

The Al Araiche diapiric field discovered by Belgian scientists on shallow Moroccan margin of the Gulf of Cadiz was investigated during TTR-12 Cruise with deep-towed side scan sonar, 5 kHz profiler, and underwater TV. For the first time, comprehensive bottom sampling with large gravity core, dredge and TV-controlled grab was carried out on most prominent structures of the field and mud volcanic breccia was recovered.

Study of mud breccia composition led to intriguing results. It showed that only minor mud breccia clasts are represented by rocks well-known from deep-sea mud volcanic deposits whereas fragments of siliciclastic, mostly subarkose and subquartzose series prevail among and compose up to 90% of all mud breccia clasts recovered in the area. These series are represented by coarse- to fine-grained sandstones and siltstones with some foraminifera and biotritus, mainly cemented by sparry, often poikilitic calcite. The rocks are often characterized by distinct cross-, ripple- convolute-lamination and grading. These fragments were recovered from all mud volcanoes sampled within the Al Araiche mud diapiric field and have never been described before for any mud volcano of the deep Gulf of Cadiz. They appear “exotic” for the Gulf of Cadiz. However, analogues of studied siliciclastic rocks were found onshore, representing Upper Miocene – Pliocene unit of Rharb basin located on the edge and to the south of Rif belt of Morocco. The basin is known as an area of major post-Miocene subsidence and its Pliocene deposits overlie on mid-Tortonian olistostrome complex.

Result of study of mud volcanic deposits of the Al Araiche field might suggest that the Neogene complexes of Rharb basin extend offshore as far as Moroccan shelf break. Essential prevalence of “exotic” sandstones and siltstones among mud breccia clasts and exceptionally large size of their fragments can be an evidence of near-surface structural position of Upper Miocene – Pliocene siliciclastic unit. Presence of limestones, claystones and sandstones, which are typical for mud volcanic deposits from the deep part of the Gulf of Cadiz, among the “exotic” mud breccia allows to assume that the Al Araiche mud volcanoes are rooted into Miocene olistostromes of the Gulf of Cadiz or underneath, in a similar way with deeper mud volcanoes. On the contrary, an extension of Pliocene sediments of Rharb basin into the deep-sea area of the Gulf of Cadiz can be ruled out as none from studied deep-water mud volcanoes extrudes “exotic” sandstones.

METHANE RELATED AUTHIGENIC CARBONATES, CHIMNEYS AND CRUSTS FROM THE GULF OF CADIZ

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During the TTR-11 (Leg 3) and TTR-12 (Leg 2) cruises (2001 and 2002 respectively), the area south and southwest of the Guadalquivir Diapiric Ridge was intensely surveyed with seismics, side-scan sonar (MAK), underwater TV and sampling. This area is characterized by a very strong backscatter on the available side scan sonar images and a very irregular seafloor, with morphological and sedimentological features evidencing fluid escape structures (mud diapirs and mud volcanoes); and sedimentary structures associated with the outflow of the Mediterranean water (MOW). Based on the data and samples collected during the TTR-11 and TTR-12 cruises, complemented with data from the *Anastasia* 2000 and 2001 cruises, it seems that this area corresponds to a large field of carbonate chimneys and crusts. Dredge profiles on the Iberico dome and west of this structure, on the main channel of the MOW, yielded a large amount of carbonate crusts and chimneys. These consist essentially of intrapelbiomicrite whose petrographic and XRD

study shows that their mineralogical composition consists mainly of dolomite, high magnesium calcite, quartz, feldspar and clays. Bioclasts of planktonic foraminifera (globigerinoids), ostracods and pellets are observed. Iron and manganese oxides are present and the cement is essentially biomicrite. In different samples from the same chimney a variation on the dolomite/calcite ratio is observed from the interior to the external part of the chimney. Values of dolomite show a variation from the interior to the exterior. Stable isotopic analysis of Carbon shown low $\delta^{13}\text{C}$ values (down to -46.88‰ vs. PDB) and $\delta^{18}\text{O}$ up to $+4.90\text{‰}$ vs. PDB, typical values of methane as a major carbon source for the carbonate. SEM observations reveal microbes like structures which indicate that microbial activity has played an important role on the carbonates minerals production.

MINERALOGY AND GEOCHEMISTRY OF METHANE-RELATED AUTHIGENIC CARBONATES FROM THE GULF OF CADIZ, NE ATLANTIC

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A number of carbonate crusts and chimneys were sampled during the TTR-12 cruise in the Gulf of Cadiz. Three main areas were studied: (1) Formosa Diapiric Ridge; (2) Jesus Baraza mud volcano; (3) fault zone near the Pen Duick escarpment. Sampled stations were chosen basing on the TV survey and acoustic data. All collected carbonates have different structure, mineralogical and chemical composition.

Underwater TV survey, acoustic and sampling data collected during the TTR-11 and TTR-12 cruises suggest that there are extensive fields of carbonate crusts and chimneys on Formosa Diapiric Ridge. Collected carbonate chimneys and slabs are brownish in color and well cemented. The carbonate cement is represented by dolomite. Microscopic analysis reveals a lot of quartz grains, quartzite and glauconite in the carbonate matrix. XRD analysis shows that their mineralogical composition mainly consists of dolomite and quartz (80%) with some admixture of calcite, magnesium calcite and clay minerals. Plankton foraminifera and some iron and manganese oxides were also observed. Individual chimney does not show big variation on petrology from the interior to the external part. Carbon isotopic composition varies from -24.5‰ to -39.6‰ PDB while oxygen isotopes are in range from -0.1‰ to $+3\text{‰}$ SNOW.

Authigenic carbonates retrieved from the Jesus Baraza mud volcano (AT390G), occurred in the form of irregularly shaped crusts. They are yellowish grey in color, porous and poorly cemented. The samples mostly consist of the aragonite (70%) with some admixture of calcite and magnesium calcite. Based on the description of thin sections and location of the crusts in the sediment sequence, samples were divided into two types. The first type consists of carbonates obtained from the surface of the mud volcano. They are more yellowish in color, which indicates oxygen rich environment. Carbonate crusts from the second type are located deeper in sediments at the depth of approximately 20 cm. They are grey in color, less porous and better cemented. $\delta^{13}\text{C}$ for both types is approximately -28‰ PDB and $\delta^{18}\text{O}$ is about $+2\text{‰}$ SNOW.

TV grab sample which was taken from the fault zone contained a lot of carbonate slabs. The carbonate slabs are represented by cemented biogermes, mostly consist of plankton foraminifera, shell debris, corals and pellets. XRD analysis shows that slabs consist of aragonite (18%), calcite (15%) and magnesium calcite (18%) with some admixture of quartz and clay minerals. Also two main types of crusts were recognized. One type is represented by grey well-cemented carbonates and the other is more yellowish but also very well cemented. The variations observed in mineralogical composition of these types are not significant. Carbon isotope composition is heavier than in previous station (from -9‰ to -15‰ PDB).