The Effects of Hydrothermal Mineralization on Rock Properties and Reservoir Quality in Paleozoic Carbonate Reservoirs, Michigan Basin, USA

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In carbonate-dominated successions, dolostone often forms the best reservoirs. Petrologic data, T_h, T_m, and oxygen isotopes in authigenic carbonates, indicate that fracture-related, hydrothermal alteration of primary limestone mineralogy and texture was an important mechanism in forming dolostone reservoirs in the Michigan basin; the Devonian Dundee-Rogers City, Upper Silurian Bass Islands, Middle Silurian Burnt Bluff, and Middle Ordovician Trenton/Black River formations. Hydrothermal dolomite in these units occurs as baroque intergranular cement, baroque fracture/vug fill, and micro-spar replacement of primary limestone matrix. Other late diagenetic phases include pyrite; bitumen; quartz; fracture-filling, sparry calcite; anhydrite; and rare fluorite. Hydrothermal mineralization apparently resulted from reoccurring interaction of primary limestone with formation fluids of high salinity (>30 wt %) and oxygen isotope compositions ranging from -5 to -12 $\__{18}O$ (PDB) at minimum temperatures of 120^o-170^oC. Hydrothermal mineralization probably resulted from the interaction of primary limestone with high pressure/high volume brines of evaporatively modified sea water origin, which interacted with a significant heat source below the sedimentary succession in the basin. Hydrothermal mineralization in these reservoirs, including pervasive dolomitization and dissolution of primary limestone, had a fundamental impact on petrophysical properties and dolostone reservoir characteristics including extreme spatial discontinuity on a variety of scales. Hydrothermal dolostone reservoirs incorporate a heterogeneous, dual porosity system with high permeability/low porosity fracture pores and volumetrically more important patchy (vuggy), intercrystalline meso-porosity in dolostone matrix. Recognizing the fracture-related, hydrothermal origin of dolostone reservoirs provides a conceptual framework for understanding the flow properties, spatial distribution, and internal geometry inherent in these reservoirs.