A mixed contour current – turbidity system from the São Vicente Canyon, Gulf of Cadiz: depositional features and significance for submarine slope stability

Gulf of Cadiz, offshore Portugal

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Area of interest

Alentejo Basin, Gulf of Cadiz

- Extensive contourite depositional system generated by the MOW;
- Several potentially tsunamigenic faults (Marques de Pombal Fault, Horseshoe Fault, São Vicente Fault, ...);
- Multiple mass transport deposits (MTDs) and scars;
- São Vicente Canyon:
  - Biggest canyon in the Gulf of Cadiz: <150 km long, 20 km wide);
  - Developed starting from the Pliocene by retrogressive erosion\(^1\);
Available data:

- Swath-bathymetry;
- 35 MCS profiles;
- IODP well 339-U1391
  - Explored the contourite deposition in the northern sector of the Gulf of Cadiz;
  - Detected discontinuities, erosional surfaces and different grain size distributions due to different MOW hydrodynamic regimes;
- INSIGHT-Leg2 (2019)
  - INS2-Line10: MCS profile linking the IODP well 330-U1391 with the Marques de Pombal Plateau;
  - SdG083-13: Gravity core (230 cm)
Main questions:

▷ How does the São Vicente Canyon interact with the MOW?

▷ Retrogressive erosion within the São Vicente Canyon generates turbidity currents within the contour current. Do they interact with contour current? Can we see depositional features related with mixed turbidity-contour currents (e.g. asymmetric levee)?

▷ Can the interaction between São Vicente Canyon and MOW impact the slope stability in the area?
Interpretation

50 km

Late Quaternary Unit - 0.3Ma
Middle Pleistocene Unit - 0.8Ma
Early Quaternary Unit - 2.2Ma
Late Pliocene Unit - 3.1 Ma

500 m thick Late Quaternary sedimentary body on the NW side of the canyon
Interpretation

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Middle Pleistocene Unit - 0.8 Ma
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Late Quaternary asymmetric levee visible on the NNW side of the Sao Vicente Canyon
Thicknesses

- Late Quaternary Unit
- Middle Pleistocene Unit
- Early Quaternary Unit
- Late Pliocene Unit

Sedimentation rate

- Late Quaternary Unit
- Middle Pleistocene Unit
- Late Quaternary depocenter
- Sed. Rate up to 1.5 m/kyr

Sedimentation rate up to 1.5 m/kyr
Gravity Core – SdG 083-13

Grain size:
- Sampled using 5 cm spacing;
- Homogeneous silt-dominated grain size with high % clay.

MSCL analysis:
- P-Wave velocity and density measured on the whole core;
- No clear discontinuities – Homogeneous top sediments.
The joined development of the Horseshoe Fault (HF) and Marques de Pombal Fault (MPF) generated a syncline fold where the deeper São Vicente Canyon sector emplaced; the contour current did not interact with the canyon at this stage.
Conceptual model

- Retrogressive erosion let the canyon expand until its current configuration (head located at approximately 200 m water depth);
- Generation of turbidity currents that transport the eroded sediments from the shallower part of the slope to the Horseshoe abyssal plan;

Modified after S. Serra et al., in press (1)
Conceptual model

- MOW Lower Core flows perpendicular to the canyon: a fraction of the water is captured by the canyon, while the remaining part is able to bypass the canyon with a considerable power loss;

- MOW interacts with the finer part of the turbidity cloud, transporting it on the NW side.
The finer fraction of the turbidity currents are deposited on the MW side of the Sao Vicente Canyon, forming an hybrid levee-drift sedimentary body as it is visible from the seismic interpretation.
Previous studies

▷ Multiple previous study recorded the existence of mixed turbidity-contour systems in smaller scale turbidity channels\(^{(3, 4, 5)}\);

▷ Experimental models from Miramontes et al. (2020)\(^{(6)}\) simulated the interaction between turbidity and contour currents. The experiments resulted in generation of hybrid levee-drift deposits on the side of turbidity channels.

From Miramontes et al., 2020\(^{(6)}\)
The 500m thick sedimentary body on the Sao Vicente Canyon NW side is interpreted as an hybrid levee-drift deposits due to the interaction between MOW Lower core and turbidity currents generated within the canyon.
Implications for submarine slope stability

▷ Many mass transport deposits in the Alentejo basin distribute around the Late Quaternary area of high sedimentation rate on the Marques de Pombal Fault block;

▷ The localized high sedimentation rate (up to 1.5 m/kyr), plus the assumed fine sediments of the sedimentary body, are likely to generate high overpressure in the underlying units;

THE QUICK SEDIMENTATION OF THE THICK HYBRID LEVEE-DRIFT AFFECTED THE STABILITY OF THE SLOPE
Conclusions

▷ The interaction between the MOW and turbidity currents within the São Vicente Canyon generated a Late Quaternary hybrid levee-drift deposits on top of the Marques de Pombal Fault block;

▷ Asymmetric channel-levee system can generate not only on turbidity channels, but also bigger size canyons;

▷ Mass transport deposits in the Alentejo basin distribute mainly around this high sedimentation rate area, suggesting that the hybrid levee – drift deposits might play an important role as pre-conditioning factor for submarine slope stability (e.g. excess pore pressure generation).
References


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