Proterozoic Stromatolites and the Search for Life on Mars

Meredith E. Perry, perryme@sas.upenn.edu
University of Pennsylvania, Department of Earth and Environmental Science, NASA Ames Research Center

ABSTRACT

The Proterozoic carbonate stromatolites of the Pahrump Group from the Crystal Spring formation of the Mojave Desert exhibit atypical growth patterns. These particular columnar stromatolites show repeated vertical growth sequences, each characterized by a layer of prolific growth followed by evidence of a geologic event represented by a dark layer with no stromatolites. Above the event layer is a recovery layer of normal sedimentary deposits with wavy laminae. The cycle repeats with another layer of columnar stromatolite growth. To determine the cause of stromatolite dormancy or extinction, I collected representative random samples from each layer analyzed them using Raman spectroscopy, thermo-gravimetric analysis (TGA), x-ray diffraction (XRD), x-ray fluorescence (XRF), scanning electron microscopy - electron dispersive spectroscopy (SEM-EDS), high performance liquid chromatography (HPLC), and optically analyzed them in thin section.

Figure 1

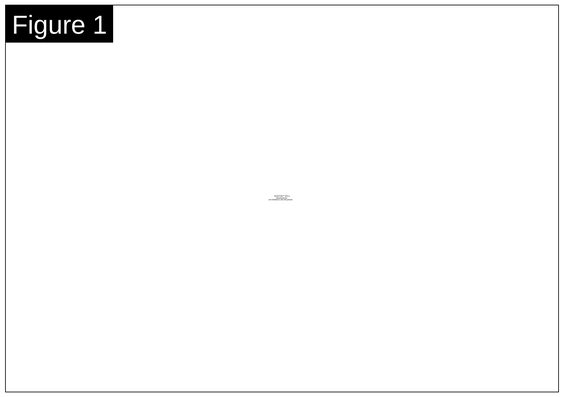

Figure 1: *Atypical stromatolite growth pattern: prolific growth (bottom) followed by an event (representing an environmental change that killed the stromatolites) and completing the cycle with a recovery layer of normal sedimentation (top).*

I analyzed differences in the sections with stromatolites and without stromatolites with the objective of determining the change that occurred at the event layers. These data help to provide a measure of stromatolitic sensitivity and can aid in understanding how stromatolite growth and morphology is affected by the surrounding environment. To my knowledge, sub-millimeter scale chemistry and structural analysis of these stromatolites has not been undertaken. My work, coupled with other stromatolite research, can advance the use of stromatolites as biosignatures in the search for microbial life on Mars.

RESULTS

Figure 2

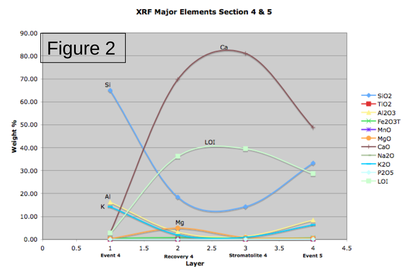

Figure 2 *(above) and* **Figure 3** *(below): XRF and XRD results indicate high concentrations of feldspar-containing material (Al, Si, K, Mg) and increased metal content at the event layers (Ba, Zn, Zr).*

Figure 3

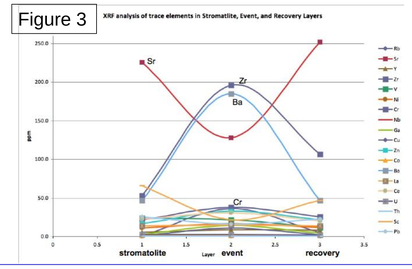

Figure 4

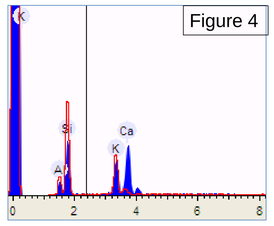

Figure 4: *SEM-EDS data confirms high concentrations of feldspathic material in the event layer.*

Figure 5

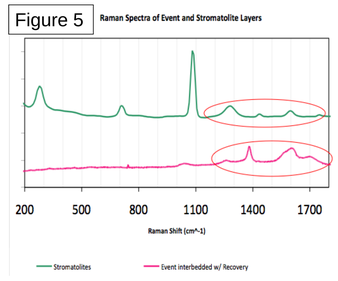

Figure 5: *Organic peaks (1289 cm-1 and 1600 cm-1) of the event and stromatolite layers are circled in red. The Y-axis correlates with intensity in linear scale; the X-axis correlates to the Raman shift (cm-1).*

Figure 6

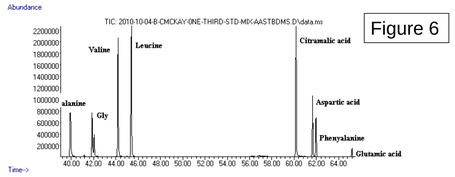

Figure 6: *HPLC analysis of one run of the standards from a stromatolite sample. ~17 nmole/g of glycine (Gly) and ~4 nmole/g of glutamic acid were measured in the sample.*

CONCLUSIONS

Repeated burial of the growing stromatolites, shielding sunlight from the organisms and inhibiting their ability to photosynthesize and grow, could have likely produced the pattern of growth to no growth that is seen in the rock face. Post burial bioturbation could have led to the repeated sequences of growth. Without cyanobacterial precipitation from their metabolic activities, a change in chemical composition at the event layers and recovery layers is expected, and was verified with the XRF and SEM-EDS analyses. In the event layers, there is a large increase in feldspathic material and metal content, neither of which are seen in the stromatolite and recovery layers. The stromatolite layers show much higher concentrations of Ca and Sr, typical of stromatolitic limestone. Given the geology of the area, it is possible that the feldspar-containing material originally was volcanic ash that buried the stromatolites either directly or was carried by wind or water from surrounding areas. The high metal content in the event layer also suggests a volcanic/hydrothermal source, especially the Ba, Zr, and Zn. The organic material present may have soaked up metals and concentrated them, as it commonly does. Further analysis of the environmental and biological changes that inhibit stromatolite growth in the Crystal Spring Formation and analysis of the relationship between the microfossils and stromatolite morphology is needed, and will provide a deeper understanding of how stromatolites can be used as biosignatures on Mars.

ACKNOWLEDGEMENTS

Chris McKay, Bin Chen, Zuki Tanaka (NASA Ames Research Center); Gomaa Omar, Jane Dmochowski, Hermann Pfefferkorn, Robert Giegenback (University of Pennsylvania); Susanne Douglas (Jet Propulsion Laboratory); NASA Astrobiology Institute; NASA Pennsylvania Space Grant Consortium; Greg and Susan Walker Endowment