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Slow periglacial mass wasting (solifluction) on Mars

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Small-scale lobes (SSL's) on Mars are landforms that show striking resemblance to solifluction lobes on Earth [1,2,3]. 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 often clast-banked arcuate front (riser) tens to hundreds of meters wide [1]. Risers are typically less than a few meters (<5m) in height [1]. 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 [1,2,5-8]. If correct, the implication is significant since it would require transient H_2O liquids and ice-lenses in the regolith. Thus a better understanding of SLL's will allow identifying environments that may have experienced transient liquid water in the shallow subsurface in the relatively recent past.

We show that the distribution of SLL's in the southern hemisphere roughly mirrors the northern hemisphere distribution. Hence, SLL's are hemispheric bimodal-distributed landforms, similar to polygonal terrain [e.g. 6] and gullies [e.g. 9]. However, despite more abundant sloping terrain in the southern hemisphere, fewer SLL's are observed. 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. 10] or CO_2–triggered mass wasting [e.g. 11] are the primary agents of erosion. As there are no CO_2 frost triggered hypotheses that can explain the occurrence of SSL's, a thaw-based hypothesis could explain both landforms. In the latter scenario gullies and SLL's may form a morphologic continuum where available water content governs the type of landform produced. Solifluction would require ice lens formation (segregation ice) to develop. Segregation ice was encountered by the Phoenix lander in 2008 [12]. Furthermore, modelling attempts may suggest that ice lenses could be widespread on Mars [13]. 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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