Constraining the calcium cycle in hydrothermal systems

ALEXANDRA V. TURCHYN[1], FLORENCE CHEN[1], ROSALIND COGGON[2], JEFFREY ALT[3], DAMON A. TEAGLE[2]

[1] Department of Earth Sciences, University of Cambridge, Cambridge CB2 3EQ, UK
[2] Ocean and Earth Science, NOCS, University of Southampton, Southampton, UK
[3] University of Michigan Department of Earth and Environmental Sciences, Ann Arbor, Michigan USA

One of the main processes in the marine calcium cycle is hydrothermal circulation. Calcium ions enter a hydrothermal system with seawater, and within the hydrothermal system, additional calcium is released from basalt through hydrothermal alteration, which occurs as seawater reacts with basalt to drive the exchange of seawater alkalis, magnesium, calcium, carbon, and other elements. Ultimately, this means that while 10mM of calcium enters with seawater, anywhere between 20 and 40mM exits from hydrothermal vents. However, the calcium cycle within hydrothermal systems is more complicated because of the formation of calcium-bearing secondary minerals, including saponite and calcium carbonate at lower temperatures (<150˚C), anhydrite at intermediate temperatures, and calcic plagioclase, amphibole, and epidote at higher temperatures >300˚C. Constraining the sources and sinks of calcium within hydrothermal systems may help constrain the relative importance of the various weathering reactions in the oceanic crust and how these may have varied over geological time.

We present forty-three $\delta^{44}Ca$ measurements of 5.9 million year old whole rock basalts from the Costa Rica Rift that have undergone hydrothermal alteration over a range of conditions in the upper oceanic crust. The $\delta^{44}Ca$ of the altered basalts ranges from -0.18‰ to +0.28‰, and varies with crustal depth rather than chemical composition of the basalt. Based on these measurements, we present a model to quantify hydrothermal fluid flux at mid-ocean ridge axes. We also model the calcium isotopic mass balance in hydrothermal systems and demonstrate that the main sinks for calcium in hydrothermal systesm are carbonate veins and altered basalts and that major ion chemistry of the ocean plays a key role in regulating the amount of basaltic calcium leaching and carbonate vein formation in ocean crust.