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Diagenesis Of The Sappington Formation, SW Montana: Insight Into Reservoir Heterogeneity In The Time-Equivalent Bakken Formation

Clayton Schultz[1], Michael H. Hofmann[2], and Marc Hendrix[2]

[1]SM Energy, Houston, TX
[2]University of Montana, Missoula, MT

ABSTRACT

The middle member of the Late Devonian-Early Mississippian Bakken Formation has been the focus of petroleum exploration and development in the Williston Basin over the last decade. Yet, the relationship between diagenesis, reservoir architecture, depositional facies, and reservoir quality has remained undocumented. Previous studies have relied on information gleaned from core and well log data, which is insufficient to provide a comprehensive understanding of the depositional and diagenetic history. This study focuses on the time-equivalent Sappington Formation, exposed across SW and central Montana and lithostratigraphically continuous with the Bakken. The excellent outcrops of the Sappington Formation in the Bridger Range, north of Bozeman, Montana, provide an opportunity to observe and quantify the influence that facies variability and stratigraphic architectures have on diagenesis. Diagenesis in the Sappington Formation is characterized by a complex paragenetic sequence that started shortly after deposition. Early dissolution of detrital feldspar created abundant secondary porosity at shallow burial depths. Subsequently, syntaxial overgrowths and illite linings formed on the surfaces of detrital quartz grains. Increased burial resulted in the precipitation of magnesian dolomite rhombs with ferroan rims, and ferroan dolomite rhombs. Later-stage pyrite and calcite cements commonly replace dolomite. Dissolution of dolomite during maturation of organic matter in the overlying and underlying shale promoted late stage dolomite dissolution and secondary porosity development. The distribution of cements in the Sappington can be linked to the primary depositional fabric, reservoir architectures, and influence from faults. Dolomite and calcite cements are most abundant in the coarsest-grained depositional facies where they occlude porosity. Conversely, well-developed illite linings are most abundant in the finer-grained facies where they inhibit abundant dolomite cementation. Clinoformal sedimentary architectural elements served to compartmentalize diagenetic fluids, resulting in large variations in dolomite cementation across clinoformal bounding surfaces. Large faults served as upward-migrating fluid conduits resulted in porosity-occluding dolomite cementation on the down- dropped side of the fault. The facies and post-depositional history between the Sappington Formation and the Bakken Formation is strikingly similar. Understanding the distribution of cements and pores within a depositional and structural framework is essential to identify and predict the best target intervals to optimize horizontal well spacing and completion design in the Bakken Formation. Integrating findings from this study to existing facies models and structural frameworks in the Bakken Formation will assist in predicting reservoir heterogeneity away from well control and enhance development strategies.