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Reducing Unconventional Reservoir Uncertainty and Optimizing Completion Design: A Multidiscipline Integration Approach for Multi-Stage Fractured Wells

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ABSTRACT

Unconventional hydrocarbon resources in ultra-low permeability, organic-rich mudrocks have recently become viable as a result of horizontal well drilling coupled with multi-stage hydraulic fracturing. Despite the success in producing from these mudrocks, there remain challenges such as hydraulic fracturing completions, well spacing and optimization of individual well recovery. An integrated study was conducted on wells targeting a Jurassic unconventional source-rock reservoir in Saudi Arabia. The objective was to reduce reservoir uncertainty, and to optimize hydraulic fracture design.

This paper provides an integrated approach for multi-discipline data integration to reduce reservoir uncertainty and optimize completion design. The study's approach illustrates integration of source rock geochemical, geomechanical and petrophysical analysis, hydraulic fracture modeling, reservoir simulation and other data acquisitions such as microseismic, chemical tracers and production logs.

Source rock geochemical and petrophysical attributes were derived from rock samples and full suites of logs that were undertaken from exploration and appraisal wells penetrating the zones of interest. Dynamic and static mechanical properties were derived from compressional and shear sonic logs. By utilizing pore pressure predicting approaches coupled with drilling events and density curves, pore pressure, overburden and effective stress were also computed. An anisotropic equation for stress was used to compute the minimum horizontal stress. The calculated pore pressure, minimum horizontal stress and static mechanical properties were calibrated by diagnostic fracture injection tests and core based measurements. These properties were used as inputs for hydraulic fracture geometry modeling. Microseismic data, when acquired with consistent fracture stimulation designs, provide a quantitative measure of fracture geometry. The microseismic are used to evaluate fracture half length, height, width and azimuth, common parameters from these acquisitions. Chemical tracers are used to assess the extent of the hydraulic fracture growth by assessing inter-well communication and comparison to microseismicity. Chemical tracer data and production logs are integrated to assess stage cleanup and contribution of each stage and cluster to optimize completion designs and set assumptions for simulation.