MORPHOLOGICAL AND SPECTRAL CHARACTERISTICS OF EL TATIO SINTER NODULES

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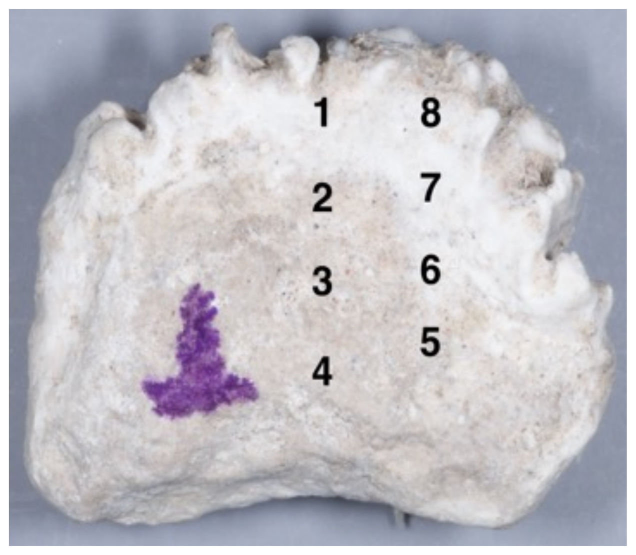
Introduction: El Tatio is the third largest geothermal center on Earth (22.33°S; 68.01°W). Located in the Andes of Northern Chile, at over 4300 meters above sea level, it is among the highest elevation geothermal systems in the world. The hot spring and geyser system forms siliceous sinters that co-precipitate with evaporative salts, iron oxides, and more exotic accessory phases [1].

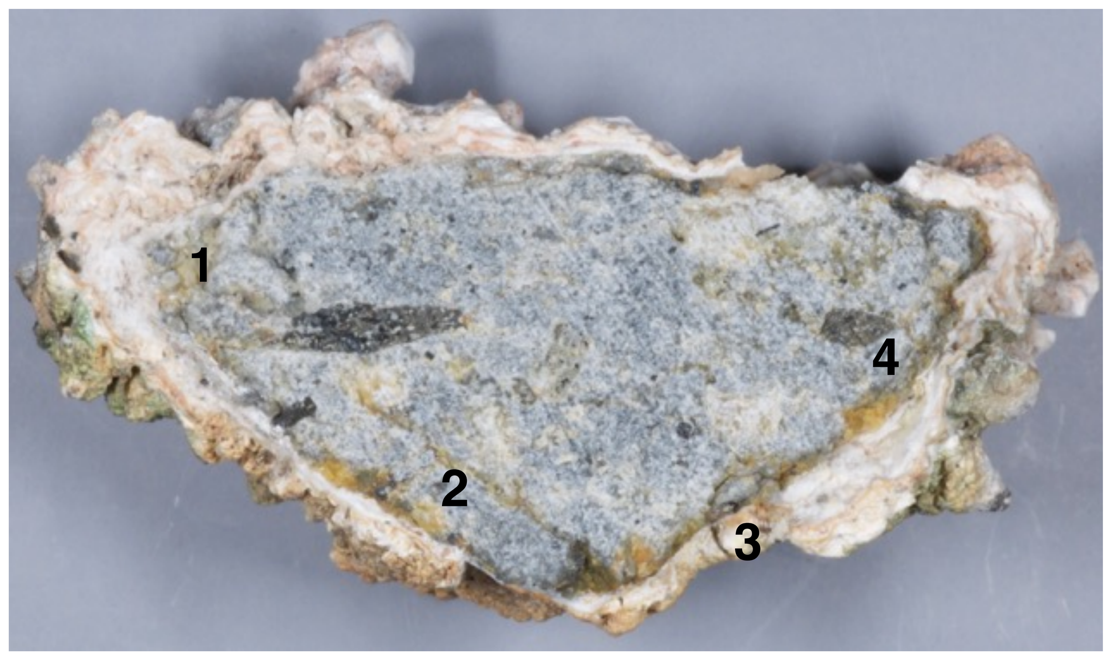
Active opaline silica-depositing hydrothermal ecosystems preserve fossil information with high morphological and chemical fidelity. Therefore, they can be used as analogs to test in situ and lab life-detection strategies. Recently, Ruff and Farmer [2] compared "digitate sinters" from El Tatio with deposits 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 [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, approximately tens of microns in diameter, precipitated as crystals on the surfaces of the sinter. Their crystal habit 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 the porosity in the massive opaline sinter deposits. The detrital material in the sinter ranged in size from small, wind-borne 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.

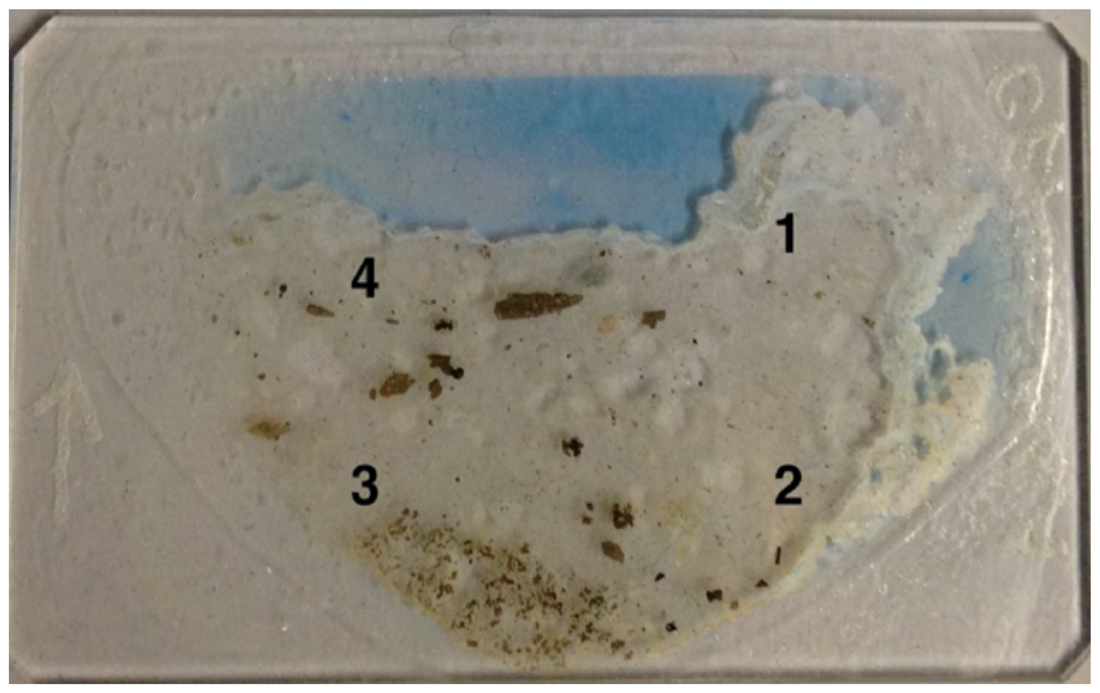
Microbial Community: A filamentous sheathed cyanobacterium (Calothrix) dominated the green pigmented filaments, typically forming clumps and colonizing surfaces. Clumps of cells developed on the sinter surfaces and via trapping. Exogenous clumps were identified by filament orientation and distribution,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



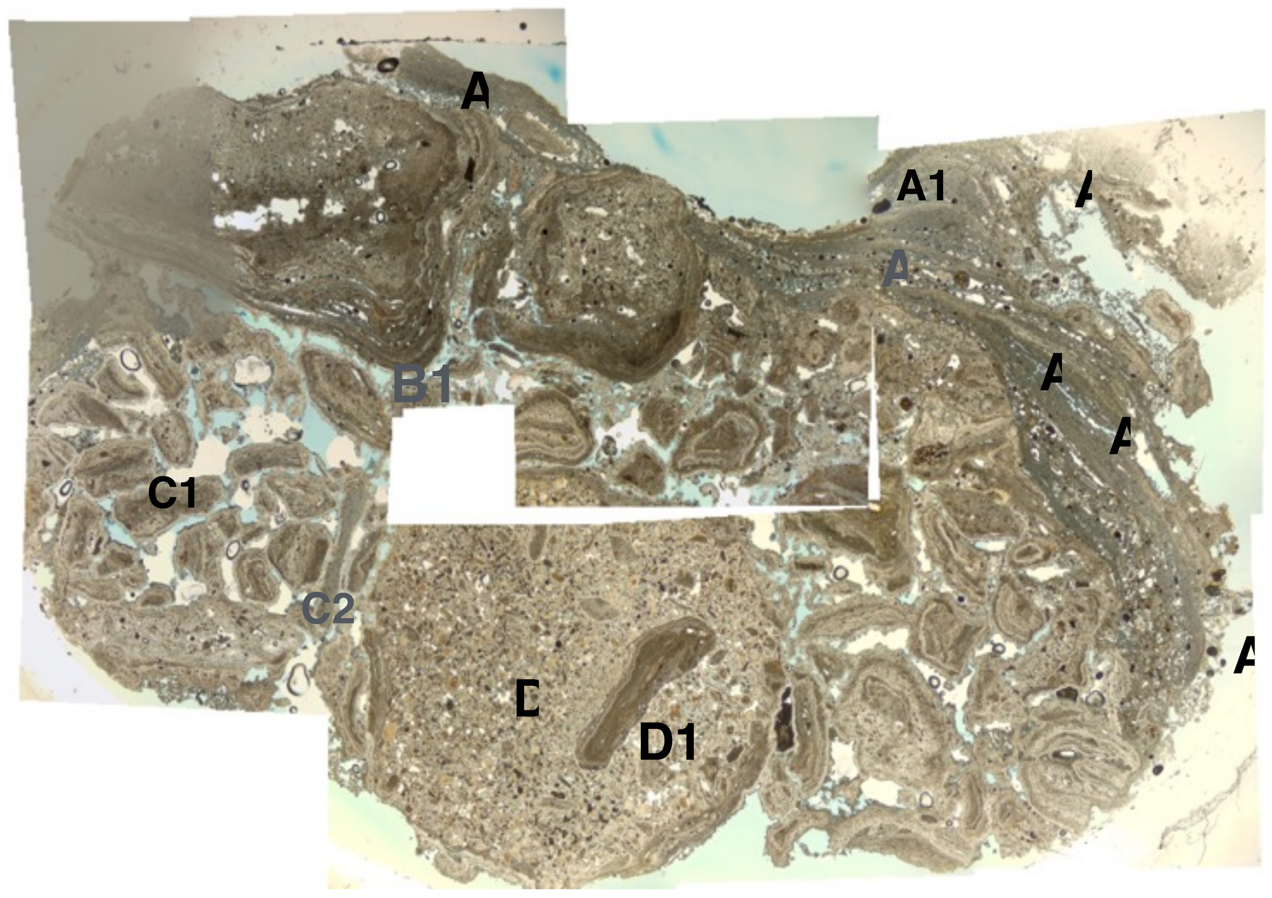
Raman Spectroscopy: Raman Spectroscopy was performed on several of the samples collected from El Tatio. The sample above and below is ET_HS020. Mineral assignments and organic signatures varied over the surface and between the exposed surface and the underside of the sample. We have identified gypsum, organic compounds, and possibly beta-carotene in our preliminary analysis.

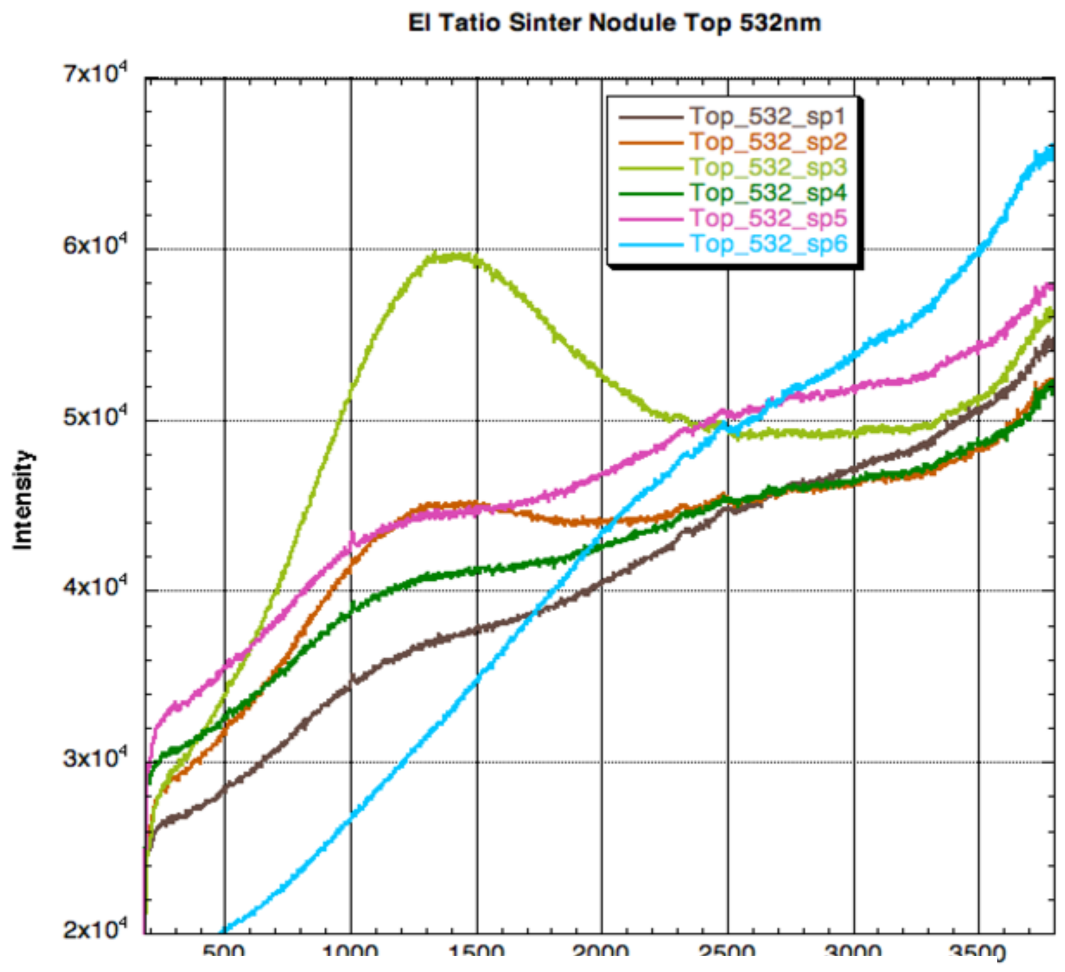


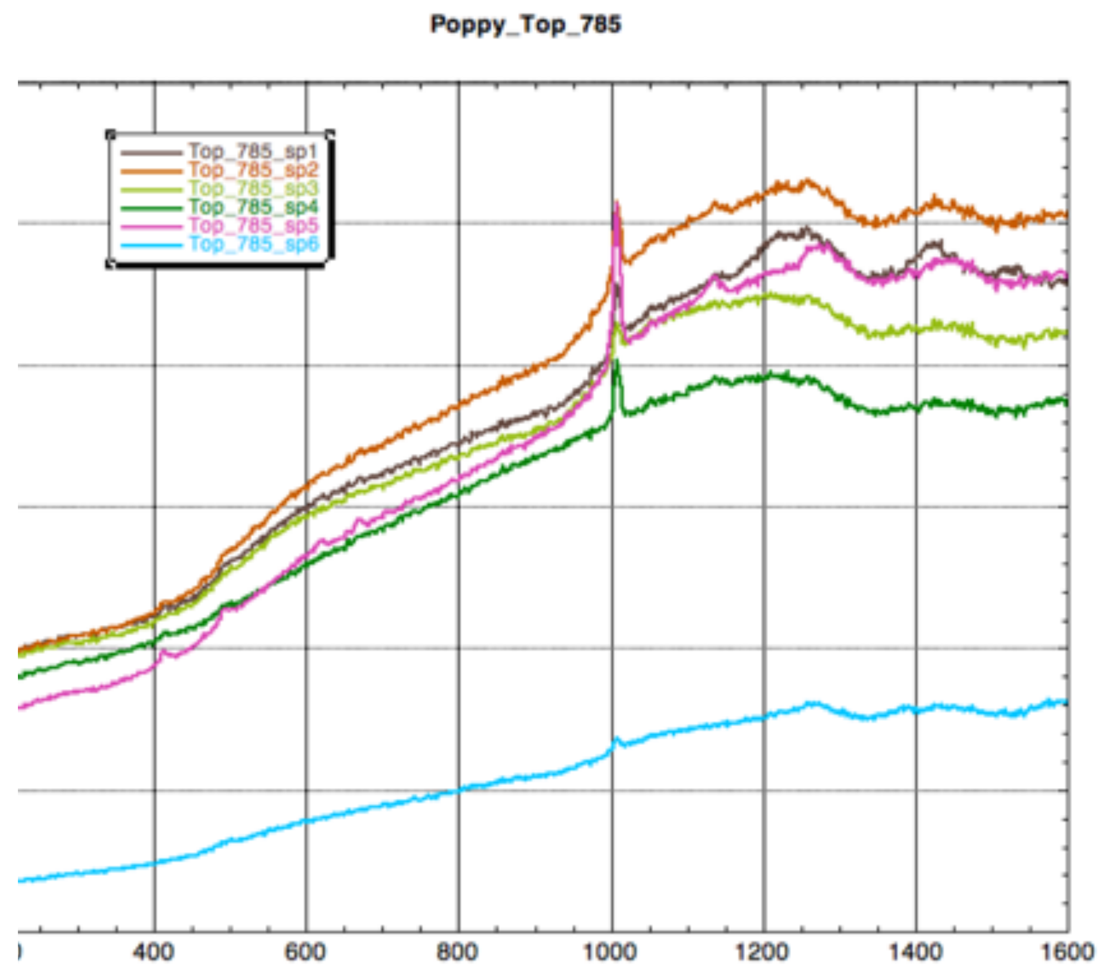
El Tatio Sinter nodule (sample CE2HS06A) top (above), interior (above right) and thin section (right). Raman spectra were taken using a 532nm and 785 nm laser excitation (below right) at several locations on thin section and on interior of rock.

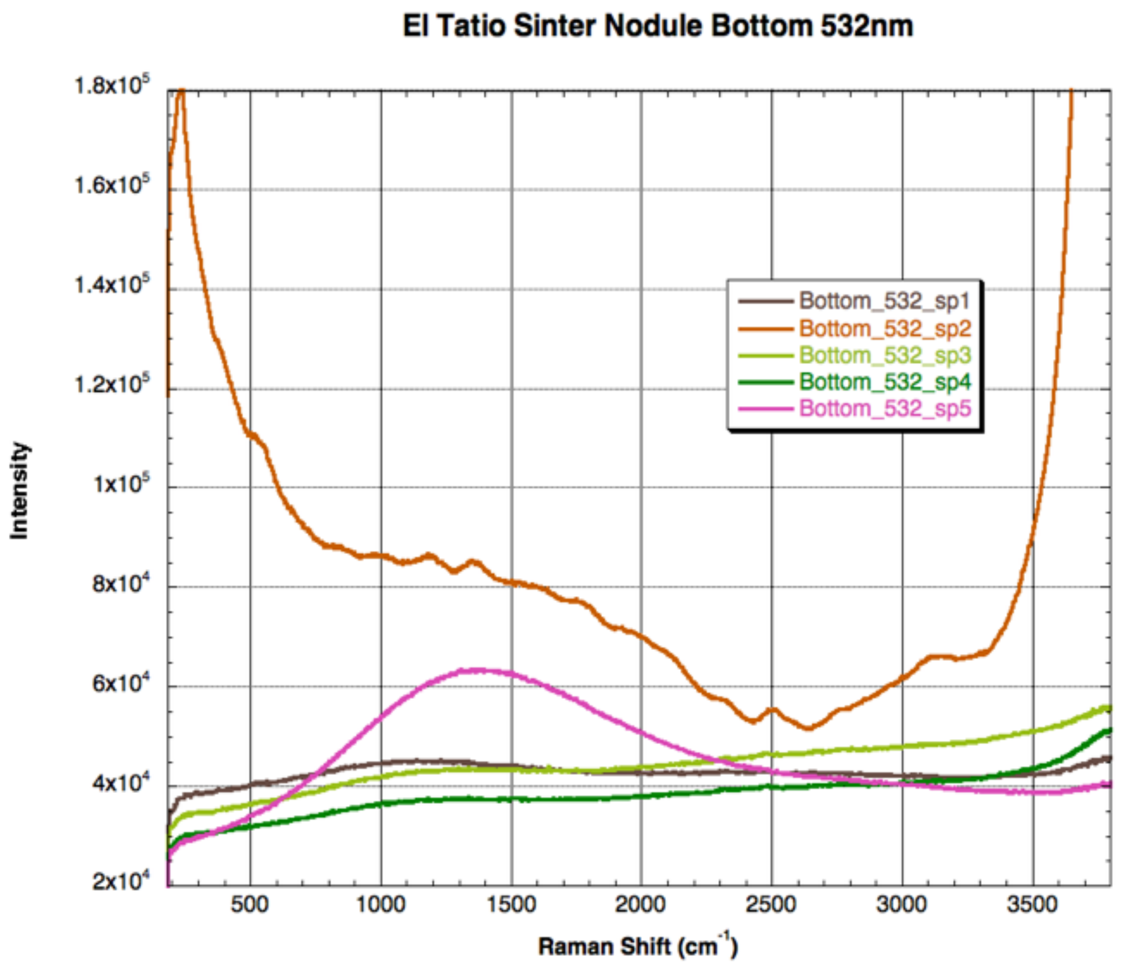


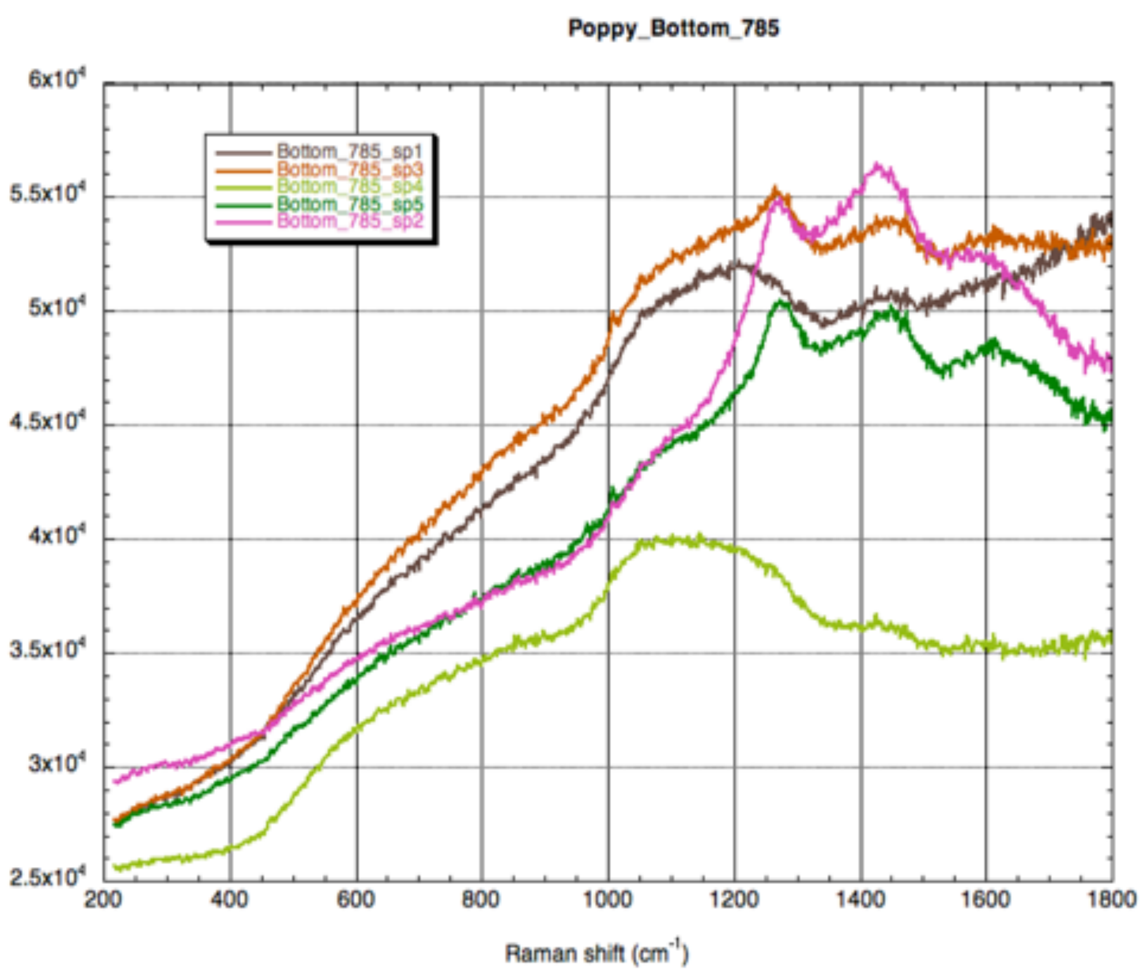
Sample ET_Poppy_HS02A from El Tatio (right). Note that many of the sinter grains have a finely layered coating. To determine whether this coating has a different biosignature suite from the bulk sample, we need to separate the top-most youngest layers "A". A major question is whether the distinct mineralogical and biological characteristics of the finely layered coating on the top can be distinguished in the data from the "bulk" sample from below, which also contains sand grains and sinter fragments that have a finely layered coating. The areas marked by "A" is the top of Poppy HS02A, which at A1 has a relatively thick finely layered coating that covers much of the sample. The remainder of the sample is a combination of cemented sinter grains, many of which are concentrically or partially coated by sinter layers. The grain at B1 is upside down as the fine layer is often conical and points away from the surface of the sample. The fine layers are likely intercalated with thin biofilm remains. In area C1 and C2, there are many sinter fragments. The large grain D1 in area D has many small sand-size fragments; some of which are partly coated.

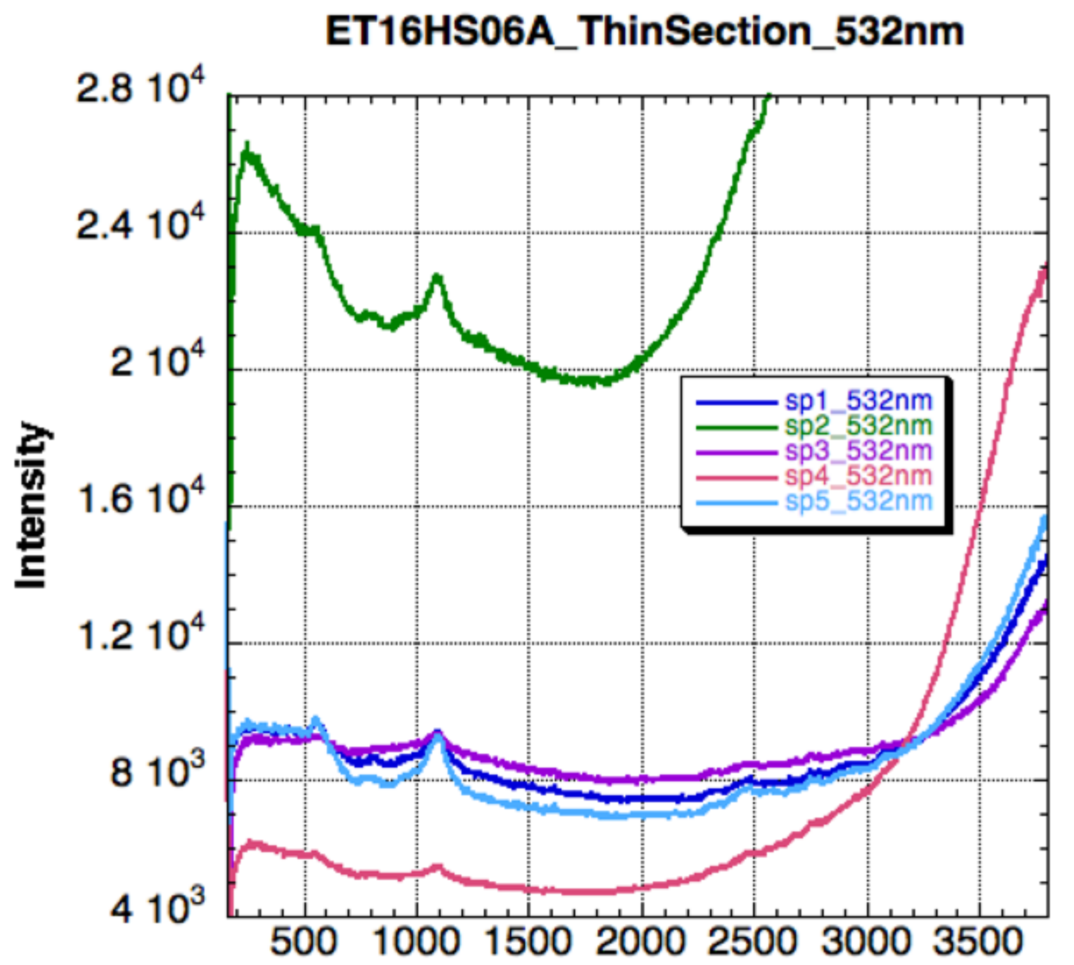


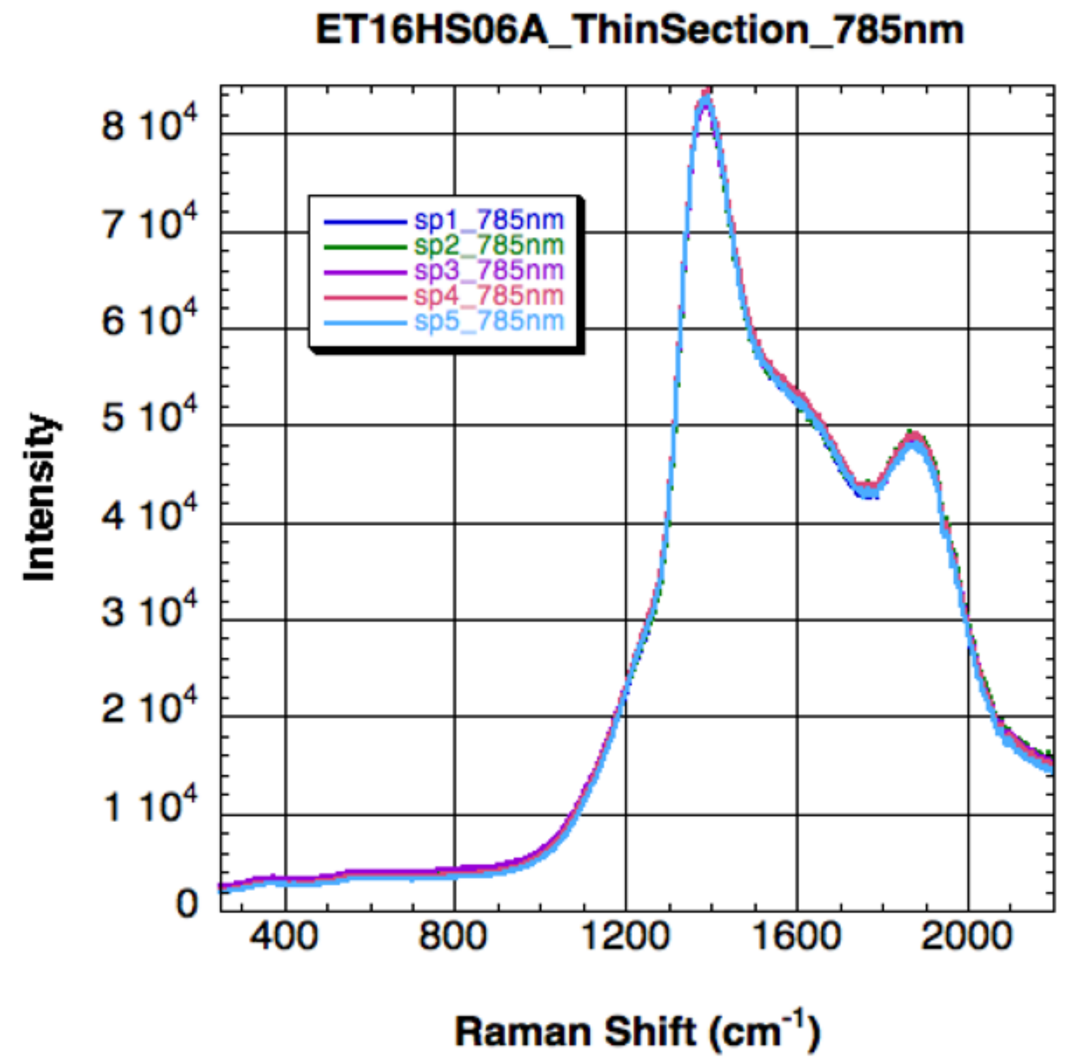












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