Exploring relationships between diagenesis and thermal maturity anomalies in the Upper Devonian Duvernay Formation shale oil and gas reservoir, Alberta, Canada

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Summary

In the Duvernay Formation shale gas and oil reservoir, gas-oil ratios generally increase with depth. However as data density has increased with continued drilling, thermal maturity and produced gas composition anomalies have been revealed (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, H^1 NMR, and MICP.

Up-dip deviations of thermal maturity and gas composition contours occur at similar orientation to and sometimes directly overlying SW-NE trending 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.

In some wells wide intra-well variations occur in both Tmax and bitumen reflectance (%BRo). Covariance of Tmax and %BRo confirms that thermal maturity variations are not artifacts of low quality data. Tmax is 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 (Knapp et al., *in press*). 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.

Acknowledgements

This work was funded by the two participating organizations: Japan Oil, Gas and Metals National Corporation (JOGMEC), and the Geological Survey of Canada. Thank you to the laboratory staff at both institutions for their analyses.

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