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CLIMATE AND DIAGENETIC IMPLICATIONS OF POSSIBLE SOFT SEDIMENT DEFORMATION OF THE BASAL AEOLIAN STIMSON SEDIMENTS IN GALE CRATER

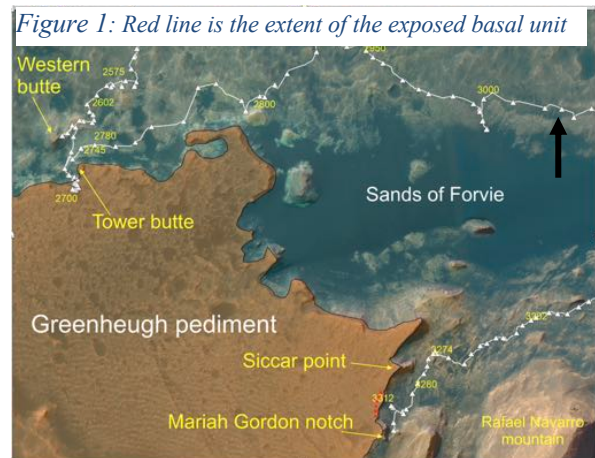
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Introduction: The accumulated sediments and erosional unconformities in the deposits of Mt. Sharp of Gale Crater record multiple periods of wet and dry cycles similar to the episodic climate aridification and later brief wet periods found across Mars [1]. Early post impact (~3.6 billion), an extended period of lacustrine conditions prevailed, leading to over 300 m of lake sediments exposed at the base of Mt. Sharp [2]. This was followed by eolian sediment accumulation perhaps with fluvial deposition interludes [3]. Accumulation ceased and extensive wind erosion shaped Mt. Sharp to nearly its present topography. This erosional event is recorded as the Siccar Point unconformity, which is preserved under a “mound skirting unit”, which locally has been documented to be the remnants of an extensive, large-scale dune field – the Stimson formation [4].

The Stimson formation and the Siccar Point unconformity are predominantly exposed along the Greenheugh pediment, a planar sloping topographic feature that lies downslope of Gediz Vallis [5]. Overlying the Stimson formation on the Greenheugh pediment is the remnant of a fan deposit [5] that may have advanced into transient deep lakes in Gale crater that postdated Stimson fm. deposition [6].

Investigation of the northern exposure of this pediment revealed that the sediments underlying the Siccar Point unconformity (the Carolyn Shoemaker formation) had undergone extensive diagenetic alteration. Nodular alteration was also noted in the basal sediments of the Stimson. These water-driven alterations led to hypotheses about the source and pathways of water which included the possibility that groundwater (derived from runoff from Mt. Sharp) may have developed in the overlying Stimson on the much less permeable fine-grained underlying lake sediments [7].

Here we report that along a southern exposure of the pediment, 0.9 km upslope from the northern area previously investigated (Tower butte area), a discontinuous thin massive unit lies at the boundary between the distinctive eolian dune bedding of Stimson and the underlying strongly diagenetically altered Carolyn Shoemaker formation. We propose that this unit is a result of soft-sediment deformation, a condition favored by groundwater saturation of this basal unit, and possibly driven by impact events before lithification of the Stimson.



Basal unit description: The Stimson exposed to the north of Siccar point is described in (Banham et al., 2022). Fig. 1 shows the ~90 m extent where the basal unit is present. South of Mariah Gordon notch the Stimson cap is thin and poorly-exposed. The basal unit lies directly on the underlying Carolyn Shoemaker and has a sharp boundary with the overlying cross-bedded Stimson (CBS) (Fig 2). The basal unit has the same blue-grey color of the CBS, but can be locally massive, or rough in appearance with some wind etched cavities. In some locations, deformed laminations can be observed. Locally some CBS contacts have an inverted “V” or pyramidal shape (Fig. 2). The overlying CBS in one outcrop may be deformed (Fig. 2 B). Unlike the underlying unit, no large-scale vein networks are visible. In some locations, vertical faces in the CBS are covered by a surface coating that extends upward from the basal unit and in one large crack the film thickens and can be seen on both sides of the open crack (Fig. 2 C).

Boulder contact. The rover drove to boulders shed from the retreating pediment cliff that revealed many blocks with preserved CBS-basal unit contact and enabled close imaging and chemical analysis. The basal unit is sandy like that of CBS, contains some relict bedding at variable orientations, and may have small veins crossing it. APXS and Chemcam analysis of the CBS and basal massive unit in one block showed them to be chemically identical to the Stimson formation.

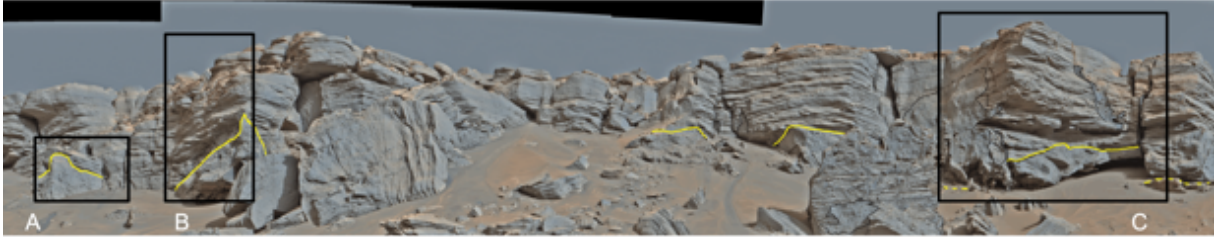
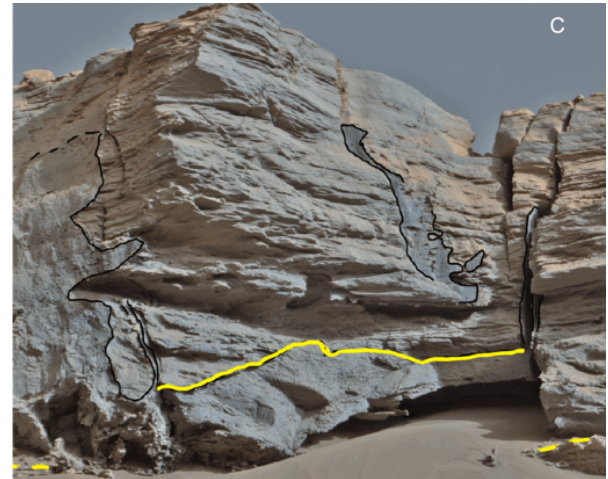


Fig. 2: Solid yellow lines: Stimson- basal unit contact; dashed line the exposed contact with the Carolyn Shoemaker. Cliff is ~ 2m high, basal unit is ~ 30 cm thick; *Mastcam mosaics processed by the Mastcam team at Malin Space Science Systems*



Origin of the basal unit: The similarity in color, grain size, presence of relict bedding, and identical composition as the overlying CBS strongly indicates that the basal unit is deformed CBS. The local

pyramidal shape contact, the possible deformation of the mantling CBS, the massive texture of the basal unit, and the apparent upward extension from the basal unit of a film along cracks in the CBS all suggest that the basal unit is the result of soft-sediment deformation.



Soft-sediment deformation likely requires groundwater and may occur during active dune migration [8]. This is the only location we have observed this unit and it is patchy in occurrence. Given its location on Mars, we suggest that a local meteorite impact could have generated this local and modest in scale deformation event. There are some parallels to the proposed earthquake-induced features documented in the Navajo Sandstone [8].

This interpretation adds support to proposals that that groundwater was present in the basal Stimson [7] before full lithification and possibly before the onset of alluvial fan burial and lake formation [6]. These waters would have contributed to Stimson and possibly underlying bedrock diagenesis.

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