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Geochemical analysis of salt minerals in potash ores – implications on the contribution of seawater evaporation to lithium enrichment in basinal brines in the Western Canada Sedimentary Basin

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The Western Canada Sedimentary Basin (WCSB) has emerged as one of the sedimentary basins in the world that host large amounts of lithium (Li) resources in basinal brines. The basin also hosts the largest potash resource in the world, which was formed in the Devonian due to high-degree seawater evaporation. Because Li behaves conservatively during seawater evaporation, it is expected the Li concentration in evaporated seawater, which may be preserved as fluid inclusions in salt minerals in the potash ores, increases with the degree of evaporation. Salt minerals (halite, sylvite and carnallite) separated from potash ores were analyzed for trace elements, including Li and Br, with inductively coupled plasma – mass spectrometry (ICP-MS). By using the Br concentrations in modern evaporated seawater to approximate the Devonian counterpart and using the analyzed Br as proxy of fluid inclusions in halite, the Li concentrations in the fluid inclusions in halite were estimated to range from 0.76 to 13.5 (mg/g), with a median of 3.14 (mg/g). These values, interpreted to represent the Li concentrations in the evaporated seawater, are much lower than those in the Li-rich basinal brines (50 to 259 mg/g). Therefore, the evaporated seawater is not a major contributor to the Li in the basinal brines. Nevertheless, the Li concentrations in the evaporated seawater are still more than 10 times higher than that in seawater and considering the vast amount of evaporated seawater associated with the formation of the evaporites, the contribution of evaporated seawater to the Li in the basinal brines is still important. More importantly, the evaporated seawater is characterized by high K and Mg concentrations, which may facilitate Li extraction from source rocks through fluid-rock interaction, particularly illitization and dolomitization. Furthermore, the dissolution of potash minerals such as sylvite (KCl) and carnallite ($KMgCl_3 \cdot 6H_2O$), can also contribute to the high K and Mg concentrations in the basinal brines. Taken together, high-degree seawater evaporation, which results in an initial enrichment of Li, Mg and K in the evaporated seawater and facilitates Li extraction from source rocks later on, plays an important role in the enrichment of Li in basinal brines.