NORTHERN PATTERNED GROUND MARGIN ON MARS: TERRAIN TYPES AND AGE ESTIMATES.

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Introduction: Small impact craters on high latitude polygonal terrains exhibit a variety of degradational stages [1]. Those craters are small and rare, almost never have raised rims and are usually devoid of ejecta fields. This indicates that the surface there is very recent, and that the polygon-forming processes are very efficient in modifying pristine craters. A systematic search for craters between 60°–70° on both hemispheres showed that northern polygonal terrain (NPT) surfaces are much younger than those in the south (SPT) [1]. This is indicative of perihelion season change: Recurring every ~50 ka, it affects polar insolation, which in turn induces net migration of H_2O towards the colder polar region and deposition of water ice there. This has smoothed or obliterated almost all small craters in NPT within the last few ka – opposite direction migration did the same in SPT 10–40 ka ago.

To investigate the extent of the NPT region and characterize the efficiency of the polygon-forming processes, we conducted a comprehensive survey of the NPT margin between 50–70°N (Fig. 1). This region covers an area of ~1200x10000 km and is generally flat (mean elevation is -4200 m; σ = 500 m). We identified several distinct terrain types, each occurring at certain latitude bands, and classified all the found impact craters according to their degradation stage.

Data and methodology: In order to obtain a sample set of uniform high quality, we selected 25 cm/pixel HiRISE images with no seasonal frost. Since our interest is the extent of a widely distributed surface unit, images covering anomalous features which may affect the development of polygons or that of impact craters were also omitted. Such terrains include interiors and ejecta fields of large impact craters (D=5–240 km), pitted, fractured and eroded regions, and topographic slopes related to mesas, knobs and scarps. Roughly 1/5 of the 1018 HiRISE images in the region fit this profile. It should be noted that their distribution is not random and clusters occur in places, most notably near the Phoenix landing site.

Clusters of small craters were considered as single atmospheric meteoroid break-up events with effective crater diameters of $D_{eff} = (\Sigma D_c^3)^{1/3}$ [2].

Terrain types: Each image was found to exhibit patterned ground forming lineaments, falling into two terrain classes. *Type 1 terrain* has a smooth undulating or hummocky ground pattern, consisting of interconnected, several meter wide troughs and intervening tens of m wide hills (Fig. 2a). In places topography may be replaced by corresponding gentle albedo patterns. This terrain is found throughout the study region, including in the north where it underies, and is distorted by, type 2 terrain. *Type 2 terrain* exhibits angularly jointed sharp polygon-forming fractures. It is divided into several subtypes according to fracture size, separation and general appearance of the ground. Subtypes fall into two general classes (Fig. 2b): Closely separated interconnected fractures (2a: fracture width <1.5 m, cell diameter <10 m), and pronounced wide fractures (2b; fracture width >1.5 m, cell diameter 10–500 m). The latter occur only intermingling with the former, and can appear in isolated segments

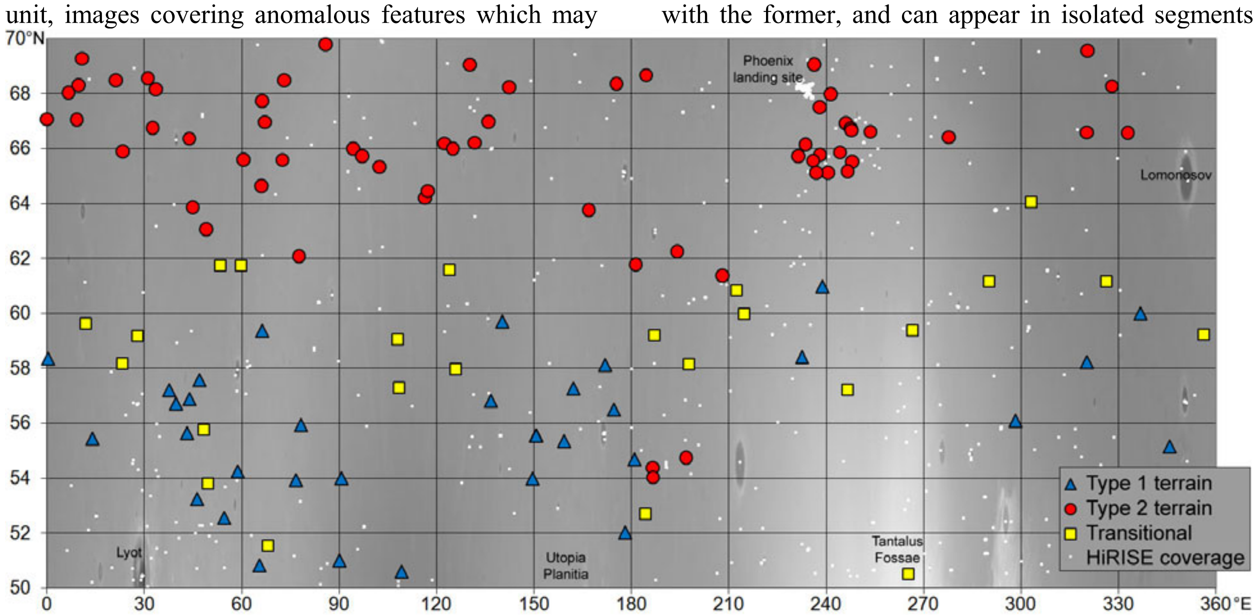

Figure 1 (previous page). Distribution of identified terrain types plotted on a MOLA DTM background. White dots represent all 25 m/pixel HiRISE images.

throughout the terrain. Almost all type 2 terrain is found north of ~61°N (Fig. 1). *Transitional terrain* is also identified. It exhibits slight fracturing (usually no polygons) on a base of type 1 terrain. This type occurs mainly between 57 and 62°N (Fig. 1). The images of type 1 terrain cover ~2200 km^2, type 2 ~3100 km^2 and transitional ~600 km^2.

Impact craters: All identified roughly annular surface features were classified, resulting in a database of ~4000 possible impact structures with diameters of 3–2000 m. These include e.g. fresh craters with ejecta fields, clusters, boulder fields, and a large number of ambiguous shallow pits and circular polygon patterns, which may or may not depict buried and/or heavily degraded craters.

The crater search revealed further differences between terrain types. Type 2 has significantly fewer craters than type 1, consistent with previous observations [1]. To investigate the difference further, 5–50 m craters on both terrains were closely examined, as they are most indicative of near-surface phenomena and recent changes. The youngest crater subpopulation, namely those with sharp slope breaks at the rim were specifically considered. Their size-frequency distributions (SFD) on both terrain types were compared to SPT craters from [1] (Fig. 3). The sharp crater (D>20 m) density of surface type 1 is much higher than SPT, indicating an older age (highly uncertain, within 20–100 ka), while type 2 is significantly younger (thousands of years). The gentle slope and roll-over at D<20 m sizes is partly caused by seasonal frost and active polygon-forming processes.

Conclusions: We find that the occurrence of polygon-forming fractures in type 2 NPT occurs north of ~61°N. This is consistent with the current shallow ground ice extent [3]. We interpret the fractures to be the result of very recent or ongoing permafrost processes within NPT. We suggest that the set of smooth undulating polygon-forming troughs was formed earlier in a similar process, and that the type 1 terrain surrounding the fractured region has previously experienced conditions with shallow ground ice. This is supported by observations of unique sharp small-scale polygonal fractures on the floors of the largest fresh craters, suggesting shallow ice exposures within them. The set of type 1 troughs is older than the sharp crater population superposed on it (20–100 ka). It could basically date back to the latest period of higher obliquity (~300 ka), but the obliteration and smoothing of small craters appears to be much younger than that. We propose that the type 1 surface has been modified in a similar fashion to what is currently occurring in the NPT, and what occurred at SPT 10–40 ka ago. It is thus suggested that type 1 terrain is a remnant of one of the latest conditions when the season of Mars' perihelion was similar to what it is now.

Extension of the survey to other longitudes and into the southern hemisphere promises more reliable and detailed results on timing of recent climate-related geological processes.

References: [1] Kreslavsky, M.A. et al. (2010) *LPSC XLI*, Abstract 2560. [2] Ivanov, B.A. et al. (2008) *LPSC XXXIX,* Abstract 1221. [3] Feldman, W.C. et al. (2004) *JGR, 109*, E09006.

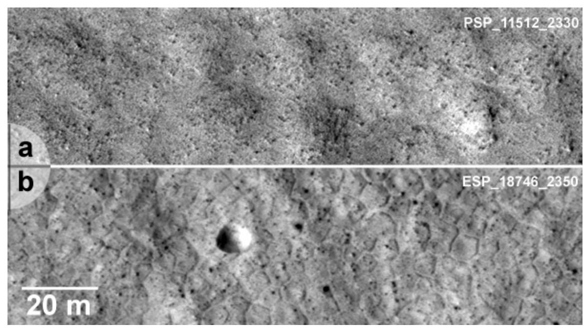

Figure 2: a) Type 1 hummocky terrain. b) Type 2a fractured terrain with a sharp crater. Note the undulating type 1 style basement. Scale applies to both images.

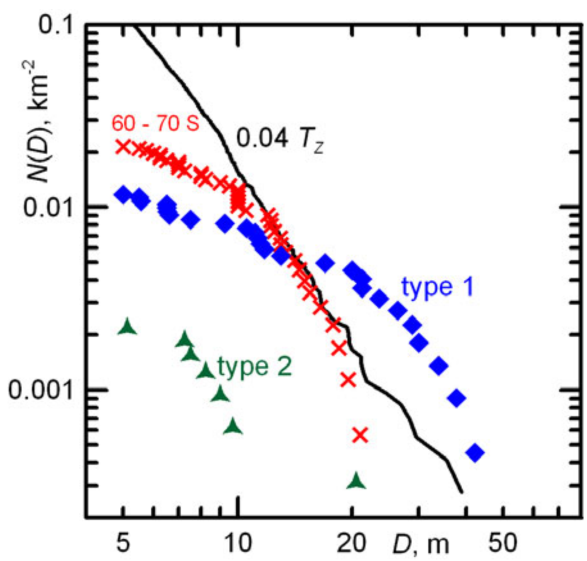

Figure 3. Crater size-frequency distributions of 'sharp' craters on terrain types 1 and 2, compared those found from latitudes 60–70°S [3]. The black line is 0.04 Zunil isochrone, a proxy for production function of small craters roughly corresponding to an age of 10–40 ka.