GEOMORPHOLOGICAL EVIDENCE OF NEAR-SURFACE ICE AT CANDIDATE LANDING SITES IN ARCADIA PLANITIA, MARS.

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Introduction: Multiple independent datasets showed that Arcadia Planitia (AP) may be an ideal region for candidate landing sites in support of science and human exploration on Mars. For example, analyses of radar [1,2], thermal inertia [2], neutron [3,4], gamma ray data [5], geomorphological observations [2,6], and combined datasets [7] all suggest the widespread presence of accessible near-surface ice in AP, essential for both scientific investigation and supporting sustained human exploration.

Candidate landing sites: Candidate landing sites for future Mars exploration in Arcadia Planitia, Phlegra Montes, and Erebus Montes were previously proposed [8], largely due to evidence for near-surface ice and meeting engineering safety criteria. In this work, we focused on three candidate sites located in AP (AP-1, AP-8, and AP-9; Fig. 1), which host the most level terrains among the three regions and where multiple datasets show the occurrence of widespread excess ice [1,3,4,7].

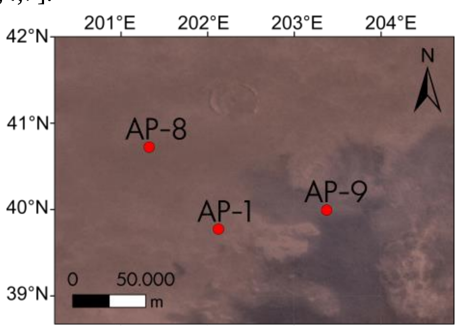

Fig. 1: Location of AP-1 (39.8°N, 202.1°E), AP-8 (40.75°N, 201.3°E), and AP-9 (40.02°N, 203.35°E) on the Mars Viking Colorized Global Mosaic basemap.

Geomorphic analysis: In this work we evaluated three AP candidate landing sites proposed by [8] and characterized the geomorphological setting, with a focus on ice-related features, using HiRISE (High Resolution Imaging Science Experiment) imagery and DEMs (Digital Elevation Models).

*Polygonal patterned ground***:** The most ubiquitous feature within the study area is the polygonal patterned ground. On Earth, this honeycomb network of fractures forms in areas with buried ground ice, following seasonal changes in temperature that cause thermal contraction; when the strength of the frozen ground is exceeded by the tensile stress, these fractures form relieving such stress. The size and geometry of polygons provide insight into the underlying ground ice since the polygons' size is related to the ice depth, and the polygons' geometries evolve as the system matures [10].

The polygons at the AP landing sites are high-centered (in some cases even reaching domical shapes), with deep troughs, and variable geometries (from hexagonal, to rectangular, to more irregular shapes) (Fig. 2A). These polygons are consistent with those identified as sublimation polygons [9], which are interpreted to form as enhanced sublimation in the central part of the polygon generates a raised central dome morphology and relatively deep troughs.

We mapped 8967 polygons in multiple sample areas. As previously mentioned, the size of the polygons is controlled by the depth of the buried ice: smaller polygons form over shallower ice tables, while larger polygons form over deeper ice tables [10]. The size of the thermal contraction polygons that we mapped is consistent through all the three landing sites regions, with a mode diameter of ~11 m (Fig. 2B), suggesting that buried ice might be laterally uniform, with no significant vertical variations. Based on previous models correlating polygon size and ice depth at the ground-truthed Phoenix landing site [10], we find that 11 m polygons are consistent with the estimated ice depth of 6-20 cm proposed by [6] in AP. Although further models are required to refine this estimation, the small size of polygons in AP is indicative of relatively shallow and accessible ground ice.

*Expanded craters and arcuate ridges***:** Sublimation processes can heavily modify pre-existing geological features. In this region we identified impact craters exhibiting degraded and extended rims due to sublimation, an asymmetrical topography, central pits or bulges, and ridges in the SW sides of the rim (Fig. 3A). These ridges, resembling partial remnants of the degraded rim, can be observed in all the expanded craters in the study area, and every ridge is characterized by the same orientation (NE-facing) and the same location (SW portion of the degraded rim). Additionally, such arcuate ridges are widespread throughout the area even in absence of expanded craters (Fig. 3B). [11] demonstrated that ice ablation rates depend on orientation and therefore exposure to insolation. As a result, scarps facing between NNW and NE are less affected by sublimation, and this is consistent with the orientation of the observed ridges in AP, facing NE. Therefore, both the expanded craters and the ridges are consistent with formation via sublimation processes and can serve as a proxy for excess ice.

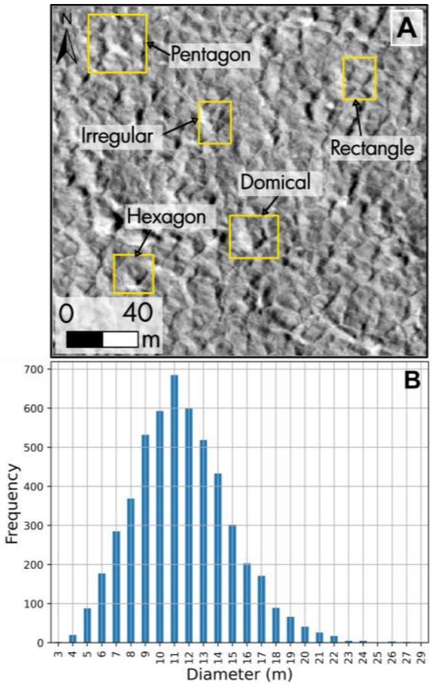

Fig. 2: A) Diverse morphologies of polygons in the area (HiRISE ESP_052490_2200); B) Frequency distribution of the polygons' diameters.

Brain Terrain: A type of landform consisting of anastomosing patterns of ridges and troughs resembling a "brain" was found in our study area. The brain terrain occurs within a terraced crater located ~2 km W of AP-8 (Fig. 4A), ~8 km NE of AP-1, and ~8 km SE of AP-1 (Fig. 4B). Recently, brain terrain was interpreted to be analogous to Vermicular Ridge Features (VRFs) [12], as both share morphological and morphometric characteristics. VRFs were interpreted as remnants of ice-cored hummocky moraines or as the result of ablation of buried glacial ice [12].

Conclusion: These preliminary results suggest that the candidate landing sites are located in an area that hosted buried excess ice in the geologically recent past and/or may still host buried ice today. The size consistency of nearly 9000 polygons measured over 1215 km^2 suggests that the buried ice would have a lateral continuity on the order of hundreds of kilometers. The measured diameters of the polygons are consistent with this ice being near-surface and therefore readily accessible to sustain a human settlement on Mars.

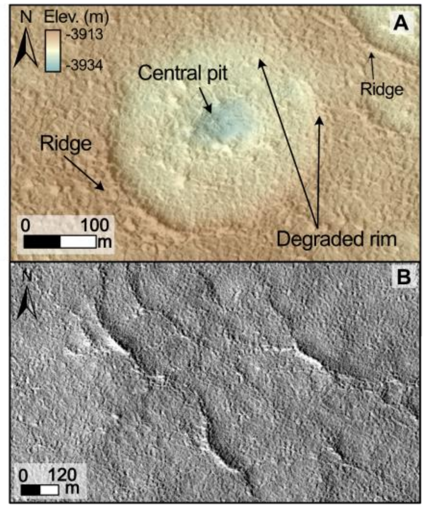

Fig. 3: A) Expanded crater and SW-bounding ridge; B) Arcuate ridges not associated with expanded craters. HiRISE ESP_052490_2200.

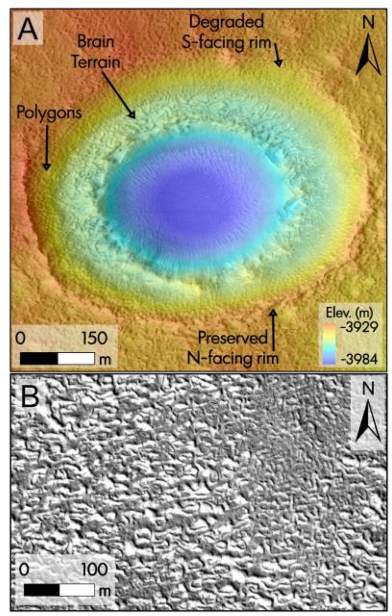

Fig. 4: A) Brain terrain, polygons, and differential ablation along the rim in a terraced crater close to AP-8. HiRISE ESP_043220_2210. B) Brain terrain 8 km SE to AP-1. HiRISE ESP_050934_2200.

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