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Hydrogeological modelling applied to mineral exploration

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A multidisciplinary approach combining a groundwater hydrogeochemical survey and a 3D groundwater flow model was applied to unconformity-type U mineralization in the Athabasca Basin (Canada), as a new supplementary guide for uranium exploration. This approach was developed at the McClean Lake Operation site (eastern part of the basin), where several uranium deposits have already been mined and others are not yet mined. The goal of ongoing exploration in this area is to find new deposits in the vicinity of known deposits to facilitate possible future mining.

Groundwater levels were measured in 60 wells and groundwater sampling was carried out in 31 of these wells, some of these wells are screened in bedrock below the unconformity and others in sandstones above the unconformity. Among these wells, we included 4 wells located near a known ore body (SABRE sector) to better evaluate the potential of our approach to identify the presence of U mineralization.

The results show that in this study area, the U concentration and saturation index maps are not good indicators of U mineralization as U concentrations are very low for all samples due to the strong reducing conditions. However, 5 of the wells show remarkable geochemical composition: the highest total dissolved solids, high Cl concentration and strong relationships between Cl and concentrations of Na, K, Mg, Ca, Fe as well as Sr and Ba, suggesting that these ions may have come from a common source. Four of these five samples belong to the deposit of the SABRE sector, but the fifth well is located upstream of this region, far from a known ore body. A 3-D groundwater model was developed for the entire basin and the flow path ending at this well screen was traced to its source by reverse particle tracking. In the structure of the groundwater model, graphite-rich fault zones are considered the main geological structures controlling groundwater flows. The up-gradient geochemical plume deciphered from the backflows allows the identification of new exploration targets. This approach appears to be an appropriate method for prioritizing locations for future exploration drilling.