SYNTHESIS OF POTENTIAL PHOSPHATE MINERAL BIOSIGNATURES UNDER MARS-RELEVANT CONDITIONS

M. H. Steiner[1], E. M. Hausrath[1], and H. J. Sun[2]. [1]Department of Geoscience, University of Nevada, Las Vegas, 4505 S. Maryland Parkway, Las Vegas 89119, steine18@unlv.nevada.edu; [2]Division of Earth and Ecosystem Sciences, Desert Research Institute, 755 Las Vegas, NV 89119.

Introduction: The Mars Science Laboratory, Curiosity, is currently exploring Mars looking for signs of life. On Earth, biosignatures include biologically controlled or mediated mineral formation [1]. Since phosphate is essential to life, an understanding of phosphate mineral formation in the presence of microorganisms may facilitate the search for evidence of life on Mars.

Recently, a new, biogenic phosphate mineral Hazenite ($Mg_2KNa(PO_4)$) was reported from Mono Lake in association with the biological activity of a cyanobacterium *Lyngbya* [2]. Here, we studied the formation of phosphate-containing minerals under simulated Mars geochemical environments in the presence of different microorganisms or extracellular polysaccharides including hazenite forming *Lyngbya*, [2] and *Proteus mirabillis*, which is known to precipitate the phosphate mineral Struvite [3], and alginate and xanthan gum, which may play an important role in concentrating cations and as a template which was purposed as a mechanism for the formation of Hazenite[2,4]. Therefore, the results of these experiments may help determine additional mineral biosignatures that may be relevant to the detection of past life.

Methods: For each set of samples, 50 ml of solution was combined with a biological or abiotic factor (or no addition, in the case of the blank) in a sterile petri dish, as shown in Figure 1. Three solutions were based on modeled evaporation of solutions based on the dissolution of a synthesized martian basalt (Mars II, III and IV), [5], one solution was based on the measurements by the Wet Chemistry Lab on the Phoenix rover [6], and one solution used had been previously shown to precipitate the phosphate-containing mineral struvite in the presence of bacteria [3]. All solutions were filter sterilized with a 0.22µm vacuum filter to avoid contamination. Each solution contained either microorganisms (*P. miribillis* or the cyanobacteria *Lyngbya)*, an extracellular polysaccharide (sodium alginate or xanthan gum), quartz as an abiotic control, or no mineral or biological addition as a blank. Each condition was placed on a dark shelf to avoid photocatalytic reactions and temperature remained constant at ~20ºC. Samples were checked at regular time intervals under an optical microscope. Precipitates were collected after four weeks from the Mars II, III, and IV solutions, and the struvite solution and analyzed using Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS), to identify the precipitates' morphology and chemical composition. The initial 50 ml conditions did not produce enough precipitate to analyze crystal structure using X-Ray Diffraction (XRD), and therefore, larger precipitation experiments are underway to precipitate larger volumes. The initial testing of the Phoenix solutions and the large batch experiments are currently in progress.

Results and Discussion: Small amounts of solid phase precipitate formed in Mars II, III, and IV solutions containing *P. mirabillis* and xanthan gum, as well as in the struvite solution with the cyanobacteria *Lyngbya* and *P. mirabillis.* Precipitates were not found in solutions containing alginate, quartz sand, or the blank.

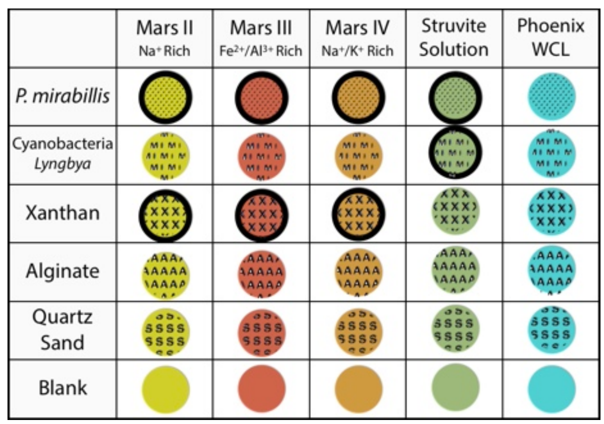

Figure 1. Table of experimental conditions. Rows represent the microbial, extracellular polysaccharide, and control treatments. Columns represent the Mars-relevant and struvite solutions. Samples circled in bold produced a solid phase precipitate after four weeks in 50ml of solution. Phoenix WCL solutions are ongoing.

Precipitates were analyzed by SEM and EDS. Not enough precipitates formed to analyze by XRD. Precipitates from both the xanthan (Figure 2) and *P. mirabillis* (Figure 3) containing conditions were found to contain phosphorus as detected by EDS. The *P. mirabillis i*n the struvite solution condition resulted in numerous angular crystals with the chemistry of struvite (Figure 4).

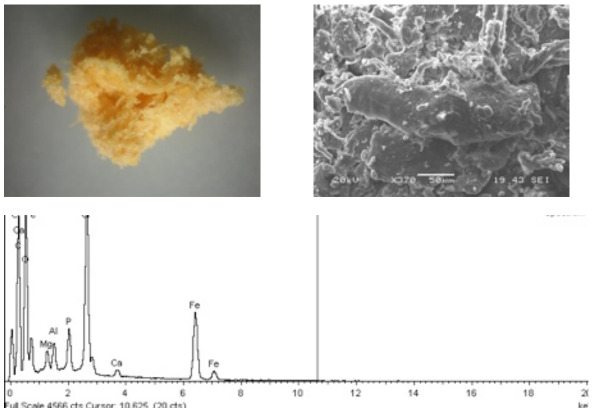

Figure 2: Precipitate formed from xanthan gum in Mars III solution as observed by optical microscopy, field of view 4mm (top left), and SEM (top right), and the EDS spectrum of the precipitate (bottom).

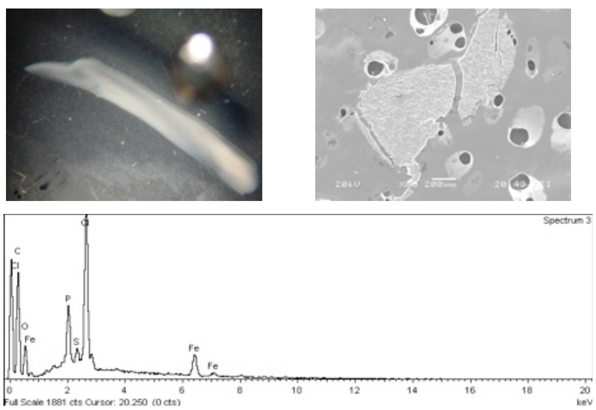

Figure 3: Precipitate formed from *P. mirabillis* in Mars III solution as observed by optical microscopy, field of view 4mm (top left), and SEM (top right), and the EDS spectrum of the precipitate (bottom).

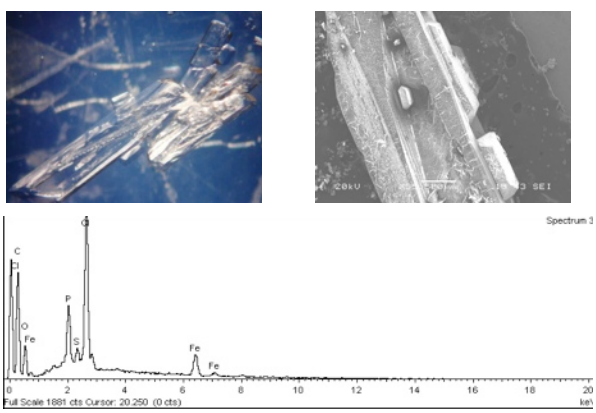

Figure 4: Precipitate formed from *P. mirabillis* in the struvite solution as observed by optical microscopy, field of view 4mm (top left), SEM, (top right), and EDS spectrum of the precipitate (bottom).

The experiments containing cyanobacteria *Lyngbya* are currently ongoing. Precipitates have been observed optically in the struvite solution. Using SEM and EDS these precipitates were found to contain phosphorus (Figure 5).

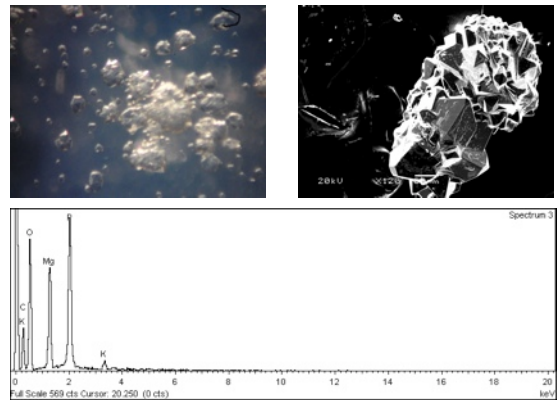

Figure 5 Precipitate formed in the presence of the cyanobacteria *Lyngbya* in the struvite solution observed by optical microscopy. field of view 4mm (top left) and SEM (top right), and EDS. (bottom).

Conclusion: Precipitates containing phosphate were formed from *P. mirabillis* and xanthan gum in the presence of the Mars II, III, and IV solutions and with the cyanobacteria *Lyngbya* in the struvite solution. Future work will include analysis of the Phoenix WCL and cyanobacterial conditions, as well as x-ray diffraction to identify the mineralogy of the precipitates. The precipitates formed in these experiments suggest possible mineral biosignatures relevant to Mars.

Acknowledgments: We would like to acknowledge NSF grant DBI REU 1005223 and NASA for funding, Dr. Kurt Regner and Dr. Eduardo Robleto as REU coordinators, and Chris Adcock and Kirstin Hulme for lab assistance.

References: [1] Fisk, M. Popa, R. Mason, O. Strorri-Lombardi, M. and Vicenzi, E. (2006) Astrobiology., 6, 48-68. [2] Yang, H. and Sun, H.J. (2004) Journal of Solid State Chemistry., 177, 2991-2997. [3] Chen, L., Shen, Y., Xie, A., Huang, F., Zhang, W., and Liu, S. (2010) Crystal Growth and Design., 10, 2073-2082. [4] Yang, H., Sun, H.J., and Downs, R.T., (2011) American Mineralogis, v. 96, p. 675-681. [5]Tosca, N.J., and McLennan, S.M., (2006) Earth and Planetary Science Letters, 241, 21-3. [6] Quinn, R.C., Chittenden, J.D., Kounaves, S.P., and Hecht, M.H., (2011), Geophysical Research Letters, 38.