MARS HEMATITE SITE: POTENTIAL FOR PRESERVATION OF MICROFOSSILS
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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-Fe₂O₃) 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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