

Triple oxygen isotopes of fluids and solids from hydrothermal systems

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The difference in $\delta^{18}\text{O}$ between Earth's oceans and upper mantle is set by the balance of high and low temperature water-rock reactions at both spreading centers and on continental crust. Quantitative models and measurements of ancient rocks indicate that the ^{18}O content of modern seawater is buffered by competing fluxes of ^{18}O -enriched hydrothermal fluid at spreading centers and ^{18}O -depleted fluids from low-temperature, off-axis basalt alteration and continental rock weathering. Such observations and models implicitly make quantitative predictions for the ^{17}O systematics of these processes. We test these predictions by making new triple oxygen isotope measurements of hydrothermal vent fluids from the East Pacific Rise and of an altered crustal section from the Cretaceous Samail ophiolite in Oman. We interpret these data in the context of a suite of simple and complex ^{17}O -enabled, time-evolving, isotope exchange models for the reaction of seawater and ocean crust.

Specifically, we observe that hydrothermal fluids from the East Pacific Rise have $\delta^{18}\text{O}$ values of 1.6–1.9‰ (VSMOW-SLAP) and $\Delta^{17}\text{O}$ values of $-0.014 \pm 0.002\text{‰}$ ($\Delta^{17}\text{O} = \delta^{17}\text{O} - 0.528 \times \delta^{18}\text{O}$ vs. VSMOW). We demonstrate that storage does not affect $\Delta^{17}\text{O}$ values because samples from 2004, 2008, and 2016 are indistinguishable within measurement error. Existing calibrations for the temperature dependence of ^{17}O exchange between silicates and water [1] suggest that these fluids equilibrated with newly-formed crust with an initial $\Delta^{17}\text{O}$ content ~0.020–0.030 ‰ higher than recent estimates of the $\Delta^{17}\text{O}$ content of the upper mantle vs. seawater, but consistent with both our simple and more complex models. In addition, we present measurements of $\Delta^{17}\text{O}$ values of both low-T and high-T altered sections of the Samail ophiolite. Results are consistent with those of previous workers [2] in that high-T and low-T alteration act in opposite directions to balance the $\Delta^{17}\text{O}$ budget of the system via hydrothermal processes.

[1] Sharp et al. (2016) *Geochimica et Cosmochimica Acta*, **189**, 105–119. [2] Sengupta & Pack (2018) *Chemical Geology*, **495**, 18–26.