

## Micro-morphologies, habitats and associated biodiversity in a fluid venting submarine structure using ROV underwater images: Mercator mud volcano (Gulf of Cádiz)

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### ABSTRACT

Mercator mud volcano has been explored by direct visual observations using a ROV at 350 to 370 m depth. Underwater images, taken mainly at the summit, have allowed characterizing the fluid venting environment, where different microforms, habitats and associated biota, with typical seepage components have been identified. Chemosynthetic bacterial communities were detected and sampled at the northeastern side of the summit at 350 m, next to pockmark-like depressions with diameters ranging 1 to 3 m, bioturbation marks, sediment mounds and authigenic carbonates of different sizes (0.1-5m length). Chemosynthesis-based communities were mainly composed by bacterial mats (patch diameter 10-30 cm), however some remains of cold seep chemosymbiotic bivalves (*Lucinoma asaphus*) were also found on the sediment. Habitat types at Mercator MV are influenced by oceanographic and sedimentation processes deposition and favouring fauna colonizing diverse substrate types, such as large sponges on slabs and sea-pens and annelids on soft bottoms.

### INTRODUCTION

Habitat characterization and mapping using underwater images has been carried out in several mud volcanoes (MVs) and cold water coral (CWC) mounds both at the Spanish and Moroccan margins of the Gulf of Cádiz (GoC) [1, 2]. MVs present heterogeneous substrate types, from anoxic environments generated along the extrusion of fluids to complex hard bottoms with abundant authigenic carbonates (AC) produced after the anaerobic oxidation of methane by bacterial communities [3]. In most of these MVs vulnerable deep-sea habitats have been observed, including anoxic bottoms with bacterial mats, sea-pen communities, sponge, antipatharian and gorgonian aggregations, and also CWC banks [1]. In this study, the summit and the upper zone of the flanks of Mercator MV (350-370m depth), located at the Moroccan margin of the GoC has been explored, allowing the study of fluid venting related features and microscale-forms and habitats.

### MATERIAL & METHODS

In March 2014, the Spanish R/V *Sarmiento de Gamboa* equipped with the multi-operational Remotely Operated Vehicle (ROV) "Luso 6000" explored 8 MVs of the GoC during SUBVENT2 expedition (SV2). A 1130 m long transect (SV2-Dive02) explored the summit of Mercator MV, from the SW flank upper zone to the NE flank upper zone and more than 7 hours of high definition underwater

images were taken. In addition, bathymetric data were acquired using the Atlas Hydrosweep DS multibeam echosounder and were processed with CARIS HIPS & SIPS yielding a bathymetric grid resolution of 15 m (Fig.1B). The characterization of habitats was based on high resolution videos and captured photographic material with MAGIX software. ArcMap 10.3.1 and Fledermaus were used for the analysis of the digital data and their cartographical presentation (Fig. 1C).

### RESULTS & DISCUSSION

Mercator MV is a submarine venting structure mainly composed of soft muddy bottoms, where the presence of large (up to 5 m) to small (less than 10 cm) authigenic carbonates, mainly slabs, increases the seafloor heterogeneity (Table 1). The sediments display high degree of bioturbation with abundant burrows, galleries and small mounds built by small crustaceans (*Munida* sp.) and annelids (*Hyalinoecia tubicola*), among other species (Fig.1, Table 1).

Four different sections have been found along the ROV transect in relation to substrate and associated fauna, and therefore displaying different habitats. Mercator MV is in general characterized by a low density and diversity of soft bottom species including: (1) Sea pen communities (*Funiculina quadrangularis*) (<1 colony/m<sup>2</sup>) intermixed

with large slabs mainly in section A and D (central and SW summit areas); (2) bacterial mats (Fig. 2C-D), together with *H. tubicola* (20 ind/m<sup>2</sup>) and chemosymbiotic bivalves remains (*Lucinoma asapheus*) next to circular depressions (Fig. 2A-B), which probably are related to seepage (i.e. pockmarks), erosive scour marks or burrows of large megafauna (*Conger conger*, *Eledone*) in Section B (central and NE summit areas) and (3) Ceriantharia aggregations (50ind/m<sup>2</sup>) with *H. tubicola* (20 ind/m<sup>2</sup>) at section C (Fig. 2E-F). Hard bottoms with exhumated slabs display a wider biodiversity, including large size sponges (mainly *Geodia* sp., *Phakellia* sp.) in Section A and D and solitary scleractinians (mainly *Caryophyllia cf calveri*) on partly buried bioclasts, crusts and medium slabs in Section C. Habitat types at Mercator MV are related with the expulsion of gas-enriched sediments and availability of AC [3], which in turn are influenced by oceanographic processes affecting sediment deposition and different hydrodynamic conditions enhancing exhumation of AC and fauna colonizing different substrate types.

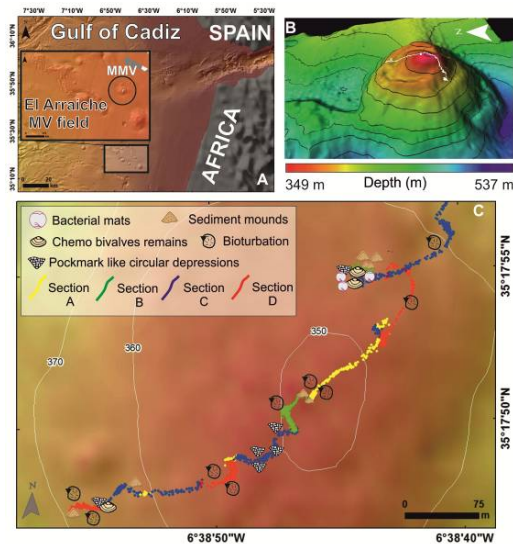


Fig. 1. Location of Mercator MV in the El Arraiche MV field (A), 3D model of Mercator MV (B) and ROV transect displaying main microscale forms and biota (C).

**ACKNOWLEDGEMENTS**

This research is a contribution to SUBVENT project (CGL2012-39524-C02, MINECO, Spain) and ATLAS project (EU, Horizon 2020). We thank EMEPC Team for their professional work operating ROV "Luso6000".

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Table 1. Summary of main features detected in the four sections along the ROV transect at Mercator MV. bu: burrows

Section	Sediment type	Slabs size	Main biota
A	Muddy bottom High bioturbation (90 bu/m <sup>2</sup> )	Large size (1-5 m)	Porifera ( <i>Geodia</i> sp.) <i>Caryophyllia</i> cf. <i>calveri</i> Sea-pen ( <i>Funiculina quadrangularis</i> ) Crustaceans ( <i>Munida</i> sp..)
B	Muddy sand bottom Circular depressions Medium bioturbation (20bu/m <sup>2</sup> )	Medium size (1-0.1 m)	Bacterial mats Ceriantharia <i>Hyalinoecia tubicola</i> Bivalve remains ( <i>Lucinoma asapheus</i> )
C	Muddy bottom Circ.depressions Medium bioturbation (20bu/m <sup>2</sup> )	Medium size (1-0.1 m)	<i>C. cf. calveri</i> Ceriantharia <i>H. tubicola</i> Crustaceans ( <i>Munida</i> sp., <i>Paramola cuvieri</i> )
D	Muddy bottom High bioturbation (90bu/m <sup>2</sup> )	Small size (>0.1 m)	Porifera ( <i>Geodia</i> sp.) Sea-pen ( <i>F. quadrangularis</i> )

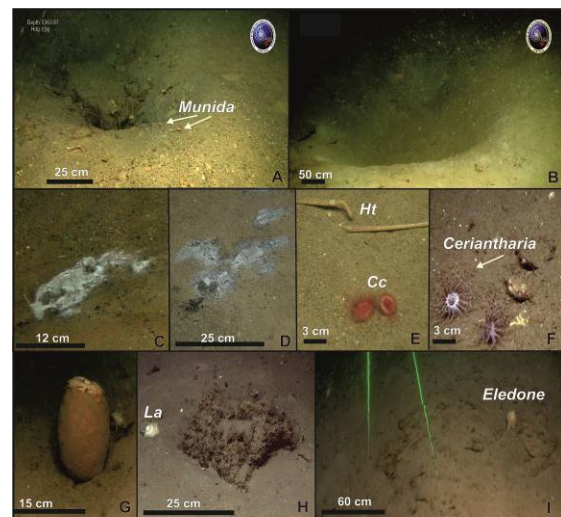


Fig.2.Underwater images from Mercator MV. A-B) Circular depressions of Sections C-D; C-D) Bacterial mats of Section B; E-F) Muddy sand with bioclasts colonized by *Caryophyllia* cf *calveri*(Cc), *Ceriantharia* (Ce) and *H. tubicola* (Ht); G) *Geodia* sp attached to a medium slab; H-I) Exhumated slabs on muddy bottoms with remains of *Lucinoma asapheus* (La).