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Valorization of Duvernay and Montney flowback & produced water: CO_2 mineralization and lithium extraction

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Among the most active unconventional gas and light oil extractions in the world are the developments of Duvernay shale reservoirs in west-central Alberta and Montney tight sandstone reservoirs in northeast British Columbia (BC), Canada, both generating large volumes of flowback and produced water (FPW) associated with the hydraulic fracturing operations. Water chemical analyses indicate a content of total dissolved solids (TDS) between 80-345 (averaged at 191) g/L for the Duvernay FPW from Fox Creek of Alberta, and between 125-300 (average of 223) g/L for the Montney FPW from Dawson Creek, BC. While their TDS is all dominated by sodium chloride, calcium concentrations average around 12 and 17 g/L for Duvernay and Montney FPW, respectively. Magnesium and strontium concentrations range from tens to 3000 mg/L. Furthermore, lithium content ranges from 19 to 79 (average of 45.1) mg/L in the Fox Creek Duvernay FPW and from 10 to 80 (average of 57.7) mg/L in the Dawson Creek Montney FPW.

Thermodynamic and experimental investigations indicate that bivalent cations Ca^{2+}, Mg^{2+} and Sr^{2+} can be readily precipitated out as carbonates by addition of $CO_3^{=}$ reagents or CO_2 into the water at basic conditions. Further addition of CO_2 to the brines at appropriate pH level can also precipitate $NaHCO_3$ as precursor material for soda ash. Preliminary results show that CO_2 mineralization capacity is in the range of 15-89 and 23-112 kg CO_2/m^3 brine for Duvernay and Montney FPW, respectively. These CO_2 mineralization capacities are comparable to the CO_2 trapping capacity of ~47 kg/m^3 of Grand Ronde basalt (Xiong et al., 2018).

Besides CO_2 mineralization, brines after multivalent cation removal via carbonation can potentially serve as a better feedstock for direct lithium extraction (DLE) using sorbent, membrane, solvent and electrochemical technologies. Moreover, the treated brines can also be reused for further hydraulic fracturing operations with reduced risk of scale formation while maintaining the desired functionality of polymer additives.

Considering the massive amounts of oilfield brines produced in Western Canada (e.g., 469 million m^3 in 2020), integrated CO_2-mineralization and DLE practice can help the oil and gas industry turn the brines from wastewater into valuable resources.