Grid mapping of ice-related landforms in Acidalia Planitia, Mars

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Abstract

Many young landforms in mid- and high-latitudes on Mars are probably related to ice, but their exact distribution and origin are still poorly understood. In an attempt to determine their extent and identify possible spatial relationships and genetic links between them, we mapped their distribution across a N-S traverse across Acidalia Planitia, following a grid-mapping approach. The general characteristics of Acidalia are similar to that of Utopia Planitia and Arcadia Planitia, which are known to host large water ice reservoirs.

Keywords: Mars; permafrost; landforms; ice; climate; grid mapping.

Introduction

Large quantities of excess water ice reside in the upper parts of the Martian crust in the northern hemisphere (e.g., Plaut *et al.*, 2009; Stuurman *et al.*, 2016; Bramson *et al.*, 2015). Although it is believed that this ice was deposited during phases of different obliquities (e.g., Madeleine *et al.*, 2009), it does survive over geological time under current conditions (Bramson *et al.*, 2017) and does not seem to be in equilibrium with the atmosphere yet (Pathare *et al.*, 2018). Among the three prominent basins in the northern lowlands, ice reservoirs were detected by geophysical methods in Arcadia Planitia (Bramson *et al.*, 2015) and Utopia Planitia (Stuurman *et al.*, 2016). Morphological evidence for water ice is also observed in Arcadia Planitia (Viola *et al.*, 2015) and Utopia Planitia (e.g., Morgenstern *et al.*, 2007).

Various recent landforms in the Martian mid-latitudes have been hypothesized to be a result of freeze-thaw processes, with melting excess ice as a possible water source, analogous to landforms in periglacial climates on Earth. As the present climate of Mars physically prevents the formation of liquid water but in some extraordinary circumstances (e.g., deliquescence of salts), a major current debate focusses on the “wet” versus “dry” formation of such landforms (e.g., widespread patterned ground in Utopia Planitia; Séjourné *et al.*, 2011).

We aim at a better understanding of the distribution of possibly ice-related landforms in Acidalia Planitia, the third major lowland basin. Our goal is to identify latitude-dependencies of such landforms and their relation to each other as well as to external parameters such as topography, and thermal inertia.

Methods

We employ a grid mapping approach based on CTX images (Ramsdale *et al.*, 2017), which enables mapping large areas at small scales (Fig. 1). Our maps show a binary (“yes” or “no”) distribution of specific landforms in each grid cell (~20 × 20 km), but allows for some ambiguity (one class is “possible”, where no decision was possible). We also document where no data were available and where a landform is dominant. Examples of resulting maps are shown in Fig. 2.

Observations

We mapped individual landforms that may have formed in association with ice or water, including polygonal terrain, gullies, and mantling material (the full list of landforms is provided by Ramsdale *et al.* (2017). Our maps are very similar to corresponding maps of Utopia and Arcadia Planitiae that were produced by the same methods.

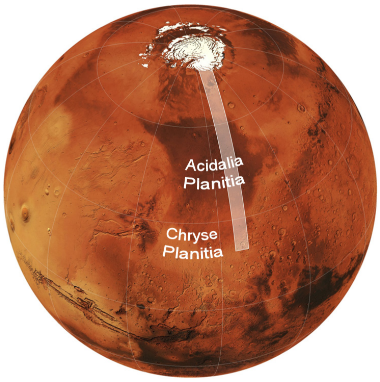

Figure 1. Location of traverse (300 km wide) across Acidalia Planitia (from 20°N to the margin of the north polar cap).

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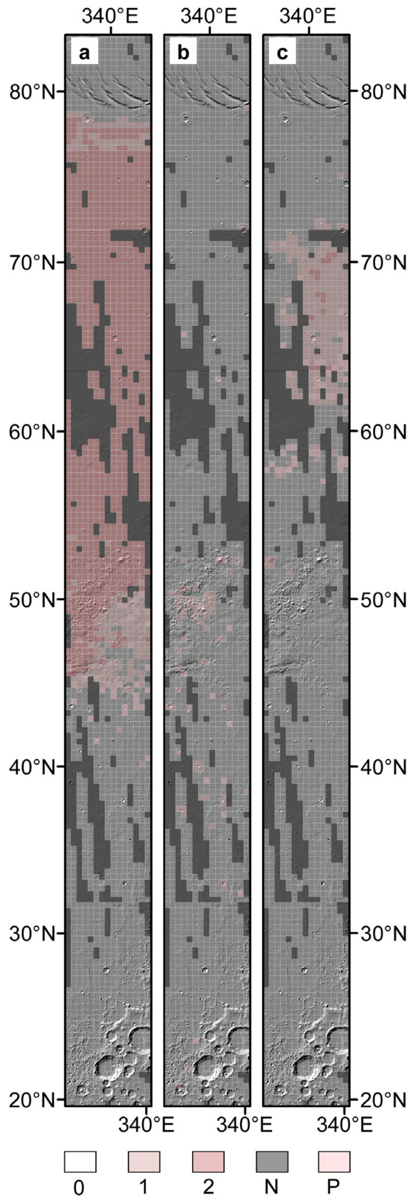

Figure 2. Selected grid maps with individual landforms. Colors indicate classification of grid cells (0=no color, just MOLA hillshade background: landform not present, 1: present, 2: dominant, N: no data, P: landform possibly present. (a) Mantling deposits. (b) Gullies. (c) Small-scale polygons.