Best Practices for Mitigating Subsurface Challenges of Natural Fracture Characterization and Fracture Modeling of Deep Unconventional Reservoirs

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Abstract

Kuwait Oil Company has recently embarked on an aggressive campaign to appraise, delineate and develop the deep unconventional naturally fractured tight carbonate reservoirs of Oxfordian-Callovian age in the northern part of encompassing eight oil and gas fields. These reservoirs mostly occur in a depth range of 14,000' to 15,000' with HP/HT operational envelope. After limited initial commercial success in vertical and deviated wells, recently a major paradigm shift has been made to drill highly deviated and horizontal wells into these sub-salt unconventional reservoirs (with permeability less than 0.01 mD) in an effort to maximize reservoir contact.

Most of the 80 wells drilled to date have a full suite of e-logs, including image logs (OBMI-UBI) along with extensive core coverage (approx. 10000'). Over the past few years, accurate and reliable reorientation of these cores (after proper calibration with the image logs) in conjunction with seismic data evaluation was carried out as part of integrated studies, which aided in developing structural evolution model for the North Kuwait Jurassic structures. Also, Re-orientated core data helped in fracture characterization viz.., quantitative fractures attribute such as fracture frequency and permeability, spacing, dip-azimuth and aperture along with mapping of in-situ stress directions. Horizontal and vertical distribution of fracture properties (with mechanical stratigraphy control) were used extensively for fracture modeling work. Three dominant fracture families were recognized based on the fracture characterization work. It is observed that, the major fracture strike directions are strongly controlled by the structural grain imprint from the different episodes (structural evolution) and proximity of faults. A comparison of these static fracture properties with mud losses (Corialis data) in recently drilled horizontal wells showed an excellent match between open/partial fracture density and the zone of maximum mud losses (PLT and PTA data was also utilized for corroborating / QC of results obtained).

Current study was a key enabler in taking critical field development decisions such as design of well trajectories, optimizing the orientation of highly deviated / horizontal wells and selection of perforation intervals. With the continuous improvement in understanding based on the 6 horizontal appraisal wells drilled till date, has resulted in a more robust fracture characterization / fracture modeling.