Phosphorus release during anoxic alteration of oceanic crust

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Phosphorus (P) is consdiered to be the ultimate limiting nutrient to primary productivity in the oceans on geological time scales and throughout Earth's history. It is well known that in oxygenated modern Earth systems, the alteration of oceanic crust efficiently removes P from solution through adsorption onto secondary Fe^{3+}-oxides. However, our understanding of the evolution of the P cycle on Earth has not sufficiently considered how different redox environments affect the P systematics of oceanic crust alteration. This deficiency has implications for our understanding of P availability on early Earth. Moreover, it also inhibits habitiability modeling of marine dominated exoplanets, which have been considered geolgoically dead due to their lack of terrestrially sourced P.

To gain a mechanistic understanding of how changes in redox conditions affect P fluxes during basalt alteration, we present P and Fe time-series concetration data from a set of crystaline basalt alteration experiments conducted in modern atmospheric oxygen concenentrations and in anoxic conditions, at 5-75° C. An intial spike of ^{29}Si to the reactant synthetic seawater solution allowed us to monitor the rate and extent of basalt dissolution with time through the decrease in the $^{29}Si/^{28}Si$ ratio. Reactant crystaline basalts were sourced from near the axis of the Juan de Fuca mid-ocean ridge.

We demonstrate increased P and Fe mobility into solution in anoxic conditions compared to oxygenated conditions. Prior to this, a clear cause and effect relationship between the formation of secondary Fe^{3+}-oxides and decreased P mobility had not been well established. These results will be coupled with XRF imaging of the reactant basalts to show the associated secondary iron-oxides. Our results suggest that in anoxic conditions, oceanic basalt alteration may be a significant source of P, which has been overlooked in our understanding of P availability throughout Earth's history. Moreover, these results have broad implications for how we think about the potential habitability of other planets.