Slope instability along a countorite-dominated margin in the Mediterranean Sea

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Abstract: *The South-Western Adriatic Margin (SWAM) has been imaged through multibeam bathymetry, sidescan sonar mosaics and high resolution chirp profiles. Geophysical investigations aims to recognize multiple slide scars and extensive mass transport complexes (MTCs) that are the results of widespread and recurrent sediment failure of contouritic drifts along the SWAM. Distinctive failures styles are mainly controlled by the source region and by the stratigraphic template of the margin. The interaction between contuor and cascading currents flowing across the SWAM plays an important role both in controlling the pre-failure depositional environment and in reshaping the morphology of the resultant MTCs.*

Key words: *Mass transport complex, Drift, Cascading current, Multibeam, Magnetic susceptibility,*

INTRODUCTION

The shelf and the slope of the South-Western Adriatic margin (SWAM) in the Mediterranean sea are swept by two main bottom-flowing water masses of thermohaline origin: the Levantine Intermediate Water (LIW), and the North Adriatic Dense Water (NAdDW) (Cushman-Roisin et al., 2001). The LIW is a steady-state, contour-parallel current that forms through evaporation in the Eastern Mediterranean and enters the Adriatic sea along a counter-clockwise path in a depth range of 200-600m. The seasonally modulated NAdDW (North Adriatic Dense Water), forms through winter cooling in the north Adriatic shelf and cascades obliquely across the SWAM slope (Cushman-Roisin et al., 2001).

Along the continental slope, the cascading NAdDW energetically interacts with the LIW, leading to locally-enhanced dynamic condition at the sea-floor (Verdicchio and Trincardi, 2006).

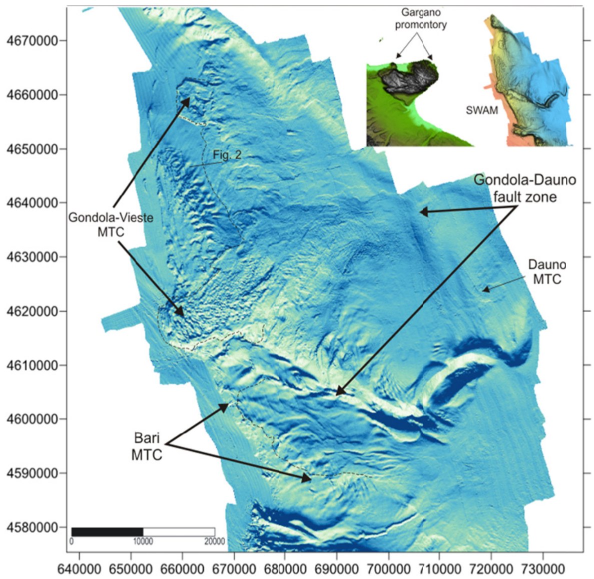

FIGURE 1. Shaded Relief image of the SWAM from DTM.

In the last 10 years, a series of geophysical surveys lead by ISMAR along the SWAM have imaged geomorfic features such as drifts and moats, sediment waves, barchans, furrows, and scours genetically linked to the action of the intermingled bottom currents (Verdicchio and Trincardi, 2006).

In addition, multibeam and high-resolution seismic surveys have revealed that the stratigraphic architecture of the SWAM is characterized by the presence of multiple and overlaying mass transport complexes (MTCs) encompassing most of the continental slope and the basin plain, between 400m and 1100m of depth (Minisini et al., 2006).

In this paper, the extensive available data set is used to address a geomorphological study of recent, mass-transport complexes (MTCs) linked to contourite failures. The analysis and interpretation of the variety of SWAM geomorphic features allows us to infer the source regions of the MTCs, their transport mechanisms and emplacement processes and thus offer the possibility to test the impact of different controlling factors on landslides ignition and evolution.

DATA AND RESULTS.

High resolution multibeam bathymetry data (Reson 8160) acquired by ISMAR-Bologna between 2003 and 2008, have been used to generate an highly-detailed Digital Terrain Model (DTM) with 20m of grid (Fig. 1). The acquired swath bathymetry data, coupled with Chirp-seismic data allowed us to image the elementary architectural elements of the SWAM margin. In particular, we focussed on the geometries of the contouritic features of the margin, in order to reconstruct the shape and the dimension of the MTCs linked to drift failures. The TOBI sidescan data were processed at the “National Oceanographic Center, Southampton”. In addition, magnetic susceptibility signatures of selected sedimentary cores have been investigated and correlated in order to estimate the minimum age of the main failure events.

Around 60% of the mapped SWAM slope is dominated by MTCs that affects the downslope flank of the shelf-edge/upperslope contourite drifts. MTCs spans form the shelf-edge to the deep basin plain, and range from simple deposit affecting a single sediment drift, to composite geometries affecting also unit older than contouritic deposit.

In the northern sector of the SWAM is characterized by two composite MTC that cover an area of around 1700km^2 (The Vieste and Gondola MTC, Fig. 1). South of the Gondola-Dauno fault zone, a prominent tectonic lineament that dissect the slope of the SWAM, an around 880km^2 MTC affects the shelf-break and the continental slope (Bari MTC, Fig. 1). At 1100m of depth, in the basin plain, the Dauno MTC affect a deep-water drift. The Vieste and Gondola MTC display contiguous evacuation regions, covering a lenght of around 95km in a NS direction. In the northern sector of the SWAM, the headwall roots in the upper-slope and have a relief less than 50m. Moving southward, it indents also the shelf-edge forming an around 10km wide amphitheatre-like scar with a maximum height of 250m. The Vieste MTC is generally thin skinned, with thickness of the failed body that does not exceed 35m, whereas the Gondola MTC, especially in the sectors where the MTC is close to the structural highs, reaches thickness up to beyond the seismic penetration of the Chirp (~80m).

Where exposed, the Vieste-Gondola MTC is characterized by a broad area of high back-scatter and with reduced acoustic penetration and diffraction hyperbolae that corresponds with rotated blocks of coherent sediment shown in the bathymetry as 30m high elements. In the other sectors, both MTCs appear buried below a 25m thick layered sedimentary cover, that, however, gives a glimpse of the underlying MTC morphology. Where is free to spread, the Gondola MTC is characterized by a seismic facies made up of weakly reflective, chaotic seismic facies, emplaced parallel to the underlying stratigraphy. On the contrary, where it is confined by the SWAM pre-existing topography, it develops erosional ramps and pressure ridges.

The Bari MTC spans through the southern sector of the SWAM and is composed of vertical and lateral stacked MTDs originated by multiple failures of upper-slope conturitic drifts. Its deposits reach the deep basin plain, at 1100m of depth, with run out that exceed 60km. Also the Bari MTC is buried by a 25m thick sedimentary cover, and is made up of fully chaotic seismic facies, with a thickness that do not exceed 35m.

Duano MTC is a slope-detached MTC that affects a basinal, deep-water drift, giving rise to 12km^2, thin-skinned deposit. Seismic correlations show that the emplacement of the MTCs of the SWAM slope is, at the resolution of the Chirp profiles, contemporaneous. Magnetic susceptibility curves analysis of selected cores has permitted to estimate the age of emplacement of the MTCs at around 40ka, during the MIS3. In addition, in most sectors, the Vieste and Gondola MTC occurred on the same basal decollement layer, whereas in other ones there are remarkable differences in the depth of the weak layer.

DISCUSSIONS

We argue that the dimensions, the planform and the morphological variations of the different MTCs of the SWAM are strongly controlled by the pre-existing topography of the margin. In particular, we consider the topographic confinement resulting from the structural framework of tha SWAM as one of the major controlling factors on landslides direction, style of transport along the slope, and emplacement dynamics.

The other main controlling factor is represented by the contour currents dynamic that act across the SWAM. The oceanographic regime seems to have played a control on the areal extension and depth of the weak layers used by the landslides. Contour currents are important both in setting pre-conditions for failure and in determining volume and areal extension of slope failure. In addition, contour currents also modify the morphological expression of the product of the failures, giving rise to buried and exposed sectors across the same MTC, depending on the depositional or erosional attitude of bottom currents.

CONCLUSIONS

The SWAM oceanographic regime controls the stratigraphic template of the margin by controlling the areal extent of sediment drifts and by controlling the depth of the weak layers of the landslides.

The landslide of the SWAM form deposits that range form single-stacked body to multiple stacked, composite MTCs. The Vieste and the Gondola MTCs are the product of a large margin failure that rooted in the middle-slope and successively propagated upslope toward the outer-shelf around 40ka. The study documents the effect of significant confinement provided by the pre-existing topography onto the MTCs rooting, evolution and emplacement.

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