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Possible slow "wet" mass wasting on Mars

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1. Introduction

Small-scale lobes (SSL's) on Mars are landforms that show striking morphologic resemblance to solifluction lobes on Earth [1-3,5]. On Earth solifluction is the net downslope movement of soil driven by phase changes of near-surface water due to repeated freeze-thaw activity [4]. SSL's on Mars consist of an arcuate front (riser) tens to hundreds of meters wide [1] (Fig. 1). Risers are typically decimeters to a few meters (<5m) in height [1]. SLL's often display "overlapping" of individual lobes when they occur as groups.

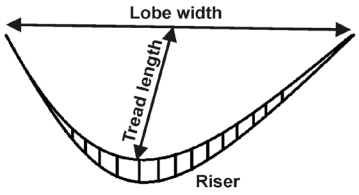

Figure 1. Sketch showing the lobe components. Lobe front points downhill.

Previously SLL's have only been studied in detail in the northern hemisphere on Mars [1,2,5,6] where they have been found to be latitude-dependent landforms [1,2]. In contrast, only a couple of observations have been made in the southern hemisphere [7,8]. Several authors argue for a freeze-thaw hypothesis for SSL formation on Mars [1,2,5-8], although this notion has recently been challenged [9]. If the interpretation of a freeze-thaw origin is correct, the implication is significant since it would require transient H_2O liquids in relatively recent history. Thus a better understanding of SLL's will allow identifying environments that are of value for astrobiological inquiries. Moreover, it may represent a previously underinvestigated process of recent hillslope degradation.

This study aims to determine the distribution of SSL's in the southern hemisphere and to investigate their relationship to other possible periglacial landforms such as patterned ground, polygonal terrain and gullies. Collectively, these landforms may be linked to phase changes of water at the surface or in the shallow subsurface.

2. Data and Methods

We used images obtained by the High Resolution Imaging Science Experiment (HiRISE) that has a spatial resolution of ~25–50 cm/pixel. We catalogued and investigated all available HiRISE images that were acquired between 2007 and 2013 in the latitude band 40°S and 80°S on Mars. A total of 2200 HiRISE images have been studied in detail. For comparison to terrestrial solifluction lobes we used the airborne High Resolution Stereo Camera (HRSC-AX). The benefits of using HRSC-AX are its ability to render detailed DTM's and a similar pixel size (20 cm/pixel) as HiRISE.

3. Observations

SLL's are observed on impact crater walls. SLL's observed in HiRISE (n: 30) show a close spatial association with gullies (77%) and polygonal terrain (47% [Fig. 2]). Moreover some lobes are superposed by striped patterns (Fig. 3). Stripes were also observed separately from SLL but within the same crater environment. On Earth stone stripes and sorted stone stripes are landforms that develop in the active layer, a layer that undergoes seasonal and/or diurnal freezing and thawing. SLL's are often, but not always, associated with slopes covered by latitude-dependent mantle (LDM) [10]. Several SLL locations show evidence of dissected mantle (26%). Moraine-like landforms were observed at ten locations (25%).

4. Summary and conclusions

A type of landform called small-scale lobes has been examined within latitude band 40°S-80°S to understand their origin. Combined with previous studies of the northern hemisphere we have shown that these small-scale lobes are located in two latitude bands in each hemisphere respectively. As such they represent a landform with latitude dependency such as polygonal terrain and gullies. Small-scale lobes occur on topography associated with relatively well-preserved craters in areas underlain by ground ice. Based on their morphology, physical setting, and comparison to Earth analogues and relation to other landforms with ground ice affinity we found that the process likely to cause the landforms are by freeze-thaw action (solifluction) within an active layer. Although we cannot rule out a formation by other processes based on image interpretation alone, there are currently no known terrestrial processes that result in the same morphological characteristics other than solifluction.

SSL's are not as common in the southern hemisphere as in the northern hemisphere even though there is a larger abundance of available hillslopes. This may be due to different surface properties that inhibit solifluction. Further work is needed to fully explain the hemispherical asymmetrical distribution of these lobes.

[11] investigates a recently emerged new potential analog landform in the Atacama Desert. Please see abstract EPSC2018-339 (this conference) for further details.

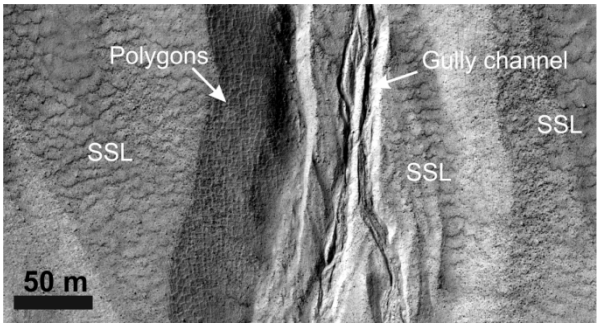

Figure 2. SLL, polygons and gullies in Ruhea crater (43.26°S/173.08°E). Fresh appearing gully channels with polygonal patterns on the gully walls. SLL dominate the scene covering the adjacent walls with overlapping lobes. The stratigraphy suggests close temporal relationship.

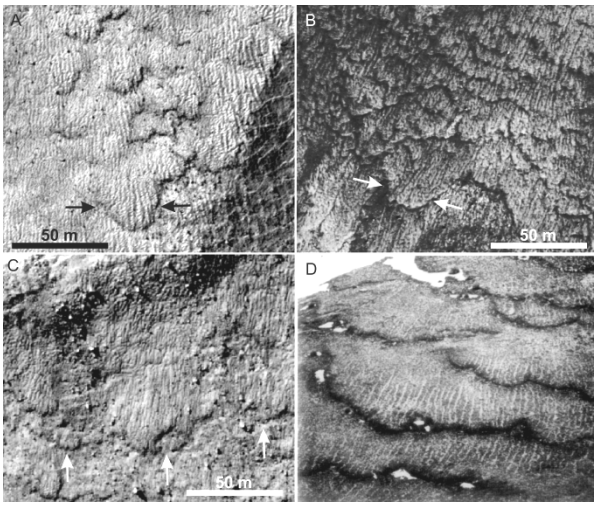

Figure 3. Examples of martian SSL and solifluction lobes on Earth. A) SSL in Ruhea crater, Mars. Overlapping lobes superposed by striped pattern. Note the polygonal terrain in lower right corner. B) Solifluction lobes superposed by stone stripes in Adventdalen, Svalbard. C) SSL in unnamed crater, Mars (45.42°S/25.74°E). Stripes are seen on the lobes. D) Solifluction lobes in New Zealand superposed by sorted stone stripes. Lobe front ~25 cm high.

Acknowledgements

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