Evaluation of oxidation state and potential for bio-signatures in Fe-bearing minerals in deep-sea minerals using spectroscopic approaches

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X-ray absorption spectroscopy has proven to be a useful way of examining the chemical state of various elements in Earth materials. Iron is the most abundant redox-active element near the Earth's surface, and is particularly abundant in oceanic rocks and minerals and biological mats that occur in hydrothermal systems. Basalt is the dominant extrusive rock that comprises the ocean crust, and is approximately 10 wt % FeO, principally as Fe(II). Hydration and oxidation of basalt during water rock reactions produces clay minerals and oxides of variable composition, crystallinity, and oxidation state on the surfaces of basalt. Sulfide minerals, such as pyrite (FeS_2) that precipitate at hydrothermal vents also undergo alteration reactions that produce Fe(III) minerals. We are using XANES (X-ray absorption near-edge spectroscopy) to examine Fe-bearing rocks and minerals from the deep sea. Our objectives are two-fold: 1) test our ability to discriminate Fe(II) from Fe(III) in rocks and minerals from the seafloor; to discriminate between Fe(II) and Fe(III) we are using a new method is proposed which is usable with only ordinary levels of energy resolution, signal/noise, and energy calibration accuracy. 2) Examine the range of natural Fe(III)-bearing minerals occurring in the deep sea in order to determine if biological activity produces a distinct signature in the short- and intermediate-range order.

The Loihi Seamount microbial observatory: An extremely common deep –sea habitat for Fe-oxidizing bacteria

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Loihi Seamount is a seismically active submarine volcano that represents an emerging Hawaiian island. Hydrothermal fluids are emitted at the summit, in vicinity to the pit craters, and at more diffuse sites long the flanks of the seamount, even down to the seamount base (5000 meters). Since discovery of this seamount a prominent microbial group that has been recognized and play prominent roles in biogeochemical cycles on the seamount are the neutrophilic iron oxidizing bacteria (FeOB). FeOB habitats include the hydrothermal vents, which range in temperature from ambient (~()°C) to about 55°C presently. The composition of the fluids at Loihi is largely dictated by magmatic degassing and consequently are enriched in carbon dioxide and Fe(II) and are depleted in sulfide by comparison to other deep-seam marine hydrothermal venting habitats. Previous studies have established that FeOB play a major role in Fe oxidation and Fe oxide deposition at the site; these processes may serve as modern analogues to past major Fe oxide depositional settings. Our ongoing studies are evaluating the communities mediating Fe oxidation, the physiology of FeOB, and the biomineralogy of Fe oxides formed by FeOB. Other habitats occupied by FeOB among other microbial groups include the bare rock of the volcano itself, theollitic basalt that undergoes hydration and oxidation reactions in the presence of oxidizing seawater, and rock that interacts with hydrothermal fluids that are being emitted. Ongoing studies are looking at the biogeochemical roles epi- and endo-lithic microbial communities play in mediating water-rock alteration reactions on basalt surfaces.