SPECTRAL PROPERTIES OF THE LAYERED SULFATE-BEARING UNIT IN MOUNT SHARP, GALE CRATER, MARS.
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Introduction: The Mars Science Laboratory Curiosity rover has been exploring Gale Crater since 2012 and is currently ascending its ~5 km high interior mound, Mount Sharp. Sulfate-bearing units have been previously identified overlying clay-bearing units in the middle layers of Mt. Sharp in the path of Curiosity's expected traverse [1, 2]. Sulfates on Mars have been recognized to represent fundamentally different environmental conditions than clay-bearing units and the transition between the two in Mt. Sharp may record regional or global changes in aqueous conditions.

Datasets: We investigate the sulfate-bearing layered terrains in Mt. Sharp using a suite of datasets derived from CRISM [3] and HiRISE [4] onboard MRO and THEMIS [5] onboard Mars Odyssey. CRISM observations were modeled to single scattering albedo (SSA) using DISORT and the Hapke function. SSA are independent of lighting and viewing geometry, have been corrected for atmospheric gases and aerosols, and have been regularized using a log-maximum likelihood method [6]. For the mixed reflectance and thermal region from ~2.6-3.8 μm, SSA is retrieved using a neural network approach [7]. HiRISE data are used in the form of a regional mosaic at 0.25 m/pixel. THEMIS data were previously converted to a regional thermal inertia mosaic [8].

Spectral and Stratigraphic Properties: The layered sulfate strata consist of bright, banded outcrops containing a polyhydrated sulfate spectral signature. Polyhydrated sulfates are identified by absorptions at 1.9 and 2.4 μm; the lack of additional diagnostic absorptions suggests the dominant species are Mg-sulfates. Additionally, the sulfate areas have enhanced 3 μm absorption features, quantified here as an integrated band depth (Figure 1). Substantial outcrops or layers containing monohydrated sulfates are not observed. These spectra are consistent with sulfate-bearing mineral assemblages rather than pure sulfate. The strength of reported parameters is influenced by mineralogy, textural properties, and surface expression of outcrops. The strongest sulfate signatures are present in deep valleys and steep slopes, likely wind-swept areas that are relatively well-exposed bedrock (Figure 2a). The strength of this sulfate signature is reduced in areas of sand and dust cover, as confirmed by higher spatial resolution HiRISE imagery and THEMIS-derived thermal inertia.

Regular layering is present throughout the section at the HiRISE scale. It is particularly well exposed in the sides of buttes and mesas, where dark and bright banding is observed down to a few meters in height. Layers can commonly be traced laterally for tens or even hundreds of meters, and tentative connections can be drawn between layers in adjacent buttes. Areas of well-exposed bedrock, as verified by HiRISE imagery, have thermal inertias 320-350 $Jm^{-2}K^{-1}s^{-1/2}$.

Marker bed: A thin, smooth, low-albedo stratum [1] can be traced across the study area near ~3800 m elevation. It dips outward from Mt. Sharp, typically at <5 degrees. Its spectral signature is consistent with pyroxene and is devoid of a sulfate spectral signature (Figure 2b).

Boxwork fracturing: Portions of the sulfate unit to the southwest of Gediz Vallis have been documented to have boxwork fractures [9]. These areas show a reduced 2.4 μm absorption while retaining a similar depth of 1.9 μm absorption (Figure 2c).

Gediz Vallis: Gediz Vallis is a U-shaped valley that begins in the relatively anhydrous duststones above the sulfate section and runs downhill towards the Greenheugh pediment [10]. Midway along its length, a ridge protrudes above the center of the vallis, gaining in elevation downslope until it terminates atop the pediment. The ridge shows scattered evidence of sulfates, possibly derived from blocks eroded from upslope. The ridge lacks the regular dark-bright banding characteristic of the layered sulfates.

Overall, the Mt. Sharp mound contains >600 m (in current elevation) of shallowly dipping strata (Figure 3), layered at the meter to tens of meters, and containing the VNIR spectral signature of polyhydrated Mg-sulfate. Subsequent to deposition, the current shape of the mound has been sculpted by aeolian erosion, leaving a series of buttes and mesas. Clear sulfate signature is obscured in many areas, especially at higher elevations in the mound, by overlying sand and dust cover.

Curiosity's Traverse: Observations with Curiosity's instruments will help to untangle the formation mechanism of these sulfates. Possibilities include primary evaporites, Meridiani-style diagenesis and cementing, and alternate formation by diagenesis. Long-distance observations from the clay unit will provide increasingly detailed images of the layered sulfate unit. Curiosity will have the opportunity to sample the transition out of the clay unit before ascending onto the Greenheugh pediment and into the sulfate section proper. Compositional measurements will provide an additional point of "ground truth" for CRISM detections of polyhydrated sulfates on Mars.

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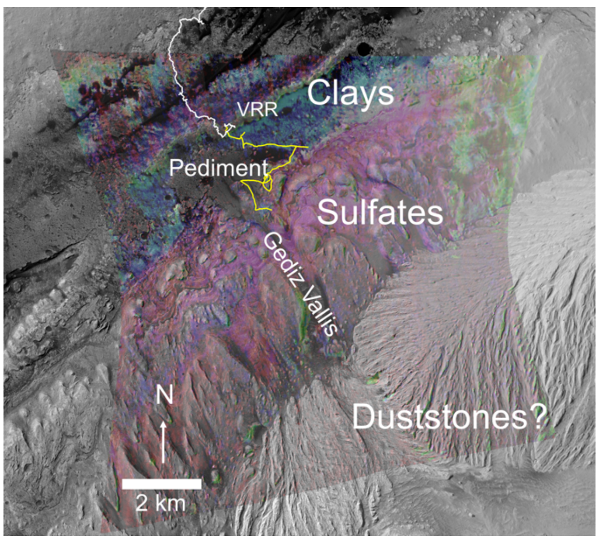

Figure 1: CRISM FRT0000B6F1 parameter map color composite overlaid on HiRISE basemap. R = SINDEX2, G = 3 µm integrated band area, B = 1900R2. Red and pink areas are sulfate-bearing. White line shows MSL traverse to Vera Rubin Ridge. Yellow line indicates notional ascent route into the layered sulfates.

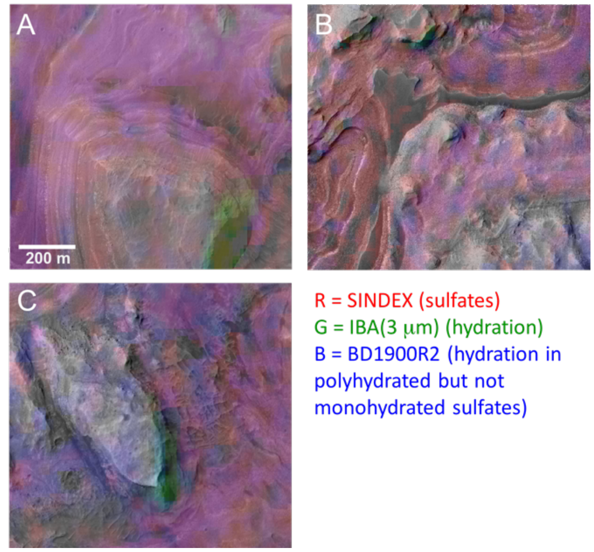

Figure 2: Subareas of the sulfate section, HiRISE basemap with CRISM parameter map overlay. A: Typical layering in the side of a butte showing polyhydrated sulfate signature. B: Marker bed with a lack of sulfate signature and layering above and below. C: Boxwork fracturing showing hydration but a weaker 2.4 µm absorption.

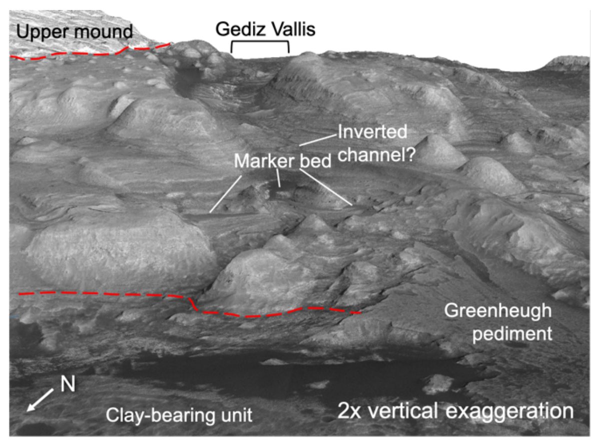

Figure 3: HIRISE DEM perspective view of lower Mt. Sharp and the layered sulfate unit (contained by red dashed lines).