

SNOT, STICKS, AND LOTS OF WATER: IRON MICROBES AS MINIMALIST ARCHITECTS

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Introduction: Substantial iron accumulation on the Earth's surface can in many instances be attributed either directly or indirectly to microbial activity. Microbial mat deposits in various periods of Earth history were iron-mineralized to various degrees and may also contain remains of the organisms that formed them [1, 2, 3, 4, 5]. The common association of microbes and iron accumulations on Earth hold out the prospect that a similar association may exist on Mars as well. Thus, Martian hematite accumulations, such as those of Meridiani Planum [6], are currently favored targets in the search for ancient microbial life on Mars.

In an attempt to understand the potential biosignatures of iron microbes we are studying an iron-microbial mat community in a small spring-fed creek. Whereas in many places where they occur iron microbes form chaotic appearing clumps and poorly defined masses of ferric hydroxide precipitates, bacterial sheaths, extracellular polymer substances (EPS), and bacteria, at this particular locality they form well defined mats and even biohermal structures [7]. This microbial community shows remarkable resilience to erosive events, rebuilding a thick creek-covering mat within a week (Fig. 1).

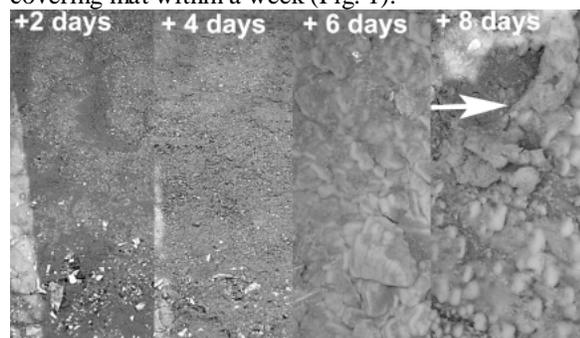


Fig. 1: Recovery of mat after a rainstorm completely washed out an existing mat. Within a week, there is dense coverage and the onset of recycling of “aged” mat (arrow). Vertical dimension ~ 1 m.

Methods: Several places were selected within the mat colonized section for an artificial mat accretion experiment. In these places, we sprinkled repeatedly fine quartz sand on top of the mat to produce time markers as well as readily seen lamina within the otherwise uniform appearing reddish mat. After two weeks we collected these “enhanced” mats to examine their internal macroscopic and

microscopic textures. Subsamples of the mat were embedded in Spurr resin for petrographic inspection, as well as shock frozen with liquid nitrogen and freeze dried for SEM studies.

Observations: Macroscopically, cross-sections of the mat show an overall laminar structure delineated by sandy laminae as well as sand-filled load casts (Fig. 2). The style of lamination is comparable to that exhibited by many other microbial mats that experience episodic sedimentation.

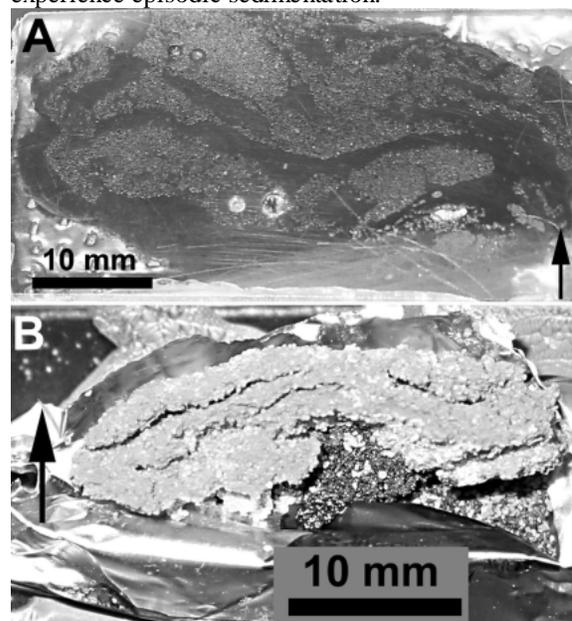


Fig. 2: Macroscopic mat fabrics. Wavy, surface conformable laminae made visible by sandy laminae (especially in B). Load cast formation reflects the very watery nature of the mats and the strong density contrast between mat layers and sand.

At a microscopic level, the iron microbe layers show a surprising degree of internal organization. Freeze dried samples, freeze-fractured perpendicular to macroscopic lamination, show a fine scale layering that consists of “stories” of matted *Leptothrix* sheaths that exhibit regular spacing of approximately 20 μm (Fig. 3). The “stories” are held apart by other *Leptothrix* sheaths that are oriented at steep angles to the planes defined by the “stories”. These structural elements are held together by a carbon-rich and iron-hydroxide encrusted matrix, presumably EPS. This structural style shows an uncanny resemblance to bamboo scaffolding that one sees in many Asian

cities, delicate appearing structures of surprising strength that consist of bamboo poles tied together by ropes.

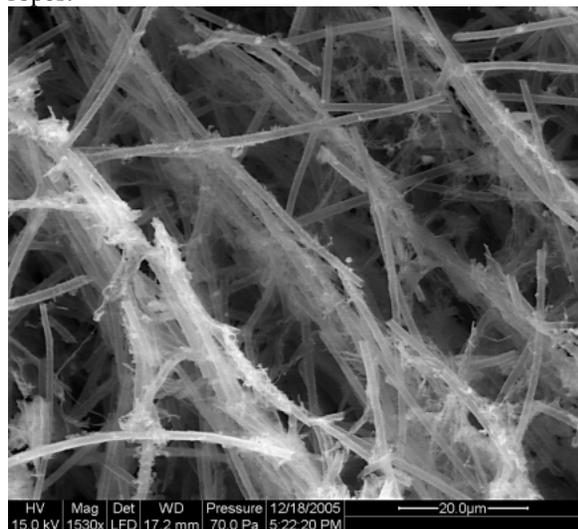


Fig. 3: Microlaminar “scaffolding” constructed from Fe-mineralized *Leptothrix* “sticks” and held together by EPS.

On breaks parallel to lamination it becomes clear that what holds the “stories” apart is a honeycomb structure of entwined *Leptothrix* sheaths, *Gallionella* stalks, unidentified filaments, and more EPS (Fig. 4).

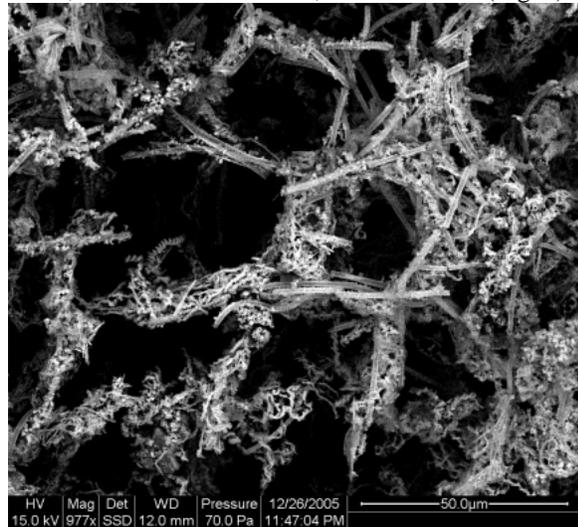


Fig. 4: “Honeycomb” structure that separates surface-parallel stories.

The outermost of these microlaminae (see Fig. 3), the actual growth surface of the mat at the time of collection, shows a surface texture that has the appearance of thin sheets of a stretchable substance criss-crossing and covering “holes” not occupied by *Leptothrix* sheaths and other microbial components

(Fig. 5). The stretched sheets consist of an organic matrix (probably EPS) that is encrusted with nanoscale balls of iron hydroxides.

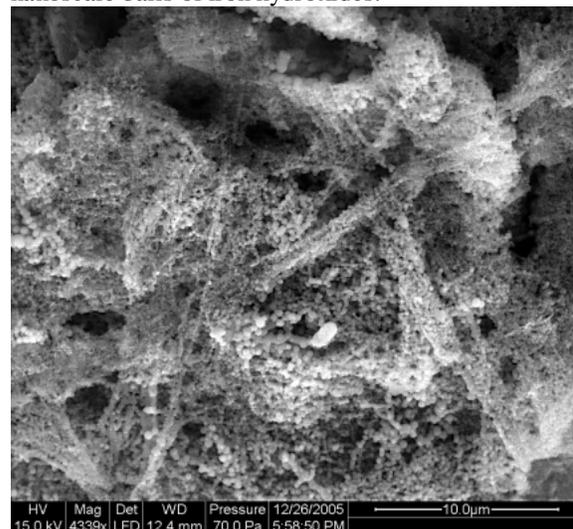


Fig. 5: Stretched EPS sheets that cover the surficial layer of the iron microbial mats. Tiny balls are iron hydroxide encrustations

Conclusions: The underpinnings of the observed mats consist of a framework in which stiff, mineralized *Leptothrix* sheaths are probably the dominant load-carrying elements. This framework compartmentalizes the occupied volume into numerous hollow spaces that are filled with water. The EPS matrix that holds the structural elements together also prevents, or at least severely limits, water exchange between compartments. Production of EPS requires energy and nutrients, and by following the observed building strategy the microbes conserve resources while still increasing their structural surface to support a growing population. The large internal surface area of this structure, as well as the numerous compartments should favor textural preservation of these mats by diagenetic mineralization or infiltrating particles, such as clays. Although fossilized iron microbial mats have yet to be reported, under the right circumstances (early diagenetic mineralization) they may have excellent preservation potential. If comparable organisms existed on Mars they could have given rise to macroscopically recognizable microbial mat deposits.

References: [1] Konhauser, K.O. et al. (2002) *Geology*, 30, 1079-1082. [2] LaBerge, G.L. (1973) *Econ. Geol.*, 68, 1098-1109. [3] Schieber, J. (1989) *Sedim. Geol.*, 64, 79-90. [4] Schieber, J. (2002) *Geology*, 30, 531-534. [5] Gerdes, G. and Krumbein, W.E. (1987) *Biolaminated Deposits*, Springer, 183p. [6] Christensen, P.R. et al. (2000) *J. Geophys. Res.*, 105, 9623-9642. [7] Schieber, J. (2004) 35th LPSC, abstract # 1369.