PHYLLOSILICATE BEARING DEPOSITS AT MAWRTH VALLIS: STRATIGRAPHY AND POSSIBLE FORMATION PROCESSES.
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Introduction: Phyllosilicates-bearing outcrops on Mars were first detected definitely by the OMEGA spectrometer [1]. These phyllosilicates have spectra consistent with those of aluminum, iron, and magnesium smectite clays [2]. Recent observations by CRISM have shown in more detail not only the areal distribution of phyllosilicates on the surface but also the vertical distribion. The two largest exposures of phyllosilicates observed on Mars are located in Mawrth Vallis and Nili Fossae [2]. Smaller exposures have also been identified scattered across the planet, usually in materials of Nochian age [1, 3]. Mars surface mineralogy holds clues to its hydrological and geochemical histories, and we can use mineralogy to constrain past formation processes.

It is generally considered that phyllosilicate minerals are function of the original mineral assemblage in parent rocks, the chemistry of fluids that interacted with the rocks, and physico-chemical conditions (pH, temperatures, and pressure) during the time of mineral formation [4]. As clay minerals may form under the different geological envirionments such as weathering, burial diagenesis and hydrothermal alteration [4], the formation of clay minerals on Mars can occur via diverse paths and the interpretation of past alteration processes is complex. In this paper, we use MRO data to refine the mineralogy and stratigraphy of large exposure of clay minerals in the Mawrth Vallis region. We suggest that both weathering and hydrothermal alteration processes contribute to the stratigraphic development of phyllosillicates in this region.

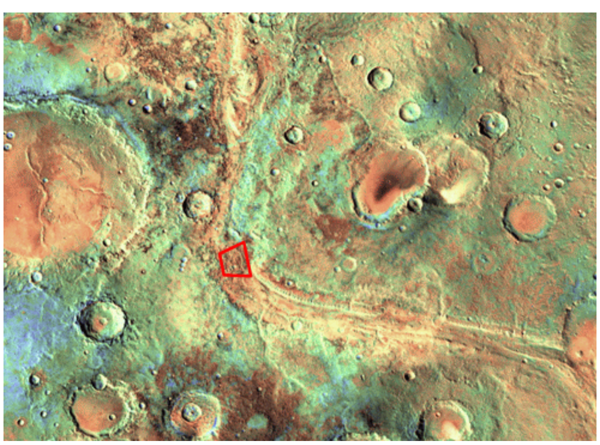

Figure 1. THEMIS regional view of Mawrth Vallis. Red box highlights the area shown in Figure 2.

Methods: The atmospheric and photometric corrections were applied to CRISM data using the standard techniques employed by the CRISM team [5]. CRISM Spectral summary parameters for absorptions at 1.9, 2.21, and 2.29 μm are used to map the spatial distribution of phyllosilicate minerals [6]. The 1.9 μm absorbtion band results from bound water in hydrated minerals. Combination tones of cation-OH stretchs result in absorptions at 2.21 μm for Al-rich phyllosilicates and between 2.28-2.35 μm for Fe/Mg-rich phyllosilicates [7]. Spectra exhibiting a band center at 2.21 μm are consistent with the Al-smectite montmorillonite and Fe/Mg-smectites (e. g., nontronite, saponite) tend to have a band at 2.28-2.35 μm [7].

Result: Phyllosilicate minerals were identified in the spectral parameter map of FRT00009326. There are also some regions in which hydration state is evident, but no strong metal-OH bands are observed. Figure 2 reveals spatial separation of the Al-Phyllosilicates (green to yellow) from the Fe/Mg-phyllosilicates (blue to pink). The color variations reflect variability of hydration state indicated by the strength of the 1.9 μm bound water band (red).

Stratigraphy: The resulting band depth map shows that raised knobs and curvilinear inverted channel contain Al-phyllosilicates (Fig. 3, A and B), whereas Fe/Mg-smectites is prevalent in other topographic lows (Fig. 3, C and D). Spectra of inverted paleochannel show that its sediments consist of Al-rich phyllosilicates (Fig. 3, A). The yellowish lower parts of knobs indicate that their phyllosilicates have more abundant bound water. The observation that Fe/Mg-smectites-bearing rocks underlie Al-clay-rich units is consistent with independent analyses of other regions at Mawrth Vallis [8, 9]. This uniform stratigraphy in Mawrth Vallis region is different from other regions, such as Nili Fossae and Thyrrena region [2, 10].

Disscussion: Several studies have interpreted the phyllosilicates-bearing rocks there as evidence for an ancient sedimentary deposit predating the formation of Mawrth Vallis [11, 12]. Alternatively, it has been suggested that Al-phyllosilicte-rich layers resulted from aqueous alteration and acid leaching of cations from the initial Fe/Mg-smectites that probably formed via aqueous alteration of basalt, the dominant lithology of the Martian Noachian highlands [8].

Clay minerals are commonly formed by chemical weathering and hydrothermal alteration. The Fe/Mg-smecites-rich unit of this area (Fig. 2) on the floor of valley appears to be the same as those of other regions around Mawrth Vallis, and they may be stratigraphically correlated in a single unit. This suggests that the mineralogical alteration are representative of regional process, which may be under hydrothermal environment. The Al-phyllosilicate exposures of inverted channel are alluvial sedimentary deposits that may have been transported from the surrounding source regions. But it is uncertain whether other Al-phyllosilicate layers overlying Fe/Mg-smectites in this area are sedimentary diposits or they formed through *in situ* alteration under aqueous environments. More comparisons of texture features of Al-phyllosilicate rich exposures found within the Mawrth Vallis region may be helpful.

References: [1] Bibring J.-P. et al. (2005) *Science, 307*, 1576-1581. [2] Poulet F. et al. (2005) *Nature, 438*, 623-627. [3] Poulet F. et al. (2007) *7th Mars Conference*, Abs, #3170. [4] Velde, B., ed. (1995) *Origin and Mineralogy of Clays*, Springer-Verlag. [5] Mustard J. F. et al. (2008) *Nature, 454*, 305-309. [6] Pelkey S. M. et al. (2007) *JGR, 112*, E08S14. [7] Bishop J. L. et al. (2008) *Clay Minerals, 43*, 35-54. [8] Bishop J. L. et al. (2008) *Science, 321*, 830-833. [9] Wray J. J. et al. (2008) *GRL, 35*, L12202. [10] Mangold N. et al. (2007) *JGR, 112*, E08S04. [11] Michalski J. R. et al. (2007) *LPSC XXXVIII*, Abs. #1065. [12] Loizeau D. et al. (2007) *JGR, 112*, E08S08.

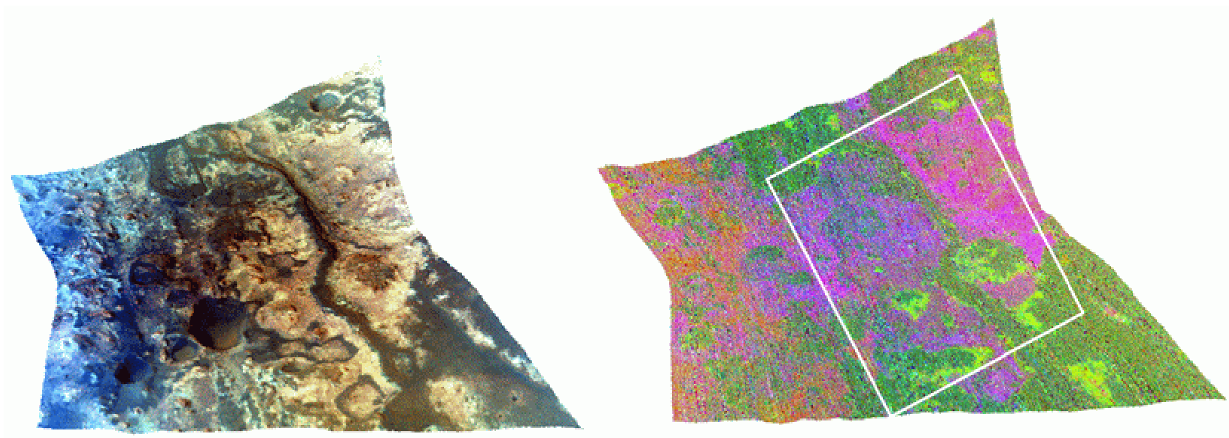

Figure 2. (left) Visible color image of FRT00009326 and (right) corresponding color composite of parameters map draped over HRSC DTM (H1293_0000), Where R: BD1900 (1.9 µm feature [6]), G: BD2210 (2.21 µm), B: BD2290 (2.29 µm). White box indicates location of Figure 3.

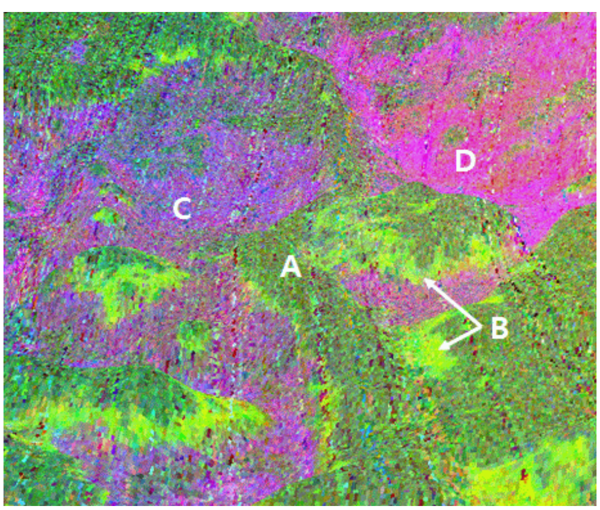

Figure 3. Portion of the spectral parameters map (Fig. 2, right) draped over HRSC DTM.

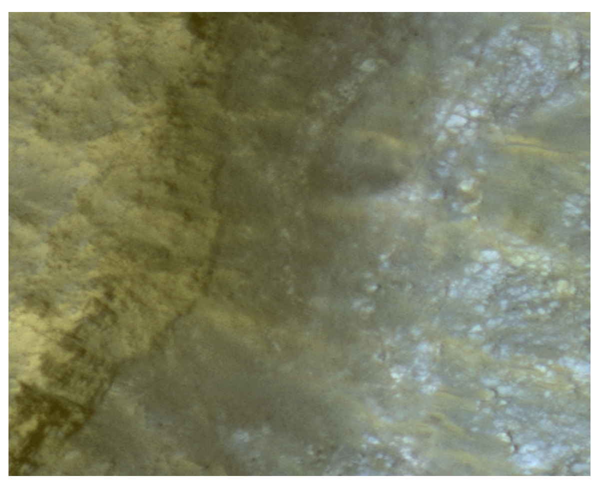

Figure 4. Portion of HiRISE image PSP_006755_2030 showing inverted channel deposits and underlying polygonally fractured Fe/Mg-smectite terrain.