

PERMAFROST AND ITS IMPLICATION IN 'LOUTH' CRATER (70.5N, 103.2E) OF MARS. H. Xie¹, S.F. Ackley¹, Z. Zeng^{1,2}, and F. Qiu³, ¹Laboratory for Remote Sensing and Geoinformatics, University of Texas at San Antonio, Texas, 78249, USA, Hongjie.Xie@utsa.edu, ²Faculty of Earth Sciences, China University of geosciences, Wuhan, 430074, P.R. China, ³School of Social Sciences, University of Texas at Dallas, Texas, 75083.

Introduction: Terrestrial permafrost regions cover about one-fourth of the Earth's land surface [1,2,3,4]. Polygonal-like features on Mars with morphology and scales very similar to Earth's ice-wedge polygons were first found by Viking [5,6] and much detail polygonal terrains have been imaged by MOC [7,8,9] and HRSC [10]. Basically, the size of the Martian polygon ranges from 7-300m and width of the wedges (or cracks) ranges from 1-5m, with shape of polygon mostly represented by hexagonal, orthogonal, and rectangular geometry. [10] suggests that Martian polygonal features were most likely formed due to the process of thermal-contraction cracking in ice-rich sediments, meaning the polygonal terrains on Mars may serve as an indicator of ground ice or ice-rich regolith. The main mechanism of polygonal formation is the frost cracking process provoked by thermal contraction in the icebearing deposits [10]. The frost cracking process is responsible for the formation of the ice-wedge polygons as the contraction cracks are repeated along the same fracture plane annually in cold seasons [10]. High Resolution Imaging Science Experiment (HiRISE) camera onboard the Mars Reconnaissance Orbiter (MRO) spacecraft has provided unprecedented detail information (sub-meter pixel) about diverse volcanic terrains, polar layered deposits, and polygonal terrains [11,12,13,14].

Water Ice in 'Louth' Crater: A water ice body and small patches in the 'Louth' crater (70.5N, 103.2E) were first imaged (on 2/2/2005, $L_s = 153.7^\circ$) and reported through the HRSC on board ESA's Mars Express spacecraft. [15] did a preliminary analysis based on THEMIS visible and thermal data and found that the major high albedo water ice only appears on the central peak of the crater in both am and pm during the later spring to later summer seasons. Based on this crater and many others, [16] proposed a conceptual model to explain the high albedo phenomenon and suggested that a relatively permanent water ice body is a must condition for the seasonal change of high albedo phenomena in the later spring and summer times, while temperature and sublimation/deposition of H₂O/CO₂ frost actually control the seasonal change of the albedo. The water ice body was left after the recession of the last polar ice cap advance. The rest of the floor is covered by sediments from crater wall/rim and wind-blown dust/sand, while the water ice on central peak has been continuously exposed due to less sediments toward the central peak of the crater. The region is usually covered by the CO₂ frost during fall and winter seasons when temperature less than the CO₂ freezing point (150K).

HiRISE and Polygonal Features: Two HiRISE images acquired on 11/11 and 12/6, 2006 are available for the study (<http://hiroc.lpl.arizona.edu/images/PSP/>). Polygonal features are found and examined in detail. Figure 1 is an index map showing the footprints of the two HiRISE images and locations of sub-scenes examined and described in detail in Figures 2, 3, 4 and 5. Small ice-wedge (1-2m) and polygonal (10-15m) systems appear mostly everywhere of the northern portion of the crater floor (HiRISE 2), while larger polygonal (70-80m) and ice-wedge (3-5m) features only appeared in areas starting from boundary (or transition zone) between water ice body and permafrost to 1-2.5km away, with one edge approximately parallels to the boundary between the water ice and the rest of the floor. Subscene "c" was found rich in scattered rocks and boulders (1-3m in diameter, a completely different event from the polygonal formation) similar as found in one of the planned Phoenix landing sites [17]. In subscene "i" (Figure 3), the low albedo region of the northeastern portion of the water ice body shows a well-developed dune field. Water ice patches/frost are seen in some of the dunes, which suggests that the water ice body was once covered the dune field, but probably very thin (less than 1 m) and gradually evaporated. This dune field is very similar to those in many craters (e.g. the Victoria crater at Meridiani Planum). Figure 4 shows the transition zone between the dune field and the polygonal features. The extensions of the dune field and major ice wedge are perpendicular, indicating a different mechanism of formation: wind-blown and permafrost. HiRISE 1 (Figure 5) differ from HiRISE 2 (Figure 2) in two ways: (1) polygonal features are not well developed while wedges are more irregular (with most 1-2 m, some 3-4m, a few up to 20 m in width) and (2) small water ice/frost patches (most 1-6m, few up to 25m across) scattered everywhere with some along the wedges or within the wedges and most in between.

Discussion: As proposed in the conceptual model [16], while water ice body exposed in the central peak of the crater, the majority of the water ice body was actually covered by sediments elsewhere on the crater floor. For most of the time, temperature in the crater was less than the H₂O freezing temperature (200K), while during most of the fall and winter seasons, the temperature in the crater was even less than the CO₂ freezing temperature (150K). So the H₂O and CO₂

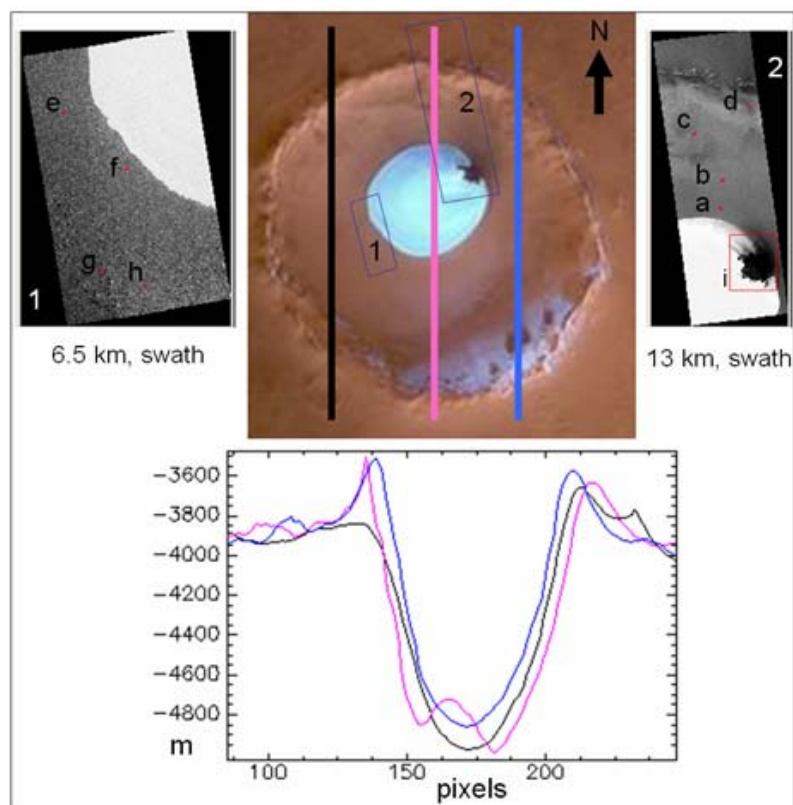


Figure 1. The HRSC (orbit 1343) true color image (courtesy G. Neukum) in the upper center with 3 MOLA profiles (black, red, and blue) and two HiRISE footprints (1 and 2); HiRISE 1 (PSP001370_2505) of the upper left (Ls=133.7, pixel size =25 cm, the Sun shine from west direction, acquisition time 15:00 pm, 11/11/2006); HiRISE 2 (PSP001700_2505) of the upper right (Ls=146.4, pixel size =50cm, the Sun shine from west direction, acquisition time of 15:23 pm, 12/6/2006); bottom plots are the MOLA elevation profiles associate with black, red, blue lines on the HRSC image. a through i on the HiRISE images corresponding to subscenes in Figures 2,3,4,5.

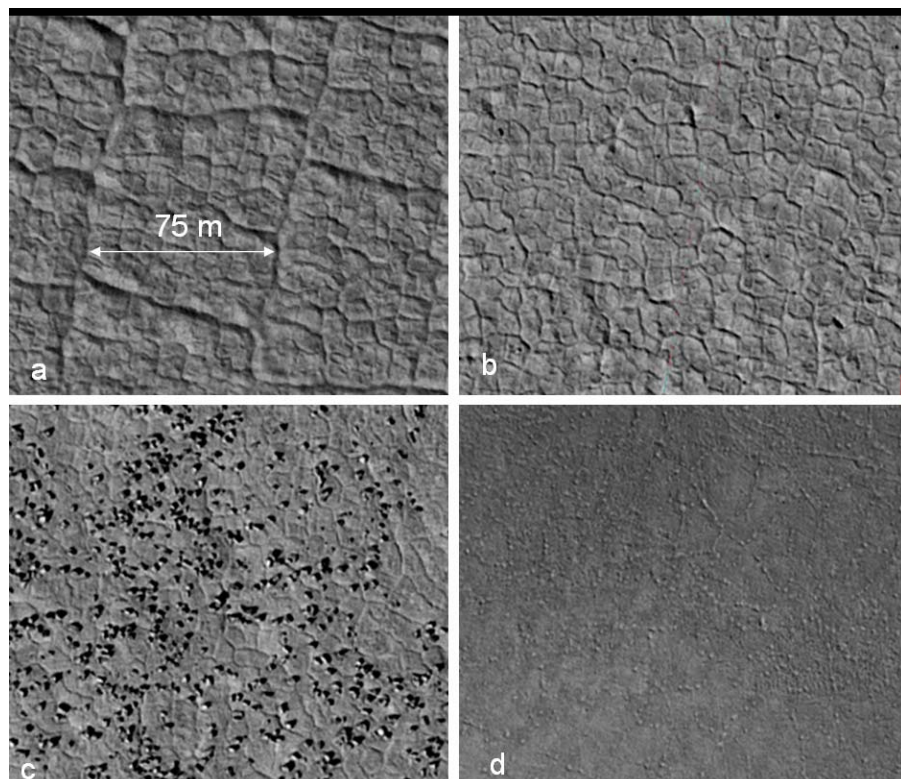


Figure 2. Subscenes of “a” through “d” of HiRISE 2 (Figure 1). “a” small polygonal-like feature 10-15 m with ice-wedges (or cracks) of 1-2 m wide (shallow and young) bounded by large ice-wedge (deep and old) of 3-5 m and polygon of 70-80 m across; “b” small polygon and small ice-wedge network; “c” small polygon and small ice-wedge network with rich rocks of 1-3 m in diameter; “d” similar small polygon and small ice-wedge but much shallower than wedges in a,b,c.



Figure 3. Subscene of “i” of HiRISE 2 (Figure 1) showing the low albedo region in the northeastern corner of the water ice body on central peak. The low albedo region is a sand dune field. Water ice/frost clearly seen in some of the dunes. The red rectangle is 450 x 375 m and enlarged in the figure 4.

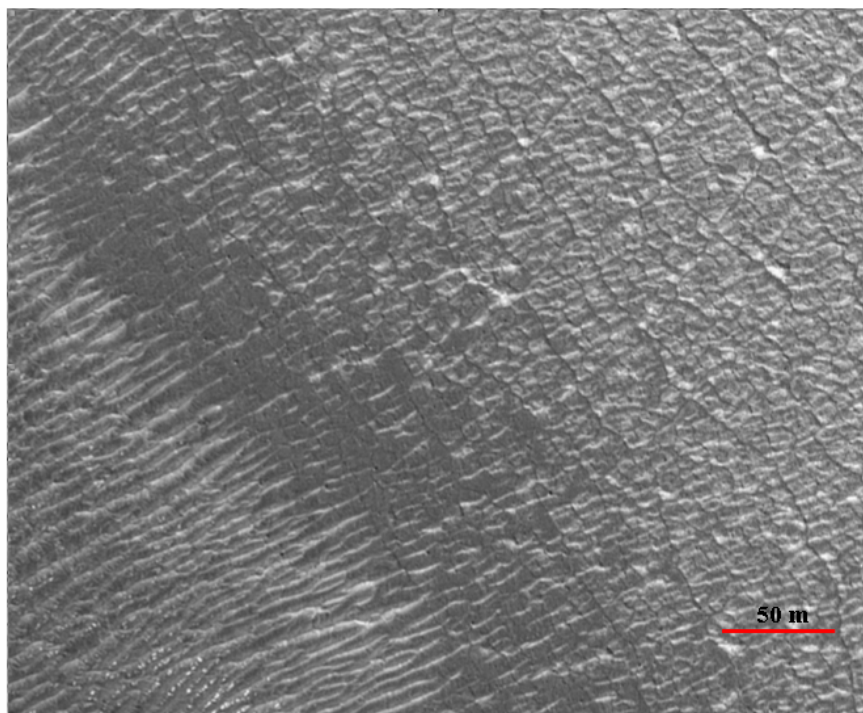


Figure 4. Subscene of figure 3 showing the transition area between the dune field and the polygonal features. The extension direction of the dune field and the major wedge extension are perpendicular.

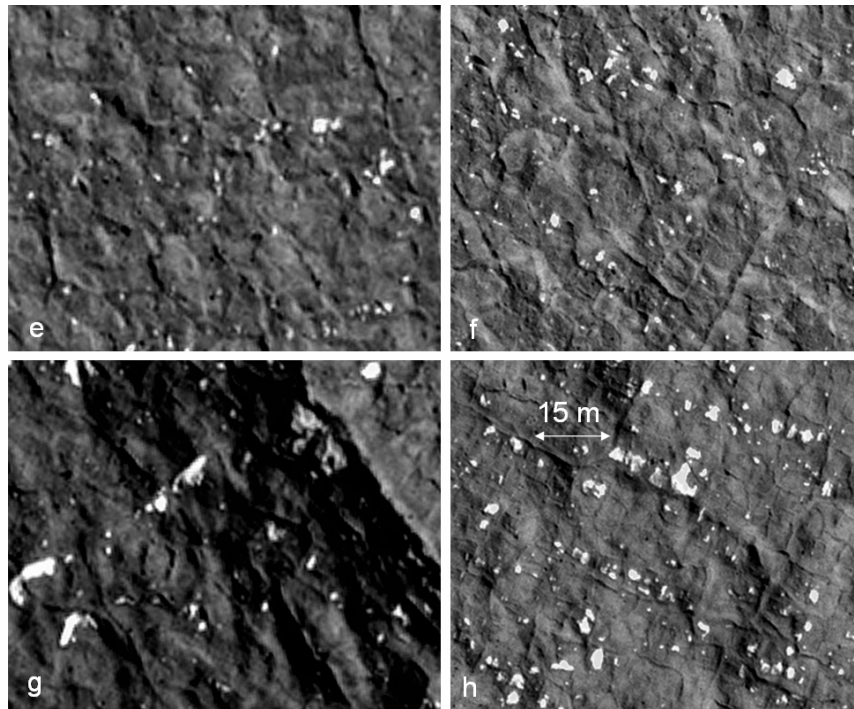


Figure 5. Subscenes of images “e” through “h” of HiRISE 1 (Figure 1). “e,f,g,h” are very similar each other with small ice patches scattered (usually between 1-6 m across), most ice-wedges of 1-2 m, some 3-4 m in width, up to 20 m in “g”. polygons are not well developed, except in “h” with some polygons of 6-9 m across.

frost cracking process was responsible for the formation of the ice-wedge polygons as the contraction cracks were repeated along the same fracture plane annually in cold seasons. The different phenomenon (in very similar season of the year) found between north (HiRISE 2) and south (HiRISE 1) portions of the crater are probably mainly due to different depths of the permafrost tables from the surface. In the north, the depth seems much larger compared to the south portion, i.e. the water ice body in the south is closer to the surface due to less sediment deposits. This is the reason why we see many water ice patches exposed on top of the sediments. [18] explained that the water ice patches were a result of melting due to possible global warming of Mars, for which we argue that global warming should first melt the water ice on the central peak before the rest of the crater floor, since the peak should receive more solar radiation than the rest of the floor and should melt before the rest of the floor. But this is not the case. However, in the north portion, the water ice body is relatively deep and the polygonal and ice-wedge system was developed very well. No water ice patches are exposed there. We suggest that the sand dune field was originally covered or partially covered by the water ice body (possibly very thin) and eventually exposed due to the water ice melting/evaporation. There is no development of polygonal features in the sand dune field, which infers that there is no ground ice underneath the sand dune system (even if there is a

water ice body, but it should be very deep, so the permafrost system could not develop).

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