THE INFLUENCE OF GLASSY COATINGS ON VOLCANIC ROCKS FROM MAUNA IKI, HAWAII AND APPLICATIONS TO ROCKS ON MARS.

Janice. L. Bishop[1], Michelle E. Minitti[2], Melissa D. Lane[3] and Catherine M. Weitz[3], [1]SETI Institute/NASA-ARC, MS 239-4, Moffett Field, CA 94035, [2]Dept of Geol. Sciences, ASU, Tempe, AZ, 85287, [3]Planetary Science Institute, 620 N. 6th Ave., Tucson, AZ, 85705.

Introduction: Yellow and orange glassy coatings have been observed on volcanic rocks in the Mauna Iki region of Hawaii. We have characterized these as part of a larger study to understand rock coatings on Mars. The coatings on these Mauna Iki samples are comprised of two layers - an SiO_2 layer and an Fe-Ti-rich pigmenting layer. Reflectance and emittance spectra have been analyzed and are discussed in relation to spectra of rocks on Mars. Both visible/NIR and mid-IR spectra exhibit properties due to SiO_2 coatings.

Samples: A lava flow several meters long protrudes from a dusty barren landscape off the Mauna Iki trail. The lava is primarily black vitreous glass and is covered on the exposed surfaces by a patchy ceramic-like coating (Fig. 1). SEM imaging of this coated rock revealed that the surface actually has a coating layer ~12-18 µm thick (Fig. 2). This ceramic-like coating may have formed during high-temperature volcanic activity following the deposition of the lava or from post-emplacement alteration. Related rock coatings are discussed in [1].

The bulk glass chemistry is basaltic (Table 1). Several chemical measurements were made as well using a JEOL 845 SEM at ASU of spots in the coating layers and near surface glass of the Mauna Iki samples. The data were averaged for 6 spots on internal portions of the glass and found to be fairly uniform (Table 1). Most of the surface coating is nearly pure SiO_2 and is translucent. A very thin (~1-2 µm) portion of the outer surface contains high concentrations of Ti and Fe. It appears that the amounts of these two elements vary substantially across the surface, which is consistent with the colors observed. Another study of white glassy coatings on volcanic rocks in the Mauna Iki region has found elevated Ti, but no Fe, on the surface [2]. We attribute black surfaces to regions where Ti and Fe levels in the coating are very low or absent.

Fig. 1 Sample of coated volcanic glass from Mauna Iki, Hawaii (~5 cm across).

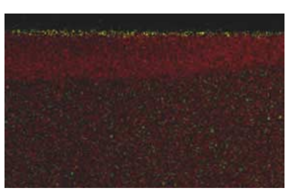

Fig. 2 SEM image showing coating layer (~12-18 µm thick) at the top (red is Si, yellow is Ti, green is Fe).

Table 1 Approximate chemical composition of the ground bulk glass (by LECO), near-surface volcanic glass (ave & σ from 6 spots by SEM) and coating layer (ave & σ from 3 spots by SEM).

Wt.%	Bulk Glass	Surface Glass	Coating
SiO_2	51.8	44.9 (1.7)	60 (21)
Al_2O_3	10.2	6.9 (0.5)	0
FeO	12.0	32.8 (1.7)	16 (13)
MgO	8.0	1.6 (0.3)	0
CaO	8.6	12.7 (0.7)	1 (1)
Na_2O	1.6	0.1 (0.2)	tr
K_2O	0.4	0.0	tr
P_2O_5	0.3	0.0	0
TiO_2	2.7	0.0	22 (12)
MnO	0.2	0.7 (0.7)	0
S	0.2	0.2 (0.0)	tr
Cl	nd	0.1 (0.1)	tr

The Fe and Ti in the coating varied substantially across the surface and Ca was found at only one spot. Small amounts (<1) of other elements were observed in some cases and are listed as tr.; nd indicates not determined.

Reflectance and Emittance Spectra. Visible/NIR reflectance spectra are shown in Fig. 3 for comparison with future Omega and Crism data of Mars. Mid-IR reflectance and emittance spectra are shown in Fig. 4 for comparison with TES data of Mars. The thin ceramic-like coatings covering the upper surfaces of the Mauna Iki glass samples exhibit some spectral properties similar to those observed for dust coatings on basalt [3]. The reflectance spectra shown in Fig. 4 were measured using a biconical on-axis geometry, which tends to overemphasize the surface properties. This was useful for gaining information about the differences between the glassy coating and the unaltered volcanic glass. Similar spectral trends were observed in the mid-IR reflectance and emittance spectra.

The reflectance and emittance spectra of the volcanic glass samples from Mauna Iki (Figs. 3, 4) are typical of basaltic glass. The <125 µm particulate sample exhibits broad bands near 1 and 2 µm due to Fe and near 3 µm due to OH and water. The silicate bands near 450 and 980 cm^{-1} are weaker for this sample and the emittance drops above ~1300 cm^{-1}.

Spectra of the colored coatings are very different from the volcanic glass surface and the particulate glass. Both coatings show a steep visible slope with a reflectance maximum near 0.64 (yellow) and 0.74 (orange) µm followed by a steep NIR slope characteristic of coatings. The orange coating also has broad bands near 1 and 1.6 µm. Mid-IR reflectance and emittance spectra were measured for similar, but not identical pieces of coated rocks. These spectra include sharp bands due to the coatings near 1100 and 1240-1250 cm^{-1}. Similar spectral features have been observed for thin SiO_2 coatings on glass [4].

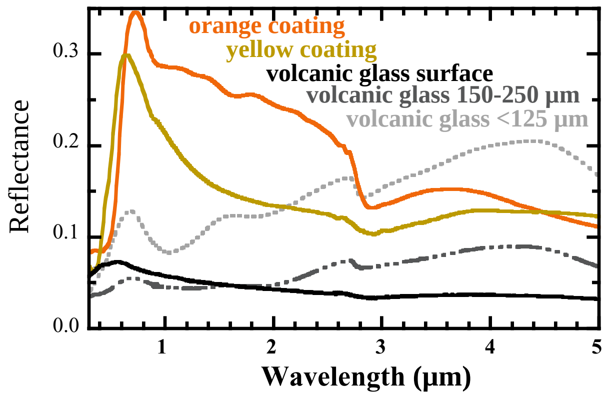

Fig. 3 Visible/NIR spectra of Mauna Iki glass (black), ground glass (gray), and glass coatings (yellow & orange).

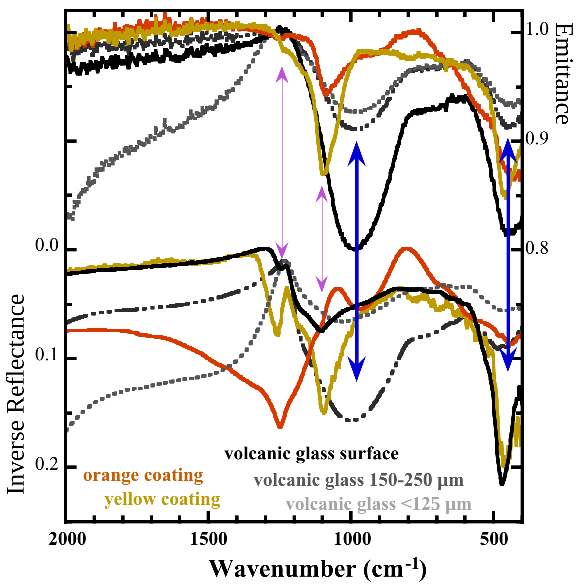

Fig. 4 Mid-IR reflectance and emittance spectra of Mauna Iki volcanic glass (black), ground glass (gray) and glass coatings (yellow & orange). Blue arrows indicate the silica bands in the glass and purple arrows mark the bands due to the coatings.

Comparison with Mars. These volcanic glass samples from Mauna Iki, HI, present interesting potential analog materials for Mars because of their chemistry and glassy coatings. At the spectral resolution of MPF-IMP (similar to Pancam on the MERs) the rocks on Mars look very different from the Mauna Iki volcanic glass (surface and coarsely ground). A coating of finely-ground volcanic glass or the ceramic-like coatings observed on the Mauna Iki samples would provide the steeper spectral slope observed for Black compared to Shark (and most other rocks observed by MPF) and could be due to the effects of a coating. However, the Mauna Iki coatings are brighter than rocks measured by MPF.

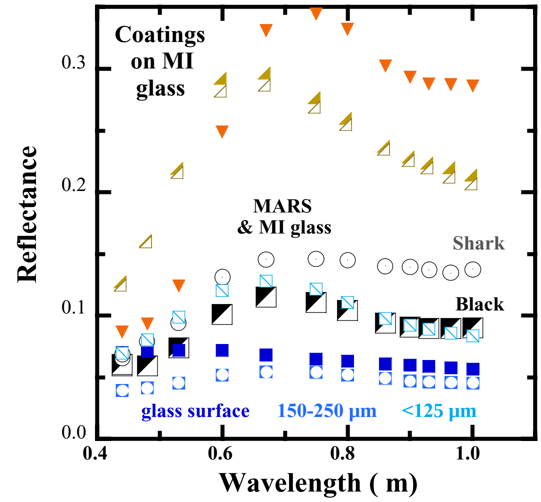

Fig. 5 Re-sampled reflectance spectra of the Mauna Iki samples compared with MPF-IMP rock spectra (from [5]).

The Mauna Iki glass spectra are not a good spectral match for either dominant spectral type observed on Mars (Fig. 6), but a volcanic glass similar to this one could be present on Mars in minor abundances and would not greatly alter the spectral character. The spectral bands due to the ceramic-like coatings correspond well to parts of the Andesite spectral type. Perhaps this spectral unit contains more coatings on the rocks compared with the Basalt spectral unit.

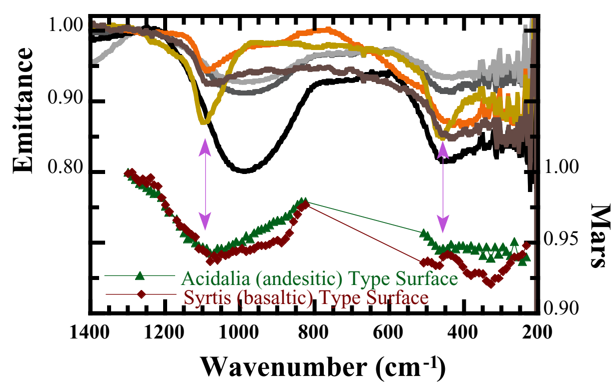

Fig. 6 Lab emittance spectra of Mauna Iki samples compared with TES spectra of Mars (from [6]). The purple arrows indicate bands due to coatings.

References: [1] Minitti M. et al. (2003) LPSC. [2] Diel K. et al. (2002) AGU. [3] Fischer, E. & C. Pieters (1993) Icarus 102, 185; Crisp J. et al. (1992) JGR 97, 14691; Johnson J. et al. (2002) JGR 107, #2. [4] e.g. Tan C. & J. Arndt (2000) J. Chem Phys. 112, 5970; Geotti-Bianchini F. et al. (1991) Glastech. Ber. 64, 205 [5] Barnouin-Jha O. et al. (2000), LPSC, #1267. [6] Bandfield J. et al. (2000) Science 287, 1626.