

ENDOLITHIC MICROBIAL COMMUNITIES IN A MARS ANALOG ACID-SULFATE FUMAROLE SYSTEM. K. L. Rogers¹, T. M. McCollom² and B. M. Hynek^{2,3}, ¹Earth and Environmental Sciences, Rensselaer Polytechnic Institute, Troy, NY 12180 (rogerk5@rpi.edu), ²Laboratory for Atmospheric and Space Physics, University of Colorado, ³Department of Geological Sciences, University of Colorado.

Introduction: Early in Mars' history liquid water and volcanic activity likely led to the widespread occurrence of fumaroles, and such systems were likely dominated by acid-sulfate conditions [1,2]. In similar environments on Earth, low pH, steep temperature gradients and diminished water and nutrient availability constrain habitability. However, fluxes of volcanic gases and the abundance of minerals with redox sensitive elements that can serve as metabolic constituents hold the potential to sustain chemotrophic microbes in these systems. In the terrestrial Mars analog at Cerro Negro volcano, Nicaragua, are fumarole systems that range in pH from <0 to ~6 with temperature up to ~450 °C. In the more moderate zones of these systems (<75 °C, pH 4-6), we have discovered several occurrences of endolithic microbial communities that contain both chemotrophic and photosynthetic primary producers as well as anaerobic and aerobic heterotrophs. Here we report on the phylogenetic and metabolic diversity of these communities and outline a metabolic model for putative analog communities on early Mars.

Geologic Setting: At Cerro Negro volcano fresh basalts with compositions similar to martian basalts are being altered by acidic, S-rich fumaroles. During several field campaigns we have identified two populations of alteration environments [e.g. 3]. Focused venting sites have high temperatures (100-450 °C), steep temperature gradients, low pH (-1 to 1), and show rapid alteration of fresh basalt to secondary mineral assemblages dominated by elemental sulfur, silica and occasional gypsum. More moderate sites (50-100°C, pH = 4-6) are characterized by diffuse venting, slower alteration, and more diverse secondary mineralogy including gypsum, amorphous silica, additional Al, Fe, and Mg sulfates (alunite, jarosite and kieserite), as well as goethite and hematite. The latter sites are more aerially extensive and represent the majority of the habitable hydrothermal niches in the system.

Endolithic Microbial Communities: While low pH and steep temperature gradients limit the extent of habitable niches near focused vent sites, endolithic microbial communities are common in the more moderate diffuse venting sites. These endolithic communities are found 0.5-2cm inside silica and gypsum alteration crusts and often mark the boundary between exterior crust and the interior altered regolith. Previously, we reported an endolithic microbial community dominated by thermoacidophilic phototrophs and a variety

of bacterial and archaeal heterotrophs within a silica crust at a single diffusive vent site [4,5]. Additional 16S rDNA phylogenetic analyses at four distinct diffusive vent sites have revealed endolithic communities with variable phylogenetic, but similar metabolic structures. In three of these locations primary production is dominated by photoautotrophs consisting of both Cyanobacteria and some acidic red algae. In locations where photosynthesis is limited by environmental conditions bacterial and eukaryotic phototrophs are replaced by facultative archaeal chemoautotrophs, including *Sulfolobus* and *Metallosphaera*. Chemoheterotrophs are dominated by thermoacidophiles, including members of *Acidobacteria*, *Acidophilum* and *Thermoanaerobacter*. S- and Fe-oxidizing lineages are also common throughout these communities. Anaerobic and aerobic chemoheterotrophs compete for organic carbon as variations in venting lead to microniches that confer physiologic and metabolic advantages to each group. Differences among these communities appear to be correlated with vent temperatures, however alteration mineralogy may also reflect additional geochemical constraints as well as preservation potential. Finally, many of the microbial lineages identified in the Cerro Negro endoliths have no cultured representatives at the *in situ* temperature and pH conditions, suggesting that the Cerro Negro fumaroles host novel lineages that could be unique to these environments.

Implications for Mars habitability: Extensive volcanism, high heat flow, and abundant liquid water on Mars early in the planet's history would have given rise to abundant, long-lived hydrothermal systems. In the terrestrial analog at Cerro Negro volcano, similar environments characterized by acid-sulfate fumarole systems host widespread endolithic microbial communities. These microbial communities can serve as a metabolic model for similar environments at Mars. Furthermore, geochemical parameters that affect habitability and are recorded in alteration mineralogy can be used to differentiate martian environments with respect to their habitable potential as well as the potential for biosignature preservation.

References: [1] Gendrin A et al. (2005) *Science*, 307, 1587-1591. [2] Murchie S.L. et al. (2009) *JGR*, 114. [3] Hynek B M et al. (2013) *JGR*, 118, 2083-2104. [4] Rogers K L et al. (2011) AGU Fall Meeting, Abstract P33B-1768. [5] Rogers K L et al. (2014) AGU Fall Meeting, Abstract P32A-02.