MARS HEMATITE SITE: POTENTIAL FOR PRESERVATION OF MICROFOSSILS

Carlton C. Allen[1], Frances Westall[2], Teresa Longazo[3], Rachel Schelble[4], Luke Probst[5], and Beverly Flood[6]
[1]NASA Johnson Space Center, Houston, TX 77058 *carlton.c.allen@nasa.gov* [2]Centre de Biophysique Moleculaire, Orleans France, [3]Hernandez Engineering, Houston, TX 77058, [4]University of Southern California, Los Angeles, CA 90089, [5]Rice University, Houston, TX 77005, [6]Texas A & M University at Galveston, Galveston, TX 77554

Introduction: Defining locations where conditions may have been favorable for life is a key objective for the exploration of Mars. Of prime importance are sites where conditions may have been favorable for the preservation of evidence of pre-biotic or biotic processes. Areas displaying significant concentrations of the mineral hematite (α-Fe_2O_3) have been identified from orbit by thermal emission spectrometry [1]. The largest such deposit, in Sinus Meridiani, is a strong candidate landing site for one of the twin Mars Exploration Rovers, scheduled to launch in 2003.

The Martian hematite site may have significance in the search for evidence of extraterrestrial life. Since iron oxides can form as aqueous mineral precipitates, the potential exists for preserving microscopic evidence of life in ecosystems that deposit iron oxides. Terrestrial hematite deposits proposed as possible analogs for the hematite sites on Mars include massive (banded) iron formations, iron oxide hydrothermal deposits, iron-rich laterites and ferricrete soils, and rock varnish [1]. We are engaged in a systematic effort to document the evidence of life preserved in iron oxide deposits from each of these environments.

Banded Iron Formations: Numerous microfossils are preserved in specimens of the ~2100 Ma banded iron deposit of the Gunflint Formation, Canada. While most of these microfossils are preserved in chert, scanning and analytical electron microscopy reveals that some of the micrometer-scale rods, spheres, and filaments are associated with iron oxides [2]. The detailed relationship between Gunflint microfossils and iron oxide mineralization remains to be determined.

Ferricrete: Several distinct generations of filamentous microfossils, as well as abundant extracellular polysaccharide (EPS), are preserved in a ferricrete sample from the soil surface near Shark Bay, Western Australia [3]. The general state of degradation of these microbial filaments indicates that they were mineralized after cell death and lysis. The intimate relationship among the microorganisms, EPS, and iron oxides suggests that the microorganisms could have influenced mineral formation, either by providing an organic substrate for precipitation or by creating a physico-chemical microenvironment conducive to such precipitation.

Rock Varnish: Bacteria, EPS, and fungi have been found in rock varnish deposits coating granitic rocks from Sonoran Desert sites in Arizona [4], as well as in varnish samples from Hoover Dam, Nevada and the Pilbara region of Australia [5]. In each case the varnish is a complex mixture of clay minerals with iron and manganese oxides. Some of the bacteria and many of the fungal bodies are apparently recent, but the varnish layers also contain evidence showing iron oxide mineralization of these microorganisms.

Mars Exploration: If the Martian hematite deposits do carry a record of extant or fossil microbes, this record will probably not be revealed by the spacecraft instruments on the Mars Exploration Rovers. Fossil microorganisms in terrestrial rocks are only detectable by optical microscopy of thin sections or by various combinations of scanning, transmission, and analytical electron microscopy. Most such features are significantly smaller than the 30 μm resolution limit of the Mars Exploration Rovers' Microscopic Imager. Thus, confirmation of an ancient Martian microbiota via direct fossil evidence will require the return of samples to terrestrial laboratories. A key function of the next generation of Mars landers may be to discover and make preliminary documentation of prime sites for future sample return missions. A hematite deposit may well be among those prime sites.

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