SEAMOUNT HYDROTHERMAL SYSTEMS AS ANALOGIES FOR OCEAN WORLDS: REACTION PATHS THROUGHOUT THE LO'IHI SEAMOUNT (HAWAII ARCHIPELAGO)

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The Systematic Underwater Biogeochemical Science and Exploration Analog (SUBSEA) project will conduct telerobotic science of the habitability potential of Ocean Worlds by exploring hydrothermal systems on seamounts as analogs for the most common volcanic systems throughout the solar system. Our role is to conduct new geochemical models of seamount-hosted hydrothermal systems that combine water-rock alteration processes with the generation of geochemical disequilibria that can support microbial communities.

The hydrothermal fluids venting at ~50°C from the Lo'ihi seamount in the Hawaii archipelago are characterized by high concentrations of CO_2, silica, and iron, and have been shown to sustain chemolithoautotrophic communities, especially iron-oxidizing bacteria [1, 2, 3]. These fluids appear to share physical and chemical features with the proposed hydrothermal fluids of Saturn's moon Enceladus [4, 5], as well as conditions thought to prevail near the ocean-rock contact on Europa [6, 7]. Thus, investigation of possible reaction paths of sea water throughout the Lo'ihi seamount will help to assess the ability of Enceladus, Europa, and other Ocean Worlds to sustain microbial life. Simultaneously, the SUBSEA project will examine the success of integrating science, operations, and technology research objectives.

Thermodynamic modeling is performed with the EQ3/6 software package [8] using customized thermodynamic data for minerals, gases and aqueous solutes from our research group. The goals for the models are to predict fluid compositions produced over a wide variety of water/rock ratios, pressures, temperatures and fluid mixing conditions, and to use those predictions to define plausible reaction processes that can explain observations of low-temperature fluids sampled previously at Lo'ihi. The geochemical supplies of energy that can support autotrophic microbial communities along these reaction processes will also be assessed.

As an example, one reaction path leading to the measured Lo'ihi fluid composition consists in seawater reacting with alkali basalt and volcanic CO_2 at 350°C and then mixing with unreacted sea water during upwelling. The high Fe and low H_2S concentrations at Lo'ihi are explained by late-stage weathering of basalt at 50°C while the fluid maintains equilibrium with pyrite. The rollover between the Fe and H_2S concentrations is highly sensitive to the pH values, which are controlled by the extent of basalt weathering and by the inputs of volcanic CO_2. This low-temperature reaction step appears to be critical for the support of iron-oxidizing microbes. In addition, given the kinetic blockings that can be expected in the precipitation of pyrite at low temperature, the dramatic rollover between Fe and H_2S may require catalysis that could be represented by microbial activity in the subsurface. In contrast, seafloor weathering of basalt at or near the temperatures of active venting (20-50°C) produces fluid compositions that lack most of the attributes of Lo'ihi fluids other than those inherited directly from seawater.

This computational walk around the Lo'ihi seamounts will help guide actual exploration in September 2018, which, in return, will allow tests of various model scenarios. Calculations are rapid enough to be implemented in real-time in telerobotic science, which will also test their applicability to assess the potential for hydrothermal systems on Ocean Worlds to sustain microbial life.

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