Desert Varnish

Desert varnish is but one of more than a dozen rock coatings (Table 1) that drastically alter the appearance of rock surfaces. The better term is *rock varnish* because this coating occurs in virtually all environments, including alpine, antarctic, arctic, desert, periglacial, stream, temperate, and tropical settings. This paper-thin accretion is characterized by extremely high concentrations, typically more than 10%, of manganese oxides that give it a characteristic black to dark brown appearance. Clay minerals, however, make up the bulk of rock varnish along with iron oxides.

There are four general explanations for how rock varnish accretes on top of rock surfaces, but all these models reject the old idea that the constituents of varnish derive from the underlying rock. The model that has not yet been falsified is the polygenetic model of rock varnish formation (see first series of photos). This explanation combines bacterial enhancement of manganese and iron with abiotic fixation of the manganese by clay minerals. The process starts with bacteria fixing manganese on cell walls. Wetting events dissolve manganese. The desert dust supplies interstratified clay minerals, and the dissolved manganese reprecipitates as nanometer-sized fragments of manganese oxides. These tiny minerals fit into the weathered edges of clays, tightly cementing clays to the rock surface. The effect is a highly layered texture at the micrometer and nanometer scales imposed both by the clay minerals and the cementing manganese-oxides.

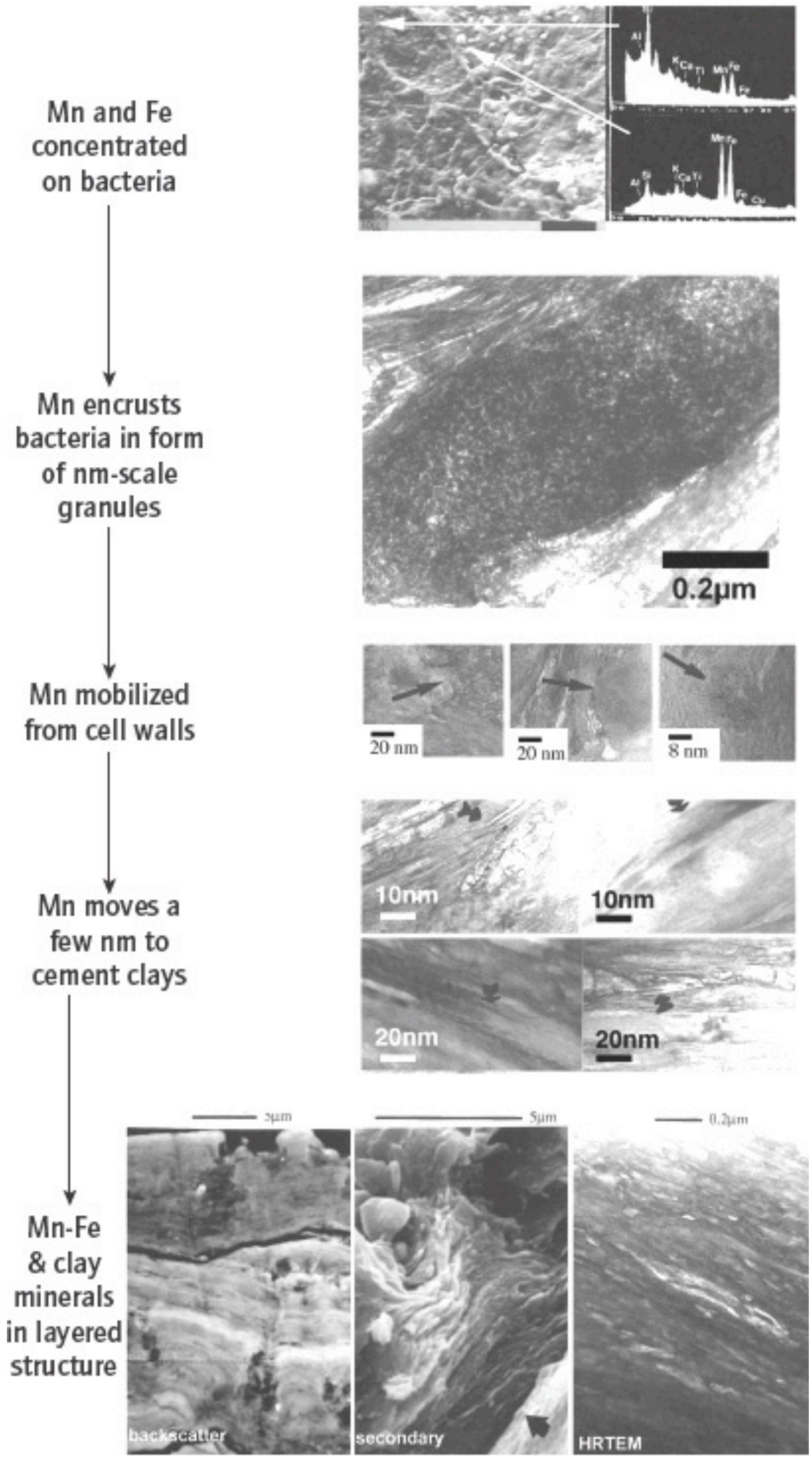
The most exciting development in varnish research in the past several decades is the development of varnish microlaminations (VMLs). This tool is based on 12 years of detailed analyses of more than 10,000 microsedimentary basins by Tanzhuo Liu (www.vmldatinglab.com). Working in the deserts of Western North America, Liu found that black varnish layers correspond with wet events and developed calibrations for the late Quaternary and a separate calibration for the Holocene. The second photo illustrates just one rock varnish VML sequence from Death Valley, California, formed over the past 20,000 years.

Coating	*Description*	*Related Terms*
Carbonate skin	Composed primarily of carbonate, usually calcium carbonate ($CaCO_3$) but sometimes magnesium carbonate ($MgCO_3$)	Calcrete, travertine
Case hardening	Addition of cementing agent to rock matrix material; the agent may be manganese, sulfate, carbonate, silica, iron, oxalate, organisms, or anthropogenic	Sometimes called a particular type of rock coating
Dust film	Light powder of clay- and silt-sized particles attached to rough surfaces and in rock fractures	Clay skins, clay films, soiling
Heavy-metal skins	Coatings of iron, manganese, copper, zinc, nickel, mercury, lead, and other heavy metals on rocks in natural and human-altered settings	Sometimes described by chemical composition
Iron film	Composed primarily of iron oxides or oxyhydroxides; unlike orange rock varnish because it does not have clay as a major constituent	Ferric oxide red staining, iron staining
Lithobiontic coatings	Organisms forming rock coatings, for example, lichens, moss, fungi, cyanobacteria, algae	Organic mat, biofilms, biotic crust
Nitrate crust	Potassium and calcium nitrate coatings on rocks, often in caves and rock shelters in limestone areas	Saltpeter, niter, icing
Oxalate crust	Mostly calcium oxalate and silica with variable concentrations of magnesium, aluminum, potassium, phosphorus, sulfur, barium, and manganese; often found forming near or with lichens	Oxalate patina, lichen-produced crusts, patina, scialbatura
Phosphate skin	Various phosphate minerals (e.g., iron phosphates or apatite) sometimes mixed with clays and sometimes manganese	Organophosphate film, epilithic biofilm
Pigment	Human-manufactured material placed on rock surfaces by people	Pictograph, paint
Rock varnish	Clay minerals, manganese (Mn) and iron (Fe) oxides, and minor and trace elements; color ranges from orange to black, produced by variable concentrations of different manganese and iron oxides	Desert varnish, patina, Wüstenlack
Salt crust	Chloride precipitates formed on rock surfaces	Halite crust, efflorescence
Silica glaze	Usually clear white to orange shiny luster but can be darker in appearance; composed primarily of amorphous silica and aluminum but often with iron	Desert glaze, turtle-skin patina, siliceous crusts, silica-alumina coating, silica skins
Sulfate crust	Sulfates (e.g., barite, gypsum) on rocks; not gypsum crusts that are sedimentary deposits	Sulfate skin

Table 1 Major categories of rock coatings

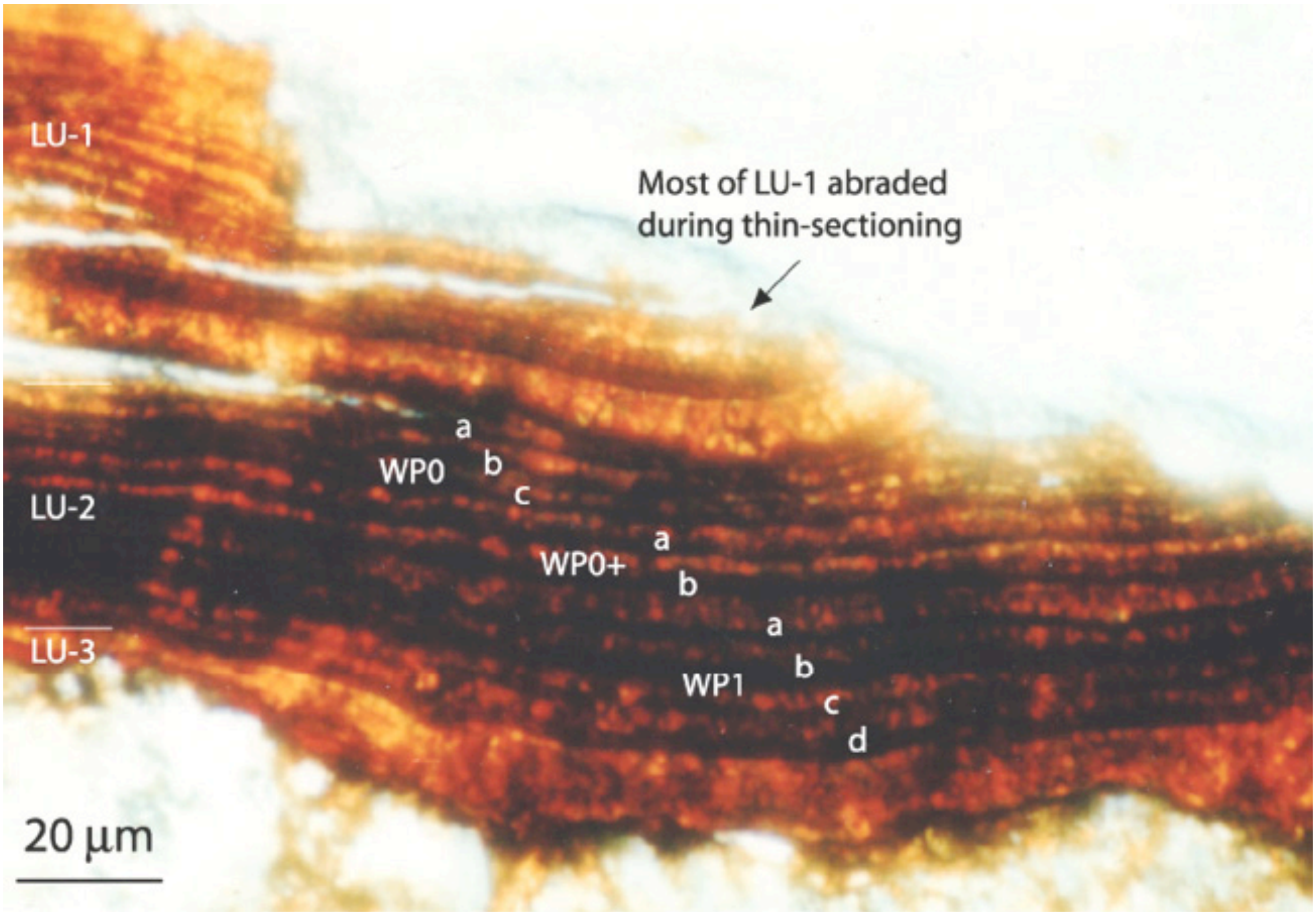
Source: Author.

Liu and other researchers in different settings are in the process of developing calibrations for other regions of the world. Although there are other dating methods that have been proposed for varnish, VML is the only method that has gone beyond the experimental stage. Subject to successful blind testing, the great power of this method is that it is now possible to determine the minimum age of exposure of the underlying rock surface. Liu and other researchers have applied VML to dating features such as alluvial fans, meteorite impact craters, faulting events, landslides, stone artifacts, and ancient petroglyphs.



Varnish formation starts with bacteria that concentrate manganese (Mn) and iron (Fe), as revealed by electron microscope observations. Then, using a high resolution transmission electron microscope, it is possible to see how the manganese moves from the bacteria and into weaknesses in the clay minerals that fall onto desert rock surfaces. The manganese and iron then fit into the clay structure in a way that cements everything together onto rock surfaces. Thus, rock varnish is analogous to a brick wall, where the bricklike clays are cemented by the mortarlike oxides.

Source: Author.



This ultrathin section of rock varnish from Death Valley, California, records wet periods in the form of black layers. The black layers in LU-1 formed during the past 12,000 years during the Holocene. The black layers in WP0, WP0 +, and WP1 accreted during the very end of the Pleistocene from about 18,000 to 12,000 calendar years ago. The oldest layer, LU-3, formed about 20,000 years ago.

Source: Reprinted by permission of Tanzhuo Liu from www.vmldatinglab.com.

—Ronald I. Dorn

Further Readings

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