Assessing Dominant Cementation Controls on Reservoir Quality for Improved Flow Characterization of a Carbonate Reservoir

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Abstract

Carbonate reservoirs are susceptible to diagenesis altering the initial texture, mineralogy, and pore-system. In general, cementation reduces the pore space, but its varying diagenetic settings and associations with multiple lithofacies put forth distinct flow behaviors. As a result, the reservoir exhibits complex porosity-permeability relationships posing challenges to reservoir quality evaluation, spatial predictions, and field development optimization. This study integrates sedimentology, petrography, and petrophysics to assess reservoir quality cementation controls. The work incorporates core descriptions, petrographic and diagenetic analyses, routine core analysis (RCA), mercury injection capillary pressure (MICP) and wireline logs to characterize the impact of cementation on porosity-permeability relationships. This scheme captures the cement's varying impact on reservoir properties by relating the cementation types, timings and frequencies to lithology, depositional textures and flow behavior in cemented intervals. The grain-dominated shoal lithofacies exhibited variable flow behaviors governed by texture, continuous mineral phase and the cementation's type, frequency and timing. Grain-dominated calcitic intervals experienced early grain dissolution and calcite cementation resulting in moldic porous intervals of low to moderate permeability. Dolomitic intervals showed enhanced reservoir properties that are relatively less affected by cement. Fabric-preserving dolomitization of the grain-dominated calcites facilitated the inclusion of intercrystalline porosity during replacement, improving the reservoir potential despite the preservation of moldic pores. Early fabric-preserving dolomitization that retained the initial grainstone rock constituents and interparticle porosity outputted excellent flow properties, even when accompanied by patchy anhydrite cements. Incomplete anhydrite cementation in interconnected, grain- or crystal-supported, dolomites lowers the porosity but retains good permeability and large throats forming good to excellent targets. Complete anhydrite cementation and intensive multiple episodes of cementation administered consistently low to nil potential. Similarly, mud-dominated intervals affected by overdolomitization exhibited a tight to microporous pore system of limited potential if not leached. Integrating diagenetic and textural analyses with petrophysical properties enhances the reservoir potential assessments across cemented reservoir zones. It resolves complex porosity-permeability relationship optimizing field planning and the exploitation of prolific zones during field development. Linkage amongst texture and the cement's diagenetic trends improves petrophysical properties placement in 3D models which may improve the history matching and reserve assessments.