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Interpretation of Stratigraphic Sequences from Geochemical Characterization in the Horn River Shale, Middle and Upper Devonian, Northeastern British Columbia, Canada

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Abstract:

Shales are organic-rich, fine-grained sedimentary rocks capable of producing economically quantities of hydrocarbon. However, the apparent homogeneity of shales makes it difficult to recognize sedimentary facies that can be used for stratigraphic correlation and interpreting depositional processes and settings. Geochemical variation within shales provides a new methodology to better understand stratigraphic sequences.

We report here on a large suite of samples, taken at dense sample spacing from a long Horn River core, comprising Evie, Otter Park and Muskwa Formations. Samples were analyzed by ICP and ICP-MS for major, minor and trace elements and Leco and Rock-Eval analysis for organic carbon. Our focus is on proxies for: (1) redox conditions that may influence deposition and preservation of organic matter, (2) basin restriction, (3) organic productivity and (4) major element ratio Al_2O_3/SiO_2. We interpret these parameters in the context of sea level variation, which in turn leads to developing associations with stratigraphic sequences.

TOC content averages 3.25% in the Evie formation, decreases to 2.84% in the Otter Park formation, and increases to 4.48% in the Muskwa Formations. This pattern correlates to some extent with enrichment in the redox-sensitive elements Mo, U and V, suggesting that reducing conditions were related to organic carbon deposition. Organic matter accumulates preferentially during transgressive episodes.

The basin restriction proxy Mo/TOC depends on the relative concentrations of Mo and TOC. Mo concentration is determined by both redox conditions and the relative rate of resupply from the open ocean, whereas TOC concentration primarily reflects redox conditions. Low values of Mo/TOC imply the greatest degree of basin restriction resulting from sea level fall due to limited resupply of Mo from the open ocean, whereas high values suggest significant exchange with the open ocean, probably resulting from sea level rise. Mo/TOC ratio increase through the lower Evie and are relatively high at the upper Evie, decrease at the Evie – Otter Park boundary, increase slightly through upper Otter Park and is variable but slightly lower in Muskwa formation.

Statistical analysis of the inorganic geochemical data shows no correlation between SiO_2 and other elements associated with feldspars and clays. SiO_2 is strongly and inversely related to carbonate content. We interpret the SiO_2 data as a biogenic silica signal. An increasing trend upward in biogenic

silica concentration may imply an elevated organic productivity. The high TOC in Muskwa formation may be due to both high productivity and reducing conditions.

High major element ratio Al_2O_3/SiO_2 in Otter Park formation suggest that it has the highest clay content, which may indicate more clastic input during a sea level lowstand period.

We can therefore demonstrate that the geochemical variability can be used to characterize sea level fluctuations and identify systems tracts. The Evie Formation forms a transgressive-highstand system tract, the overlying Otter Park forms a lowstand system tract, and the Muskwa sequence forms the onset of a transgressive system tract.