THUMBPRINT TERRAIN AND SINUOUS TROUGHS WITH MEDIAL RIDGES IN THE NORTHERN LOWLANDS OF MARS: ASSESMENT OF THE GLACIAL HYPOTHESIS USING NEW SPACECRAFT DATA. W. J. Pomerantz and J. W. Head, III, Planetary Geosciences Group, Department of Geological Sciences, Brown University, Box 1846, Providence, RI 02912 (William_Pomerantz@brown.edu).

Introduction: Many workers have described the thumbprint terrain (TT)—terrain consisting of nested curvilinear features visible throughout much of the Northern hemisphere of Mars in Viking data (see Fig. 1)—and the troughs with medial ridges frequently associated with that terrain [1-7, see references within]. Interpretations of TT have included: accumulations of eolian deposits; ice-shoved glaciotectonic features; chains of cinder cones; moraines; and paleocurrent markers [1-7, see references within]. Kargel et al. [1995] is one of the most comprehensive recent treatments of TT. They attribute the entire system to glacial processes, positing the thumbprint terrain as moraines and the troughs as tunnel channels with medial eskers. This study evaluates the mechanism of origin from [1], testing it against new data available from the Mars Global Surveyor (MGS).

Pre-MGS Characterization: Kargel et al. [1], using Viking data, characterized the thumbprint terrain (TT) as "whorled ridges, spaced about 2-6 km and forming lobate patters with lobe widths of about 150 km." The authors liken the TT to recessional moraines in central North America and northern Europe, citing similarities of size, spacing, cross-sectional profile, and regional expanse. However, they note that many other landforms share similar characteristics: such as sublacustrine moraines, ice-thrust ridges, and subglacial water-saturated till deformation features. The deep troughs with medial ridges they compare to tunnel channel-esker complexes—frequently formed during the collapse of terrestrial glaciers [9, 12]—in scale, sinuosity, and pattern of integration. The authors also commented on the 'knobs' or 'mounds' found interspersed with the troughs in one of their main sites, Arcadia Planitia, interpreting them to be probable kames. All of these features require the presence of glaciers, so the authors concluded that, although the exact formation mechanism could not be ascertained, glacial formation was a very strong probability. Comparing these hypotheses with the regional context of the sites, they found glacial formation hypotheses to be plausible, and even suggested that these features might mark regions where a southerly-advancing ice sheet compressed against the lowlands/highlands border. Kargel et al. [1] point out two major facets of their interpretation that require further research: 1) the absence of drumlin fields, and 2) the unusual convex nature of the TT with respect to the trough complexes. Drumlin fields are expected in localities with extensive glacial movement and erosion [9]. Kargel et al [1] attribute the lack of drumlin fields to resolution and illumination problems in the Viking images. The convexity of the TT leads them to hypothesize that the TT might have formed after the toughs during a period of glacial retreat.

Characterization Using New Data: Analysis of the two regions studied in detail by Kargel et al [1] using newer spacecraft data allows for the testing of the glacial formation hypothesis.

Arcadia Planitia. The general layout of the relevant regions of Arcadia Planitia agrees with the sketch map presented by Kargel et al [1] (Fig. 2); however, key differences are apparent. Data from the Mars Orbiting Laser Altimeter (MOLA) show that the trough system is larger, more complex, and more interconnected than evident in the Viking images. In addition, the "mounds" interpreted by Kargel et al [1] as kames are much more ubiquitous and much more correlated to the trough than noted in that paper. The quantity and the location of the mounds—frequently found directly within the troughs, completely blocking off the 'channel'—calls into question the interpretation of the troughs as subglacial drainage systems, as such systems would presumably flow around obstructions. However, the mounds could have formed after the trough system, or could have formed before the troughs and acted as local point sources of meltwater; therefore, the presence of the mounds does not preclude the glacial formation mechanism for local topography.

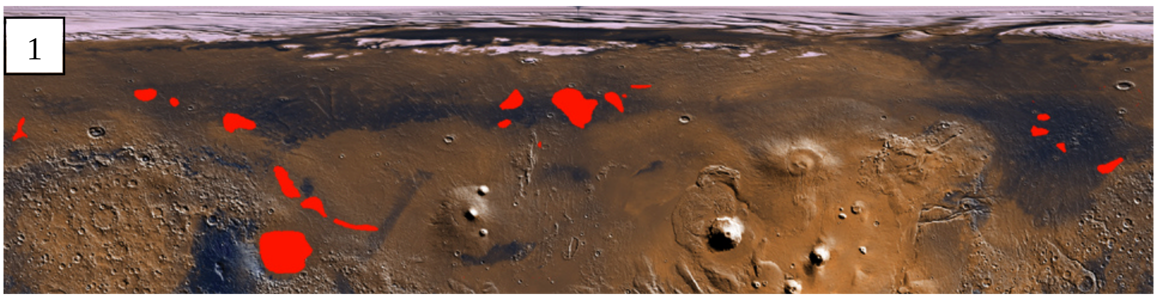
Utopia Planitia. As with Arcadia Planitia, analysis of Utopia Planitia with MOLA data principally confirms the sketch maps and analysis found within Kargel et al [1] (Fig. 4). One key feature lacking in previous discussion is the highly linear region of troughs noted in Fig. 4 (bottom left). The continuity and linearity of these troughs over tens of kilometers suggests a different formation mechanism than the sinuous, anastamosing troughs found elsewhere in Utopia and Arcadia Planitae. These troughs also cut across topography. A preferential salt-weathering mechanism such as that suggested by Selby and Wilson [1971] for Antarctic terrain, wherein remnant salts left behind by sublimed ice or snow weaken soil along preexisting fracture lines, may be a factor in the formation of these straight troughs [8]. Again, this mechanism is consistent with the context of a glacial formation for the local topography.

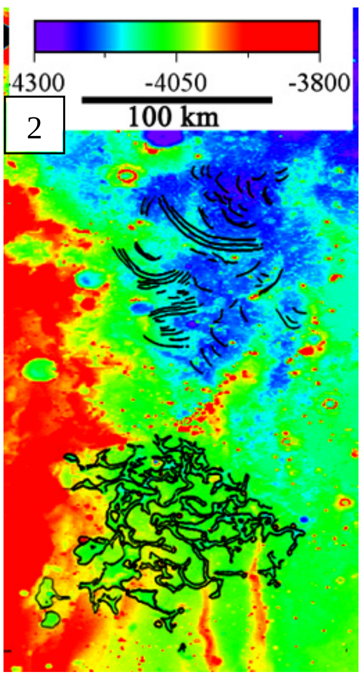
MOLA data also show that the more sinuous, anastamosing troughs in Utopia Planitia frequently appear to cut across topography. This may imply that, if the channels were formed by meltwater, the water must have still been underneath the glacier, generating the hydraulic head necessary to drive the water up- and across-slope.

Altimetry data show that individual ridges in the TT of both Arcardia and Utopia Planitae rise ~10-70m above surrounding topography, roughly 1-5km wide, and spaced every ~1-5km. These values for height and spacing are well within the broad ranges found for terrestrial moraines [9]. In places, ridges alternate with parallel curvilinear troughs ~5-20 m below surrounding topography. This may indicate that TT formed in depressions, giving areas between the appearance of being below surrounding topography, or it may indicate a different formation mechanism is carving out troughs.

Summary and Conclusions: Reanalysis of the work of Kargel et al. [1] based upon data from MOLA and other instruments principally supports the authors claims that the TT as well as the associated trough systems were formed by a glacial mechanism. MOLA data show that the trough systems consistently lie topographically above the TT; this implies that if they were they formed by the same glacier, the troughs must have formed before the glacier retreated and formed the TT. The absences of drumlin fields, noted by Kargel et al [1], is still noted in MOLA data; this may suggest that the glaciers responsible for forming the local topography were cold-based, and thus did not deform the substrate in a manner so as to form drumlins [10,11].

References: [1] Kargel et al., 1995, *JGP-Planets*, **100**, 5351-5368. [2] Chapman M., 1994, *Icarus*, **109**, 393-406. [3] Schaeffer M., 1990, *Icarus*, **83**, 244-247. [4] Rossbacher and Judson, 1981, *Icarus*, **45**, 39-59. [5] Kreslavsky and Head, 2002, *JGR-Planets*, **109**, 2686-2710. [6] Lucchitta B., 1981, *Icarus*, **45**, 264-303. [7] Scott and Underwood, 1991, *Proceedings of Lunar and Planetary Science*, **21**, 627-634. [8] Selby and Wilson, 1971, *GSA Bulletin*, **82**, 471-476. [9] Benn and Evans, 1998, *Glaciers and Glaciation*, Arnold Publishers. [10] Head and Marchant, LPSC 43, #1247. [11] Marchant and Head, LSPC 34, #1245. [12] Brennand and Sharpe, 1993, *Can. J. of Earth Sci*. **30**, 928-944.





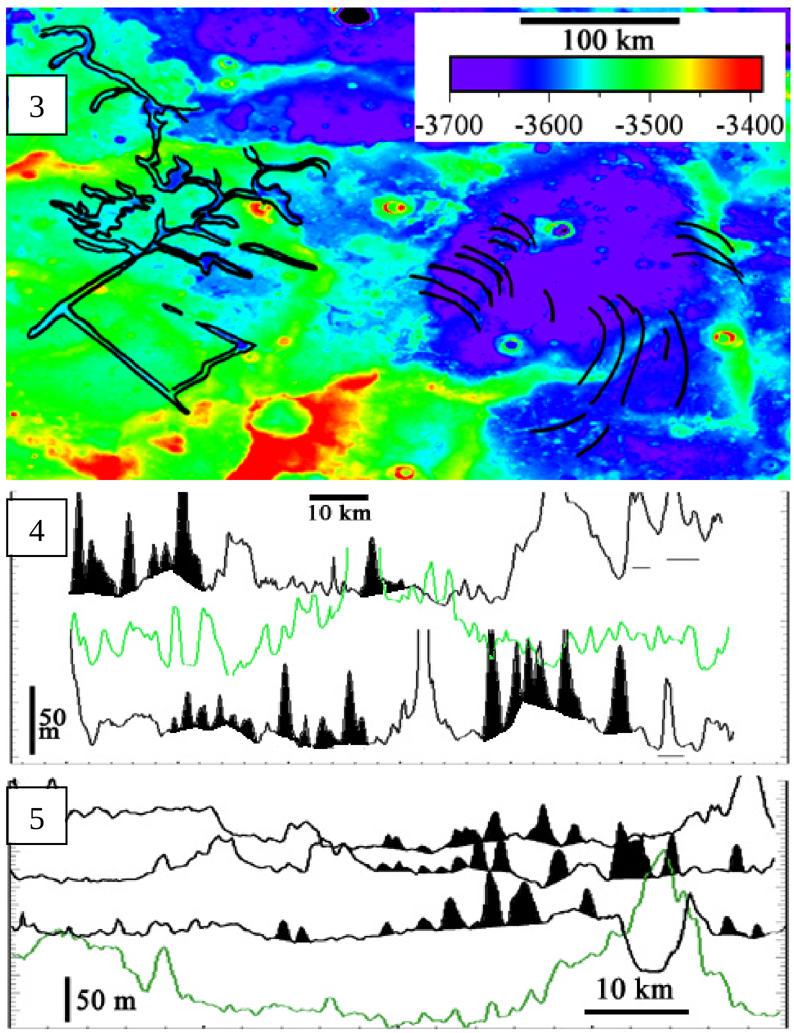


Figure 1: Map showing distribution of TT (red) in northern hemisphere. Adapted from [1]. **2**: Sketch map on MOLA Topography data of Arcadia Planitia superposed on Viking mosaic. Centered at 47˚ N, 183˚ W. **3**: Sketch map on MOLA data for Utopia Planitia. Centered at 50.5˚ N, 291˚ W. **4-5**: MOLA profiles for Arcadia (**4**) and Utopia (**5**) Planitae. Plots show similar MOLA tracks within (black) and immediately adjacent (green) to TT (solid pattern) at the same vertical exaggeration to show relative scale.