Diagenetic Controls on Reservoir Character of the Lower Permian Wolfcamp and Bone Spring Formations in the Delaware Basin, West Texas

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Abstract

Understanding the impact of diagenesis on reservoir quality is key to successful production in unconventional reservoirs. Cores of basinal shales and mixed carbonate-siliciclastic deposits of the Lower Permian Wolfcamp and Bone Spring Formations in the Delaware basin were studied from four wells in Reeves and Loving County, Texas. Petrographic and fluid inclusion microthermometric analyses, supplemented with geochemical data (e.g. $\delta^{13}C$ and $\delta^{18}O$, 87Sr/86Sr, and U-Pb dates), are used to construct a detailed paragenetic sequence and interpret the diagenetic history. There is a complicated early and late diagenetic history that is highly variable depending on lithofacies and geographic location. The earliest diagenetic features were developed during shallow burial and include framboidal pyrite, concretions (calcareous and phosphatic), compactional fractures, dolomitization, and early cements. Early compactional vertical fractures, commonly filled with calcite (or rarely pyrite), can be ptygmatic to relatively planar depending on the lithology. In calciturbidites and calcidebrites, early cementation by chalcedony, chert, calcite, and dolomite cements occluded nearly all primary pore space. Later stages of diagenesis show replacement of allochems by calcite, quartz, pyrite, dolomite and/or authigenic feldspar, as well as the formation of secondary porosity due to multiple stages of fracturing and dissolution of siliceous and calcareous phases. Fractures range from vertical to horizontal and are usually filled with sparry calcite cements. Horizontal fractures filled with

calcite ‘beef’ are restricted to carbonate-rich, argillaceous mudstones and shales, whereas horizontal fractures in carbonate intervals are sealed with equant sparry calcite. The $\delta^{18}O$ values (VPDB) for calcite beef range from approximately -8.1 to -7.5‰ in one well and from –5.7 to –5.3‰ in another well, whereas the $\delta^{13}C$ values (VPDB) vary between 0.4 to 0.9‰ and 0.8 to 2.2‰, respectively. Equant calcite associated with the beef contain two-phase aqueous fluid inclusions that yield high temperatures. This suggests high temperature formation of calcite beef, but differing conditions of formation in different wells. Liquid hydrocarbon inclusions within calcite beef are found in healed microfractures that cut across the calcite fibers, indicating that they are secondary. Bitumen inclusions are primary in the beef. Thus, beef formed during a pre-oil bitumen phase. The main liquid hydrocarbon migration/generation event occurred after beef formation. Later fractures are filled with dolomite, baroque dolomite, calcite and megaquartz cements that contain primary hydrocarbon inclusions.