COMPARATIVE INVESTIGATION OF POLYGON MORPHOLOGY WITHIN THE HAUGHTON IMPACT STRUCTURE, DEVON ISLAND WITH IMPLICATIONS FOR MARS. J. E. Hawkswell[1,2] E. Godin[1], G. R. Osinski[1,2], M. Zanetti[1], and A. Kukko[3]. [1]Department of Earth Science/Centre for Planetary Science and Exploration, University of Western Ontario, London, ON, Canada, N6A 5B7 jhawkswe@uwo.ca, [2]Department of Physics and Astronomy, University of Western Ontario, London, ON, Canada, N6A 5B7. [3]Centre of Excellence in Laser Scanning Research, Finnish Geodetic Institute

Introduction: Devon Island, located in the Canadian High Arctic (75.1982° N, 81.8512° W) is in the continuous permafrost zone where periglacial features are widespread [1]. Patterned ground, and specifically ice-wedges polygons, are periglacial features of interest that can provide insight into past climate, water availability, and geologic substrate on both the Earth and Mars [2,3]. In this study we investigate polygons found in the area of the Haughton Impact Structure (HIS), a 23 km wide well-preserved impact crater on Devon Island [4]. The Haughton Impact Structure is found in a High-Arctic polar desert climate and has often been considered an ideal analogue site for Mars [3,4]. Patterned ground and ice-wedge polygons are commonplaces at the HIS, and are primarily thermal contraction polygons of various morphologies [5]. Polygons of various types are also found ubiquitously across mid-latitude Martian terrain [6, 7] and are of interest as they are indicative of thermal contraction and potential presence of water-ice [1]. This research focuses on sites within the area of the HIS that display significant variation in polygon morphology, and we seek to understand characteristics (e.g., geology, grain size, sediment horizons, active layer depth and hydrology) and other factors that influence the variation of polygon morphology. By better understanding local polygon variation we can adapt our ground-truth observations to variants observed on Mars.

Field Sites: In this preliminary case study we consider sites are 1) The Haughton Formation (HF) consisting of high-centered ice-wedge polygons (hcp) within Miocene-aged lake sediments and 2) Lake Orbiter consisting of low-centered polygons (lcp) and flat polygons in well sorted fluvial/fluvio-glacial dolomites [5]. Two other sites (Ice-wedge polygons formed in impact melt breccia polygons and those surrounding Lake Comet are also under investigation, but not reported here). The two sites are located with ~8 km of each other and experience much of the same climatic conditions [8].

Methods: Field work was conducted in late July 2017, after snowmelt and when the ground-thaw depth was approximately equal to the active layer depth. Soil pits were dug to observe changes in sediment with depth and for sample collection. The active layer depth was measured using a steel probe and pits dug in several locations at each site. Each site was mapped with high resolution drone images (for image context and stereophotogrammetry), tripod LiDAR Scans (using a new Polaris instrument supplied by Teledyne Optech), and a novel backpack-mounted Kinematic Mobile LiDAR scanner (KLS) (developed by at the Finnish Geospatial Institute) [9] scans were collected at each site to investigate morphology and morphometry. By using multiple topography measuring instruments we have created the highest-resolution digital terrain models (~1 – 5 cm/pixel) ever created of ice-wedge polygons, covering nearly 2 acres across the 4 sites. Satellite (0.46 m) (2013) and airborne imagery (2007, 2008, 2016) was also used for pre- and post-field mapping, co-registration of topographic data, and morphometric analysis.

Results: *Haughton Formation (HF) Polygons:* The HF is a low lying, terraced area with streams running across low ground throughout the formation. The site (Fig. 1) displays hcp ranging from 20—30 m in diameter and are set in fine-grained silts and sands. The polygon contours are mostly orthogonal with some geometric irregularity (more regular than site 2) and well defined by deep troughs 1-5 m wide and 0.5—1 m deep (Table 1). The polygons are heavily degraded with edges crumbling easily. Pooling water was found in some trough junctions. Light vegetation (grasses and moss) cover much of the polygons. The thaw depth ranges from 21 cm—68 cm deep in the polygon centers and 28 cm—55 cm deep in the troughs.

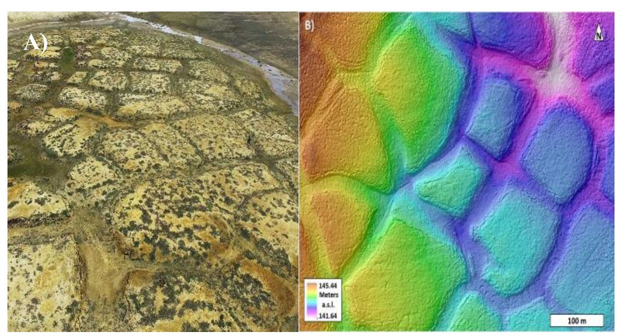

Figure 1a. Airborne (20 m) image of the Haughton Formation polygon field. Medium-large degraded hcp seen ubiquitously across the study site. Small stream borders polygon field in top right. Polygons are ~30 m. 1b. High resolution LiDAR scan image of the same area made by combining Polaris and KLS.

Orbiter Lake Polygons: Lake Orbiter (Fig. 2) displays 20-50 m diameter thermal contraction polygons distributed throughout the low-lying plain surrounding the small lake (Table 1). The plain consists of small-medium sized well sorted pebbles and cobbles. The south section of the plain has a collection of lcp with pooling water in some centers seen well in LiDAR scans (Fig. 3). The polygons junctions are mostly orthogonal with significant geometric irregularity and have narrow troughs with poorly defined 10–20 cm trough rims (Table 1). The troughs of the polygons range from 30—50 cm deep and some troughs and junction pits contain pooled water. Lake Orbiter has no vegetation cover and is surrounded by small streams except on the east side which has the lake.

Figure 2. Airborne (20 m) image of Lake Orbiter polygon field. Large thermal contraction polygons are seen along the bottom and right side. Lcp seen in top left with pooling water in some centers ATV for scale bottom-middle.

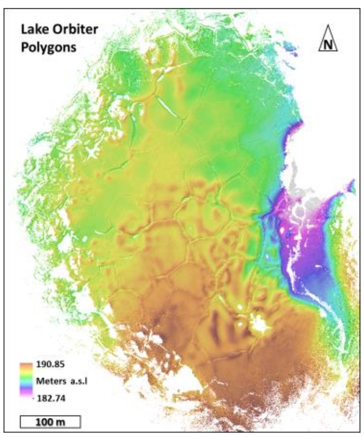

Figure 3. LiDAR image of Lake Orbiter made using a combination of Polaris LiDAR and the KLS.

Discussion: The polygons at the two field sites are significantly different. The degradation of the hcp at HF creates a stark contrast to the flat and low-centered polygon field at Lake Orbiter. The differences in morphology likely lie within the depositional environment, sediment type and water availability. The depositional environments of a drained lake versus glacio-fluvial make for much finer sediments at HF than at Lake Orbiter. Such a contrast in sediment type enables changes in possible ice development conditions such as ice lensing, size of the ice wedges or limited by water availability, having major implications for polygon morphology. Both sites are relatively low lying and bordered by small streams that likely input

Table 1. Main attributed of the Haughton Formation and Lake Orbiter field sites.

	Haughton Formation	**Lake Orbiter**
Polygon type	Degraded high-centered	Flat and low-centered ice wedge
Depositional Environment	Lacustrine (drained)	Alluvial / fluvio-glacial
Size Range	20 –30 m	20 –50 m
Substrate Material	Fine grained lacustrine sediments with organic rich layer at depth	Coarse gravel within a sandy matrix. Richer in finer sediments with depth. Gravel present throughout
Trough Depth	0.5 –1 m	0.3 –0.5 m
Thaw Depth	42 –56 cm	45 –50 cm

sediments and water during summer melt. Detailed analysis of morphometry using high resolution LiDAR data is ongoing.

The lessons learned from this study will be applied to variations of polygons observed in Utopia Planitia on Mars. Initial investigations in Utopia Planitia show both high and low-centered polygons approx. 5-10 m in diameter within a small area. Investigation of highly detailed LiDAR of the field sites will continue alongside subsurface data to support interpretations of depositional environment and factors such as water and ice availability and active layer depth influencing polygon morphology. Research using Earth as an analogue for Mars will contribute to a greater understanding of the Martian surface and how water and ice may have played a role in the formation of periglacial landscapes on Mars.

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