

MT. SHARP'S CLAY-SULFATE TRANSITION: A REGIONAL PERSPECTIVE FROM ORBITAL SPECTRAL AND GEOMORPHIC DATASETS. A. A. Fraeman¹, R.E. Arvidson², K.M. Stack¹, J. R. Christian², R.Y. Sheppard³, M. J. Meyer⁴, M. N. Hughes² ¹Jet Propulsion Laboratory, California Institute of Technology (afraeman@jpl.nasa.gov), ²Washginton University in St. Louis, ³Planetary Science Institute, ⁴Brown University

Introduction: A major reason Mt. Sharp (formally Aeolis Mons) was selected as a landing site for the Mars Science Laboratory's Curiosity Mars rover was orbital data that showed it preserved a transition from phyllosilicate-bearing to sulfate-bearing sedimentary rock that might reflect a globally significant climate change [1]. Details of the clay-sulfate transition are difficult to ascertain from orbital data alone due to the complexity of the regions' geomorphology and the tens of meter spatial resolution of orbital spectral data. Proposed mineral stratigraphies include alternating sulfate and phyllosilicate-bearing strata, co-occurring sulfate and phyllosilicates in the same strata but with varying abundances, or possibly a single transition from phyllosilicate to sulfate-dominated strata [1, 2].

Curiosity's recent investigation of a section of the clay-sulfate transition coupled with advances in processing of orbital spectral datasets motivate a renewed examination of the nature of this transition as seen from orbit in order to provide regional context for Curiosity's observations, and perhaps give additional insight into this key time in Mt. Sharp's history.

Methods: Data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) were atmospherically corrected using discrete ordinates method of radiative transfer (DISORT) to model aerosols and the "volcano scan" method developed for CRISM data to account for gasses at the short wavelength absorptions [3, 4]. Data were then modeled as single scattering albedos (SSA), which are independent of lighting and viewing conditions, using

the Hapke model. Finally, the observations were regularized in both the spatial and spectral dimensions using the log maximum likelihood method to retrieve the best estimate of surface SSA in the presence of Poisson noise [5]. CRISM spectral indices [6] were used to explore the spatial distribution of the minerals of interest (Fig. 1).

Orbital views: The spectra over much of Curiosity's traverse through the clay-sulfate transition all have 1.9 μm absorptions indicative of hydration, and sometimes weak 2.3 μm and 2.4 μm absorptions (Fig. 2). Combined, these absorptions are attributed to hydrated minerals, possibly Fe/Mg phyllosilicates and polyhydrated sulfates, although the shallow nature of the 2.3 and 2.4 μm absorptions when they are present (similar in magnitude to the CRISM instrument noise) make conclusive identification difficult. Marker Band valley, where Curiosity acquired the Canaima drilled sample, is the first region explored by the rover where CRISM data are interpreted as strong evidence for polyhydrated sulfates because that region contains several spatially contiguous pixels that have deep 1.9 μm and 2.4 μm absorptions (Fig. 1, 2).

The appearance of weak and spatially variable 2.4 μm absorptions, as well as the loss of strong 2.3 μm absorptions, loosely correlates with the base of the "Unit 1 polygonal bedrock" in the geomorphic map of the clay-sulfate transition from [7] (Fig 3, top). In contrast, regions with spatially contiguous pixels that have deep

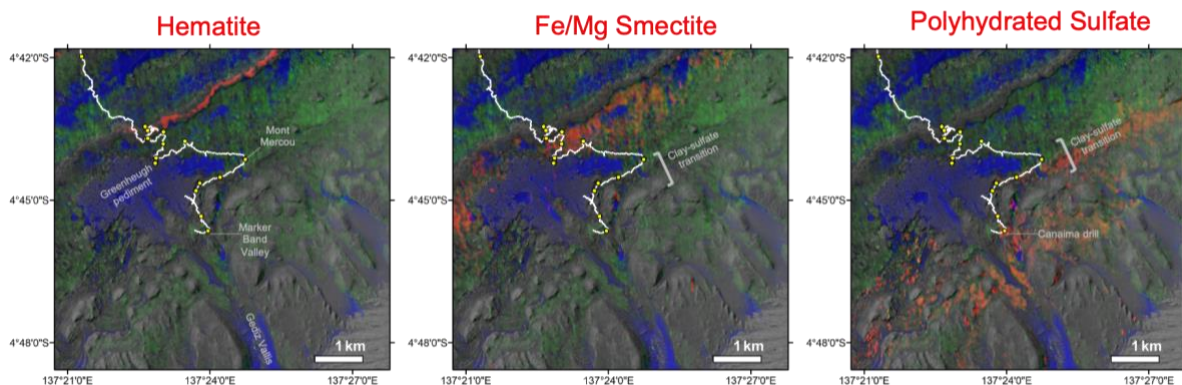


Figure 1: CRISM spectral parameter maps from FRT0000B6F1 modeled to SSA in the presence of Poisson noise. In all cases, greens show hydrated minerals (D1900R, stretch: 0.001 – 0.015) and blues show basaltic materials (HCPINDEX, stretch: 0.001 – 0.02). From left to right, red shows hematite (BD860_2, stretch: 0.0001-0.005), Fe/Mg smectite (D2300, stretch: 0.005-0.01), and polyhydrated sulfates (SINDEX2, stretch 0.005 – 0.01). Curiosity's traverse through sol 3672 shown in white, yellow dots indicate drill locations.

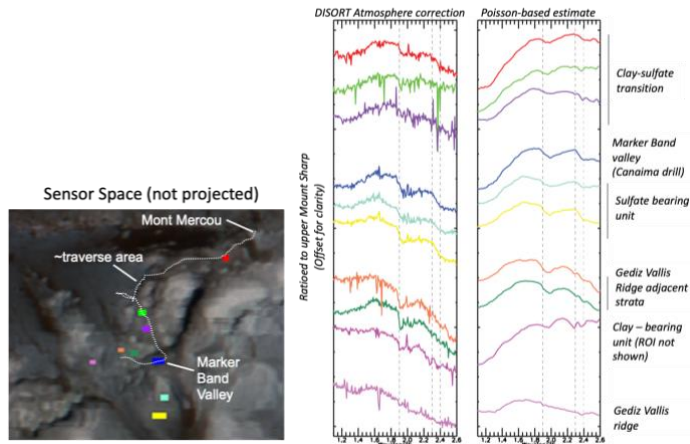


Figure 2: (Left) Locations of regions of interest (ROI) for spectra. (Middle) Atmospherically corrected, SSA spectra ratioed to upper Mount Sharp, (Right) SSA modeled using log maximum likelihood method. Vertical lines are 1.9, 2.3, and 2.4 μm .

2.4 μm absorption (such a Marker Band valley) are not associated with distinct geomorphic units (Fig. 3, top).

Relevant *in situ* observations: There are not clear associations between orbital spectral properties and stratigraphic members mapped from Curiosity's *in situ* data [8] (Fig. 3, middle). ChemCam and APXS measured elevated Mg and S in centimeter sized nodules throughout most of the clay-sulfate transition [9]. APXS and ChemCam also measured moderately elevated Mg, S and other salts associated with bedrock in the transition, and the highest Mg and S abundances were found in bedrock in Marker Band valley [9, 10]. CheMin data show that the bedrock in most of the clay-sulfate transition contains little to no phyllosilicates, and crystalline polyhydrated Mg-sulfate is only present in the "Canaima" drilled sample collected in Marker Band valley [11].

Preliminary conclusions and future work: The interpretation that CRISM data show strong evidence of polyhydrated sulfates in Marker Band valley was validated by CheMin XRD analysis [11].

[12] concluded that at least some of the spectral absorptions attributed to polyhydrated sulfates in CRISM data within the clay-sulfate transition are caused by diagenetic features that are not time congruent with original depositional strata. The lack of correlation between CRISM spectral properties, geomorphic units, and stratigraphic members supports this interpretation. Combined orbital and *in situ* observations of the clay-sulfate transition are most consistent with a model where clay minerals become less abundant with elevation and diagenetic sulfates are variably distributed throughout the region in the form of cements and diagenetic textures.

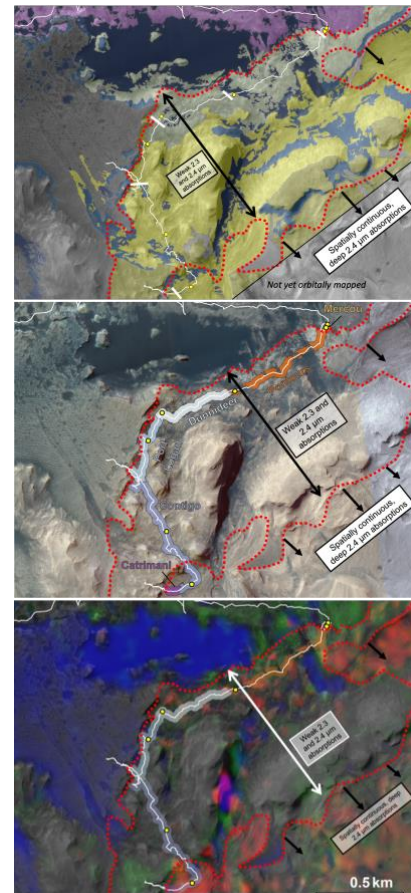


Figure 3: (Top) Orbital geomorphic map from [7]. (Middle) Geologic members from [8]. (Bottom) Same as Fig. 1 right, zoomed in.

Intriguingly, the strongest sulfate spectral indicators higher in the sulfate-bearing units are associated with local topographic lows (Fig. 4). Future work will explore why and expand regional mapping of the correlation between geomorphic units and spectral properties in the clay-sulfate transitional region.

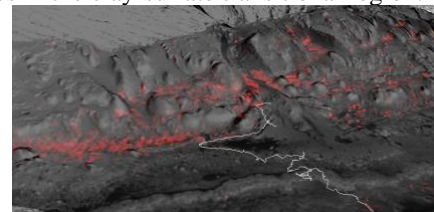


Figure 4: SINDEXT values from FRT0000B6F1 (red) overlain on 3x VE view of Mt. Sharp.

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References: [1] Milliken et al., (2010) *GRL* 37(4) [2] Sheppard et al., (2021), *JGR*, 126(2) [3] Starnes et al., (2000) [4] McGuire, P et al., (2009), *PSS* [5] He et al., (2022) *JGR*, 127(9), [6] Viviano, C.E. et al., (2014), *JGR*, 119(6), [7] Stack, K., (2017), *LPSC* #1889., [8] Gupta et al., this conf, [9] Rapin et al., this conf, [10] Thompson et al., this conf, [11] Rampe et al., this conf. [12] Meyer et al., (2022), *LPSC* #1934.