OCCURRENCE OF ROCK VARNISH AT YUNGAY, ATACAMA DESERT, CHILE. Kimberly R. Kuhlman[1] and Christopher P. McKay[2], [1]Planetary Science Institute, 1700 East Fort Lowell Blvd., Suite 106, Tucson, AZ 85719 USA (kim@psi.edu), [2]NASA ARC, MS 145-3, Moffett Field, CA 94035 USA (cmckay@arc.nasa.gov)

Introduction: Rock varnish is generally understood to be a 5-500 micrometer thick nanostratigraphic coating consisting of approximately 70% clay glued together by 30% iron and manganese oxides, which forms on the surfaces of rocks in most semi-arid to hyper-arid climates [1-4]. This is a very strict definition of rock varnish, which distinguishes it from a variety of coatings that can masquerade as varnish, such as silica glazes, heavy metal skins and geothermal deposits [4]. Rock varnish forms very slowly, at rates thought to be between about 1 to 40 μm per 1000 years [5]. Archeologists have long been interested in dating the age of varnishes to place petroglyphs etched into varnish by ancient cultures into their full historical context [6,7]. Unfortunately, radiocarbon dating of varnish has proven difficult, and results must be used with caution [8-11].

Rock varnish appears to be ubiquitous in semi-arid to hyper-arid environments and may contain a record of the microclimates in which it is found [8,12-14] a hypothesis that has been disputed [15,16]. Some investigators suggest that rock varnish may harbor a historical record of important environmental processes such as long-term climate change. Bao, et al, 2001 studied the preservation of atmospheric signatures in rock varnish and concluded that rock varnishes or other surface deposits may provide a record of paleoclimatic information and sulfur biogeochemical cycles [8]. As a nanostratigraphic deposit, rock varnish may record the activity of dust storms, moisture and temperature fluctuations, biological activity, and the occurrence of fires over many thousands of years.

While the mechanism of its nucleation and growth remains unknown, many believe the formation of rock varnish is microbially mediated, at least in part [17]. The concentration of manganese in rock varnishes has been established to be well above that of the geological background, resulting in the popular notion that biology is involved in varnish formation [18,19]. Other investigators believe that rock varnish is abiotic in origin [20,21]. Rock varnish is most likely formed by a combination of microbial and abiotic processes and may indeed consist of layers formed by entirely different processes depending on prevailing environmental conditions at the time of deposition [18].

Rock Varnish at Yungay: The samples described here were collected in the Mars-like hyper-arid core of the Atacama Desert near Yungay (GPS coordinates -24.069867, -69.866033) [22]. The majority of the rocks at the site are andesite and rhyolite as noted for the northern Atacama by Jones (1991) [23].

Rock varnish appears to ubiquitous in the Mars-like conditions present at Yungay (Fig. 1). The rocks host a dark red varnish, which was especially noticeable on a piece of chert. Petrographic thin sections were made of a sample of an andesitic rock. A transmission optical micrograph of microbasin filled with varnish is shown in Fig. 2. This microbasin is similar to those found in many other deserts [24] and clearly shows the orange and dark variations typical of varnish cross-sections. The light orange layer at the top of the microbasin is similar to that seen in varnishes from the Mojave desert and may consist of clay particles cemented together by silica glaze or opal as proposed recently [21]. The surface texture of this varnish lies between that of botryoidal and lamellate and is shown in Fig. 3. Scanning electron microscopy (SEM) shows an absence of microcolonial fungi (MCF).

The presence of Mn in varnishes from the Atacama Desert has been the subject of some debate [4,23]. The petrographic cross-section was analyzed using SEM (Fig. 4) and EDS. This analysis showed that the dark layers in the petrographic thin section have enhanced Mn (Fig. 5). All samples of varnish from Yungay analyzed to date show evidence of this manganese enhanced layer under the outer layer of varnish. Clay particles that are roughly aligned with the surface of the substrate are also prevalent throughout the varnish, particularly when imaged in using scanning transmission electron microscopy (STEM). Preliminary evidence shows that the Yungay varnish does fit the strict definition of rock varnish of approximately 70% clays and 30% Fe and Mn oxides.

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Fig. 1. An example of a large varnished rock at Yungay. Note the flaking of the varnish across the top of the rock. The lens cap is 58 mm across.

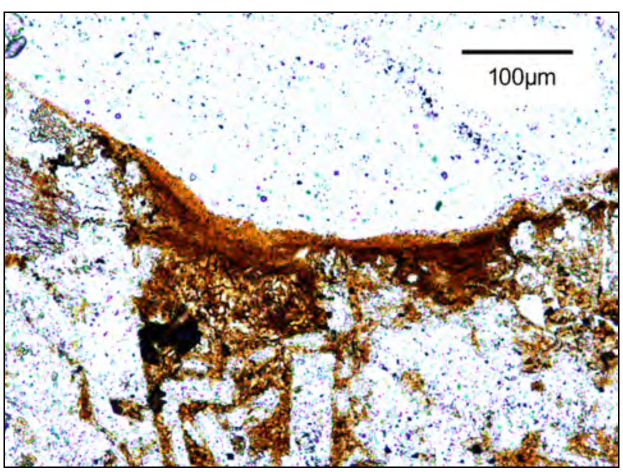

Fig. 2. Optical micrograph of a petrographic thin section of rock varnish from the Yungay collection site.

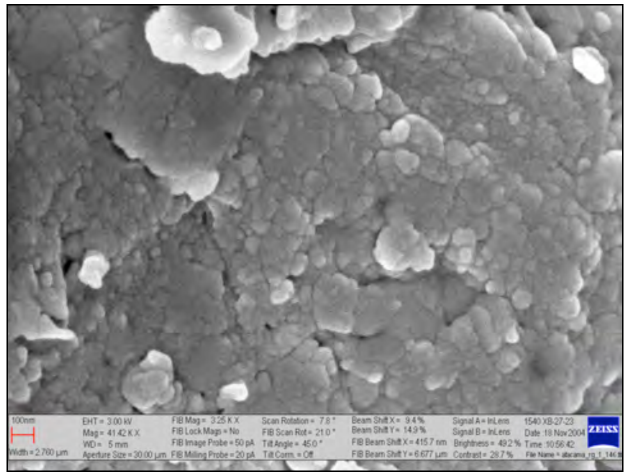

Fig. 3. SEM image of the surface of rock varnish from Yungay. Note that the clay particles overlap each other as they are being cemented to the surface.

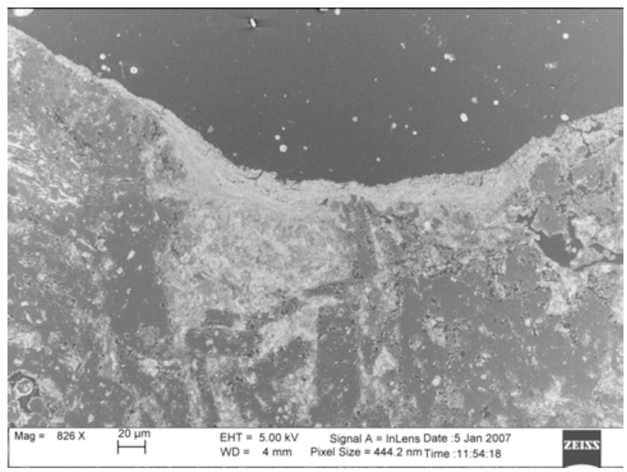

Fig. 4. SEM image of the microbasin shown in Fig. 2.

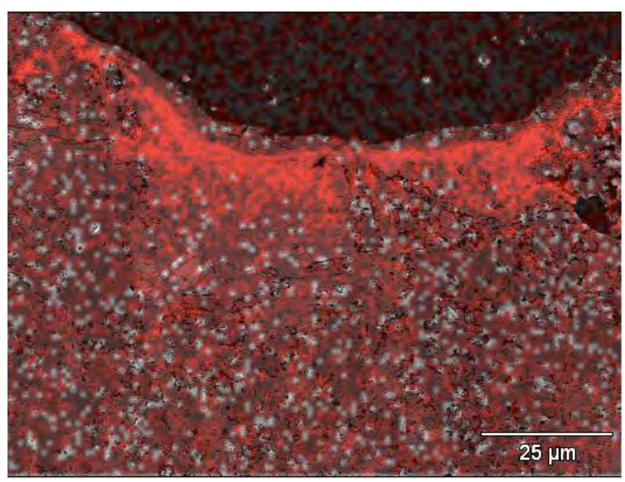

Fig. 5. SEM image of microbasin in Fig. 4 shown with an EDS Mn map overlay.