National Aeronautics and Space Administration

Aeolian processes on Mars: hypothesis testing with experiments and remote sensing

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Strategic Focus Area: Planetary Atmospheres and Geology

Objectives

The objective of the proposed work is to improve understanding of aeolian processes, climate, and environmental evolution on Mars by testing working hypotheses for the formation of transverse aeolian ridges (TARs) and periodic bedrock ridges (PBRs) using experimental methods and remote sensing data analysis.

Background

- Wind is a primary agent of both ancient and modern surface changes on the surface of Mars. Martian sediments deposited by wind record critical information about the timing and nature of past Martian climate.
- This research project focused on two enigmatic Martian aeolian sedimentary features: transverse aeolian ridges (TARs) and periodic bedrock ridges (PBRs). PBRs are likely significantly under-recognized on the martian surface.
- Terrestrial analogs have been proposed for both of these features, however none fully exhibit the characteristic features.
- An experimental effort to replicate PBR patterns, coupled with global and local surveys of PBR occurrences on Mars, offers important insights into the formation of these uniquely martian aeolian features.

Significance/Benefits to JPL and NASA

- This SURP project has made significant progress towards an understanding of the origin of aeolian features that were wholly unanticipated by traditional (i.e. Earth-based) geologic theory, allowing JPL to participate in fundamental questions of landscape evolution, sedimentation, and erosion.
- This project has provided JPL access to unique experimental wind tunnel facilities hosted at UCLA, with demonstrated success in creating Mars-relevant erosional surfaces in controlled laboratory settings.
- By expanding the geologic context of known PBR sites, this project has opened questions of PBR dependence on wind regime that can be uniquely tested by rover data.

Approach and Results

- PBR formation is not yet well-constrained, with two proposed mechanisms: either through a flow-separation model of self-reinforcing fluid vortices in the atmosphere, or through banded patterns of armoring from TARs in which inter-ridge spaces are subject to preferential erosion.
- Using the UCLA wind tunnel, we tested the hypothesis that TARs mediate PBR formation by armoring parts of a bedrock surface using a foam substrate and 3D-printed analog TAR bedforms fixed to the foam surface. Results showed that erosion by saltating sand was confined to inter-bedform space, consistent with geometries observed on Mars.
- We carried out an orbiter image-based study of periodic bedrock ridges in Gale crater, the field site of the MSL Curiosity rover, identifying more than 25 new fields of bedrock ridges, classified into 5 distinct morphotypes, within the central sedimentary mound of Gale crater (Figure 1).
- Ridges are often on the uppermost exposed surface of the bedrock, and cross-cut layering, consistent with an interpretation as erosional ridges caused by relatively recent aeolian abrasion.
- Ridge orientation varies widely, except those in the Mound Skirting Unit (MSU) . These ridges show remarkable consistency in E-W orientation around the base of the mound, indicating formation by dominant N-S transverse winds unaffected by mound or paleo-mound topography (Figure 2 and 3).

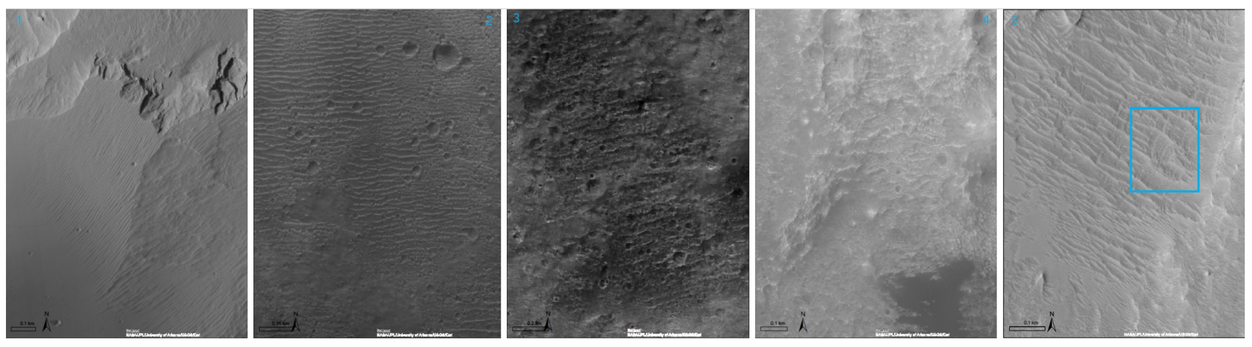

Figure 1. Five morphologic classes of bedrock ridges in Gale crater. Bedrock ridges in the MSU are of Types 2 and 3.

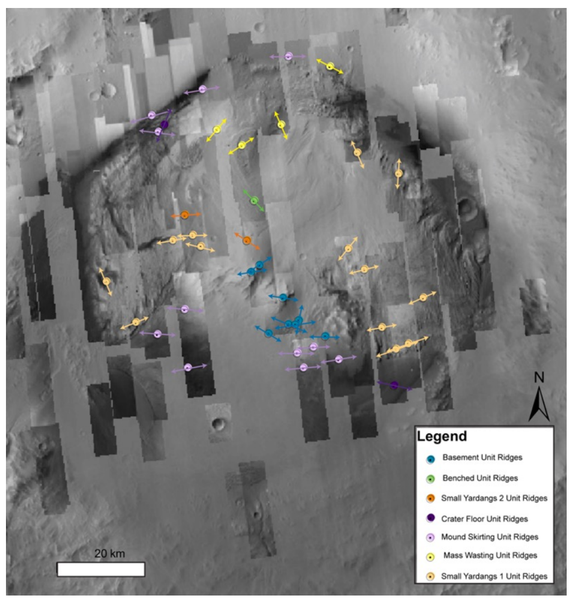

Figure 2. Average orientation for each bedrock ridge field in Gale crater

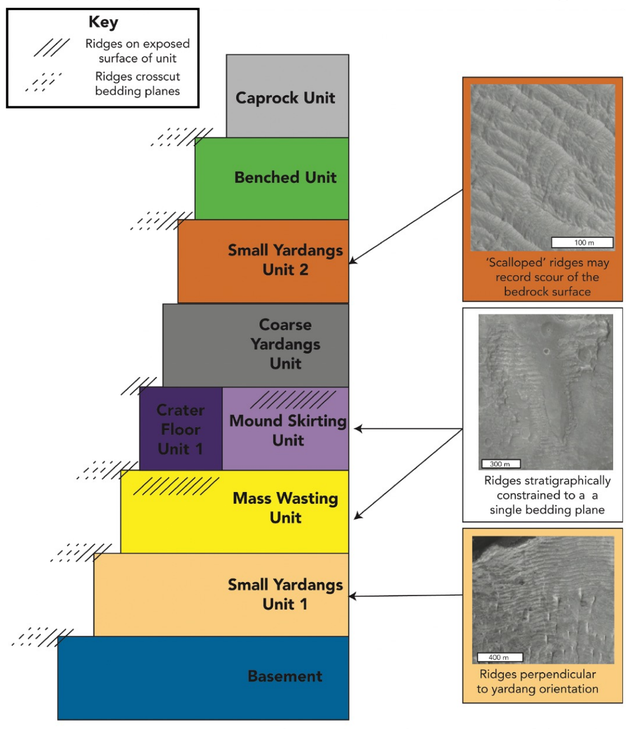

Figure 3. Stratigraphic distribution of bedrock ridges within geologic units of Gale crater.

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Publications:

[A] Jordan Bretzfelder et al., "Ridged Bedrock Terrain in Gale Crater, Mars," *GSA 2022*.
[B] Jordan Bretzfelder et al., "Bedrock Ridges in Gale Crater, Mars," submitted to *AGU 2022*.

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