D

DESERT VARNISH AS A PALEOCLIMATE PROXY

Desert varnish, a paper-thin accretion on rock surfaces (Figure D34), greatly alters the appearance of bare rock faces. Almost any lithology can host varnish, but the surface must remain stable for thousands of years in order to accumulate varnish in most desert environments. Rock varnish is the better term because this same rock coating forms on rocks in all environments, for example, alpine, Antarctic, Arctic, periglacial, stream, temperate, and tropical environments. The term desert varnish is most often used in arid regions (Dorn, 1998).

Environmental changes influence varnish. Lichens and many fungi, for example, secrete biological acids that destroy desert varnish by dissolving the manganese and iron oxides. Where rocks exist in a desert pavement or in other settings such as an opened rock crevice, local environmental conditions play the key role in varnish development. However, where rock faces are not greatly influenced by the local microenvironment, varnish layers, called visual microlaminations (VML), record changes in the aridity of an area. Varnishes seen in ultra thin sections (<5 µm) with a light microscope reveal orange-yellow and black layers.

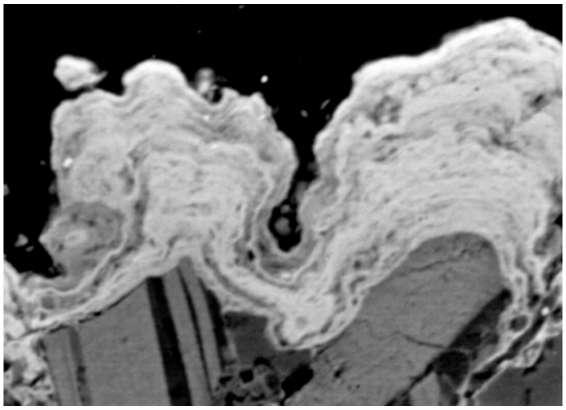


Figure D34 Backscattered electron microscope view of brighter rock varnish formed on granodiorite (feldspar and quartz minerals) at Kitt Peak, Arizona. The varnish is only about 0.05 mm thick. Note the distinct boundary between varnish and rock, indicating that varnish is an accretion.

In these boulder-top positions, wetter climates favor bacterial enhancement of manganese (Figure D35), producing the black layers. Drier climates with more alkaline dust foster development of orange-yellow (Mn-poor) layers that record arid periods (Dorn, 1990). In places where VMLs have been calibrated by radiometric dating methods, they can yield correlated ages for rock surfaces (Liu, 2003, 2006), as revealed in a recent test: "*. . . results of the blind test provide convincing evidence that varnish microstratigraphy is a valid dating tool to estimate surface exposure ages*" (Marston, 2003, p. 197). Based on a decade of detailed analyses of over 10,000 microsedimentary basins, Liu (2003, 2006) found that black varnish layers correspond with Heinrich events, the Younger Dryas (Figure D36), and wet events during the Holocene.

The wet periods recorded in rock varnish, however, do vary in timing regionally. Cremaschi (1996), for example, found a mid-Holocene Mn-rich layer in Tunisian varnish correlating with a regional wet pulse in North Africa. When regionally calibrated, varnish microlaminations provide archaeologists and geomorphologists a powerful Quaternary tool, because they reveal both climatic change and a time signal (Figure D37). The potential of VML extends beyond the Quaternary in circumstances where varnish is preserved in sedimentary environments; investigators can infer from VML that the environment probably fluctuated between arid and less arid environments (Dorn and Dickinson, 1989).

There are other paleoclimatic indicators found in association with desert varnish. When other types of rock coatings (Dorn, 1998) alternate with desert varnish, the change in coating type often has implications for environmental change. Changes in the trace element geochemistry of varnish, for example, changes in carbon isotopes and lead (Dorn, 1998), also record environmental changes. Still other indicators include micromorphological

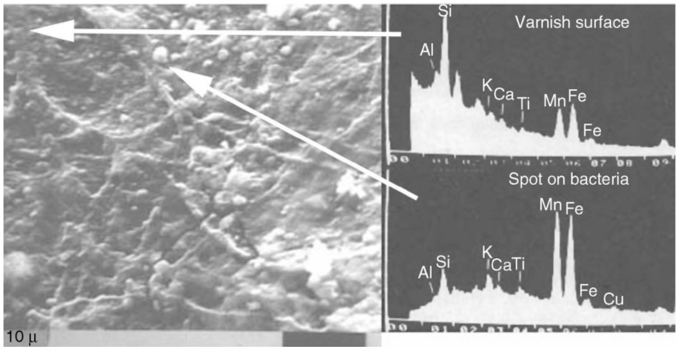
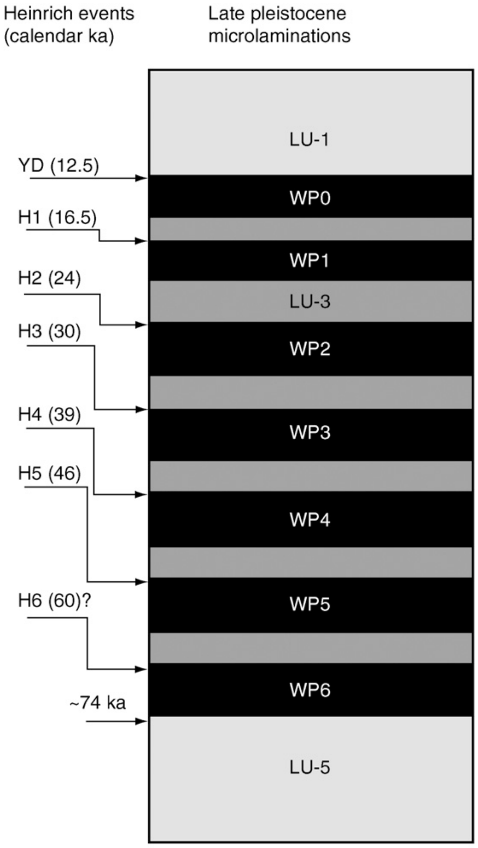


Figure D35 Budding bacteria concentrate manganese in rock varnish, as seen here through electron microscopy and energy dispersive chemical analyses of Negev Desert varnish.



Graph not drawn to scale

Figure D36 Calibration of varnish microlaminations from the basin and range of western North America (based on data in Liu, 2003), where ka is thousands of years.

changes in varnish layering that provide an indicator of the dustiness of the depositional setting. Because desert varnish is a weathering feature, sensitive to climatic change, changes in its physical and chemical structure provides researchers opportunities to understand paleoclimatic changes in arid regions.

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Cross references

Dating, Radiometric Methods
Heinrich Events
Mineral Indicators of Past Climates
Weathering and Climate
Younger Dryas

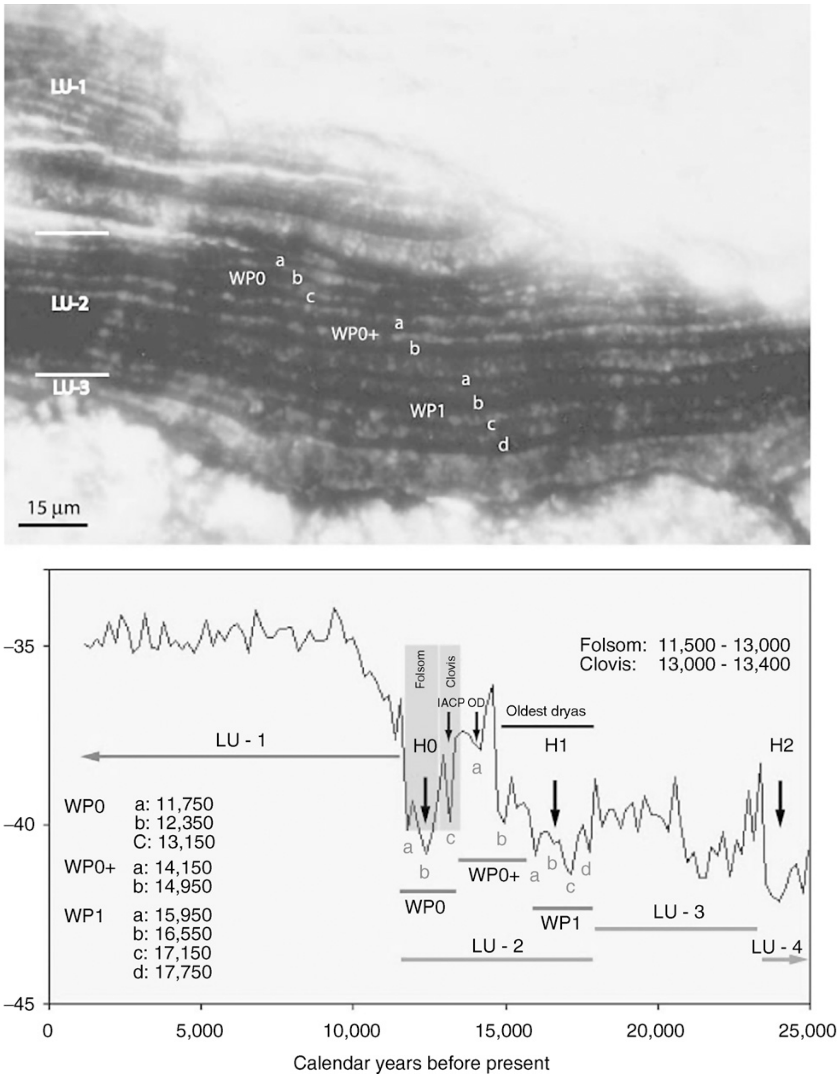

Figure D37 Rock varnish record of the latest Pleistocene wet events in Death Valley, California and its *possible* correlation with GISP2 δ^{18}O ice core record in Greenland (*below*), where the graphic is modified from Liu (2006). In fast accumulating varnishes, such as this sample from Death Valley, there are three wet phases in the Younger Dryas event (*WPO*), four wet phases in Heinrich event 1 (*WP1*), and two wet phases between them (*WPOT*) that can discriminate different events in the terminal Pleistocene.