INVESTIGATION OF A MARS-ANALOG BASALTIC SUBSURFACE LAVA TUBE ENVIRONMENT. A. C. McAdam[1], C. N. Achilles[1], D. M. Bower[1,2], C. B. Fishman[3], M. Millan[1,3], S. S. Johnson[3], M. Napoleoni[4], C. A. Knudson[1,2], M. Weng[3], J. E. Bleacher[1], R. D. Arevalo[5], M. Musilova[6,7,8], and K. E. Young[1], [1]NASA/GSFC, Greenbelt, MD 20771, Amy.McAdam@nasa.gov, [2]CRESST, Univ. of Maryland, [3]Georgetown Univ., [4]Freie Universität Berlin, [5]Univ. of Maryland, [6]International MoonBase Alliance, [7]Inst. of Robotics and Cybernetics, Bratislava, Slovakia, [8]Slovak Organisation for Space Activities (SOSA), Slovakia.

Introduction: Surface lacustrine or fluvial sediments are often targeted for detection of potential martian biosignatures, but subsurface areas may also host habitable environments and support biosignature preservation. Subsurface environments, such as lava tubes, can provide more stable conditions than surface environments and lessen radiation exposure. A fuller understanding of lava tube habitability and microbiological metabolisms may inform our interpretation of biosignatures, such as microbially-mediated mineral deposits and/or the products of respiration. Sample mineralogy can also provide insights into the environment inhabited by the microbes or which preserved biosignatures through time (because minerals can provide constraints on the fluids involved in their formation, e.g., pH, temperature, salinity). Also, astronauts may one day use lava tubes as a resource, making it useful to evaluate their biological potential or other properties that could affect human exploration.

Description of field site: The studied lava tube is located on the north flank of the Mauna Loa volcano in Hawai‘i. Our work at this site is a collaboration between the Hawai‘i Space Exploration Analog and Simulation (HI-SEAS [1]) team (the HI-SEAS station is located near the lava tube) and two GSFC groups, the Goddard Instrument Field Team and Fundamental Laboratory Research. The basalts and lava tube are very young (~200 years old) and at ~8,000 foot elevation away from direct input from ocean aerosols. The tube is intermittently exposed to acidic aerosols from the Kïlauea volcano and from past lava flows emplaced adjacent to the tube. Interactions with volcanic aerosols are a commonly discussed mechanism for acidic alteration during parts of martian history [e.g., 2,3].

Methods: We are carrying out a geochemical, mineralogical, and microbiological study of rocks, water samples, coatings, and other alteration features in the lava tube. In the field, features were interrogated with portable instruments to assess in place mineralogy and chemistry. These included handheld X-ray fluorescence (XRF), handheld Laser Induced Breakdown Spectroscopy (LIBS), and portable Raman spectroscopy. These instruments bear similarities to those on current, or proposed for future, missions (including possible future crewed missions) facilitating application of our results to mission data interpretation. In addition, samples were collected for laboratory analyses including X-ray diffraction (XRD), evolved gas analysis mass spectrometry (EGA-MS), pyrolysis gas chromatography mass spectrometry (pyro-GCMS), 16S rRNA gene and metagenomic sequencing and inductively coupled plasma mass spectrometry (ICPMS) analysis of tube waters. The light level at each location was noted (full sunlight, dim sunlight, or darkness) since this may affect microbial populations.

Preliminary results: Raman, XRD and EGA-MS data, together with chemical data from XRF and LIBS, have indicated a variety of minerals including Na, Ca and Mg sulfates, carbonates, basaltic primary minerals, and amorphous material. ICPMS results so far show variations in water chemistry throughout the tube. Raman, pyro-GCMS and EGA-MS indicate a variety of organic compounds. Raman data have indicated microbial pigments, amino acids, fatty acids and organo-metal complexes. Pyro-GCMS has indicated hydrocarbons, polycyclic aromatic hydrocarbons, N- and O-bearing organics, and smaller amounts of S-, Cl- and P-organics. Alkanes/alkenes detected are likely decomposition products of fatty acids, and other potential organic biosignatures were also observed. Assessment of bacterial diversity has indicated that Proteobacteria and Actinobacteria are significant but a variety of aerobic and anaerobic microbes were also identified that play roles in C, N, and S cycling. Heat- and radiation-tolerant microbes and pathways for sulfate reduction and methanogenesis were also found.

This work aims to inform alteration mechanisms, microbe-mineral associations and microbial metabolisms in this Mars analog environment. The results will be timely given current interests in potential subsurface martian habitats [e.g., 4], have implications for habitability, astrobiology, and life detection approaches on Mars, and shed light on the conditions for sustaining life in young subsurface basaltic terrains. In addition, this study can provide information relevant to human exploration or use of lava caves on Mars.

Acknowledgments: Support for this research was provided by NASA’s PSD Research Program.

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