

Seafloor Weathering as a Source of Phosphorus on Ocean-Covered Exoplanets

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On Earth, the delivery of phosphorus (P)—a limiting nutrient to biological productivity—to the oceans is controlled by the subaerial weathering of continental crust. However, P fluxes must be different on completely ocean-covered planets (“waterworlds”), where the sole potential source of P is the submarine weathering of oceanic crust. Our previous work using thermodynamic modeling to dissolve a variety of basalt-like rocks showed that dissolved P concentrations in porewater span a wide range ($\sim 10^{-9}$ to 10^{-4} mol/kg) as a function of crust lithology (e.g., calcium abundance) and the carbonate system (e.g., dissolved CO_2). While these results provide valuable insights into the geochemical controls on aqueous P, they cannot directly predict the amount of P that will ultimately be delivered to the ocean. Here, we present preliminary results on adapting a continental weathering framework to marine systems using constraints from our equilibrium modeling. This model accounts for how hydrology (e.g., porosity and flow path length) and tectonics (e.g., supply of fresh, unweathered crust) modulate the concentration of weathered products, like P. This allows us to parameterize seafloor weathering in terms of physical processes that depend on planetary properties, such as radius and mantle heat flux. We show how each variable controls the seafloor-to-ocean P weathering flux, which determines the range of possible seawater P concentrations available to support a biosphere. Ultimately, this study will place more robust constraints on waterworld nutrient availability, and therefore the feasibility of remotely detecting biosignatures (such as O_2) in the atmospheres of these exoplanets.