

Deposition and degradation of a volatile-rich layer in Utopia Planitia, Mars

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We investigate a region in western Utopia Planitia, where several morphological features like polygons and pits or depressions show close similarities to terrestrial permafrost structures. Their origin has been attributed to periglacial processes and permafrost degradation, but aeolian processes and structural control have also been suggested. We investigate an area of about 92.000 km², extending from about 80° to 85°E and from 40° to 50°N, on the basis of image and topographic data. We focus on degradation features and their formation, and compare the observations with our own field experience in Arctic Siberia. Visual examination reveals that the region is affected by surface degradation. On scales of hundreds of meters, the flat terrain is interspersed with rampart craters and broad depressions of compound shape and several decametres depth, which often have steep cliffs at their southern margins, while the other margins display smoother slope angles. The percentage of the total surface covered by these depressions was mapped in a GIS and amounts to 24% of the study area. Towards the south of the study region, the depressions seem to be larger in extent and their floors are populated by an abundance of small craters. On images with a higher spatial resolution (few meters per pixel), which cover only a small percentage of the study area, the landscape was examined in more detail. The terrain outside the large depressions which appears to be smooth in lower-resolution images (tens of meters per pixel) shows polygonal patterns with pits and small depressions. The asymmetry of the latter (steep southern cliffs and often smooth and subdued boundaries towards the north) is consistent with that of the large depressions. The polygonal pattern shows a preferred orientation of larger cracks in N-S to NNE-SSW direction in undisturbed and flat terrain, but elsewhere its orientation is controlled by topographic features like crater rims. It is absent on the floor of the large depressions. We propose a model of landscape genesis for western Utopia Planitia. It assumes the subaerial deposition of a stack of probably ice-bearing sedimentary layers on a cratered basement and its post-sedimentary degradation, resulting in the present complex landscape morphology. We discuss several possible processes and factors of landscape evolution in the light of terrestrial periglacial analogues of permafrost degradation including surface fracturing, sublimation of ground ice, and other periglacial as well as aeolian activities.