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Modeling the formation of sublimation depressions on Mars: the role of permafrost and regolith properties.

Mara Mantegazza[1] María Rojas[2] Mauro G. Spagnuolo[2]

[1]IDEAN (UBA_CONICET), [2]IDEAN (UBA-CONICET)

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Mars is currently described as a cold desert, although the martian poles are covered by extensive ice deposits, the polar regions are not the only places where ice can be found. In mid and low latitudes, several landforms related to the presence of surface or subsurface ice have been recognized. In the current martian climatic conditions, in these regions the ice would only be stable in the subsurface, although past climatic conditions could have allowed the deposition and accumulation of ice in regions between 30° and 60° latitude. Similarly to Earth, glacial periods appear to be strongly linked to variations in orbital parameters, in particular the obliquity.

In Utopia Planitia several authors have described a variety of landforms that might be related to the sublimation of a permafrost of amazonian age. Sublimation of a buried ice might result in the formation of depression, similar to terrestrial thermokarst. In this work, we aim to understand the formation of two types of depressions: pit craters and scalloped depressions. Pit craters are circular to sub-circular conic and rimless depressions. Scalloped depressions are asymmetrical depressions that can be found as larger scalloped terrains.

To analyze their formation and evolution, we performed laboratory analog models. A simple subsurface structure is modeled: a basement, a CO2 permafrost and a mantle. In each model we modify the properties of some of these layers (thickness, composition or morphology) and record the sublimation process with two cameras, in order to generate DEMs.

Since collapse landforms and the slope morphology is highly dependent on the physical properties of the regolith, we used a sediment with a grain size distribution similar to martian soil. We used grain sizes from 500 to 1 nm in different proportions to reproduce the distribution of simulants previously formulated by other authors such as JSC Mars-1.

We present initial results on the key factors in the formation of pit craters and scalloped depressions. We find that the formation and morphology of these depressions are highly dependent on three key factors :1) basement topography, 2) permafrost sediment/ice ratio, 3) cover thickness and sediment cohesion. Basement topography, although not crucial to the generation of depressions, might favor them (e.g. the presence of buried craters). The ratio of sediment to ice is crucial since there needs to be a minimum ice proportion, but not an excessive amount. Otherwise, instead of local depressions, regional subsidence is observed. Finally, the cohesion of the top layer seems to be critical for the formation of local steeped slope depressions.