National Aeronautics and Space Administration

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

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Program: FY21 SURP **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.

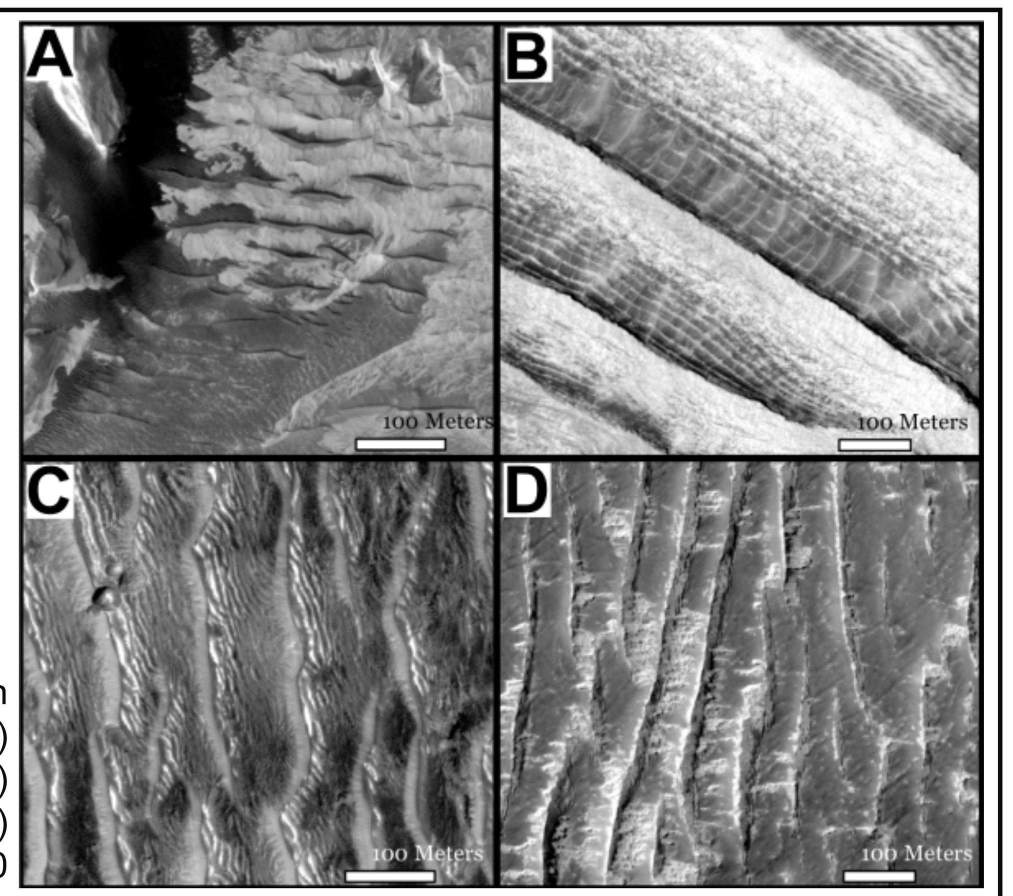

Figure 1. Examples TAR and PBR sites on Mars. (A) PSP_003806_1975, (B) ESP_024503_2015, (C) PSP_005887_1585, (D) ESP_019509_1530

Background

- Wind dominates the surface of Mars and is a primary agent of both ancient and modern surface changes.
- Martian sediments deposited by wind record critical information about the timing and nature of past Martian climate.
- This research project focused on two enigmatic and uniquely Martian aeolian sedimentary features: transverse aeolian ridges (TARs) and periodic bedrock ridges (PBRs) (Figure 1). 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 a global survey and characterization of candidate PBR occurrences on Mars, offers the potential for important insights into the environmental conditions and mechanics necessary to create these aeolian features.

Publications

Sneed, J.W. et al. (2020). Experimental Hypothesis Testing of the Origins of Periodic Bedrock Ridges. Sixth International Planetary Dunes Workshop. Virtual. Abstract 3040.

Sneed, J.W. et al. (2020). Large-Scale HiRISE Survey Demonstrates a Genetic Relationship Between Martian Periodic Bedrock Ridges and Transverse Aeolian Ridges. AGU Fall Meeting 2020. Virtual. Abstract EP018-0009.

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 used long-term abrasion conditions to reconstruct erosional patterns in low-density surfaces under high-velocity winds and sustained saltation by mm-scale quartz grains. Results of this work showed that in these conditions, sand erosion is dominated by wind-parallel effects (as in yardangs), disfavoring flow separation models of PBR formation.
- We continued the second year of a global-scale inventory of PBR sites, using the subset of orbital data with both CRISM and HiRISE ortho-pair coverage of the same surface region. 658 HiRISE images were analyzed, resulting in the discovery of 13 previously undocumented PBR sites (Figure 2).
- At each new site, we carried out a detailed characterization of both erosional and aeolian bedforms, including ridge length and spacing, overall area of PBR systems, and alignment and orientation of PBR and TARs (Figures 3). PBR orientation was assessed with respect to traditional indicators of dominant wind direction. Thermal inertia was estimated using both TES and THEMIS-derived thermal inertia models (Figure 4).
- This survey and detailed characterization significantly expanded the known attributes and geologic contexts of PBR systems. PBRs were found across a wide variety of elevations and atmospheric densities. Wavelength of PBRs was systematically greater than closely associated TARs (Figure 4).
- Of the 13 new sites, 12 were assessed for thermal inertia, with an upper range of ~450 t.i.u. suggesting soft, friable bedrock exposures.

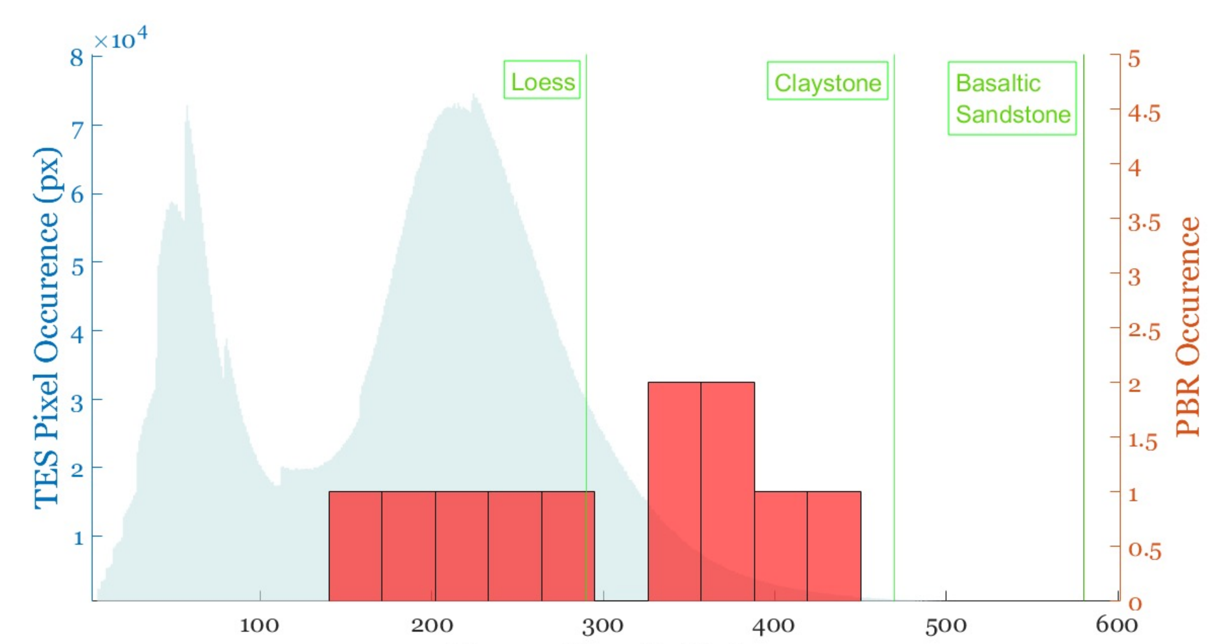

Figure 4. Thermal Inertia of PBR-bearing bedrock units (red histogram) is consistent with highly friable, easily eroded deposits.

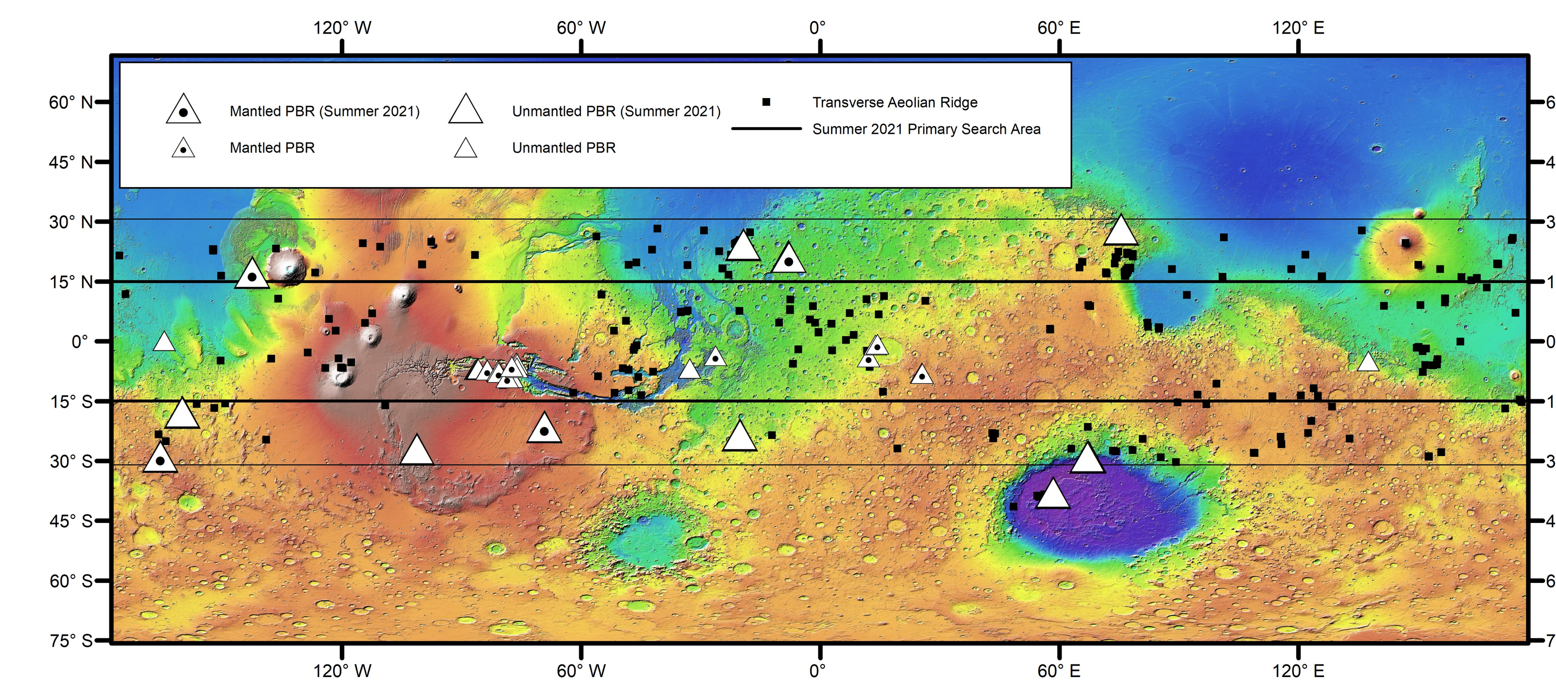

Figure 2. 13 additional PBRs (white triangles) were found during Year 2 between 15-30° N and 15-30° S or in the Hellas Basin region, with 4 of the 13 (black dots) displaying sediment mantling. The survey included all HiRISE orthopairs that intersected with CRISM products in the specified latitudes.

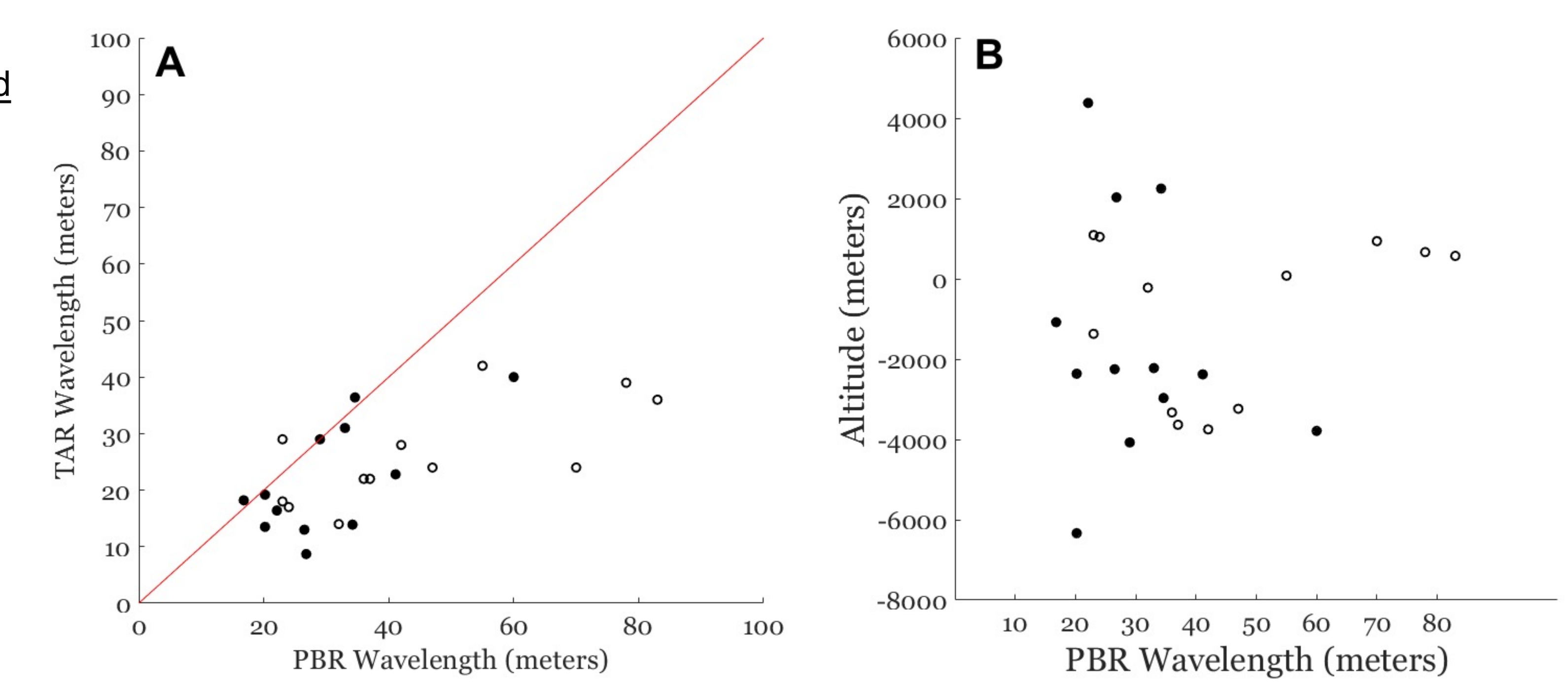

Figure 3. (A) Where PBR and TAR units are found in close proximity, PBR units wavelength is predicted to have a longer wavelength. **(B)** No correlation is seen between PBR wavelength and altitude across a range of ~10 km, suggesting that PBR wavelength is not dependent on the modern Martian atmospheric density. Open circles are units between 15° S and 15° N, filled circles are between 15° and 30° latitude, added during summer 2021.

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.

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