A NOVEL TRACE ELEMENT BIOSIGNATURE FOR LIFE ON EARLY EARTH AND MARS. A. Gangidine[1], J. Havig[1], and A. D. Czaja[1] [1]Department of Geology, University of Cincinnati, 500 Geology-Physics Bldg., Cincinnati, OH, 45221-0013, agangidine@gmail.com, jeffhavig@gmail.com, andrew.czaja@uc.edu.

The burden of proof for confirming the existence of life outside of our planet will be unprecedented in scientific history. Finding extraterrestrial microorganisms (whether fossil or extant) would provide the most direct evidence of life. Given planetary protection concerns, we are more likely to sample fossil microorganisms (microfossils), but the biogenicity of even ancient terrestrial microfossils is debated owing to often poor preservation [1,2]. Thus, in the absence of convincing morphology, other biosignatures are required to establish the biogenicity of putative ancient microfossils and other microbial structures [3], typically organic and/or isotope geochemistry [4]. We report here our initial results and our plan to develop a novel biosignature for ancient terrestrial and extraterrestrial life based on trace element abundances. To do so we are studying modern silica-entombed microbial systems from Yellowstone National Park (YNP), a Mars and early Earth analog environment, as well as ancient microfossils preserved in silica.

Preliminary data from modern biofilms from silica-depositing environments indicate that certain trace elements are preferentially enriched in biological material relative to the surrounding mineral matrix [5]. We will expand this work to compare the trace element compositions of additional modern to recent sinter deposits, modern biofilms, Precambrian microfossils, and microbial mats of various levels of preservation (Figure 1). In particular, for the modern and recent samples, focus is being placed on sinter from Steep Cone in the Sentinel Meadows locality of YNP. This is a 9-m-tall active hot spring with layers of silica precipitate exposed along the sides and base of the cone by a stream cut. Silica-rich water flows from the spring at the top of the cone, preserving mats and stromatolitic structures in sinter. By analyzing samples from the outflow and various locations throughout the strata, we will produce a timeline to compare with the ancient fossil samples, and thus characterize the preservation of this biosignature in silica-rich environments over all time-scales.

Samples of fossil and modern material were imaged by optical and scanning electron microscopy to locate and document regions for trace element analyses. Trace elements are analyzed by secondary ion mass spectrometry, allowing us to determine the concentration of trace elements in each sample on a micron scale across biological structures and into the surrounding silica matrix. Through these analyses, we compare quantitative and qualitative trace element values of several clearly biological and non-biological regions on an individual sample, and across several samples to demonstrate the biological control of trace element abundances.

By developing this novel biosignature and combining it with multiple techniques for establishing biogenicity, we can find more robust evidence of life. Such techniques will be invaluable tools for the search for extraterrestrial life, particularly from samples from Mars collected by the upcoming Mars 2020 mission.

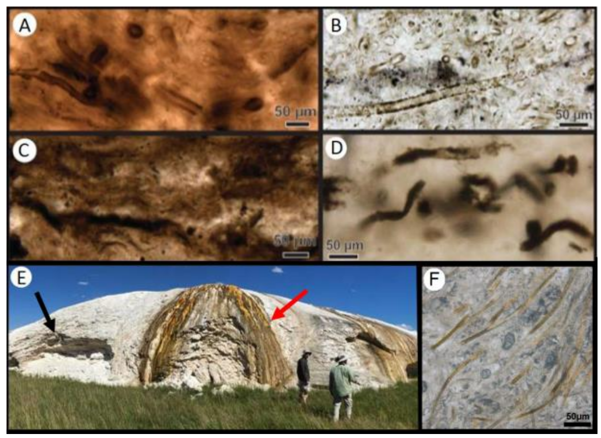

Figure 1: Examples of fossil and recent silica-entombed microorganisms to be studied. A) Exceptionally well preserved fossilized microbial mat containing multiple taxa of filamentous probable cyanobacteria from the 1,200 Ma Angmaat Fm., Baffin Island, Canada [6]. B) Poorly preserved microbial mat from the Angmaat Fm. showing organic matter preserved within lamina [6]. C and D) Filamentous microorganisms preserved in mat-like textures from the 2,521 Ma Gamohaan Fm. of South Africa [7]. E) Steep Cone, YNP, with visible layers of old sinter (black arrow) and modern, actively forming mats (red arrow). F) Filamentous bacteria in siliceous sinter from Steep Cone, YNP.

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