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Preliminary model for the generation of basinal brine-hosted lithium deposits

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Basinal brine-hosted lithium (also referred to as oilfield brine or petro-lithium) is emerging as an important new deposit type, with significant mineral resources having been discovered across North America. However, current exploration is generally limited to where fluid samples can be collected from producing hydrocarbon wells; therefore, understanding the processes which generate lithium enrichments is crucial for identifying new exploration targets. Isotopic and geochemical studies have shown that lithium is sourced from sediments, yet the processes which lead to its accumulation in brines remain uncertain.

Here, we seek to constrain the processes that govern the genesis of basinal brine-hosted lithium deposits and propose a unified deposit model based on commonalities from lithium-rich stratigraphic intervals across North America. Similar to salar deposits, we posit that lithium is sourced through diagenesis of lithium-rich, volcanically derived clay minerals. Seawater evaporation in restricted basins leads to increased ion concentrations which drive diagenetic processes at elevated temperatures, including dolomitization and illitization, which releases lithium from these clay minerals. Further, heterogeneity in both the vertical and lateral lithium concentrations across the Duperow Formation of the Williston Basin suggests that enrichments are generated at the local, rather than regional scale, with recent work highlighting that mineralogy, depositional environment, and basinal hydrogeology are also important. We propose the development of these deposits requires a confluence of processes, similar to a traditional ore deposit, which includes a suitable lithium source; favourable depositional environment, fluid chemistry, and hydrogeology; diagenesis at elevated temperature; and necessary time to allow for lithium accumulation in the brines. Ultimately, our goal is to develop an exploration framework that can utilize existing information, such drill core, geophysical well logs, and geological models, to assess the lithium potential in the absence of a fluid sample. Developing a comprehensive exploration approach is important for driving exploration to new frontiers where the lithium potential is currently unknown, such as Ordovician and Silurian sequences of the Williston Basin, or the Paradox and Michigan basins, and is thereby important for developing new supplies of this critical mineral crucial for the energy transition.