

**MULTI-SPECTRAL STUDY OF PHYLLOSILICATES AND APPLICATIONS TO MARS.** Janice L. Bishop<sup>1</sup>, Melissa D. Lane<sup>2</sup>, M. Darby Dyar<sup>3</sup>, and Adrian J. Brown<sup>1</sup>, <sup>1</sup>SETI Institute/NASA-ARC, Mountain View, CA, 94043 (*jbishop@arc.nasa.gov*, *abrown@arc.nasa.gov*), <sup>2</sup>Planetary Science Institute, Tucson, AZ, 85705 (*lane@psi.edu*), <sup>3</sup>Mount Holyoke College, South Hadley, MA, 01075 (*mdyar@mtholyoke.edu*).

**Introduction:** We are investigating several high-purity phyllosilicates in a multi-spectral study in order to compare spectral features across several techniques and to enable analyses of current Martian data. Visible-infrared reflectance, thermal emission and Mössbauer spectroscopy are the focus of this study; visible and infrared spectra are presented here and Mössbauer spectra in a companion abstract [1]. Elemental abundances and XRD were measured previously. All samples contain at least some iron. Four classes of phyllosilicates are included here:

Chlorite: clinocllore

Mica: celadonite, zinnwaldite, biotite, glauconite

Serpentine: chrysotile

Smectite: nontronite, Fe-smectite, montmorillonite

**Background:** The extended visible region spectra of these phyllosilicates are dominated by features due to Fe<sup>3+</sup> and Fe<sup>2+</sup> excitations, the near-infrared (NIR) region is dominated by overtones and combination bands of the structural OH (octahedral site, bound to a cation) stretching and bending vibrations and H<sub>2</sub>O stretching and bending vibrations, and the IR region is dominated by fundamental OH, H<sub>2</sub>O and Si-O vibrations. The samples were selected for this study to illustrate a variety of spectral features and to facilitate interpretation of Martian spectra. Phyllosilicates have been identified in Nili Fossae and other regions using OMEGA [2, 3] and CRISM [4] data. Phyllosilicates may also be contributing to the TES and Mini-TES data [5].

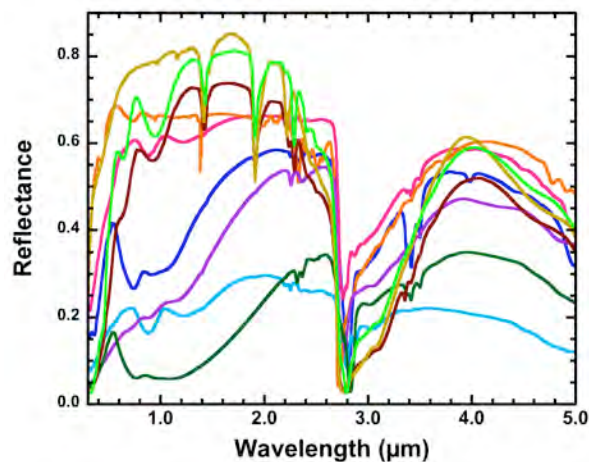


Fig. 1 VNIR phyllosilicate reflectance spectra.

**Results:** Spectra were measured of powders dry sieved to <45 μm except for the fibrous chrysotile. The smectites were fractionated to <2 μm before sieving. All spectra are plotted with the same color scheme to facilitate comparison of features among figures. The VNIR spectra are shown in Figure 1. Fe<sup>2+</sup> bands are present for all of the micas and the glauconite spectrum has the strongest ferrous band. The smectites exhibit the strongest water bands near 1.4, 1.9 and 3 μm. Mid-IR reflectance and emission spectra are shown in Figure 2, where in general the two datasets match up well. The chlorite and smectite spectra exhibit strong Si-O vibrations near 1070 cm<sup>-1</sup>, while the mica and serpentine spectra exhibit a stronger Si-O vibration near 900 cm<sup>-1</sup>. The chlorite has a band near 480 cm<sup>-1</sup> that is consistent with the phyllosilicate-type feature observed by TES for Mawrth Valles [5].

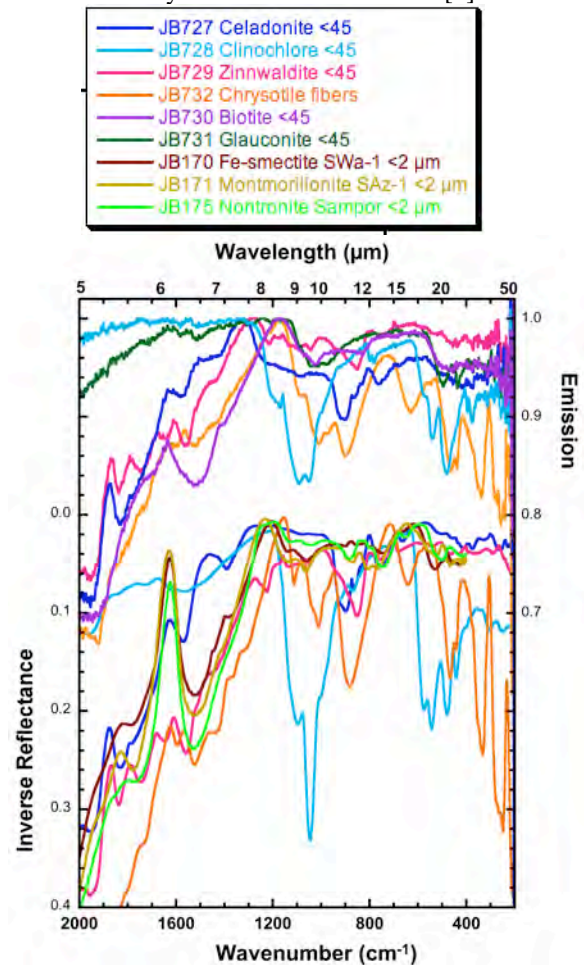


Fig. 2 Mid-IR reflectance and emission spectra.

In order to better characterize and compare the NIR-region OH combination bands, a continuum was removed using the MR PRISM program developed by co-author Brown [6]. Each spectrum was subset and automatically processed to remove the overall continuum, or spectral slope. These continuum-removed spectra are shown in Figure 3. The mica and chlorite spectra all have very weak water  $\delta+\nu$  combination bands near 1.91  $\mu\text{m}$ , while the smectites have relatively strong features here and the serpentine spectrum also exhibits a band. The band centers are marked on Figure 3 for some of the OH  $\delta+\nu$  combination bands: Al-OH bands are observed for chlinochlore and zinnwaldite at 2.204  $\mu\text{m}$  and for montmorillonite at 2.218  $\mu\text{m}$ . Fe-OH and Mg-OH bands are observed at longer wavelengths; some examples include a band near 2.256  $\mu\text{m}$  for biotite, chlinochlore and zinnwaldite, and a doublet at 2.317 and 2.364  $\mu\text{m}$  for glauconite.

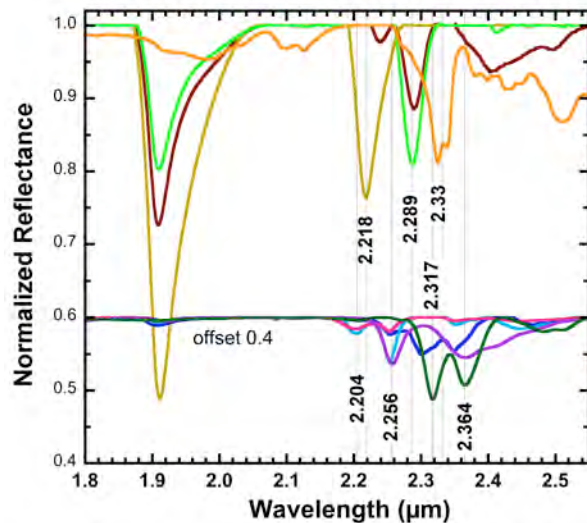


Fig. 3 Continuum removed spectra exhibiting OH combination features near 2.2-2.4  $\mu\text{m}$  and a  $\text{H}_2\text{O}$  combination band near 1.9  $\mu\text{m}$ .

These phyllosilicate spectra were resampled to the 11 Pancam filters [7] in order to evaluate how these minerals would appear if measured by Pancam on the rovers. These data are shown in Figure 4 along with some Pancam spectra extracted from the Paso Robles Sol 426 image [8]; the “dust” spectrum here is typical of the surface spectral features observed for much of the planet. Most of these phyllosilicate spectra are much brighter than what is generally observed on Mars, however, the brightness of the chlinochlore, biotite and glauconite spectra are similar to those of Martian spectra. The celadonite and glauconite spectra differ greatly from most Pancam spectra and are unlikely present in regions measured to date by Pan-

cam. The other phyllosilicate spectra shown in Figure 4 could be present as a minor component in the Martian surface material.

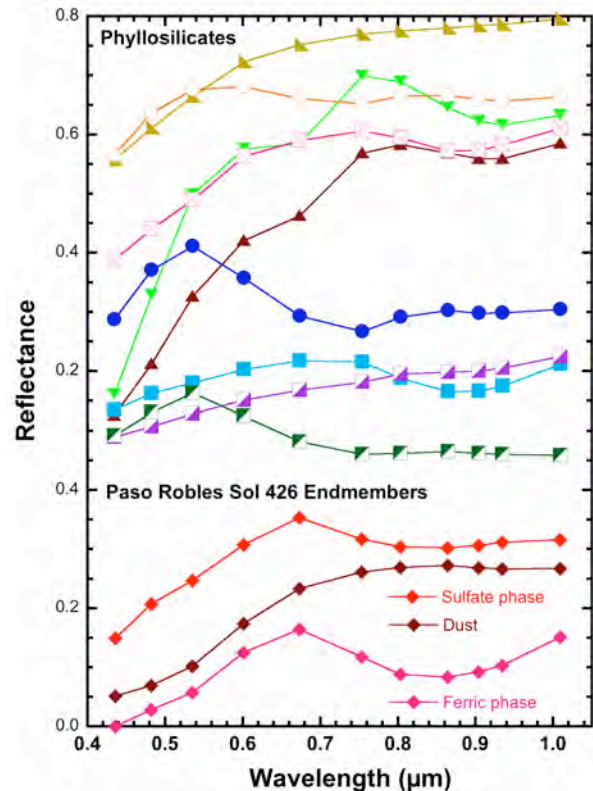


Fig. 4 Extended visible region spectra resampled to Pancam filters compared to selected Pancam spectra.

**Conclusions:** Ongoing studies of phyllosilicates in multiple CRISM images are confirming past phyllosilicate determinations [2] and identifying new phyllosilicate features [4]. We hope this study will enable correlated VNIR, thermal IR and Mössbauer studies of phyllosilicates on Mars.

**Acknowledgments:** Thanks are due to T. Hiroi for measuring the reflectance spectra. Spectra were measured at Brown/RELAB and ASU.

**References:** [1] Dyar M. D. et al. (2007) *LPS XXXVIII*. [2] Poulet F. et al. (2005) *Nature*, 438, 632-627. [3] Bibring J.-P. et al. (2006) *Science*, 312, 400-404. [4] Murchie S. (2007) *LPS XXXVIII*, Pelkey S. M. et al. (2007) *LPS XXXVIII*, Ehlmann B. L. et al. (2007) *LPS XXXVIII*. [5] Michalski J. R. et al. (2006) *LPS XXXVII*, Abstract #1242. [6] Brown A. J. & Storie-Lombardi M. (2006) *Proc. SPIE Optics Photonics*, 6309, doi:10.1117/12.677107. [7] Bell, J. F., III et al. (2006) *JGR*, 111, E02S03, doi:10.1029/2005JE002444. [8] Parente M. et al. (2007) *LPS XXXVIII*.