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The mixing of several regional hydrogeochemical end-members leading to continental salinisation of shallow groundwater

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In the Saguenay-Lac-Saint-Jean region, with its general physiography of graben, several studies identify brackish to saline groundwater at depths of less than 100 m. The origin of this salinity and the hydrodynamic conditions leading to groundwater salinization are a major issue for groundwater resources on which 90% of the municipal territory depends. The aim of our study was to determine the origin of these brackish to saline saline groundwater. A combined approach of isotopic analysis and 2D numerical modelling of flow and advective-dispersive transport of age was developed to explore the hydrodynamic conditions of the bedrock. The numerical results show that graben faults act as preferential pathways, favouring the upward circulation of very ancient waters. A multi-tracer approach (isotops, major and minor chemical elements) was then used to identify regional compositional end-members and propose a regional hydrogeological conceptual model. The results reveal three main sources of shallow salinity: Holocene marine water, Palaeozoic marine brine, and Precambrian brine from the Canadian Shield (age > 100 Ma) containing 1-5% mantle helium from the sub-continental lithospheric mantle. The presence of Wisconsinian glacial waters (between 8.2 and 25.5 Ka BP) and deep brines (between 7.5 and 12.5 km) circulating via graben faults is also confirmed by the multi-tracer approach. The adaptation and application of the M3 model (Multivariate Mixing and Mass balance calculations) made it possible to estimate the proportions of each of these sources. These results provide a useful basis for better understanding local hydrogeological dynamics by identifying tracers specific to end-members, which may ultimately lead to better protection of drinking water sources. Above all, the study shows the importance of considering the geological history of a given area in order to understand local hydrogeology and hydrogeochemistry.

