EPSC Abstracts
Vol. 9, EPSC2014-480-2, 2014
European Planetary Science Congress 2014

Aspect dependence of small-scale lobes in the Northern Hemisphere of Mars

E. Nyström and A. Johnsson.
Department of Earth Sciences, University of Gothenburg, Sweden (gusnystre@student.gu.se)

Abstract

Well preserved small-scale lobes on northern mid- and high-latitude crater slopes on Mars have been proposed to represent candidate solifluction landforms. Thus they may represent geomorphic expressions of recent freeze-thaw activity. This, in turn, would imply periods of liquid water in the near surface. We have surveyed images acquired by HiRISE in 2012 and 2013 for small-scale lobes in the latitude band of 55°–80° north. Thirty full perimeter craters were selected to investigate if lobes display aspect dependence as a function of latitude. We also investigated their association to gully landforms. Preliminary results show a latitudinal aspect dependence and a close relationship to gullies and polygonal patterns.

1. Introduction

Present Mars is a cold and hyper-arid permafrost planet. The question whether Mars has been continuously cold and dry in the late Amazonian is under debate [1,2]. Several studies have suggested that the northern mid-and high-latitudes may have been subjected to thawing conditions in recent climate history [2,3,4]. One of the key geomorphic indicators of freeze-thaw action has been small-scale lobes. These lobate features have been interpreted to be formed by solifluction processes based on morphology [2,3], morphometry and Earth-analog studies [4], by their close spatial proximity to fluviatile gullies and polygonal patterns [3,4] and by modeling [5]. Preliminary studies by [6] in the southern hemisphere on Mars may suggest a bimodal distribution of small-scale lobes similar to polygonal patterns [7] and gullies [8,9]. Here we report on a new survey of small-scale lobes in the northern hemisphere using HiRISE images acquired in 2012 and 2013. Our objectives was to (1) extend the previous mapping by [3,4] (2) investigate whether there is an aspect-dependence as a function of latitude and (3) investigate spatial relationship to gullies and polygonal patterns. This is an on-going bachelor thesis project.

1.1 Solifluction processes on Earth

Solifluction is generally defined as the "slow downslope flow of saturated unfrozen earth materials" [10]. In permafrost areas it may consists of multiple processes that either work in tandem and/or at different temporal scales (diurnal or annual) [11]. In permafrost environments solifluction occur within the active layer. Frost creep is the downslope motion of sediments due to frost heave perpendicular to the slope and vertical settling by thaw consolidation. Gelifluction is the elasto-plastic deformation of near saturated soil above a frozen substrate [12]. Plug-like flow may occur in areas with two-sided freezing where the sediments close to the top of permafrost are saturated by ice lenses. Upon thawing of the bottom ice lenses the whole slope may move en masse [11].

2. Data and methods

In this study we have used 942 HiRISE images located between latitude 55°–80° N. HiRISE observation dates were between January 2012 and December 2013. Only images containing (1) crater topography and (2) good resolution were selected. Where craters are only partially covered by HiRISE, we used CTX data to outline the presence of small-scale lobes. Image studies were made with the HiView software. A distribution map was created using the ESRI ArcGIS 10.2 software.

3. Results and observations

A total of 942 images were investigated. Of these images 245 contained crater topography. Small-scale lobes were found in 69 craters. By applying the above criteria 30 craters were selected for detailed analysis. The 30 craters have full or partial coverage by HiRISE.

We categorized the images into two separate latitude bins, a mid-latitude (55°–65°; n 19) and a high latitude (65°–80°; n 11) bin. Fig. 1 show the preferred aspect of small-scale lobes. 27 % of the studied craters that display small-scale lobes show no apparent aspect dependence, the majority of these craters are located in the high latitude bin. Fig. 2 show two craters which have full HiRISE coverage. 87% display observable polygonal patterns and 60% of the craters display both gullies and polygonal patterns. The distribution of the investigated craters containing small-scale lobes is presented in Fig.3.

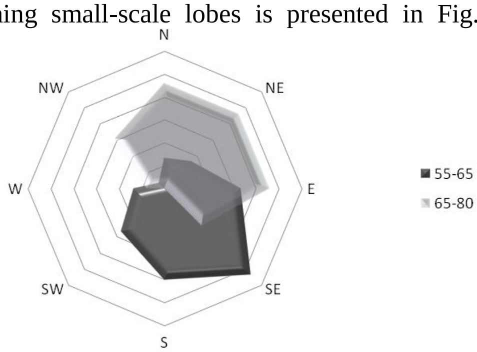

Figure 1: Radar chart displaying the preferred aspect of small-scale lobes in mid-(dark gray) and high-(light gray) latitudes.

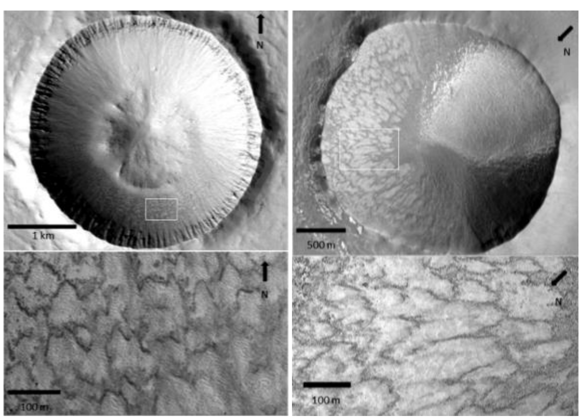

Figure 2. Two examples of craters with full HiRISE coverage. (Left) Crater located at 60°N with poleward facing small-scale lobes. (Right) Similar sized crater located at 72°N with west facing small-scale lobes. Image credit: NASA/JPL/UofA for HiRISE.

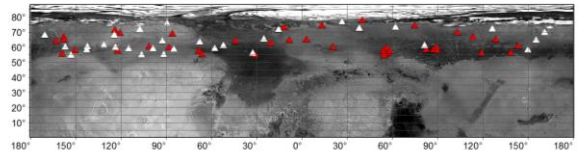

Figure 3. Map of Mars' northern hemisphere show the distribution of craters that display small scale lobes (red and white triangles) and craters used in the study of aspect dependence (white triangles).

4. Discussion

Small-scale lobes have recently gained a lot of attention [2,3,4,5]. Previous studies have proposed a formation by freeze-thaw activity rather than by permafrost creep [e.g., 4]. The formation of small-scale lobes may be linked to warmer-than-thought climate or to the presence of soil salts which may suppress the freezing temperature of near surface ground ice allowing liquid water at sub-zero temperatures [2,4]. Preliminary results from our study may suggest a close spatio-temporal formation to gullies as well as formation under similar climatic conditions.

5. Preliminary conclusions

We have shown that small-scale lobes display aspect dependence as a function of latitude, though more work is needed to fully determine this relationship. Nevertheless, mid-latitude lobes occur mainly on pole-facing lobes whereas high latitude lobes occur more radially in craters. Their close spatial proximity to gullies may suggest that lobes and gullies represent a continuum of thaw induced landforms.

6. References

[1] Levy et al., 2009. EPSL. [2] Gallagher et al., 2011. Icarus 211. [3] Gallagher and Balme, 2011. GSL. [4] Johnsson et al., 2012. Icarus. [5] Kreslavsky and Head, 2014. LPSC abstract #2715. [6] Johnsson et al., 2014. LPSC abstract #1105. [7] Mangold, 2005. [8] Balme et al., 2006. JGR. 111. [9]. Kneissl et al., 2010. EPSL 294. [10] van Everdingen, 2005. National Snow and Ice Data Center. [11] Matsuoka, 2001. ESR 55. [12] Harris et al., 2003. ESPL 28.