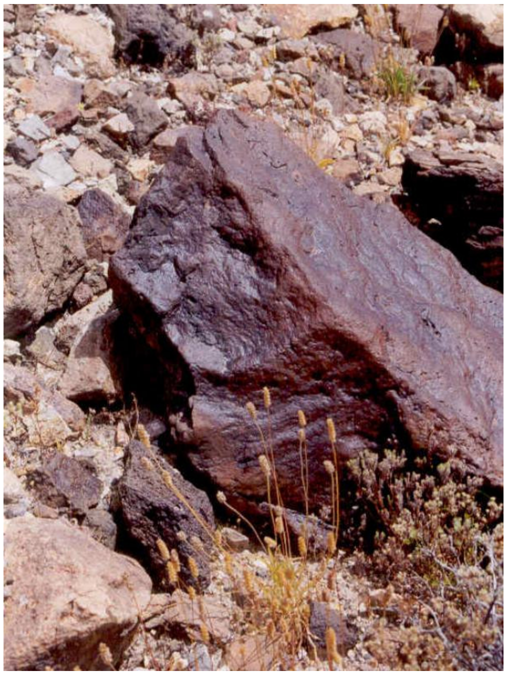
Desert varnish



Desert varnish or **rock varnish** is a dark coating on rocks found in arid regions. The coating is composed dominantly of fine-grained clay minerals. Within the clays are black manganese oxide and red iron oxide. A more general term is rock varnish, which applies to dark coatings on rocks in general. It is one of fourteen different types of rock coatings.

Varnish Formation

Desert varnish forms only on physically stable rock surfaces that are no longer subject to frequent precipitation, fracturing or sandblasting. The varnish is primarily composed of particles of clay along with iron and manganese oxides. There is also a host of trace elements and almost always some organic matter. The color of the varnish varies from shades of brown to black.

Composition

The results of the analysis revealed that the main constituent in desert varnish, totaling about 70%, is clay, not manganese and iron oxides. The oxides form the remaining 30%. The red coating on the underside of the varnished rocks, previously believed to be iron oxide, turned out to be 90% clay incorporating an iron oxide stain, similar to the iron in the black finish on the rocks' exposed portions. In addition it was found that all desert varnish, whether it formed on the side of a cliff or on a 10-inch boulder, shares a similar composition.

It was concluded that most of the coating collects from sources outside the rock rather than from material leached out of it, as many geologists had believed. One reason for this conclusion is that varnish is found covering non-manganese or iron bearing quartz crystals. Although some rocks may contribute oxides through weathering, the primary source seems to be wind deposited particles.
Fine, windblown clay particles are a critical ingredient in forming the varnish, which first forms on rough, porous surfaces. These surfaces allow dew and other moisture to collect, depositing a thin film of clay when the water evaporates. This film of sediment on the rock's surface encourages water to migrate through tiny pores inside the film, depositing traces of manganese and iron as the water evaporates.

The formation of desert varnish is interdependent upon the clay and oxides. The dry, fluffy clay particles depend on the oxides to form a resistant cementing agent. The oxides, in turn, require clay particles for transportation and deposition. This is the underlying reason why all desert varnish that was examined contained both clay and manganese and iron oxides -- never one without the other.
Desert varnish is dominantly clay. The clay minerals represent the clays found locally in the region where the varnish develops. In the clay layer, black manganese oxide (the mineral birnesite) and red iron oxide (the mineral hematite) add color.

Originally scientists thought that the varnish was made from substances drawn out of the rocks it coats. Microscopic and microchemical observations, however, show that a major part of varnish is clay (which could only arrive by wind). Clay, then, acts as a substrate to catch additional substances that chemically react together when the rock reaches high temperatures in the desert sun. Wetting by dew is also important in the process.

Another important characteristic of desert varnish is that it has an unusually high concentration of manganese. Manganese is relatively rare in the earth's crust, making up only 0.12% of its weight. In desert varnish, however, manganese is 50 to 60 times more abundant. This significant enrichment is thought to be caused by biochemical processes (many species of bacteria use manganese).

Even though it contains high concentrations of iron and manganese, there are no significant modern uses of desert varnish. However, some Native American tribes created petroglyphs by scraping or chipping away the dark varnish to expose the lighter rock beneath.

Petroglyphs in desert varnish at the Valley of Fire near Las Vegas, Nevada. Area shown is about 1 meter across.

Desert varnish often obscures the identity of the underlying rock, and different rocks have varying abilities to accept and retain varnish.

Limestones, for example, typically do not have varnish because they are too water soluble and therefore do not provide a stable surface for varnish to form. Shiny, dense and black varnishes form on basalt, fine quartzites and metamorphosed shales due to these rocks' relatively

Description

Desert varnish is a hard, dark-brown or black, dull or lustrous (if wind polished) coating that accumulates on the exposed surfaces of rock fragments and outcrops. Its composition is independent of the composition of the host rock. It is common on **gravel plains**, especially on **alluvial fans** with **desert pavement**. Tone, intensity, and color of the varnish depend mostly on climate variations (e.g., precipitation) and on the relative age of the exposure of the rock surface.

Layers of varnish are relatively thin, commonly 0.005 to 0.5 mm thick, but thickness varies from locality to locality as well as over the surface of a single stone. Varnish gives a similar spectral reflectance signature, or appearance, to rocks of different composition and origin. It develops best on resistant, coarse-grained materials whose surfaces do not disintegrate too rapidly, such as granite, sandstone, basalt and other volcanic rocks, and many metamorphic rocks. Limestone that are not silicified generally do not support a varnish because the surfaces dissolve faster than the varnish can develop. Because varnish is thought to form slowly (over decades), its presence indicates stability of the plains surfaces.

Origin

Theories of varnish formation and rates of its development are controversial. Varnish commonly forms on rocks that contain little or no iron and manganese, indicating that these elements are carried to the rock surface by wind, water, or both. Further development can take place by the biological action of manganese-oxidizing microorganisms. The development rate is; however, relatively slow, i.e., measured in years, decades, and millennia.

One item of interest associated with the lore of desert varnish is that British fuel cans left in the eastern Sahara since World War II have been found that have a well developed layer of varnish (not rust!) on their upwind sides.

In general, about 70% of a varnish coat consists of clay minerals. The remainder is composed of oxides of iron (Fe) and manganese (Mn).

Variations in the ratios of these two oxides, probably due to variations in climate during their accumulation, cause variations in varnish color, ranging from dark bluish-black (Mn rich) to dark brownish-black (Fe rich). Whether or not we can reliably differentiate among varnishes of various compositions by field and laboratory spectral measurements in the reflected solar spectrum (0.4-2.5 micra), and subsequently do so via multiband and hyperspectral imagery remains to be determined. Complicating the issue from a remote sensing point of view is the fact that the overall darkness of a varnished desert pavement is also a function of the spacing of the fragments in the pavement.

Another characteristic of rock fragments in desert pavements is that their undersides are reddened ("rubified") by bright red clays and iron hydroxides derived from the soils in which they lie.

Significance

The dark tones of desert varnish, which can be seen in association with **gravel plains** in air photos and some Landsat images, generally indicate a firm, stable, and trafficable surface. Except for areas of steep slopes in swales and incised drainages, or of roughness due to boulders, these surfaces can support vehicular traffic--not because of the varnish, but because of the nature of the desert pavement associated with it. Generally, surfaces stable enough to develop varnish also have developed an accretion mantle of fine sand and silt, which immediately underlies the surface layer of varnished rocks or pebbles. Repeated passes or vehicles tracking each other can disrupt the surface and expose the underlying dust, producing fines.

In some cases, a single pass of a vehicle can leave a track that persists for many years, because overturned rocks leave a bright trail among the varnished rocks.

Foreign Names and Synonyms

(common names are in bold) Desert lacquer, **patina**, Wustenlack, vernis desertique, patine du desert, weathering rinds