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Cause of the rupture and distribution of carbonate chimneys in the Contourite Cadiz Channel (Gulf of Cadiz, southwestern of Peninsula Iberica)

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The Gulf of Cadiz is an area where important oceanographic, sedimentary and tectonic processes converge. The oceanographic setting is characterised by the exchange of water masses between the Mediterranean Sea and the Atlantic Ocean through the Strait of Gibraltar. The Mediterranean Outflow Water (MOW) enters in the Gulf of Cadiz as an intermediate flow along the middle slope. The interaction of the MOW with the seafloor has developed a huge contourite depositional system. The tectonic structure of this area is a consequence of the development of the Betic-Rif orogen, due to convergence movement of the African and Eurasia plates, along the Azores-Gibraltar Fracture Zone.

The study area is located in the central part of the middle slope of the Gulf of Cadiz, in the Cadiz Contourite Channel, developed at the south side of the Cadiz Diapiric Ridge. This work has been carried out based on the data obtained by dredging and images taken during the Anastasya 2000 and 2001 cruises for the TASYO project. A high density of chimneys overlying the sea floor where identified and observed by means of an underwater camera.

The main objective of this study is determining the relation between the distribution of the chimneys and the tectonic and oceanographic processes in this area. A systematic analysis of 1,798 submarine photographs has been considered to analyse the orientation of the chimneys along the Cadiz Channel. The results show that the carbonate chimneys have a regular spatial distribution in a NW-SE direction. Moreover, the basal morphology of these chimneys shows common characteristics of an angular breakage associated with flexo-traction processes, typical of slender structures.

The responsible force for fracturing these structures could be linked to bottom currents strength or the inertia associated with oscillatory movement of land due to a seismic event. After considering the results obtained from the mechanical behaviour of the chimneys, the force exerted by the mentioned causes of rupture and the spatial distribution resulting from the action of these forces, the following assumptions can be deduced:

A) The flow speed necessary to produce the chimney's rupture would be aprox. 140 m/s, higher than the velocity of the MOW observed in this sector, which is 0.8 m/s. On the other hand, the direction of the current in the study area is NE-SW, perpendicular to the preferential orientation of the broken chimneys.

B) Being chimneys rigid objects, the most representative parameter of the damage will be the maximum horizontal acceleration for zero second period (PGA). In this study a rupture model is proposed, where: 1) the chimney is considered as a perfect cylinder of smooth outer surface; 2) the effect of the earthquake is simplified, considering only one direction of displacement, which is modelled as a simple harmonic motion, and that will depend on the ground characteristic period; and, 3) the chimneys move within a turbulent flow. The PGA results are between 0.4g and 1.29g. Applying a number of attenuation relations and taking into account the location and characteristics of the ground, it is obtained that the rupture may has been due to: I) an earthquake magnitude Ms or Mw $\geq$ 7.0, within a radius of shortest distance to the projection of the fault surface of 4 km; and II) an earthquake magnitude Ms or Mw $\geq$ 5.7 at the chimneys location. These results are consistent with the existing seismic records in the study area. Moreover, the carbonate chimneys are distributed in favour of the direction of seismic beam.

Finally, according to the obtained results, it can be established that the carbonate chimneys distribution of the Gulf of Cadiz can be related to a seismic event.