

Processes Influencing Kerogen Characteristics in the Oil Shales of the Duvernay Formation

NIKOLA VAN DE WETERING¹, BERNHARD
MAYER¹, HAMED SANEI²

¹ Applied Geochemistry Group, Department of
Geoscience, University of Calgary, Calgary,
Alberta, Canada T2N 1N4.

nvandew@ucalgary.ca

² Geological Survey of Canada—Calgary, 3303 33rd
Street N.W., Calgary Alberta, T2L 2A7, Canada.

The Devonian Duvernay Formation of the Western Canada Sedimentary Basin is a significant unconventional hydrocarbon play in North America, but its geochemical evolution is poorly understood. In order to better understand the organic and inorganic interactions which may control the distribution and type of hydrocarbons present, two locations were selected for high-resolution, integrated geochemical analyses on core materials. Kerogen parameters (RockEval), major, minor, trace and rare earth element concentrations (ICP-MS), and stable isotope ratios of organic matter (C), carbonate (C and O) and sulphide (S) minerals were determined and interpreted in this study. The Duvernay Formation samples are rich in kerogen Type I/II and TOC ranges from 0.15 – 6.22 wt %. Organic matter occurs as bitumens coincident with authigenic calcite and pyrite. Oxygen isotope ratios of calcites are depleted in ¹⁸O compared to Devonian sea water (DSW). O isotope ratios of dolomites are also depleted in ¹⁸O, although $\delta^{18}\text{O}$ values plot closer to the DSW range. This may indicate dolomitization resulted from and calcite precipitated from an *ex situ* fluid source. C isotope ratios of carbonates (average $\delta^{13}\text{C}$ -3.3 ‰ VPDB) do not suggest interactions with kerogens. The wide range of $\delta^{34}\text{S}$ values for pyrites (-9.5 to +16.1 ‰ CDT) indicates bacterial sulfate reduction (BSR) of Devonian sea water sulfates may have occurred within the system, though thermochemical sulfate reduction (TSR) is also possible. Post-depositional mobilisation of trace elements (V, Mo, Ni, Cu, Cd, Co, U, Th) indicates a significant increase in reducing conditions, relative to other North American shales (NASC). This reducing environment associated with relatively enriched LREE, and depleted HREE patterns, Ce* (0.8), Gd* (1.2) and Eu* (1.1), suggests coeval seawater and secondary fluid mixing. In summary, these data suggest that diagenesis during sulfate reduction is the primary contributor to elemental, isotopic and kerogen characteristics in the Duvernay Formation.