

REFLECTANCE SPECTROSCOPY OF NONTRONITE AND RIPIDOLITE MINERAL MIXTURES IN CONTEXT OF PHYLLOSILICATE UNIT COMPOSITION AT MAWRTH VALLIS. L. M. Saper¹ and J. L. Bishop², ¹Brown University (69 Brown Street, Box 7201, Providence, RI 02912; Lee_Saper@Brown.edu), ²SETI Institute and NASA ARC (515 N Whisman Rd, Mountain View, CA 94043 jbishop@seti.org).

Introduction: A diverse assemblage of Noachian phyllosilicate minerals has been detected in Mawrth Vallis and the surrounding Western Arabia Terra by OMEGA and CRISM visible/near-infrared (VNIR) observations [1,2] of thick phyllosilicate outcrops up to hundreds of meters in scale belonging to a geographically contiguous stratigraphy spanning at least 10^6 km² [3, 4, 5]. Presence of bound H₂O and the variety of phyllosilicate metal hydroxides in Mawrth Vallis minerals suggest a prolonged period of variable aqueous activity in the region. Distinct stratigraphic units of older nontronite (Fe/Mg smectite) and younger montmorillonite (Al-clay), kaolinite, and hydrated silica have been identified using characteristic metal-hydroxide VNIR absorptions. The formational environment of the clay units can be constrained by identifying other less obvious spectral mineral components and tracking variation within stratigraphic units. To test the hypothesis of a sedimentary versus diagenetic setting of formation laboratory spectra of mineral mixtures were compared to CRISM spectra in an attempt to understand a potential change in redox conditions at the contact of the nontronite and montmorillonite unit, indicated by a chemical shift to reduced iron. Analysis of the absolute and relative positions of vibrational spectral bands and crystal field absorptions in the VNIR will help accurately characterize the mineralogy of the region [6].

Methods: Fe-Mg nontronite (NAu-2) and ferrous clinoclone ripidolite (CCa-2) endmembers were sieved to <125 μ m and <45 μ m respectively. NAU-2 and CCA-2 are from the Clay Minerals Society Source Clays Repository.

Several mixtures were weighed and homogenized by sieving in ambient laboratory conditions. Reflectance spectra from 0.35 – 50 μ m were acquired using RELAB at Brown University. Here we focus on the VNIR wavelengths from 0.65 – 2.00 μ m.

Full-resolution targeted MRO/CRISM images collect 544 wavelengths from 0.36 to 3.9 μ m in ~ 10 – 12 km wide swaths at 18 m/pxl spatial resolution [7]. Images were processed for instrumental effects, converted to I/F and the atmospheric effects are minimized by scaling the image to the same column density of CO₂ as a CRISM image of Olympus Mons. To help visualize mineralogy, summary products were used to create a spectral parameter map of the CRISM image as described in [8]. Spectra were extracted from 3x3 pixel regions and larger irregularly shaped regions of interest

in order to sample a large number of spectrally similar pixels within a continuous geologic unit.

Discussion: Ripidolite was mixed with Fe/Mg-nontronite to determine the effects of the addition of a ferrous mineral component on the shape and positions of spectral bands from a Fe/Mg clay (Figure 1). Addition of a relatively small amount of ripidolite (<20%) increases the steepness of the slope from 1 – 1.8 μ m such that reflectance at 1.0 μ m decreases by about 30% while remaining within 5% reflectance at 2.0 μ m.

A concave upward positive slope from ~ 1 – 1.8 μ m is observed in many phyllosilicate outcrops in Mawrth Vallis. This band has been attributed to ferrous iron crystal field absorptions, possibly from ferrous clay, and is most prominent at the contact of the Fe/Mg-smectite and Al-phyllosilicate units [3]. Units containing this ferrous component appear consistently throughout the region but in many places significant erosion makes it difficult to determine the physical and spectral parameters of this transitional phase.

A fresh crater in CRISM image FRT000094F6 offers a relatively pristine window to spectrally sample phyllosilicate deposits (Figure 1). Consistent with previous observations there are three main spectral types present: (i). Fe/Mg-smectite (nontronite) at low elevations based on bands at ~ 1.4 , 1.92, 2.29, and 2.40 μ m; (ii). Hydrated Al-silica (altered volcanic glass) at higher elevations based on bands at ~ 1.4 , 1.92, and a broad feature around 2.2 μ m; (iii). Thin unit of ferrous material at the boundary of units (i) and (ii) with a strong ~ 2.3 μ m band and occasionally a weak ~ 2.2 μ m band (Figure 2, Figure 3). Analysis of 155 bright pixels correlating with unit (iii) indicate that it is likely a mixture of units (i), (ii), and an unknown ferrous material. Some spectra from the apparent ferrous unit in the crater and elsewhere in Mawrth Vallis have a steep positive slope from 1 – 2 μ m but only a strong 2.3 μ m Fe/Mg-OH band.

The ripidolite endmember has vibrational bands at 2.25 and 2.35 μ m positioned nearly symmetrically about either side of the 2.3 μ m band in the nontronite endmember. In a mixture with 75% nontronite and 25% ripidolite, the 2.25 μ m band appears as a shoulder, the 2.35 μ m is not visible, and the 2.3 μ m Fe-OH band center is unshifted. These bands are similar to those in the CRISM spectra with the exception that the 2.3 μ m band is shifted to 2.29 μ m, consistent with a Mg-rich nontronite. The 50% mixture shows evidence of both 2.25 and 2.35 μ m bands as well as a shift to

wards longer wavelengths for the 2.3 μm band but the ferrous component abundance is likely minor in Mawrth Vallis clays ($\ll 50\%$ of bulk composition). The effect of the symmetry of the ripidolite bands about the 2.3 μm nontronite band may explain why the band center does not shift when the ferrous slope is observed in CRISM data (Figure 1). If this unit contains a similar mixture of Fe/Mg-smectite and Fe^{2+} clay it will help inform our understanding of the aqueous conditions during formation of the clays. Variable redox chemistry can act as an energy source for life and should be probed further at Mawrth Vallis, a candidate site for the 2011 MSL mission.

References: [1] Noe Dobrea E. Z. et al. (2010) *JGR*, 115, 1 – 27. [2] Poulet F. et al. (2005) *Nature*, 438, 632 – 627. [3] Bishop J. L. et al. (2008) *Science*, 321, 830 – 833. [4] Loizeau D. (2010) *Icarus*, 205, 396 – 418. [5] McKeown N.K. et al. (2009) *JGR*, 114, 1 – 20. [6] Bishop J. L. et al. (2008) *Clay Minerals*, 43, 35-54. [7] Mustard J.F. et al. (2008) *Nature*, 454, 305 – 309. [8] Pelkey S.M. et al. (2006) *JGR*, 112, 1 – 18.

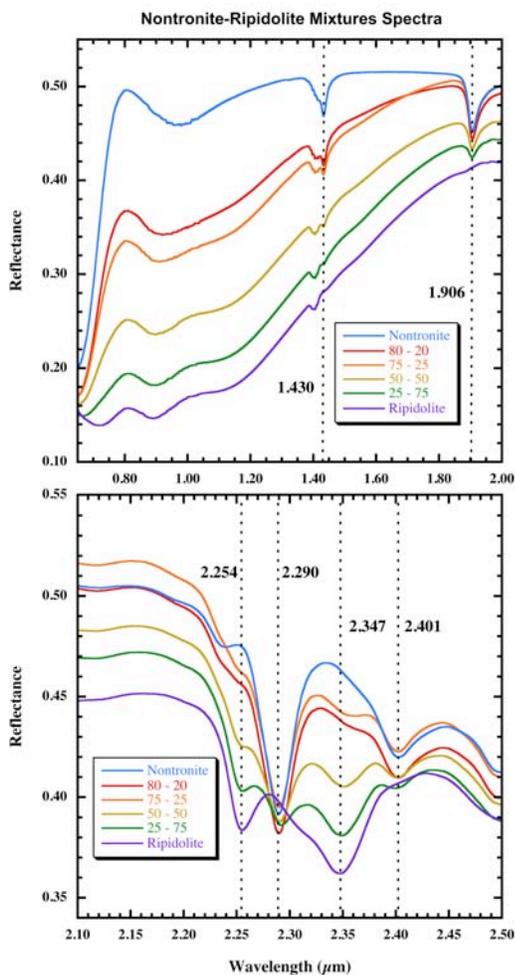


Figure 1.

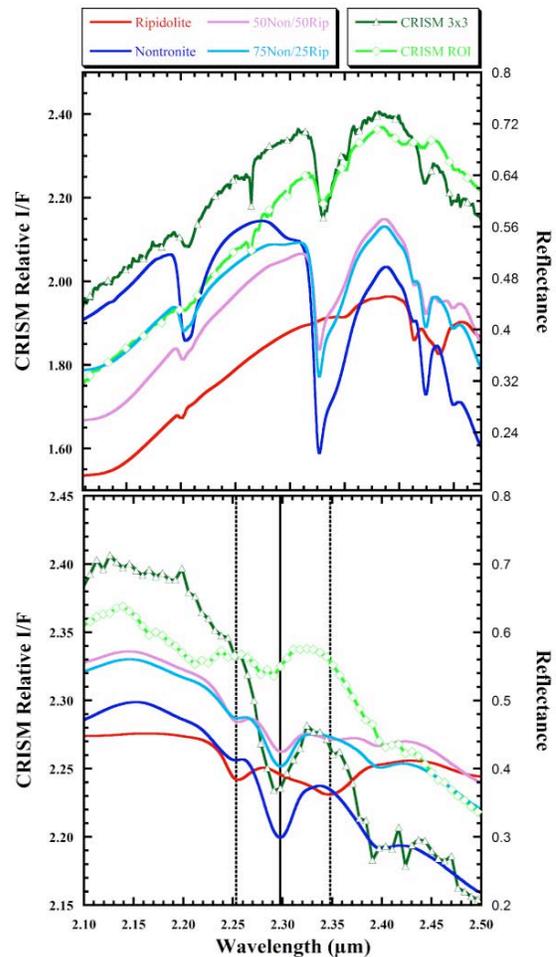


Figure 2.

Figure 1. Reflectance spectra of mineral mixtures given in %nontronite-%ripidolite. Top: 0.65 – 2.0 μm , Bottom: 2.1 – 2.5 μm .

Figure 2. CRISM ROI spectra from FRT000094F6 and laboratory mixture spectra for comparison. Top: 1-2 μm .

Figure 3. A. CRISM image FRT000094F6 displayed with band parameters; R: D2300, G: OLINDEX, B: BD2210. **B.** ROIs used for spectra; R: Nontronite, G: Ferrous Slope, B: Al/Si-OH. **C.** HiRISE IRB-color image PSP_004052_2045 showing clay layers in the crater.

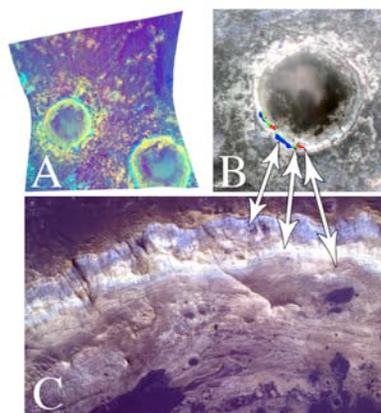


Figure 3.