SENSING BIOSIGNATURES WITHIN ROCKS OF THE ATACAMA DESERT - AN ANALOG FOR MARS ENVIRONMENTS. T. J. Gnanaprakasa[1,2], K. Domanik[1], J. DiRuggiero[3], T. J. Zega[1,2 *]. [1]Lunar and Planetary Laboratory, The University of Arizona, Tucson, AZ 85721, United States [2]Department of Materials Science and Engineering, The University of Arizona, Tucson, AZ 85721, United States [3]Department of Biology, Johns Hopkins University, Baltimore, MD 21218, United States. (*tzega@lpl.arizona.edu)

Introduction: With the potential for a Mars sample return mission and the task of analyzing mineralogical samples for traces of biologic activity, it is essential to improve our knowledge of terrestrial analogs. Particulary important is how to distinguish biologically induced structure and organization patterns from inorganic phenomena. Biosignatures are the remnants of organisms, their macromolecules, and evidence of their metabolic activities. They are morphological, chemical, structural, and isotopic traces of organisms preserved in minerals, sediments, and rocks [1].

We have been investigating potential biosignatures and mineral microstructure alteration of rocks from the Atacama Desert in Chile. These materials represent Martian analogs and are known to contain colonizing bacteria [2]. Understanding the microstructural and crystal-chemical effects of bacterial colonization of these rocks could provide a useful reference for similar investigation of Martian rocks.

Samples and Analytical Methods: Two mineral substrates – ignimbrite and gypsum – from the Atacama Desert were analyzed for bacterial colonization. The samples were embedded in an epoxy resin and polished smooth to reveal regions of bacterial colonization in the pores within the minerals. Optical analysis was performed on a Leica DMI6000 multifunctional motorized inverted microscope, which can capture 5 megapixel color brightfield images through a Leica DCF450 camera. The microscope had fluorescent filter cubes for dyes such as DAPI (excitation wavelength: 320-400 nm), FITC/GFP (excitation wavelength: 440-520 nm), Rhodamine (excitation wavelength: 535-557 nm), and CY5 (excitation wavelength: 560-680 nm). The samples were analyzed across a range of excitation wavelengths to investigate the wavelength range at which we obtain autofluorescence. The images were captured and analyzed using the proprietary Leica LAS-AF software.

Microorganisms can induce natural fluorescence, most commonly called autofluorescence; which is the intirinsic fluorescence of bacterial cells without added dyes, and has been shown as a powerful tool for the detection of bacteria in environmental or industrial microbiology [3]. We adopt this phenomena to detect the presence of endolithic microbial organisms within the minerals.

To compliment our research work, the ignimbrite and gypsum samples were analyzed using an Electron Microprobe (Cameca SX-50). The X-ray maps showed the presence of Si, Mg, Ca, Fe, Na, Al, K, Ti, P, and S. Changes in microstructure between the colonized and non-colonized regions was also investigated using a FEI Helios Nanolab 660 focused-ion-beam scanning electron microscope (FIB-SEM), equipped with an EDAX energy-dispersive spectrometer (EDS).

Results and Discussion: Fluorescence microscopy analysis revealed the presence of endolithic bacteria within the pores of the mineral. The colonization was clearly visible when the CY5 filter with an excitation wavelength of 560 – 680 nm (short IR region) was used. Electron Microprobe analysis and data from X-ray mapping reveal the presence of Si, Mg, Ca, Fe, Na, Al, K, Ti, P, and S within the mineral deposits, with Ca and S deposits along the region where there was colonization. Scanning electron micrographs (SEM) clearly show morphological differences between the colonized and non-colonized regions. Here, the colonized regions showed a vesicular structure with ‘cocci-like’ particles. These particles were found to be bacterial colonization after correlation of the SEM micrographs with fluorescence microscopy images. Non-colonized regions show a smooth surface morphology. Continued investigation will reveal whether these signatures are unique to these samples or more broadly applicable to rocks from hyperarid regions.

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