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Small-scale lobes in the Southern Hemisphere, Mars: Suggestive of transient liquid water in the recent past.

A. Johnsson
Department of Earth Sciences, University of Gothenburg, Gothenburg, Sweden (andreasj@gvc.gu.se / Fax: +46-31-786 1986)

Abstract

Small-scale lobate landforms that may be indicative of recent freeze-thaw activity are cataloged on the southern hemisphere on Mars. All publically available HiRISE images between latitudes 40°S and 80°S on Mars are being used in this study. Preliminary results show that small-scale lobes, similar in form to solifluction lobes on Earth, exist on slopes in Mars' southern hemisphere. Compared to previous studies of small-scale lobes in the northern mid-and-high latitudes, these landforms also occur, in most cases, in close spatial proximity to fluvial gullies and polygonal terrain. This is an ongoing project.

1. Introduction

The question whether Mars' mid-and-high latitudes been continuously frozen and dry or subjected to recent freeze-thaw activity are debated [1]. Polygonal patterns, which are common on Mars, develop in cold regions due to stresses and cracking of the permafrost [2]. Certain types of polygons may indicate thawing on Earth. On Mars, however, polygons have been shown to be ambiguous [3]. The presence of small-scale lobes on Martian slopes has the potential to elucidate the question of freeze-thaw activity more firmly.

In Earth's permafrost regions, solifluction lobes are strong indicators of past and present freeze-thaw activity. Terrestrial periglacial solifluction lobes are formed by frost creep (combination of repeated frost heave and thaw consolidation) and gelifluction (visco-plastic deformation of near saturated soil) in the active layer on top of the permafrost table [4]. Small-scale lobes (SSL) have been studied in detail in the northern hemisphere on Mars (Fig. 1), where they are widely distributed at high latitudes between 59°N and 80°N [5]. SSL's are proposed to represent freeze-thaw activity late in Martian climate history [5,6,7]. SSL's on Mars broadly occur as two types: (1) Sorted or clast-banked lobes which have a concentration of clasts at the front, while the tread surface is relatively clast free. (2) Non-sorted or fine-textured homogenous lobes with no visible clasts at front. Both types occur, in most cases, in close proximity to gullies and polygonal terrain. Previous results from morphometric analysis of the northern SSL's are in agreement with terrestrial counterparts [5]. SSL's differ from permafrost creep (i.e. rock glaciers) in having low fronts, decimeters to a few meters (<5 m) in height. They lack compression ridges and furrows and are not confined to topographic niches (i.e. valley confinement). The presence of small-scale lobes raises the question whether they have formed by a warmer-than-thought-climate, or by the influence of soil salts (i.e. perchlorates) under sub-freezing conditions [6].

At present, no comprehensive studies of SSL's have been made in the southern hemisphere on Mars. This study aims to investigate whether the southern SSL's differ from the northern counterparts in terms of morphology and distribution. Furthermore, spatio-temporal relationships to landforms with ground-ice affinity, such as gullies and polygonal terrain, are investigated. This may have implications for the climate in Mars recent past.

2. Data and method

In this study we used images obtained by the High Resolution Imaging Science Experiment (HiRISE) with a resolution of ~25 cm/pxl. All HiRISE images from 2007 to 2013 have been compiled from the PDS Geosciences Node *Mars Orbital Data Explorer* (http://ode.rsl.wustl.edu/mars/index.aspx). Data has been catalogued in an Excel. HiRISE images have been processed using ISIS3 software and analyses have been done in ArcGIS v. 10.1.

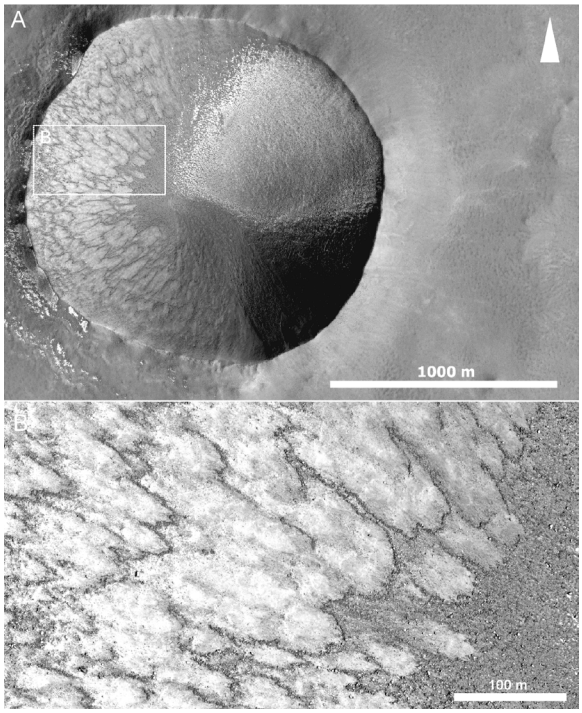

Figure 1: (A) HiRISE image showing an example of high-latitude small-scale lobes on the northern hemisphere, Mars. (B) Lobes display a well-defined front with clasts and a relatively clast free tread surface. Image credit: NASA/JPL/University of Arizona.

3. Observations

Early observations suggest that SSL's are primarily found in relatively pristine craters in the southern hemisphere. Compared to the northern high-latitude counterparts they are found more equatorward, with positive observations as low as ~40°S. The majority occur in close proximity to gullies and polygonal patterns (Fig. 2). Well-defined examples show roughly similar plan-form morphology, with overlapping lobe fronts. In contrast to the northern bound SSL's these have shorter tread lengths and lobes are less wide. So far, no clear observations of the non-sorted type have been made.

6. Summary and Conclusions

To date more than a hundred HiRISE images have been investigated for small-scale lobes in Mars' southern hemisphere. Early results indicate that the small-scale lobes are distributed more equatorward than in the north. Morphometry and morphology suggest that they are distinct from permafrost creep. The project is on-going and more work is required to firmly establish their distribution and their association to gullies and polygonal terrain. Though landforms indicative of freeze-thaw activity may be rare on flat terrain on Mars, there is growing evidence that freeze-thaw conditions may have been met on mid-and-high latitude slopes.

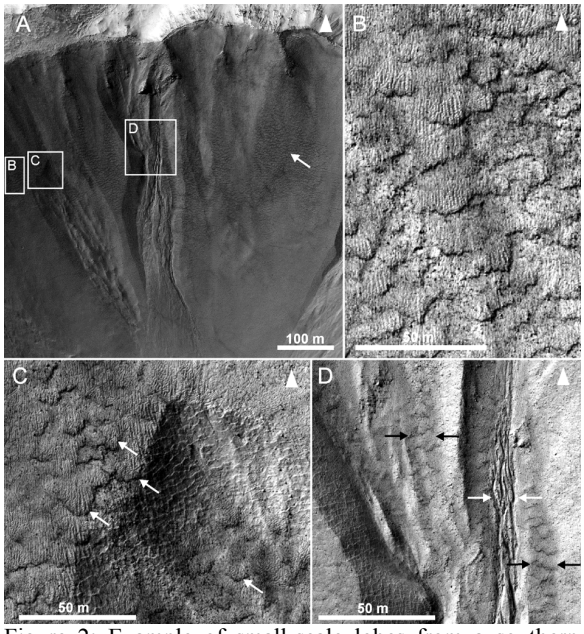

Figure 2: Example of small-scale lobes from a southern mid-latitude crater, Mars. (A) Overview of crater slope with fresh-appearing braided gullies. White arrow shows the location of additional patches of lobes. (B) Well-defined lobes close to gully alcove. Note the striped pattern on lobe treads. On Earth striped patterns are associated with additional freeze-thaw processes resulting in sorted stripes. (C) Lobes on the rim of gully alcove (upper white arrows). Note that lobes are seen within the alcove as well (lower white arrow). (D) Braided gully channel (white arrows) and proximate lobes (black arrows). Image credit: NASA/JPL/University of Arizona.

Acknowledgements

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References

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