Evaluating the Controls on Reservoir Quality and Heterogeneity of Silurian Pinnacle Reefs, Michigan Basin

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A detailed sequence stratigraphic analysis of Silurian (Niagaran) “pinnacle” reefs in the Michigan Basin provides insight into the lateral and vertical variability of reservoir facies observed in the subsurface. Previous models have shown continuous reef growth during a single relative sea level rise with deposition of the Salina “A” Formations representing the end of Niagaran reef growth. In depth core analysis tied to wireline logs show that reefs consist of at least two orders of cyclicity. This sequence hierarchy is manifested by high-frequency sequences (few meters thick) driven by relative sea level variations and superimposed on large order sequences (10’s of meters thick) controlled by globally recognized sea level changes. Local changes in relative sea level are likely controlled by the combination of higher frequency eustatic variations along with subsidence and autocyclic mechanisms related to reef growth.

The higher frequency cyclicity plays a major role in controlling the vertical heterogeneity of these reservoirs. For example, reservoir quality in skeletal grainstones is related to their position within the higher frequency cycles. Grainstones deposited during transgressive phases retain higher porosity and permeability relative to those deposited in regressive phases which were prone to preferential cementation and porosity occlusion that occurs at or near cycle boundaries. In contrast, higher porosity and permeability values within the framework reef are associated with the regressive intervals and are due to exposure-related preferential dissolution and porosity enhancement, although in some reefs this porosity may be rapidly occluded by deposition of overlying evaporites. Understanding of the sequence hierarchy in these Silurian reefs provides additional insight into the episodic growth of the reefs relative to sea level fluctuations, and provides a means to better explain, and thus predict, the vertical heterogeneity observed in reservoirs.