Origin and Distribution of Li in WCSB brines

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Abstract

Decarbonization of the transportation sector and the transition to electric vehicles (EVs) is driving a global lithium (Li) boom, with forecasts predicting an increase in demand of up to 8x by 2040. Currently, Li is produced primarily from spodumene and continental brine deposits, with Australia, Chile, and China leading global production, however these currently discovered deposits will likely be unable to meet future demand. While Canada has a number of advanced Li exploration projects, there is only one mine currently producing Li, contributing to supply chain and mineral security concerns. This situation has resulted in Li being among six commodities prioritized in Canada's Critical Minerals Strategy. Additionally, there are numerous environmental and social issues related to increased Li production. Recovery of Li from deep basinal brines, including those from the Western Canada Sedimentary Basin (WCSB), can help alleviate these concerns by providing a new, environmentally friendly, domestic source to power the energy transition.

Elevated Li concentrations have been known to occur in brines from Upper Devonian-aged strata in Alberta since the 1990s and Saskatchewan since the early 2000s. Increased interest from the respective provincial geological surveys throughout the 2010s has spurred industrial activity through the 2020s including the drilling of wells specifically targeting Li brines and the development of pilot extraction facilities. However, unlike ore deposits and hydrocarbon systems, an exploration model for Li in these brines has not yet been developed, with the bulk of Li exploration occurring in areas where there was historical data produced by the surveys. Therefore, developing an exploration model is critical for expanding Li exploration into so far overlooked areas of the WCSB where brine data is lacking, and one of the most important factors to consider is the Li source.

In this presentation, the distribution and proposed sources of Li in WCSB brines are discussed and new geochemical and isotopic evidence from both the brines and drill core are presented. Four competing hypotheses have been suggested as the source of Li in these brines including: seawater evaporation, evaporite dissolution, contributions from the Precambrian basement, and in-situ water-rock interactions. A number of Li-enriched samples from the Duperow Formation have Na-Cl-Br signatures that indicate salinity is derived from seawater evaporation which could cause the high Li values, however this mechanism is unlikely because it would require significant evapoconcentration rates of up to 1000x modern seawater. Conversely, dissolution of Li-enriched evaporites was proposed as the source of Li in waters in Alberta, but there is a large body of research that indicates Li is highly conservative and does not readily incorporate into evaporite minerals. Alternatively, radiogenic Sr and light δ^{7}Li values coupled with the proximity of the Leduc Formation to the Precambrian basement in NW Alberta provided evidence for Li inputs from either water-rock interaction with Precambrian lithologies or hydrothermal fluids. Although this model does not explain elevated Li concentrations in the Duperow Formation which is stratigraphically distant from the basement, it does provide evidence for water-rock interactions as the dominant Li source. Geochemical and isotopic evidence from both brine and core studies in the WCSB and sedimentary basins globally indicate that Li may come from in-situ water-rock interactions with clay minerals. This is a similar mechanism which occurs

in the salars of South America, where shallow groundwaters interact with volcanically derived clay minerals enriching the waters in Li.

Constraining the Li source is only one facet involved in developing a Li exploration model. Other considerations include the release mechanism of Li from the clays, depositional environment and stratigraphic constraints, the geochemistry of the fluids, and fluid flow models. Additionally, the importance of proper sample collection and analysis to ensure consistency among studies and sites is crucial. Developing a Li exploration model is important for further understanding Li distributions across the WCSB, de-risking future exploration, and discovering new areas or stratigraphic intervals that could host economic Li concentrations. Recovering Li from brines in the WCSB could play a key role in the energy transition in western Canada by providing new employment opportunities and crucial raw materials for clean energy technologies.

Biography

Brendan Bishop is currently in the final year of his PhD program in geology at the University of Regina. His research is centred on finding and characterizing new sources of critical metals in western Canada integrating geochemical, stratigraphic, and machine learning techniques. Specifically, he is focused on developing an exploration model for lithium in basinal brines and assessing the extraction potential of rare earth elements from coal waste. Brendan completed his BSc and MSc in Earth Sciences at the University of Alberta before working as a hydrogeologist focused on regulatory and remediation projects pertaining to the Alberta oilsands prior to starting his PhD.