



Oxygen isotope exchange between the ocean and the upper oceanic crust

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It has been suggested that the O-isotopic composition of seawater has stayed approximately constant over much of Earth history due to buffering by exchange between the ocean crust and seawater in hydrothermal systems. However, this model is controversial. We have undertaken a detailed study of the behaviour of O-isotopes in off-axis hydrothermal systems utilizing the lava section of the Troodos ophiolite as a study area. Different crustal sections with contrasting histories of fluid-rock interaction allow the role of environmental conditions during alteration to be investigated. Bulk-rock O-isotope compositions range from 8 to 26 per mil, averaging 16 ± 5 , and correlate with the amount of K and radiogenic Sr added to the rock during low-temperature, off-axis, hydrothermal alteration. The affect of this preferential uptake of ^{18}O into the rock on the average fluid O-isotopic composition depends on the water-to-rock ratio. Based on thermal constraints, and the C content of these altered lavas, water-to-rock ratios are predicted to be between 500 and 5000 suggesting negligible change in average fluid O-isotopic composition. Based on the assumption that carbonates precipitated from Cretaceous seawater, carbonate O isotope compositions (29 ± 2 per mil) suggest off-axis alteration typically occurred at $\leq 10^\circ\text{C}$ above bottom water temperature. We are testing the assumption that these carbonates precipitated from a seawater-like fluid using clumped isotope measurements on carbonates from the same rocks. Data collection is ongoing, but currently the data (22 measurements) give an average fluid O-isotopic composition of -1.1 per mil assuming that the carbonate grew slowly. This is remarkably similar to estimates of Cretaceous (ice-free) seawater, consistent with the interpretation that large water-to-rock ratios lead to minimal changes in fluid O-isotopic composition despite large-scale O-isotope exchange with the upper oceanic crust. Mass balance models will be presented to constrain the O-isotopic (and temperature) evolution of hydrothermal fluids during low-temperature off-axis hydrothermal alteration of the crust under different environmental conditions. A model that couples the global oxygen (isotope) and alkalinity cycles will be presented and used to test models of the secular variation in seawater O-isotopic composition.