

## Morphological characterization of contourite and mass-wasting recent processes at the Guadalquivir Bank Margin uplift, Gulf of Cadiz

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**Abstract:** The Gulf of Cadiz records the interplay of a variety of sedimentary processes related to the circulation of water masses. The most important one is the Mediterranean Outflow Water (MOW) that exits the Mediterranean Sea, but other water masses also affect the seafloor, with complex variations along time and space. This work studies the interplay between oceanographic and gravitational sedimentary processes on the Guadalquivir Ridge, based on bathymetry and high-resolution seismic profiles. A series of morphological features including flat terraces, circular/elliptical depressions, semi-circular scarps and valley-shaped features are analysed in order to better understand the interaction between water masses circulation and mass-wasting processes of the Gulf of Cadiz.

**Key words:** Gulf of Cadiz CDS, morphology, oceanography, swath bathymetry.

### THE GULF OF CADIZ: GEOLOGICAL AND OCEANOGRAPHIC SETTING

The Gulf of Cadiz is located at the Atlantic side of the Strait of Gibraltar. It records the interplay between sedimentary processes and the oceanographic dynamics. The Gulf of Cadiz Contourite Depositional System (CDS) is related to the maintained flow of the Mediterranean Outflow Water (MOW) as it overflows into the Atlantic Ocean. In this complex system along-slope processes dominate over mass wasting, turbidity currents and pelagic/hemipelagic settling processes. The CDS is composed of differentiated morpho-sedimentary sectors, each showing different depositional and/or erosional features (Hernández-Molina et al., 2006). Terraces have been identified on the middle slope, associated to the flow of distinct cores of the MOW and the interphases between water masses (Hernández-Molina et al., 2014).

The oceanography of the Gulf of Cadiz is dominated by the warm saline MOW exiting the Mediterranean Sea (Baringer and Price, 1999). The MOW accelerates through the strait of Gibraltar and it flows along the Gulf of Cadiz continental slope towards the west Iberian Margin. Along the mid-slope of the Gulf of Cadiz, the velocity is locally enhanced and split by interaction with diapiric ridges. In the Gulf of Cadiz the MOW is overlaid by the Eastern North Atlantic Central Water (ENACW), the modified Antarctic Intermediate Water (AAIW) and the Surface Atlantic Water (SAW) (Hernández-Molina et al., 2014). The interaction of the water masses with the seafloor presents a high spatial and temporal variability.

The Guadalquivir Bank Margin uplift is characterized by two main SW-NE aligned reliefs located on the middle slope of the Gulf of Cadiz. that

reaches minimum depths at the Guadalquivir Bank, at the western extreme of the ridge (275m), and close to the eastern extreme at the Gamboa Dome (350m) (Fig. 1). The ridge is cut by the Diego Cao Contourite channel that forms a 4-5km wide, SE-NW oriented channel. It delimits two relatively flat contourite sheeted drifts (SD): the Faro SD at the east (~ 600m) and the Bartolomeo Dias SD, at the west (~750m).

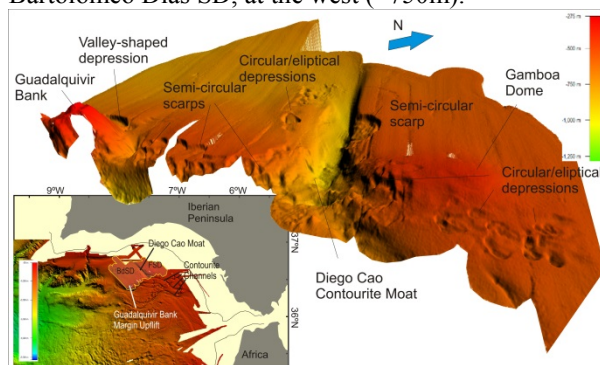


FIGURE 1. Study area and 3D bathymetric model analysed in this study. BdSD: Bartolomeo Dias Sheeted Drift; FSD: Faro Sheeted Drift.

### MORPHOLOGICAL FEATURES

High resolution data reveal the existence of a variety of features. Semi-circular scarps up to 10s of km long, occur at the SE side of the Guadalquivir Bank Margin uplift (Fig. 2A, B). They occur at depths of 640 to 750m and form steep steps of up to 80m of height and 5km of length. They are in some cases overlapped one on each other at different depths. Truncated reflectors indicate recent erosion on the scarps. The most remarkable scarp occur at the SW side of the Bartolomeo Dias SD, at the rim of the Diego Cao contourite channel (Fig. 2C). It is about 5km long and up to 100m deep, with steep walls of up to 20°. Inside the semi-circular space delimited by

the scarp there is a secondary step, and a deeper, valley-shaped incision to the SE side. Truncated reflections occur at the walls of the scarp, and no deposit associated to it can be identified.

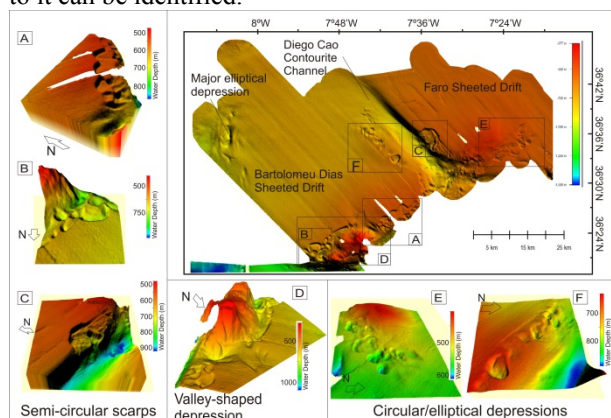


FIGURE 2. Bathymetric model and 3D blocks showing the main features analysed in this study.

A valley-shaped depression surrounds the N side of the Guadalquivir Bank (Fig. 2D). It is about 30km long, with incision depths of up to 200m and it runs parallel to the shape of the bank main relief. Truncated reflections occur at the northern wall, that erodes the Bartolomeu Dias sheeted drift.

A series of elliptical to circular-shaped depressions occur at the SE side of the Gamboa Dome, aligned in a WSW-ENE direction, at depths of 480 to 550m (Fig. 2E). They are 10s of meters deep, up to 3km wide and have steeper SW walls. Seismic profiles show truncated reflections on the walls. A series of circular- to elliptical-shaped depressions also occur at the eastern side of the Bartolomeu Dias SD, close to the rim of the Diego Cao channel, roughly parallel to it (Fig. 2F). They occur at depths of 650 to 750m on the SD, have maximum widths of 2km and depths of up to 100m. They have generally steeper SE walls (up to 20°) showing truncated reflections on seismic profiles. A major elliptical depression, oriented N-S occurs at the NW part of the Bartolomeu Dias SD (Fig. 2, regional map). It is 5km long and 3km wide and reaches depths of 150m, with steeper eastern wall, up to 16° and a smoother western wall (<8°). Smaller depressions with N-S to WNW-ESE orientations occur at the surroundings of the major depression, with diameters of less than 2km and depths of up to 20m. Walls show truncated reflections on seismic profiles.

## DISCUSSION AND CONCLUSIONS

The interaction between the circulation and the bathymetry of the Gulf of Cadiz middle slope is responsible for the major erosive and depositional features. Diapiric ridges (Cadiz and Guadalquivir), diapiric intrusions, and structural features determine the seafloor shaping that affects and is affected by the water masses circulation. The step-like profile of the middle slope can also be related to the circulation of water masses and their interphases. The morphological features presented in this study are the result of the MOW interaction with the morphology, in particular of

the effect of the slopes delimiting terraces, morphological highs and the Guadalquivir Bank uplift on the circulation of the northernmost branches of the MOW Lower Core. Scarps are interpreted as mass-wasting features, where the triggering factor is the erosive action of the currents as they are accelerated by interaction with morphological highs and slopes. Resulting mass-wasting deposits would be transported by the currents to deeper areas of the Gulf of Cadiz. The valley-shaped depression around the Guadalquivir Bank can be interpreted as a contourite moat related with the acceleration of the current by the interaction with the high. Circular-elliptical depressions result from the complex interaction of the current with the topography. The current intensification as it impinges on the slopes delimiting terraces and morphological highs produces asymmetric flows surrounding the obstacles and irregular flow patterns that may produce the erosion of contouritic deposits (Turnewitsch et al., 2013). Mass-wasting and contouritic deposition may have interplayed during the development of these features, as suggested by the erosive surfaces overlaid by prograding deposits. Collapse processes resulting from structural deformation may also be responsible for the origin of the depressions at the SE side of the Gamboa Dome.

## ACKNOWLEDGEMENTS

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