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THE STIMSON FORMATION AT THE GREENHEUGH PEDIMENT: STRATIGRAPHY, ARCHITECTURE, AND CORRELATION. S.G. Banham^{1*}, C.C. Bedford², S. Gupta¹, A.L. Roberts¹, W.E. Dietrich³, A.B. Bryk³, D.M. Rubin⁴, J.P. Grotzinger⁵, Aaron Weintraub⁶, C.H. House⁷, G. Caravaca⁸, R.M.E. Williams⁹, L.C. Kah¹⁰, and A.R. Vasavada¹¹, ¹Imperial College London (*s.banham@imperial.ac.uk), ²LPI, URSA, ³University of California Berkeley, ⁴University of California Santa-Cruz, ⁵California Institute of Technology, Pasadena, CA, ⁶Northern Arizona University, ⁷ Pennsylvania State University, University Park, PA. ⁸IRAP, Univ. Paul Sabatier Toulouse, France, ⁹PSI, Tucson, AZ, USA, ¹⁰University of Tennessee Knoxville, Knoxville, TN, USA ¹¹Jet Propulsion Laboratory, Caltech, Pasadena, CA.

Introduction: The Stimson formation, Gale crater represents the preserved expression of a major dune field which coalesced on the eroded flank of Mount Sharp [1-3]. This unit, which records spatial and temporal relations between interacting dunes can be used to gain insight into aeolian processes, interactions, and dune field construction processes on other planetary bodies. Here, the current understanding (as of spring 2022) of the Stimson formation at the Greenheugh pediment is summarized.

Stratigraphic architecture: Across the Greenheugh pediment, the Stimson formation forms a relatively thin capping unit that ranges between ~2-10 m in thickness. Here, and uniquely for the Stimson, the formation can be subdivided into three stratigraphically distinct intervals. This is based on sedimentary architecture and cross-bed dip-azimuth orientations observed near Tower butte. In stratigraphic order: the Gleann Beag; the Ladder; and the Edinburgh intervals. At present, these stratigraphic subdivisions have not been correlated to the east side of the pediment (adjacent to Mariah Gordon notch). Some outcrops on the east side of the pediment contain attributes which could indicate that a correlation is possible: such as south-dipping planar cross sets, and northeasterly dipping compound cross-sets.

Sedimentary architecture: Three architecturally distinct types of cross-strata were observed in the study area, which are interpreted to arise by migration of morphologically distinct dunes:

Compound cross-bedding, characterized by an angular divergence between cross-lamination and associated

sub-set bounding surface dip-azimuths [4] were observed at Tower butte, and in the basal Gleann Beag interval (Fig. 1). Here, cross-laminations in sets 0.3-0.8m thick dip toward the northeast. These sets are bounded by subset-surfaces that dip toward the northwest. This architectural arrangement suggests these compound cross-sets were generated by oblique migration of superimposed dunes across larger primary dunes, similar to those observed at the Murray buttes [3]. Compound cross-sets have been identified at the Blackcraig outcrop on the east of the pediment, just above the basal unconformity. This is at the same stratigraphic position as those observed at Tower butte.

Planar cross-bedding, characterized by planar cross-laminations parallel to their subset-bounding surfaces [5] were observed in the Edinburgh interval (Fig. 2). Here, a planform section through the cross-set was observed, where cross-laminations can be traced for laterally for >35 m. The Edinburgh interval contain interstratified, alternating packages of windripple laminations, avalanche and grainfall strata. These are interpreted to represent cyclic cross-bedding: subset-bounding surfaces are interpreted to be reactivation surfaces [5], indicating fluctuating flow [6] or autocyclic processes [7]. The planar nature of the cross-sets are interpreted to arise from bimodal sediment transport – with a major and subordinate transport direction – which resulted in the straightening of the dune crestline [8]. At the Auchinleck outcrop (east pediment), apparently planar cross-sets have been observed.

Simple cross-bedding, characterised by trough cross-laminations were observed on the top section of the

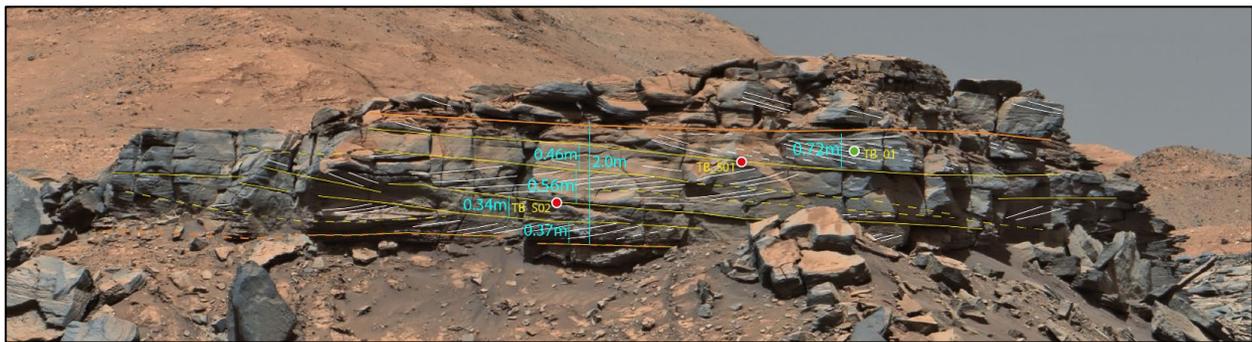


Figure 1. Compound cross-strata (Tower butte). Orange lines: interdune surfaces. Yellow lines: subset bounding surfaces. White: cross-laminations

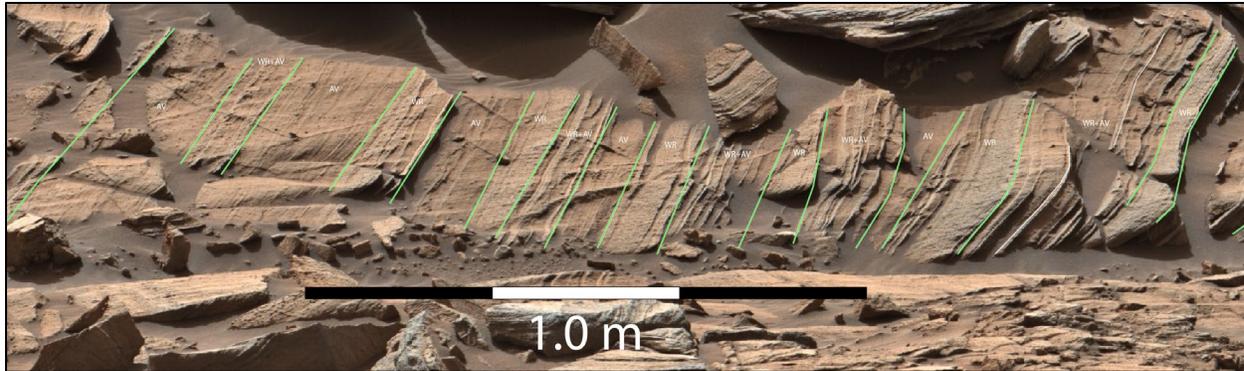


Figure 2. Planar cross-bedding (Edinburgh Interval), containing interstratified windripple, avalanche and grain fall strata.

pediment. The dip-azimuth of these cross-sets are oriented west. These are interpreted to represent simple sinuous crested dunes, migrating toward the west.

Sediment transport direction: Sediment transport directions are well constrained in the north section of the pediment, for the identified intervals (Fig. 3). The Gleann Beag cross-lamination dip-azimuth is toward the northeast, with superposition surface dip-azimuth oriented north-northwest. This would suggest a sediment transport direction toward the north, or the north-northeast. For the planar cross-sets of the ladder interval, cross-lamination dip-azimuth is south-southwest. For the Edinburgh interval, dip azimuth of the simple trough cross-sets are oriented west.

Preliminary observations of cross-set dip-azimuths indicate a range of transport directions for the pediment on the east side. Currently, apparent dips toward the north have been identified at the Siccar Point and Blackcraig outcrops. At the Auchinleck outcrop, a section of outcrop with architectural similarities to the ladder section has been observed.

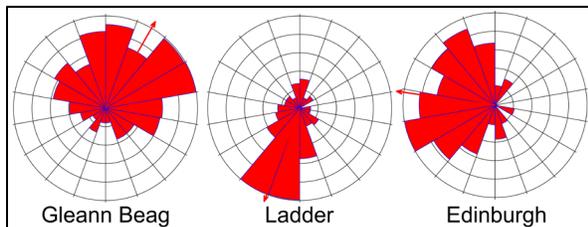


Figure 3. Rose diagrams depicting cross-lamination dip direction for each interval. Laminations.

Conclusions: The Stimson formation records a complex but incomplete record of shifting wind patterns and changing dune morphologies during the Hesperian period. Depending on the spatial and temporal location, compound dunes (Fig. 4A) in the erg centre [3] coexisted with simple dunes at the erg margin [1]. Temporal changes in wind pattern resulted in a shift of dune morphology to straight-crested simple dunes, generated by fluctuating flow: airflow normal to the crest generated avalanche and airfall strata, oblique airflow generated windripple strata (Fig. 4B).

ChemCam observations indicate that the north and east pediment outcrops share the same geochemical affinity [9], but despite sharing common depositional structure on both sides of the pediment, currently remain stratigraphically uncorrelated.

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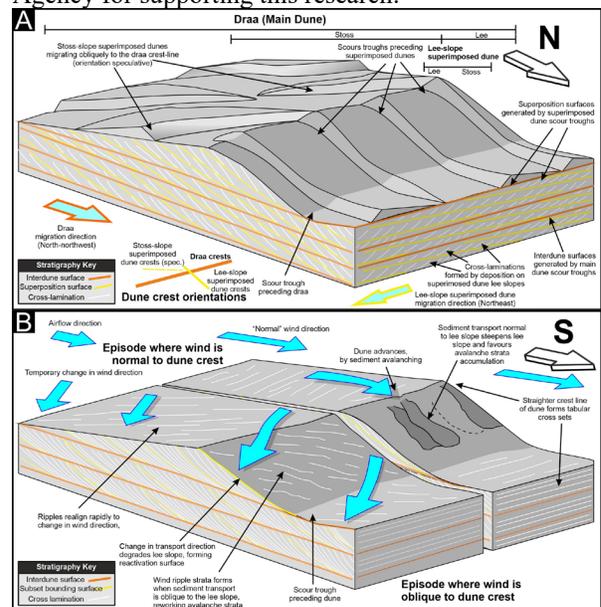


Figure 4. Depositional models for (A) compound dunes and (B) straight-crested dunes.

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