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The significance of light hydrocarbon geochemistry for the assessment of low-permeability reservoirs of the Montney Formation, WCSB

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Summary

Conducting geochemical correlation studies on the Montney Formation continues to be restrained by the low concentration of biomarkers in many of the unconventional gas/condensate accumulations. Such limitation not only restricts fluid-source correlation for currently producing gas/condensate fields but also makes it impossible to be compared with previous correlations established for conventional fields in the past decades (which were based on biomarker data). An approach to overcome this obstacle relies on the evaluation of low-molecular weight (LMW) compounds for geochemical assessment, as the LMW compounds occur in the entire range of liquid petroleum (crude oil to condensate). In this study, we present the distribution of selected light hydrocarbon parameters (molecular indices based on LMW components in the C_7-C_{15} range) in a regional sample set from low-permeability Montney Formation reservoirs. Additionally, we investigate the compound specific carbon isotope profiles of some of these samples and how they compare with that of the fluids from other source rocks such as the Duvernay Formation and the Bakken Formation. Liquid petroleum from Montney Formation exhibits a large variability in their light hydrocarbon properties. These parameters do not seem to be controlled by thermal maturity effects, at least not regionally. Mapping of molecular indices also shows that they do not correlate with each other and may indicate different geochemical processes. Our current stage of research opens a new path for geochemical evaluation of the Montney Formation's assets.

Method

A total of 85 liquid petroleum samples were analyzed as whole oil via gas chromatography with flame ionization detector (GC-FID). The stable carbon compound specific isotope analysis (CSIA) of 15 whole oils was performed using gas chromatography – isotope ratio mass spectrometry (GC-irMS), and the isotope ratios are expressed as $\delta^{13}C$ in ‰.

Results

The molecular parameters employed in this study include the following: (1) aliphaticity ratio C [(*n*-hexane + *n*-heptane) / (cyclohexane + methylcyclohexane)], (2) the *iso*-heptane value I [(2+3)-methylhexanes]/[(1,3-cis + 1,3-trans + 1,2-trans)-dimethylcyclopentanes] both by Thompson (1983), (3) the K1 value [(2,3-dimethylpentane + 2-methylhexane) / (2,4-dimethylpentane + 3-methylhexane)] by Mango (1987), and (4) the transformation ratio Tr2 (*n*-heptane / 1,1-dimethylcyclopentane) by Halpern (1995).

The I, C, Tr2 and K1 values vary significantly in oils and condensates from the Montney Formation. They do not correlate with each other, and their regional distribution does not show an obvious thermal maturity control. The variability in light hydrocarbons geochemistry of Montney fluids may be attributed to the Montney's nature of being a multiple-sourced petroleum system, although some variability could also be attributed to thermal alteration effects since the accumulated oil continued to evolve thermally during Montney Formation's burial. Hydrocarbon migration and phase fractionation may also affect light hydrocarbon parameters in these samples.

Correlation could be established between some produced fluids from the Montney Formation and fluids from Doig Formation and Gordondale Member of Fernie Formation source rocks according to their C and I parameters. However, 46% of the samples have much higher C and I values, which deserve consideration of additional sources for these fluids (whether they are different processes or different source rocks). The same 46% of samples also have a different K1 value than fluids from the above-mentioned sources.

The stable carbon isotope profile of *n*-alkanes from Montney fluids is distinct from that of Duvernay- and Bakken-sourced fluids. Both increasing and decreasing $\delta^{13}C$ trends with increasing carbon number are observed in Montney liquid petroleum, which is consistent with previous findings by Cesar et al. (2020).

The assessment of Montney Formation petroleum resources using light hydrocarbons geochemistry will potentially overcome the limitations experienced by previous bulk and molecular (biomarker) geochemical studies conducted for correlation purpose.

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