Remote sensing

Desert varnish (*May 2008*)

Just as vultures hate a glass eyeball, so geologists who use remote sensing detest vegetation cover. But the spectral blanket thrown over geology by grass and other plants is not the only irritation, and one of them occurs where least expected. Arid terrain usually pays the best dividends in remote geological mapping, because the spectral properties of rocks and their constituent minerals emerge in reflected and emitted radiation and bear close relationships to those determined in laboratories. Images captured from orbit that use carefully chosen wavebands are often stunningly informative in deserts. The bugbear is desert varnish, an often shiny black coating that completely masks what lies beneath, even in the field, be it basalt, granite, sandstone or carbonate. Generally it is no more than a millimetre thick, and often far thinner. Close examination often shows a minutely botryoidal texture and parallel laminae in cross section, very like a tiny stromatolite. Basically, desert varnish is such a biofilm, and the responsible organisms are cyanobacteria, as in stromatolites, but exceptionally sturdy ones. However, the bulk of the material is inorganic, and it is spectrally featureless, hence the problem in remote sensing.

Widespread as it is in arid environments, desert varnish has not been deemed an appropriate subject of study, so any information is welcome (Garvie, L.A.J. *et al*. 2008. Nanometer-scale complexity, growth and diagenesis in desert varnish. *Geology*, v. **36**, p. 215-218; DOI: 10.1130/G24409A.1). Hailing from Arizona University, the authors are well placed. Their approach is not so much directed at organic aspects, which is a shame, but at the geochemistry of this annoying gunk. As has been long known, they show the dominance of manganese phases, but mixed in with very fine-grained quartz, clays and iron oxy-hydroxides. The varnish seems to contain a wind-blown component, but the manganese and probably the iron is derived in some other way, having grain sizes less than 100 nanometres. Iron and manganese minerals dominate the fine laminae, and at very high electron microscope resolutions their grains show yet finer structure at 1 nm scale. The authors ascribe the cyclical structures and mineralogy to repeated wetting and drying, with leaching and oxidation of Fe and Mn. Both iron and manganese are multi-valent, Mn more so than Fe. For both to be leached, i.e. drawn into solution as Fe^{2+} and Mn^{2+} ions, requires strongly reducing conditions, and then oxidation to precipitate Fe^{3+} and Mn^{4+} or Mn^{7+} minerals. At this minute scale, whatever the source of the Fe and Mn, a biological influence seems crucial.

Renewed interest in desert varnish seems to be connected with Mars – the study was partly financed by NASA. Yet, none of the Martian remote sensing studies report annoyance with huge tracts blacked out by manganese minerals. Such surface alteration that has been analysed by the Mars Rovers proved to be iron-enriched with little significant manganese enrichment. If desert varnish is biogenically mediated, then its occurrence on Mars would be cause for excitement bordering on hysteria. The cyanobacteria in terrestrial varnishes are tough, and may date back into Precambrian times as the first colonisers of dry land. As yet, there have been no attempts to examine their genetic affinities.