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Fracture Modes in the Silurian Qusaiba Shale Play, Northwest Saudi Arabia and their Geomechanical Implications

Mohammed S. Ameen

Unconventional Resources Exploration Department (URED), Saudi Aramco, Dhahran, Saudi Arabia

Abstract

Fracture studies were conducted for unconventional prospect evaluation in the Silurian Qusaiba Shales, northwestern Saudi Arabia. Borehole image logs, oriented cores, seismic, and drilling observations were used in the studies. The fractures include natural fractures and induced fractures. The induced fractures (drilling-induced tensile fractures and breakouts) are a manifestation of borehole deformation due to in situ stresses and were studied to assess the stress regime in terms of directions and magnitudes. The results show that the present day maximum horizontal in situ stress trend varies from NNW-SSE to NNE-SSW, and show a regional pattern dominated by the Arabian plate tectonics.

The natural fractures include extension and shear fractures (joints/veins and faults, respectively). The fractures vary from microscopic (microfractures) to macroscopic (macrofractures) and show various degrees of clustering into fracture and fault zones, with widths varying by up to 3 orders of magnitude. Fault lengths and displacements vary by up to 4 orders of magnitude. A regional natural fracture system is identified comprising up to five distinctive sets: one gently dipping (bedding parallel) and up to four moderately to steeply dipping fracture sets: an easterly striking set is the oldest, followed by three younger major sets striking NNW-SSE, N-S and NNE-SSW. The younger fractures are nearly parallel to the present day maximum horizontal in situ stress. All fractures show partial to complete mineralization or coating, dominated by calcite and dolomite with aqueous and hydrocarbon fluid inclusions. The orientations, dimensions, aperture types, and degree of clustering of the fractures, and the current in situ stress regime impact the reservoir-scale geomechanics, and response to hydrofracture stimulation.