OBSERVATION AND INTERPRETATION OF GIANT POLYGONS IN UTOPIA PLANITIA, MARS.

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Introduction: Polygonal fractures of all scales have been observed in Utopia Planitia. Polygons at the Viking 2 Lander site are <10 m in diameter and their component troughs are ~1-2 m wide [1]. High-resolution Viking Orbiter images show polygons ranging from 50-300 m in diameter [2] with bounding troughs generally 4-10 m in width [3]. Also evident in the Viking Orbiter images are 3-30 km diameter polygons with steep-sided troughs <0.5 - 7.5 km wide and <5 - 115 m deep [4]. Many researchers have classified these different scales of polygonal features. [3] defined small-scale polygons as those 10-250 m in diameter and giant polygons as 3-10 km across. However, [5] describes small scale polygons as those 5-20 m in diameter, middle size as 100-200 m in diameter and giant polygons as those 1-20 km in diameter.

A new evaluation of the giant polygons in Utopia Planitia is performed. Their locations are mapped and their topography and morphology are re-examined using newer, higher-resolution data sets.

Models of Giant Polygon Formation: A number of hypotheses for the origin of the martian polygons have been proposed, from the cooling of lava to frost wedging to the desiccation of wet sediments [6, 7, 8, 9]. These were all derived from comparison with familiar features on the Earth. General consensus indicates that polygons smaller than 250 m are most likely periglacial features that form due to ice-wedging [3, 5]. However, these are 1-2 orders of magnitude smaller than the giant polygons and [10] showed that none of the familiar processes, including frost wedging, could be scaled up to the giant dimensions.

Two models for polygon origin [11,12] attempt to explain the scale of the giant martian polygons. Both of these models postulate drape folding [13,14] of a cover material, either sedimentary or volcanic, over an uneven, buried surface. The drape folding would produce bending stresses in the surface layers that increase the probability of fracturing over drape anticlines and suppress the probability of fracturing over drape synclines. However, both models require an additional source of extensional strain to produce the total strain needed to produce the observed troughs.

[11] concluded that the loci of fracturing are controlled by drape folding, but the total strain produced by the folding is an order of magnitude too small to account for the polygonal troughs. They proposed that the needed additional strain is produced by the overall shrinkage of the cover material. Wet soils shrink as they dry because the surface tension of the water pulls the grains toward each other. The resulting strain due to volume loss can easily be large enough [e.g. 15] to account for this additional strain [11].

[16] argue that compaction is a three-dimensional, volumetric contraction. Polygonal fault systems in Lower Tertiary mudrocks in the North Sea are bounded by grabens 100-1000m long, which have diameters as great as 1 km. Studies of these polygons determined that the horizontal extensional strains responsible for faulting are due to radial contraction during compaction with no net extension [16].

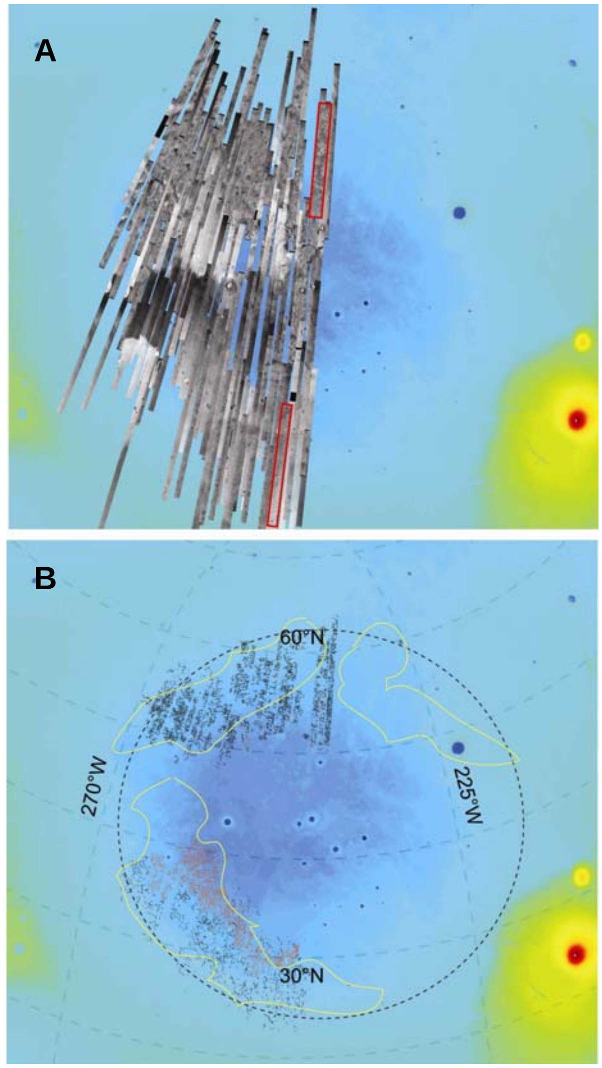

Figure 1. a) THEMIS mosaic over MOLA topography of the Utopia basin. Red boxes indicate location of Figures 2 (lower box) and 3 (upper box). b) Polygonal fractures mapped over MOLA topography of the Utopia basin. Yellow shapes indicate regions of giant polygons as mapped by [11].

Similar polygonal faulting has been identified in the fine-grained sedimentary rocks of at least 27 other globally distributed basins [17,18,19]. Furthermore, [18] observed that the North Sea polygons accommodate extensional strains up to 20%, comparable to the 20% extension that [11] required to produce the grabens in Utopia Planitia. [20] determined that volumetric compaction could explain the giant polygons and corresponding circular graben observed in Utopia Planitia.

Methods: Past evaluations [e.g. 4, 9, 11, 21] utilized Viking imagery, which is best displayed across southern flank of the Utopia basin. However, polar surface processes kept any in-depth examination of the polygons to the north of the Utopia basin from being completed. THEMIS has more adequately covered the northern polygonal terrains and so a mosaic of THEMIS daytime infrared images of the Utopia basin is used as a base map for our study (Fig. 1a).

Observations: Giant fracture-bounded polygons (Fig. 2,3) encircle the Utopia Basin (Fig. 1b). A noticeable difference is observed between polygons to the south and north of the basin. The southern polygons (Fig. 2) are 5 to >30 km in diameter, are irregularly shaped and not completely closed (the troughs do not always meet). Those closer to the center of the basin have steep-sided and deep bounding troughs,while those farther away appear subdued.

The northern polygons tend to be smaller (<1 to 5 km diameter), more regular in shape and completely closed. Smaller polygons can be observed nesting inside the larger northern polygons. Mapping of these different types of giant polygons will enable us to better evaluate the models of their formation.

Discussion: The arrangement of the giant polygons around the Utopia basin implies a common formation mechanism. However, the differences in morphology between the northern and southern giant polygons indicates different formation mechanisms.

We suggest that it is probable that similar processes caused the large-scale fracturing to both the north and south of the Utopia basin, whether it be by drape – folding of the cover material over buried topography [11], uplift of the basin floor [4], or volumetric compaction of the cover material [20]. Polar processes then possibly affected the size and morphology of the resulting northern polygons.

Conclusions: Newer data covering the northern Utopia basin allows high-resolution mapping of giant polygons in the region. Polygon morphology is significantly different depending on location around the basin. These differences suggest that polygon formation histories are not the same to the north and south.

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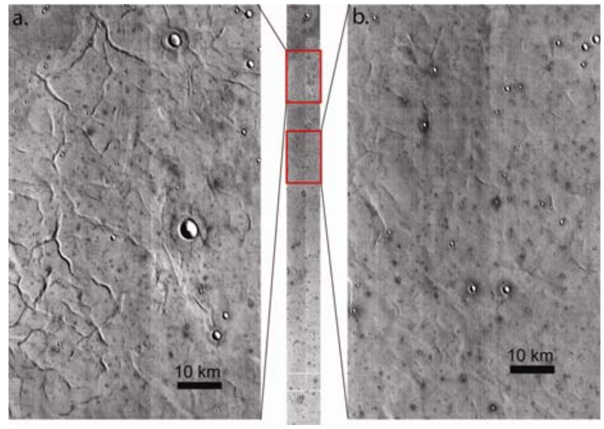

Figure 2. Example of southern style giant polygons (left) and subdued southern giants (left) in THEMIS daytime infrared.

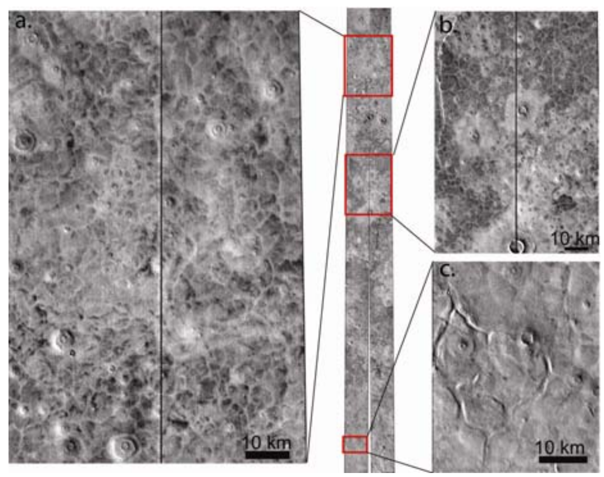

Figure 3. a) Example of northern style giant polygons. b) Polygons in the north are more frequently obscured by fluidized crater ejecta and pseudo-craters (rootless cones? pingos?). c) There are some southern style polygons in the north.