**THE MARKER BED AT GALE CRATER, MARS: PREDICTIONS FOR EXPLORATION BY CURIOSITY ROVER.**
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**Introduction**: A dark-toned marker bed is observed within the sulfates at Gale crater [1], but its extent and origin are unknown. The marker bed is characterized by a dark, smooth surface and is both underlain and overlain by brighter, fractured sulfate-bearing rocks. The bed is used to define the boundary between middle and upper members of the Lower formation of the ~5 km thick Aeolis Mons [1].

In this study, we utilized HiRISE and CTX images to identify and map the occurrence of the marker bed within northwestern Aeolis Mons. CRISM data were used to analyze the marker bed composition as well as the sulfates above and below it. We also utilized HiRISE stereo-derived Digital Terrain Models (DTMs) to determine elevations, orientations, and dips for the marker bed across northwestern Aeolis Mons. Additional marker beds have been identified lower in stratigraphy along the northwestern side of Aeolis Mons and in southern Aeolis Mons [2], but in our study we are focusing on the upper marker bed in NW Aeolis Mons that will be examined by the Curiosity rover during its extended mission phase. Our findings can assist the MSL science team with possible origins for the marker bed by providing orbital observations across NW Aeolis Mons that cover a larger area compared to the small area to be examined by the rover.

**Observations**: We mapped the marker bed across much of the northwestern portion of Aeolis Mons (Fig. 1). The bed is patchy in exposure moving westward and it is not observed along the northeastern portion of the mound. HiRISE images that cover the marker bed were analyzed to characterize the morphology of the bed. In general, the marker bed is darker in reflectance and does not exhibit the blocky, fractured surface of the sulfate materials surrounding it. The marker bed is also more resistant to erosion relative to the sulfates, which explains why it appears as a sharp and prominent ledge compared to the diffuse edges of the sulfates above and below it. In larger areal exposures of the marker bed, we can identify 2-3 possible layers within it (Fig. 2). Erosion of the upper brownish material can expose either lower darker material or reddish materials. In Fig. 2, fractures are visible where the overlying brownish material has been removed. Fresh impact craters are retained better on the marker bed relative to the more blocky and loose nature of the sulfates (Fig. 2). Eolian ripples are also commonly observed on the marker bed.

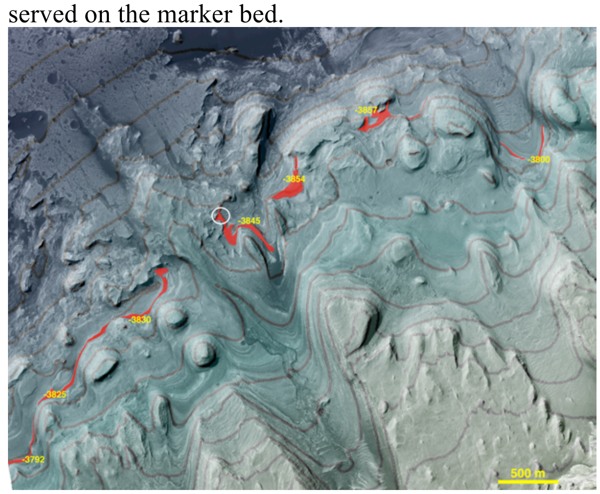

**Figure 1.** HiRISE image of northwestern Aeolis Mons with topography overlain in color and 50 m contour lines drawn. The marker bed is outlined in red and elevations of the bed are listed next to each outcrop. The white circle shows the approximate location where Curiosity is expected to reach the marker bed during the extended mission.

Utilizing DTMs, we measured surface slopes along the marker bed that range from 1-3° compared to 8-10° surface slopes for the sulfates above and below it (Figure 3). Elevations of the marker bed along northern Aoelis Mons vary from -3863 meters in the northeast to -3783 meters in the northwest. From two HiRISE DTMs that cover the northwestern section of Aeolis Mons, we measured strike and dips of the marker bed and several sulfate beds using the method of [3]. The sulfate beds and some portions of the marker bed have dip directions to the northwest with dips between 3-7° consistent with values measured by [4,5]. However, we also measured marker bed dip directions to the northeast with values between 2-8° that are perpendicular to the surface slopes and consistent with 3-4° northeast dips reported by [6] for the lower eastern flank of Aeolis Mons.

CRISM images and spectra were also analyzed for the marker bed and nearby sulfates. Fig. 4 shows a CRISM spectral parameter image in color merged to HiRISE images. The marker bed appears dark blue in color due to the presence of high calcium pyroxene.

Other locations with a similar blue color have darker eolian sands collecting on surfaces as seen in HiRISE images. Spectra extracted from the marker bed exhibit features consistent with sands composed of high calcium pyroxene.

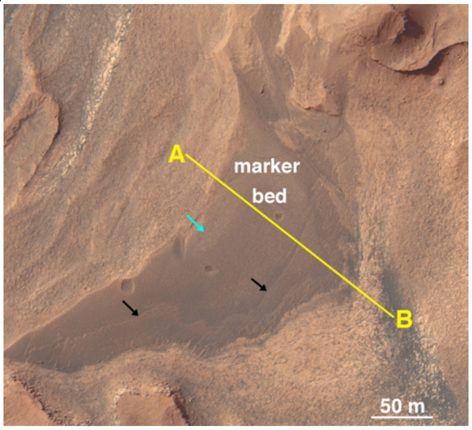


**Figure 2.** HiRISE enhanced color image showing an exposure of the marker bed in NW Aeolis Mons. Black arrows identify layering and the blue arrow shows fractures along the base of the marker bed. Yellow line identifies the topographic profile given in Fig. 3.

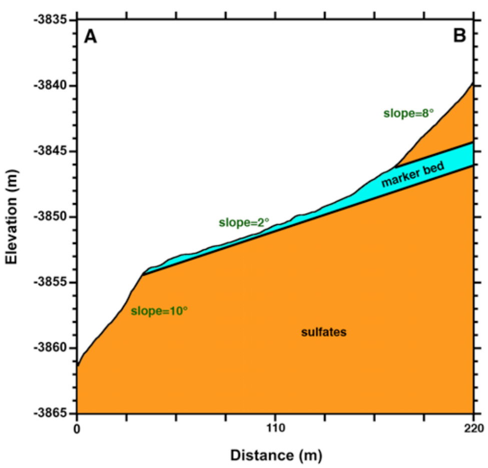


**Figure 3.** Topographic profile taken across the marker bed given in Fig. 2. The surface slope across the marker bed is only 2° compared to the 8-10° surface slopes for the sulfates above and below it. V.E. is 7.3X.

**Discussion:** We speculate that eolian basaltic sand, dust, and talus derived from eroded sulfates is collecting on the smooth, flatter marker bed surface, giving it a darker, brownish appearance relative to the adjacent brighter and redder sulfates. CRISM data show a composition similar to soils and eolian sands, consistent with the bed being covered by a thin regolith. Variable amounts of eolian sand, dust, and talus can explain heterogeneities in the appearance of the marker bed, such as whether it appears brown, red, or black.

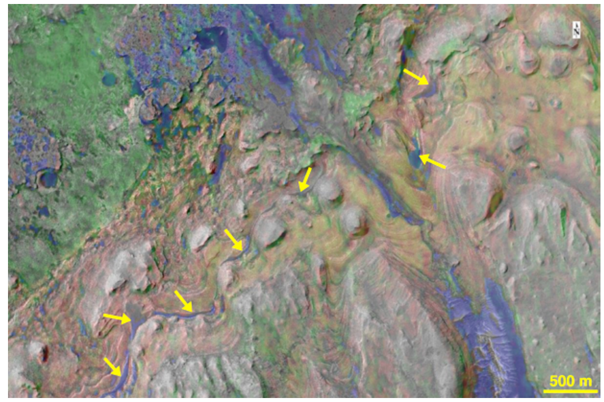


**Figure 4.** CRISM spectral parameters in color (R=SINDEX2, G=BD1900R2, B= HCPINDEX) overlain on HiRISE images. The marker bed (yellow arrows) appears dark blue in color, similar to other locations where dark eolian sand and debris is collecting on surfaces. CRISM image FRTB6F1.

Our observations indicate the marker bed is a more indurated material relative to the sulfates that underlie and overlie it. Layers seen in the marker bed and the conformity of the marker bed to the overlying and underlying sulfate beds indicate it was deposited as part of the same sequence that laid down the sulfates, rather than as a younger unit that intruded into the pre-existing strata, such as a volcanic sill. The marker bed could be more lithified sulfates that are more resistant to erosion relative to the other sulfates. Why this bed is stronger relative to the other sulfates is unknown, but it could have experienced increased cementation and/or diagenetic episodes analogous to the more resistant Vera Rubin Ridge, which is part of the Murray formation within Aeolis Mons [7,8].

**Predictions for Curiosity's exploration of the marker bed**: We predict the marker bed is an indurated sulfate material that has a thin regolith of variable eolian sand, dust, and talus along its flat surface. Although the root cause of the marker bed's higher strength relative to the sulfates above and below it remains unclear, data to be collected by the Curiosity rover could determine if factors such as grain size, composition, diagenesis, and(or) cementation caused the enhanced induration.

**References:** [1] Milliken, R.E. et al. (2010) *GRL, 37*, doi:10.1029/2009GL041870. [2] Rudolph, A. et al. (2019) *9th Intern. Conf. Mars*, Abstract 6358. [3] Kneissl, T. et al. (2010) 41st *LPSC*, Abstract 1640. [4] Stack, K.M. et al. (2013) *JGR 118*, 1323-1349. [5] Kite, E.S. et al. (2016) *JGR 121*, 2282-2324. [6] Lewis, K.W. and O. Aharonson (2014) JGR, 10.1002/2013JE004404. [7] Edgar, L. et al. (2018) *49th LPSC*, Abstract 1704. [8] Fraeman, A.A. et al (2020) *JGR, in review*.