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Polygonal Patterned Ground in Northern Victoria Land, Continental Antarctica: A Mars Analogue

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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. This study investigates polygonal networks in ice-free parts of continental Antarctica to help distinguishing between different hypotheses of their origin on Mars.

Our study sites are located in the Transantarctic Mountains of Northern Victoria Land, both near the coastal Gondwana Station (74.635°S/164.22°E) and at the more interior located Helliwell Hills (HH; ∼71.73°S/∼161.38°E). Fieldwork was performed during the austral summer of 2015/2016 and in November 2018. In all investigated areas, the ice-free surfaces are covered by glacial drift consisting of clasts with diverse lithologies. In contrast to the ancient surfaces in the McMurdo Dry Valleys, the surfaces in the study area were deglaciated since the LGM and are, therefore, relatively young. Near the coast, the mean annual air temperature is -14.7°C, and temperatures regularly exceed 0°C in January. No detailed climate data are available for the HH, but data from the closest permanent weather stations suggest that the air temperatures never exceed 0°C.

Thermal contraction cracks are ubiquitous at almost all ice-free surfaces. Wind-blown snow accumulates in the troughs between high-centered polygons and accentuates their appearance when seen from above. Typically, the uppermost ∼40 cm of regolith in the HH are dry and unconsolidated. In contrast, at the sites near the coast the thickness of the uppermost, unconsolidated and uncemented regolith is much thinner, consistent with a wetter environment where more water vapor is available to diffuse into the regolith. Below that uppermost layer, there is commonly a sharp transition to either excess ice or very clear (glacial?) ice with few bubbles. Sampling of the ground in trenches across polygon-bounding troughs revealed ice in most (but not all) troughs. If present, ice was found at the same depth at all locations along the trenches. This implies that ice wedges would have to be at least as wide as the trenches, which had typical widths of 1 to 1.5 m. This, in turn, would imply a considerable thickness of ice-wedge tops, which appears unlikely, especially in the dry environment of the HH. We hypothesize that polygons at the coast are likely to be ice-wedge polygons, consistent with published studies, but polygons in the interior and at higher elevations may form in a surficial veneer of glacial drift above a continuous layer of glacial ice. The latter situation may be comparable to the Phoenix landing site on Mars, where polygons characterize the terrain that is underlain by a contiguous layer of relatively pure ice.

Although the local conditions are clearly different at the different sampling sites (with respect to climate, lithology, and local topographic context), the plan-view appearance of the polygons was remarkable similar. We conclude that thermal contraction polygon morphometry is not necessarily indicative of polygon origin (e.g., ice-wedge polygons vs. sublimation polygons), neither on Earth nor on Mars.