DECAMETER-SCALE IMPACT-RELATED AEOLIAN FEATURES SURROUNDING WELL-PRESERVED IMPACT CRATERS ON MARS.

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Introduction: Fluted surfaces and wind streaks that emanate radially from impact craters have long been recognized on Mars [1, 2]. Previous studies have used laboratory experiments and numerical simulations to understand the nature and influence of impact-related winds [e.g., 3,4,5,6,7]. Near-surface impact winds are generated by the expanding vapor plume ("blast winds") as well as the impact of ejecta materials [8]. Fluted surfaces and yardangs caused by sustained winds are known from many terrestrial deserts [1]. Impact blast winds, however, create conditions for catastrophic scouring of planetary surfaces, a phenomenon without well-known terrestrial analogues. The present work aims to characterize impact wind features in high-resolution imagery, with the goal of illuminating formation processes and identifying applications to understanding the long-term modification of the martian surface.

Methods: Task 1 of this study consisted of detailed mapping of boulder-adjacent wind tails (Fig. 1A) within 300 km of Zunil Crater (D = 10.1 km) using HiRISE imagery [9,10]. Task 2 (ongoing) is a survey of aeolian features in HiRISE images that are within 100 km of six additional impact craters. These craters have been identified in previous work as showing signs of good preservation, according to their morphological and thermophysical expression [12,13,14]: Dilly (D = 3 km), Gratteri (D = 6.9 km), Noord (D = 7.8 km), Resen (D = 7.6 km), Tomini (D = 7.4 km), and Zumba (D = 2.9 km). In addition to wind tails, we have recorded occurrences of (a) extensive fluting (Fig. 1B) and (b) small impact craters (D = 10-100 m) that exhibit a pattern of erosion and deposition consistent with scouring by horseshoe vortices [1] (Fig. 1B-D).

For task 1, we recorded the endpoints of wind tails that formed behind meter-scale boulders. We computed the angle θ to be the difference between the azimuth of each windtail and the azimuth to the putative source crater. A wind emanating directly from the source crater is indicated by small values of $180°-\theta$. The uncertainty of this measurement was estimated as $\arctan(2L/w)$ for tail length L and average boulder width w. In task 2, we record the approximate radial distance (± 500 m) of large assemblages of the features mentioned above (fluting, horseshoe-scoured craters, wind tails) as well as the thermophysical expression of context terrains in THEMIS nighttime infrared (nTIR) [11].

Results: The angle $180°-\theta$ is plotted in Fig. 2A as a function of downrange distance. We find that the majority of wind tails exhibit an approximately radial azimuth with respect to Zunil crater from 20-70 km, with the range broadening outward from 0-20° to 0-40°. The radial span of these features is broadly consistent with the radial extent of outgoing high-velocity blast winds predicted by numerical models of similarly-sized impacts [4]. We find no corresponding clustering of wind tail azimuths with $\theta < 40°$, as might be expected from high-velocity return winds. The average length of wind tails is 10 ± 6m; we found no dependence of length on radial distance.

Our work on task 2 reveals that Resen crater exhibits the most extensive and best-preserved set of features, where a close connection can be drawn from morphological to thermophysical expression. In the vicinity of Resen, horseshoe-scoured craters occur in a region at least 50 km from the crater center.

Related thermophysical features: Zunil Crater formed in the Amazonian lava plains of eastern Elysium Planitia, a region of anomalously low thermal inertia. In nTIR imagery, the ejecta and blast region surrounding Zunil exhibits almost no brightness contrast. This is despite a large region (out to 70 km from center) that has been extensively streamlined by impact winds, as shown by our measurements (Fig. 2). Many of the other craters surveyed as part of task 2 exhibit bright interior regions that extend beyond the continuous ejecta blanket, and are to varying degrees surrounded by an nTIR-dark halo deposit, consistent with the proximal abrasion and outward displacement of fine particles to the distal discontinuous ejecta [12,15].

At Resen crater, we find a strong correspondence between regions that are bright in nTIR and the presence of horseshoe vortex-scoured craters. These regions often have a relatively smooth appearance and sometimes exhibit a sharp contact with surrounding terrain (Fig. 1B). Fluting occurs inside as well as outside of these regions. In several locations around Resen, we find clusters of secondary craters on plains with horseshoe-scoured craters (Fig. 1D). The smooth, horseshoe-bearing, nTIR-bright regions may respresent areas of especially pronounced scouring of regolith or bedrock. From the available HiRISE imagery at Resen crater, these surfaces are closely-spaced to approximately continuous (while pocked with secondaries) out to ~25 km, and occur discontinuously (surrounded by nTIR-dark terrains) to at least ~50 km downrange.

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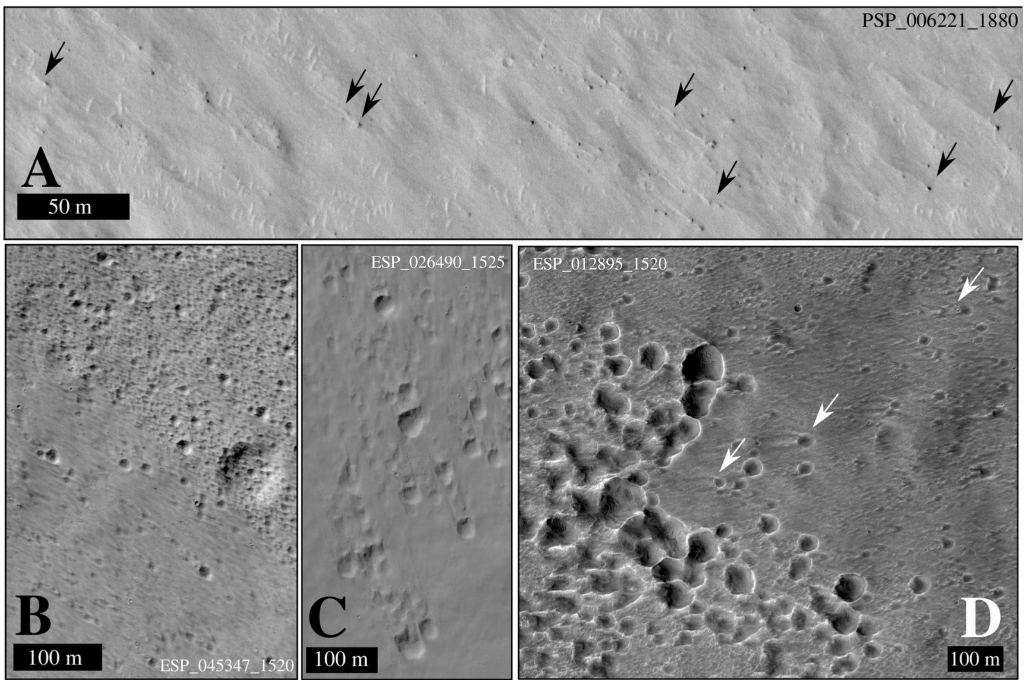

Fig. 2: (A) boulder-adjacent wind tails northwest of Zunil crater; (B) Fluted, smooth, nTIR-bright terrain with small, horseshoe-scoured craters (lower left) adjacent to higher-roughness terrain, also fluted, and darker in nTIR. (C) Craters with horseshoe scours north of Resen crater. (D) Probable Resen secondary clusters on plains bearing horseshoe-scoured impact craters (west of Resen crater).

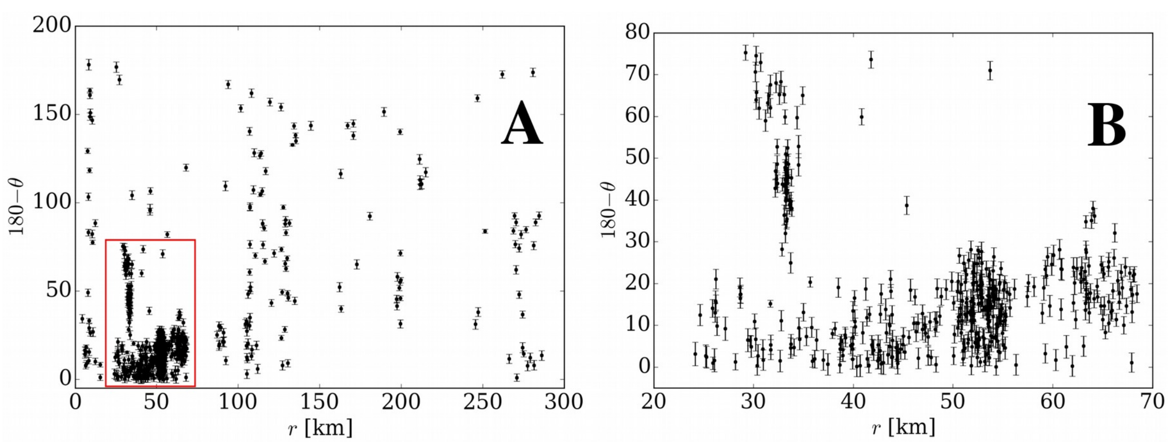

Fig. 1: (A) θ is the angular separation between the azimuth to putative source crater and azimuth of boulder-adjacent wind tails around Zunil crater (measured *from* boulder *toward* tail); we plot 180°- θ versus downrange distance. Values of 180°- θ near zero indicate radial alignment (wind directed away from source crater). (B) The region in the red box in (A).