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Parasequence Expression in Organic-Rich Mudstones: Examples from Duvernay Formation Core in the Kaybob Area

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Sequence stratigraphy has been used as a tool to predict sediment composition and distribution away from data control in the petroleum industry for decades. As the petroleum industry's focus shifts to drilling horizontal wells in mudstone-dominated, organic-rich intervals interpreted as condensed sections, this predictive approach has been limited in its application. This is not because these depositional models break down; but instead stems from the challenge of differentiating genetically related beds and bed sets bounded by flooding surfaces in fine grained rocks due to the apparent lack of facies contrast within sedimentary units. These subtle changes in composition, diagenetic overprint, sedimentary fabric, or bioturbation intensity can be difficult to observe, often petrographic and microscopic analyses to distinguish them. When adequately documented, these heterogeneities can be integrated into a predictable genetic model, which leads to better subsurface decision making and ultimately improves resource recovery.

This study examined 58 publicly available cored wells from the Upper Devonian, Duvernay Formation in the Kaybob area. These cores were analyzed to characterize temporal and spatial sediment distribution and comparisons were made to similar-aged mudstones deposited in adjacent epicontinental basins on North America. The parasequences documented show aggradational to progradational stacking patterns as wells as predictable changes in composition, organic-richness, bed-thickness, and bioturbation. Sediment composition appears to be associated directly to lateral extent of the associated sedimentary bodies. Siliceous and argillaceous mudstones appear to be widespread with high lateral continuity and carbonate-rich mudstones tend to show more limited spatial extent, generally restricted to ~25 km away from the carbonate factory or less.

Parasequences can be correlated across the Kaybob study area, showing onlapping terminations, which suggests that bedload transport dominated the deposition of the Duvernay Formation and bottom-currents were active in transporting sediment across the basin. Using these relationships and the techniques described above, a robust sequence stratigraphic framework can be developed for the highly productive Duvernay reservoir. The results of this study provide a regional context that allows for accurate stratigraphic correlation and prediction of reservoir heterogeneities. Understanding stratigraphic architecture and parasequence boundaries helps build more accurate reservoir models, which facilitates higher precision drilling and the standardization of completion designs.