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Mapping the northern plains of Mars: origins, evolution and response to climate change – a new overview of recent ice-related landforms in Utopia Planitia

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Abstract

An International Space Science Institute (ISSI) team project has been convened to study ice-related landforms in targeted areas in the northern plain of Mars: Acidalia Planitia, Arcadia Planitia, and Utopia Planitia. Here, over western Utopia Planitia, ice-related landforms were identified and recorded in a sub-grid square. The end result of the mapping is a "raster" showing the distribution of the various different types of landforms across the whole strip providing a digital geomorphological map (Fig. 1).

1. Introduction

In the northern plains of Mars, the main questions this project aims to answer are:

1) *"What is the distribution of ice-related landforms in the northern plains, and can it be related to distinct latitude bands or different geological or geomorphological units?"*
2) *"What is the relationship between the latitude dependent mantle (LDM) and (i) landforms indicative of ground ice, and (ii) other geological units in the northern plains?"*
3) *"What are the distributions and associations of recent landforms thought to be indicative of thaw of ice or snow?"*

Rather than traditional mapping with points, lines and polygons, we used a grid "tick box" approach to efficiently determine where specific landforms (see [4] for details). Here, we describe our mapping in Utopia Planitia.

Western Utopia Planitia (UP) shows an assemblage of possible periglacial landforms: scalloped depressions [5-10]; spatially associated small-sized polygons [6-11]; polygon-junction pits [7, 12]. There seems to be a general agreement that these relatively recent landscape features are indicative of a permafrost that is probably ice-rich [8]. However, the Gamma Ray Spectrometer detected only a small percentage of water-equivalent hydrogen (4 % wt of ice) content in the near-surface of UP (depth < 1 m) [13] but ground-ice is predicted to be stable at these latitudes at depth > 1 m [14]. Interestingly, UP lies in the area of the young latitude-dependent mantle thought to have been emplaced during obliquity variations of Mars [15].

Questions concerning the distribution of periglacial landforms and characteristics of the ice-rich permafrost in UP remain unanswered.

2. Method

We conducted a geomorphological study of all landforms in UP along a strip from 25°N to 75°N latitude of 250 km wide (Fig. 1). The goals are to: (i) map the geographical distribution of the ice-related landforms; (ii) identify their association with subtly-expressed geological units and; (iii) discuss the climatic modifications of the ice-rich permafrost in UP. Our work combines a study with CTX (5-6 m/pixel) and MOLA, supported by higher resolution HiRISE (25 cm/pixel) and a comparison with analogous landforms on Earth. The mapping strips were divided into grid of squares for each study area, each approximately 20×20 km [4].

3. Results of the grid mapping

The mapping shows that the scalloped depressions, pits and 100 m polygons occur over a broader area than previously shown (from 40°N to 65°N on Fig. 1). Coalesced scalloped depressions of several km in diameter are concentrated near 50°N. Different impact craters are observed with CCFs (see [16] for details). We also observed that the thumbprint terrains, high-albedo mounds of different

diameter (see [17] for details) and km-scale polygons are mostly seen in the southern UP (from 30°N to 40°N on Fig. 1).

Based on their correlated distribution at regional scale but also at local scale where they are associated spatially, several assemblage of landforms can be defined. The scalloped depressions, pits and 100 m polygons are spatially associated at local scale because interrelated, pits cross-cut polygons that are degraded by scallops and at regional scale because same area between 40°N to 50°N. The mantling deposits and the textured terrains are found at the same latitudinal band. The thumbprint terrains, high-albedo mounds of different diameter and km-scale polygons are mostly seen between 30°N to 40°N.

4. Summary and Conclusions

Our knowledge of the distribution of ice-related landforms in UP was improved. Based on their spatial association, there are different assemblages of landforms. Their distribution is not only related to latitude but also on topography, geological context. The next step is to define unit : based on assemblage of landforms, albedo and/or crater counting. The differences/similarities of the key 3 regions in the northern plains reflect their complex geological history.

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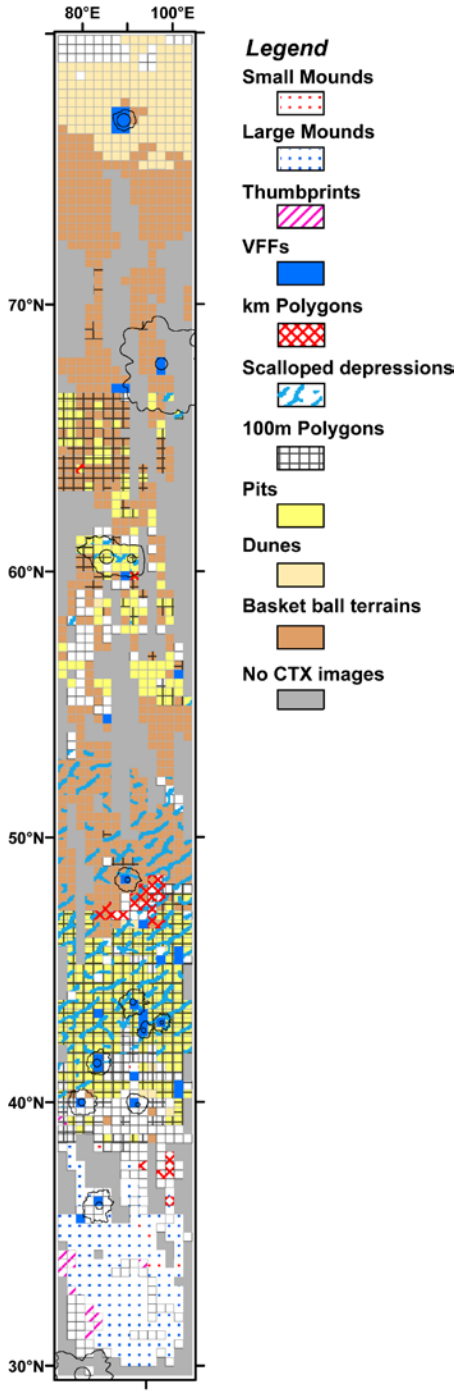

Figure 1: Geomorphological grid map of the ice-related landforms in western Utopia Planitia