POSSIBLE ICE-WEDGE POLYGONS IN UTOPIA PLANITIA, MARS, AND THEIR POLEWARD LATITUDINAL GRADIENT. R.J. Soare,[1] S.J. Conway,[2] L.E. Mc Keown,[3] J-P. Williams,[4] E. Godin,[5] and J. Hawkswell.[5] [1]Geography Dept., Dawson College, Montreal, Canada (rsoare@dawsoncollege.qc.ca), [2]CNRS UMR 6112, LPG, Nantes, France, [3]School of Natural Sciences, Trinity College Dublin, Ireland, [4]Dept. of Earth, Planetary & Space Science, UCLA, Los Angeles, USA, [5]Dept. of Earth Sciences, Western University, London, Canada.

Introduction: Here, we describe and evaluate: **a)** the presence and distribution in Utopia Planitia (*UP*), Mars (~40-50º N, ~110-124º E), of small-sized polygons, (~10-25 m in diameter), with low centres (*lcps*) or high centres (*hcps*) relative to their margins; **b)** the spatial, perhaps periglacial, association of these polygons and thermokarst-like depressions or basins; and, **c)** statistical data that support the hypothesis that ice-wedges underlie *lcp/hcp* margins.

***LCPs/HCPs* on Earth**: Geographically-expansive complexes of ice-wedge polygons (be they *lcps* or *hcps*), thermokarst, thermokarst lakes and alases, i.e. thermokarst depressions of basins absent of water, are commonplace in the Tuktoyaktuk Coastlands (*TC*) of northern Canada and the Yamal peninsula (*YP*) of eastern Russia [**1-4**]. In these and similar arctic-regions surface/near-surface water is abundant, freeze-thaw cycling is ubiquitous and the permafrost is ice-rich to depth [**1-4, Fig. 1**].

Ice-rich permafrost comprises *excess ice*: "the volume of ice in the ground which exceeds the total pore-volume that the ground would have under natural unfrozen-conditions" **[5]**. Ice lenses, veins, wedges or larger masses of consolidated ice are typical examples of excess ice **[5]**.

Thermokarst comprises excess ice. This makes it particularly sensitive to volumetric inflation as ice aggrades, when mean temperatures remain stable or fall, or volumetric deflation as ice degrades, when mean temperatures rise and meltwater is evacuated by drainage or evaporation from the thaw zone.

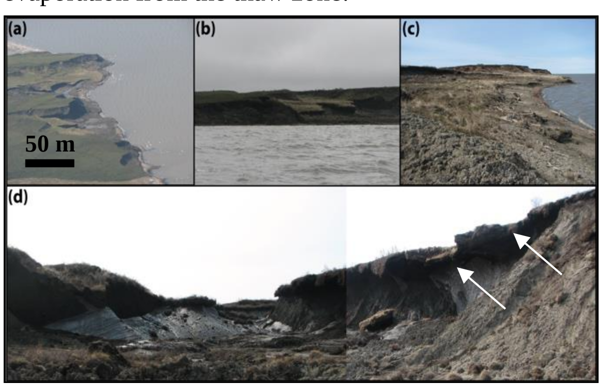

Fig. 1. Near-surface ice and ice wedges at Peninsula Point, SW of Tuktoyaktuk: **(a-c)** recessional terraces resulting from thermal destabilisation of coastline. **(d)** Surface depressions above degrading ice-wedges; massive-ice exposures centre/centre left. Image credit, R. Soare.

Spatially-associated assemblages of *lcps* and *hcps* also are geological markers of climate change. Stable or falling mean-temperatures engender ice-wedge aggradation and the uplift of polygon margins. Rising mean-temperatures induce ice-wedge degradation and the collapse of uplifted margins, giving these polygons a distinctly high-centred appearance **[1-7]**.

Sand or soil-sand admixtures also are associated with polygon-margin fills and may generate individual fields of *lcps* and *hcps* **[**e.g **7]**. The closely-set spatial association of *lcps* and *hcps* in *wet* periglacial-landscapes on Earth, however, often is indicative of ice-wedge polygons, albeit in disparate phases of evolution.

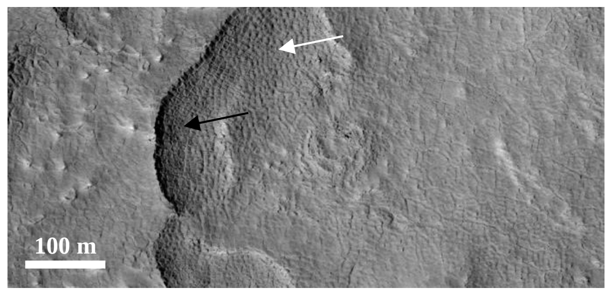

Fig. 2. Possible thermokarst/polygon complex in *UP*. *LCPs* adjacent to scarp on left side of image (black arrow); *HCPs* above and to the right (white arrow) (*HiRISE* ESP_026094_2250; 44.657º N, 111.415º E). North is up. Image credit, *NASA/JPL*/Univ. of Arizona.

LCPs/HCPs* in *UP: The presence of *lcps/hcps* at the mid-latitudes of both Martian hemispheres, as well as the spatial and possibly periglacial-association of these polygons with alas-like landforms **(Fig. 2)**, are noted in the literature **[**e.g. **8-12]**. On the other hand, questions concerning the range, density or sparcity of *lcp* and/or *hcp* distribution in *UP* **(Figs. 3-4)** have not been explored fully.

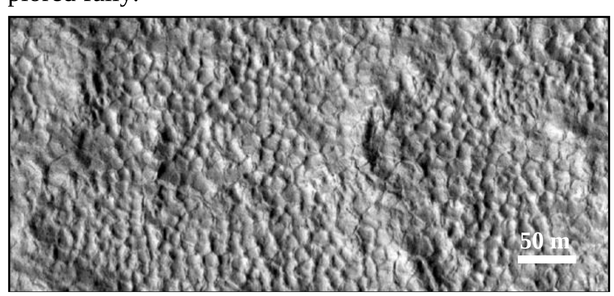

Fig. 3. Dense distribution of *lcps* near crater central-peak (*HiRISE* ESP_011523_2235; 42.953º N, 115.670º E). North is up. Image credit, *NASA/JPL*/ University of Arizona.

One of the keynotes of our study is evaluating the ratio of *lcp/hcp* distribution by latitude. If a statistical analysis of this distribution shows that the presence of *lcps* as well as the ratio of *lcps/hcps* increases polewardly, then this would be consistent with and corroborative of the polygons being underlain by ice wedges. Mean temperatures fall with latitude and also have diurnal variances that are narrower. As such, the stability of near-surface ice rises with latitude **[14]** and the greater presence of *lcps* at higher vs lower latitudes would be expected were the latter underlain by ice wedges.

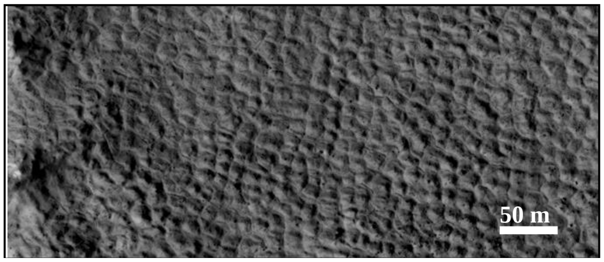

Fig. 4. Dense distribution of *HCPs* on equator-facing crater-wall with alas-like depressions (not shown here) (*HiRISE* ESP_018960_2240; 43.468º N, 116.999º E). North is up. Image credit, *NASA/JPL*/Univ. of Arizona.

Methods: All *HiRISE* images in our study region (*N*=109) were used in this ongoing study. This area exhibits wide-ranging spatial assemblages of possible ice complexes, possibly originating in the Late Amazonian Epoch **[**e.g. **8-12]**.

Data sets comprised of lower-resolution images were not used. This is because the elevated shoulders and depressed marginal-troughs associated with the *lcps* or *hcps* are metres to sub-metre in scale and can be resolved clearly only with *HiRISE* imagery (~25-50 cm/pixel).

Each *HiRISE* image was gridded into 403 (13x31) boxes of equal area. In order to avoid operator (interpretive) error or bias introduced by extremely-localised boundary conditions that could generate thermal anomalies, five or more *lcps* or *hcps* per box were required for a confirmed presence to be noted. Each box was recorded as a datapoint and the corresponding central-latitudes of the *HiRISE* images were noted. A total of 31 *HiRISE* images showed *lcps*, *hcps* or both.

Results: Our image analysis and evaluation of *lcp/hcp distribution* produced three key findings:

1) *hcps* occur more frequently than *lcps.*
2) *lcps* are widespread but occur only where *hcps* also are observed.
3) The ratio of *lcps/hcps* increases polewardly with latitude (**Fig. 5**). This is consistent with the hypothesised increase of stable near-surface ground ice with latitude **[**e.g. **13-14]**.

Discussion: Antecedent hypotheses favouring the possible presence of ice-wedge *lcps* on Mars have been weakened by the morphological similarity of and possible equifinality between Martian *lcps* and terrestrial sand-wedge polygons [e.g. **7**]. Additionally, although Martian *lcps* exhibit spatial association with other possible *wet* periglacial landforms and landscape features, i.e. *hcps* and alas-like depressions, present-day Martian atmospheric conditions are inconsistent with current regional or sub-regional freeze-thaw cycling of water [e.g. **15**].

We propose that the synonymity between the general increase of *lcp* distribution with latitude in eastern *UP* and expectations of ground-ice stability at poleward latitudes indicates that *lcp* margins are underlain by ground ice. In turn, this suggests that atmospheric conditions consistent with the freeze-thaw cycling of water cannot be ruled out at the time of *lcp* formation in the geologically recent past.

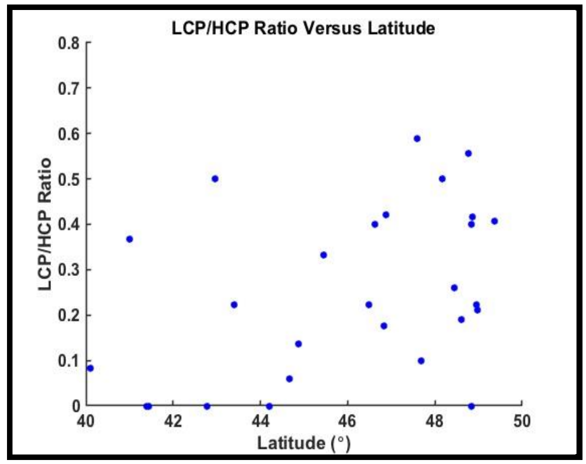

Fig. 5. Plot that shows increase of *lcp/hcp* ratio with poleward latitude. Pearson's *R* coefficient = = 0.21. This is a weak but promising correlation that could be strengthened by carrying on with our work in an expanded study region.

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