Integration of Marine Geology of the Strait of Gibraltar with Paleo-stress History of the Tangier Peninsula, Morocco: Implications for the Messinian Gibraltar Corridor

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Abstract

Previous workers have used stratigraphic studies to identify three potential marine gateways that connected the Atlantic and Mediterranean during the Messinian salinity crisis (MSC): the Strait of Gibraltar that remains a 300-900-m-deep channel to the present-day and the Betic and Rifian corridors now exposed on-land in southern Spain and northern Morocco, respectively. Comparison of deepsea cores from the Atlantic and Mediterranean have shown that there was no significant or sea-level rise during the Messinian leaving a tectonic or climate control as the most likely cause for Messinian drying of the Mediterranean and that was followed in the early Pliocene by the re-flooding of Atlantic waters in the dessicated and evaporite-filled Mediterranean basin. In this study, we integrate bathymetric, GPS data from the Tangier Peninsula and its offshore areas with paleostress measurements at 25 sites ranging in age from Jurassic to Miocene. Offshore data from the Strait of Gibraltar indicates that the main ENE-lineament on the seafloor is a major right-lateral strike-slip fault whose sense is consistent with: 1) WNW-trending GPS vectors; 2) the arrangement of positive restraining and negative releasing bends; 3) formation of a 15-20-km-wide syncline within the Strait that deepened with continued compression; and 5) the right-lateral offset of the Mesozoic Calcaire Dorsale Ridge by \~7 km. Paleostress sites on-land in rocks of Oligocene to early Pliocene age indicate three events: 1) east-west compression of Miocene age inferred to record the formation and eastward motion of the Gibraltar arc; 2) NW-SE compression inferred to record the closure of Nubia and Iberia with compression of the Gibraltar arc; and 3) NE-SW compression inferred to represent continued compression of the Gibraltar arc that accompanied continued formation of the large syncline within the strait. We postulate that the offset of the highly resistant and 1-km-thick Calcaire Dorsale allowed the initial deep channels to open between the Atlantic and Mediterranean. We see no evidence for north-south-striking normal faults as postulated in strait-opening models based on roll-back of the Gibraltar slab.
ABSTRACT

Previous workers have used stratigraphic studies to identify three potential marine gateways that connect the Atlantic and Mediterranean during the Messinian salinity crisis (MSC): the Gibraltar Strait, the Betic-Cordillera Trough, and the Gibraltar Arch. Marine gateways were re-opened in Southern Spain and North Morocco, respectively. Integration of marine geology of the Strait of Gibraltar with paleostress history of the Tangier peninsula, Morocco: implications for the Messinian Gibraltar corridor

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1. Along-strike structures of the Africa-Eurasia plate boundary

2. Tectonic history of Africa-Eurasia convergence

3. Comparison of structure and age of the Betic (Spain) and Rif (Morocco) belts

4. Regional map of Tangier Peninsula

5. Structural cross sections and marine seismic data

6. Stereoplots of striated faults

7. Conclusions – Future work

Our study, utilizing bathymetry, GPS, and paleostress data, provides valuable insights into the tectonic controls and geological events associated with the Messinian salinity crisis and the re-opening of the Gibraltar Arch. The identification of a significant right-lateral strike-slip fault in the Strait of Gibraltar, coupled with evidence of compressional events, establishes a unique geodetic fingerprint for the period of opening and closing of the corridor. Further corroborative studies centered on the Gibraltar Arch would help in better constraining the timing of the Messinian marine incursions and their implications for the Messinian corridor.