

CHARACTERIZATION OF PHYLLOSILICATE UNITS AT MAWRTH VALLIS: COMPARISON OF CRISM OBSERVATIONS AND INTIMATE PHYLLOSILICATE MIXTURES. N. K. McKeown¹, J. L. Bishop², J. Cuadros³, E. Amador¹, E. Silver¹, ¹University of California Santa Cruz (Earth and Planetary Sciences, 1156 High St., Santa Cruz, CA 95064, nmckeown@pmc.ucsc.edu), ²SETI Institute/NASA-ARC (515 N. Whisman Rd., Mountain View, CA 94043), ³Natural History Museum (Cromwell Rd., London, SW7 5BD, UK).

Introduction: Mawrth Vallis is one of the oldest outflow channels on Mars, cutting through Noachian-aged terrain on the border of the southern highlands and northern lowlands at $\sim 25^\circ\text{N}$, -20°W [1, 2]. OMEGA detected large exposures of the phyllosilicates nontronite and montmorillonite in this region [3-6]. CRISM has refined these observations with the detection of an Fe/Mg-phyllosilicate such as Mg-nontronite, hydrated silica, and kaolinite in addition to nontronite and montmorillonite [7-10]. However, the montmorillonite and kaolinite spectra appear to be mixed with another material, possibly hydrated silica [7, 11]. We have prepared laboratory mixtures of a) montmorillonite and obsidian, b) kaolinite with montmorillonite, and c) kaolinite with altered ash from Kilauea dominated by opal-A in order to better characterize the CRISM spectra collected at Mawrth Vallis having a band near 2.2 μm .

Methods: Kaolinite (KGa) and montmorillonite (SWy) were sieved to $<125 \mu\text{m}$ and then mixed at intervals of 25 wt%, from pure montmorillonite to pure kaolinite, with additional measurements at 15, 30, 40, and 60 wt% kaolinite. The mixtures were then sieved to $<125 \mu\text{m}$ to homogenize the mixture and break up any clumps that may have formed. Kaolinite (KGa) and hydrated silica (SiOH) from Kilauea were sieved to $<125 \mu\text{m}$ then mixed at 25 wt% intervals, with additional mixtures at 30 and 40 wt% kaolinite, and then sieved again. Montmorillonite and obsidian were sieved to $<125 \mu\text{m}$ and mixtures prepared of 2, 5, 8, 10, 20, 50, and 80 wt% montmorillonite. The spectra were then measured in the lab relative to spectralon using a contact-probe ASD handheld spectrometer. The laboratory spectra were then compared to spectra previously collected from CRISM images [7, 8].

Results of Mixture Studies: We have focused here on the $\sim 2.2 \mu\text{m}$ absorption feature due to a combination of the OH stretching and bending modes since the greatest change in spectral features is observed at this wavelength. In all cases, the 1.4 and 1.9 μm hydration features are reduced in strength as the amount of phyllosilicate decreases.

Montmorillonite-obsidian. Montmorillonite spectra have an absorption at 2.210 μm due to Al_2OH and obsidian spectra have a broader absorption centered at 2.216 μm due to SiOH species; therefore, the band center of the mixtures does not shift greatly (fig. 1). However, since the obsidian feature is broader, the

maximum inflection point on the longward side shifts to longer wavelengths with decreasing amounts of montmorillonite. At 50 wt% montmorillonite the inflection is still in the same position as for pure montmorillonite, but is not as sharp. At 20 wt% it is in an intermediate position, at 10 wt% it is slightly shorter than pure obsidian, and at 8 wt% it is in the same position as pure obsidian (fig. 1).

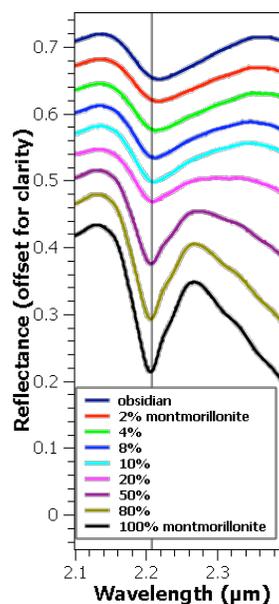


Fig.1 (left). Reflectance spectra from 2.1-2.4 μm of mixtures of montmorillonite and obsidian. Vertical line marks band center in pure montmorillonite at 2.21 μm .

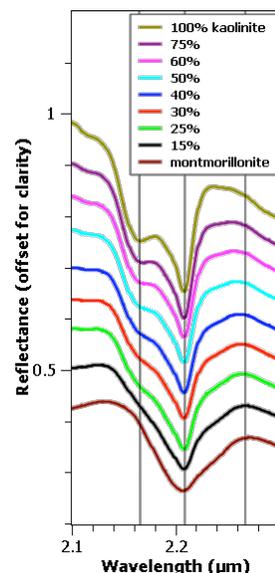


Fig. 2 (right). Reflectance spectra from 2.1-2.3 μm of mixtures of kaolinite and montmorillonite. Vertical lines from left to right show the position of the 2.17 and 2.21 μm doublet and the maximum inflection point of pure montmorillonite longwards of 2.21 μm .

Kaolinite-montmorillonite. Kaolinite spectra have a doublet at 2.17 and 2.21 μm with very steep slopes. Montmorillonite spectra have a single absorption at 2.21 μm with an asymmetry to longer wavelengths. With decreasing kaolinite, the maximum inflection point on the longward side of this absorption shifts to longer wavelengths, more similar to montmorillonite (fig. 2). Additionally, the absorption at 2.17 μm is reduced. At 60 wt% kaolinite, this feature is a clear shoulder, while at 50 wt% it is a more gradual shoulder, and at 25 wt% it is barely detectable (fig. 2).

Kaolinite-SiOH. The Kilauea SiOH spectrum has an absorption at $\sim 2.26 \mu\text{m}$, slightly longer than that of

kaolinite. As a result, the depth of the kaolinite absorption with decreasing wt% kaolinite is greatly reduced on the longward side, but the maximum inflection point does not shift wavelengths (fig. 3). There is a clear 1.17 μm absorption observed at 75 wt% kaolinite, a clear shoulder down to 30 wt%, and a weak shoulder at 25 wt% (fig. 3).

Analysis of CRISM Spectra: Spectra from multiple images at Mawrth Vallis exhibiting a band near 2.2 μm were compared with the lab mixture spectra. The mixture with 20 wt% montmorillonite-80% obsidian appears to most closely match the majority of CRISM spectra collected from Mawrth Vallis on the longward side of the ~ 2.2 μm feature (fig.4). Most Mawrth Vallis spectra with a band near 2.2 μm exhibit a gradual slope on the shortward side of the ~ 2.2 μm absorption which is not observed in the mixtures. Therefore, more mixtures are needed to try and explain the shape of this feature.

The kaolinite-Kilauea SiOH mixtures do not match the CRISM observations as the 2.21 μm band is not broadened (fig. 5). Future mixture experiments with kaolinite and a pure opal or hydrated glass component are planned to test this further.

The 2.21 μm feature is broadened in spectra of the kaolinite-montmorillonite mixtures, but not to the extent observed in CRISM spectra (fig. 6). Additionally, the mixture spectra show a break in slope at ~ 2.24 μm which may be present in spectrum 43EC-b but is not resolved in the other CRISM observations (fig. 6).

In summary, CRISM spectra of the Mawrth Vallis region having a band near 2.2 μm appear to be most consistent with mixtures of hydrated glass with either montmorillonite or kaolinite. The kaolinite doublet is observable in mixtures down to ~ 25 wt% kaolinite.

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References: [1]Scott, D. H., et al. (1986) *USGS MI*, I-1802-A. [2]Edgett, K. S., et al. (1997) *GRL*, 24, 2897-2900. [3]Loizeau, D., et al. (2007) *JGR*, 112, E08S08. [4]Bibring, J.-P., et al. (2007) *LPS XXXVIII* Abstract #2160. [5]Bibring, J.-P., et al. (2005) *Science*, 307, 1576-1581. [6]Poulet, F., et al. (2005) *Nature*, 438, 632-627. [7]Bishop, J. L., et al. (2008) *Science*, 321, 830-833. [8]McKeown, N. K., et al. (2008) *LPS XXXIX* Abstract #1400. [9]Noe Dobrea, E. Z., et al. (2008) *LPS XXXIX* Abstract #1077. [10]Wray, J. J., et al. (2008) *GRL*, 35, L12202. [11]Milliken, R. E., et al. (2008) *Geology*, in press.

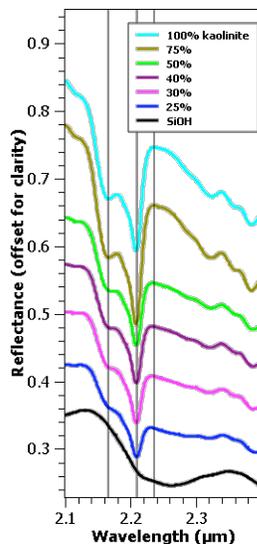


Fig. 3 (left). Spectral results of kaolinite-Kilauea SiOH mixtures. Vertical lines from left to right show the position of the 2.17 and 2.21 μm doublet and the maximum inflection point of pure kaolinite.

Fig. 4 (right). Comparison of montmorillonite-obsidian mixtures with CRISM observations from image FRT0000848D, labeled a-c. Vertical lines show the center of the 2.21 μm feature and the maximum inflection point in the CRISM observations. Note how well CRISM spectra a and b match the spectrum of 20% montmorillonite longwards of 2.21 μm .

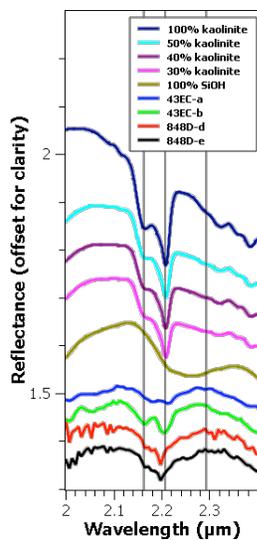
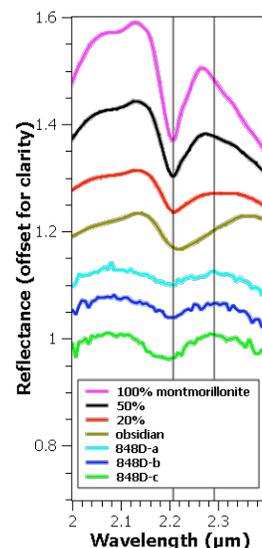


Fig. 5 (left). Comparison of kaolinite-SiOH mixtures with CRISM observations from images FRT0000848D, labeled d and e, and HRL000043EC, labeled a and b. Vertical lines from left to right show the position of the 2.17 and 2.21 μm doublet and the maximum inflection point of the CRISM observations. None of the mixtures match the CRISM observations.

Fig. 6 (right). Comparison of kaolinite-montmorillonite mixtures with the same CRISM observations as in fig. 5. Vertical lines from left to right show the position of the 2.17 and 2.21 μm doublet and the maximum inflection point of the CRISM observations.

