

Evolving Ocean chemistry influences mineral formation in the oceanic crust

ANGUS FOTHERBY¹, EOIN WALSH¹, HAROLD BRADBURY², BEN TUTOLO³, DANIELLE SANTIAGO RAMOS⁴ AND ALEXANDRA (SASHA) V. TURCHYN¹

¹University of Cambridge

²University of British Columbia

³University of Calgary

⁴Rutgers University

Presenting Author: af606@cam.ac.uk

The formation of secondary minerals in hydrothermally altered oceanic crust has been suggested to play a key role in the regulation of ocean chemistry and the carbon cycle. However, the primary controls on secondary mineral formation remain enigmatic, and the relative influence of changes in seawater temperature, pH and the major ion balance of the ocean are unclear. Here, we present a reactive transport model of on-axis hydrothermal circulation describing how changes in temperature, pH and the major ion balance of the ocean impact carbonate and anhydrite precipitation in altered oceanic crust. The flow of seawater through the crust is modelled in a one-dimensional column of basalt rock matrix, which undergoes alteration as the fluid descends. This modelling approach focusses on diffuse fluid flow through the crust, rather than the faster flow that occurs through the fracture network. We verify the model based on modern vent fluid chemistry, then conduct a series of experiments, systematically changing the model boundary conditions to simulate changes in the chemical and physical composition of the ocean and how they impact the alteration of basaltic crust. Our model supports previous work, suggesting that changes in ocean temperature, and not ocean pH, influence the amount of calcium carbonate that precipitates in altered oceanic crust. Our results also suggest that magnesium concentration of the ocean influences carbonate mineral precipitation, with higher concentrations leading to less carbonation of the oceanic crust. The largest control on the amount of calcium carbonate that will precipitate in hydrothermally altered oceanic crust is the amount of dissolved inorganic carbon (DIC) in the ocean, suggesting more direct feedback between ocean DIC and carbonate mineralisation of the oceanic crust than via temperature, pH, or the major ion balance of the ocean. We also demonstrate that the amount of anhydrite precipitation depends strongly on the sulfate concentration of the ocean, and not on the calcium concentration, temperature, or pH.