LAB EXPERIMENTS TO SIMULATE COATINGS ON PHYLLOSILICATE ROCKS AND COMPARISON WITH CRISM DATA OF MARS. Mario Parente1,3, Janice L. Bishop1,2, and Javier Cuadros4,
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Introduction: This study aims to test the spectral properties of potential Martian dust particles on phyllosilicate rocks in order to explain the visible and near-infrared (VNIR) spectral properties observed for the phyllosilicate-rich terrains in the Mawrth Vallis region of Mars. The Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [1] detected exposures of an Fe/Mg-smectite such as Mg-nontronite, hydrated silica, montmorillonite and kaolinite [2-4]. These studies have focused on the spectral features in the range 1.4-2.5 μm. In evaluating the extended visible region CRISM spectra where different clay minerals are observed, we found only subtle variations in spectral properties attributable to Fe electronic transitions in the different phyllosilicate units.

We performed experiments to test the spectral properties of dust on phyllosilicate rocks and the possibility that volcanic ash is only partially altered to phyllosilicates in the ancient rocks. One set of experiments evaluates the spectral effects of deposition of fine-grained ferrihydrate and altered basaltic ash particles on nontronite and montmorillonite rocks. A second experiment involves measuring the VNIR properties of chemical mixtures of partially altered volcanic tuff samples from a previous study [5]. Our results show promising similarities of CRISM spectra of Mawrth Vallis terrains with the laboratory spectra.

Method: Two phyllosilicate rocks were obtained from the Clay Minerals Society, Source Clays Repository: nontronite NG-1 from Hohen-Hagen, Germany, and the Ca-montmorillonite SAz-2 from Arizona. The dust particles used for these experiments include an altered volcanic basaltic ash from Haleakala that was dry sieved to <45 μm for a previous study [7] and a ferrihydrite sample from Iceland [8].

We simulated dust deposition by sprinkling progressively increasing amounts of dust on top of the rocks using a spatula. We measured the spectra from 0.3 to 2.5 μm of the rock surfaces and the rocks with different amounts of both ferrihydrite and Haleakala ash on a black Teflon dish using an ASD spectrometer under ambient conditions. In order to qualitatively assess the amount of dust present on the rocks, we captured images of the samples with a microscope at multiple magnifications after dust deposition.

The volcanic tuff samples were primarily composed of rhyolitic glass and were exposed to hydrothermal alteration in the lab at temperatures ranging from 60 to 160 °C for up to a year [6]. VNIR and mid-IR reflectance spectra were measured at RELAB, Brown University. The alteration product is a random mixed-layer illite-smectite (I-S) with 75% smectite.

Results: VNIR reflectance spectra of the dust cover simulations are shown in Figs. 1-2.

Montmorillonite rock: The montmorillonite spectrum in Fig. 1 contains features due to Al-OH at 1.41 μm (OH stretch overtone) and 2.21 μm (OH bend+stretch combination band), interlayer and adsorbed H2O near 0.9, 1.2 1.4 and 1.9 μm. The altered volcanic ash sample from Haleakala includes related weak broad features near 1.93 μm due to H2O and near 2.2 μm due to non-crystalline Al/Si-OH species. The ferrihydrite spectrum includes broad water bands near 1.4 and 1.9 μm as well as a weak ferric minimum near 0.92 μm. The main effect of Haleakala ash deposition is the change in curvature in the montmorillonite visible spectrum near 0.6 μm and the loss of spectral contrast of vibrational bands in the NIR. The ferrihydrate deposition on the other hand primarily increases the spectral ratio of the montmorillonite from 0.4-0.7 μm.

Nontronite rock: The spectrum of nontronite (Fig. 2) exhibits H2O bands near 1.4 and 1.9 μm. This sample and has bands due to Fe-OH at 1.42 μm (OH stretch overtone) and 2.29 μm (OH bend+stretch combination band). Another Fe-OH band is present near 2.41 μm, but is weaker. The Haleakala ash mutates the feature near 0.53 μm in the nontronite spectrum, while spectral contrast in the NIR is increased. The ferrihydrate dust experiment on nontronite behaviour seems consistent with the case of montmorillonite.

Spectra of selected altered glass samples are shown in Fig. 3 where the illite and Al-OH smectites exhibit an Al-OH stretching + bending band around 2.22 μm. The water band positions are typical of smectites. A magnified version of the visible part of the spectrum is also shown in Fig. 3. The main difference occurring in the spectra of the hydrothermally altered samples occur near 1 μm where the glass absorption band centered at 1.1 μm changes shape and shifts towards 1.0 μm for increasing smectite content.

Discussion: Relation to CRISM spectra. CRISM spectra from the Mawrth Vallis region on Mars (image ID FRT0000A2C2) were selected to compare with these lab data. The images were atmospherically and photometrically corrected using standard techniques by the CRISM team [9]. Residual artifact were removed using a destriping algorithm [10]. The short (S) and long (L) detector images were automatically spliced in order to obtain a complete spectrum of the pixels in the range of interest [11]. Removal of an instrument effect
around 1.2 μm was also performed. Fig. 4 represents a direct comparison of the CRISM spectra with the results of the two lab studies revealing that fine-grained dust is dominant at visible wavelengths in all spectra. Both altered glass and dust deposition seem to have an effect on the feature around 1 μm.

**Summary:** Our experiments indicate that only a few grains of ferrihydrate or altered volcanic ash coating a rock surface are sufficient to alter the spectral properties of the rock in the visible region. At the same time these coatings have only a minor effect on the glass bands from 1.9 to 2.5. Our experiments further show that partially unaltered glass mixed with phyllosilicates in rocks could account for the presence of the ~1 μm band in the clay units at Mawrth Vallis.


**Fig 1,2:** Spectra from the dust deposition experiment on a SAz-2 montmorillonite rock (left) and an NG-1 nontronite rock (top right) using altered volcanic ash and Ferrihydrate.

**Fig. 3:** (center right). Spectra of volcanic glass containing progressively larger smectite abundances.

**Fig. 4:** (bottom right). Comparison of spectra from CRISM image A2C2 with lab spectra: altered glass 1 contains 8% smectite, while altered glass 2 contains more smectite. The montmorillonite and nontronite rock spectra have thin coatings of ferrihydrite (Fh) and altered volcanic ash from Haleakala (ash).