Geochemical trends in core, gases and produced fluids from ten fields in the Montney Formation, Canada

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Tight, fine-grained unconventional oil and gas reservoirs are currently the most heavily explored and developed hydrocarbon plays in North America. Despite intense exploration and development in these unconventional hydrocarbon plays, such as the Montney, Duvernay, and Marcellus formations, challenges persist with successful resource exploitation. In particular, there is only limited insights into the interactions of hydraulic fracturing fluids with formation water and reservoir rocks.

Within the Western Canada Sedimentary Basin (WCSB), the Montney Formation, a tight siltstone deposit, is currently the most actively produced hydrocarbon resource. In 2018, 570 wells were drilled into the Montney Formation in the WCSB, with significant recovery of gas, oil and condensate. The objective of this study was to demonstrate the usefulness of geochemical and isotopic approaches to improve the understanding of hydraulic fracturing fluid, formation water and reservoir rock interactions within the formation. Water, gas and core samples were collected from 31 horizontal Montney wells across ten fields that extend from low to high maturity areas. Isotope compositions ($\delta^{34}S_{SO4}$, $\delta^{34}S_{Bulk}$, $\delta^{18}O_{SO4}$, $\delta^{13}C_{org}$, $\delta^{13}C_{inorg}$, $\delta^{13}C_1$, $\delta^{13}C_2$, $\delta^{13}C_3$) and compositional data were obtained and interpreted to identify stratigraphic and spatial trends across the basin. Sulfur isotope results were used to decipher between introduced fracturing fluids, pyrite oxidation and formation fluids as the source of elevated concentrations of dissolved sulfate in produced water samples. Results revealed that the excess sulfate was primarily attributable to dissolution of anhydrite present in the fine-grained reservoir rock. Carbon isotope results for gas samples provided insights into out-of-zone contributions indicating locations which may be influenced by faulting in the area. A review of all isotope data indicates that while some stratigraphic trends exist (e.g. $\delta^{13}C_{org}$) the dominating trends are spatial which is congruent with the complex structural history of the area. The methodologies and resulting implications of this work can be used to refine exploration and development models for Montney Fm operators across the WCSB and are also applicable to other newly emerging unconventional resource plays.