Desert Varnish

Figure 1. Streaks of desert varnish formed on a rock wall where water commonly flows during rainstorms in Capital Gorge, Capital Reef National Park, Utah. The black coloration is due to birnessite as the dominant pigmenting agent. Chuck Kime photo, WoodChuck Images.

If you have traveled through the southwestern United States, you may have noticed black or reddish-brown stripes, like giant paintbrush strokes, on rock cliffs (fig. 1) or shiny black surfaces on rocks on the desert floor (fig. 3). These coatings are collectively known as desert varnish (Whalley 1983). Desert varnish is composed mostly (70 weight percent) of clay minerals (phyllosilicates) with oxides of manganese and iron comprising the remaining 30 percent (Potter and Rossman 1977, 1979). Of the oxide minerals, birnessite (MnO\textsubscript{4}) (fig. 2) and hematite (Fe\textsubscript{2}O\textsubscript{3}) are most common. Both of these minerals are strong pigmenting agents and give desert varnish its characteristic black or red colors, respectively. Mixtures of these two oxides yield intermediate shades of brown. When birnessite is abundant, the desert varnish can be very shiny with an almost submetallic luster. The coatings of desert varnish are thin, usually less than 0.5 mm, and their rate of formation is slow, taking as long as two hundred thousand years to form in some cases (Liu and Broecker 2000). Although it is most obvious in arid environments and is found in deserts all over the earth, including Antarctica (Dorn et al. 1992), desert varnish can form in a wide range of terrestrial environments (including alpine and tropical environs) and is thus sometimes referred to more generally as rock varnish (Dorn and Oberlander 1982).

How desert or rock varnish forms is not well understood, however. This issue is a particularly hot topic among scientists today, especially for those who are looking for possible evidence of life on Mars. It turns out that the mineralogy of the varnish is independent of the rock type on which it forms and is not the result of the weathering of those rocks. Instead, it is thought that the clays in desert varnish are derived from airborne dust (Potter and Rossman 1979), whereas iron and manganese are thought to be carried by both wind and water. In general, there are two hypotheses for the formation of desert varnish. One mechanism is completely inorganic (i.e., occurs without biological influences). The other proposed mechanism of desert varnish, which is gaining more and more supportive evidence, involves biological activity, specifically that of bacteria (Dorn and Oberlander 1981; Perry and Kolb 2004).

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Figure 2. Layers of octahedrally coordinated manganese and water molecules compose the atomic structure of birnessite shown here.

Figure 3. Black coatings of desert varnish on sandstone.

Figure 4. Petroglyphs in desert varnish, Arches National Park, near Moab, Utah. Photo courtesy of the Moab Area Travel Council.

Desert varnish is such an important component of the visual makeup of the Southwest landscape that an artificial desert varnish (PERMEON™) has even been developed and has been used by local municipalities in the restoration of the natural appearance of rocky cliffs that have been disturbed by construction.

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REFERENCES


