Forward geochemical modeling as guiding tool for seafloor exploration

V. MILESI[1*], E. SHOCK[1**]

[1]GEOPIG, School of Earth and Space Exploration, Arizona State University, [*]vmilesi@asu.edu, [**]eshock@asu.edu

As planetary exploration looks toward icy moons, geochemical modeling can offer an effective way to constrain decision making processes during exploration, by enabling the forward mapping of rock alteration, fluid compositions and chemical energy supporting microbial communities thriving in extraterrestrial hydrothermal systems. As part of the SUBSEA project, we performed forward modeling to provide a guiding tool for the exploration of the Lo'ihi seamount (Hawaii) in 2018, seen as analog of the low-temperature (50-200°C) hydrothermal systems which may populate the seafloor of the Saturn's icy moon, Enceladus.

The 20-50°C fluid venting at Lo'ihi are characterized by high Si, Fe, CO_2 and CH_4 concentrations and H_2 and H_2S below detection limit (SUBSEA team) [1]. Our forward modeling includes 900 reaction paths chosen to vary the temperature maximums (50 to 400°C), amounts of reacting rock, gas inputs, and extent of water-rock reactions as the high temperature fluid mixes with seawater during its upwelling to the seafloor.

Whereas the concentrations of major cations and sulfate in the fluids venting at seafloor are controlled by mixing with seawater, pH and silica concentrations are correlated with the maximum reaction temperature (Fig. 1). The high Fe^{2+} concentrations, known to support iron-oxidizing microbial communities at Lo'ihi, results from the shallow alteration of basalt at low temperature.

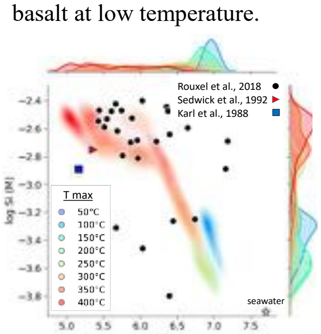

Fig 1. Modeled Si and pH compositions of 30-40°C fluids venting at Lo'ihi.

Preliminary calculations assuming non-equilibrium chemistry indicate that the chemical energy available for microbial metabolisms depends on the maximum reaction temperature and the extent of mixing. As the silica concentration is also function of these two parameters, it could serve as indicator for actively exploring biological communities thriving on Earth and extraterrestrial hydrothermal systems.

[1] Karl D.M. et al. (1988) Nature, 335(6190), 532.