EXPERIMENTAL HYPOTHESIS TESTING OF THE ORIGINS OF PERIODIC BEDROCK RIDGES. J. W. Sneed[1*], M. D. Day[1], K. M. Stack[2], A. A. Fraeman[2], [1]UCLA department of Earth, Planetary, and Space Sciences (sneedjw@g.ucla.edu), [2]NASA Jet Propulsion Laboratory

Introduction: Periodic Bedrock Ridges (PBRs) are erosional surface features found on the modern wind-dominated surface of Mars. Transverse with respect to prevailing wind direction and often crosscutting any host rock stratigraphic boundaries (Fig 1A) [1], their formation is poorly understood. To date, two competing hypotheses suggest that PBRs are an autogenic product of airflow over exposed bedrock [2], or formed via erosion between transverse bands of armoring sediment [3].

Although PBRs are not depositional features, they nonetheless share characteristic wavelength (~40 m) and amplitude (~5 m) with a ubiquitous sedimentary feature of the Martian surface: Transverse Aeolian Ridges (TARs) [4]. Further, interplay between PBRs and TARs can be seen in some regions (Fig. 2B), with loose sediment following PBR crests and leaving low-relief troughs of exposed bedrock.

Intermediate in scale between ripples and dunes, TARs are wind-formed sedimentary bedforms aligned perpendicular to the wind direction, often in zones of topographic confinement (such as a valley floor) associated with directed airflow [5]. They are symmetrical with limited mobility, such that inter-ridge bedrock exposures are predominantly static over observational timescales, and potentially subject to abrasive erosional forces, rather than being periodically buried as in dune systems [6, 7]. Although no lander has yet explored a mature TAR field, the Curiosity rover traversed Dingo Gap in 2014, a ridge bearing morphological (and possibly structural) similarities to TARs [8]. Of particular interest is its mixed grain size, with a coarse outer surface armoring fines and dust grains in the interior [9]. Here, we discuss experimental procedures which test the viability of each endmember hypothesis using a new wind tunnel laboratory at UCLA.

Possible Genetic Relationships: The shared attributes between PBRs and TARs motivate the hypothesis that PBRs form in the presence of TAR systems, heavily scouring exposed bedrock between crests that are armored by loose sediment [3]. Sedimentary deposits near the Puna region of Argentina have been proposed as Earth analogues for such an erosional process [10], however, to date, no laboratory experiments have replicated transverse abrasion patterns under airflow.

As an alternative hypothesis, small-scale ripple-like erosional patterns in solid materials are a known product

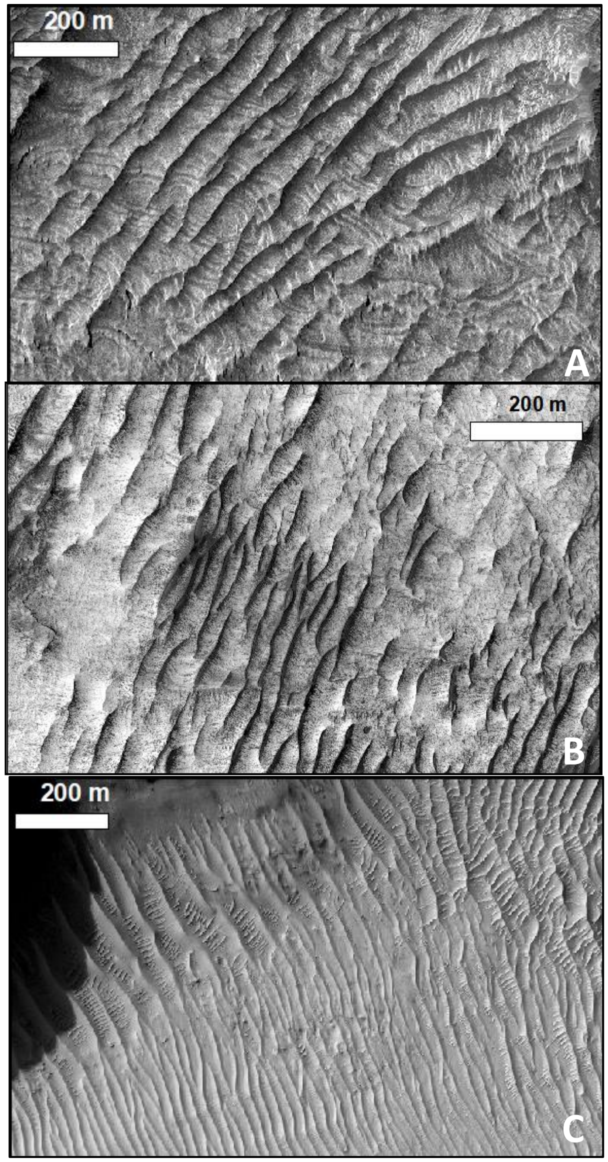

Figure 1: A) *Periodic Bedrock Ridges on the floor of West Candor Chasma, incised into layered stratigraphy. (HiRISE image PSP_008313_1730).* ***B)*** *Megaripple fields overlapping with PBRs on the floor of West Candor Chasma, following existing ridgelines with low-relief troughs exposed. Darker lineae are raised armored bedforms, lighter areas are low-relief scour zones. (HiRISE image PSP_006164_1750).* ***C)*** *Transverse Aeolian Ridges in Nirgal Vallis with similar wavelength and height. (HiRISE image ESP_018808_1525).*

of unidirectional flow in high energy environments on Earth [11]. When scaled to Martian atmospheric density, empirically derived models predict wavelengths on the order of 10 m [2]; however, these models are developed primarily in a liquid water context rather than air flow. A similar extension of these models predicts cm-scale transverse abrasion patterns in Earth-based subaerial flows, but has not yet been observationally confirmed.

Methods: Using the wind tunnel at UCLA, we test both bare-rock and periodically armored PBR formation environments to more effectively constrain each of these endmember hypotheses. The wind tunnel used here can mobilize sediment under wind speeds varying from 5-14 m/s. Chamber dimensions are 7 m length, 1.7 m width, and 1 m height (Fig. 2). We use seven 1080p visual cameras for views of cm-scale bedform development or sediment accumulation. Two time-flight camera and infrared laser Kinect stations produce digital elevation models with millimeter-scale vertical resolution, quantifying any topographic changes. An erosional substrate was constructed from polyurethane foam with a density of 16 kg/m^3 and maximum thickness of 5 cm, with a known erosion-rate scaling factor to natural rock [12]. Sand was graded to a range of 1.1-1.45 mm (very coarse) rounded to subrounded quartz and feldspar grains, supplied to the system at a fixed rate of ~ 30 cm^3 per minute.

We test the validity of each endmember hypothesis separately. The bare-rock transverse erosion hypothesis of [3] is simulated using a horizontal polyurethane base with dimensions of 1.5 m x 3 m at the tunnel floor, exposing the substrate to coarse grain saltation. Separately, the investigation of TAR-mediated abrasion incorporates transverse shielding with a symmetric triangular cross section. We used 3D-printed rigid plastic with a symmetric wave height of ~2 cm and a periodicity of 10 cm, overlying horizontal 1.5 m x 3 m foam flooring.

In both arrangements, digital elevation models are captured at 30 minute intervals during the experiment, and imported to Matlab for visualization. Difference maps between images establish mm-scale losses due to abrasion, or net sediment accumulation where ridges trap saltating grains.

Scaling from Earth to Mars: Transverse bedrock ridge wavelength is estimated by $\lambda = K\mu/\rho U$, with λ = wavelength, μ = dynamic fluid viscosity, ρ = fluid density, U = fluid velocity, and K as an empirical constant estimated as 22,500 [2]. On Mars, this gives a value on the low end of observed PBRs, approximately 10-15 m. In an Earth-based wind tunnel, the predicted value is ~4 cm, independent of target rock cohesion or tensile properties. Thus, Earth-based results are readily applicable to larger-scale features on Mars.

Figure 2: *Wind tunnel experimental setup showing 7 x 1.7 x 1 m dimensions, fixed-point Kinect station visible at top. Sub-mm scale grains are readily mobilized by wind speeds > 8 m/s, creating saltation impacts across the tunnel floor.*

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