

# **Structural Restoration and Forward Modeling to Quantify Paleo-Deformation in a Naturally Fractured Reservoir**

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## **Abstract**

Detection, characterization, and paleo-deformation related to natural fractures for carbonates is critical in the oil and gas industry. Fractures in reservoirs govern hydromechanics with important bearing on the success of well designs and placement for fluid production and injection and field development. The majority of tectonic fractures in sedimentary rocks are either fold- or fault-related. In this study, we apply 3D structural restoration and geomechanical forward modeling techniques in petroleum prolific carbonate strata to identify the relative geological times of various tectonic events and the relationship to natural fractures. Subsurface information such as faults and horizons from 3D seismic reflection volumes were interpreted and applied in 2D and 3D structural restoration techniques in order to deduce the consistency of faults and horizon depth markers to predict the likelihood of fold- and fault-related fractures from elastic theory of stress-strain relationship. The present-day geometry is the result of episodic reactivation of a major steep-dipping fault system in the basement rocks below the sedimentary strata of the Arabian Platform. The deep-seated faults terminate below the studied strata, but its upward growth created an asymmetric anticline of a steeper forelimb and a gentler dipping back-limb. Faulting-related and folding-related fractures were calibrated with restoration results. There were two deformation events that affected the region: the first major tectonic event happened during the Upper Cretaceous and the second event occurred during the Oligo-Miocene and it seems to be associated with shortening of the platform interior due to the collision of the platform margin with the Asian Plate in the Zagros region. Our results demonstrate that both tectonic events induced transpressive reactivation of the basement-rooted fault system and folding. Observed natural fractures sets at the forelimb correlate to the fold hinge stretching, comprising around 5% of the observed fractures across the structure. The forward geomechanical modeling results show that 85% of observed fractures representing the dominant fractures are at a high fit with a strike slip transpressive regime. Saja