ROCK COATINGS: POTENTIAL BIOGENIC INDICATORS. M.N. Spilde[1], P.J. Boston[2], D.E. Northup[3]and K.J. Odenbach[4], [1]Inst. of Meteoritics, Univ. of New Mexico, Albuquerque, NM 87131, mspilde@unm.edu; [2]Dept. of Earth & Environmental Sci., NM Tech, Socorro, NM, 87801; [3]Biology Dept, UNM, Albuquerque, NM 87131; [4]Ohio State Univ., Plant Pathology Dept., Columbus, OH

Introduction: Many Mars surface rocks, photographed by the Mars Exploration Rovers, appear to have shiny, dark coatings. These coatings resemble terrestrial rocks covered with rock varnish. In arid terrestrial regions, this hard, dark coating (also called desert varnish) is manganese-rich and also contains sheet silicates and widely varying levels of silica. Desert varnish has long been linked to simple bacteria and fungi [1,2], but unequivocal proof of a biogenic origin has yet to be shown. Both bacteria and fungi have been isolated from desert varnish, and manganese-oxidizing microorganisms such as *Bacillus, Pedomicrobium, Cremonium, Cladosporium, Penicillium,* and *Verticilium* are among them [3]. The microbes remove metal particles from atmospheric dust and fog, oxidize them, and then build up layers and layers of varnish, with phyllosilicates acting as "glue". Researchers have speculated that the manganese-oxides may aid microorganisms by acting as ultraviolet screens [1, 3, 4] or may facilitate radiation resistance, which has been shown for cyanobacteria [5].

Analysis of martian rocks by Spirit and Opportunity has shown that they have a remarkable geological diversity and that many have undergone substantial chemical (hydrous) alteration [7]. Furthermore a type of "case-harding" of the outer surface of some rocks has been observed [8]; certainly the Rock Abrasion Tool (RAT) has shown thick weathering rinds with significant chemical differences between the inner composition and the outer surface of some rocks [9].

Analysis Methods: Samples of desert varnish on numerous types of rock substrates were collected at sites throughout the southwestern United States, including Mojave Desert area, California; Hanksville, Utah; Socorro and Carlsbad, New Mexico. Samples were imaged in a JEOL 5800LV scanning electron microscope and quantitatively analyzed on a JEOL 8200 electron microprobe. Samples were aseptically collected for culturing and for DNA analysis; both natural and cultured samples were extracted, PCR amplified, and sequenced. Fungal DNA was analyzed using 18S and bacterial DNA analyzed using 16S primers.

Results: Microprobe analysis of samples from the Socorro, NM region yielded lead in percent levels. Anthropogenic lead is usually present in ppm levels in desert varnish but is much higher at Socorro due to lead smelters that operated there at the end of the 19th century. Importantly, the lead acts as a tracer in our samples to reveal a varible rate of varnish growth. While many samples exhibit high lead concentrations at the outer surface, others contained lead at some distance under the surface, yielding growth rates as high as 30 μm per millenia. Varnish from rock surfaces occasionally wetted by runoff exhibited the highest lead concentration at the greatest distance under the surface. Our results indicate that rock varnish grows at different rates, depending on the rock surface environment, growing fastest where occasionally wetted and slowest where constantly dry. On the other hand, the sample exposed to the most water run off had the lowest lead level presumably attributable to fluid removal of atmospherically deposited lead.

DNA analysis of samples indicates that a diverse microbial community is associated with desert varnish, in agreement with the findings of many other workers. Imaging and DNA analysis of cultures reveals that manganese is sequestered into distinct features by several types of fungi. Likewise fungi can rapidly colonize rock surfaces, even these exposed to constant sun and receiving only occasional water.

Discussion: Chemical analysis of martian meteorites has revealed that Mars boasts more manganese and iron than Earth. Seasonal fogs on the red planet could moisten the rocks with enough water to sporadically supply resident organisms [6]. Thus manganese- or other metal-rich rock coatings may hold implications for Martian biogenic origin of similar rock coatings. Likewise, our work has shown that a microbial community associated with rock coatings can be present deep under the surface of porous rocks where they are protected from radiation and desiccation. In this case, the metal-oxides produced by the community help to produce a case hardening effect that acts as sunscreen and dessication retardant for the microbial communities.

Implications for Mars Sample Return: If biogenic signatures are present in rock coatings, abrasive (RAT) tools for in situ analysis will very likely destroy such delicate and three dimensional evidence. Therefore the return of samples, especially cores samples that include rock coatings and underlying substrate, is essential to understanding the origin of such coatings.

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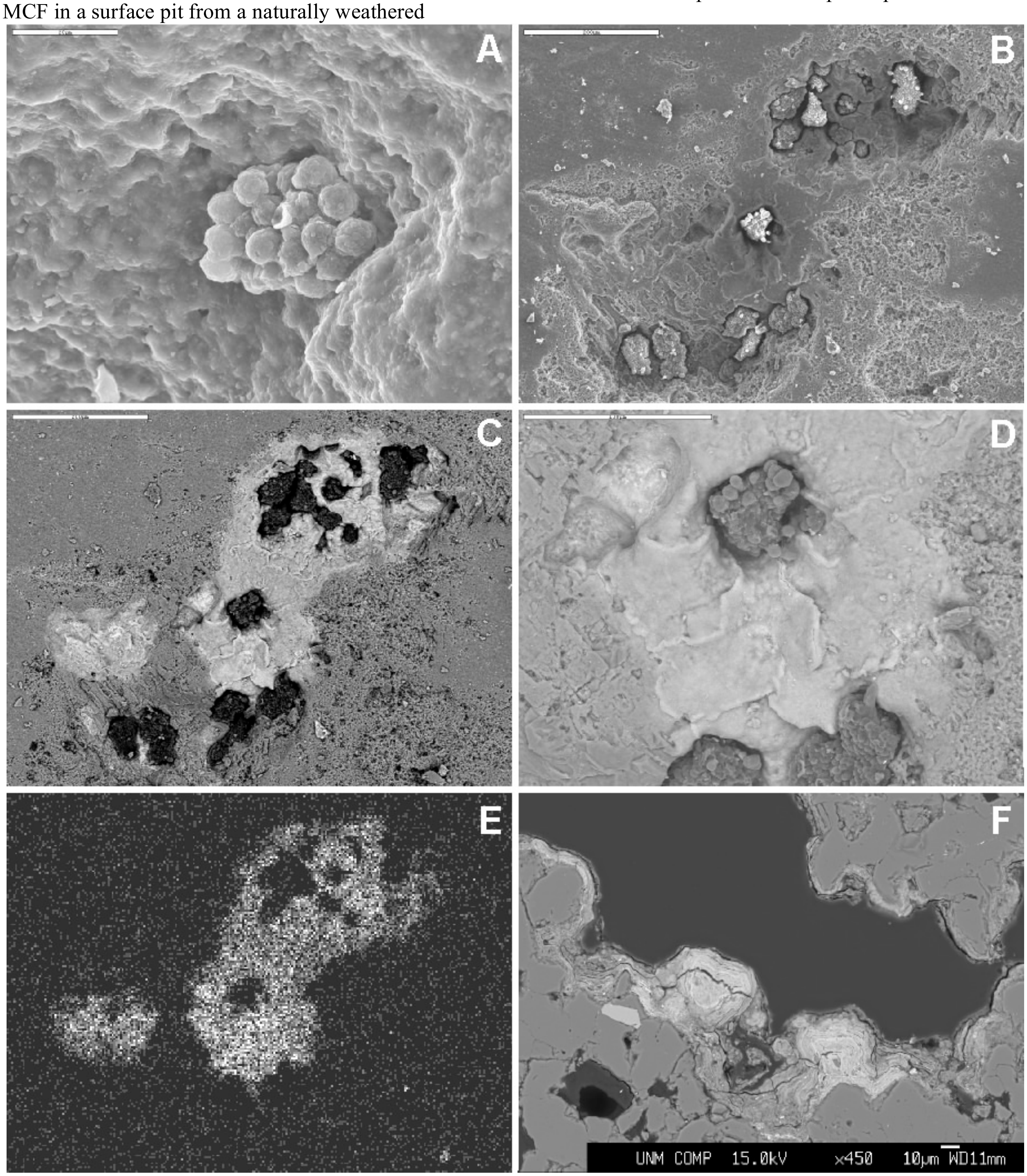

Figure 1. Electron micrographs taken from the surface of non-varnished rocks. A) MCF in a pit on the surface of a sample from a blasted road cut. Scale bar = 20 µm. B) MCF in a surface pit from a naturally weathered sample. Scale bar = 10 µm. C) BSE image of incipient varnish in image B above. MCF appear dark while incipient rock varnish (Fe- and Mn-rich) is light. Scale bar = 200 µm. D) Close up on incipient varnish in lower center of image C. Scale bar = 100 µm. E) EDS manganese map on the same area as image C above. F) Varnish colonies deep in surface-exposed pore.