POLYGON TERRAIN MORPHOLOGY WITHIN SCALLOPED DEPRESSIONS, UTOPIA PLANITIA, MARS.

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Introduction: Within Utopia Planitia, a major topographic basin in the northern plains of Mars, previous work has illustrated that the region contains ice-rich sedimentary deposits whose emplacement could possibly have occurred in relatively recent times [1-2]. In support of this notion, a number of geomorphic indicators suggest the past or present existence of shallow subsurface ground ice reserves.

For example, small-scale polygonal terrain – a network of interconnected shallow trough-like depressions – is ubiquitous throughout the area (Fig. 1). On Earth, these features are formed through a process known as thermal contraction cracking and are known to be indicative of ice rich substrates [3]. The Phoenix mission recently confirmed that polygonal terrain can potentially be used a reliable indicator of subsurface ice presence on Mars, as well [4].

Additionally, erosional features referred to as "scalloped terrain" (Fig. 1) are freqeuently observed within Utopia Planitia. These scallops are landscape depressions ranging from tens of meters to several kilometers across and meters to tens of meters deep [5], and are believed to be caused by surface deflation resulting from the loss of underlying ground ice bodies due to sublimation [5] or evaporation [2].

Through the analysis of MOC imagery, previous researchers have noted that small-scale polygons approximately 50m across are typically present in the plains containing the scalloped depressions [6]. More recently, however, inspection of HiRISE images have revealed the occurrence of even smaller polygonal patterns (<10m across) on the depressed surfaces found at lower elevations within the scallops themselves [5].

The overarching goal of this work is to examine polygonal morphologies at various elevations within the scalloped depressions. An interpretation of these polygonal features may reveal insight into local substrate characteristics and can be used to trace various stages of scalloped terrain development.

Lanscape Evolution:

Polygonal Terrain: Polygonal terrain on Mars is thought to be formed through a similar thermal contraction process as those on Earth [7]. Seasonal decreases in local temperatures induce a tensile stress in the ground that, when in excess of the tensile strength of the substrate, result in a series of millimeters-wide vertical cracks that extend laterally in planform. Eventually, these cracks connect and form enclosed polygonal shapes in the ground. Repeating the process over hundreds or thousands of years enhances the shapes seen at the surface.

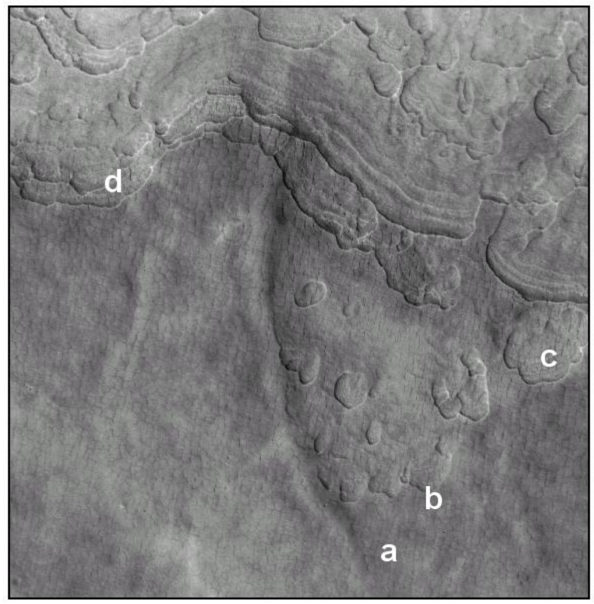

Fig. 1: *Example of scalloped and polygonal terrain, Utopia Planitia (Subset of HiRISE image PSP_003125_2250). Letters on upper image designate locations of image subsets in Fig. 2.*

Scalloped Terrain: Though the development of scalloped terrain is not fully understood, a number of hypostheses have been put forth in an attempt to explain their appearance [2,5]. It is generally believed that the scallops are representative of degradation processes acting upon the ice-rich latitudinally dependent mantle layer described by [8]. As the underlying ice sublimates away the remaining overburden collapses, resulting in 'thermokarst' scarring of the landscape. As the sublimation continues, the depressions continue to grow both laterally and vertically, eventually resulting in the complex erosional pattern as illustrated in the upper portion of Fig. 1.

HiRISE Imagery: A systematic search of all HiRISE images was performed for the region within Utopia Planitia between 80-100ºE and 40-50ºN. Images were downloaded from the online HiRISE database and visually inspected for the presence of scalloped and polygonal terrain.

Although a total of 46 images are available within this area, 22 constitute stereo-pair halves; as such, only 35 individual locations are represented. Of these, 25 images displayed scalloped terrain in various stages of development. In all instances where scallops are present, polygonal terrain dominates the uppermost terrace level with the surrounding plains.

Summary of Findings: In the examined imagery, at least four distinct stages of scalloped terrain development can be seen. Sequentially, polygonal morphology appears to become modified as the scallops mature.

In Stage 1 (Fig. 2a; "Inititaion"), a slight deflation of the upper mantle is evident, perhaps a few meters deep. At this stage, the pervading polygonal patterns of the surrounding plains remain virtually intact, with dominant N-S trending and E-W diameters of approximately 50m.

In Stage 2 (Fig. 2b; "Enhancement"), the depressions have become wider and deeper – even individual depressions are now hundreds of meters across – and the coalescence of adjacent scallops has begun. The upper mantle polygonal patterns remain present but appear slightly 'muted', possibly as a result of erosion or infilling of cracks with deflated materials.

In Stage 3 (Fig. 2c; "Coalescence"), the depressions have continued to deepen and grow laterally and have now coalesced. Remnants of the upper mantle polygonal patterns are still visible, but haave become increasingly muted. Additionally, the partial subdivision of the original upper mantle patterns has occurred, with newer and smaller polygons now measuring approximately 15-20m across.

Finally, in Stage 4 (Fig. 2d; "Deflation") entirely new networks of small-scale, regular polygons are now present (~5m across), and no evidence of the upper mantle patterns remain.

It is possible that these differences in polygonal morphology may represent variations in the factors responsible for their formation. Specifically, polygonal geometry is is known to be dependent on local climate and substrate composition. However, the climate throughout the image would be relatively constant given the regional proximity, and thus it is expected that variations in substrate composition (e.g. ice content, regolith consolidation) are responsible for the variety of forms seen.

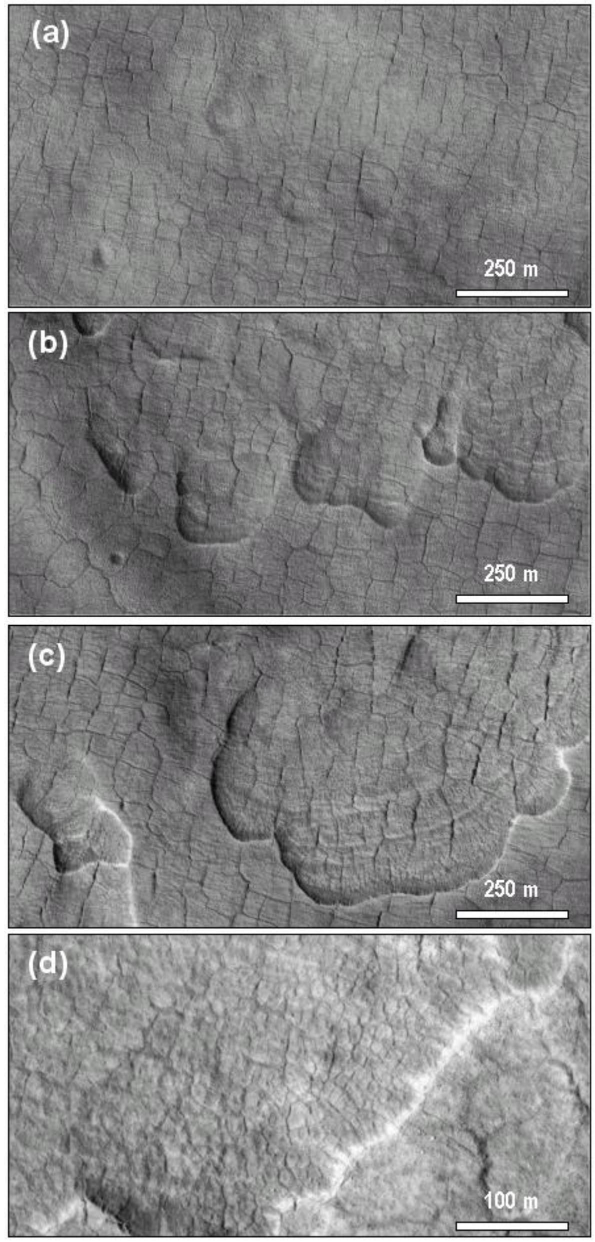

Fig. 2: *Various stages of development for polygonal morphologies within scalloped terrain.*

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