Morphological and Spectral Characteristics of El Tatio Sinter Nodules. V. Gulick[1], N. W. Hinman[2], N. A. Cabrol[1], K. Warren-Rhodes1, and S. L. Cady[3], [1]NASA ARC/SETI Institute, NASA Ames Research Center, MS 239-20, Moffett Field, CA 94035, [2] University of Montana, Missoula, MT, [3]Environmental Molecular Sciences Laboratory, Pacific Northwest National Laboratory, Richland, WA, Contact: Virginia.C.Gulick@nasa.gov.

Introduction: El Tatio is the third largest geothermal center on Earth (22.33°S; 68.01°W). The hot spring and geyser system forms siliceous sinters that co-precipitate with evaporative salts, iron oxides, and more exotic accessory phases [1].

Active opaline silica-depositing hydrothermal ecosystems preserve fossil information with high morphological and chemical fidelity. Therefore, they can be used as analogs to test *in situ* and lab life-detection strategies. Recently, Ruff and Farmer [2] compared "digitate sinters" from El Tatio with deposits At Gusev Crater on Mars that display a similar morphology. Their work illustrated the potential importance of silica-preserved biosignatures in briney hot spring systems. In 2016, members of the SETI NAI team took a field expedition to El Tatio to observe the impacts of high, dry, UV-intensive conditions on the preservation of biosignatures (see [3]).

Mineralogy and Crystal Habit: Our subsequent laboratory based analysis of "digitate sinters" that we collected from El Tatio indicates that the samples are comprised primarily of different silica mineraloids, defined by their initial porosity and their appearance pre/post silica infilling, which include white, glassy, sometimes porous opaline silica; beige, often porous opaline silica with a typical matte luster, and a "dirty-looking" white porous sinter that contains the majority of the fine-grained detrital material. Evaporite minerals, including salt crystals and acicular needles of gypsum (on the order of tens of microns in diameter), were found as crystals that precipitated on the surfaces of the sinter. The habit of these crystals indicates that they were formed abiotically during episodic evaporation, as the acicular crystals grew perpendicular to the sinter surface, regardless of crystal orientation, and the salt crystals were admixed into the opaline silica matrix, which also formed abiotically. The crystal morphology of the evaporates also contributes to some of the porosity observed in the massive opaline sinter deposits. The detrital material in the sinter ranged in size from small, windborne grains to larger grains that likely were suspended and delivered by water flowing in the outflow channel of the hot spring. The sinter also contained small amounts of accessory minerals.

Microbial Community: A filamentous sheathed cyanobacterium (Calothrix) dominated the green-pigmented filaments, typically forming clumps and colonizing surfaces. Clumps of cells developed on the sinter surfaces and via trapping. Exogenous clumps were identified by filament orientation and distribution, whereas endogenous clumps formed when a filament adhered to the surface, replicated, and spread.

Laser Raman Spectroscopy: Laser Raman Spectroscopy (LRS) was performed on the sample. Mineral assignments and organic signatures varied over the surface and between the exposed surface and the underside of the sample. Gypsum and organic compounds, possibly beta-carotene, have been identified.

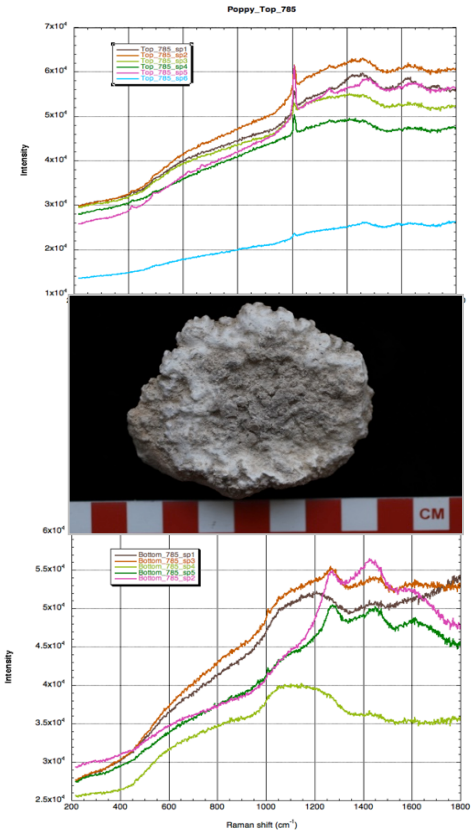

Figure 1: *Transect of Raman spectra through sample.*

References: [1] M. Garcia-Valles et al. (2008) *American Mineralogist 93.* 1373-1383, doi: https://doi.org/10.2138/am.2008.2583. [2] Ruff and Farmer (2016) *Nature Communications, 7,* doi:10.1038/ncomms13554. [3] Cabrol et al. (2017) *AbSciCon 2017*, this meeting.

Acknowledgments: This work funded by the NASA Astrobiology Institute (NNX15BB01A and NNA15B061).