A Physical Oceanography contribution to understand the processes affecting El-Arraiche Mud Volcano field (NW Moroccan Margin)

Inês Martins[1], João Vitorino[1], Thomas Vandorpe[2] and David Van Rooij[2]

1 Instituto Hidrográfico, rua das Trinas, 49, 1249-093 Lisbon, Portugal. marina.martins@hidrografico.pt, joao.vitorino@hidrografico.pt
2 Dpt. Geology & Soil Science, Ghent University, B-9000 Ghent, Belgium. Thomas.Vandorpe@ugent.be, David.VanRooij@UGent.b

Abstract: *The EL-Arraiche mud volcano field is located in the NW of the Morrocan margin and consists of 8 mud volcanoes in water depths between 200 and 700m (Van Rensbergen et al, 2005). These are geologic features where sub bottom fluids can emerge and contribute to specific marine ecosystems. The physical oceanography of the geographic region where the mud volcano field is included is largely unknown due to lack of dedicated observational studies. Some efforts towards the hydrographical characterization have been taken in the last years by several teams. Here are presented some of the results of the dedicated physical oceanographic campaign in the scope of the European project Hermione together with an opportunity collection of hydrographic data during a seismic survey focused on the sedimentary history of drift deposits.*

Key words: *Physical Oceanography of NW Moroccan Margin***,** *El-Arraiche mud volcano field.*

INTRODUCTION

The Atlantic margin of Morocco is an exciting yet poorly known oceanic area. The discovery in 2002 (Van Rensbergen et al., 2005) of giant mud volcanoes and the associated biological communities (cold water corals) galvanized the scientific community and lead to increased efforts to study this geographical area. Examples of these efforts were the European projects HERMES and HERMIONE which gathered in the Moroccan margin some of the leading European institutions in the study of these subjects. As partner in both these projects Instituto Hidrográfico (IH) proposed to complement the geological and biological studies of the Moroccan fluid escape structures with the understanding of the physical oceanography of the area. A first multidisciplinary cruise (IHPT2009-HERM2) was conducted by Instituto Hidrográfico (IH) in June 2009 for the observation of the oceanographic conditions on the NW Moroccan margin, with particular emphasis on the El-Arraiche mud volcano (EA MV) field. These observations included short-term (10 days) currentmeter mooring measurements at 3 positions along the slope (one located over the EA MV field) and CTD/LADCP coverage of the global area complemented with VMADCP measurements (Fig. 1). In 2013 the opportunity was taken for IH to participate in the COMIC2013/16 mission conducted by the University of Ghent in the same area. This participation served the proposed to extend the data set of physical oceanography measurements (Fig. 1) available for this area, improving our understanding of the processes playing a role in the EA MV field and to evaluated the add value of some of the observation methods that IH presently uses (Lowered ADCP and Vessel Mounted ADCP) in a framework of a mission not dedicated to the physical oceanography component.

The present contribution aims to describe the ongoing work of analysis of the 2009 data set and the new insight that is provided by the 2013 data set.

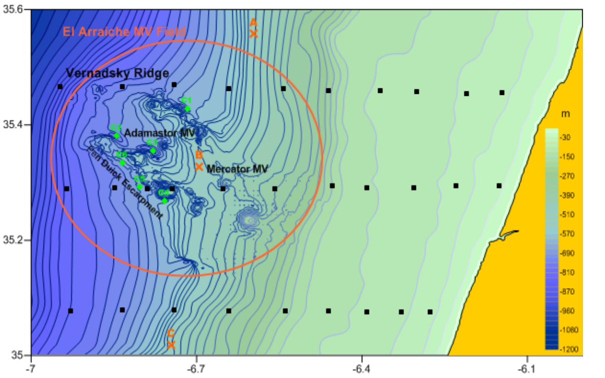

FIGURE 1. El-Arraiche and Moroccan margin bathymetry. Hermione CTD/LADCP stations (•), Hermione moorings (✖) and CTD/LADCP station of the COMIC survey (◆).

RESULTS AND DISCUSSION

The general circulation and water mass distribution observed in June 2009 in the NW Moroccan margin is being analysed in Vitorino et al (in prep) through the combined use of CTD data and a numerical model for the area. At surface levels (upper 100 m) they show details of the recirculation towards south of the eastward directed Azores Current, feeding the upwelling southward flow along the Morocco shelf and upper slope. At deeper levels the data/model results reveal the occurrence of a poleward slope current down to depths of about 700m. At the deeper levels this slope current advects to the EA area, water with a contribution of Antarctic Intermediate Water (AAIW), relatively fresher. This can be seen here from the θ-S diagrams that were draw with the CTD data collected on the EA area during the IHPT2009-HERM2 and COMIC2013/16 cruises (Fig. 2). Below the levels of influence of North Atlantic Central Water (subtropical component in orange and sub polar component in green), both diagrams show evidences for the presence of high salinity Mediterranean Overflow Water (MOW, in dark red/gold) in the oceanic area offshore and of a salinity minimum at depths of 600-800m in the stations along the slope, which reflect the influence of AAIW (in blue/dark blue).

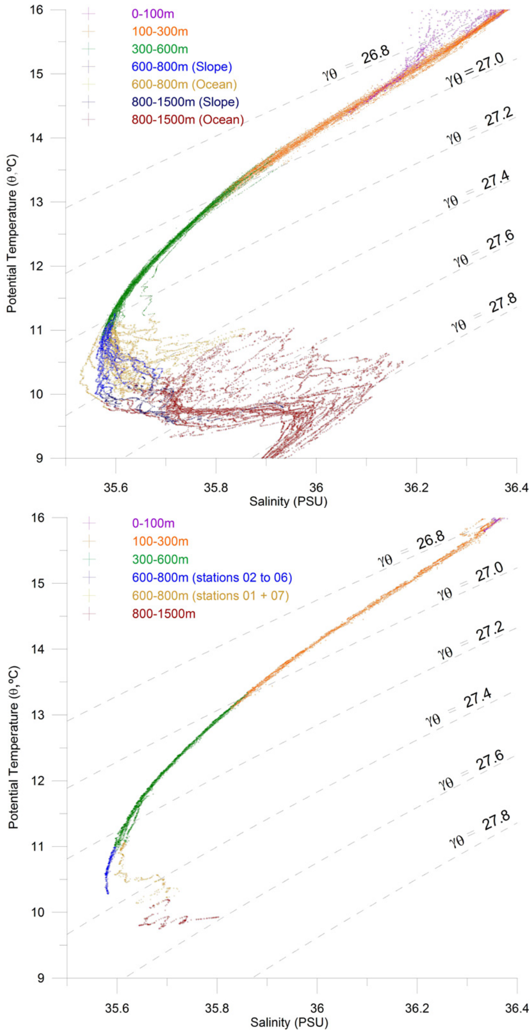

FIGURE 2. θ-S diagrams of the Hermione 2009 CTD stations (above) and COMIC 2013 CTD stations (below).

The data collected during the COMIC2013/16 cruise add details on this picture, showing that the water with AAIW contribution is found along the Pen Duick Escarpment (PDE) and along the Renard Ridge in the direction to Adamastor MV. Details on the physical processes affecting the EA MV field in June 2009 are being analysed in Martins & Vitorino (in prep) from the CTD/model results and direct current measurements. One of the aspects focussed in this study is the impact of high frequency motions over the seafloor of EA. The currentmeter data revealed important internal tidal motions, which are bottom intensified at 500m, in the moorings North and South of the MV field. Inside the MV field, however, this intensification was not so clear, which may indicate that some of the internal tide energy was blocked by the eastern flank of the Mercator MV. This data also shows that the poleward slope current extends over the interior of MV field. The high resolution model provides details on the circulation in this area of complex topography. Further insight on the deep slope circulation around the PDE and EA MV field is provided by the LADCP data collected during the COMIC2013/16 cruise. Figure 3 shows the along topography current measured by the LADCP following a section that extends along the PDE and Renard Ridge bases. The along slope current is positive when flowing in the direction that leaves shallower topography to the left. A bottom current seems to flow along PDE in roughly the NW direction. This flow seems to turn around the PDE Northern tip and to progress along Renard Ridge in direction towards the Adamastor MV, extending inside the EA MV field. Only at station 5 we observed a reverse in the bottom circulation. This can be associated with an overshoot of the current in this area of bottom curvature, which leads to a recirculation there.

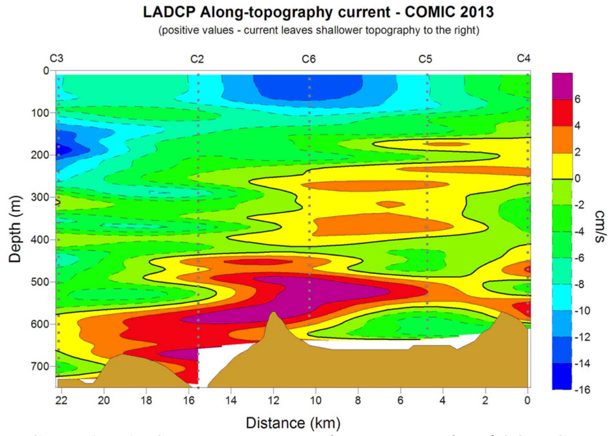

FIGURE 3. LADCP current section along topography of COMIC 2013 stations 4, 5, 6, 2 and 3.

CONCLUSIONS

Physical observations collected during IH cruise in June 2009 and during the UGhent cruise in May/June 2013 provided consistent views of the dynamics and hydrography in the EA area. One of the main aspects that rise from these studies is the presence of a poleward slope current. At depths from 200 to 500m this flow penetrates inside the EA MV field. At deeper levels the flow advects water with AAIW contribution and follows northward along the PDE, turning at its northward tip and continuing along Renard Ridge towards the inner part of EA MV field. This dynamical pattern will most likely have an important impact on the MV field.

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REFERENCES

Martins, I. & J. Vitorino. Oceanographic conditions affecting the NE Atlantic margin of Morocco in June 2009. Part 2: Physical processes affecting the El-Arraiche Mud Volcano field. *In prep*.

Van Rensbergen, P., et al., 2005. The El Arraiche mud volcano field at the Moroccan Atlantic slope, Gulf of Cadiz. Mar. Geol., 219, pp.1–17. doi:10.1016/j.margeo.2005.04.007

Vitorino, J., I. Martins & C. Borges: Oceanographic conditions affecting the NE Atlantic margin of Morocco in June 2009. Part 1: Shelf and Slope circulation. *In prep*.