Paleoceanographic Evolution of the Late Devonian Duvernay Formation: Insights from the Geochemistry of the Western Canada Sedimentary Basin

Marilyn Wisler, Steve Dworkin, Stacy Atchley, Anna Thorson, David Yeates
Baylor University

9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

The Late Devonian Duvernay Formation contains abundant organic-rich mudrocks and is an unconventional oil and gas reservoir in the Western Canada Sedimentary Basin (WCSB). This study investigates the geochemical attributes of Duvernay Formation mudrocks in order to reconstruct paleoceanographic conditions and identify chemostratigraphic units within the two sub-basins comprising the WCSB, i.e., the East and West Basins. These stratigraphic units have distinct trace metal concentrations, TOC, and isotopic ratios that reflect deposition under awide range of paleoceanographic conditions. The goals of this study are to build a chemostratigraphic framework, determine paleoredox conditions, characterize nutrients, and enhance our understanding of the hydrographic setting during Duvernay deposition. Two Duvernay subsurface cores from both the East and West Basins (four total cores) were described and sampled at two foot intervals. Core descriptions include the characterization of facies, carbonate texture and grains, ichnofabric index, and presence of pyrite. A total of 284 samples from the cored wells were analyzed for quantification of TOC, C/N, trace and majorelements, $\delta^{13}C_{org}$, and $\delta^{15}N_{org}$. Geochemical analyses reveal the presence of five chemostratigraphic units across the WCSB. Chemostratigraphic units were primarily identified by varying concentrations of Mo, TOC, and the nitrogen isotopic composition of preserved organic matter. Three chemostratigraphic units are characterized by high TOC and Mo

enrichment and represent periods of basin-wide anoxic conditions. These anoxic units are punctuated by two interstratified oxic units characterized by low productivity and have $\delta^{15}N_{org}$ composition indicating denitrification. West Basin wells accumulated within a more basinal (siliceous and argillaceous-rich facies) setting that resulted in significant trace element (Mo enrichment factor up to 60) and TOC (up to 6 wt.%) enrichment. East Basin wells document a more open marine setting (calcareous-rich facies) with lower Mo enrichment and TOC abundance than in the West Basin. Low $\delta^{15}N_{org}$ values in preserved organic matter, averaging about 2‰ across the WCSB, indicate that nitrogen fixation was the dominant nutrient pathway. This suggests that depositional nutrient dynamics of the Duvernay Formation were controlled by coastal upwelling in an open marine hydrographic setting.