Mineralogy of Methane- Related Sediments of the Atlantic Moroccan Shelf

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INTRODUCTION.

The Gulf of Cadiz is one of the most important areas to study mud volcanoes and fluid venting related structures. Most of them are clustered in vast fields in the Spanish, Portuguese and Moroccan margins and are located at different depths. The occurrence of these features is linked to the very complex geological evolution of this area and the presence of the Olistostrome Unit (Medialdea et al., 2009 among others).

Although most of the studies have focused on the microbiological activity on these environments, the study of the mineralogical composition of mud volcanoes can provide us valuable information as it is related to the nature and origin of the parent layers feeding these structures, the interactions with deep fluids and with diapiric structures. The published mineralogical data of the mud volcanoes situated in the Moroccan fields are still rare (Mhammedi et al., 2008). Thus, the aim of this work is to present the preliminary results of bulk mineralogy of Meknes mud volcano and of a possible near gas-related structure, and to compare them with the mineralogical results of other gas-related sediments of the gulf of Cadiz, of the Iberian margin, in order to determine if there is any resemblance or any connection between the source units of the mud volcanoes of different areas of the Gulf of Cádiz (Fig. 1).

MATERIALS AND METHODS.

The Meknes mud volcano was first discovered during the TTR 14 survey in 2004 on board O/V *Pr Logachev*. It presents one central pear shaped crater at 650 m water depth, and a width/mwd of 1 km.

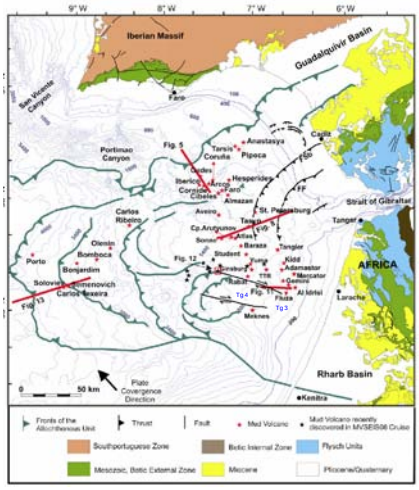

fig 1. *Geological setting of the area showing the location of the studied cores (blue arrows) (From Medialdea et al, 2009).*

The two gravity cores (TG3 and TG4) studied in this work were collected during the oceanographic mission MVSEIS/08 on board of R/V Hespérides. TG4 was taken on the top of the mud volcano Meknes (650 mwd) and is constituted by two units: a mud breccia and a foraminifera-rich hemipelagic unit at top. TG3 was taken on a possible diapiric structure at 600 m mwd, and is essentially made of brownish mud.

Both cores were sampled on board every 10 cm. The bulk mineralogical analysis, X- Ray Powder diffraction (XRD) was performed with a Bruker instrument of the University of Cádiz. A microscopic study of smear slides were made in order to determine the different biogenic, clastic and authigenic components of the sediments. Total organic carbon (TOC) and organic matter

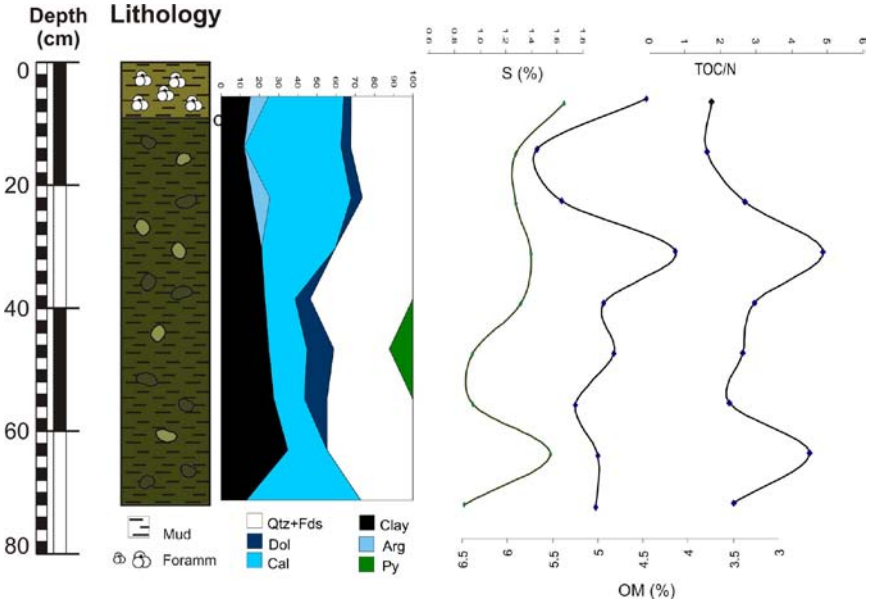

fig 2. *Vertical profiles of bulk mineralogy of TG4 (Meknes mud volcano). Total sulfur (S, %), Organic Matter content (OM, %) and Total organic Carbon / Total Nitrogen (TOC/N) are also shown.*

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(OM), were determined by Loss on Ingnition method (LOI), and C and N elemental analysis were performed with a CHNS-932 LECO of the University of Cádiz. C/N ratio is shown as organic Carbon and total Nitrogen (Co/N) following Meyers, (1994).

RESULTS AND DISCUSSION.

The principal minerals present in Meknes mud volcano are carbonates, calcite, dolomite and aragonite (15-60%), quartz (17-45%) and phyllosilicates (Illite, smectite and chlorite) (12-35%). Feldspars and pyrite represent minor phases and they are absent in most of the levels sampled of the core. The vertical evolution of the minerals shows different pattern between the mud breccia unit and the upper hemipelagic level. Clays (illite, chlorite, smectite) are more abundant at the lower part of the core showing a calcite increasing content to the top. From 40 to 60 cm depth, a dolomite raise with a pyrite occurrence is detected (Fig.2).

The diapiric structure TG3 presents similar mineralogical composition than the Meknes mud volcano, but shows different amounts and distributions of the main minerals. Calcite is the main mineral ranging from 31 to 50%, quartz (23-36%), and feldspars are more abundant (7-21%) than in TG4 and are present in the totality of the samples analyzed, nevertheless, clays shows lower percentages (6-12%) comparing to Meknes mud volcano. The vertical mineralogical profile shows a more uniform composition than in TG4.

Microscopic study of smear slides of TG3 and TG4 show differences in both the nature and the abundance of the biogenic to clastic components between the two structures, being the mud breccia (TG4) richer in clays, carbonates and quartz than the diapiric structure. Much of the calcite of both cores corresponds to abundant coccolithophorids remains.

TOC, OM, and C/N ratio also show notable differences between both cores. TG3 shows higher organic matter content (6.8 % on average) than TG4 (5.0 % on average). C/N values range up to 17 for the diapiric structure to 2.84 for the mud breccia unit in TG4.

The different distribution patterns of the minerals, clay mineral association, biogenic fragments, OM, and C/N values between sediments of both structures suggest a different origin for both type of sediments and also a different nature than the autochtonous or hemipelagic sediments of the area.

Meknes mv and the diapiric ridge show a mineralogical composition similar to the observed in other areas of Gulf of Cadiz like , Guadalquivir Diapiric Ridge (GDR), and Tasyo field but with greater percentages of clays, making up to 50% (Martín-Puertas et al., 2007).

The mineralogical data of the gas-related structures of the Gulf of Cadiz shows different assemblages and vertical distribution patterns of the minerals between the different mud volcanoes and gas-related structures. Taking into account that the source units or parent material for these sediments can be at different depths, this dissemblance can be explained by the presence of different units underneath the chaotic body of the Olistostrome Unit, and by different pathways of the fluids.

When comparing with marine sediments of the slope and the shelf, a common mineralogical feature of mud breccia can be found and there is an increase in clay minerals and dolomite (Martín-Puertas et al., 2007 and Alaoui Mhammedi et al., 2008). The origin of dolomite and pyrite, as in Meknes mud volcano, can be indicative of diagenetic processes as anaerobic oxidation of methane (Boetius et al. 2000). Low C/N ratios in mud breccia as found in Mekenes mud volcano, can be also indicative of abundant bacterial presence in these sediments.

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