MARS THERMAL CONTRACTION CRACK POLYGON CLASSIFICATION AND DISTRIBUTION: MORPHOLOGICAL CHARACTERIZATION AT HIRISE RESOLUTION. J. S. Levy[1], J. W. Head[1], D. R. Marchant[2], [1]Brown Univ. Dept. of Geological Sciences, Providence, RI, 02906 [2]Boston Univ. Dept. of Earth Science, Boston, MA, 02215. joseph_levy@brown.edu.

Introduction: Polygonally patterned ground has been identified on Mars since the Viking era [1], and has long been interpreted as a signal of the presence of subsurface ice deposits [2-4]. The origin of ice in the shallow martian subsurface, whether by cyclical vapor diffusion or primary deposition, remains an area of active inquiry [5-9]. Recent modeling suggests that high-latitude terrains on Mars may support buried ice sheets, produced by direct atmospheric deposition within the past 5 My [5], overlain by a sublimation lag deposit ranging in thickness from 10s to 100s of cm [8]. These results are consistent with coarse-resolution (100s of km per pixel) neutron-spectrometer results correlating high-latitude patterned ground with subsurface water [4, 10, 11], as well as a suite of geomorphological observations linking young terrains to recently deposited, ice-rich units [5-7].

Polygon classification in terrestrial polar environments is based on morphology, structure, and origin processes. On Earth, thermal contraction crack polygons are divided into three types: ice-wedge, sand-wedge, and sublimation polygons; each of which forms under a unique set of climate and substrate-composition conditions [12, 13]. Although the thermal contraction cracking process under martian conditions is well understood [14], classification systems for polygonally patterned ground on Mars have until now relied primarily on imaging data at resolutions comparable to the scale of the polygons of interest [3]. We build on the identification of sublimation polygons in the NASA Phoenix landing area [15], starting with an initial classification of polygons into morphological species (groups distinguishable by characteristic surface morphologies). This morphological classification will provide the basis for further analysis of polygon evolution processes [16].

Survey Parameters: We present a survey of 301 HiRISE images of the martian northern hemisphere (30-80°N), at resolutions of ~30 cm/pixel, spanning primary science phase orbits 001331 to 003595 [17]. Of the surveyed images, 220 contain polygonally patterned ground (73%). Polygon diameters were measured using center-to-center point distance measurements between adjacent polygons, and were averaged across the four nearest-neighbor points to give a representative diameter.

Polygon Classification and Distribution: We divide polygons into 7 morphological species (Figure 1). Commonly more than one species is present in a single HiRISE image, suggesting variability in polygon-forming substrate conditions on 100 m to km length scales [18]. Polygon species is generally latitude-dependent, suggesting a climatic control on polygon morphology.

High Relief (HR). Initially described by [15], HR polygons are well-formed and have strong contrasts between polygon centers and depressed polygon margin troughs. HR are morphologically similar to S1 terrain described by [3], averaging 6.1 m in diameter (N = 160). HR polygon distribution is centered at 70.3°N.

Basketball Terrain (BBT). Originally described by [2], basketball terrain is composed of boulder-rich rubble piles [19] over fine-scale polygons. Boulder piles can have a lineated or stippled distribution. Boulder piles have an average spacing of 110 m (N = 120). Both stippled and lineated BBT are distributed about ~71°N.

Northern Plains (NP1-3). Northern plains polygons are the predominant northern hemisphere polygon species (177 occurrences). NP were first described at the NASA Phoenix landing site [15], and are present in three varieties: NP1, consisting of well-formed, low-troughed polygons present on boulder-topped mounds (mean diameter 5.2 m, N = 138); NP2, consisting of less-sharply defined polygons, present on both smooth, and gently hummocked surfaces (mean diameter 5.3 m, N = 121); and NP3, which are poorly polygonalized features, commonly consisting of long, sinuous cracks which form coarse networks (mean diameter 5.6 m, N = 147). NP polygons are all broadly similar to the S group described by [3]. On the basis of aspect-dependent asymmetries (steep pole-facing slopes and shallow equator-facing slopes, determined from HiRISE stereo topography), NP1 were identified as features genetically similar to terrestrial sublimation polygons, which form on a substrate of buried excess ice (ice > pore space) and in the absence of an active layer [15]. NP polygons are distributed latitudinally in the northern hemisphere, with NP1 occurring most commonly to the north (distribution center at 69.7°N), NP3 occurring to the south (distribution centered at 66.7°N), and NP2 occurring at intermediate latitudes (distribution centered at 67.9°N).

Northern Plains Subdued (NPS). NPS polygons average 16 m in diameter (N = 145) and are bounded by depressed troughs that are less sharply defined than those outlining NP1-3 polygons. NPS commonly have small, >1 m-scale boulders accumulated in inter-polygon troughs, forming networks of lineated boulders. If these boulders have been gravitationally sorted into polygon troughs by oversteepening of polygon interiors [13], which have subsequently been flattened, these observations may suggest significant removal of subsurface ice and deflation of NPS-surfaced terrains. NPS distribution is centered on 54.9°N.

Peak-Topped (PT). Peak-topped polygons are characterized by steeply peaked polygon interiors, surrounded by shallow, narrow polygon troughs. PT form in association with BTC polygons (see below) as well as in isolation. PT average 9.1 m in diameter, and are present in a range centered on 48.0°N.

Scalloped Terrain. Scalloped terrain present in Utopia Planitia, and has been interpreted to be an ice-rich sublimation residue [20]. Polygons exist at two scales in scalloped terrain: a large scale with pitted troughs (mean diameter 70 m, N = 125), and a small scale, with well-defined mounds and troughs (mean diameter 11 m, N = 117). Features similar to small-scale scalloped polygons are also present in south-circum-Argyre images (for example, PSP_002914_1275). Northern hemisphere scalloped terrain is centered on 45.0°N.

"Brain Terrain" Covering (BTC). Initially described by [21] as "brain coral terrain," brain terrain is an arcuate and cuspate surface texture commonly associated with lineated valley fill (LVF), lobate debris aprons (LDA), and concentric crater fill (CCF), which does not contain visible thermal contraction cracks. Polygons present on a mantling unit overlying the brain terrain, brain-terrain-covering (BTC) polygons, average 11 m in diameter (N = 123). BTC distribution is centered at 41.6°N, and is a subset of the more widely distributed brain terrain.

Discussion: Morphological analysis and classification is the first phase in a comprehensive analysis of small-scale polygonally patterned ground on both Earth and Mars [13, 16]. In the northern hemisphere, we focus on two groups of polygons. First, we consider the HR-NP1-NP3 polygons. Gradational contacts between these polygon species suggest that localized changes in surface conditions strongly control polygon morphology in this suite. Subtle changes in surface insolation, shallow-subsurface ice distribution, and obliquity-driven thermal history may be recorded in these polygons for the last major period of polygon generation and evolution. Second, we consider the BTC/PT group. The close spatial association of these polygon species with LVF/CCF/LDA, coupled with the latitudinal agreement between these polygons and latitude-dependent mantle (LDM) [7], suggest that they may hold important information regarding the distribution and history of ice in large lobate features, providing insight into LVF/LDA/CCF and LDM formation, timing, and alteration history.

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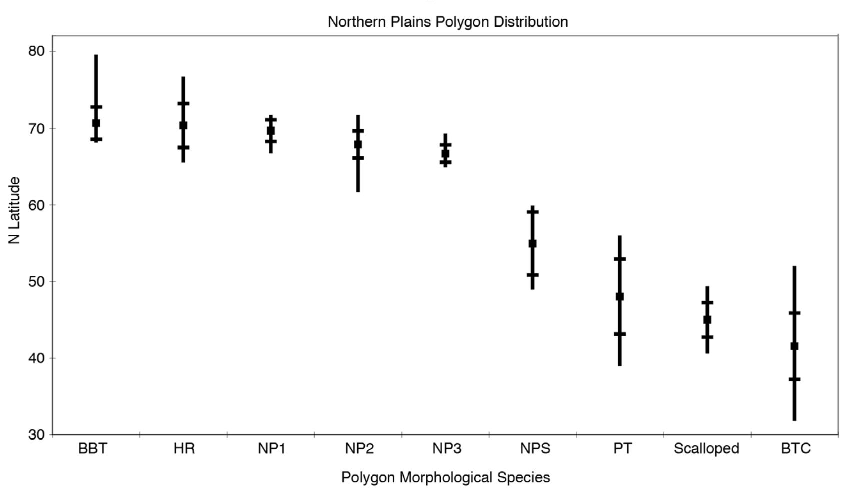

Figure 1. Distribution of thermal contraction crack polygon morphological varieties in the northern hemisphere of Mars. Dots indicate center of distribution; vertical bars indicate range of polygon species, and small crossbars indicate one standard deviation of the range distribution. BBT is Basketball Terrain, HR is High-Relief polygons, NP1-3 are Northern Plains types 1-3, NPS is Northern Plains Subdued, PT is Peak-Topped polygons, and BTC is "Brain-Terrain" Covering polygons.