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Multiphase Fault Evolution in a Rotational Margin Setting: Offshore Sirte Basin, Libya

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The aims of this study are to present a new structural interpretation of a well-calibrated regional 2D seismic dataset to constrain the timing and style of faulting in the Sirte embayment, offshore Libya, a Mesozoic–Cenozoic extension of the Sirte basin onshore north Africa. Due to rotation of the African continent since the Mesozoic, present-day fault orientations are not the same as during fault formation at various times since the early Palaeozoic. The approach has therefore been to integrate a structural model with published plate tectonic reconstructions in order to progressively restore fault orientations throughout the evolution of the Sirte embayment. Multiple phases of rifting can be observed in the offshore area, with major faulting episodes during the Aptian–Albian, Upper Cretaceous, mid-Eocene and Oligocene. Paleozoic basement structures have a dominant role in controlling the locations of later faults.

The model shows how pre-existing structures have been reactivated during the main Cretaceous basin-forming episode, with some deeply-rooted basement faults remaining active into the mid-late Cretaceous. The orientation of basement faults with respect to the inferred regional stress direction appears to be a key influence on the type of faulting observed. In many parts of the Sirte Embayment, active faulting during the later Mesozoic is concentrated in fault zones directly above, or in the immediate hanging wall of older, deeper faults. The dominant stress field since the Cretaceous is consistent with the onshore Sirte trend with extension generally to the NE-SW giving NW-SE striking faults and fault zones. The orientation of pre-Mesozoic faults can be shown to have rotated anti-clockwise by 40º between formation and Cretaceous deformation, with a further 17º to the present day giving a total rotation of 57º.

While the present day onshore trend of NW-SE horst and graben blocks has the greatest influence on the structure of the Sirte embayment, influences from the surrounding parts of North Africa, such as inversion associated with the Cyrenaica Platform, strike slip associated with Sabratah-Cyrenaica fault zone and further extension associated with the development of oceanic crust in the Ionian region give rise to other structural styles, particularly towards the basin edges. Our new structural model accounts for the modification of the Sirte trend by near- and far-field tectonic influences while showing the effect of margin rotation over time. Understanding these influences is critical to the fault and basin evolution in the offshore region.