

**CENTRAL MOUNDS IN MARTIAN IMPACT CRATERS: ASSESSMENT AS POSSIBLE PERENNIAL PERMAFROST MOUNDS (PINGOS).** S. E. H. Sakimoto<sup>1</sup>, <sup>1</sup>Department of Civil Engineering and Geological Sciences, 156 Fitzpatrick Hall, University of Notre Dame, Notre Dame, IN, 46556, Email: ssakimot@nd.edu.

**Introduction:** Impact craters on Mars are a window into the martian surface and near-surface revealing local target properties as well as local geologic processes. The central peaks or mounds of martian impact craters are key indicators in determining these target properties and processes. Here, we show some of the range of non-typical crater central peaks and consider post-impact formation and modification origins for some or all of their topographic signature, with particular emphasis on pingo-like (perennial permafrost mound) modes of origin.

**Data and approach:** The typical central peak topography for martian impact craters has been well-defined (e.g. [1]), and some anomalies have since been studied as having probable post-impact major modifications, such as the layered stratigraphy in Gale crater [2], (see Figure 1), the broad central mounds of the north polar impact craters (e.g. [3], Figure 2 and Figure 3), and the pitted cones in the south polar region near Malea Planum (see Figure 4).

Recent work in the equatorial region of Mars has suggested that there is evidence for pingo-like or small perennial permafrost mounds in the Athabascan, Valles region [4,5] that may be tapping sources of water related to the proposed late Amazonian floods in the region (e.g. [6]). While these equatorial features are small (tens of meters), the globally mapped near-surface ground ice abundance [7,8] is also very low. These small features mapped by Burr et al., [4,5] are within fluvial channels, rather than impact craters. While the equatorial impact craters might have a larger potential groundwater or permafrost budget than the equatorial channels, the central mounds of impact craters in the equatorial regions generally show more apparent evidence of sedimentary filling and exhumation than of possible permafrost processes. For example, Gale crater [2, 9] and Figure 1, shows ample evidence of probable sedimentary stratigraphy [2, and others], and central peak rising above the rim elevations, and is superposed on the dichotomy boundary [9]. We are therefore considering polar impact craters for permafrost processes and pingo formation. The polar impact craters have profoundly different styles of central mounds than any other regions on Mars [3]. In the north polar region, these mounds occupy a large fraction of the crater floor, are roughly concentric to the crater center with a

usual shallower southern exposure (inverted in the south polar region) that suggests a significant volatile component lost through solar-driven sublimation (see figures 2 and 3). Several of the most pole-ward examples retain bright frost cover throughout local summer seasons, but regardless of such apparent surface frost, the topographic signature for polar region craters frequently includes these gentle central mounds, which are frequently difficult to detect in images due to their subdued topography and probable dust cover [3]. While these craters are clearly potential cold-traps for retaining frost and dust and thus accumulating layered central polar-like deposits, we suggest that these central mounds have a possible alternate origin as pingo-like features. In support of this, we have the overall mound-like shape, with a concentric low that is difficult to model with solely sedimentary accumulations, the generally systematic equator/poleward slope differences, with the mound slope facing the poles steeper than the equatorial slopes (suggesting possible uneven volatile losses). On earth, pingos come in hydrostatic (closed system pingos generally found in flat terrains with continuous permafrost) and hydraulic (open system pingos found in local basins or valleys) varieties. On Mars, the impact crater topography may well provide the hydraulic head and permafrost disruption (initial or topographic) to initiate pingo formation and growth. Long periods of permafrost action not generally available on Earth could explain their growth to such large sizes (an order of magnitude or more larger than terrestrial varieties). Pingo collapse can form summit pits within the mounds, as seen in the possible equatorial features discussed by Burr et al. [4,5]. There are at least several polar impact craters with pronounced central mound features with collapse pits, which were previously suggested as potential volcanic features (see figure 4). These may have alternate possible origins as perennial ground ice features. This study presents topographic characterization and modeling of several dozen polar impact crater central deposits as potential pingo features. And compares the scaling, possible growth times, and morphology to terrestrial features.

**References:** [1] Garvin et al., 2003, 6<sup>th</sup> International Conference on Mars, Abstract # 3277, [2] Edgett and Malin, LPSC Abstract # 1005, 2001, [3] Garvin et al., ICARUS, vol 144, pp329-352,

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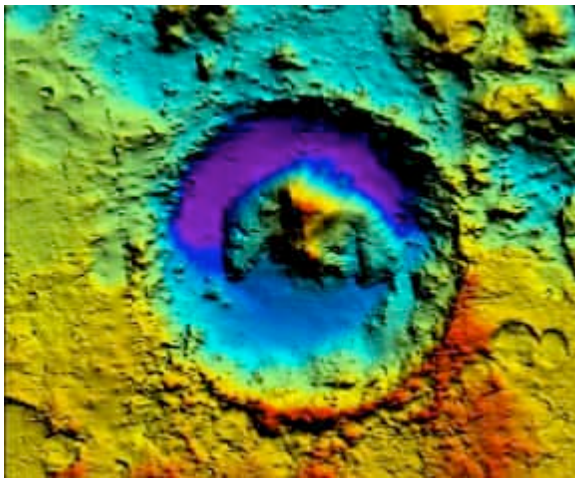


Figure 1. MOLA topography for the 155 km diameter Gale crater near 6S, 138E. The central mound rises nearly 5 km above the lowest floor regions, lies above much of the the rim, and shows clear signs of layering [ ].

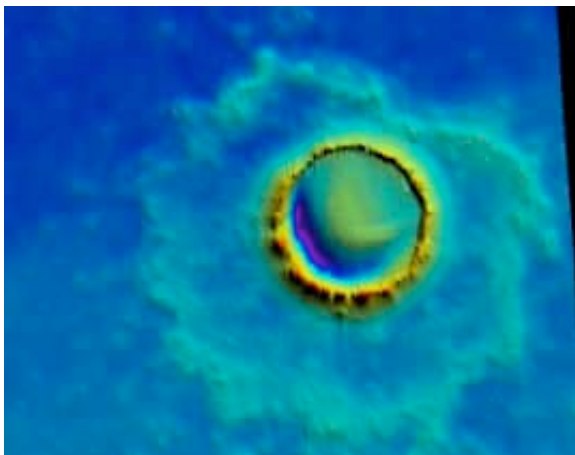


Figure 2 MOLA topography for a north polar region crater approximately 30 km in diameter near 77N, 90E with an asymmetric central mound 500 m

high. Note that central mound is ringed by a concentric depression.

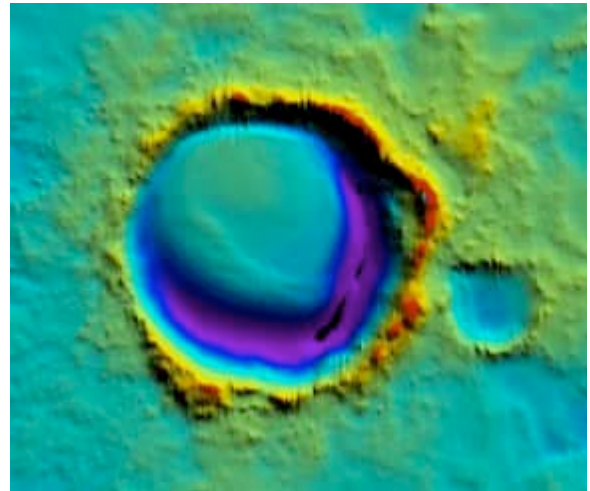


Figure 3. MOLA topography for a north polar region crater near 77N, 215E approximately 55 km in diameter with a asymmetric central mound filling much of the crater floor. Note that central mound rises 1.4 km above lowest current floor elevations, and is ringed by a concentric depression.

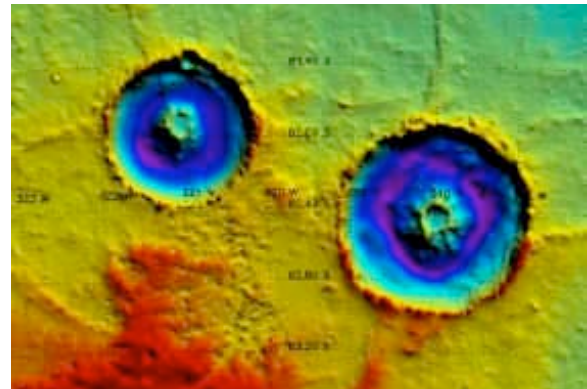


Figure 4. MOLA topography for two south polar region craters near 62S, 40E with central mounds with summit depressions. The left and right impact craters are approximately 50 km, and 65 km in diameter, respectively, with central mounds up to 1.1 km high.