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An integrated geochemical and petrophysical study of the Upper Devonian Duvernay Formation of Alberta: insights within a sedimentological and stratigraphic context

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Summary

The Upper Devonian Duvernay Formation is a significant unconventional exploration target in Alberta, particularly for liquids. We focus on the origin of heterogeneities in the Duvernay that are significant to the producibility of hydrocarbons. In other reservoirs, this variability may reflect variations in primary composition, diagenetic alteration, and thermal maturity. Sea level exerts a first order control on depositional processes and stratigraphic relationships in the Duvernay, which in turn are linked to mudstone composition and development of organic porosity. Establishing relationships between sea level cycles and shale porosity and permeability is an important part of our research. Shale composition exerts control over porosity and pore size distribution and the potential of the pore system to store and deliver gas. Data will be presented describing the relationships between geochemistry and pore system characteristics.

Hand samples were cut at 1m intervals and splits were cut for individual analyses. Organic matter was analyzed using Leco-TOC plus Rock-Eval. Major, minor and trace elements were analyzed using ICP-MS. Core based petrophysics included helium porosimetry, pulse decay permeability, mercury injection, BET analysis and ion milled SEM imaging.

We report here on results and interpretations from long cores in five wells across the maturity gradient, including high resolution geochemical and petrophysical datasets. Interpretations are compared to a parallel sedimentological and stratigraphic analysis, providing an unusual opportunity for independent corroboration of models. Basinal facies are generally carbonate-poor mudstones, and massive to finely laminated. Shallower water facies are more carbonate-rich, often bioturbated, and contain a higher abundance of silt-sized shell debris. TOC decreases in carbonate-rich intervals and can be unrelated to the clay content. Geochemical redox proxies indicate that deposition of TOC-rich intervals was associated with more reducing conditions. SiO_2 varies inversely with carbonate content and is interpreted to have a predominantly biogenic source.

Ion milled samples, representing a range of TOC values, were examined with field emission SEM photographs. Types and abundance of porosity varied with TOC content. The lowest TOC sample had low porosity, and pores were dominantly hosted between mineral grains. The highest TOC sample had high porosity, and pores largely occurred within organic matter. Organic matter content is highest in TST and HST deposits and increased biogenic silica creates brittle, non-fissile strata. By integrating geochemical properties and petrophysical parameters within the context of sea level, our goal is to improve the ability to identify and predict favourable locations where factors affecting production are optimized.