Reservoir Characterization of Silurian (Niagaran) "Pinnacle" Reefs in the Michigan Basin

Grammer, G. Michael [1]; Noack, Amy K.[2]; Qualman, Heather [3]; Ritter-Varga, Audrey [3]; Wold, Jessica [3]; Sandomierski, Anthony E.[3]; Harrison, William B.[1] (1) Geosciences/MGRRE, Western Michigan University, Kalamazoo, MI. (2) EOG Resources, Midland, TX. (3) ExxonMobil, Houston, TX.

Silurian (Niagaran) reefs are significant hydrocarbon reservoirs in the Michigan Basin, having produced over 490 MMBO and 2.9 TCF of gas. Primary production from these reservoirs is typically low, averaging about 25%, due to the complex internal heterogeneity of the reservoir. Incorporating a detailed sequence stratigraphic framework into the reservoir characterization and geostatistical modeling of these reefs provides an enhanced understanding of the complex lateral and vertical variability of reservoir facies often observed in the subsurface, and should lead to better reservoir prediction at both exploration and production scales.

The sequence stratigraphic hierarchy within the reefs is manifested by 4th order high frequency sequences (10's of meters thick), and thinner 5th order cycles (few meters thick) resulting from relative sea level variations. Incorporating the sequence stratigraphic framework into a 3-D stratigraphic model illustrates the episodic nature of reef growth as exhibited by the stacked nature of framework reef and capping grainstones with sequence boundaries often characterized by well-developed exposure horizons. In addition to a predictable facies stacking pattern that controls vertical reservoir heterogeneity, the reef complexes show distinct differences between windward and leeward margins, illustrated in both the reef geometry and the resulting distribution of reservoir facies. Windward margins are steeper due to higher rates of aggradational growth and typically contain better reservoir quality in both the reef core and fore reef facies. In contrast, leeward margins are characterized by more gently dipping slopes made up of finer-grained facies that are of poorer reservoir quality.

The stratigraphic hierarchy plays a major role in controlling the overall quality and vertical heterogeneity of the reservoir units. Reservoir quality in reef and capping grainstones are best developed at 4th order boundaries due to extensive dissolution and resulting porosity development. Capping grainstones in 5th order cycles that are not associated with 4th order sequence boundaries, however, generally exhibit poor reservoir quality due to extensive cementation and porosity occlusion. 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 predict the lateral and vertical reservoir heterogeneity.