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Does evolving ocean chemistry influence mineral formation in the oceanic crust?

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The formation of authigenic minerals in the ocean plays a key role in global geochemical cycles, allowing for elements to be removed from the hydrosphere and potentially stored in the lithosphere. One key example of the importance of authigenic mineralisation in the ocean is the formation of calcium carbonate minerals, which represents the dominant removal pathway for carbon from Earth's surface; this removal is thought to be the regulator in the thermostat that keeps Earth's climate equable and the carbon cycle balanced over geological timescales. The operation of this thermostat has long been understood to be regulated by silicate weathering on land, which delivers alkalinity to the ocean, resulting in the precipitation of calcium carbonate minerals. However, there is a growing understanding that silicate weathering of oceanic crust formed at the seafloor may operate as a second thermostat regulating Earth's climate on geological timescales.

We use a reactive transport model to explore how changes in seawater major ion concentrations, ocean temperature and ocean pH influence mineral formation in the oceanic crust, specifically calcium carbonate and anhydrite. Our modelling supports previous work in suggesting that changes in ocean temperature, and not ocean pH, influence the amount of calcium carbonate that precipitates in oceanic crust. However, our results also indicate that changing the magnesium concentration in the ocean influences carbonate mineral formation by a similar amount to changing the temperature of bottom water. Our modelling suggests that the largest control on the amount of calcium carbonate that will precipitate in the oceanic crust is the concentration of dissolved inorganic carbon in the ocean. We also show that anhydrite precipitation depends solely on the sulfate concentration of the ocean, and not on the calcium concentration, temperature, or pH. Our model indicates that changes in marine calcium concentrations have minimal impact on changes in the amount of calcium carbonate or anhydrite mineralisation in the crust, which we suggest is due to the short reaction length of calcium during hydrothermal circulation.