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Surface-Subsurface Relationships of Polygonal Terrain on Earth and Mars

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Introduction:

Polygons are a prevalent periglacial feature on Mars and vary widely in morphology in terms of size, shape, regularity, relief, and organization of rocks. There is ongoing discussion about the type of polygons present on Mars, which has major implications for past climate and near-surface ice, particularly at candidate human mission landing sites. Polygonal terrain has the potential to provide valuable information about the depth, volume and geometry of near surface ice. However, polygons can appear superficially similar at the surface regardless of subsurface ice content. Thus, there is a need to further investigate the linkage between surface morphology and subsurface properties of polygonal terrain.

Methods:

This research combines geophysical measurements, machine learning and statistical analysis to provide ultra-high resolution information on Canadian High Arctic polygon surface and subsurface properties and their spatial variations at 12 sites.

- Subsurface characteristics: Ground Penetrating Radar & trench/pit observations
- Surface characteristics: LiDAR & Uncrewed Aerial Vehicle
- Mapping and data extraction and analysis: Python, GIS & Principle Component Analysis

Preliminary Results:

Our findings from manually mapping ~ half of the polygon sites with varying geology, substrate, topography, hydrology and wedge composition (before statistical analysis) suggest:

- Substrate homogeneity (regarding grain size and composition) does not consistently affect polygon diameter or orthogonality (i.e., pattern) as expected suggesting other factors must be considered
- Regional topography affects trough width as expected
- Circularity and aspect ratio does not appear to be closely linked to substrate
- the influence of substrate on polygon morphology and morphometry is not yet well constrained well constrained.

Next Steps:

- Presently developing a python script designed to map polygons and extract surface data automatically
- Principal Component Analysis to identify consistent relationships across polygon sites between surface and subsurface characteristics
- Apply analogue findings to Arcadia Planitia, Mars case study to assess near surface ice content

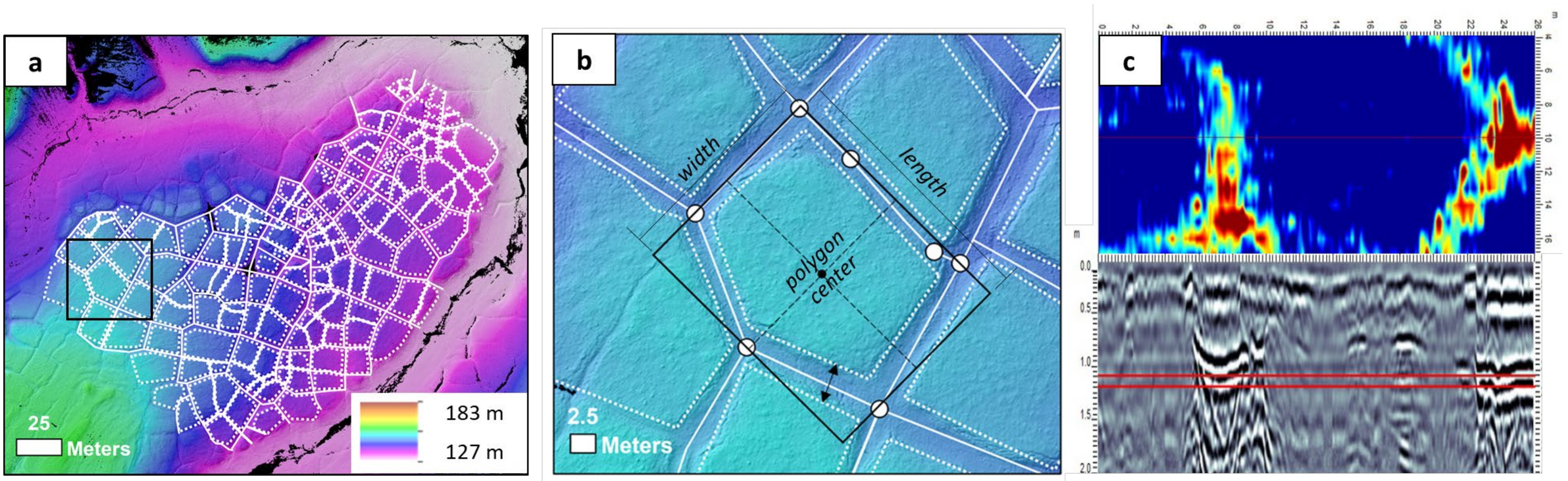

Figure 1. Surface morphometric extraction methods from Ulrich et al. (2011) and subsurface characteristic extraction. (a) Manual digitization of polygon networks using data from high resolution LiDAR DEMs. (b) Morphometrics to be extracted for each individual polygon. (c) 3D (top) and 2D (bottom) GPR data used to extract geometry and volume of wedges in troughs.

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Publications:
Hibbard et al. (Icarus, 2020); Hibbard et al., (Geomorphology, 2021), Hibbard et al., (Geomorphology, In Review), Hibbard et al., (Nat. Geo, In Prep), Hibbard et al., (PSS, In Prep).

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