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A major E-W directed fault zone in the Gibraltar Strait? An approach through onshore-offshore correlations

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The Gibraltar Strait is the neck between the southern Europe and northern Africa tips that links the Atlantic Ocean and the Mediterranean Sea. It consists in an ENE-WSW directed trough of rugged topography down to -800 m depth that straddles and erodes the Gibraltar Arc system. This trough comes to an end against the Camarinal Sill, NNE-SSW directed, which reaches less than 100m depth and connects both Spanish and Moroccan shelves. The basement of this Sill is mainly composed of Flysch Trough Units. These units are part of the Betic-Rif external zones and are formed by deep-water siliciclastic rocks early Cretaceous to early Miocene in age. Their thrusting and folding during Miocene times represent the main building episode of the Gibraltar Arc accretionary prism, and contributes to the isolation of the Mediterranean Sea at 5,6Ma. It is generally accepted that the Mediterranean flooding after the Messinian salinity crisis was induced by the local immersion of relieves of the Betic-Rif mountains at the Gibraltar site. Nevertheless, the causes and mode proposed for the opening of the Gibraltar Straits, are still an open question: topographic lowering by tectonic collapse, regressive erosion of a stream that was flowing toward the dessicated Mediterranean basin, eustatic rise of the Atlantic or a combination of these factors are generally evoked for the origin of the Gibraltar Strait.

We present a structural interpretation of the Camarinal Sill and its relationship with both the Moroccan and Spanish shelves, based on morphological analysis of ultra high-resolution bathymetry. Our 3D map shows complex and abrupt relieves and the distribution and orientation of highs, crests, scarps and small closed basins permit to characterize three zones bounded by two main E-W directed morphological lineaments that cross the Camarinal Sill. In the Sill central zone, E-W to ENE-WSW directed linear features separate highs and lows with a step-like geometry. According to the sea-floor sampling data, the highs correspond to Flysch type rocks and the lows to recent sediments. Moreover, it is frequent to observe how N-S directed crests are segmented and displaced by small E-W to ENE-WSW directed lineaments.

We compare the submarine topography of the Camarinal Sill with the structural features observed on land. As a whole, the Camarinal Sill represents a NNW-SSE directed high (between isobaths 90 and 300m), whose direction is similar to the structural trend of the Gibraltar Arc system on both shores in the Gibraltar area. Accordingly, it probably reflects a tectonic heritage and its primary origin could be related with the shortening structures associated with the mountain front development in the Flysch Trough Units. Onshore, on both margins and near the coastline, conjugated strike-slip fault systems and/or high angle-normal faults that cut the previous fold-and-thrust system were mapped. In particular, in the Spanish branch of the Gibraltar Strait, the kinematic indicators along one of these faults, the Tarifa fault, shows an oblique movement, with both dextral and normal components.

To conclude, we suggest that the linear features observed offshore and that cross the Camarinal Sill, together with the faults recognized onshore, can be interpreted as a major fault zone, broadly E-W directed. This fault zone seems to control the position of the relative basement highs and depressions and can be responsible for, or contribute to, the opening of the Gibraltar Strait after the Messinian Salinity Crisis. It is also a good candidate as a zone of channelling and strong erosion during the water-infill of the Mediterranean Sea.

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