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Hydrocarbon Generation and Expulsion Modeling in Two Transects in the Western Canada Sedimentary Basin

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Summary

We present results of 1D and 2D basin modeling along two southwest – northeast transects in the Western Canada Sedimentary Basin. Our modeling employs detailed stratigraphy based on wells, allows lithologies to vary along the transects and uses borehole temperature, pressure and porosity data to build robust present-day geothermal profiles. Heat flow values are then modeled in geologic history to match available thermal maturity data. Kinetic parameters for Type II, Type IIS and Type III kerogens are assumed in order to predict the thermal thresholds for hydrocarbon generation and generated volumes of oil and gas

Previously publishedmodern basin modeling studies (ie. Berbesi et al., 2012; Higley et al., 2009) have been regional in scale and focused, in particular, on the source of Mannville and McMurray heavy oils and the timing of generation and migration. These studies considered several potential source rocks, including the Paleozoic Duvernay (Devonian) and Exshaw (Devonian-Mississippian) Formations, and the Mesozoic Doig Formation (Triassic), Fernie Group (Jurassic) and Mannville Group (Cretaceous). The authors identified the Fernie Group as a major and early contributor to the heavy oils, a function of the high TOC and the presence of Type IIS kerogen, which results in low temperature cracking to oil. The Gordondale and Poker Chip shale formations generated considerable oil between 80 and 75 Ma, whereas the deeper Duvernay actually generated between 68 and 60 Ma.

Our study map out variability in source rock generation at a finer scale, specifically within areas of significant shale oil development in the Duvernay Formation. Through 2D models, we test the roles that varying lithology – for example, the coeval carbonate reefs – and faults played in migration of hydrocarbons from the source rocks and the residual oil left in the shales after expulsion. Models for expelled and residual oil and gas are described in probabalistic terms through the application of Monte Carlo simulations.

Methods

The study relies on model input from data available in well files, including formation tops, lithologies, and well logs. Borehole temperatures were primarily corrected logging run temperatures, supplemented by well test temperatures. Present-day thermal conductivity models were built from lithologies and porosity data, mostly from well logs. The modeled heat flows were checked against the available high quality regional heat flow maps.

Burial histories were built in BasinMod 1D, using generally accepted stratigraphic ages and formation tops. Past heat flow histories are developed from calibration of thermal maturity data, including vitrinite reflectance, Rockeval pyrolysis and other maturation data in well files and Alberta Geological Survey reports. Multiple wells are integrated into BasinMod 2D transects, using published maps and cross-section to locate geologic structures. Assumptions of fault permeability were varied to test the effect on expulsion and migration of hydrocarbons from source rocks.

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References

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