CONSTRAINING PHYLLOSILICATE ABUNDANCES ON MARS USING CRISM SPECTRA AND LABORATORY MIXTURES. A. Honma[1], J. L. Bishop[2], N. McKeown[3], A. J. Brown[2], and M. Parente[4], [1]University of Hawaii, Hilo, HI, 96720 (ahonma@gmail.com), [2]SETI Institute/NASA-ARC, Mountain View, CA, 94043 (jbishop@seti.org), [3]University of Calif., Santa Cruz, CA, 95064, [4]Stanford University, Stanford CA, 94305.

Introduction: We performed laboratory mixtures of the phyllosilicate minerals montmorillonite, nontronite and Fe/Mg-smectite with altered basaltic ash in order to gain information on detection limits for these minerals on the Martian surface. Visible/near-infrared (VNIR) hyperspectral images collected by the Observatoire pour la Minéralogie, L'Eau, les Glaces et l'Activité (OMEGA) instrument [1, 2] and the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [3, 4] have detected phyllosilicate minerals in many locations on Mars. These detections include phyllosilicate minerals such as Fe/Mg-smectite, nontronite and montmorillonite. Our results indicate that as much as 30-40 wt.% phyllosilicate could be present in parts of Mawrth Vallis based on the metal-OH band strengths in the 2.2-2.3 µm region.

Methods: The altered volcanic basaltic ash is from Haleakala and was dry sieved to <45 µm for a previous study [5]. The SWy-1 montmorillonite and Sampor nontronite samples were dry sieved to <45 µm although the particle sizes are ~1-3 µm [6]. The Fe/Mg-smectite (Mg-bearing nontronite) from Flagstaff Hill, CA, was contributed by G. Swayze, and was dry sieved to <45 µm. Samples were weighed and mixed by gently stirring the particles then shaking them in a sieve. VNIR spectra were measured using an ASD spectrometer under ambient lab conditions of the particulate samples on a black Teflon dish.

Crusts were prepared for two samples by applying a drop of distilled H_2O to the particulate mixture, stirring gently to mix in the water, then letting the samples dry in air for 2 days. These samples were gently crushed to form a particulate texture then spectra were measured.

Continuum-removed lab spectra were prepared using MR PRISM software developed by A. Brown [7]. Band depths were determined by measuring the percent reflectance of the feature of interest in the continuum-removed spectra.

Results: VNIR reflectance spectra of the mixtures are shown in Figs. 1-3. The montmorillonite spectrum in Fig. 1 contains features due to Al-OH at 1410 nm (OH stretch overtone) and 2210 nm (OH bend+stretch combination band), interlayer H_2O at 1410 nm (H_2O stretch overtone) and 1910 nm (H_2O bend+stretch combination band), and adsorbed H_2O at ~1450 nm (H_2O stretch overtone) and 1970 nm (H_2O bend+stretch combination band). The altered volcanic ash sample from Haleakala includes related weak broad features near 1930 nm due to H_2O and near 2200 nm due to non-crystalline Al/Si-OH species. The characteristic montmorillonite Al-OH band at 2210 nm is clearly visible in the 10 wt.% montmorillonite mixture spectrum in Fig. 1.

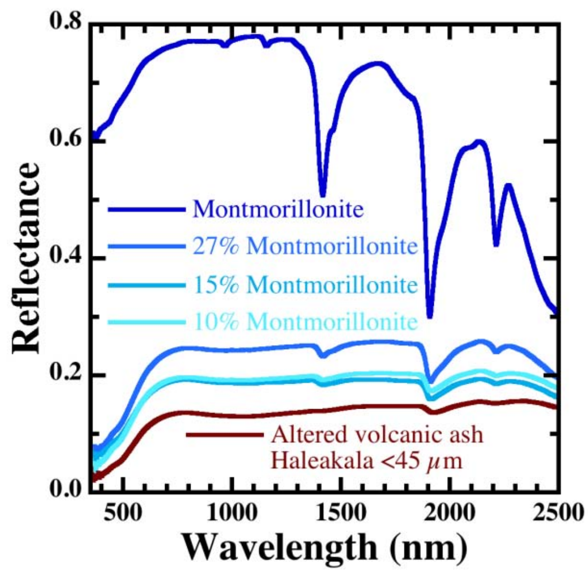

Fig. 1 VNIR reflectance spectra of mixtures of montmorillonite in altered volcanic ash.

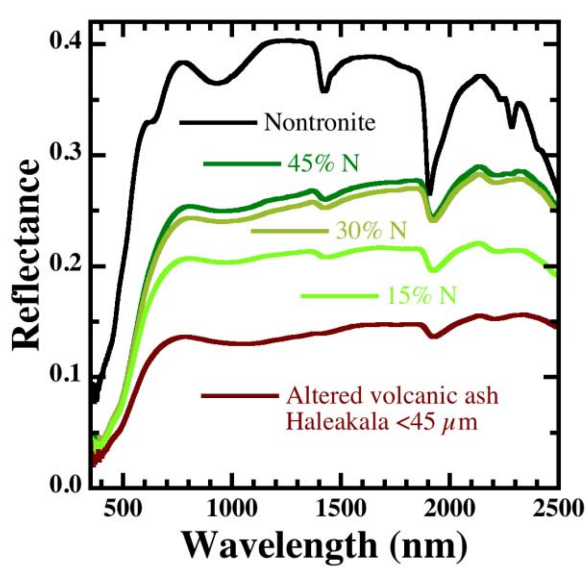

Fig. 2 VNIR reflectance spectra of mixtures of nontronite in altered volcanic ash.

The spectrum of nontronite (Fig. 2) exhibits H_2O bands as in the spectrum of montmorillonite. This sample contains primarily Fe in the octahedral sites and has bands due to Fe-OH at 1420 nm (OH stretch overtone) and 2290 nm (OH bend+stretch combination band). Another Fe-OH band is present near 2410 nm, but is weaker and only poorly resolved in the mixture spectra. The 2290 nm nontronite band is detectable in the 30 and 45 wt.% mixture spectra, but is not present in the 15 wt.% mixture spectrum. The Fe/Mg-smectite spectrum (Fig. 3) exhibits bands very similar to those of standard nontronite. Differences include Fe-OH bands present at 2300 and 2390 nm. Both bands are clearly visible in the mixture spectra, even for abundances as low as 15 wt.% Fe/Mg-smectite.

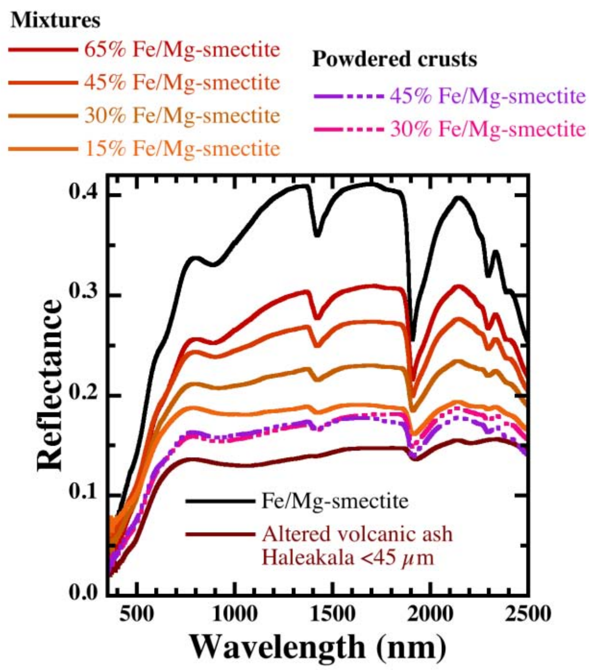

Fig. 3 VNIR reflectance spectra of mixtures of Fe/Mg-smectite in altered volcanic ash.

Crust Experiment. Crusts were prepared for two Fe/Mg-smectite mixtures in order to test the influence of hydration/dehydration on the spectral features. The overall reflectance for these crust spectra is much darker than the reflectance of the original spectra, however, the band depths in these crust spectra are comparable to those observed in the original spectra.

Band depths. Band depths are displayed in Fig. 4 for the metal-OH combination bands near 2200-2300 nm for the montmorillonite, nontronite and Fe/Mg-smectite mixture spectra in Figs. 1-3. The Al-OH band strengths in the montmorillonite mixture spectra are stronger than the corresponding Fe-OH features in the nontronite and Fe/Mg-smectite mixture spectra.

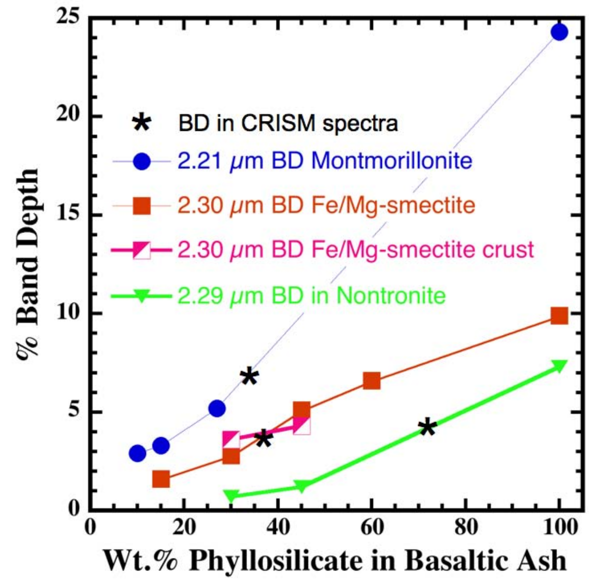

Fig. 4 Band depths of phyllosilicates verse % composition in altered volcanic ash.

Relation to CRISM spectra. CRISM spectra from the Mawrth Vallis region on Mars [3, 8] were selected to compare with these lab data. Examples of the strongest phyllosilicate detections were taken in order to constrain upper bounds of phyllosilicate abundance on Mars. Band depths were estimated from CRISM ratio spectra by measuring the depth of the band compared to the average reflectance on either side of the band. The CRISM values for montmorillonite and Fe/Mg-smectite type spectra are consistent with about 33-37 wt.% phyllosilicate mixed with altered basalt. The nontronite spectrum gave a higher value, but this might not be reliable as the Fe-OH bands were much less resolved in the nontronite mixture spectra than in the other mixtures in our study. Future experiments are needed to test the influence of grain size and other mafic mixture components. Nonlinear spectral unmixing based on the Shkuratov radiative transfer theory by Poulet et al. [9] has suggested upper limits of 60 volume % for phyllosilicates in the Mawrth Vallis region.

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