In-situ insights into microbially-mediated basalt weathering and metal biomineralization at active Seamounts

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Weathering reactions of basaltic glasses are driven by the large disequilibrium between highly reduced volcanic rocks and cold, oxygenated seawater. Geochemically, the biocorrosion of basaltic glasses may have a significant impact on the rates of dissolution and the chemical composition and stability of secondary phases that form, particularly if microbial activity enhances differential rates of ion exchange and precipitation.

In laboratory simulations of deep-ocean environments, we are using synchrotron-based surface-sensitive spectroscopic and scattering techniques to demonstrate that specific metabolic activities, such as Fe(II)-oxidation, Mn(II)-oxidation, or the oxidation of small-molecular weight organic carbon compounds, each produce distinct chemical profiles at the surface of volcanic glasses. By integrating long period x-ray standing waves, TR-XRF, x-ray reflectivity, x-ray diffraction and grazing-angle x-ray absorption spectroscopy, we can probe chemical transformations occurring at the microbe-mineral interface at the angstrom to nanometer scale. These laboratory experiments can be compared to 3-mo to 1-yr deployments of reactive glass surfaces at Loihi and Vailulu'u Seamounts. The "synchrotron-slabs" serve as precise sensors of (bio)mineralization reactions during crustal weathering, due to the high sensitivity and spatial resolution of the analytical techniques. Incipient alteration layers rapidly form on the surfaces deployed along the flanks of the Seamounts, providing a high-precision record of element inputs and removal from the materials that is directly dependent upon the ambient fluid chemistry and specific rates of microbial activity. For example, Mn-biomineralization processes have been directly observed in these deployments and will be discussed.