Desert varnish, a coating of manganese and iron oxide grains held together in a clay matrix on the surface of rocks, is widespread in Earth’s deserts. Its formation is thought to involve weathering processes acting in conjunction with microbial activity. Analyses of varnish samples from the Lake Lahonton desert area of Nevada and Cortez, Colorado were conducted using differential thermal analysis coupled with gas chromatography and infrared spectroscopy. Data from the DTA/GC and the spectral analyses of the desert varnish reveal that they contain not only birnesite and hematite in a clay matrix, but also, magnetite. Scanning electron microscopy (SEM) analysis of magnetic grains confirms the presence of euhedrally-shaped magnetite a few microns in diameter and smaller. The occurrence of magnetite in desert varnishes is a new finding. The presence of magnetite in desert varnish is significant because by outward appearances it should be too oxidizing to be stable. This situation is similar to that of Mars where magnetite is found yet the surface of Mars is oxidizing and not favorable to magnetite stability.

Introduction: Rock varnishes (desert varnishes), are typically described as thin (< 500 µm), black layers of manganese oxides (birnesite) and iron oxide (hematite) held in a clay matrix on the surface of rocks [1, 2]. Rock varnishes occur in a wide range of terrestrial environments, but are especially prominent in deserts. The principle components of the varnishes are the iron and manganese oxides which can each comprise 20-30% of the varnish by weight. The source of the iron and manganese is from soil, which reaches the rock surface through wind action. Many other components exist in the soil, however, that are not found in varnish. Thus, varnish formation involves the selective deposition of iron and manganese in the form of oxides and the removal of most other inorganic elements that arrive with the soil. Although the complete mechanism of varnish formation is not well-defined, a combination of both biological and non-biological weathering mechanisms have been proposed to explain the selective deposition of the iron and manganese and thereby the origin of the varnish [3, 4, 5, 6, 7].

Mars is a cold, dry, planet with an oxidizing surface bombarded by ultraviolet and ionizing radiation that creates an oxidizing surface environment. Although the surface of Mars is oxidizing, magnetite has been found in the surface material. It is unknown how the magnetite formed on the surface and it is unclear why it exists in an oxidizing environment. In that regard it is similar to the magnetite found in terrestrial desert varnish.

Methods. Basaltic rocks were collected from the Lake Lahonton desert area in northern Nevada dating to the Pleistocene. Sandstone rocks were collected in the southwest region of Colorado just outside of Cortez. This study includes a combination of Differential Thermal Analysis (DTA), visible/infrared reflectance spectra and secondary electron (SE) imaging of rock varnishes and their parent bodies. Preliminary results on the Reno rock varnish are shown here. A strong magnet was used to extract the magnetic grains from ground desert varnish. SEM was performed using a field emission SEM, Hitachi S 4000. The accelerating voltage was 20KV for all the measurements.
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Results: Previous studies using chemical and infrared methods found that the iron in the rock varnish was in the form of hematite [1, 2]. Another study found that the varnish that formed on rocks from new Mexico and Nevada contained a magnetic component [8]. In this study we have focussed our attention on the magnetite grains found in the rock varnish of our two samples. Terrestrial magnetite occurrences are primarily from magmatic, or metamorphic sources. Igneous rocks frequently contain magnetite as an important minor mineral, in addition to the major silicate rock-forming minerals. Less frequently, magnetite is found in sedimentary rocks. The dry non-reducing environment in which desert varnish forms, is generally not conducive to the formation of iron oxides such as magnetite and the weathering process itself typically converts magnetite to hematite. Therefore the presence of magnetite in desert varnish is somewhat unexpected.

Spectral and chemical data measured by instruments on Mars Pathfinder (MPF) suggest that many of the rocks are covered with coatings [9]. Comparison of the spectra of Martian meteorites and the rocks near the MPF landing site show that the pyroxene bands characteristic of Martian meteorites are either not present or are masked by a surface coating [10]. Chemical reaction of the dust/soil particles may be creating alteration rinds on the rock surfaces. Alternatively, acid-fog reactions of aerosols in the atmosphere may be corroding the surfaces of Martian rocks [11]. Continued study of terrestrial rock varnishes may help us to identify potential formation processes of rock coatings on Mars.


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