

$\delta^{88}\text{Sr}$ and $\delta^{44/40}\text{Ca}$ fractionation along groundwater flow paths in the peridotite aquifers of Oman

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Low-temperature peridotite alteration produces hyperalkaline fluids rich in calcium ions (Ca^{2+}) that are capable of sequestering large amounts of CO_2 into carbonate. The origin of the Ca^{2+} in these fluids determines the impact of this carbonate precipitation on the global carbon cycle, as there is no impact if the source rock is a carbonate, but a net uptake of CO_2 if it's a silicate. In the Oman-UAE ophiolite, this is estimated to sequester 4×10^4 tons of atmospheric CO_2 per year. However, the sources of Ca^{2+} in hyperalkaline springs, and the water/rock reactions responsible for the formation of these fluids, are still unconstrained.

In this study, variations in the $\delta^{88}\text{Sr}$ and $\delta^{44/40}\text{Ca}$ of groundwater samples were used to track the geochemical processes occurring along the water flowpath in peridotite aquifers. Together with other chemical parameters, including $^{87}\text{Sr}/^{86}\text{Sr}$, pH, [DIC], [Ca], [Mg] and [Sr], they enable the main reactions responsible for the development of Type I (Mg-HCO_3^- rich, pH < 10), and Type II (Ca-OH^- rich, pH > 10) waters to be resolved. Our results demonstrate that dolomitisation (the replacement of Ca^{2+} by Mg^{2+} in carbonate) is likely to be the main process controlling the Ca and Sr concentration and isotope composition of the fluids, via dissolution/re-precipitation in Type I waters, and cation exchange in Type II waters. Serpentinisation (the transformation of olivine and pyroxene into serpentine and brucite) is also found to play a significant role in controlling the stable strontium isotope composition of the fluids, via the mobilisation of the serpentinised peridotite matrix in Type I waters, and sorption onto brucite in Type II waters. The combined use of the $\delta^{88}\text{Sr}$ and $\delta^{44/40}\text{Ca}$ isotope systems in this manner is consequently able to discern the principle water/rock reactions that control fluid chemistry evolution through the aquifer, and demonstrates the potential of these geochemical tools for assessing the impacts of serpentinisation and carbonation reactions in natural systems.