**Introduction:** The burden of proof for confirming the existence of life outside of our planet will be unprecedented in scientific history. As Mars 2020 will soon launch with a primary mission objective of searching for evidence of past life on Mars, it is crucial that robust biosignatures exist which can be applied to samples returned from a future sample-return mission. Finding microbial fossils (microfossils) would provide the most direct evidence of life, but even on Earth the biogenicity of ancient microfossils is often debated owing to simple morphology and often highly altered host rocks [1–3]. Thus, since morphology alone is often not sufficient for proving the biogenicity of microfossils and other microbial structures, other biosignatures are required and are most effective when applied as a “cascade of evidence”, wherein multiple lines of evidence are consistent with a biological interpretation. We report here our results establishing a novel biosignature detection method based on trace element abundances relative to silicified microbial life.

**Background and Results:** Initial results from samples obtained from Yellowstone National Park (YNP), a Mars and early Earth analog environment, indicate that certain trace elements are preferentially enriched in and around biological material relative to the surrounding mineral matrix. Samples were collected from Steep Cone, a sinter (amorphous silica) mound in the Sentinel Meadows locality of YNP which features an active hot spring and layers of silica precipitate exposed along the side of the structure by a stream cut (Fig. 1A). This allows the collection and comparison of modern microbial life from outflow streams (Fig. 1B) and silicified microbial life of increasing age from the exposed strata. These samples were analyzed via secondary ion mass spectrometry in order to determine the concentration of trace elements on a micron scale across biological structures (and into the surrounding silica matrix) relative to primary elements typically associated with life (e.g., C, N, P, etc.). Through these analyses, we compared trace element values of several clearly biological and non-biological regions to demonstrate the biological control of trace element abundances. Multiple trace elements were found to be preferentially preserved in and/or around modern and silicified microbial mats and filaments (e.g., Fig. 1C) [4].

The robustness of this biosignature has also been investigated in samples containing silicified microbial life from other geographically and geochemically distinct terrestrial hydrothermal settings of varying age and maturity, including modern/sub-recent samples from Chile (El Tatio [5]) and New Zealand (Orakei Korako and Umukuri [6]), and even in highly-altered mid-Paleozoic chert samples from Queensland, Australia (Drummond Basin [7]). These data show elemental sequestration trends similar to those observed in YNP samples, suggesting that this biosignature is applicable across a broad range of conditions including geochemical setting, host-rock alteration, and age.

Thus, this biosignature detection method is minimally destructive, offers high resolution and low (ppb) detection limits, and has been applied to a suite of Mars-analogue environments. It is therefore directly relevant to samples collected by the Mars 2020 rover, specifically those which may be collected from the crater rim of Jezero, which may host evidence of impact-induced hydrothermal activity.

![Figure 1: Steep Cone and the life it harbors. A) Steep Cone mound in YNP, with strata exposed via stream cut (black arrow) and modern microbial life dwelling in outflow streams (red arrow). B) SEM image of a microbial filament (with a silica-coating) collected from the outflow stream in panel A. Scale bar = 5μm. C) Photomicrograph of a silicified microbial filament from the base strata of Steep Cone, with subsequent images showing SIMS-generated elemental maps for the noted element. Color bar shows relative intensity from low (black) to high (red). Scale bar in panel C = 25μm and applies to all subsequent panels.](image)

**References:**