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Geochemical characterization of source rocks at different thermal maturity levels: Application to the Triassic Montney and Doig Formations in the Western Canada Sedimentary Basin

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Summary

Geochemical characterization of source rock kinetics is widely performed by either open or closed-system pyrolysis. These experiments are usually performed on immature source rock or isolated kerogen samples to estimate the petroleum generation kinetic parameters. Here, we characterize a maturation series from the Triassic Montney and Doig Formations in the Western Canada Sedimentary Basin (WCSB), in order to investigate the evolution of the source-rock properties and their corresponding kerogen kinetic parameters as a function of the thermal maturity. Organic petrography was used to estimate the unconventional source rock properties, e.g. the thermal maturity and the type of organic matter. Rock-Eval Shale Play analyses were then applied to assess the presence of free and sorbed hydrocarbons still contained in the sample as well as the hydrocarbon generation potential. Based on vitrinite reflectance values, three kerogen samples from the Doig Phosphate Zone were finally selected for analysis of bulk-kinetic parameters (e.g. activation energy distribution, frequency factor) using programmed open-system pyrolysis for different thermal maturity levels. Additionally, we evaluated the type of hydrocarbons and determined the molecular composition of organic compounds which comprise the first two Rock-Eval peaks (Sh0 & Sh1) obtained during the improved temperature thermovaporization program. TD-GC-MS/FID analyses were carried out on rock samples from 100°C to 200 °C and then from 200°C to 350 °C in order to characterize the composition of hydrocarbons released by each Rock-Eval “Shale Play” peak. Free and sorbed low-molecular weight aliphatic and aromatic hydrocarbons ($<C_{20}$) are detected for the temperature range corresponding to the Rock-Eval “Shale Play” Sh0 parameter. Medium and high-molecular weight hydrocarbons ($<C_{30}$ aromatics and saturates) are thermally released for the temperature range corresponding to the Rock-Eval “Shale Play” Sh1 parameter. Results show both an increasing activation energy and loss of petroleum generation potential as thermal degradation proceeds. Sh0 and Sh1 parameters can be now used to estimate an early measurement of oil in place. The Shale Play method allowed here an improved separation between the generated fluids (Sh0+Sh1) and the residual kerogen (Sh2) providing a more accurate Rock-Eval T_{max}.