARCHAOMETRIC STUDY ON COMMON WARES FROM THE FORUM OF POMPEII, ITALY

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Key terms: Pompeii; Common wares; LA-ICP-MS; archeometry

We present the preliminary results of an archeometric study performed on different pottery classes found in the archaeological site of Pompeii, during the I.E. 1980-81 excavations. The selected ceramic group, coming from the western side of the Forum of Pompeii, is the principal evidence of the commercial and cultural development of the ancient Pompeii town and it is ideal for an archaeological and archeometric study.

In the following work, we considered the common wares, both cooking wares and plain wares, dated in a large time span between the end of the fourth century B.C. and 79 AD. On the basis of the morpho-typological analysis, most of these vessels can be considered of local production, instead an extra-regional provenance is supposed for a small group.

The strong morphological and technological changes in the pottery production is an evidence of a large socio-cultural revolution that characterizes the considered period (IV B.C.-I AD. In particular from the II century B.C., but especially from the first century B.C., the Campanian town has highlighted the opening of new extra-regional common ware trade, in the Bay of Naples.

Optical microscopy (OM), X-ray diffraction (XRD), X-ray fluorescence (XRF), scanning electron microscopy (SEM/EDS) and Laser Ablation Inductively-Coupled Plasma Mass Spectrometry (LA-ICP-MS) were performed on the vessels in order to obtain information regarding provenance and technological change in the ceramic production (firing temperature and raw material source area) during the studied period of time.

Petrographic and chemical characterization verified the archaeological hypothesis about the presence of extra-regional productions. The identification of the provenance areas will provide important information on the complex trade mechanisms in the Bay of Naples.

GEO9-26 Poster Vaggelli, Gloria

10.1474/Epitome.04.1253.Geoitalia2011

NON-DESTRUCTIVE ANALYSIS OF GLASSES BY MICRO-XRF

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Key terms: Islamic glass weights; Fatimid age; micro-XRF; coin reference

Analysis of glass objects in the field of Cultural Heritage primarily aims at determining chemical composition in order to obtain information on production techniques and geographical provenance. In fact, chemical composition may allow one to shed light on the raw materials used, and in some cases, the provenance of these may be ascertained; all this may provide useful data for a chronological assessment of the studied objects. In order to achieve such information the detection of major, minor and trace elements is strongly recommended.

This paper reports the results of an analytical approach for a non-destructive study of glass finds by the μ -XRF technique, which is suitable for quantitative analysis of small sized solid samples, showing lower limits of detection than electron microprobe analysis.

The Brandani-Rava collection consists of 62 Islamic glass weights from Egypt, mainly belonging to the Fatimid age (952-1170 a. D.), used as reference weights for coin production. Due to the legends impressed on the samples, that may contribute to their chronological classification, a non-destructive analytical technique had to be used, with the aim of determining whether the samples had been produced by recourse to evaporites or sodic ash as a source for the introduction of the network modifier in the glass batch. Forty four glass weights were analysed in this study; out of these, 37 may be assigned to the Fatimid age thanks to the legend impressed, reporting the name of the caliph ruling at the time of their production, three may be tentatively assigned to the later Mameluk age thanks to the symbol impressed on them, while the last four are of unknown allocation.

Major and minor (Na, Mg, Al, Si, S, K, Ca, Ti, Mn, Fe), as well as trace elements (Cr, Ni, Cu, Zn, Sr, Zr e Pb) were determined and quantified. The obtained results show that the composition of the analysed samples is consistent with a production based on the use of sodic plant ash, due to the relatively high contents of K₂O and MgO; in addition, the lack of correlation between the contents of Al and Ca, as well as the Sr contents, suggest the use of a non-calcareous sand, in agreement with the use of plant ash. Two opaque samples of late Fatimid age feature a high lead content together with the occurrence of Sn, related to the use of SnO₂ as an opacifier.

In conclusions, micro-XRF proved to be a well suited technique of elemental analysis for the non-destructive study of glass finds. The homogeneous composition of the analysed samples, while confirming the use of ash as a flux in Fatimid age, further suggests that comparable quantities of similar raw materials were employed in the course of several centuries; this further points to a consolidated tradition of glass production, appropriate for obtaining reference coin weights with matching features.

GEO9-27 Poster Cantisani, Emma

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CHROMATIC ALTERATION OF FLORENTINE SANDSTONES: ONLY A NATURAL PHENOMENON ?

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Key terms: Florentine sandstones; Chromatic alteration; Valdese Church

The stone materials mainly used in Florentine architecture are two sandstones: Pietraforte, mostly used during the Middle Ages as building structures and during the Renaissance as facing, and Pietra Serena used for ornamental purposes. The first one is found in abundance in the hills at south of the city, whereas Pietra Serena is outcropping out in the hills near Fiesole (north of the city).

Pietraforte is a sandstone belonging to the turbiditic formation present in the allochthonous complex of the External Liguridi superposed on the Tuscan Series; Pietra Serena, instead, belongs to the sandstones of the Macigno Formation which consists of beds of turbiditic sandstones separated by pelitic levels which are the finest components of single turbidity current.

Petrographically, Pietraforte is a fine-grained lithic sandstone made in the same proportion by silicatic grains (quartz, feldspars and magmatic fragments) and carbonatic grains (dolostones). The grains are bounded by a mainly calcitic matrix that makes the rock particularly strong. Pietra Serena can be defined as a medium coarse-grained greywacke made by quartz, feldspars, micas, fragments of metamorphic and magmatic rocks. The matrix is quite abundant and is made by illite, kaolinite and chlorite-vermiculite (present only in some outcropping areas).

It is well known that the processes of decay of the sandstones are related to the type of matrix, the amount of cement, the kind of clay minerals present and to the distribution of porosity, which lead to water infiltrations, resulting in swelling and peeling.

The sandstones have a bluish-grey color in fresh cut, but is easily oxidized acquiring an ochraceous - reddish brown color on buildings. Such changes in color, appear to be due in part to the oxidation of iron, proceeding very quickly from the surface to the inside, without cohesion decrease. Indeed the chromatic changes not necessarily implies a deterioration of characteristics of the material, but they often seem to represent a natural patina acquired with the time. However, in some cases the thickness of oxidized layer and its hardness could also be the result of treatments performed in the past.

In Florence, several monuments and buildings are affected by such phenomenon, in particular it is possible to note an intense and diffuse reddish coloring on bell tower of Valdese Church entirely constituted by Pietra Serena sandstone, in the exterior columns of the Church Santissima Annunziata and in the historical building of Santa Croce square etc. About the origin of the color change, the hypothesis most reliable is a natural decay of stone, due to iron oxidation. On the other hand the presence of an intense and homogeneous distribution of the red color could be due to the application of conservative treatments, as a possible consequence of a recent restoration.

This study intends to verify the real and more probable causes of this frequent chromatic alteration and the processes which determine it.

GEO9-28 Poster Di Benedetto, Claudia

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THE NEAPOLITAN YELLOW TUFF PETROPHYSICAL PARAMETERS: EXPERIMENTAL INVESTIGATIONS ABOUT RECOVERY AND CONSERVATION OF A MACROPOROUS BUILDING STONE

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Key terms: Neapolitan Yellow Tuff; Durability; Weathering; Consolidation
Cultural heritage represented by buildings, monuments and archaeological finds must be considered an asset of inestimable value as outlines the historical and cultural evolution of a country.

The use of the stone as building and decoration material has ancient origin and Italy offers several example of stone used over the centuries in sculpture, decoration, building pavement, etc.

The Neapolitan Yellow Tuff (NYT) is the oldest building material in the Naples area and the most represented in monuments and buildings of its historical centre. In some case tuff is coated by plaster but in the case of monumental buildings it was frequently used facciavista.

NYT is the most important volcanic product in the Neapolitan area. The factor which promoted the use of NYT for building is the local availability but also its physical and mechanical properties. However its mineralogical composition with the abundant presence of zeolites (>50%) and the high porosity make it extremely vulnerable to deterioration caused by weathering.

The interest in the protection of building made up of NYT is increased by its utilization in important monument such as the gothic churches (S. Chiara, S. Domenico Maggiore), Castel dell'Ovo and Castel Sant'Elmo. In this monuments the risk for deterioration is increase by sea-salt aerosol. In the recent years the awareness of having an architectural heritage, rich but "fragile", has produced a greater effort to preserve the stone and/or improve resistance to weathering.

In fact during the past intervention, replacing damaged blocks was a cheap solution thanks to good availability of NYT; at this time the closure of many quarries requires the preservation of this stone.

More recently however many efforts have been made to search products able to consolidate and stabilize weathered material and to reduce stone decay, without isolating it from the environment but protecting it from the causes of degradation.

The aim of this research is the testing two commercial product: an anti-hygro, a protective product which reduces the swelling ability of clay and zeolitic minerals and a polymeric consolidant (ethyl silicate) applied to the NYT.

Moreover in order to better evaluate the mechanisms of stone consolidation, it was selected, for comparison, a porous sedimentary rock, Pietra di Vicenza, with a pore radii distribution similar to TGN.

The two stones were saturated by immersion under laboratory conditions. The specimens were divided into test group: untreated, treated with consolidant and treated with antihygro and consolidant.

Investigations were conducted before and after consolidation and included mineralogical and petrographic analyses (XRD, XRF, SEM), and physical and mechanical determinations (porosity, pore radii distribution, capillary water uptake, water absorption, ultrasonic wave velocity measurements, compressive strength, colorimetric measurements).

The consolidated samples were subjected to ageing tests, weathering simulations such as wet-dry and freeze-thaw cycles, salt crystallization tests and salt spray.

This has made for measuring the effectiveness of consolidation and to study the changes in stone properties.

The products modify the physical properties of consolidated tuff and change the behaviour of weathering: all the treated samples show a decrease in porosity and water absorption, a color variations and an increase in durability against weathering.

GEO9-29 Poster Castelli, Daniele

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GENESIS AND OCCURRENCE OF JADEITITE FROM THE MONVISO META-OPHIOLITE, WESTERN ALPS

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Key terms: jadeitite; plagiogranite; Monviso meta-ophiolite; Cultural Heritage; stone axeheads

A composite boudin is exposed in the antigorite serpentinite of Vallone Bulè, within the Basal Serpentinite Unit of the Monviso massif (Piemonte zone of calcschists with meta-ophiolites). The boudin consists of a quartz-jadeite rock core and a jadeite rim, very similar to the lithologies used by prehistoric men to make stone axeheads (e.g. Ricq-de Bouard & Fedele, 1993; Compagnoni et al., 1996).

In spite of their different bulk-rock compositions, both core and rim show the same trace and REE patterns suggesting a common protolith. The quartz-jadeite rock exhibits a major, trace and REE composition consistent with that of oceanic plagiogranite, most likely a dyke cutting across upper mantle peridotites, later hydrated to serpentinites (e.g. Castelli & Lombardo, 2007, with refs.). Conversely, the jadeitite, which consists mainly of zoned jadeite crystals progressively enriched in the diopside component from core to rim, is significantly depleted in Si but enriched in Mg and Ca with respect to the quartz-jadeite rock. The trace and REE similarities and the ubiquitous presence of small zircons suggest that the jadeitite derives from an original plagiogranite -the present quartz-jadeite rock- through a metasomatic process involving a significant desilication and Mg- and Ca-enrichment connected to the peridotite serpentinization. The process, responsible for the transformation of the plagiogranite into a jadeitite, should have occurred during prograde Alpine high-pressure (eclogite-facies) metamorphism, since the first Na-pyroxene formed is a jadeite, corroded and partly replaced during the metasomatic process by a progressively more omphacitic pyroxene.

Because similar rocks -mostly jadeitites, but even meta-plagiogranites- are reported from other localities from the Western and Maritime Alps, it is likely that the raw materials of most jadeitites used to make stone axeheads, which are spread all over the Western Europe, have a similar genesis and derive from the Western Alps as long since suggested (Damour, 1881).

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GEO9-30 Poster Grieco, Giovanni

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FAMOUS MINERAL LOCALITIES: THE RE-OPENING OF TREPÇA MINE, KOSOVO

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Key terms: Trepça Mine; Kosovo; lead-zinc ore; hydrothermal; skarn

The Trepça mine, whose full name was in past Trepça Stari Trg and has now been changed to Trepça Stan Terq, is one of the most famous mineral localities in the world, but also the most valuable mining site of former Yugoslavia, that produced lead, zinc, silver and minor cadmium and bismuth. The mine underwent in the nineties of last century a rapid decline in production and suffered a forced closure due to the Kosovo war in 1999.

The mine is located in the Vardar Zone of the Dinarides Alpine Belt and is related to the intrusion of Tertiary post-tectonic magmas into a sequence of Paleozoic basement and Mesozoic sedimentary cover and ophiolite nappes. The Trepça ore deposit consists of a series of mantle orebodies and mineralized skarns within the sedimentary pile. The main orebodies are intercalated between thick marbled limestones at the bottom and thick schists at the top. The distribution of mineralization was controlled by a trachite and dacite volcanic chimney surrounded by an explosion breccia. Deposit formation is due to a hydrothermal plume of magmatic origin mineralizing carbonate host rocks, similar to the Kipushi model (Feraud et al., 2007).

Mineralogical paragenesis of Trepça Mine is extremely rich, with more than 60 different mineral species reported. Several of these minerals form valuable aggregates of bright metallic sulphides and well grown crystals of quartz, dolomite, calcite and rhodocrosite of collector interest. Moreover tens of specific studies were devoted to particularly interesting phases such as phosphates (e.g. childrenite, crandallite and ludlamite) and sulphides (e.g. galena, bournonite and cosalite).

Mining at Trepça is documented since the late Middle Ages when the most valuable metal extracted was silver. Mining continued under Turkish rule, but after 17th century declined rapidly till closure in the 19th century.

Modern mining at Trepça was begun in 1930 by the British owned Trepça Mine Ltd at the site of the open pit Middle Ages mine and went on in underground. During the following 60 years Trepça Mine, together with other nearby mines, was the most important mining district of Yugoslavia and one of the largest in the world for lead-zinc production, with a total production of about 3 millions tons of lead and 2 millions tons of zinc. Decline, that had already begun in the '70th, accelerated under Serbian rule in the '90th and culminated with closure of the mine during the Kosovo war of 1998-99. The two smelters were destroyed and the mine completely flooded.

Trepça Stan Terq Mine was reopened thanks to the efforts of the mine management and workers in 2005 with a production, in its first year, of 15.000 ton of lead-zinc ore. Since then production has increased each year, reaching 128.000 tons in 2010.

Reserves are still huge and could be enlarged by further exploration as the ore bodies have not yet been bounded. Assessed resources total about 40 millions tons at 4.02 % Pb, 3.25 % Zn and 76 g/t Ag.

Future development plans comprise: new exploration in the Trepça mineralized belt, increase of production from known resources construction of a new flotation plant, a standard procedure for control of mine production and, eventually, construction of lead and zinc foundries at Mitrovica Industrial Park.

A preliminary agreement between University of Milan, University of Pristina and Mine management led to a visit of the mine in April 2011. During a short survey of the exploitation front at level XI, 640 m below surface, several samples of collector interest were taken. The preliminary agreement is being improved in order to open Trepça Mine to scientific study, comprising collection and study of mineralogical samples, geological interpretation of ore deposit and characterization of huge tailing dumps.

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GEO9-31 Poster Moroni, Marilena

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AL-SPINEL-SULPHIDE BEARING DIKES AND THE FATE OF CHROMIUM IN MARGINAL REACTION ZONES AT BALMUCCIA.

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Key terms: chromium; spinel; lherzolite; dike

The Balmuccia peridotite massif is one of the subcontinental mantle peridotite bodies intruded in the mafic-ultramafic Ivrea-Verbano complex in the Western Alps, Northern Italy. The Balmuccia body consists of dominant foliated lherzolites crosscut by several generations of pyroxenite dikes, approximately belonging to an earlier "Cr-diopside suite" and a later "Al-augite suite". These dike suites are interpreted as mineral segregations from melts which percolated into the lherzolite, refertilized it and caused focused dunitization of the host peridotite. Our study is focused on some thin, cm- to dm-thick pale grey-violet dikes presumably belonging to the late-stage Al-augite suite and intersecting the lherzolite mass at its eastern margin, near the intrusive contact with the Ivrea-Verbano complex. These dikes often show a spotted texture due to the segregation of abundant coarse vitreous black spinel phenocrysts. The mineral assemblage is both Al- and sulphide-rich. The silicate-oxide assemblage includes dominant clinopyroxene (diopside-augite) and blue-green, transparent Al-rich spinel, with minor Ti-rich Na-K pargasite amphibole, Al-bearing orthopyroxene (enstatite), accessory Ti-rich phlogopite and plagioclase and rare olivine (intergrown with spinel droplets). Abundant Fe-Ni-Cu sulphides (pentlandite, pyrrhotite, chalcopyrite and bornite) are widely disseminated across the dikes both as mm-sized polyphase nodules interstitial to the silicate-spinel matrix and as tiny, locally extremely abundant drop-like inclusions in spinel.

Assemblages containing bornite exclusively occur as inclusions in spinels, which host a redox-dependant equilibrium pentlandite-chalcopyrite-bornite association. The richness in Ni sulphides copes with the scarcity of olivine in this association and is one of the interesting features of these dikes. Another curious feature involves the margins of the dikes. The contacts

with the host lherzolite are sharp but not tectonic and are characterized by lateral passage from dike-related undeformed to lherzolite-related, variably foliated assemblages (olivine, ortho- and clino-pyroxenes, fine-grained dark brown spinel and rare amphibole). A visual inspection of the host lherzolite/grey dike contact zones showed a peculiar, progressive change in colour of the spinel from dark brown, in "distal" position, to green transparent near the dike margin. That was the most visible evidence of the interaction between lherzolite and intruding dikes, as an actual reaction zone is not easy to recognize texturally. Analytical transects across these mm- to cm-sized "contact zones" by means of microprobe showed that there may be a cryptic reaction zone. The lherzolite phases do record some changes in major element composition, and in particular spinel, pyroxenes and amphibole show variations in Chromium concentration, among others. Across the reaction zones lherzolite spinel vary their Cr content from about 19 wt% Cr₂O₃ to <1%. They also decrease their Fe²⁺ content whereas Al and Mg are enriched. Clinopyroxene shows a variable "response" to this reaction zone as it shows a tendency to Cr depletion coupled with Ti enrichment and fluctuations in alkalis. Accessory amphibole crystals in lherzolite show a trend of Cr depletion and Ti enrichment as well as a variability in Al and Na contents towards the dike margin. Cr is rather low in lherzolite orthopyroxene, however it shows a tendency to Cr and Mg depletion (and Fe enrichment) towards the dike contact. Olivine tends to be more forsteritic in a distal position. Ongoing and future analytical investigations are aimed to characterize and verify the meaning and the extent of this Cr-depleting Al-enriching and dike-lherzolite metasomatic interaction. Of particular interest is the fate of Cr, one of the economic elements enriched (after mobilization from a source) in relation to metasomatic processes, e.g., dunitization, affecting peridotites.

GEO9-32 Poster Rapisardo, Gianmarco

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PRELIMINARY REPORT ON MINEROGENETIC PROCESSES IN THE TGV (SABATINI VOLCANIC DISTRICT)

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Key terms: Zeolites; genesis; Latium; minerogenetic aspect

Many ignimbritic deposits of Central and Southern Italy are deeply affected by minerogenetic process leading to the zeolitization of the volcanic products.

Zeolitization processes in volcanoclastic formations, develop by interaction between alkaline solutions and a precursor represented by a volcanic glass. This interaction mainly depends on the temperature conditions of the deposits, the glass composition, the cationic content of the interacting solution and its pH (Hall, 1998).

Phillipsite and Chabazite are the main zeolites occurring within the volcanoclastic deposits of central-southern Italy, such as the Neapolitan Yellow Tuff and the Campanian Ignimbrite from Campania region, and the *Rivieto-Bagnoregio* Ignimbrite (*Tufo rosso a scorie nere*), the *Sorano* formation (Sorano Yellow tuff) from Vulsini district, the *Tufo Giallo della Via Tiberina* from Sabatini volcanic district and the *Lionato* tuff from Albani Hills volcanic complex (Lazio and Toscana regions) (de Gennaro et al., 1995).

The present research reports the preliminary results of a detailed mineralogical characterization of the *Tufo Giallo della Via Tiberina* (TGV), Sabatini volcanic district (Nappi and Mattioli, 2003). The main goal of the study was to correlate the volcanological features (eruptive styles, emplacement mechanism, etc.) with the post-depositional minerogenetic processes (type of zeolite, areal and stratigraphical variations of authigenic phases, etc.) in order to propose a suitable minerogenetic model.

The investigated samples come from four quarries (*Cannetaccio*, *Perina*, *SICAT*, *Fantini*), located close to Riano (Rome). Optical microscopy (OM) on thin section and scanning electron microscopy (SEM) allowed to identify the major phases and their relationships. Quantitative mineralogical analyses were performed by X-ray powder diffraction (XRPD) using RIR-Rietveld (Bish and Post, 1993) methods. Chemical analyses were carried out by XRF for bulk rocks and by EDS for crystal phases.

The main zeolitic phases are chabazite and phillipsite (total content ranging between 25% and 55%). Analcime, was only occurring in samples from "*Cannetaccio*" quarry. Primary constituents are sanidine, calcite, pyroxene and an amorphous matter.

OM revealed that the occurrence of calcite, identified by XRPD, is related to the calcareous clasts from the underlying sedimentary basement. Further analyses are in progress to establish whether a carbonatic cement is present too, linked to post depositional carbonatic water circulation. EDS data shows that chabazite always display Ca as main extra-framework cation, followed by K, and vice versa for phillipsite. Analcime is probably related to the alteration of leucite. SEM observations show the presence of low-temperature K-feldspar (adularia).

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GEO9-33 Poster Rossetti, Piergiorgio

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EL CRESTON PORPHYRY-MO DEPOSIT (SONORA STATE, MEXICO): MINERALIZATION, ALTERATION PATTERN AND FIRST FLUID

INCLUSIONS DATA

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Key terms: polyphase hydrothermal evolution; hydrothermal alteration; deep porphyry-Mo deposit

El Creston is a porphyry-moly deposit with proven and probable mineral reserve of 146,705,000 tonnes grading 0.077% Mo (+ Cu±Zn±Ag as byproducts). It is located in the Mexican part of the Basin and Range Province, where a metamorphosed Proterozoic basement, mainly composed of a metagranite body (Creston metagranite) intruded in a sequence of phyllites, quartzites, gneisses and metavolcanics, rests as a roof pendant on the Tertiary Sonoran batholith, which includes several intrusions mostly ranging in composition from granite-granodiorite to quartz monzonite. The deposit is related to the emplacement of porphyry stocks in the basement (particularly, the Creston metagranite). The mineralized system underwent a complex tectonic history, the most relevant structures being low-angle normal faults (dipping N35/30°) with horizontal displacement.

A polyphasic hydrothermal evolution is testified by several types of hydrothermal veins and breccias. The following main veins types have been recognized (older to younger, even if some reversals surely occur):

- Qtz + Kfs ± Ab ± Mlb (molybdenite) ± Phl (phlogopite) ± Ms ± Py ± Rt veins (QTZ-KF).
- Qtz + Kfs + Phl ± Mlb veins (QTZ-PHL).
- Bt + Mgt veins (BT-MT).
- Qtz + Ms + Rt ± Py ± Sp ± Ccp ± Td-Tn (tetrahedrite-tennantite s.s.) veins (QTZ-MU).

- Zn-Sd (zincian-siderite) ± Ms ± Sp ± Ccp ± Td-Tn veins (ZN-SID). Different types of breccia occur, including pre-mineralization intrusive breccias and hydrothermal breccias.

Among the 7 alteration facies identified, the most significant are:

- Qtz + Kfs + Ab ± Ph ± Zrn ± Py (KF), connected with the QTZ-KF veins;
- Bt + Mgt ± Ms ± Zrn ± Ep (MT);
- Qtz + Mu + Py ± Ccp ± Rt (MU), related to the QTZ-MU veins.

Apart from an early (relict) albittization stage, the KF and (often overprinting) MU are the strongest alteration facies; the envelope of MT alteration around the KF alteration likely represents its slightly lower T equivalent. Mineralization is mostly connected with the KF veins and related alteration. At least locally, however, molybdenite enrichments are found in Py-Ms-bearing assemblages and at the contact between the two alteration facies.

Strong enrichments also occur in the quartz (+ Kfs ± Phl) matrix of hydrothermal breccias.

A reconnaissance fluid inclusion study performed in quartz from the QTZ-KF and MU veins led to identification of the following populations:

- L+V+several solid phases (Phl, Ms, Cal, Mgt, Tur, Ccp...): these are the earliest inclusions, only occurring in QTZ-KF veins;
- L+V±Ccp: these are the most abundant inclusions, connected with the MU alteration;

- L+V+HI±Hem: rarely occurring in QTZ-MU veins, or QTZ-KF veins with MU overprinting;

- V+L±Ccp: VLC inclusions surely not due to necking are rare. Often in samples containing the halite-bearing inclusions, they may be coeval with them.

A striking feature of the fluid inclusions picture is the paucity of hypersaline inclusions. This observation and microthermometry/Raman preliminary data suggest that in the QTZ-KF veins fluids with low salinity and moderate CO₂ content, of likely magmatic derivation, were trapped above the solvus in the H₂O-NaCl-CO₂ system, thus implying a great depth of formation for the deposit. Also during cooling the fluid remained above the solvus, and only episodically unmixed: cooling and, probably, water-rock reaction, more than fluid immiscibility, played an important role for molybdenite precipitation at El Creston.

GEO9-34 Poster Rossetti, Piergiorgio

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UNIDIRECTIONAL SOLIDIFICATION TEXTURES AND MINERALIZATION: THE KULE PORPHYRY-MOLYBDENUM SYSTEM (XINJIANG UYGUR, CHINA)

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Key terms: magnetite-bearing UST; high volatile content; porphyry-Mo deposit; Variscan calc-alkaline magmatism

The Kule valley is located close to the western end of Xinjiang Uygur Autonomous Region, 100 km southeast of Yining. The area belongs to the western sector of the > 2500 km long, east-west trending Tian Shan mountain range. In this part of range (central Tien Shan) the Yili Terrane, a wedge-shaped Precambrian craton, is exposed, and bound by the North and South Tien Shan ranges. Variscan calc-alkaline granite and granodiorite bodies (dated 400-250 Ma) crop out over much of the Yili block, representing a still poorly understood magmatic arc derived from orogenic events on both sides of the block.

The Kule area is composed of a suite of magmatic rocks of inferred upper Carboniferous to Permian age. Based on field relations and petrographic features, the following units are recognized:

- Granite Unit, composed of: a) medium-grained, equigranular to porphyritic granite, affected by a pervasive "propylitic" alteration; b) microphyritic granite, made of plagioclase, K-feldspar and quartz phenocrysts in a micrographic matrix; c) microphyritic leucocratic granite, showing peculiar (UST) textures which are described below.
- Rhyolite Unit: it is a mixture of rhyolite lava and volcanoclastic rocks with the same composition. It includes massive rhyolite bodies related to emplacement of rhyolitic magma under hypobassal conditions.
- Tuff Unit: shows the same composition of the Rhyolite Unit, but displays features typical of pyroclastic (to epiclastic) deposition. Its primary bedding shows a NNE-SSW trending subvertical attitude, suggesting (in agreement with other evidences) that the Kule sequence suffered a tilting towards WNW.

- Andesite Unit: intrudes the Tuff Unit and is composed of porphyritic andesite affected by propylitic alteration. Dykes related to the Andesite Unit intrude the Rhyolite Unit.

The sequence is affected by veining, alteration and Mo mineralization. The following main veins types occur (older to younger):

- Qtz - Kfs ± Mgt (magnetite) veins: they crosscut the microporphyritic granite and rhyolitic rocks, producing a strong "potassic-type" alteration given by brown Bt + Qtz + Mgt ± Kfs;
- Qtz - Ms + Py ± Mib (molybdenite) veins and breccias: crosscutting the microporphyritic granite, rhyolitic rocks and Tuff Unit, they produce a mild to very strong alteration given by the same assemblage.
- Qtz ± Chl ± Ep ± Cc veinlets: they only occur in the medium-grained granite and Andesite Unit, where produce a pervasive Chl - Ep - Ab - Ttn ± green Bt ("propylitic") alteration.

When restored to its primary position, the Kule sequence shows features (e.g., calc-alkaline volcano-plutonic setting; multiple veining and alteration, with a "potassic" core surrounded and in part overprinted by a "phyllitic" envelope; hydrothermal breccias; molybdenite) typical of a (low-F) porphyry-Mo system.

The microgranite porphyry, that in the restored setting lies below the potassic core, shows a "layered texture", given by cm-thick coarse-grained, crenulated quartz - magnetite layers separated by leucocratic granite. Both quartz and magnetite crystals within the layers grow in the same direction, thus representing Unidirectional Solidification Textures, like those firstly recognized in the Henderson porphyry-Mo deposit (Shannon et al., 1982). Peculiar of the Kule microgranite is the occurrence of coarse-grained magnetite within the layers. However, the absence of hydrous magmatic phases in the microgranite (the only mafic mineral being fine-grained magnetite) strongly suggests, as proposed for other UST occurrences, release of (ore) fluid to the time of crystallization and solidification of the apex of a stock.

The occurrence of Unidirectional Solidification Textures at the Kule porphyry-Mo system further emphasizes their importance, as features indicative of high primary volatile content and ore fluid release in magmatic-hydrothermal systems.

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SESSIONE GEO11

Geofisica applicata

GEO11-1 Orale Iacopini, David

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TRACKING STRAIN IN DEEPWATER RESERVOIR USING SEISMIC ATTRIBUTES

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Key terms: exploration geophysics; reservoir characterization; fault imaging; post stack processing; seismic attributes

Nowadays most the interpretation models proposed within basin and reservoir system assume and simplify the seismic structures as simple line or surface strands. Faults are commonly picked as single plane or sharp discontinuity through the center of the fault.

Similarly, in compression system, deep-water toe thrust anticlines have been interpreted using traditional simplistic models such as fault-propagation folds, detachment folds, and both simple- and pure-shear fault bend folds. High quality 3D seismic data show that the deep-water anticlines typically display extreme variations in along-strike fold morphology which are not accounted for by any individual one of the above models; multiple conflicting kinematic models would have to be applied to explain different parts of a single structure (Higgins et al., 2009). Even in very high quality 3D seismic lines the thrust anticline structures are often represented by wipe out zones that are critical to determining the trap elements in compression thrust system (Kostenko et al., 2007). Drilling in such a zones disclosed a much more complicate picture of the thrust and zones system. Exploration success in the offshore fold belts depends on understanding and visualizing their architecture and those low signal/noise zones using specific seismic attributes. A detailed and correct 3D visualization of their architecture represents necessary steps toward a correct conduit-reservoir -cap rocks characterization. A specific studies focusing on the seismic image processing and mapping of fault distortion zone within thrust fault system is still lacking in the literature (Iacopini & Butler, 2011; Iacopini et al., 2011). In this contribution we describe specifically the main image processing workflow and underline the potentiality of combining seismic attributes through volume visualization techniques to describe, map and highlight some deformation properties of the seismic disturbance zones (SDZ) at the seismic resolution (10 to 100 m). As a result of the post stack seismic image processing we investigated discontinuities using semblance attributes (that quantify and delineate the short-range anomalies on the intensity of reflector amplitudes), collecting these into so-called "disturbance geobodies" and proposed a possible workflow to detect deformation in low signal/noise zones bounding the thrust and main forelimb. Disturbance geobodies (fig 1b) define tracts of closely spaced, small-offset reflector discontinuities, interpreted here as subsidiary thrust faults adjacent to the main thrust breaks identified in conventional amplitude displays.

We thank Steve Toothill and colleagues from CGGVeritas for permission to work and publish on the 3D dataset from the Niger Delta. We also thank ffa for provision of their SVI Pro software to the University of Aberdeen.

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GEO11-2 Orale Capizzi, Patrizia

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GPR MEASUREMENTS FOR STRENGTH CHARACTERIZATION OF CONCRETE

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Key terms: GPR; ultrasonic measurements; concrete; characteristic resistance

Ultrasonic survey for both non-destructive test and characterization of concrete artefacts is a rather established methodology (Blitz and Simpson, 1995), whereas GPR measurements, even though widely used for non-destructive investigations, are not sufficiently used for material characterization. In this paper we present an attempt of correlation between the mechanical properties of concrete and the material permittivity. GPR measurements on a set of concrete specimens (physical models) were acquired and US measurements had been carried out for results comparison.

The possibility of material characterization through the GPR measurements, taking into account the integration with the ultrasonic technique, has been studied and possible relationships between the permittivity of materials and their bulk density are discussed. A series of samples of concrete, characterized by different material properties, were used for georadar and ultrasonic measures, seeking correlations among experimental data.

GPR data were acquired using an IDS K2 GPR system with an IDS Aladdin Full Polar antenna (2000 MHz), whereas US measurements were obtained using a Boviari TDAS 16 system with probes characterized by a resonant frequency of 55 kHz. The concrete cubic specimens (edge of 15 ± 0.1 cm) have been used for detecting their permittivity (GPR reflection measures) and their mechanical strength (US measures). The US measures allow to calculate Young modules, E, by means of the US velocity, VUS, and density, d:
 $E = d \cdot VUS^2$.

Once every measure was completed, samples were subjected to the uniaxial compression tests to estimate their compressive strength. The apparent conductivity values achieved by GPR measurements were used to estimate seismic velocity V modifying empirical relationship (Wyllie et al., 1956), obtaining:

$$\frac{1}{V} = \frac{\phi - S\phi}{V_{air}} + \frac{S\phi}{V_{fl}} + \frac{1 - \phi - A}{V_{cement}} + \frac{A}{V_{aggregate}}$$

where ϕ is the concrete porosity, S is the porosity saturation, A is the aggregate fraction and V_{fl} , V_{cement} , V_{air} and $V_{aggregate}$ are, respectively, the seismic velocity in the fluid, in the cement, in the air and in the aggregate.

The values of characteristic resistance calculated using the relations (Italian law, D.M. 9/01/1996):

$$Rck = (E/5700)^2$$

were compared (Fig. 1). The Rck values estimated by GPR measurements show a poor correlation with the Rck values measured and calculated by US measurements, also because the permittivity increases with both the bulk density (increasing with the Rck) and water content (decreasing with Rck).

GEO11-3 Orale Mele, Mauro

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NEAR-SURFACE GEOPHYSICAL PROSPECTION TO REVEAL THE HIDDEN STRUCTURE OF THE TERRAMARA SANTA ROSA, POVIGLIO (ITALY)

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Key terms: Archaeogeophysics; Terramara Santa Rosa; Bronze age; Electrical resistivity imaging; Electromagnetic induction

The Terramara Santa Rosa (Poviglio, northern Italy) is an archaeological site which developed between Middle and Recent Bronze age, constituted by two settlements and delimited, as seen by aerial photograph, by earth rampart. The smaller settlement (Villaggio Piccolo; VP) to the North is the oldest part, founded during the Middle Bronze age. To South, a U-shaped rampart delimits the larger part of the younger site (Villaggio Grande; VG), which mostly dates to the Recent Bronze age.

The archaeological excavation has revealed that the settlements was surrounded by wide moats, running parallel to the villages fences and being part of a complex hydraulic system. The latter was built not for defensive purposes but to redistribute water toward the surrounding fields. The moat was fed by surface water probably taken form an adjoining Bronze Age Po palaeochannel and by groundwater drained by water wells dug inside the loamy clay ground to reach shallow and thin sand aquifers.

The Bronze landscape is today sealed by alluvial clay accumulated by Po river floods, 3-4 m thick, which fill depressions (moats and external areas) and hide the archaeological features.

Stratigraphic excavation was performed within the VP, at the transition between the VG and the hydraulic system, to the South. A large-scale geophysical survey (2008-2010) was carried out to provide an improved map of the buried structure and useful information to plan future archaeological excavations. Direct Current Electrical Resistivity Imaging (ERI) and Electro-Magnetic Induction (EMI) methods were applied to reveal the lateral and vertical heterogeneities between the near-surface, fine-grained sediments and the buried archaeological targets in order to improve the likelihood of locating the villages, the moats and other hidden targets in the surroundings.

70 ERI profiles, with Wenner and Wenner-Schlumberger array, were used to investigate the transition between the villages, the moats and the adjoining areas. Data were collected with roll-along technique and electrode spacing ranging from 1 m to 3 m, for an exploration depth of 15

m below the ground surface and a total length greater than 9000 m. EMI survey was conducted over a 16 ha wide area in order to map shallow heterogeneities at the site scale. Data acquisition was conducted with a ground conductivity meter, simultaneously transmitting at 5 kHz and 15 kHz frequencies, and using a vertical magnetic dipole configuration with 1.2 m distance between the coils. Measures were acquired in continuous mode (data sampling 1 Hz) with a snaked pattern of parallel profiles with 5 m separation.

ERI and EMI data revealed consistent apparent resistivity anomalies, supported by the results of the DC ERI data inversion. Since the electric and electromagnetic response of the site is strongly controlled by the presence of very fine, and therefore electrically conductive, loamy-clay sediments for which the presence of coarser textures (fine sand) increases the electrical resistivity, the geophysical survey highlights in a very neat and definite way i) the location of the villages, characterized by the highest values of electrical resistivity due to the increase of sandy textures that build up the point-bar complex where the villages were built on, ii) the moats that surrounds the villages, which appear as a conductive structure and iii) several local anomalies in the surroundings, some of which can represent possible archaeological targets.

GEO11-4 Orale Perri, Maria Teresa

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A SALINE TRACER TEST MONITORED VIA BOTH SURFACE AND BOREHOLE ELECTRICAL RESISTIVITY TOMOGRAPHY: COMPARISON OF TIME-LAPSE RESULTS AND CONSIDERATIONS ON RESOLUTION AND DATA USE.

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Key terms: ERT; electrical resistivity tomography; tracer test; hydrogeology

During the last decade, hydrogeophysics has emerged as a discipline that, by using geophysical techniques, can complement the traditional hydrogeological data. Geophysical measurements are non-invasive, cost effective and can be performed with high spatial and temporal sampling. The most commonly applied technique is electrical resistivity tomography (ERT), both from the ground surface and in cross-borehole configurations. To infer reliable results from such a hydrogeophysical application, however, the uncertainty related to the data inversion has to be taken into account and specific attention must be paid to the experimental set-up and design, especially when the main target of the study is expected to be a quantitative estimation of the relevant hydrological quantities. The sensitivity and resolving power of ERT depend in fact on the type of acquisition methodology; operating from the ground surface only, for example, could lead to severe limitations in terms of resolution, and the corresponding results can be viewed only in qualitative terms. In this work, we present the results of a saline tracer test experiment performed in the saturated zone at the water works facility at Valdobbiadene (Treviso, North-East Italy), where an alluvial phreatic aquifer is heavily exploited for irrigation and drinking water supply. The experiment was monitored by time-lapse ERT acquisitions, using both surface and cross-borehole configurations. We compared the results of the two approaches and concluded that in general ERT can provide fundamental information on hydraulic characteristics as derived from tracer tests, but we also evidenced the strong limitations inherent in using surface electrode configurations only.

GEO11-5 Poster Affatato, Alessandro

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SHALLOW GAS OCCURRENCE IN THE EASTERN LAGO FAGNANO (TIERRA DEL FUEGO)

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Key terms: Shallow gas; Eastern Lago Fagnano; Seismic analysis

Lago Fagnano, the southernmost ice-free reservoir of water in the world, occupies a deep tectonic depression developed along the E-W-trending Magallanes-Fagnano transform fault in Tierra del Fuego. It is 105-km-long, 7-km-wide in average, and has a maximum depth of 206 m. In the frame of an Italian-Argentinean scientific project funded by the Italian Ministry of Foreign Affairs, and jointly coordinated by the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS) of Trieste and the Instituto de Geofísica "D. Valencio" of the Universidad de Buenos Aires, a series of high-resolution single-channel seismic reflection profiles were acquired on November 2009 and March 2010. These seismic data, collected by a Boomer source (150 kJoule) and a 10-hydrophones solid-state, single-channel streamer, complement and complete the seismic surveys carried out in the past in the Lago Fagnano. Ten gravity piston cores (with recovered sediment samples lengths variable from 80 cm to 170 cm) have been also collected to analyze the stratigraphy of the most recent (Middle to Late Holocene) sedimentary cover in the eastern sector of the basin.

Along some high-resolution seismic profiles the actual presence of shallow gas layers has been inferred because the typical very strong reflection and multiple reflections and acoustic blanking characterizing the seismic signal. The gas-related features observed on the seismic profiles include an amplitude phase reversal on top that creates multiple reflections. The gas abundance is well detected in seismic section because the sediment/gassy sediment interface (SGI) has a characteristic reflector with strong amplitude and reversed phase with respect to the bottom. The gassy sediments exhibit high attenuation (blanking) that hide geological sub-surface structures. The lake-floor morphology does not reveal any evidence of clear gas escape from the floor. The top of the acoustically high-amplitude layer is located between 0.3 and 1.7 m below the lake-floor. Seismic characteristics and velocity data

seem to suggest a low concentration of gas, most likely less than 1%. We assume that the main origin of gas could to some extent be linked to the presence of a shallow, thin peat-rich layer of Middle-Late Holocene age. In fact, the mapped gassy zone occurs in correspondence of the outlet of the Rio Turbio, the principal input of eastern Lago Fagnano, which discharges the waters coming from a relatively small sag pond located immediately to the east of the eastern shore of the lake, one of the numerous peatlands that characterize most of the Tierra del Fuego lowlands.

GEO11-6 Poster Bochiolo, Massimo

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SHORT-TERM VARIATIONS IN RADON CONCENTRATION IN A DEAD-END MINING GALLERY

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Key terms: radon flow; natural hazard; underground environment;

time-series analysis; stress change

Radon is the densest gas known under normal conditions and the only noble gas to present a natural radioactivity. Because of such properties, it is considered a health hazard. Although radon dissipates rapidly into the air, in poorly ventilated underground environments it concentrates and can contribute to ionizing radiation exposure. For these reasons, a better knowledge of the several factors controlling the radon migration can be of crucial importance for the hazard assessment as well as the concern over the health risk in underground environments.

The radon escape from a rock is rather complex process which depends on a number of chemical, physical and mechanical properties of the rock, such as uranium content and distribution in the mineral grain, size and specific surface area of grains, degree of fracturing and fissuring, presence of water in cracks, and effective permeability. Concerning the bulk rock properties, the presence of discontinuities (fractures, thrust/shear planes, etc.) provides potential pathways for radon migration and favors air and water circulation resulting in higher radon exhalation. Besides, atmospheric pressure and temperature variations can control the radon flow. In this paper, we present the results of an analysis of time-series of radon concentration and environmental parameters recorded in a dead-end mining gallery, located in the Maritime Alps.

The mine is composed by a main tunnel, with a rather regular (roughly circular) section, which ends in two short dead-end branches. Near the entrance, a side shaft with slightly larger dimensions departs perpendicularly from the main tunnel. The mine was bored in metarhyolites and porphyric schists mainly composed by quartz, feldspar, sericite and fluorite. U-bearing minerals are generally concentrated in veins heterogeneously spaced and made of thin laminated yellowish crystals of metaautunite and of greenish tabular crystals of metatorbernite.

Radon air concentration monitoring was performed with an ionization chamber which was placed in different times at the bottom of each branch. During the monitoring, hourly mean values of temperature, pressure, and relative humidity as well as radon air concentration were measured. External data logs of atmospheric temperature, pressure and rainfall data were also available from a meteorological station located nearby, at a similar altitude of the mine.

Measurements have shown several unexpected results. The observed radon concentration very clearly exhibits daily and half-daily periods. Besides interaction and mass transfer with the external atmospheric environment, a detailed analysis confirms that these variations are also related to lunar-solar tides. Moreover, the amplitude of the anomalies is surprisingly large. This can be explained by the fact that the mine is close to the Ligurian Sea coast. When the sea tides change the water level at the shore, this produces additional pressure which increases the deformations (this phenomenon is called sea loading). Searching for radon concentration changes and monitoring their amplitude as a function of time can provide important clues on the complex emanation process. During this process, radon reaches the air- and water-filled interstices by recoil and diffusion, where its migration is directed towards lower concentration regions, following the local gradient. The radon emanation from the rock matrix could also be controlled by stress changes acting on the rate of migration of radon from the solid and the fluid phase to pore, fissures, and fractures. This yields emanation boosts due to rock extension and the consequent crack broadening, and emanation decrease when joints between cracks close.

SESSIONE GEO12B

Oceanografia

GEO12B-1 Orale Pierini, Stefano

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A NONLINEAR THEORY OF THE KUROSHIO EXTENSION LOW-FREQUENCY VARIABILITY

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Key terms: Kuroshio Extension; low-frequency variability; oceanographic modeling; dynamical systems theory

The Kuroshio Extension (KE) is a highly stratified, eastward-flowing free inertial meandering jet formed by the confluence of the Kuroshio and Oyashio western boundary currents; it constitutes, therefore, a front separating the warm subtropical and cold subpolar waters of the North Pacific Ocean [1]. The KE displays a decadal variability of bimodal character connecting a zonally elongated, fairly stable, energetic meandering jet and a much weaker, highly variable and convoluted jet with a reduced zonal penetration [2]. Understanding the mechanisms that produce such low-frequency variability is relevant not only from a purely oceanographic point of view but also from a more general climatic perspective, as KE fluctuations are associated with vigorous air-sea heat exchanges known to be able to affect considerably the variability of the midlatitude coupled ocean-atmosphere system in the North Pacific region. In this context, modeling results of an ocean circulation model suggest

that the KE low-frequency variability may be basically due to nonlinear intrinsic oceanic mechanisms. A double-gyre reduced-gravity shallow water model of the KE [3], forced by a time-independent climatological wind and whose domain of integration is bounded to the west by a schematic coastline, exhibits a fairly realistic mean jet and a decadal chaotic bimodal variability whose characteristic period (of around 10 years), flow patterns and relevant transition details are found to be in significant agreement with altimeter data [4]. A complex dynamical mechanism supporting such internal oscillations, and involving the bimodal behavior of the Kuroshio south of Japan, is proposed in [3]. Moreover, the same variability is interpreted in [3-4] in the framework of dynamical systems theory as a homoclinic orbit in phase space resulting from a global bifurcation associated with the reconnection of the stable and unstable manifolds of the saddle fixed point corresponding to the weak -contracted- jet state [5]. Further extensions of these results are outlined. This theory and the one according to which wind-induced Rossby waves and the effect of mesoscale eddies are crucial in determining the variability are critically compared in [6]. The role played by the basin geometry in the double-gyre modeling approach discussed above is found to be absolutely crucial in [7]. The mechanism of coherence resonance is shown in [8] to occur for the modeled KE in a parameter range that precedes the global bifurcation responsible for the bimodal variability, provided the wind forcing is perturbed by an appropriate red noise. The same conclusions are drawn in [9] by using a spectral quasigeostrophic model that retains only the first four modes in a Galerkin projection. Finally, sequential importance sampling is used in [10] to assess the impact of observations on an ensemble prediction for the KE low-frequency variability based on an identical twin experiment using model [3]. This particle filtering approach gives access to the probability density of the state vector, which, in turn, allows us to determine the predictive power (an entropy based measure) of the ensemble.

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GEO12B-2 Orale Artale, Vincenzo

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THE NEW PROBLEMS AND PROSPECTS ON THE THERMOHALINE CIRCULATION STUDY WITH PARTICULAR EMPHASIS ON THE MEDITERRANEAN CIRCULATION.

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Key terms: THERMOHALINE CIRCULATION; DYNAMICAL SYSTEM; MEDITERRANEAN CIRCULATION

Since of the '50s Stommel's pioneering works, the dominant paradigm of the ocean conveyor belt is based on the concept that the horizontal pressure forces resulting from the hydrostatically balanced horizontal density differences drive the ocean flow.

More recently, many studies have revitalized the role of the ocean's eddy and wind field in establishing the characteristic and variability of the global thermohaline circulation. These recent finding reconcile Stommel theory with the modeling results of '70 regarding the effect of eddies on the deep flow, still an important component of the THC.

Moreover, due to the intrinsic heterogeneity and nonlinearity of the ocean circulation, describable by many variables that vary significantly over space and time scale covering many order of magnitude, if only due to the dominance of advective fluxes within the ocean water 3-D domains, but also to the many complex feedback between the domains. As consequence positive (negative) feedback can lead to instability that drives the system to new modes of behaviour that bear little resemblance to the external forcing, if such destabilising processes are not properly represented, the ocean circulation, for example simulated in the OGCM, may not be able to display important observed modes of ocean internal variability.

In this talk we review those studies, which collectively, are changing the classical view of the global conveyor belt; in particular we discuss how these results have had an influence on some recent theoretical and numerical results on the Mediterranean thermohaline circulation and on its future development.

GEO12B-3 Orale Berta, Maristella

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SURFACE TRANSPORT IN THE NORTHEASTERN ADRIATIC SEA DURING BORA AND SIROCCO EVENTS FROM FINITE-SIZE LYAPUNOV EXPONENTS.

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Key terms: Finite Size Lyapunov Exponent; Adriatic Sea; Lagrangian transport; sea surface currents; coastal radar

In two-dimensional flows, a simple time dependence in the velocity field is enough to induce turbulent structures and consequently chaotic advection in particles trajectories.

Analysing these fields in the context of dynamical systems, an Eulerian approach would provide the configuration of the eddies at a given scale and time, while the application of a Lagrangian technique will show the

spatio-temporal variability of these eddies.

The fundamental assumption of chaotic advection is the sensibility of trajectories to initial conditions, meaning that fluid elements initially very close would follow diverging trajectories.

The exponential rate of separation between two particles is defined by the Lyapunov exponent λ .

The classical definition of Lyapunov exponent refers to the exponential rate of divergence, over infinite time, of infinitesimally closed initial points. The FSLE technique keeps the original idea of capturing the rate of divergence between trajectories, but its new formulation overcomes the limit operations dealing with real data:

$$\lambda_T(\mathbf{x}_i, \delta_i, t, r) = \frac{1}{T} \ln r$$

Since the choice of δ and r depends mainly on currents characteristics and length scale of the structures of interest, there is not a parameters choice suitable for any velocity field.

FSLE technique shows how portions of fluid initially compact can be stretched and/or folded as time goes by, producing a "cascade" of inhomogeneities from large to smaller scales. This allows to identify dynamical structures within scales far below the finest resolution achievable by the classical Eulerian analyses, without any assumption on the sub-grid velocity field.

In the previous years, the FSLE technique was applied in the Adriatic Sea dealing with dispersion studies based on drifters experiments or on velocity data produced by NCOM model. These analyses, involving different areas and times, led to the identification of the whole basin mixing scales (Lacorata et al., 2001; Haza et al., 2008) and to the characterization of an hyperbolic point located in the South Adriatic (Haza et al., 2007).

The new analysis proposed involves the northernmost part of the Adriatic Sea and it is based on high resolution measurements of the velocity field coming from a radars system placed along Italian and Croatian coasts.

Data, belonging to NASCUM project - North Adriatic Surface Current Mapping, are available for the period 2007-2008 and cover a regular grid with the following dimensions and resolution: 50km x 50km with 2km spatial resolution and 1h temporal resolution.

Since Adriatic Sea is strongly affected by Bora and Sirocco winds the aim is to find a correlation between wind forcing over the basin and surface dispersion.

Typical wind events have been already identified in the wind forecast maps available from ALADIN Numerical Weather Prediction Model. During these episodes, a FSLE analysis has been done on the sea currents field, identifying peculiar filamental structures developing (such as hyperbolic points or barriers to transport). Preliminary results will be shown in this work.

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GEO12B-4 Orale Mancero Mosquera, Isaac

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WATER FLOW IN THE INLETS OF THE GRADO-MARANO LAGOON SYSTEM, NORTHERN ADRIATIC SEA

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Key terms: lagoon; inlets; water flow; tidal channel

The lagoon system Grado-Marano is connected to the open sea by three inlets, Grado, Lignano and Porto Buso. They are about 400-500 m wide and less than 12 m deep. The aim of the research project led by the Autorità di Bacino Regionale del Friuli-Venezia Giulia, in collaboration with the Department of Geosciences at the University of Trieste and the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, is to monitor the water flow, water volume and sediment mass transport and exchange through the inlets. For this purpose, two bottom-mounted Acoustic Doppler Current Profilers (ADCPs) have been placed in the inlets of Grado and Lignano. Measurements started on the 6th and 7th July of 2010, respectively, with 0.5 m of the vertical resolution, and 10 minutes sampling interval, yielding a 3-components vector time series. Preliminary results, based on a six months long time, series show that the flow is highly polarized along the channel axes. The along-channel Principal Component (PC1) has more than 99% of the total energy. The first EOF (Empirical Orthogonal Function) mode of the PC1, representing the barotropic flow, accounts for about 99% of the variance in the Grado inlet and 98% in the Lignano inlet. Hence, vertically averaged time series are produced and a PC1 time series computed for further analysis. Average currents appear to be out flowing with magnitudes about 14 cm/s, while variability is about 60 cm/s (standard deviation). Current speeds can reach 1.3 m/s during the maximum inflow and outflow in both inlets. More than 90% of this variability corresponds to the astronomical forcing: the semi-diurnal constituents M2, S2 and the diurnal K1 make up also over 90% of the tidal energy in both records. Provisional estimates show that the K1 signal in Grado is out of phase with that of Lignano by about 10 hours, while M2 and S2 are almost in phase with 2 minutes and 20 minutes difference respectively, Lignano leading Grado. A comparison between the Lignano current velocity series and the sea level at the nearby Tre Canai station, inside the lagoon, shows a leading tidal signal at Lignano, with the maximum sea level recorded at Tre Canai 3 hours after the maximum inflowing through Lignano. In addition, measurements from the bottom mounted ADCPs have been compared to vessel-mounted ADCPs measurements carried out in the Grado and Lignano inlets. Linear relationship has been found between the vertically averaged current PC1 and the total volume transport following the model $Q = aV + b$; V is the current velocity in m/s and Q is the transport in m³/s. The parameter "a"

is 1768.2 and 2748.9, while "b" is 15.6 and 306.2 for Grado and Lignano respectively. Judging by the RMS values (0.6 m/s in the Grado and 0.53 m/s in the Lignano inlets); the transport can easily surpass 1000 m³/s in the former and 1900 m³/s in the latter inlet. An out flowing peak of 1.3 m/s detected on October 6th, 2010, can produce a water transport of over 2300 m³/s in the Grado inlet and 3800 m³/s in the Lignano inlet.

GEO12B-5 Orale Manzella, Giuseppe

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CLIMATE CHANGE: READ AND INTERPRET

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Key terms: *Climate change; in situ data; oceanography*

During the last decades there have been many efforts to collect marine environmental data collected in Europe. In the Mediterranean Sea between programs that have helped build the data base for studies on the variability and climate change, there were: Mediterranean Oceanographic Data Base (MODB), Mediterranean Data Archeology and Rescue (Medar-MedAtlas) SeaSearch, SEADATANET. Many data are available and accessible through information systems developed by various Italian institutions. A single portal is offered by www.seadatanet.org.

A careful analysis of these data have been done to see the consistency of these and associated errors. This has been done on the basis of knowledge of various instruments used to collect data and the different technologies used. Were then made estimates of errors and data are now assessed on the basis of criteria based on possible instrumental errors, and variability observed in the past.

GEO12B-6 Orale Mosetti, Renzo

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A NEW FILTERING APPROACH AND REGIME SHIFT ANALYSES ON THE CLIMATIC DATA IN THE GULF OF TRIESTE

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Key terms: *long time series analysis; climate change; Gulf of Trieste*

The times series of mean monthly values of air and sea temperature and total rainfall, recorded at the CNR station of Trieste from 1921 to 2010, are analysed by means of a new filtering method. The method selects the time intervals in which the considered parameters significantly increase or decrease in a much more accurate way than any trend analysis. This leads to single out typical fluctuations on scales of climatic relevance. Then, on the filtered data a regime-shift analysis has been applied in order to test the statistical significance of the fluctuations above. The main result is the evidence of a marked anomaly with respect to the behaviour ascribed to the green house effect, as commonly assumed, both in the past and in very recent years.

GEO12B-7 Orale Cataletto, Bruno

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THE GULF OF TRIESTE: A LONG TERM ECOLOGICAL RESEARCH (LTER) SITE

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Key terms: *LTER; Gulf of Trieste; Planktonic communities*

The investigation of the planktonic communities of the Gulf of Trieste boasts an important tradition that, as far as some of its components, dates back to the beginning of the Seventies of the last Century. The analysis of the populations' fluctuations has called for the need to follow their temporal evolution with respect to the modifications of environmental parameters. For this reason we have spotted a steady location where to collect a series of subsequent temporal information. The site (called C1) is located close to the Riserva Naturale Marina di Miramare (45° 42'03"N, 13°42'36"E) and represents the study area where most ecological planktonic investigations in the North Adriatic were concentrated. To the zooplanktonic component, which from a historical point of view was the major part of the local Gulf investigations, other observations have been added, such as those on the dimensional plemto-, pico-, nano- and micro- fractions, both autotrophic and heterotrophic. Today, the Biological Oceanography Department (Bio) of OGS, continues to collect information at the C1 site, proceeding with ecological investigations on the plankton, with the aim of understanding the mechanisms that underlie the observed fluctuations of the populations subjected to natural (climate change) and human influences (impact). As much important it is, in parallel, the assembly of information aimed at understanding the ecology of the species (life cycle, intra- and interspecific interactions) that represent the foundations to appreciate structure, function, hence, the temporal evolution of the biological communities.

The relevance of historical studies and the progression and implementation of the research allowed the Gulf of Trieste to be included in the LTER Italia network, whose aim is to promote long-term ecological studies and investigations in all the environments, but especially in the marine one.

GEO12B-8 Orale Lipizer, Marina

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ROLE OF ENVIRONMENTAL FORCINGS ON BLOOM DYNAMICS IN THE LONG TERM ECOLOGICAL RESEARCH STATION THE GULF OF TRIESTE, NORTH ADRIATIC SEA.

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Key terms: *bloom dynamics; long term ecosystem research; chlorophyll a; nutrients*

The Gulf of Trieste is a very dynamic system due to the concurrence of severe meteorological and hydrological forcing factors which determine pronounced inter-annual, seasonal and shorter term variability in hydrological and biogeochemical properties, as well as in biological processes.

Bloom temporal evolution shows pronounced inter-annual variability considering both the total autotrophic biomass in terms of chlorophyll-a and the relative importance of different size-classes.

This study aims at evaluating the temporal scales of variability in phytoplankton bloom evolution, taking into consideration in particular the role of continental inputs and nutrient availability on bloom development using monthly, bi-weekly and weekly data from a Long Term Ecosystem Research station in the Gulf of Trieste, North Adriatic. The short term dynamic of bloom evolution has been investigated with particular attention on the possible environmental factors triggering the onset and then determining bloom exhaustion.

The typical seasonal evolution of phytoplankton biomass is characterized by a late winter - spring bloom (February - May), with the largest chlorophyll-a concentrations generally measured in February, and a second autumn bloom occurring in October - November. The late winter-spring blooms are usually due to micro- and nano-plankton size fractions, while the autumn bloom is mostly due to picoplankton. However, episodic meteorological events, alterations in continental runoff and in nutrient inputs may significantly alter this seasonal pattern, changing the timing of bloom development, modifying the contribution of the different size classes and determining the rapid exhaustion of phytoplankton biomass.

GEO12B-9 Orale Favali, Paolo

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EMSO AND EUROSITES: SYNERGIES AND PERSPECTIVES

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Key terms: *Eulerian component of Ocean Observing System; long-term observations; seafloor and water column*

EMSO, an ESFRI large-scale Research Infrastructure (European Strategy Forum on Research Infrastructures Roadmap, <http://cordis.europa.eu/esfri/roadmap.htm>), is the European-scale network of multidisciplinary seafloor and water column observatories. EMSO and EUROSITES synergies and perspectives are discussed, the entire marine community recognises the importance of sharing a common vision in which the ocean world is considered as a whole. This allows convergence towards a unique infrastructure, a tool that can serve all the scientists and end users interested to fixed-point observations. EMSO can perform this role.

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GEO12B-10 Orale Partescano, Elena

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THE LATEST DEVELOPMENTS OF OGS NODC INFRASTRUCTURE: EASY MANAGEMENT OF META-DATA DIRECTORIES AND REAL-TIME COLLECTION, VALIDATION AND STORING OF MARINE DATA.

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Key terms: *relational database; meta-data; XML; real-time; oceanography*

The OGS NODC information system is completely integrated within the European distributed network of oceanographic data centers and is able to answer to the requests of information through the network by means of a standardized interface and making use of the XML technology to exchange and qualify information. The oceanographic database archives more than 200 millions of measurements of physical and biogeochemical parameters, of current, wave motion, sea level and meteorological data. The information in the data archiving system are fully validated, continuously updated and accessible through a dedicated Web Portal, available on Internet. All the metadata are public while the access to archived data is subjected to a Data Policy, defined in agreement with the data providers. All the data and metadata are contained in an Oracle relational database and all the metadata are managed using the XML format, in agreement with the European projects standards. The XML formats and exchange schema's are based on ISO 19115 content model that have been defined for the metadata services.

The latest developments of OGS NODC infrastructure concern:

- the management of CSR (Cruise Summary Report) metadata: in detail, a new interface has been developed, to insert the information related to CSR. This functionality gives us the possibility to insert new CSRs and to update the old ones. To realize this interface we used some forms developed with Open Office, connected to the database using the Oracle JDBC Driver;
- the management of EDMERP (European Directory of Marine

Environmental Research Projects) and EDMED (European Directory of Marine Environmental Datasets) metadata, with the direct storage of XML file into the database, using the Oracle XML DB. This set of technologies, is supported by the W3C and it gives the possibility to store, query, update, and transform XML data while accessing it using SQL. The XML files inserted directly on the database give us the possibility to manage the information associated with EDMERP and EDMED metadata directories. It is possible to access text node and attribute values using SQL/XML. In addition, we developed a RESTful Web Service, to manage these XML files, decoupling the applications from the database. In this way, we can use any application capable to handle http URLs, like Mikado (a tool developed into SeaDataNet project);

- the realization of a real-time data management system with the automation of the entire data handling process: from the measurement of raw data to the end-users use. This solution allows to cut down the time needed to the harvesting of multiple data formats, the conversion in a standard format, the structuring in a database and the validation. The real-time data management system is related to the real-time collection of several marine data types by automatic population of a relational database, granting interoperability and resilience. This prototype is produced for the management of the local meteo-marine network for the Civil Protection of Friuli Venezia Giulia. The interoperability is guaranteed using XML and OGC standard schemata for data transport and representation. The java library "ServingXML" is the core of that system, that allows to convert textual data, this conversion generates a new XML file which schema we have defined. The resilience of the application is obtained adopting a new approach using "Apache Camel" as rule-based routing and mediation engine operating in an event driven way, decoupling software services, in a Java environment.

In the NODC, except for the Oracle database, we use only Open Source software. Inspired by its European working experience the NODC is building, in collaboration with other OGS groups, this technological infrastructure. At the moment the data come from a wide range of instruments like: meteo-oceanographic buoys, CTD profiler, current profilers and directional wave; but in the future we will increase the types of data covered.

Indice degli Autori



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