THE DISTRIBUTION AND MINERALOGY OF HYDRATED MINERALS IN WALL AND FLOOR MATERIAL OF VALLES MARINERIS.
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Valles Marineris: The chasma system provides a window into laterally extensive geologic units, revealing evidence for aqueous processes that modified the surface and subsurface through the history of Mars. The walls of Valles Marineris (VM) expose Noachian to Hesperian terrain, providing a record of volcanic and sedimentary processes on Mars for over a billion years. CRISM data were first used to identify phyllosilicates within deposits near VM, including those exposed in wall units and transported deposits [1]. The purpose of this study is to determine the vertical and lateral distribution and mineralogic variability of minerals exposed in the valley walls and floor materials. If phyllosilicates are exposed in laterally continuous deposits, this may indicate they were formed through burial of layered phyllosilicates or hydrothermal alteration. If they are discontinuous in distribution, they might be associated with exposures of buried craters [*e.g.*, 2].

Phyllosilicate Stratigraphy & Distribution: Flahaut et al. [3] observed that in eastern Coprates Chasma, Mg-rich phyllosilicates were exposed from -2000 to -400 m (Fig. 1, green) overlaying an Low-Ca Pyroxene (LCP)-rich unit; tracing the stratigraphy to Juventae and Capri Chasma suggests that these units shallowly dip in elevation from west to east. At the top of the stratigraphic sequence exposed by VM are shallow "plateau phyllosilicates" interpreted to be a pedogenic sequence of Al- and Fe/Mg-phyllosilicates [4]. The lack of phyllosilicates identified in the valley walls in western VM were interpreted to be a product of a steeply plunging dip from east to west as a result of tectonic subsidence or "sagduction" via loading of volcanic material [3, 5, 6]. The identification of nontronite in Ius Chasma [4] was the first indication that phyllosilicate-bearing material is present in the western portion of VM. However, Flahaut et al. [3] interpreted nontronite-bearing units as unrelated in origin to those in eastern VM since they do not apparently overlie an LCP-rich unit. Here we argue that the nontronite exposed in western VM is an extension of the pedogenic Fe/Mg phyllosilicate unit [4] and that it is obscured by dust and deposition of floor material including sulfates and a 'hydrated silicate' phase [7].

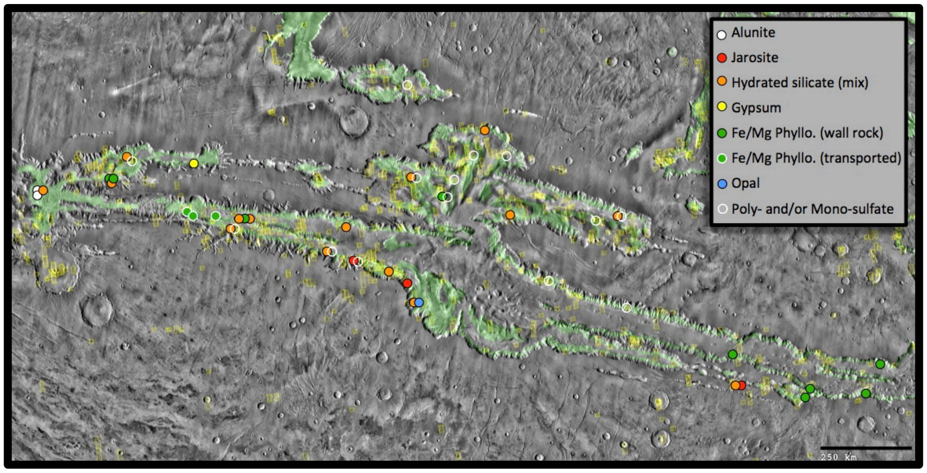

Figure 1. Mineral endmember distribution and diversity in Tithonium, Ius, Candor, Hebes, Ophir, Melas, and Coprates Chasma at elevations between -2000 and -400 m (indicated in green).

Hydrated Silicate Distribution & Composition: The 'hydrated silicate' material that drapes over nontronite-bearing wall material has a mineralogy not yet conclusively identified and is observed in, Noctis Labyrinthus [7], Ius [8] Ophir [9], and Coprates Chasma [10]. The spectral characteristics of this phase are: 1) H_2O absorptions at 1.40-1.42 µm and 1.91-1.92 µm, 2) a sharp doublet attributed to metal-OH at 2.20-2.22 and 2.27-2.28 µm, and 3) a relatively minor absorption or shoulder near 2.4 µm [8]. In Ius Chasma, the relative depth of the 2.21 and 2.27 µm absorptions vary, suggesting the phase may be a mixture of at least two endmembers. Roach et al. [8] suggest the mineralogy is 1) neutral to acid-neoformed $FeSiO_2$ (leached phyllosilicate), 2) a montmorillonite/jarosite mixture, or 3) a montmorillonite/ferromagnesian smectite mixture.

We have identified the same spectral signature in Tithonium Chasma, directly to the north, in E. and W. Candor Chasma, and in Melas Chasma (Fig. 1, orange). Our investigation reveals outcrops with spectral signatures that have definitive absorption features that limit the spectral interpretation of this widespread unit. Figure 2 shows CRISM ratioed I/F reflectance spectra from 6 scenes within VM. Ratios are taken from >30 pixel averaged regions of the spectral unit of interest and spectrally-neutral material within the same column of a CRISM scene calibrated through the latest processing techniques [11]. Spectra have been ordered to demonstrate correlated spectral shifts that suggest mixing of two phases. A relatively deep 2.21- and 1.9-µm band and a shallow 2.27-µm band are characteristic of the spectrum from scene FRT0000BB2A (FRTBB2A). Conversely, the spectrum from scene FRT3F5B has a relatively deep 2.27-µm band, apparent 2.4-µm shoulder, the presence of an absorption at 1.85 µm, and a weak to no 1.9-µm band. The 1.85-µm feature is unique to jarosite and provides a positive identification for one of the mixing endmembers. This suggests that hypothesis 2 (a mixture of jarosite and montmorillonite) from Roach et al. [8] is the most likely mineralogy that contributes to this light-toned unit throughout the chasma in localized draping deposits. Although the 1.85 µm band is absent some of the spectra, the 'hydrated silicate' deposits still exhibit the strongest absorptions from jarosite, which would be expected if the Al-OH phase were in greater abundance.

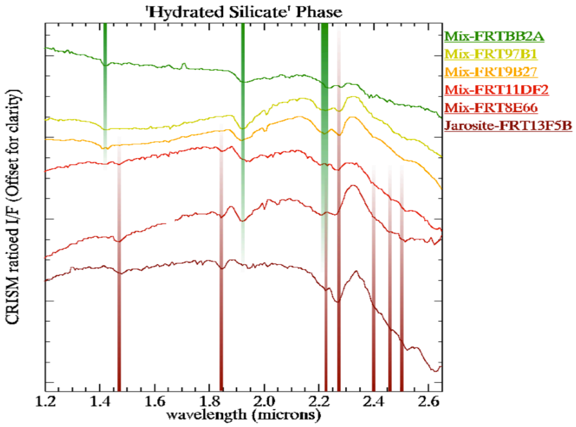

Figure 2. Example spectra of jarosite and 'hydrated silicate' phase ordered to show mixing of jarosite (red lines=1.47, 1.85, 2.27, 2.40, 2.46, and 2.50 µm absorption) and an Al-OH phase (green lines =1.41, 1.91, and 2.20-2.22 µm absorption).

Nontronite exposures in Tithonium and Ius Chasma: Although some of the nontronite exposures in Ius Chasma exhibit morphologies indicative of transport [*e.g.* 8], there are small outcrops in both Ius and Tithonium Chasma where nontronite is exposed in chasma wall units (see Fig. 1). The nontronite-bearing unit in Tithonium is overlain by spectrally-bland material within the wall, and unconformably overlain by a 'hydrated silicate' bearing deposit that drapes across the valley floor (Fig. 3). The nontronite-bearing material is only exposed in one location at the lowest part of

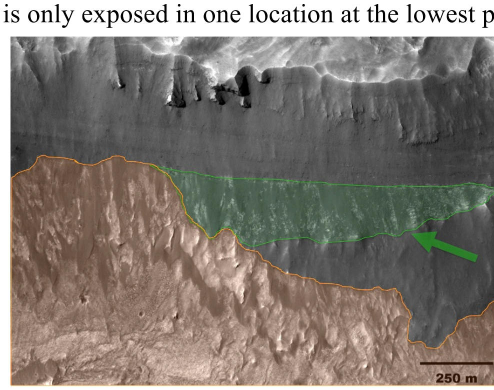

Figure 3. 'Hydrated silicate' material (orange) draping over nontronite-rich wall unit (green) in HiRISE scene PSP_006916_1745. Mineralogy determined from FRT97B1.

the Tithonium chasma wall (exposed from -1200 to -1080 m), within the elevation range for "plateau phyllosilicates" observed in eastern VM (-3000 to 3000 m), but unlike eastern VM they are buried by nearly 6 km of Hesperian lavas. A similar stratigraphic relationship between these mineralogies is also observable in Ius Chasma (FRT9B27). In eastern VM, significant exposures of the Fe/Mg phyllosilicate are readily detectable as the walls and surround plateau are relatively dust-free. On the other hand, in western VM, phyllosilicates in the valley wall are often draped by floor material and surfaces are significantly more dusty surfaces.

Spectral Endmember Identifications: We detected alunite in Noctis Labyrinthus (scenes FRT9180 and FRTA48D) through the identification of a dominant 2.17-µm absorption feature characteristic of alunite, as well as a 1.75-µm absorption feature that is shared by gypsum. Although observed elsewhere on Mars [*e.g.*, 12] to our knowledge this is the first identification of alunite within the VM system and is consistent with other acid-leached minerals, such as jarosite. Further west of this occurrence, Weitz et al. [7] identified two mineralogically diverse troughs in Noctis Labyrinthus containing sedimentary Fe/Mg and Al clays, sulfates, opal, and the 'hydrated silica' phase.

Discussion and Conclusions: VM and the surrounding plateau preserves a laterally extensive possibly pedogenic Fe/Mg-phyllosilicate unit within the walls of the chasma, although the majority of this deposit is likely obscured in western VM. This hypothesis is inconsistent with the interpretation that the stratigraphy in western VM is dipping from east to west (via thrust faulting, basin formation, or tectonic loading) [3, 5, 6]. The small exposures of nontronite preserved in Ius and Tithonium Chasma walls suggest that the pedogenically related "plateau phyllosilicates" [4] extend westward underlying several kilometers of younger lavas. This unit only dips ~0.1° from east to west across VM, which is inconsistent with a steeply plunging stratigraphy, unless pedogenesis took place after the structural mechanism that caused subsidence, sagduction, etc. was complete. The deposition and draping of a spectrally unique unit occurs along the VM floor and is identified to be a mixture of jarosite and an Al-OH phase. Further investigation of the mineralogy and stratigraphy in western VM will help identify the extent and timing of aqueous alteration and tectonic deformation of the crust.

References: [1] Murchie et al. (2009) *JGR*, 114. [2] Frey et al. (2002) Ancient lowlands on Mars, *Geophys. Res. Lett.,* 29. [3] Flahaut et al. (2012) *Icarus*, 221, 420-435. [4] Le Deit et al. (2011) *JGR*, 117. [5] Quantin et al. (2012), *Icarus*, 221, 436-452. [6] Dohm et al. (2001) *JGR*, 116, 32943-32958. [7] Weitz et al. (2012) *Geology*, 39, 899-902. [8] Roach et al. (2010) *Icarus*, 206, 253-268. [9] Wendt et al. (2011) *Icarus*, 213, 86-103. [10] Grindrod et al. (2012) *Icarus*, 218, 178-195. [11] Seelos et al. (2012), *Plnt. Data: A Wrkshp Urs & Dvlprs*. [12] Wray et al. (2011) *JGR*, 116.