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Quantitative Investigations of Polygonal Ground in Continental Antarctica: Terrestrial Analogues for Polygons on Mars

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Polygonally fractured ground is widespread at middle and high latitudes on Mars. The latitude-dependence and the morphologic similarity to terrestrial patterned ground in permafrost regions may indicate a formation as thermal contraction cracks, but the exact formation mechanisms are still unclear. In particular, it is debated whether freeze-thaw processes and liquid water are required to generate the observed features. This study quantitatively investigates polygonal networks in ice-free parts of continental Antarctica to help distinguishing between different hypotheses of their origin on Mars. The study site is located in the Helliwell Hills in Northern Victoria Land (∼71.73°S/161.38°E) and was visited in the framework of the GANOVEX XI expedition during the austral summer of 2015/2016. The local bedrock consists mostly of sediments (sandstones) of the Beacon Supergroup and mafic igneous intrusions (Ferrar Dolerites). The surfaces are covered by glacial drift consisting of clasts with diverse lithologies. Thermal contraction cracks are ubiquitous. We mapped polygons in the northern part of Helliwell Hills in a GIS environment on the basis of high-resolution satellite images with a pixel size of ∼50 cm. The measured spatial parameters include polygon area, perimeter, length, width, circularity and aspect. We also analyzed the connectivity of enclosed polygons within a polygon network. The polygons do not display significant local relief, but overall the polygon centers are slightly higher than the bounding cracks (i.e. high-center polygons). Sizes of polygons can vary widely, dependent on the geographical location, between 10m2 and >900m2. In planar and level areas, thermal contraction cracks tend to be well connected as hexagonal or irregular polygonal networks without a preferred alignment. In contrast, polygonal networks on slopes form elongated, orthogonal primary cracks, which are either parallel or transverse to the steepest topographic gradient. During fieldwork, excavations were made in the center of polygons and across the bounding cracks. Typically, the uppermost ∼40 cm of regolith are dry and unconsolidated. Below that, there is commonly a sharp transition to ice-cemented material or very clear ice with no bubbles. Soil profiles were recorded, and sediment samples were taken and analyzed for their grain size composition with laser diffractometric measurement methods. External factors such as slope gradient and orientation, insolation and composition of surface and subsurface materials were included in the analysis.