

Andrew GANGIDINE – Lewis and Clark Fund in Astrobiology

“Exploration and collection of sinter deposits and biofilms in Yellowstone National Park, WY for the development of a novel trace element biosignature analysis.”

## Project Report

Backpacks loaded to the brim with pH meters, test tubes, probes, rock hammers, and a suite of other scientific instruments, our Yellowstone science team marched across the treacherous quaking bog of Silvan Spring, carefully prodding the ground in front of us to find any grass-covered bogs lest our feet found them first. After setting up camp, a shuffle in the woods revealed a white wolf glaring at us, sternly letting us know we were in *their* territory. Bear mace equipped, we dug out our sampling equipment to begin the day. Silvan Spring is a site of high interest due to its ever-changing environment. Strangely, from year to year, several hot springs drastically changed pH, going from highly alkaline (pH ~9) to acidic (pH ~4) in one year's time, and then back to a pH of 8 the next! Several samples were collected from these springs, in hopes that we may be able to track down what is preserved from year to year in the precipitated silica, fossilizing any nearby microbe. Specifically interested in trace element sequestering, we hope to observe if any differences can be noted in the trace element concentrations when this site is more acidic vs. more alkaline. Other sites in Silvan Spring have remained highly acidic year after year, providing a great location to collect acidic based samples to observe trace element concentrations. Several biological mats, stromatolites, and filament samples were collected.

Our next site, Rabbit Creek, was a notable adventure. Joining us in the field was origin of life scientist Dr. Bruce Damer of UC Santa Cruz, who has a well-researched hypothesis that terrestrial hot springs are the most likely origin of life on Earth. Several water samples were collected here in order to test their polymerization capabilities when added to various lipids, as well as several biologic mats, stromatolites (Supplemental Image #1), and silica “gel” substances which will be tested for how they formed as well as how they sequester major and trace elements. This site possessed a variety of hot springs with notable distinctions, such as water clarity, temperature, and pH. With some pools displaying a vibrant red color (Supplemental Image #2), presumably from dissolved iron, others blue due to dissolved silica, and some that were crystal clear. Samples taken from each site will allow us to research the differences in trace element sequestration, morphological preservation, and overall silica precipitation in a variety of distinct settings for comparison.

The following day our team set out for our longest hike into the Sentinel Meadows in the Greater Obsidian Pool Area. This site is home to Steep Cone, an elevated mass of sinter resulting from ~10,000 years of silica precipitating out of solution from the hot spring. This site is the focus of my PhD work, and still has many secrets to be uncovered. The most notable distinction of Steep Cone is the fact that the side of the mound has been cut into by a meandering stream, creating a natural cross section of this geologic feature 10,000 years in the making (Supplemental Image #3). This allows us to simply walk up to the side of the mound, and take samples from various heights in order to get a direct timeline of samples from top (modern) to bottom (oldest). Samples taken from Steep Cone will be used to create a short-term diagenetic timeline, where I will be able to observe what happens as microbes go from living creatures on the surface of the geyser to silicified cells which become buried. I will analyze what happens to the trace elements in these samples, as well as other major elements.

Boulder Creek was the next site of our sampling trip – a unique, fuming hot spring home to several distinct types of stromatolites and microbially introduced sedimentary structures, including characteristic “roll-up” mats near the end of the stream, resulting from the outflow turbidity of the hot spring. Several of these features were samples for trace element sequestration analysis. This site was also a textbook example of observing the transitional states of chemotrophy into phototrophy. As the hot spring outflow progressed, different colors of bacterial growth could be observed as the water cooled,

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showing different bacterial communities dwelling in the same spring, with different metabolic properties and resistances. Several biologic samples were collected to observe the difference in silicification.

Geyser Creek, our final stop, was a unique site where the ground was entirely comprised of bright white silica sinter. Upon closer inspection, it was clear that the sinter was biogenic in origin – small, palisade textures, typical of bacterial communities forming in silica, could be observed in the chips on the ground (Supplemental Image #4). Along with several bacterial mats, stromatolites, and filaments, several ground chips were also collected. We will analyze these chips to see if any biosignatures can be determined even after several thousands of years of having been removed from their source, and having been continuously bombarded with cosmic rays and UV radiation. This will allow us to determine more precisely the preservation potential of silica sinter.

After returning back to the lab, several samples are being mounted to thin sections for microscopy, Scanning Electron Microscopy (SEM) and Biological Secondary Ion Mass Spectrometry (BIO-SIMS) which will show us very precise measurements of any trace elements in our samples. Another method of sample analyses for living samples we collected is Cryosectioning analyses – thin section mounting carried out by cryo-freezing samples and cutting off micron-thin slices for mounting. This preserves the morphology and elemental composition of the sample with great success. These in-depth analyses will be carried out over the course of the next ~2 months.

A sincere thank you is given to the American Philosophical Society and NASA Astrobiology Institute for sponsoring this research that contributed so greatly to my overall PhD.

**Supplemental Material:**



**Image #1**

A stromatolite found in a hot spring in the Rabbit Creek locality

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**Image #2**

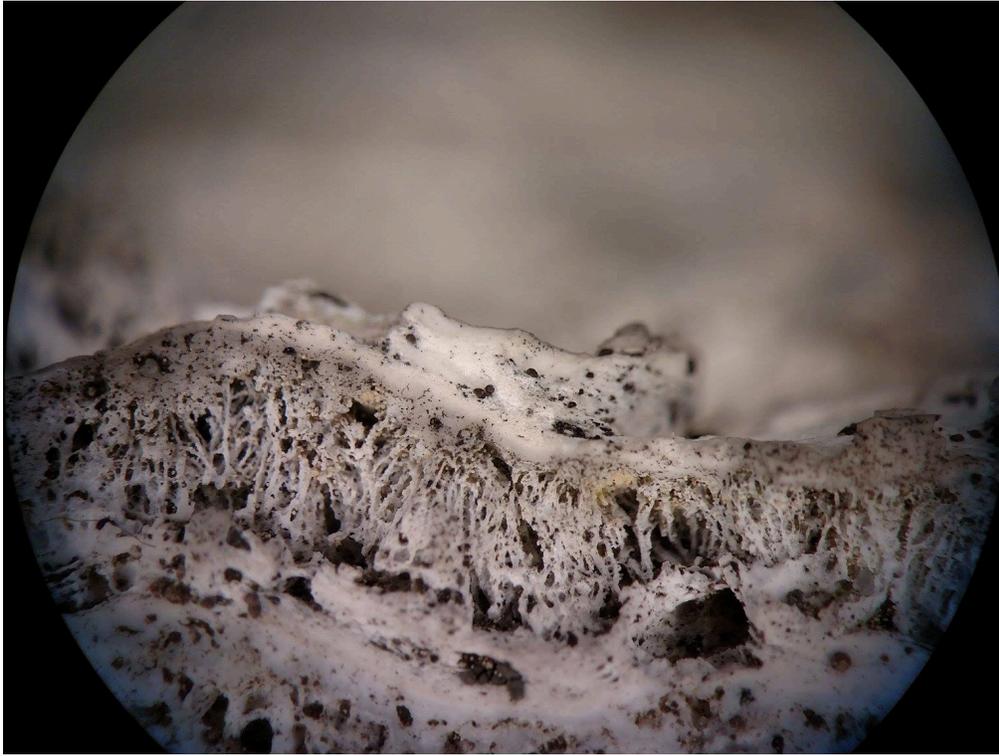
A “tomato soup” hot spring in the Rabbit Creek locality, with an unusual deep-red color



**Image #3**

Steep Cone in the Sentinel Meadow locality, with clearly visible stratigraphy displayed

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**Image #4**

A close up view of a silica chip at Geyser Creek, showing visible filamentous structures made of silica