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THE SEDIMENTOLOGY AND STRATIGRAPHY OF TEXOLI BUTTE: CURIOSITY'S INVESTIGATION INTO THE SULFATE-BEARING UNIT OF MOUNT SHARP, GALE CRATER, MARS

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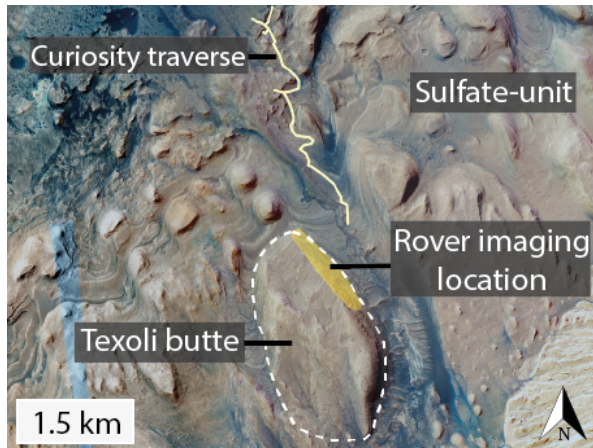


Fig. 1 – Location of Texoli butte in Gale crater. HiRISE colour mosaic; Credit: Fred Calef.

Introduction: The sulfate-bearing unit of Aeolis Mons (Mount Sharp) in Gale crater is currently being investigated by NASA's Mars Science Laboratory (MSL) Curiosity rover [1] (Fig. 1). The transition from the phyllosilicate-bearing strata of lower Mount Sharp to the overlying sulfate-bearing unit has been a key part of Curiosity's exploration in Gale crater. Investigations of Aeolis Palus and Aeolis Mons showed a once habitable environment existed, with lacustrine and fluvial deposits recording a prolonged aqueous palaeo-environment [2-5]. The sulfate-bearing unit was identified from orbit as likely recording a more arid palaeo-environment [6] and Curiosity's investigation here so far has indicated that the palaeo-climate was likely more complex than a linear drying regime [7-11].

Texoli butte (Fig. 2) lies within the sulfate-bearing unit of Gale crater between -3680 to -3530 m making up the western wall of Gediz Vallis. Here, we aim to investigate the sedimentology and stratigraphy of the Texoli butte in order to further decipher the palaeo-environment of the sulfate-bearing unit at Gale crater.

Data and Methods: High Resolution Imaging Science Experiment (HiRISE) [12] orbital data were used to map the spatial extent of surfaces identified in Texoli. Within the ongoing Curiosity imaging campaign, the Mastcam [13] and ChemCam [14] instruments are utilised for attaining high-resolution imagery of Texoli from ~2.5 km to 510 m distance (~50-10.2 mm/px). We compare our long-distance observations to nearfield sedimentary rocks observed from Curiosity and to examples on Earth [9, 11, 15]. These studies aid our inference of the geology of Texoli butte that currently lacks near-field observations.

Stratigraphic Architecture and Facies Associations: We identify 15 stratigraphic units within Texoli butte (Table 1) spanning ~150 m of stratigraphy. Units are defined by changes in facies associations and the occurrence of large-scale erosional surfaces. We have defined 4 facies within the scarped cliff-faces of Texoli butte [Fig. 3], allowing us to delineate the stratigraphic architecture (Table 1).

1. *Planar:* The planar bedded facies (Fig. 3.1) are identified by parallel, laterally extensive bedding surfaces comprised of consistent, alternating, resistant-recessive beds that range from 3.2 cm – 36.4 cm in thickness. We believe this unit could represent the migration of sandsheets as has been well described in previous research [9, 16-17].

2. *Wavy-Planar:* The wavy-planar facies (Fig. 3.2) are found exclusively atop erosional surfaces (discussed below). The wavy-planar beds range from 2.3 cm – 9.5 cm in thickness. The bedding infills troughs formed by the erosional surfaces often creating distinct lenticular features. The bedding is observed to downlap onto the basal erosional surface and has occasional internals irregularities and internal truncations likely owing to the irregularity of the basal surface. Wavy bedding has been associated with the migration of sandsheets [16-17] and interdune environments [18].

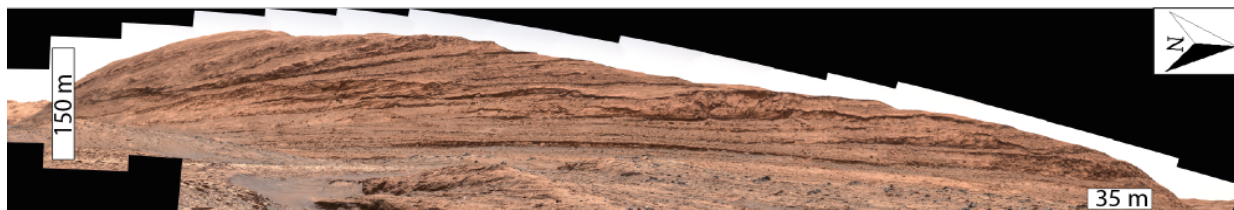


Fig. 2 –Texoli butte imaged from MSL Curiosity rover. Mastcam mosaic: NASA/JPL-Caltech/MSSS – Sol 4111.

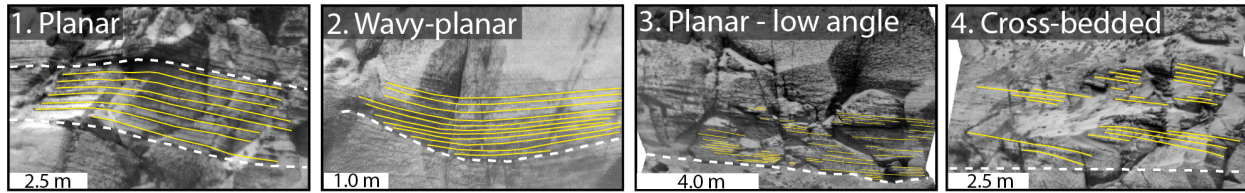


Fig. 3 – The four facies identified in Texoli butte, discussed in-text. Yellow lines denote bedding. White dashed lines are bounding surfaces. ChemCam LD RMIs: NASA/JPL-Caltech/IRAP

3. *Planar to low-angle cross stratification*: Bed sets exhibit horizontal to low-angle cross stratification (Fig 3.3). The laterally extensive beds range in thickness from 1.8 cm – 24.8 cm. Bedding often diffuses vertically into more massive appearing units where subtle bedding structures are present and are likely not observed throughout due to resolution, lighting, or possibly diagenetic overprinting of the primary bedding structures [18]. This unit may also represent migration of sandsheets [9, 16-17] or proto-dune formation [19].

4. *Cross-bedding*: Cross-sets have been measured to range from 4.5 cm to 30.2 cm and often display complex internal geometries (Fig 3.4). Smaller internal stratifications within the bed-sets range from 2.0 cm - 11.7 cm, suggesting there are multiple orders of cross-sets. We interpret the cross-bedded units to represent the migration of sand dunes.

Erosional Surfaces: Throughout the stratigraphy, we note the presence of at least 8 large-scale, laterally continuous erosional surfaces. There appear to be two types of erosional surface identified: 1) irregular, undulating surfaces (Fig. 4) that truncate up to 4 m of underlying strata, and 2) more planar surfaces in which there is less truncation of the underlying strata. The possible origin of these surfaces includes aeolian deflation, flooding, and dune/interdune migration [11, 20-21]. The erosional surfaces contain multiple generations of deeper scours (Fig. 3.2) both laterally and vertically that could represent multi-storey fluvial channels [22]. The lenticular nature of the scours is also suggestive of a fluvial origin however there is a lack of clear fluvial deposits observed within the scours. The wavy-bedding infilling the scours downlaps onto the basal erosional surface at a planar-low angle (Fig. 3.2). In places the scours can be observed to pinch out and truncate neighbouring scours. Prior research within the stratigraphy below Texoli has identified smaller scours that have been interpreted as aeolian scour-and-fill structures [11] and the Texoli scours may also have a similar origin.

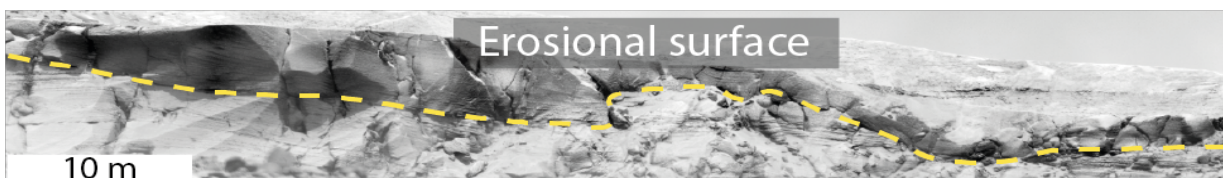


Fig. 4 – An irregular erosional surface in Texoli butte. ChemCam LD RMI Sol 4043: NASA/JPL-Caltech/IRAP

Preliminary Interpretations: The stratigraphic architecture of Texoli is dominated by strata inferred to be aeolian in origin interspersed with extensive erosional surfaces. The observations of cross-beds and more planar strata are interpreted here as fluctuations between arid dune environments and sandsheet and/or interdune environments [9-11, 16-19] suggesting Texoli represents a largely aeolian environment. The erosional surfaces suggest deposition was discontinuous, possibly owing to a change in palaeo-climate leading to aeolian deflation, or a cessation in sediment flux. The analysis of the morphology and infill of generations of scours within these erosional surfaces can provide insight on the conditions during and post- erosional surface formation.

References: [1] Grotzinger et al. (2012) *Space Sci. Reviews* 1, 5-56. [2] Williams et al., (2013) *Science* 340, 1068-1072. [3] Grotzinger et al., (2014) *Science* 343(6169). [4] Grotzinger et al., (2015) *Science* 350(6257). [5] Bennett et al., (2022) *JGR: Planets* 128(1). [6] Milliken (2010) *Geo Res. Letters*. 37, 4. [7] Rapin et al., (2021) *Geology*. 49, 842-846. [8] Gupta et al., (2023) *LPSC*: 2707. [9] Roberts et al., (2023) *LPSC*: 2945. [10] Edgar et al., (2024) *LPSC*: 1016. [11] Roberts et al., (2024), Mars10. [12] McEwen et al., (2007) *JGR: Planets*. 112, E5. [13] Malin et al., (2017) *Earth & Space Sci.* 4, 506-539. [14] Maurice et al., (2012) *Space Sci. Rev.* 170, 95-166. [15] Gross et al., (2023) *Sedimentology*. 70, 145-178. [16] Kocurek & Nielson (1986) *Sedimentology*. 33, 795-816. [17] Fryberger et al., (1979) *J. of Sed. Res.* 49, 733-746. [18] Grotzinger et al., (2005) *Earth & Plan. Sci. Letters*. 240, 11-72. [19] Phillips et al., (2019) *Aeolian Res.* 36, 9-26. [20] Langford & Chan (1988) *GSA Bulletin*. 100, 1541-1549. [21] Fryberger (1993) *Geol. Soc. Spec. Pub.* 73, 167-197. [22] Gibling (2006) *J. of Sed. Res.* 76, 731-770.