BRAIN TERRAIN ON EARTH? A POTENTIAL PERIGLACIAL ANALOGUE IN THE CANADIAN HIGH ARCTIC. S. M. Hibbard and G. R. Osinski, Centre for Planetary Science and Exploration / Dept. Earth Sciences, University of Western Ontario, London, ON N6A 5B7, Canada (shibbard@uwo.ca).

Introduction: The mid-latitudes of Mars are characterized by ice-related processes and landforms [1–5]. Glacial landforms, such as lineated valley fill, lobate debris aprons, and concentric crater fill indicate significant water-ice deposition in the past [3–6]. Periglacial features, such as patterned ground, can be found across the mid-latitudes of Mars [7–9]. Brain terrain, also referred to as brain coral terrain [10] and crenulated terrain [7], has been proposed to be as a periglacial landform characterized by a series of sinuous ridges and troughs [7,11]. It has been separated into two categories: (1) closed-cell and (2) open-cell brain terrain (Fig. 1; 11). In this study, we have identified comparable crenulations in the Canadian High Arctic for the first time that may have significant implications for understanding the origin of brain terrain and for Mars’ past climate.

Field Site and Methods: Crenulated terrain was found and imaged along the coast of Devon Island near Dundas Harbour, in Nunavut, Canada (74°31′45.5″ N 82°21′02.9″ W). Aerial images were captured using a DJI Phantom 3 drone at 20–30 m above the ground. Images are 12 megapixels captured using the Pix4Dcapture application. An orthomosaic and digital elevation model were produced using Agisoft Photoscan Professional 1.4.4 with a WGS 1984 UTM 16N projection.

Results: Crenulations found at Dundas Harbour are characterized by anastomosing ridges and troughs that occur in an active periglacial environment (Fig. 2). These occur on a very gentle regional slope of approximately 5–10° and exist in a ground moraine of till deposits from a once extant valley glacier. A 10–20 cm layer of organic soil blankets the surface of the glacial diamict. Depth to permafrost roughly follows surface topography with an active layer between ~0.5–1.5 m thick.

Figure 1: Examples of brain terrain in concentric crater fill in Utopia Planitia, Mars. (a) Closed-cell brain terrain with grooves along the axial trace of some ridges (red arrow). Ridges are 20 m wide and up to 100 m long. Boulders rest on top of and along the margins of the ridges. (b) Open-cell brain terrain with closed and open circular ridges. Ridges are 4–6 m wide and ~2 m high. Example of a closed circle with trough indicated by a yellow arrow. Example of a closed circle without trough indicated by an orange arrows. Images from PSP_002175_2210. Modified from [11].

Figure 2: (top) Orthomosaic of Dundas Harbour crenulations from aerial drone imagery. Ridges are up to 4 m wide and 1.5 m high. Cracks are visible along the axial trace of the ridges (red arrows). Closed and open sinuous ridges. Closed circle with trough (yellow arrow). Closed circle without trough (orange arrow). (bottom) Field perspective of crenulated terrain. Person in the distance for scale.

The ridges form a sinuous network of closed and open circles. Ridges are convex-up that grade into concave or flat-floored troughs. Ridges are no greater than
brain terrain ridges have grooves along the long axis of the crest of ridges that appear to be similar to the cracks seen along the crenulations in Dundas Harbour. Boulders present along the margins of Martian crenulations on concentric crater fill may indicate large grain sizes in the material, or simply mass wasting contribution from the crater walls [11]. Brain terrain has been documented within ice-rich deposits interpreted to be similar to rock glaciers [3, 16]; but also in mid-latitude flat plains dominated by patterned ground [7].

The formation mechanism for brain terrain on Mars is still unknown and remains debated. It has been suggested that brain terrain is analogous to stone circles in Spitsbergen, Svalbard, and may have formed from periglacial processes in a previously warmer and wetter environment in the past [10]. Levy et al. [11] has provided a schematic process for the development of brain terrain suggesting a topographic inversion model produced by cold-desert processes.

Cold-desert processes currently dominate Mars’ climate; however the climate may have been different during the early Amazonian. Levy et al. [11] suggest these are an active cold-desert process, while [10] suggests these are relict landforms produced by a wetter climate in the past. Although we do not know the exact formation mechanism of Arctic crenulations, we can infer these are active periglacial processes due to wet soil conditions near freezing temperatures.

Dundas Harbour crenulations may not have formed in the same way as the brain terrain seen on Mars; however, it is possible. This would have huge implications for Amazonian climate on Mars. This would mean that Mars climate would have had to have been warmer and wetter than observed today.

References:  

Acknowledgements: The authors would like to thank Dr. Etienne Godin, Chimira Andres, Josh Laughton, and Peter Christofferson for their assistance in the field.