

COMPOSITION AND SPECTRA OF SEVERAL HAWAIIAN ROCK COATINGS. Michelle E. Minitti¹, Catherine M. Weitz², Melissa D. Lane², and Janice L. Bishop³, ¹Dept. of Geological Sciences, ASU, Tempe, AZ 85287, ²Planetary Science Institute, 620 N. 6th Avenue, Tucson, AZ 85705, ³SETI Institute/NASA-ARC, MS 239-4, Moffett Field, CA 94035.

Introduction: We acquired five samples of rock coatings from the Big Island of Hawaii. The coatings appear distinct in color and morphology. Both reflectance and thermal emission spectra were acquired for the coatings and for uncoated portions of the samples. SEM analyses provided compositional information about the coatings. Our goal is to apply the results of Hawaiian rock coatings to potential weathering rinds on Martian rocks.

Sample Description: The five studied samples are Hawaiian basalts from various vents and flows, but each has a distinctive coating. Two samples are from Mauna Iki (MIO and MIY), two samples are from Kilauea (KW and KWY) and a single sample is from Mauna Ulu (MUO). Samples MIY and MIO were collected at Mauna Iki, located about 10 km southwest from Kilauea caldera. MIY has a patchy but uniform brownish-yellow coating on a flat, dense substrate of basalt. MIO has an orange-brown coating whose color varies across the sample surface. The substrate basalt appears weathered throughout and most of it appears orange due to oxidation of the entire sample. Other samples collected from Mauna Iki were also analyzed for this study [1].

The two samples from Kilauea were acquired within one hundred meters from the degassing Halemaumau vent. KW (Fig. 1) has a hard, white coating that has accreted over much of the glassy pillow lava from the 1982 flow. KWY has a mixture of white and yellow coating on its surface and was taken from a very vesicular lava fragment/pumice. The white and white-yellow coatings were commonly seen on the lava surfaces around the vent, with the yellow coating dominating closer to and downwind of the vent, suggesting an association with released volcanic gases.

Finally, MUO was collected from a lava channel at Mauna Ulu, which is located about 10 km southeast of Kilauea caldera. The powdery coating is orange in color and is easy to wipe off the rock surface, unlike the coatings on the other four samples, which are cemented onto the surfaces.

SEM Results: Using the electron dispersive spectroscopy (EDS) mode of the JEOL 845 scanning electron microscope (SEM) at Arizona State University, we derived x-ray maps and qualitative compositional information from the rock coatings. SiO₂ is the predominant component in all five coatings. All Hawaiian basalts seem to develop such silica coatings over time [2].

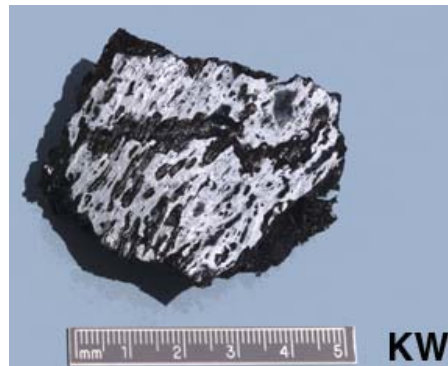


Figure 1. Example of one of the Hawaiian rock coatings (KW). This coating, from near the Kilauea caldera, has a white cemented coating that tends to fill in low spots along the rock surface.

In addition to SiO₂, each coating contains varying concentrations of Fe, Ti and S either distributed uniformly throughout the SiO₂ coating or located in distinct layers within or capping the SiO₂ coating. The MIO coating consists of Fe-bearing SiO₂ intercalated with Fe- and Ti-rich layers while the MIY coating has an Fe- and Ti-rich layer deposited on the SiO₂. Both the KW and KWY coatings contain S-bearing SiO₂. The MUO coating consists of Fe-bearing SiO₂. The presence of Fe, Ti and/or S in each coating seems to correspond to the color each coating exhibits, with Fe- and Ti-rich coatings exhibiting yellow-to-orange coloring and S-rich coatings exhibiting yellow-to-white coloring. The S-rich nature of the Kilauea samples is consistent with their collection in proximity to a degassing vent. The correlation of Fe, Ti and S in the coatings with coating color suggests that only small amounts of Fe-, Ti- and S-bearing material are needed to impart color to the predominantly SiO₂ coatings.

In addition to the chemical differences observed between the coatings, differences in the thickness range of each coating were measured. Of the Fe- and Ti-bearing coatings, the MIO coating thickness is 25-80 μm , the MIY coating is 6-18 μm and the MUO coating is 2-3 μm . The two S-bearing coatings are similar, with the KW coating thickness ranging between 10-25 μm compared to 10-45 μm for the KWY coating.

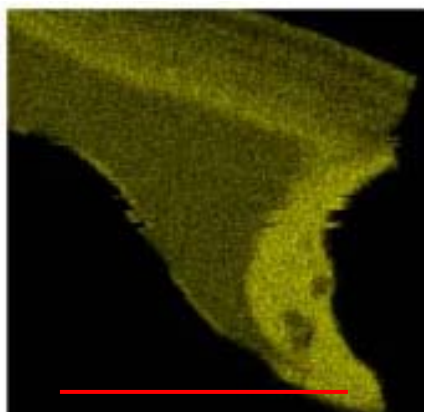


Figure 2: X-ray map showing SiO₂ distribution in KW. The coating is SiO₂-rich (bright area to right), similar to all the coatings in this study. This coating also contains S. Scale bar is 100 microns.

Reflectance and Emission Spectra: Reflectance and thermal emission spectral data were obtained from coated surfaces and from other exterior sample surfaces that did not have colored coatings. Reflectance spectra were obtained from the RELAB facility at Brown University (not shown). The reflectance spectra show strong variations between the surfaces with the colored coatings, as expected from their distinct color differences in the visible. Thermal emission spectra were taken using the Thermal Emission Spectroscopy Laboratory at ASU (Fig. 3). The thermal emission spectra reveal that surfaces with colored coatings have weaker absorptions at 1100 cm⁻¹ than presumably uncoated surfaces (Fig. 3). However, spectra from both surfaces are similar in shape. This result suggests that the “uncoated” surfaces may still be coated, but with SiO₂ coatings containing insignificant amounts of coloring elements (e.g. Fe). The spectral character of the analyzed surfaces are likely due to a combination of the amount and nature of glass in the substrate basalt and the coatings on the basalt. Two potential factors related to coatings that might influence the character of the sample spectra are coating chemistry and thickness. Another potential factor is the degree of silica polymerization within the substrate glass, which [3] noted leads to the development of an absorption edge between 1100-1300 cm⁻¹ in Hawaiian basalt spectra.

Conclusions: Compositions of rock coatings from five different Hawaiian basalts as determined by SEM show well-known high SiO₂ contents, variations in Fe, Ti and S content and variations in coating thickness. The spectral signatures of SiO₂-rich coatings are most prominent at visible wavelengths. Thermal emission spectra of surfaces with colored and transparent coat-

ings show variations, likely due to a combination of the nature of the substrate basalts, the thickness and the chemistry of the coatings. Future steps include spectral analysis of the interiors of the five samples of this study for comparison to the exterior surfaces and analyses of rock coatings taken from Mount Etna in Italy to determine if these samples also contain SiO₂-rich coatings or are affected by other coatings. After analyses of these terrestrial rock coatings, we will apply our results to martian spectra in order to determine if similar coatings can be identified on Mars.

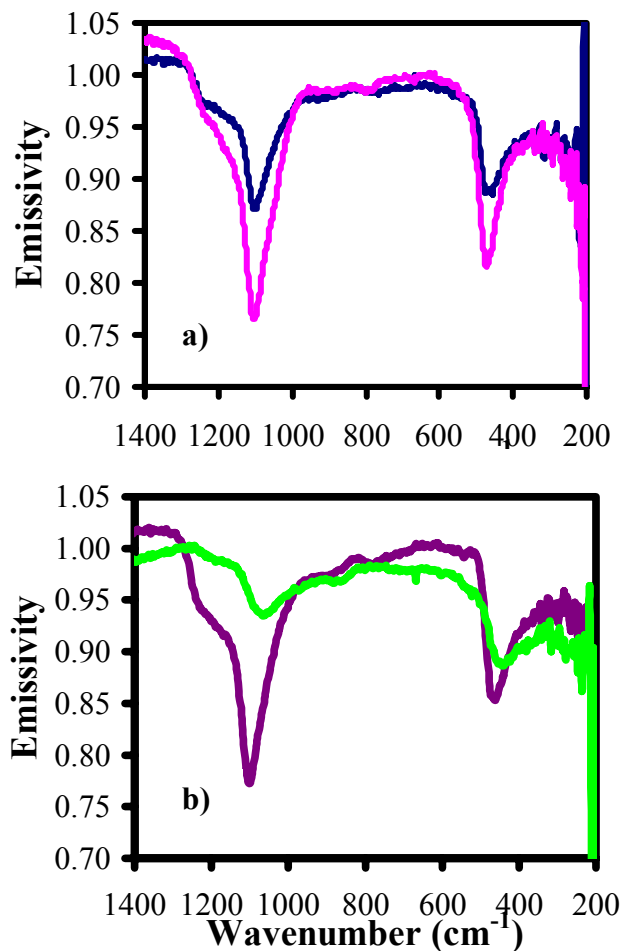


Figure 3: Examples of thermal emission spectra of coated portions of the studied samples. Surfaces with colored coatings have similar but weaker absorptions than the surfaces with transparent coatings. a) Transparent (pink) and colored (blue) coatings of sample KW. b) Transparent (purple) and colored (green) coatings of sample MIO.

References: [1] Bishop J.L. et al. (2003) *LPSC 34*, this volume. [2] Farr T.G. and Adams J.B. (1984) *GSA Bull.*, 95, 9, 1077-1083. [3] Crisp J. et al. (1990) *JGR* 95, 13, 21657-21669.