Egyptian Red Sea Frontier Rift Basin Evolution Impacts Seismic Imaging and Exploration Potential

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Abstract

The Egyptian Red Sea is currently largely underexplored, yet contrarily, holds an estimated mean volume of 5 bn bbl of undiscovered but recoverable oil and 112 tcf natural gas (Schenk et al., 2010). The northwestern part of the Egyptian Red Sea rift basin has attracted the attention of exploration companies due to its proximity to the renowned success in the adjacent Gulf of Suez (GoS), and is expected to host both, the known source rock sequences of the pre-rift Cretaceous (Dakhla, Duwi) , also outcropping at the coast, and the syn-rift Miocene (Nukhul, Rudeis, Kareem, Belayim), considered containing oil and gas-prone kerogen types in the mature window. This is supported by hydrocarbon shows in the Red Sea wells. The Pre-rift Cretaceous and the Syn-rift Early-Mid Miocene, outcropped onshore Egypt and drilled in the GoS, represent the sand-rich reservoir sequences but 2023 long offset multisource 3D acquisition reveals that the structuration and stratigraphy are in stark contrast to the subsurface in the GoS, which makes it challenging to identify the expected sequences in the greatly deformed strata. This study will show that the resulting subsurface image from a multi-geophysical integrated approach gives confidence in the data quality being fit for purpose of de-risking exploration potential in the Egyptian Red Sea.

Gravity, Magnetic (GM), outcrops, borehole data and seismic from the northwestern Red Sea indicate several structural regimes, different in their fault trend, sedimentary fill and depositional setting, which developed during four major tectonic phases from rifting to transfer to current drifting throughout the Late Cretaceous and Cenozoic With such complex structures, deformation, and consequently high lateral variability of the basin infill, it is paramount to exclude certain geological scenarios during velocity model building (VMB), which in the case of this 2023 3D study is based on signal driven elastic FWI. Integrating the elastic inversion with legacy data from 2018 2D and 2019 3D and the new 2023 high-density GM data allowed identifying targets below salt and in the deeper rifted structures for the first time, and in some places even to de-risk prospects in pre- and syn-rift reservoir targets. Interpretation of the data identified highly variable and deformed pre-salt strata over an extreme base Syn-rift relief, revealing a range of targets within the pre-rift fault blocks and Syn-rift growth sequences in erosional or strongly tilted settings. These findings are significant since they appear dissimilar to the GoS subsurface settings and explain the lack of success of the exploration wells in the basin.

The independent geophysical QC of the VMB from the integrated multi-physics project is crucial to identify the main structural and depositional differences to other Salt basins and understanding the complex imaging challenges for future follow-on campaigns. This approach in combination with modern elastic modelling provided subsurface data that is a solid basis for revising the interpretation of reservoir distribution and updating the framework for source rocks maturation and migration pathway modelling. These observations may result in the African side of the Red Sea yielding greater prospectivity than has been identified so far.