Anhydrite Cemented Carbonate Shoal Rock Type in a Permo-Triassic Gas Reservoir in Saudi Arabia

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ABSTRACT

A major Permo-Triassic carbonate gas reservoir was deposited on a broad, shallow, and restricted marine platform across the Arabian plate and consists of interbedded carbonates and evaporites with episodes of minor windblown clastic influx. A recurring observation is the abundant presence of anhydrite in various forms throughout the formation. Overall, the anhydrite is present in this gas reservoir in all four habitats: nodular, pore filling, matrix replacement and cement. The shoal facies are originally an ooid grainstone with high interparticle porosity and permeability. Sequence stratigraphic studies have proposed that early diagenetic anhydrite pore cements precipitated from sulfate rich fluids that derived from stacked, cycle-capping, tidal-flat facies deposited in parasequences succeeding the shoals. This deeply buried carbonate gas reservoir produces by gas depletion drive, so as the gas is produced, the effective formation stress steadily increases. Hence, the stress dependence of the reservoir is very important to include in the reservoir model and the rock typing process. A rock-pore typing workflow has been developed for the highly variable carbonate lithology to incorporate stress effects by classifying the matrix using the continuous mineral "framework". The workflow utilizes scanning electron microscope mineral images (QEMSCAN) to determine the continuous "framework" mineralogy. To this framework is added, petrographic pore types. From the same samples, Thomeer parameters from MICP data are used to define the pore throat structures of these rock-pore types in detail. This workflow has identified a previously undetected pore system that retains permeability even at low porosity and with increasing applied stress. The anhydrite cemented dolomitized shoal interparticle pore system rock type retains more permeability at low porosity than all the other rock types and retains more permeability than its' low remaining porosity would normally indicate. The anhydrite cemented shoal rock type demonstrates a very different stress path compared to the other rock types. The early anhydrite cement of the high energy shoal grainstone dominated by interparticle porosity occludes porosity on a volume basis however the permeability deterioration is less severe.