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Hydrochemical Analysis of Lithium in the Williston Basin: Bakken and Frobisher Aquifers

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Summary

Lithium (Li) isotope ratios $^{7}Li/^{6}Li$ have proven to be beneficial in analyzing fluid flow regimes within the earth's crust with ability to trace fluid migration and aid in the understanding of complex fluid-rock interactions. The enrichment of lithium in the Williston Basin's formation waters has been studied over the past three decades, however, the cause of enrichment is not entirely understood. Given lithium's susceptibility to low temperature (<100°C) fractionation and high fluid mobility, tracing the evolution of lithium concentrations provides insight into the local and regional hydrogeologic system. (Tomascak *et al*, 2016).

Introduction

Hydrocarbon production is commonly associated with formational waters that are enriched with different chemical compounds, some reaching concentrations that are economically promising. Lithium is among the chemical elements found in these brines, and is known to occur in concentrations that may be deemed viable for lithium production (Rostron *et al*, 2002; Jensen and Rostron, 2017). Besides the economic aspect, past researchers have shown the lithium isotope ($\delta^{7}Li$) in hydrocarbon-associated brines to be useful for tracing fluid migration and deciphering rock-water interactions (Phan *et al*, 2016; Pfister *et al*, 2017). The purpose of this study is to explore $\delta^{7}Li$ values (‰ relative to LSVEC) in produced water within selected stratigraphic units of the Williston Basin (Figure 1). This will be performed by building on the current knowledge of oxygen ($\delta^{18}O$) and hydrogen (δD) isotopes that have previously been used to differentiate brines within the basin (Rostron and Holmden, 2003).

Globally published studies to date, indicate $\delta^{7}Li$ values within produced water from hydrocarbon bearing basins lie between +4.21‰ to +31‰ (relative to LSVEC), with the latter value representing the $\delta^{7}Li$ value of modern seawater (Pfister *et al*, 2017). It is believed that aquifer lithology plays an extremely important role in the development of lithium concentrations and $\delta^{7}Li$ values (Phan *et al*, 2016). To further define the water-rock interaction, samples have been collected from the lithologically different rocks of the Frobisher 'Beds' (upper units of the Mission Canyon Formation), and the Bakken Formation (Figure 2). Samples are taken from the wellhead of producing oil wells. Produced water is immediately extracted by filtration through glass wool, followed by filtration through a 0.45-micron Polyethersulfone (PES) membrane filter. Brine samples are analyzed for major ions, minor ions, $\delta^{18}O$, δD and $\delta^{7}Li$. This study aims to enhance the current knowledge of brine chemistry and offer advancements in Williston Basin hydrogeology / petroleum systems.

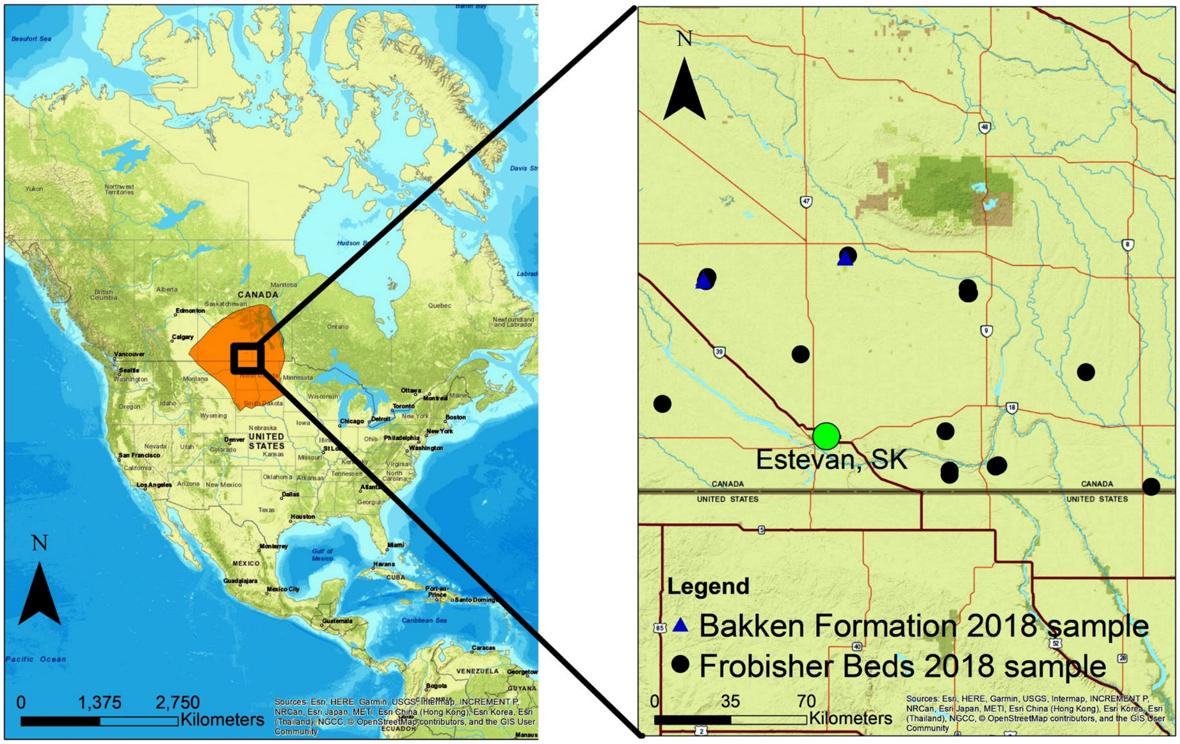

Figure 1: Williston Basin, highlighted in orange (left). Localized study area in southeast Saskatchewan with Frobisher and Bakken sample locations (right).

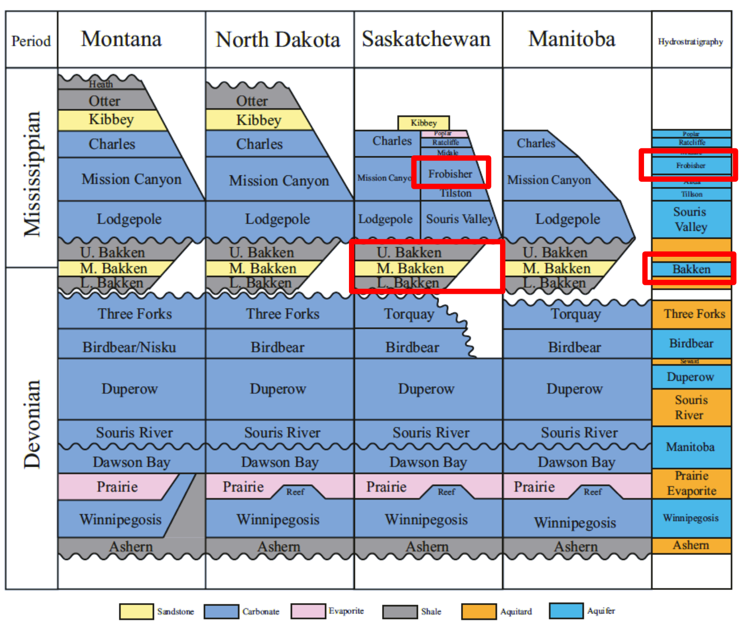

Figure 2: Stratigraphic column of the study area correlated to hydrostratigraphy. Stratigraphic units sampled in this study are highlighted in red. Modified after Skoreyko (2017).

Results and discussion

The alteration of brine chemistry after deposition can be extremely complex in sedimentary basins. To derive the origin of salinity, chlorine (Cl) and bromine (Br) concentrations are plotted along the seawater evaporation trajectory (Figure 3) (Carpenter, 1978). All samples collected from the Frobisher Beds and the Bakken Formation in this study indicate salinity derived from varying degrees of halite dissolution. This is supported by comparison of the Cl/Br and Na/Br concentration ratios relative to seawater (Figure 4) (Carpenter, 1978).

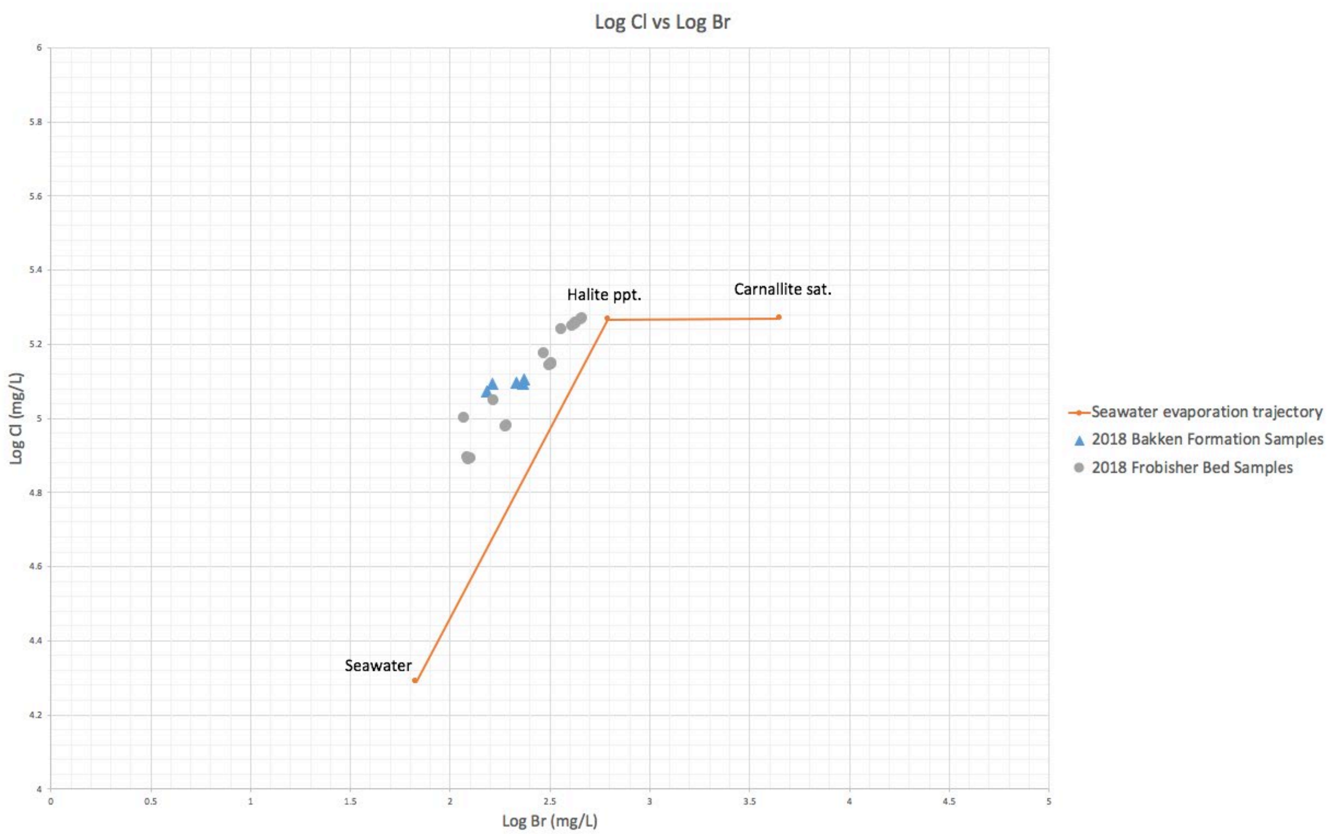

Figure 3: Log Cl vs Log Br "carpenter" diagram for all 2018 samples. Seawater evaporation trajectory modified from Carpenter (1978).

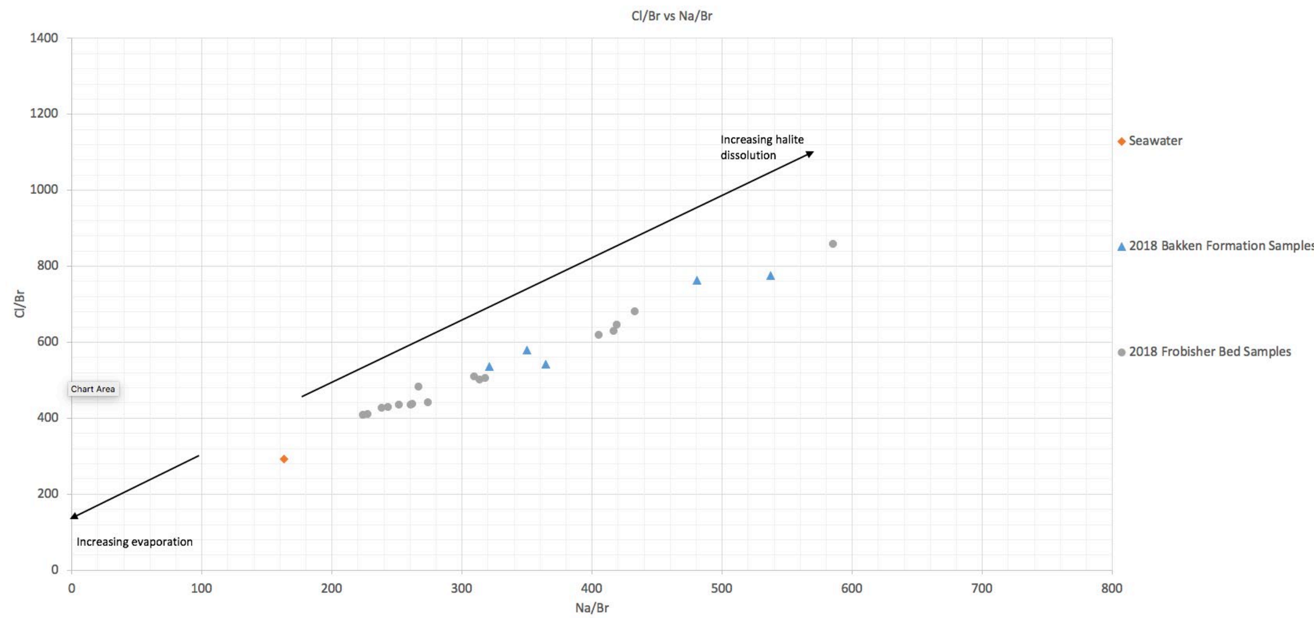

Figure 4: Cl/Br vs Na/Br ratios for all 2018 samples. Seawater modified from Carpenter (1978).

Conclusions

Lithium concentrations in hydrocarbon bearing brines present a unique economic potential along with a significant scientific importance. Stable lithium isotope values are anticipated to clarify complex subsurface water-rock interaction and aid in the identification of the provenance of the lithium.

Acknowledgements

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