

Investigating the Role of Mineralogy on Thermal Maturity Anomalies in the Upper Devonian Duvernay Shale Oil and Gas Reservoir, Alberta, Canada

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Abstract

Thermal maturity and organic matter type are first order controls on in-situ hydrocarbon composition in shale oil and gas reservoirs. Gas-oil ratios generally increase with depth, however in the Duvernay Formation, thermal maturity and produced gas composition locally deviate significantly from the burial depth trend (Preston et al., 2016). This study presents preliminary observations of thermal maturity trends based on published data and analysis of hundreds of core samples from three wells in the West Shale Basin of the Duvernay Formation. Analysis included XRD, ICP-MS, Rock-Eval 6 pyrolysis, organic petrology, reflectance measurements, FIB-SEM, helium porosimetry, H1 NMR, and MICP. Distinct SW-NE up-dip deviations of thermal maturity and gas composition contours occur at similar orientation to and sometimes directly overlying basement structure lineaments and reef complexes, suggesting these features may have acted as conduits for heat flow upwards into the Duvernay Formation. The similarity of gas composition and thermal maturity maps negates up-dip gas migration as the main cause of gas composition anomalies. Wide intra-well variations occur in both T_{max} and bitumen reflectance (%BRo). Covariance of T_{max} and %BRo confirms that thermal maturity variations are not artifacts of low quality data. T_{max} is strongly positively correlated to biogenic silica, and drops sharply at Sequence Boundary 2 (Knapp et al., 2019), concurrent with decreased biogenic silica, TOC, and porosity, and increased carbonates and clays. Biogenic silica sourced from radiolarian

dissolution (Knapp et al., 2017) occurs as widespread microcrystalline quartz throughout the matrix, and its concentration is not related to thermal history. Biogenic silica enhances porosity and pore size in Duvernay samples by creating a load-bearing rigid mineral framework. Duvernay porosity and permeability are positively correlated (Dong et al., 2019). These observations suggest that heat may have convected laterally through strata-bound porous and permeable siliceous mudstones at some time between deposition and present day.