Network analysis on geochemical and biological signatures from Cerro Negro volcano and implications for life on ancient Martian

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Volcanic craters observed by Martian rovers and orbiters have revealed that ancient Mars experienced global volcanism. Among these observations, acid-sulfate altered Martian basalts indicate past hydrothermal activity, adding to the inventory of potentially habitable environments early in Mars' history. To study the habitability of such systems, we used the Cerro Negro Volcano, Nicaragua as an analog for a steam-driven, acid-sulfate, hydrothermal system.

Sampling of fluids, gases, minerals and endolithic microbiomes have yielded both geochemical and biological data from 22 sites around the volcano. Geochemical data includes both temperature from the sediment layers (45-96˚C) and pH of condensed steam (<1 to 5). More than 40 types of minerals were identified. Biological data consists of amplicon sequencing of PCR-amplified 16S rRNA genes of the microbial communities, primarily endolithic communities. These were used to characterize the diversity of microbial communities across sites with variable geochemical and mineralogic attributes. In addition to phylogenetic classification, the general attributes (e.g. thermophile, chemoautotroph, or phototroph) of abundant species were inferred from closely related isolates.

Combining geochemical, phylogenetic, and metabolic/physiologic data together, we use both traditional statistical methods and novel algorithms (e.g. network analysis) to identify correlations of the geochemical and biological signatures. Preliminary results indicate that pH could be one key environmental parameter that differentiates microbial communities. The network analysis results suggest several distinct bacterial community types that are each represented at several locations across the hydrothermal system. Understanding the environmental driving forces for each of these community types will delineate the potential for habitability for similar environments on ancient Mars.