Lower Prairie Evaporite Aquifer System underlying the Mineable Athabasca Oil Sands Area

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ABSTRACT

A regional and highly transmissive aquifer has been identified within the Devonian-aged Prairie Evaporite Formation in the Mineable Oil Sands Area (MOSA) in northeast Alberta. Through dissolution of evaporites by down-dip groundwater flow over geologic timescales, a process of dedolomitization has created a high transmissivity aquifer system (10^{-4} to 10^{-1} m^2/s) within the laminites in the lower Prairie Evaporite Formation. Flow patterns are circuitous and well scale heterogeneity is very high. However, regional connectivity has been well established, at least in a north-south direction.

Groundwater chemistry in the Prairie Evaporite aquifer system evolves along the regional flowpath from east to west, controlled by the mineralogy and dissolution history. Near the basin edge in the east, dolomite is the primary soluble mineral, and waters tend to be dominated by bicarbonate. Farther to the west, waters interact with anhydrite and are dominated by sulphate with total dissolved solids (TDS) typically in the 4 to 8 g/L range. Near the Athabasca River, the waters have a signature of halite dissolution: sodium and chloride dominance with TDS approaching 100 g/L. Stable isotopic signatures indicate recharge from the Laurentide continental ice sheet, contrasting with the warmer signature of more modern shallower groundwaters and sluggish formation waters of the deep basin groundwaters to the west. Radiocarbon data indicates residence times of approximately 5,000 to 30,000 years. The halite dissolution signature and TDS higher than the saturation limit of anhydrite (about 5 g/L) reflect either pockets of halite that are not encountered during drilling or ongoing diffusion from the lower-permeability matrix and, in the area of the Athabasca River, mixing with deep basin flow systems. Reactive transport modelling and consideration of the full data set suggests that the halite dissolution signature (e.g., higher TDS east of the Athabasca River) is due to ongoing diffusion from the lower-permeability matrix.