Calcium isotope fractionation in ocean ridge hydrothermal systems

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Hydrothermal circulation at mid-ocean ridges is an important source (and sink) of elements to the ocean. Temporal changes in ocean chemistry may be linked to changes in chemistry and flux of hydrothermal fluids to the oceans. We have studied the chemical and isotopic compositions (Ca and Sr) of epidote sampled from the sheeted dike section of the Cretaceous Troodos ophiolite to address the net effect of hydrothermal processes on the Ca isotopic (δ^{44}Ca) composition of the oceans.

Epidote Sr isotopic compositions are intermediate between paleo-seawater and fresh ocean ridge basalt, indicating extensive exchange between the hydrothermal fluid and host rock. Ca isotopes, in contrast, are all isotopically lighter than paleo-seawater, by up to ~1.3‰ and most samples are isotopically lighter than MORB by 0.1-0.6‰. Ca isotopic compositions are correlated with epidote Sr/Ca, similar to calcite precipitated under controlled, low temperature laboratory conditions. We interpret these data to mean that Ca isotopes undergo kinetically controlled fractionation during incorporation into the epidote crystal structure.

Preliminary modelling suggests that despite the large fractionation factor between epidote and hydrothermal fluid the δ^{44}Ca of modern hydrothermal fluids is similar to MORB, likely due to high fluid-rock ratios. Cretaceous vent fluids, however, may have been intermediate between seawater and MORB due to incomplete seawater-rock exchange, largely due to higher seawater Ca concentrations and lower Mg/Ca.

The subduction of continental crust, the origin of PO granitoids, and the evolution of the Svecofennian Shield

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Slices of felsic continental crust subducted into the mantle during collisional orogeny may either undergo metamorphism and exhumation towards the surface as coherent high pressure/ultrahigh pressure (HP/UHP) terranes or, if stalled in the mantle, melt and return towards the surface as magmas. Some exposed HP/UHP terranes contain synorogenic granitoid bodies demonstrating that both exhumation and melting occur. Therefore, crust that is not exhumed, but remains trapped in the mantle should also melt when temperatures reach the appropriate solidi through conductive heating and/or radioactive decay. The generated magmas will intrude through the overlying mantle wedge and into the continental crust to form post orogenic (PO) granitoids and possibly anorogenic granitoids (± anorthosite suites) depending on the time required to reach solidus temperatures. The melt traverse through the wedge may explain the hybrid mantle/crust nature of most PO granitoids. Subducted terranes with hydrous phases will undergo hydrate-breakdown melting. Terranes lacking hydrous phases will melt by adiabatic decompression as heated crust becomes ductile and rises diapirically. Geochemical characteristics will depend on P-T conditions, the chemistry/mineralogy of the subducted terrane (especially the presence of hydrous phases), and the degree of melt interaction (i.e. the traverse length) with the mantle wedge. The mantle component should increase with distance from the collisional suture as a tapered mantle wedge increases in thickness. The evolution of the Svecofennian Shield (Baltica) documents a change from largly slab melting during the early/mid Proterozoic Svecofennian and Gothian Orogenies to both slab exhumation and melting during the late Proterozoic Sveconorwegian Orogeny to slab exhumation without melting during the mid-Paleozoic Caledonian Orogeny. This evolution may signal a change in the behavior in subducted continental crust as a result of the secular cooling of the mantle through time.