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Reservoir Modelling and Simulation for Thermal Oil Recovery in Fractured Karst Carbonates in Bahrain

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ABSTRACT

The Late Cretaceous Mishrif limestone is known locally in Bahrain as the “Rubble” due to extensive tectonic fracturing and karst brecciation which may have tens to hundreds of times the permeability of the tight matrix where most oil resides. As a consequence, containment of injected steam during thermal heavy oil recovery pilots is compromised, so heat transfer to viscous crude in the matrix is less efficient.

To address this challenge, 3D reservoir static and dynamic modeling is used to test various thermal processes (cyclic steam stimulation, forced imbibition, and steamflood) and design the most effective program. Two new full-field models are being built to replace older small secular models. The first one is a Petrel geocellular model utilizing simplified erosional surface truncations and fault networks to facilitate STARS simulation runs. Natural fracture orientation, density, and aperture modeling is guided by wellbore image logs and core. These fractures have porosities, permeabilities, and pressures that differ from the matrix. Representative crude and matrix thermal characteristics are applied. From this full-field model, smaller sectors are extracted to history-match the results of existing thermal pilots, design future cycles, and simulate the potential thermal recovery in other parts of the field.

The second model is a structural framework model that honors more complex fault and fracture networks, erosional truncations, and karst features interpreted in 3D seismic, well logs, and core. This model is used for understanding intra-well communication during thermal cycles and making operational decisions. It is not used for dynamic reservoir simulation.

Together, the two models help us understand the reservoir dynamics in the Rubble heavy oil formation during steam stimulation and identify the best thermal recovery processes.