

## Seabed morphology and bottom water masses related to benthic habitats at the Cristóbal Colón diapir (NW of the Guadalquivir ridge, Gulf of Cádiz)

**Desirée Palomino<sup>1</sup>, Juan-Tomás Vázquez<sup>1</sup>, José Luis Rueda<sup>1</sup>, Luis Miguel Fernández-Salas<sup>2</sup>, Nieves López-González<sup>1</sup>, Víctor Díaz-del-Río<sup>1</sup>**

1 Instituto Español de Oceanografía, Centro Oceanográfico de Málaga. Puerto Pesquero S/N. 29640 Fuengirola, Spain. [desiree.palomino@gmail.com](mailto:desiree.palomino@gmail.com)

2 Instituto Español de Oceanografía, Centro Oceanográfico de Cádiz. Muelle Pesquero S/N. 11006 Cádiz

**Abstract:** *The seabed morphology and the sub-superficial characteristics of the Cristóbal Colón diapir located on the continental slope of the Gulf of Cadiz have been analysed from data obtained in the framework of the LIFE+INDEMARES/CHICA project. The aim of this study is to recognize the morphological features and the geological processes generated by the bottom water masses and their influence on the habitats and associated benthic communities. The NACW affects the generation of morphological features on the summit, revealing that different oceanographic conditions favoured the carbonate mound growth in the past. The interface between the NACW and the MOW sweeps the bottom from the SE to the NW and the presence of benthic communities dominated by filter feeders on the contouritic drift indicates that this current is strong enough to favour the availability of nutrients and organic particles and to develop both the contouritic deposits on the SE flank and the moats on the N and W flanks.*

**Key words:** *carbonate mounds, contourite drift, benthic habitats, hydrodynamics, Gulf of Cadiz.*

### INTRODUCTION

Diapirs are characterized by a surface bulging that results from a slow uplift of massive plastic materials from the deep layers to the surface due to density differences. In the uplift process, diapir ridges deform the middle continental slope of the Gulf of Cadiz and can reach the surface (Fernández-Puga et al., 2007). Diapir outcrops interact with the water masses changing the water circulation pathways and velocities, and also affecting the sedimentary processes in their vicinity (Davies and Laughton, 1972). This situation provokes a local circulation pattern that can support different habitats and associated benthic communities if both nutrient supply and substrate are adequate. Changes in the oceanographic conditions can give rise to changes in the seabed morphology and the habitats.

The study area is located in the channels and ridges sector in the middle slope of the continental margin of the Gulf of Cádiz (Hernández-Molina et al., 2006). The Cristóbal Colón diapir is placed on the northeasternmost outcrop of the Guadalquivir Diapiric Ridge, at the north of the Gusano contouritic channel.

The aims of this communication are to study (1) the seafloor morphology and the sub-superficial characteristics of the Cristóbal Colón diapir, (2) their relation with the hydrodynamic of the water masses and (3) their influence on the benthic habitats.

### DATA AND RESULTS

The data set obtained during oceanographic cruises carried out in the LIFE+INDEMARES/CHICA project comprised: bathymetric information from a Kongsberg

Simrad EM-710 multibeam echosounder; very high resolution acoustic profiles from the system TOPAS PS018; one box corer surface sample; and ROV images and videos.

The zone is characterized by different water masses: the North Atlantic Central Water (NACW) flowing in different directions from the surface to 450m depth; the Mediterranean Outflow Water (MOW) flowing to the north and west between 550-700m water depth; the interface between the NACW and the MOW that flows between 450-550m water depth (Fernández-Salas et al., 2012).

Cristóbal Colón diapir is located between 389m and 525m water depth and displays a tabular plan view, slightly elongated toward NE-SW direction (Figure 1). The major and the minor semiaxes are 5.5 and 2.5km long, respectively. At the summit, the slope is not very sharp but with a flat tendency interrupted by small linear depressions and mounds. Mounds have an average height of 10m with higher backscatter values than the adjacent seafloor. The main mound, named Isabel de Castilla, is 35m high and 300m wide and is located at the east of the summit (Figure 1). ROV videos and samples collected on the mound display abundant coral rubble (mainly *Madrepora oculata*, with scarce *Lophelia pertusa*) that is colonized by a wide variety of small gorgonians (*Bebryce*, *Switia*, *Placogorgia*), but no living corals were found here although they could occur on other unexplored mounds. The northern and western base of the diapir is bound by depressions of 15m depth and two ridges of 20m average height, 0.15km and 0.2km wide, and between 1.2km and 2km long, respectively. In contrast, the southern flank of the main diapiric structure is

characterized by a plastered contouritic deposit that ascends the diapir flank and is colonized by sea-pens (mainly *Funiculina quadrangularis*, *Pennatula aculeata* and *Kophobelemnion stelliferum*).

## DISCUSSION

Mounds on the summit have been interpreted as relict carbonate mounds, containing hard substrates made of coral fragments and benthic fauna within a matrix of hemipelagic sediments that could provide the high backscatter values. Ridges on the northern and western base of the diapir are related to tectonic scarps that could have been colonized by corals in the past. The NACW has more influence on the diapir summit, at 380-420m water depth (Fernández-Salas et al., 2012) and this current may not be strong enough to support living corals. The hemipelagic sedimentation could bury the coral mounds. The large amount of coral rubble suggests different oceanographic conditions in the past that favoured the carbonate mound growth, and allowed the water mass to provide enough nutrients and the correct current speed to support cold-water coral reefs.

The interface between the NACW and the MOW flows from the SE to the NW affecting the seafloor sediments. This current generates the plastered contourite drift observed on the SE flank giving rise to a low slope surface. In the high resolution profiles there are no evidences of these deposits on the top of the diapir. In this zone, sea-pens favour the muddy sediments and the flow. The interaction of this current with the diapir generates an increase of the flow speed and triggers the erosion on the lee side of the diapir producing elongated depressions (moats). The strong current is also evidenced by the erosion of the surface of the faulted scarps.

## CONCLUSIONS

The interaction of two water masses with a diapiric structure has been interpreted as the main controlling

factor for relict morphology and habitats developing. The NACW affected the summit and could favour the carbonate mound growth as coral reef patches that declined in subsequent periods. Below this water mass, the interface between NACW and MOW swept the seafloor to the NW supporting the contouritic deposits on the SE flank of the diapir favouring sea-pen communities and the moats on the N and W flanks.

## ACKNOWLEDGEMENTS

This work has been developed in the framework of the LIFE+INDEMARES/CHICA project.

## REFERENCES

- Davies, T.A., Laughton, A.S., 1972. Sedimentary processes in the North Atlantic. In: Laughton, A.S., Berggren, W.A. (Eds.) *Init rep deep sea drilling project*, vol 12. US Government Printing Office, Washington, pp 905-934.
- Fernández Salas, L.M., Sánchez Leal, R., Rueda, J.L., López González, N., Díaz del Río, V., López Rodríguez, F.J., Bruque, G., Vázquez, J.T., 2012. Interacción entre las masas de agua, los relieves submarinos y la distribución de especies bentónicas en el talud continental del Golfo de Cádiz. *Geo-Temas* 13: 198.
- Fernández Puga, M.C., Vázquez, J.T., Somoza, L., Díaz del Río, V., Medialdea, T., Mata, M.P., León, R. 2007. Gas related morphologies and diapirism in the Gulf of Cádiz. *Geo-Marine Letters* 27, 213-221.
- Hernández-Molina, F. J., Llave, E., Stow, D.A.V., García, M., Somoza, L., Vázquez, J.T., Lobo, F., Maestro, A., Díaz del Río, V., León, R., Medialdea, T. and Gardner, J. 2006. The Contourite Depositional System of the Gulf of Cadiz: a sedimentary model related to the bottom current activity of the Mediterranean Outflow Water and the continental margin characteristics. *Deep Sea Research II*, 53: 1420-1463

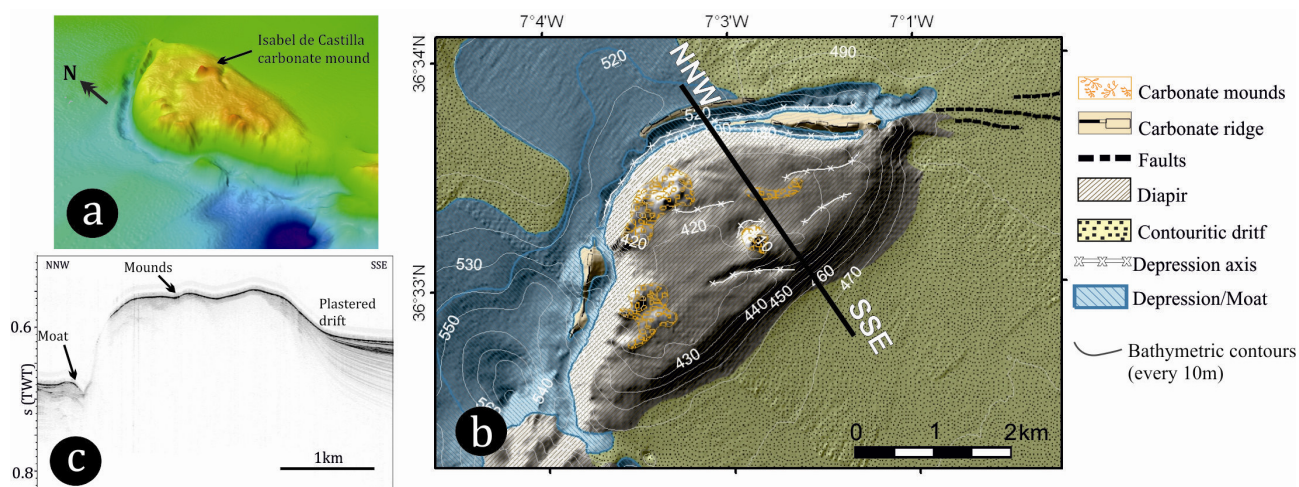


FIGURE 1. a) 3D model with illumination source azimuth 315° and 15m resolution, b) Geomorphological interpretation draped over a hillshade map, c) Very high resolution acoustic profile crossing the Cristóbal Colón diapir.