Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.23400

Strontium isotope ratios to decipher groundwater sources in a multi-aquifer system

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Strontium isotope ratios ($^{87}Sr/^{86}Sr$) serve as valuable tracers in elucidating liquid/solid interactions within aquifers, offering insights into groundwater composition sources. This study focuses on a complex hydrogeological setting characterized by three interconnected aquifers (granite and gneiss x sandstone x diabase), with groundwater extraction through tubular wells for drinking water supply. Here, we apply $^{87}Sr/^{86}Sr$ data to glean additional insights into groundwater origins across the wells.

The study's initial motivation was elucidating the source of dissolved uranium (~ 60 µg/L) in the groundwater from one well. We established a robust local hydrogeological conceptual model after geophysical logging, hydraulic and hydrodynamic characterization techniques with straddle packers, and groundwater sampling, followed by hydrogeochemical and isotope measurements. Our findings ascertain that dissolved uranium in groundwater originates from the weathering of crystalline rocks, while the water composition favors its solubility as calcium uranyl carbonate complexes. Furthermore, apparent groundwater ages are correlated with $\delta^{7}Li$ values, suggesting longer residence times lead to ^{7}Li enrichment. Some trace elements in the groundwater samples also helped attribute their prevalent aquifer sources.

Comparative analysis of strontium isotope ratios between groundwater samples from four wells and discrete depths within one well, alongside $^{87}Sr/^{86}Sr$ values from rock samples analogous to the aquifers, reveals insights into the local groundwater evolution. The obtained $^{87}Sr/^{86}Sr$ for the groundwaters vary from 0.718353 to 0.720002, while those of the rock samples range from 0.706306 (diabase) to 0.751781 (gneiss). The groundwater samples with lower radiogenic signals are those of the wells assigned as prevalently from the diabase aquifer. The deepest discrete groundwater sample presented the highest radiogenic $^{87}Sr/^{86}Sr$ value, and its average of three discrete samples approaches the well's open-hole sample Sr isotope composition. Remarkably, all groundwater samples expected to interact solely with the crystalline rocks exhibit much lower Sr isotope ratios than the analyzed analog rocks, hinting at some mixture with water from the diabase aquifer. These findings underscore the complexity of underground circulation in the area, necessitating additional tracers and a more intensive sampling strategy for comprehensive elucidation.