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Small-scale lobes on Mars: Solifluction, thaw and clues to gully formation.

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Small-scale lobes (SSL) on Mars are landforms that show striking morphologic resemblance to solifluction lobes on Earth [1,2]. Solifluction is the net downslope movement of soil driven by phase changes of near-surface water due to freeze-thaw activity [3]. SSLs on Mars consist of an arcuate front (riser) tens to hundreds of meters wide [1,2]. Risers are typically decimeters to a few meters (<5m) in height [1]. Where the riser is outlined by visible clasts the tread surface is relatively clast free [1]. SLLs often display overlapping of individual lobes. Previously SLL's have only been studied in detail in the northern hemisphere on Mars [1,2,4,5] where they have been found to be latitude-dependent landforms [1,2]. In contrast, only a few observations have been made in the southern hemisphere [6,7]. Several authors argue for a freeze-thaw hypothesis for SSL formation on Mars [1,2,4-7]. If correct, the implication is significant since it would require transient H_2O liquids in a frost-susceptible regolith over large areal extents. Thus a better understanding of SLL will allow identifying environments that may have experienced transient liquid water in the shallow subsurface in the recent past.

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

We show that the distribution of SLLs in the southern hemisphere roughly mirrors that in the northern hemisphere distribution. Hence, SLLs are hemispherically bimodal-distributed landforms, similar to polygonal terrain [e.g. 5] and gullies [e.g. 8]. However, despite more abundant sloping terrain in the southern hemisphere, fewer SLLs are observed, except in the Charitum Montes region. This is in contrast to gully landforms which are more abundant in the southern hemisphere.

Martian gully landforms and their formative processes have received considerable attention in the last decade and there are currently conflicting ideas whether liquid water [e.g. 9] or CO_2–triggered mass wasting [e.g. 10] are the primary agents of erosion. As there are no CO_2 frost triggered hypotheses that can explain the occurrence of SSL, a thaw-based hypothesis could explain both landforms. In the latter scenario gullies and SLLs may form a hydrologic continuum where available water content governs the type of landform produced. Solifluction would require ice lens formation (excess ice) to develop. Excess ice was encountered by the Phoenix lander in 2008 [11]. Furthermore, modelling attempts may suggest that ice lenses could be widespread on Mars [12]. However more work is needed to understand the physical environment related to the CO_2 paradigm and the full suite of slope landforms predicted by it. Hence, we suggest that any model to explain gully formation must incorporate the geomorphologic context in which they occur.

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