UNIQUE SPECTRAL FEATURES DETECTED IN THE MAWRTH VALLIS REGION OF MARS: IMPLICATIONS FOR THE SEARCH FOR THERMALLY ALTERED CLAYS ON MARS.

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Introduction: Phyllosilicates are detected several geologic contexts on Mars, but are primarily associated with ancient Noachian terrains [e.g., 1-4]. These phyllosilicate deposits might have been altered by multiple processes. We hypothesize that dehydrated and/or dehydroxylated phyllosilicates may be present on Martian surface as one of the consequences of widespread impacts and volcanism during Noachian and early Hesperian periods. The objective of this ongoing project is to identify, map, and characterize these dehydrated and/or dehydroxylated phyllosilicates on Mars (which are spectrally distinguishable from impact-altered phyllosilicates [5], if any, using TES and CRISM data. The significant suite of our previous laboratory spectra [6-7] will be the basis for the TES and CRISM data analysis.

Using a variety of spectroscopic methods, our previous analysis of remote sensing data in the Nili Fossae region of Mars suggests that thermally altered (~400 ℃) Fe-rich smectites may be present in the region [8]. Here we continue the studies on areas of interest and present the evidence that some visible and near IR (VNIR) spectral features in the Mawrth Vallis region of Mars may be consistent with features of thermally altered Al-rich smectites, specifically 500-700 ℃ heated montmorillonites.

Thermal behavior of montmorillonite: Figure 1 shows NIR reflectance spectra of thermal treated montmorillonite sample [7]. The 1.41 μm feature does not show obvious changes upon heating to 400 ℃. Then the 1.41 μm feature shifts to 1.4 μm at 600 °C and a new 1.366 μm feature is present in the spectrum from 400-800 ℃. The 1.9 μm band decreases in intensity at 700 ℃, before disappearing completely upon heating to 800 ℃. For the montmorillonite analyzed here, there are obvious spectral changes observed in the 2.2-2.4 μm region upon heating to 500 ℃: the 2.21 μm feature displays slight shifts to shorter wavelengths (2.2 μm) and a new strong band at 2.311 begins to develop. At 800 ℃ the NIR spectrum only exhibits an extremely weak 2.2 μm band and at 900 °C montmorillonite loses all spectral features in the 2.2-2.4 μm region.

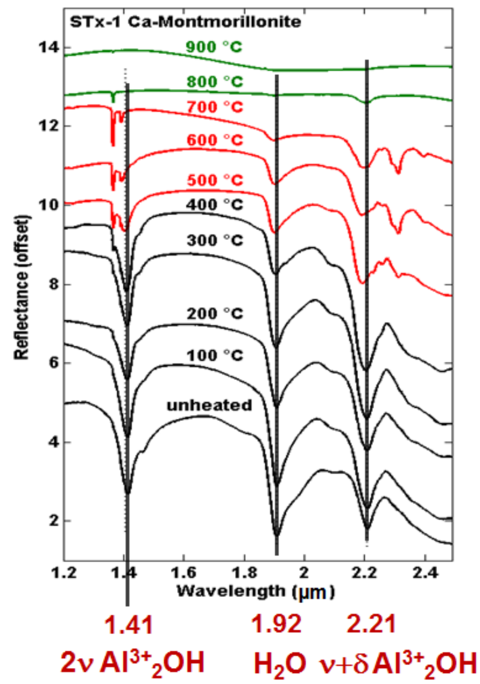

Figure 1. 1.2-2.5 μm diffuse reflectance spectra of Texas montmorillonite (STx-1) calcined at various temperatures. Linear vertical offset is applied to the spectra for clarity [7].

Based on the investigation of the thermal behaviors of montmorillonites by thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), and X-ray diffraction (XRD) analysis [6-7], the NIR properties of montmorillonite are largely affected by their dehydroxylation processes. At ~550 ℃ an endothermic reaction commences and ends at ~750 ℃, which is followed immediately by a second endothermic effect centered at ~850-900 ℃. These two endothermic peaks are interpreted to be caused by the loss of structural OH groups and breakdown of the anhydrous montmorillonite to an “amorphous” phase [9], respectively. Therefore, we account for the combination of 2.2 and 2.311 μm feature associated with dehydroxylation of the montmorillonite occurring at 500-700 ℃.

Results and Discussion: Figures 2-3 show potentially thermally altered phyllosilicates in Mawrth Vallis. The upper image in Figure 2 is a false color composite image displaying bands centered at 2.28 μm Fe-rich clays (red), 2.21 μm Al-rich clays (green), and an olivine index (blue). Spectra (Figure 3A) from purple regions are consistent with features of nontronite (1.43, 1.9, and 2.85 μm). Spectra (Figure 3B) from light blue regions are consistent with features of montmorillonite (1.41, 1.9, and 2.21 μm). There are some areas (region C and Figure 3C) displaying features that might be due to a mixing of nontronite and montmorillonite minerals.

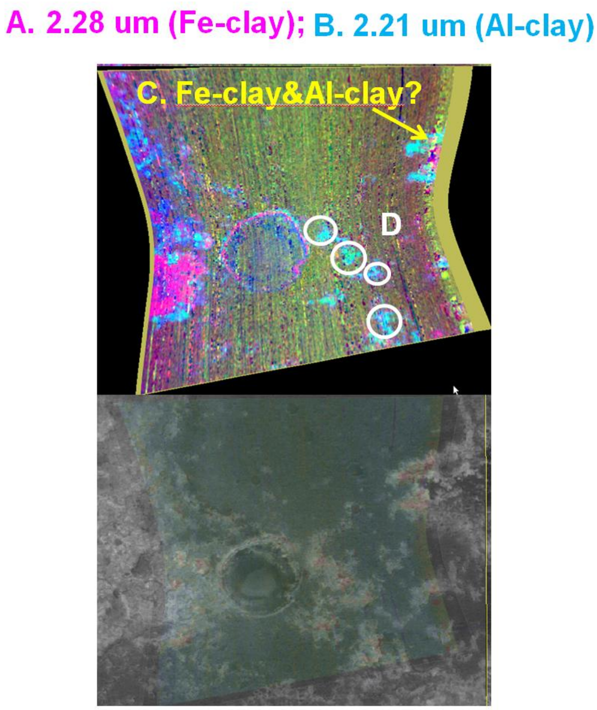

Figure 2. CRISM image FRT0000C596 covering the clay-rich unit in the Mawrth Vallis area, Mars.

The four red spectra in Figure 3D are collected from the isolated light-toned deposits shown in Figure 2 (region D) and they display spectral features different from those collected from surrounding large size of outcrops. The CRISM spectra in Figure 3D all show a combination of 2.2 and 2.311 μm feature, similar to the high temperature treated montmorillonite. This unique combination of 2.2 and 2.311 μm features is also observed in several other CRISM scenes.

The 2.2 and 2.311 μm features in Figure 3D could also be indicative of mixing of Al-rich clays and Mg-rich clays. However, our initial analysis of this area shows that the Mg-rich clays might be rare. In this case, we favor the interpretation of its being due to thermally altered montmorillonites and additional spectroscopic methods will be used to evaluate this hypothesis.

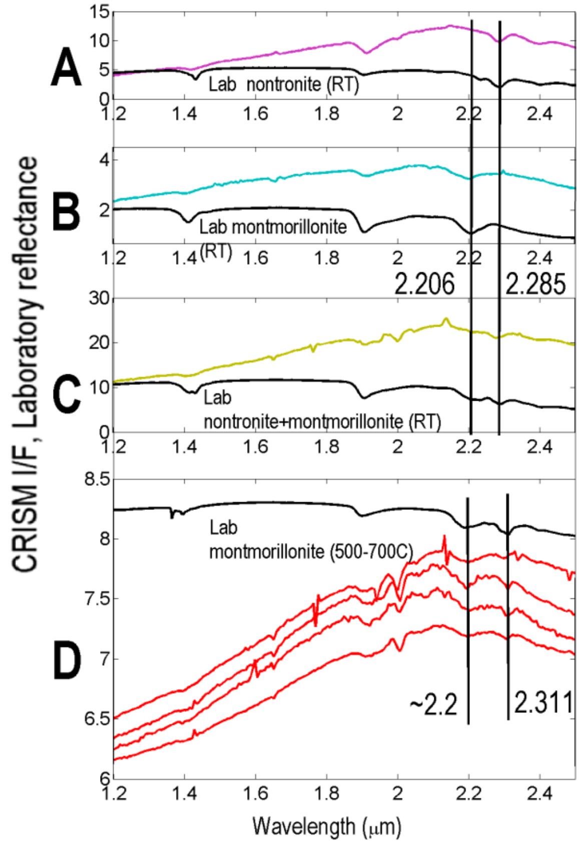

Figure 3. Lab (black) and CRISM ratio spectra (colors) showing variations in CRISM image FRT0000C596. Spectra collected from region D displays a combination of 2.2 and 2.311 μm and are consistent with thermally altered montmorillonite.

Summary: Analysis of VNIR reflectance data from MRO CRISM hyperspectral imager has revealed a unique spectral shape in the Mawrth Vallis region of Mars. This spectral shape has spectral absorption features consistent with the presence of thermally altered Al-rich smectites, specifically 500-700 ℃ heated montmorillonites.

References: [1] Bibring, J. -P. et al. (2006) *Science* 312, 400--404. [2] Loizeau, D. et al. (2007) *J. Geophys. Res.* 112, E08S08. [3]Poulet, F. et al. (2005) *Nature* 438, 623--627. [4] Mangold, N. et al. (2007) *J. Geophys. Res.* 112, E08S04. [5] Friedlander, L. R., and T. D. Glotch (2014), this conference. [6] Che, C. et al. (2011) *J. Geophys. Res.* 116, E05007. [7] Che, C. and Glotch, T. D. (2012) *Icarus*, 218, 585-601. [8] Che, C. and Glotch, T. D. (2013) *Geophys. Res. Lett.* in press. [9] Greene-Kelly, R. (1957) The Differential Thermal Investigations of Clays. Mineralogical Society, London, pp. 140–164.