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IMPLICATIONS OF THE LOCAL TOPOGRAPHY OF THE MARKER BAND CONTACT, GALE CRATER

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Introduction: Satellite-based investigations of Mt. Sharp stratigraphy in Gale Crater show a unit with distinctive tonal and erosional expression that can be traced in extended outcrops at several locations along the mountain's southern, western, and northern margins [1, 2, 3]. Slopes measured on the exposed outcrop suggested a radial deposition pattern in the construction of Mt. Sharp, with important implications for formation mechanisms and spatial extent of mountain construction (2). Alternatively, the slopes have been proposed to be due to differential compaction of initially near-horizontal layers [4]. The distinct character of the unit, referred to as the Marker Bed (now labelled the Marker Band), has motivated various theories for its origin (recently summarized in [3]), ranging from better induration due to arid depositional setting, to its being a volcanic ash.

By Sol 3351, the Curiosity rover approached an area with multiple exposures, now known as Marker Band valley (Fig. 1), which enabled the first close observations of the Marker Band. Observations of the Marker Band and several associated units continue and are presented in multiple 2023 LPSC abstracts. Our report is based on examination of over 20 Curiosity ChemCam Long Distance Remote Micro Images and Mastcam images.

Marker Band outcrop, basal contact, and alteration zone beneath the contact: Observations of the surrounding valley walls show the band to be thin (< 50 cm), and upon close inspection to consist of two primary units: (1) a wavy laminated basal unit (15-20 cm thick) that shows wave ripples on its upper surface, overlain by (2) a rhythmically laminated upper unit (Fig. 2 and 3). The latter unit typically is about 30 cm thick, but can be more variable in thickness.

Fig. 2 shows the Marker Band and its two sub-units that crop out as separate lines of blocks. The ribbed surface of blocks displaced downslope is due to wave ripples. The bench to the left (west) of the outcrop is underlain by the upper laminated unit, although just to the south the rippled unit underlies the local shelf expression of the Marker Bed. The beds appear to dip into the outcrop. The basal contact of the Marker Band with underlying bedrock is covered by loose debris.

In Fig. 3 (upper image, Site E of Figure 1), the thin Marker Band sticks out from the outcrop, but no shelf has formed on this west facing side of Orinoco. The

stretched image highlights the light toned alteration band just below the contact. The lower image of Fig. 3 shows the north facing side of Bolivar (site D in Figure 1) where the distinct Marker band layers are missing. Yet, a sharp boundary can still be traced continuously from the eastern edge of Bolivar (site C in Fig. 1), where the Marker Band is present. All along the north facing side of Bolivar, there is a distinct alteration zone directly below this contact, as shown in Fig. 4.

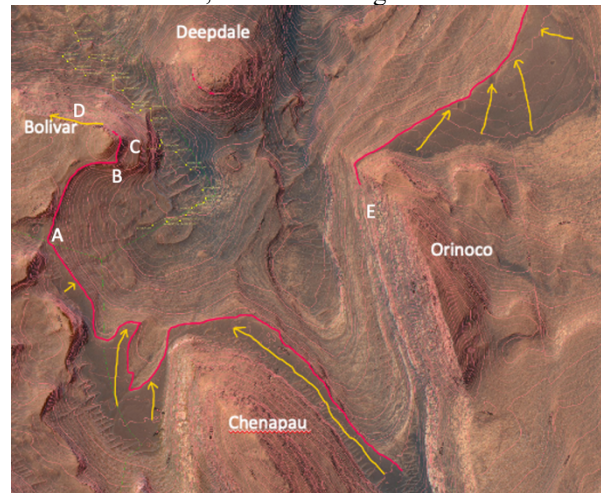


Figure 1: 1 m contour interval map of the Marker Band valley. The red lines delineate the exposure of the Marker Band. Yellow arrows show the local slope of the base of the Marker Band

Fig. 4 shows two vertical profiles across the basal contact and the Marker Band. The wavy bedding in the basal unit is most likely correlated to the ripple layer observed at A (Fig. 1). The rhythmic laminated upper unit is better developed at B (Fig. 1), where the total thickness of the two units is about 50 cm. At both sites (B & C), as well as at site E, the basal contact of the Marker Band is sharp and immediately underlain by a bleached alteration zone, about 50 cm thick. Other images of site C suggest that the Marker Band layers may dip towards the west rather than downslope.

Topography of the basal contact: The consistently thin layering of the Marker Band in outcrops suggest that where the band outcrops in the characteristic shelf form, the slope of the shelf is a good proxy for the slope of the basal contact. Fig. 1 shows with yellow arrows the topographic pattern generated by tracing lines

perpendicular to the local 1 m contours of the Marker Band surface. In addition, the basal contact along the north face of Bolivar is also shown in yellow. The arrows suggest a bowl shape to the east of Orinoco. Slopes along the yellow arrows are 2 to nearly 4 degrees, except along the northern face of Bolivar where the slope is 8 degrees to the west. Sites A and C (both exposing ripple layers) are the same elevation, but site C is higher than B (Fig. 1). The Deepdale contact sits 5 m higher than the corresponding contact at Bolivar, representing a slope to the west of 2 degrees, and is 5 m higher than the northern tip of Chenapau (equal to a slope of 1 degree to the South). The contacts at Deepdale and the northern tip of Orinoco are the same elevation over a 200 m distance.



Figure 2. Exposure of the Marker Band where the rover crossed it (tracks visible in left corner). Credits: NASA/JPL-Caltech/MSSS:Sol_03684_ML_103274

These observations indicate that the basal contact topography between Deepdale, Orinoco, Chenapau and Bolivar forms a shallow bowl shape. This geometry is suggestive of a localized depression that contained a shallow lake where wave action produced the observed ripple bedding. The Marker Band sediments may thus have accumulated in scattered smaller water bodies and as such may not have required a lake filling a large portion of Gale crater. The lateral continuity of the observed rippled layers (>130m), however, strongly suggests standing bodies of liquid water larger than those previously inferred from Curiosity observations of the Prow [5]. Alternatively, the observed topography may be the result of differential compaction [4]. Significant variability in local Marker Band dip has been noted elsewhere [3]. To the immediate west, undulating highs and lows also are detectable in the Marker Band unit. Further detailed mapping of the wavy rippled unit will be used to help assess the origin of the topographic variability.

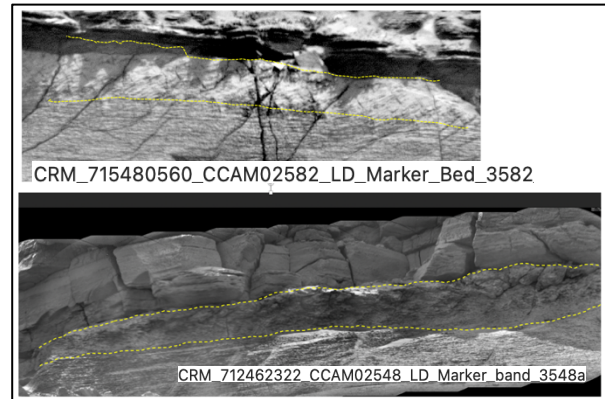


Figure 3. Examples of the Marker Band and its contact with exposure of the underlying strata. The images are from the base of Orinoco (E in Fig. 1: CRM_715480560_CCAM02582_LD_Marker_Bed_3582) and the north facing side of Bolivar (D). Dashed yellow lines mark the alteration zone beneath the basal contact.

The extensive outcrop of the Marker Band along Mt. Sharp may record a common basal erosional contact, and conditions favoring localized lake formation elsewhere, or may indicate wet conditions contributing to cementation of sediment and generation of erosional resistance. The occurrence of the alteration zone where the Marker Band is absent raises the possibility that the alteration predates the Marker Band.

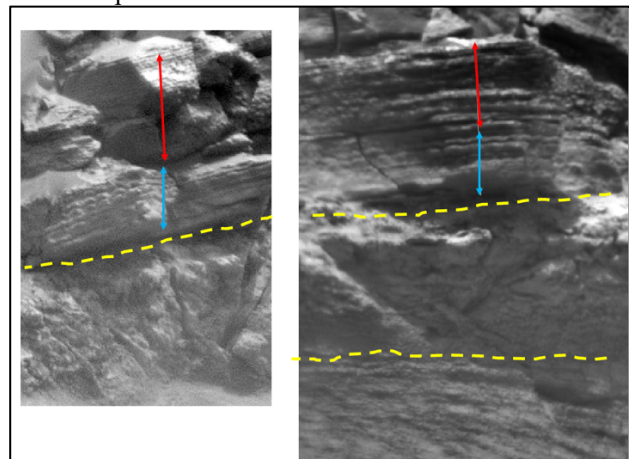


Figure 4: The two images show locations B (left) and C (right) in Figure 1, on the south and east facing side of Bolivar. Blue arrow indicates basal unit with wavy laminations (ripples). Red arrow shows the rhythmic laminated upper unit. Total thickness ~ 50 cm. Dashed yellow line marks the basal contact of the Marker Band and in the right image also the base of the alteration zone beneath the contact at location C.

References: [1] Milliken R.E. et al. (2011) *Geophy Res Let* [2] Kite, E. S. et al. (2013) *Geology*, 41 (543-546). [3] Weitz, C. M. et al. (2022), *JGR Planets*. [4] Grotzinger, J. et al. (2015), *Science*, [5] Gupta, S., et al. (2022) *EPSC*.