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## Episodic aqueous conditions punctuated dominantly aeolian deposition within the layered sulphate-bearing unit, Gale crater (Mars)

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The stratigraphy preserved within Aeolis Mons (Mount Sharp) in Gale crater (Mars) shows a major transition from mudstone-rich strata (with subordinate sandstones) recording deposition in lacustrine to fluvial settings into a major sulphate-bearing unit (the Layered Sulphate-bearing unit (LSu)) [1, 2]. This transition is interpreted to represent a major environmental change from wetter conditions toward a more arid palaeoclimate on early Mars. A stratigraphic section over this transition constructed along Curiosity's traverse shows a vertical change from mudstones with interstratified sandstones of the Glasgow and Mercou members of the Carolyn Shoemaker formation into strata of the Pontours member which have a strong diagenetic overprint, and thence into large-scale cross-stratified sandstones of the Mirador formation that are interpreted to be the deposits of large, migrating aeolian dunes. The lower section of the LSu is dominated by stacked, cross-bedded facies with variable diagenetic overprint, that likely records a purely dry aeolian dune environment [3]. However, higher up in the studied section, approximately 80 m above the base of the Mirador formation, there is a transition into a succession still dominated by large-scale cross-beds but with interstratified lenses of a different sandstone facies. The presence of these lenses within large-scale cross bedded rocks is denoted by a transition to the Contigo member of the Mirador formation.

Whilst a number of lenses are visible in the stratigraphy of the Contigo member in cliffs along

Curiosity's traverse, the Mars Science Laboratory science team selected one lens, informally named The Prow to investigate in detail. Here, we describe the sedimentology of The Prow at a range of scales using Navcam, Mastcam, ChemCam Remote Micro-Imager(RMI), and Mars Hand Lens Imager (MAHLI) images with a focus on characterizing sedimentary structures, their depositional process interpretation and comparison to Earth analogs. The 3D geometries of The Prow's sedimentary structures are analysed by [4].

The Prow was investigated during sols 3349 and 3379 in early 2022 and had been identified as a target of interest from long distance observations suggesting that it formed contrasting facies to surrounding rocks. The Prow is an ~18-m-long, ~0.5-1-m-thick lenticular sedimentary body that is interbedded with large-scale cross-stratified facies interpreted to be aeolian dune deposits. The nature of the lower contact of The Prow is unclear. The lens pinches out to the south.

The Prow shows a range of sedimentary structures suggestive of deposition under predominantly aqueous conditions. These structures differ from structures in surrounding bedrock indicating contrasting environmental conditions. The lowermost part of The Prow section appears to comprise decimetre-scale cross-beds indicative of deposition from subaqueous dune migration. The scale of these cross-beds is quite different from the large metres-scale trough cross-beds in rocks surrounding the lenses.

The upper sections of The Prow are dominated by cm-scale ripple structures well observed in cross-section. In particular, lenticular and flaser geometries are observed. Lenticular ripple forms with convex upper surfaces are common with concave lower surfaces where they overlie underlying ripple forms. The ripple forms occur vertically stacked and laterally offset. The individual lenses are commonly interconnected forming complex interwoven structures. The crests generally show rounded symmetric profiles. Locally, symmetric vertical accretion over ripple crests is observed implying rapid sediment aggradation. Many ripple forms do not appear to show internal lamination, although this may be due to a lack of grain size variation. In a few examples where internal lamination is observed, preserved foresets are suggestive of unidirectional flow.

RMI and MAHLI images reveal that ripple forms appear to have a finer-grained drape overlying ripple crests and extending into ripple troughs. MAHLI data confirm initial ChemCam observations and show that ripple cores comprise a sandstone and draping laminations are finer grained and likely below MAHLI-resolution (~60 microns). The drapes are provisionally interpreted as mud drapes formed from suspension fallout onto ripple topography during low energy quiescent episodes. The overall sedimentary geometry resembles flaser- to lenticular bedding common in Earth examples.

The symmetric form of many of the ripple structures with preservation of form sets is suggestive of formation by oscillatory flow by wave action. Locally, there is evidence of asymmetric accretion which is likely indicative of combined flow ripples. The presence of drapes of finer-grained material superimposed on coarser-grained ripple forms is interpreted to record episodes of higher-energy sand transport separated by recurrent intervals of low-energy conditions during which sand grains could not be mobilised. Wave and current activity caused bedload transport of sand constructing symmetric and asymmetric ripples. Between these episodes, there were quiescent periods where active flow ceased and finer-than-sand grains deposited out of suspension onto temporarily fossilised ripple forms. The preservation of stacked well-preserved ripple forms with crests intact suggests conditions of rapid deposition.

Locally, planar laminated beds with laterally continuous laminae are present; these may be interpreted as either wind-ripple laminations formed by aeolian transport or as upper flow regime plane beds.

The presence of mudstone-draped wave and current ripple forms in the upper section of The Prow is strongly indicative of deposition from aqueous flows and moreover suggests the existence of a likely aerially small, shallow standing body of water in which the sediments were deposited. We compare the observed structures to forms observed in 1 Ga lake deposits from the Diabaig Formation of the Torridon Group (NW Scotland).

We tentatively infer that The Prow and by inference the other lenses observed in the Contigo member may record the episodic interdune or scour-fill presence of transient small standing bodies of water in an otherwise dominantly dry aeolian dune-dominated environment. The vertical transition from the underlying Dunnidear and Port Logan members of the Mirador formation that are dominated purely by large-scale trough cross bedding indicative of dry aeolian conditions indicates a change to a more mixed environmental setting with episodic fluvial/lacustrine activity perhaps from transient snow-melt or precipitation events occurring in otherwise arid conditions. Lenses such as The Prow demonstrate fluvio-lacustrine intervals punctuated dominant aeolian environment in the layered sulphate-bearing unit.

References: [1] Milliken *et al.*, 2010, *Geophys. Res. Lett.* **37**, L04201; [2] Rapin *et al.*, 2021, *Geology* **49**; [3] Rapin *et al.*, 2022, *EPSC, this meeting*; [4] Caravaca *et al.*, 2022, *EPSC, this meeting*.