IDENTIFICATION OF PERIGLACIAL FEATURES NEAR GULLY ALCOVES AT THE HAUGHTON IMPACT STRUCTURE: ROLE OF GROUND-ICE MELTING IN GULLY EVOLUTION. V.G. Rangarajan[1,2], G.R. Osinski[2], E. Godin[3] and L.L. Tornabene[1,2], [1]Institute for Earth and Space Exploration, University of Western Ontario, London, ON, Canada [2]Dept. of Earth Sciences, University of Western Ontario, London, ON, Canada (vrangara@uwo.ca), [3]Centre d'Études Nordiques, Université Laval, Québec, Canada.

Introduction: The Haughton impact structure is a 23-km diameter complex impact crater formed ~31 Ma on Devon Island, Canadian High Arctic [1]. It is one of the most well-preserved complex impact craters on Earth and is often considered as a terrestrial analogue for Mars [1,2]. Gullies have been previously identified within the Haughton River Valley (i.e. HRV) [e.g., 3,4]. The best morphologic examples are observed to incise into Bruno Escarpment comprised of erosional remnants of the impact melt rocks that unconformably overlie uplifted target rocks (Fig. 1). These well-formed gullies have been interpreted to post-date the last major glaciation event in Devon Island. Present-day gully modification has been attributed to melting of seasonal snowpack [3] and/or ground ice [4]. A statistical analysis of these gullies using high resolution remote sensing data was also presented by [5], which suggested gully morphology was greatly influenced by the type of rock it incised into (i.e. either impact melt rocks and/or bedrock), and presence of secondary water sources.

This contribution reports on the results of a field campaign to the Haughton impact structure in the summer of 2022 to ground truth previous satellite-based observations [5] and supplement them with field based inputs.

Methods: A field campaign to survey these gullies was conducted from July 1 to July 13, 2022. 149 (out of the 214 previously mapped) gullies were assessed in-situ for: (i) overall gully morphology (simple/complex), (ii) head alcove characteristics (gully incising materials, presence/absence of snow pack,), (iii) presence/absence of periglacial features near/bisecting the head alcove, and (iv) gully deposit characteristics (average debris particle size and composition). Additionally, high resolution multispectral and LiDAR images were also acquired from a drone over the HRV. These were acquired at a resolution of ~4-5 cm/pixel, twice during the field season – on July 1 and July 12, 2022. 2D and 3D mosaics were also produced from individual drone images using the DJI Terra software package.

Results: *General gully characteristics.* While most of the target materials west of the Haughton River are predominantly impact melt rocks, the eastern side of the river has outcrops that are a combination of melt rocks and uplifted bedrock, that served as incising materials for gullies. In general, the melt rocks are observed to be more massive and homogenous than the uplifted bedrock, and hence are easily erodible. Gullies west of the river are observed to have shallower slopes and are typically longer, as compared to those on the eastern side of the river valley. This may be attributed to the naturally steeper slope of the outcrops on the eastern side of the HRV, due to recent and ongoing erosion by the Haughton River. Additionally, in the case of complex gullies with multiple alcoves, greater volume of snow pack was observed to linger on north- and east-

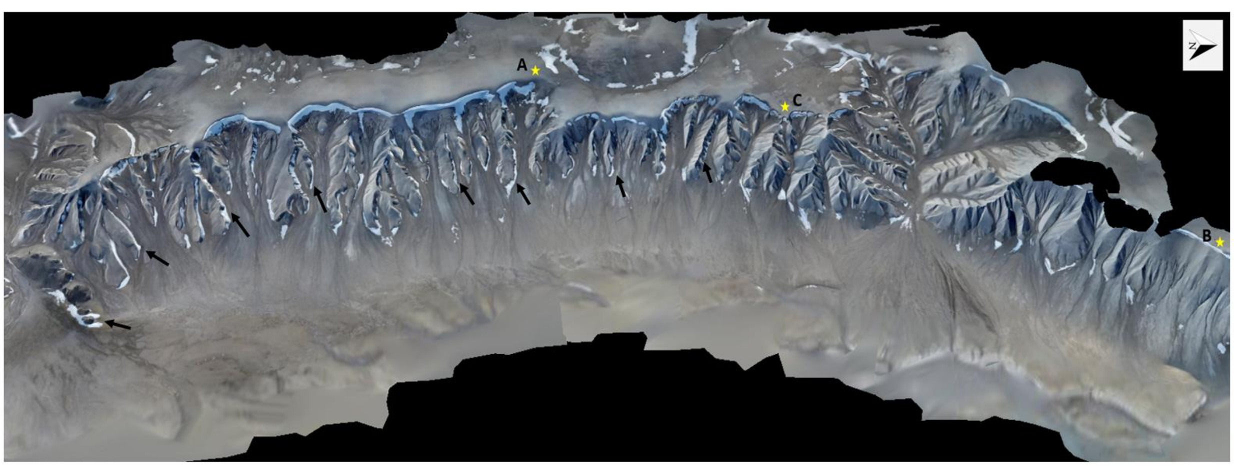

Figure 1. 3D view of the gullies on the western side of the Haughton river valley. This 3D model was generated by mosaicking 1275 drone images acquired on July 1, 2022. The black arrows show a few examples of lingering snow pack on north-facing slopes observed in the escarpment. Labels A, B and C denote locations of the periglacial features described in Figure 2.

facing slopes (Fig. 1), resulting in greater gully activity downslope from these orientations. Most gullies are also observed to be debris-flow dominated, with a gradual reduction in debris particle size observed along the channel slope.

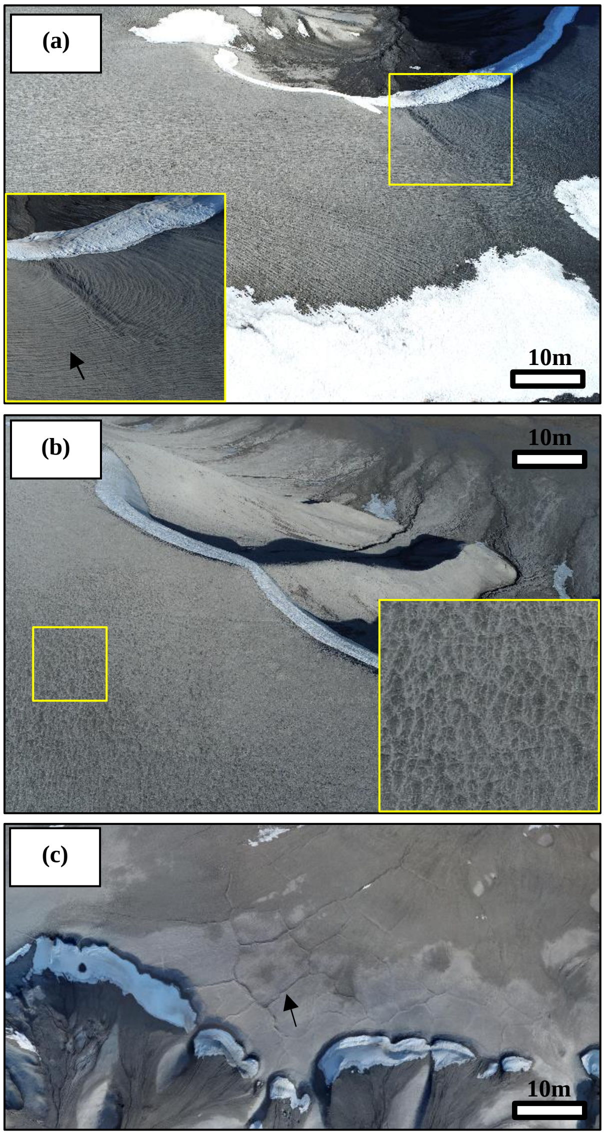

Figure 2. Examples of (a) periglacial stripes, (b) small-scale patterned ground and (c) thermal contraction polygons observed near the gully alcoves west of the Haughton River. Zoomed-in views of features in (a) and (b) are also provided. (a)-(c) are drone images acquired on July 1, 2022. For better context, locations of these features are labeled in Figure 1.

Periglacial features. We identified a variety of periglacial features near gully alcoves west of the HRV from our field survey. Some of these features were identified for the first time, possibly due to their sub-resolution scale for satellite imagery, and hence could not be well-characterized by previous satellite mapping campaigns [e.g., 4, 5]. We identified three types of features in the area: (i) periglacial stripes (Fig. 2a), (ii) small-scale patterned ground (Fig. 2b), and (iii) thermal contraction polygons (Fig. 2c).

While there has been no spatial correlation established between specific gully morphology and the type of periglacial feature near the alcove in past studies, we find that patterned ground (Fig. 2b) and periglacial stripes (Fig. 2a) seem to be the most common features, with their presence recorded near ~40 and ~43 of the surveyed 149 gullies, respectively. [4] had previously shown evidence of well-defined polygons intersecting gully alcoves east of the river. Similar observations of well-defined thermal contraction polygons were also made in the west of the river valley (Fig. 2c). Some regions also exhibit poorly developed polygons. In most such cases, they were accompanied by other periglacial features, like patterned ground and stripes. These observations suggest that, apart from transient snow-melt at the onset of summer, some fluid from the melting of ground-ice and permafrost may also drive debris-flow activity during the short summer months.

Discussions: Satellite observations are limited by the quality of data (resolution, cloud cover, illumination, etc.) – hence, inputs from field observations are critical to enable a complete and holistic assessment of gullies. It is clear that snow melt has played a major role in evolution of these gully systems and greater snowpack is observed preferentially on north- and east-facing slopes. Consequently, gullies in those orientations are more developed, and are observed to have greater activity. Additionally, our observations of a variety of periglacial features closely associated with gully alcoves, presented here, show that, apart from snowmelt, ground ice may also have played an important role in formation and evolution of these gully systems. Inferences from this work regarding the contribution of ground ice to gully evolution could point towards a comparable process for Martian gullies, where currently, a dry CO_2 frost-based formation mechanism is envisaged.

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