

FORMATION OF STROMATOLITES AND OTHER POTENTIAL MICROBially INFLUENCED STRUCTURES AND TEXTURES IN TERRESTRIAL (AND MARTIAN?) CHEMICAL SEDIMENTS

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The widespread occurrence of sulfates on Mars [e.g. 1, 2] suggests that chemical sedimentation was an important process in aqueous sedimentary environments in the martian past. The potential habitability of chemical sedimentary environments, such as evaporites, makes them a prime target for astrobiological exploration: in addition to being habitable, the rapid *in situ* mineralization that prevails in chemical sedimentary systems can promote the formation and preservation of biosignatures such as stromatolites and microbially-influenced textures, fossilized cells and organic material, and chemical fossils. However, the diagenetic processes in these systems may alternatively destroy biogenic features, partially overprint them, or otherwise confound their detection and interpretation. In addition, limited understanding of how microbes specifically influence or mediate sedimentation further complicates the interpretation of potential biosignatures. Much of what is known arises from studies of carbonate sediments and post-Archean environments (i.e. a period when the biosphere was well-established), and may therefore have limited applicability to sulfate systems on a planet where life may have flourished only briefly.

A better understanding of what microbially mediated structures may look like in an ancient martian evaporite deposit can be gained by examining partial analogues on Earth. Messinian (~6 Ma) gypsum stromatolites of Cyprus and Crete are well developed terrestrial examples of microbial sedimentary structures in ancient evaporitic sulfate deposits. Early Archean (3430 Ma) stromatolitic carbonates of the Strelley Pool Formation in the Pilbara, Australia, on the other hand, contain examples of probable microbially-influenced sedimentary structures formed in a very young biosphere [3, 4]. Between them, these formations provide important insights to some of the processes involved in formation of microbially-influenced structures and textures in Mars-relevant, chemical sedimentary systems.

Both the Messinian gypsum and Early Archean carbonate stromatolites show evidence of a complex mix of syn- and post-depositional, biological and non-biological processes. Those processes can include: chemical precipitation at the sediment-water interface; precipitation and settling of crystals from the water column; laterally or temporally heterogeneous microbial mat development; templated mineral precipitation

on microbial mats or adhesion of crystals to mats; displacive, replacive or inclusive growth of crystals in the subsurface; and early diagenetic dissolution-reprecipitation reactions. In the gypsum deposits, very early diagenetic processes (in the top few cm of the sediment pile) sometimes strongly influenced not only the textural evolution of the sediments and organic preservation, but also the development of high standing stromatolitic structures at the sediment-water interface. Conversely, there are also instances where the pre-existence of a stromatolite evidently influenced diagenetic crystal growth. The structures and textures found in these systems cannot therefore be considered simply as biotic or abiotic features formed at the sediment-water interface and subsequently affected by diagenetic processes, because in many cases the formation of diagenetic and syndepositional features was intrinsically linked.

To maximize the potential for detection and interpretation of potential microbial signatures in chemical sedimentary deposits, an *in situ* Mars rover mission would need significant exploration and measurement capabilities. These capabilities would include, for example: the ability to make mineralogical measurements, and to relate sub-mm and larger scale structure and texture to mineralogy; the ability to detect and map organic deposits in relation to visible features at mm- to cm scales; the ability to map basin architecture, stratigraphy and facies; and the ability to map the nature and distribution of potential bio-mediated features across the basin in relation to the palaeoenvironment. A mission with these capabilities would be well positioned to detect any biosignatures if they existed at the landing site. Alternatively, if no biosignatures are found, these capabilities would be essential to understand why the site may have been uninhabitable or unfavorable for biosignature preservation, and where we might next focus our search.

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