Integrative Structural Analysis of a Prospective Zone Affected by Inversion, Abu Gharadig Basin, Western Desert, Egypt

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Abstract

A comprehensive 3D structural model and analysis was performed on a prospective multi-phase structure in the West El Fayoum Concession, located along the southern margin of the Abu Gharadig Basin, a significant pre- existing tectonic lineament in the Western Desert, Egypt. The area has experienced varied stress fields over time, influencing its current structural configuration. The prospective zone of interest is closely linked with the history of movements on two major fault zones (one W-E trending and pre-existing master fault and a NNE-SSW trending younger thrust fault). The primary aim of this structural evaluation was to conduct a detailed 3D structural interpretation and to quantify exploration risk. This involved a detailed quality control (QC) of existing structural interpretation and new interpretations. Furthermore, the study aims to inform and guide future seismic reprocessing efforts in the area.

Initially, a thorough QC of the main structural elements of the prospective zone was conducted. Our approach involved the integration of various data sources: standard 3D seismic volumes (time domain), coherency and pseudo relief attributes. Additionally, data from 10 key wells, eight existing seismic grids, digital elevation models (DEM), cultural data and geological surface data were integrated into this analysis. These data sources were complemented by both public and internal reports.

The first step in the workflow was a comprehensive 3D seismic interpretation, focusing on horizons and faults, leading to a watertight structural model and the development of a velocity model. The second step involved a 2D kinematic structural restoration of selected transects. This step was crucial in QC-ing the seismic interpretation and refining the structural framework. The third step encompassed a 3D kinematic assessment, along with a lithostratigraphic fault juxtaposition and Allan Map evaluation.

Based on our integrative structural assessment, we confirm that: (a) the W-E trending master fault likely originates from Jurassic and Early Cretaceous extensional movements, (b) this master fault was subsequently overprinted by E-W directed contraction during Late Cretaceous into Paleocene times that lead to the formation of a major NNE-SSW trending thrust fault, (c) the earliest possible time of trap formation dates back to Cenomanian times, (d) the minimum horizontal extension in N-S direction was ~1600 meters, while E-W contraction was about 800 meters. Collectively, these results underscore the early existence of proto-traps at the Bahariya Fm. level in this region.

Remaining model and data uncertainties include areas of poor seismic imaging, e.g. in fault shadows or highly compartmentalized domains. These zones challenge the interpretation and the velocity modeling. As suggested, and based on the velocity models provided here, a new PSDM volume has been generated and is currently under evaluation for refined structural assessment.