Desert varnish: an environmental recorder for Mars

Randall S Perry and Mark A Sephton discuss a target material for Mars Sample Return: rocks coated with desert varnish, a mineral layer that records past surface climates on Earth, and probably on Mars too.

**ABSTRACT**

With the prospect of a Mars Sample Return mission in the next two decades, attention is now focusing on the types of samples that would be most useful for returning to Earth for laboratory analysis. Recent data on desert varnish reveal that laminated coatings on rocks from extreme environments are a passive recorder of past and present environments. Martian desert varnish would contain a chronology of the martian setting, perhaps extending back to a wetter and more biologically active period.

Our current attempts to find evidence of life elsewhere in the solar system are firmly focused on the planet Mars. Recent information provided both from orbit and at the planet’s surface suggest that liquid water was once abundant, raising the likelihood of life either at the present time or in the past (e.g. Squyres et al. 2004). The European Space Agency is planning the ExoMars mission for robotic in situ analyses of martian soil for life’s chemicals. Yet this mission will also prepare the way for a more ambitious interplanetary adventure. Mars Sample Return is scheduled for launch in the next two decades and will involve martian materials being returned to Earth for analysis.

Current proposals are for a miniature drill to collect samples of martian soil at certain depths. Deeper samples may contain organic matter that has escaped the destructive influence of the oxidizing and radiation-rich surface. However, recent research on Earth rocks from hot desert environments suggests that specific types of martian samples may be readily collectable and information-rich targets.

**Desert varnish**

In desert environments on Earth, whole mountain ranges are coloured black or brown by a 10 µm coating containing silica minerals and oxidized iron and manganese (figure 1). It is the black, shiny nature of most desert varnish that makes rocks coated in this way distinctive and has attracted the attention of observers since the mid-19th century (Humboldt 1852, Darwin 1871). Interestingly, Humboldt noted the similarity of this shiny coating to the fusion crust of meteorites and stated: “What is the brownish black crust, which gives these rocks, when they have a globular form, the appearance of meteoric stones?” Even at the present day, many amateur meteorite hunters present desert varnished samples to museum curators believing that they have found an extraterrestrial sample, only to be informed that their meteorite is in fact a “meteorwrong”.

Laboratory analyses have revealed that desert varnish contains percentage levels of organic carbon made up of life molecules such as amino acids and DNA. Partly for this reason, the enigmatic organic-rich coating has often been ascribed to the action of biology on desert rock surfaces. Dorn and Oberlander (1981) believed that desert varnish was formed by colonies of bacteria living on the rock exterior. The manganese and iron were thought to have been

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Evaporation of small amounts of silicic acid may be formed as moisture and other components are added, forming complex chemical cauldrons (figure 2). Desert varnish (Perry et al. 2006), are highly analogous and also entomb environments; for instance, bacterial DNA in varnish coatings is usually similar to local soils. The source materials include wind-blown grains, aerosols, microbes and microbial components (Perry and Adams 1978). The accumulation of environmental products in desert coatings preserves a biological, climatological and environmental record (Liu 2003, Perry et al. 2003). The importance of silica to the formation of desert varnish means that other silica-rich rock coatings should be considered as part of the same class. Siliceous deposits around hot springs, e.g. Taupo Volcanic Zone, New Zealand (Perry and Lynne 2006), are highly analogous and also entomb evidence of past life.

A varnish record through time

The environmental record contained in desert varnish extends through time because it occurs in very fine layers that grow over each other (figure 3). The growth pattern is very similar to that seen in stromatolites (layers produced by the growth of particle-binding bacteria that ultimately harden to form rock) and each layer records the environment in which it formed. The deepest, oldest layers in the varnish may have formed in very different conditions to the shallowest, youngest layer. These layers, and all the ones in between, represent a record of environmental change. So these lustrous coatings can become a window on the local surroundings, back through time.

Desert varnish on Mars?

If silica exists in desert varnish-like coatings on Mars (DiGregorio 2002) or in hydrothermal deposits (Bock and Goode 1996) then, as on Earth, it may contain ancient microbes or chemical signatures of previous life. It is possible that on Mars the earliest formed layers in any stromatolite-like sequence may have recorded a wetter, more biologically amenable martian environment. Moreover, it is likely that martian desert varnish would be a better preserver of organic matter than its Earth counterpart. The current martian environment is much colder and drier than that on Earth. Martian desert varnish records may also extend further back in time. On Earth desert varnish is a relatively recent rock coating generated in time periods commonly less than 100 000 years; older examples are removed by physical and chemical weathering. Evidence on Mars of ancient surfaces and events suggest that physical and chemical weathering is less aggressive than on our planet. Martian desert varnish, it appears, would be a sample worth collecting and returning to Earth in future space missions.

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References


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