Serpentinization of ultramafic rock: constraints from Calcium isotope signatures

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Hydrothermal activity along mid-ocean ridges is one of the major factors controlling the chemical composition of the ocean water. Here seawater-derived fluids are modified during interaction with the oceanic lithosphere, which itself undergoes significant chemical and mineralogical transformations. The chemical signatures recorded in the altered rock provide constraints on the composition and temperature of the interacting fluid, the extent of water-rock interaction, and the source and pathways of the alteration fluid. In this study, we use calcium and carbon stable isotope, as well as, $^{87}Sr/^{86}Sr$ signatures to track water-rock interaction during alteration of ultramafic rocks.

The variably serpentinized peridotites from the Iberian Margin (ODP Legs 149, 173) and the 15°20'N Fracture Zone along the Mid-Atlantic-Ridge (ODP Leg 209) show a range in $\delta^{44/40}Ca$ values between typical mantle and Cretaceous and modern seawater compositions, respectively. Variations in the $\delta^{44/40}Ca$ of the carbonate fraction and the $^{87}Sr/^{86}Sr$ signatures suggest that carbonate veins formed from seawater-derived Ca at variable temperatures. Similarly, the $\delta^{44/40}Ca$ of the silicate fraction indicates a closed system down-hole evolution of a seawater-derived fluid. This results in $\delta^{44/40}Ca_{silicate}$ values of up to 1.53‰ in samples from the Iberian Margin, which coincides with a decrease in seawater input with increasing depth as also recorded in the carbon isotope signatures. In contrast, several samples from the Santa Elena ophiolite in Costa Rica have $\delta^{44/40}Ca_{silicate}$ values below the typical mantle composition. Our results show that serpentinized peridotites cover a range in $\delta^{44/40}Ca$ of at least 0.78 to 1.53‰. These results demonstrate that the degree of serpentinization and water/rock ratios have a major impact on the $\delta^{44/40}Ca$ isotope signatures of serpentinized peridotites.