EXPERIMENTS ON FOSSILIZATION OF IRON MICROBES – A PRELIMINARY REPORT. J. Schieber, M. Glamoclija, and K. Thaisen, Department of Geological Sciences, Indiana University, Bloomington, Indiana 47405, jschiebe@indiana.edu.

Introduction: As part of a Mars analog study, we are examining an iron microbe dominated terrestrial environment for isotopic characteristics of iron microbial mats and for potential morphological preservation of microbial matter in accumulating sediments. The iron microbes we are studying occur in a small spring-fed creek and part of a persistent iron-microbial mat community. The iron microbes form well defined microbial mats and biohermal structures that show remarkable resilience to erosive events and rebuild a thick creek-covering mat within a week of erosive events [1].

The dominant mat forming iron microbe is *Leptothrix* sp., an organism that produces sheaths consisting of parallel arranged polysaccharide nanofibers held together by an outer capsular layer [2]. These sheaths are encrusted with amorphous to poorly crystalline (ferrihydrite) iron oxyhydroxides, are produced in large quantities, and are the main structural component of the microbial mats [1]. From study of freeze dried materials it appears that "discarded" sheats (not containing *Leptothrix* trichomes) strongly dominate the organic material produced in these mats. These sheats, due to their abundant production and mechanical stability, were considered to have the highest potential to be preserved once buried in sediments.

Methods: The following diagenetic scenarios were placed in glass jars in order to examine possible modes of degradation and preservation: (1) mat material in water - anoxic; (2) mat material in clay matrix – oxic; (3) mat material in clay matrix above organic-rich stratum; (4) mat material in clay matrix with organic matter – anoxic; and (5) mat material in NaCl brine – oxic. The various scenarios contained an addition of organic pond muck to provide a broad range of degrading microbes and were allowed to incubate from a few weeks (scenario 5) to two years. The jars were sampled by soda straw, sediment was placed on glass slides, and examined with an EDS-equipped ESEM.

Observations: In scenario (1), most material was degraded by other microbes and formed a dark gray to black biofilm in which only a tiny fraction of sheaths were still recognizable. Iron coatings on sheats dissolved and were partially re-precipitated as Fe-monosulfides in the vicinity (Fig. 1). In scenario (2), iron coatings partially dissolved and were re-precipitated as clusters of nanoscale spheres, and sheats began to collapse, split open, and fray into bundles of nano-fibers (Fig. 2). Recognizable sheats were easy to find.

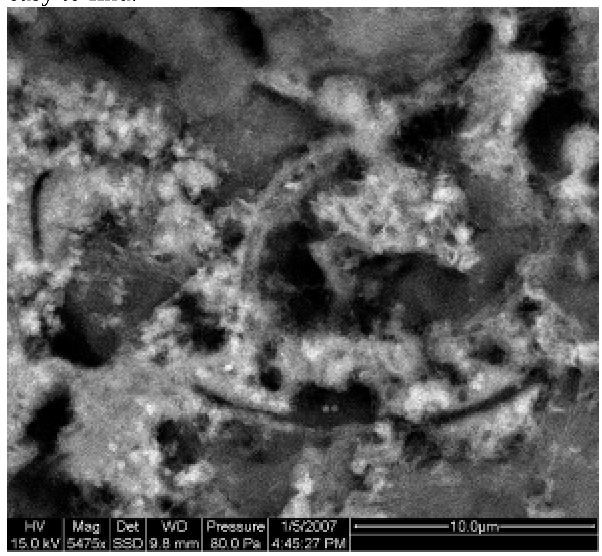

Fig. 1: Dissolution of Fe from sheaths and reprecipitation as Fe-sulfide (light areas) in vicinity.

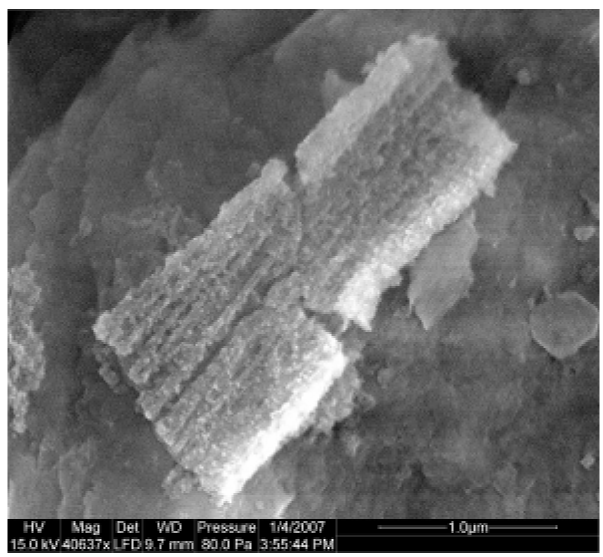

Fig. 2: Degradation of organic sheath structure causes collapse and reveals underlying nano-fiber structure.

In scenario (3), abundant pyrite formed in the sediment as framboids, octahedra, and cubes (Fig. 3). When recognizable sheats were found they showed 3D preservation and their iron hydroxide coating had been converted to pyrite. Non-mineralized sheats were not observed. In scenario (4), well preserved sheats are common. They show 3D preservation and their iron hydroxide coatings also have been converted to pyrite (Fig. 4). The textures of encrusting iron sulfides between scenarios (3) and (4) are comparable. In scenario (5), sheats and EPS of mat material are enclosed in halite crystals and easily recognizable (Fig. 5). Halite simply encloses sheath material and does not appear to excert forces that deform and disfigure sheaths. Even the sheath surface texture remains unchanged and more delicate structures, such as twisted *Gallionella* sp. stalks, are well preserved as well. The latter do not appear to survive the conditions present in the other fossilization scenarios.

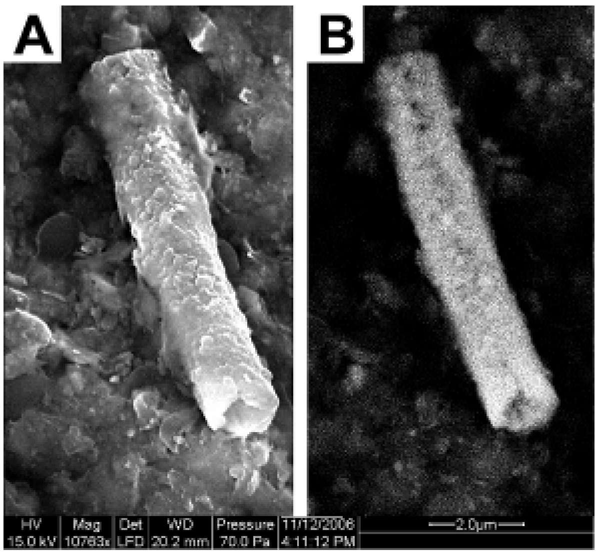

Fig. 3: Sheath preservation by pyrite formation (EDS analysis). (A) SEM image showing flaky surface texture, (B) backscatter image that shows high density of pyritized sheath.

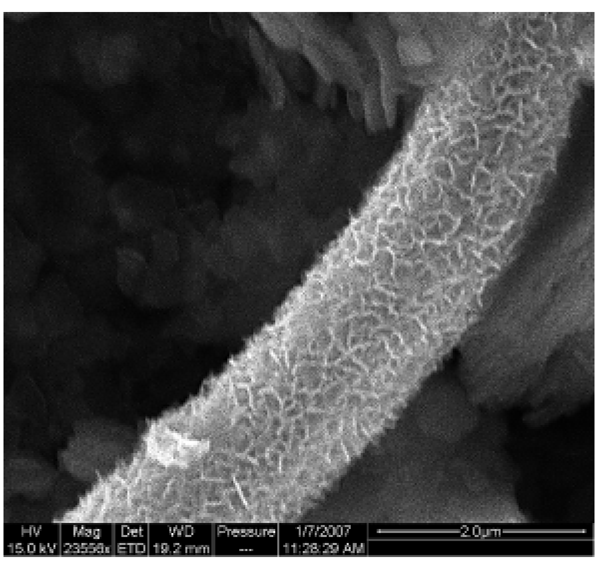

Fig. 4: Sheath preservation by pyrite formation (EDS analysis). The surface texture differs from Fig. 3A, but there is some indication that thicker encrustation leads to a texture as seen in Fig. 3A.

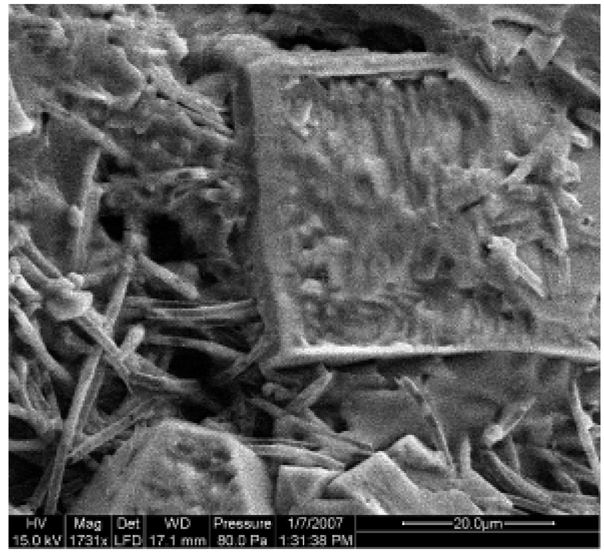

Fig. 5: Sheath preservation by enclosure in growing halite crystals.

Conclusions: Burial of organic matter will in most instances result in reducing conditions. Under reducing conditions, and in presence of microbes that are engaged in sulfate reduction (a plausible scenario on Mars [3]), chances are good that buried sheath material of iron oxidizing microbes is morphologically preserved [4]. Replacement of iron hydroxides by pyrite appears to occur readily, although the proximity of the sulfide source (decaying organic matter) to the sheath may be critical. At present it appears that decay of sheath organic matter does not drive the pyritization process, but rather that other, more readily degraded organic material, is that main source of sulfide. Potential deposits that might harbor such fossils should occur in condensed portions of depositional sequences, such as the distal bottomsets of lacustrine deltas. Enclosing iron microbial sheath material into growing salt crystals appears to result in excellent preservation, much better than for simple microbial cells. If comparable forms once flourished on the Martian surface, there is a good chance that they will be found in Martian evaporites.

References: [1] Schieber J. et al. (2006) *37th LPSC*, abstract no. 2004. [2] Emerson D. and Ghiorse W. C. (1993) *Journal of Bacteriology, 175,* 7808-7818. [3] Tosca N. J. and McLennan S. M. (2006) *Earth Planet. Sci. Lett., 241*, 21-31. [4] Schieber J. (2002) *Geology*, *30*, 531-534.