ROCK COATINGS FROM VULCANO, A MARTIAN ANALOG ENVIRONMENT. M.E. Minitti[1], C.M. Weitz[2], M.D. Lane[2] and J.L. Bishop[3], [1]Center for Meteorite Studies, Arizona State University, Tempe, AZ, 85287-1404 (minitti@asu.edu), [2]Planetary Science Institute, 1700 E. Fort Lowell Rd., Suite 106, Tucson, AZ 85719, [3]SETI Institute/NASA-ARC, 515 N. Whisman Rd., Mountain View, CA, 94043.

Introduction: Previous studies have shown weathering environments in Martian analog sites on Earth can lead to coatings or rinds that alter the chemistry and spectral properties of original lithologies [e.g. 1]. Understanding such coatings is important for interpreting chemical and spectral data from Martian lithologies given suggestions [2] and observations [3] of the presence of coatings on Mars. We previously demonstrated that leaching of glass-rich Hawaiian basalts, sometimes in the presence of fumarolic gases, leads to formation of opaline coatings with minor amounts of Fe, Ti and S [4]. The basalts illustrated that coatings as thin as 3 μm were sufficient to mask the substrate spectral character at both visible and near-infrared (VNIR) and thermal infrared wavelengths. Because coating formation processes and products can vary depending on substrate rock and weathering environment, we initialized a study of coated rocks from another analog Martian weathering environment, Vulcano (Aeolian Islands, Italy). Relative to Hawaii, Vulcano rocks have a different composition, experience less rainfall (25”-29” per year; G. Capasso, pers. comm.) and are subjected to a different balance of fumarolic gases [5]. Vulcano, like Hawaii, serves as a reasonable analog to Martian weathering given the periodic availability of water and the presence of fumarolic gases, which are hypothesized to influence Martian lithologies through acid fog weathering [e.g. 6].

Samples: We have currently studied three samples collected from around the summit of Vulcano along the rim of Gran Cratere at the summit of the Fossa cone. The samples, potassium feldspar-rich trachytes, are pyroclastic rocks from phreatomagmatic and other explosive eruptions that occurred during the most recent eruption of Vulcano between 1888 to 1890. All activity at Vulcano since then has been confined to degassing along fumaroles. In addition to K-feldspar, the trachytes contain SiO_2-rich (~79 wt.%) interstitial glass, augitic pyroxene and minor Ti-bearing magnetite. Vulcano Red (VR) and Vulcano Orange (VO) both have thin, competent coatings that are sharply divided from their respective substrate rocks, both of which appear unweathered. Vulcano White (VW) has a thicker, chalk-like coating with patches of yellow material intermixed with the white coating material. The VW coating completely coats the rough, pebbly surface of the substrate rock, creating a smooth surface. The weathering of VW appears to be more pervasive throughout the substrate rock.

Analytical: We studied the morphology and qualitative chemistry of the Vulcano samples using a JEOL 845 scanning electron microscope at Arizona State University. Imaging was conducted using a backscattered electron detector and qualitative chemistry and elemental X-ray maps were obtained using the electron dispersive spectroscopy system. We also collected preliminary thermal infrared spectral data using the thermal infrared spectroscopy laboratory at Arizona State University. Spectra were collected from 200-2000 cm^{-1} at 2 cm^{-1} spectral sampling. We are planning to measure VNIR reflectance spectra soon.

Results: Despite similar starting chemistries, all three analyzed samples exhibit very different coating morphologies and chemistries.

Vulcano Orange. The orange coating corresponds to thin (2-6 μm) material whose distribution and composition do not change whether overlying glass or mineral-bearing portions of substrate (Fig. 1).

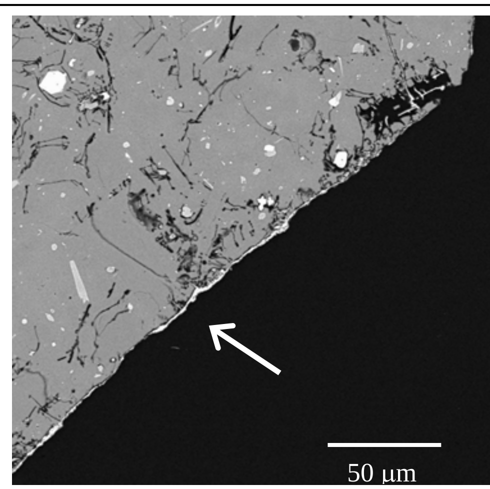

Figure 1: BSE image of material corresponding to orange coating of VO (arrow).

Distribution of the coating is relatively uniform across the sample, but there are areas that do not exhibit the coating. The material possesses an unusual Fe- and P-rich chemistry with subequal amounts of Si and Al. It is unclear what mineralogy corresponds to the measured chemistry. The thermal infrared spectrum of the coated surface differs from the VO interior spectrum (Fig. 2). The coating primarily influences the spectrum of the sample between 800-1250 cm^{-1}, leading to a bifurcation of the single, V-shaped absorption expressed by the sample interior. The spectra demonstrate that even thin coatings are capable of masking the spectral character of original lithology.

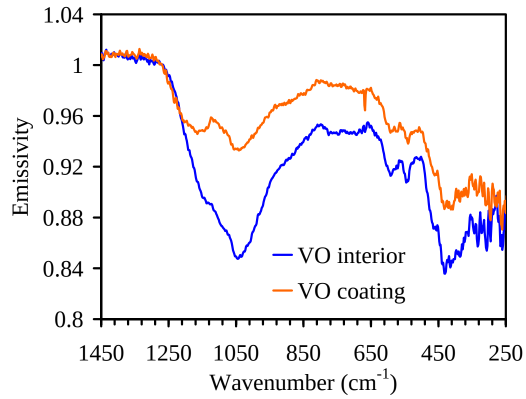

Figure 2: Thermal infrared spectra of interior (blue) and coating (orange) of VO.

Vulcano Red. The red coating corresponds to µm-sized K-feldspar fragments cemented by a S-bearing matrix more SiO_2-rich than the interstitial glass of the substrate (Fig. 3). The coating is uniformly distributed across the sample with an average thickness of 30 µm. The coating is present whether overlying glass, feldspar or pyroxene in the substrate. A second, similar coating material is occasionally found overlying the uniformly distributed coating (Fig. 3). This outermost coating has a predominantly SiO_2 matrix containing K-feldspar fragments but has a more porous structure and a more S- and K-enriched chemistry than the uniformly distributed coating. The hydration state of the SiO_2-rich matricies of both coatings is currently unknown.

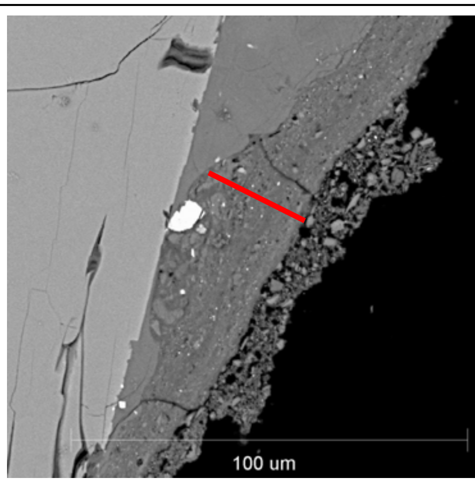

Figure 3: BSE image of coating types on VR. The most common coating (red bar) uniformly coats the sample while the more porous coating is occasionally found overlying the common coating.

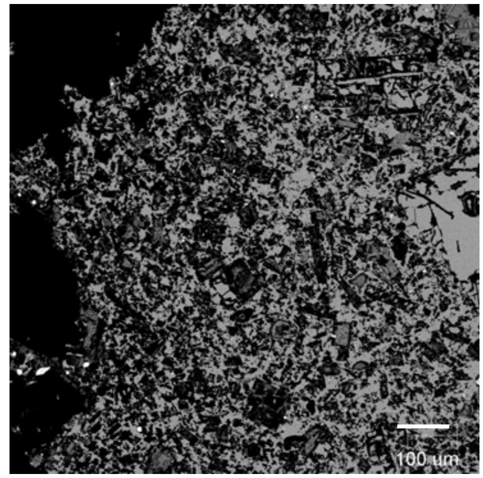

Figure 4: BSE image of material corresponding to white coating on VW. Scale bar is 100 µm.

Vulcano White. The white coating does not appear to correspond to a coating material unique from the substrate rock, but resembles a porous version of the substrate rock (Fig. 4). Rectangular voids are present throughout the white coating, which measures up to millimeters in thickness on some areas of VW. The rectangular voids are filled with almost pure SiO_2 material and are surrounded by glass with compositions effectively identical to the SiO_2-rich interstitial glass of the substrate rock. These observations suggest that the white coating is a weathered version of the substrate rock in which weathering has preferrentially affected the K-feldspar crystals in the sample. The white coating and some of the yellow patches of material found in the white coating possess an unusual Al-, K- and S-dominated phase which is not present in the substrate rock.

Discussion: This initial assessment of coated Vulcano samples demonstrates the complexity of coatings at the microscale and the variety of coatings at the macroscale that can form on a single rock type in a given environment. When compared to coatings on Hawaiian basalts [4], the Vulcano coatings illustrate the influence that starting composition and weathering environment can have on coating formation. Further studies will be required to determine the mineralogy and spectral character of the coatings and to separate the influences of substrate chemistry and weathering environment on the Vulcano coatings.

References: [1] Morris R.V. et al. (2003) *LPS XXXIV*, #1874. [2] Johnson J.R. et al. (1999) *JGR, 104*, 8809-8830. [3] Gellert R. et al. (2004) Science, *305*, 829-832. [4] Minitti M.E. et al. (2003) *LPS XXXIV*, #1937. [5] Martini M. et al. (1986) *Geothermics*, 15(2), 205-209. [6] Banin A. et al. (1997) JGR, *102*, 13,341-13.356.