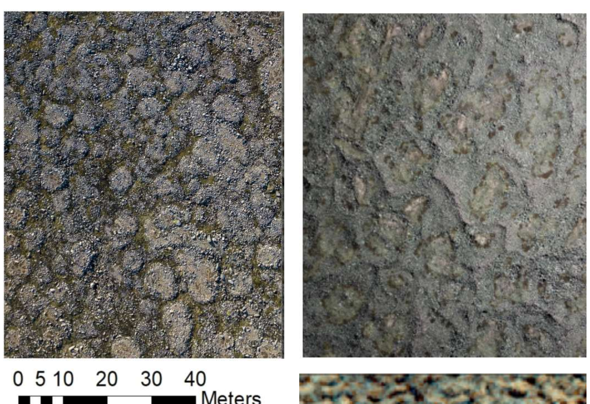
USING THE ASPECT OF RELIC PATTERNED GROUND TO DISTINGUISH BETWEEN FREEZE-THAW AND THERMAL CONTRACTION J.P. Knightly[1], J. Tullis[1], J. Dixon[1], V.F. Chevrier[1], [1]Space and Planetary Sciences, University of Arkansas, 1 University of Arkansas, Fayetteville, AR 72701, jknightl@uark.edu

Introduction: Patterned ground and polygonal features identified across the Martian mid- to high-latitudes share similarities in surface and subsurface morphology to periglacial patterned ground on Earth [1, 2, 3]. Subsurface water ice was observed by the *Phoenix* mission [3, 4], but the present-day climate and subsurface conditions on Mars are not conducive to producing the same freeze-thaw cycles that are observed in terrestrial periglacial regions. It has been hypothesized that under a warmer environment during periods of high obliquity, freeze-thaw may be possible, which carries important implications regarding the nature of liquid water on Mars in the recent past [5, 6, 7, 8]. Thermal contraction is thought to be possible under present Mars surface conditions [9, 10] and has been observed on Earth within the arid Antarctic Dry Valleys [11]. We examined the aspect profiles of terrestrial and Martian patterned ground at the micro-morphological scale to determine if feature orientation can be used to distinguish between freeze-thaw and thermal contraction processes.

Description: Relic terrestrial patterned ground imagery was collected during field events at sites in Utah [12, 13] and Iceland [13] using the stock 12MP camera on a DJI Mavic Pro aerial drone. The Mavic Pro collected images along programmed transects at altitudes between 7.6-83 meters above ground surface, and the



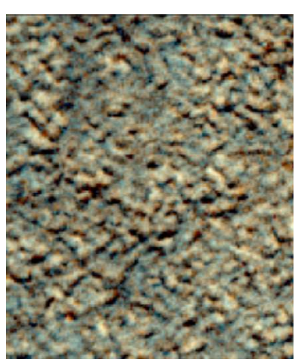


Figure 1 – Drone images of (a.) relict sorted circles in Iceland and (b.) relict patterned ground hummocks in Utah. (c.) HiRISE image of hummocky patterned ground in the vicinity of the Phoenix *landing site.*

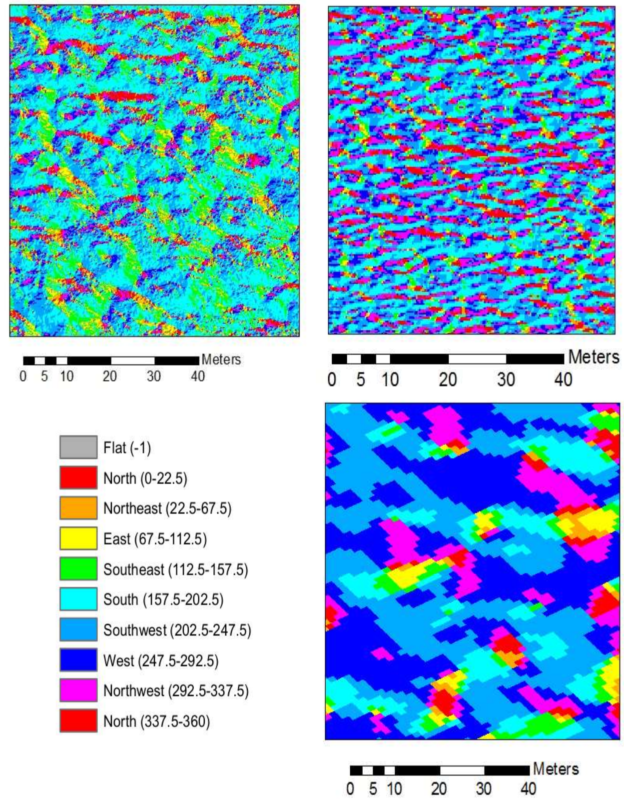


***Figure 2** – Sample of aspect raster layers generated for relic patterned ground in (a.) Utah and (b.) Iceland and (c.) patterned ground near the* Phoenix *landing site derived from images PSP_008301_2480 and PSP_008143_2480.*

resulting photos were stitched into orthoimages with a minimum scale of 2.5 cm/pixel and decimeter-scale DTMs using Agisoft Metashape.

Existing HiRISE DTMs of patterned ground sites were sourced through the Planetary Data System (PDS). New HiRISE DTMs were constructed from existing anaglyph image pairs using best-practice procedures developed for Ames Stereo Pipeline (ASP) [14] – an open source photogrammetry program that integrates with the USGS ISIS3 program. Martian site locations included image pairs centered in Utopia Planitia (46.71ºN, 89.24ºE; 54.64ºN, 83.40ºE) and the *Phoenix* landing site (67.97ºN, 234.95ºW) from which 5 DTMs were generated from smaller segments to isolate patterned ground and polygonal features from the surrounding terrain. The aspect of the terrestrial and Martian DTMs were then calculated within ESRI ArcMap (Fig. 2) from which average aspect orientation angles could be obtained by viewing the statistics for each raster image.

Results: Trends were observed in the relic terrestrial and Martian patterned ground that support previous observations of solar-dependent patterned ground orientation on both planets [8, 9, 14]. At the sub-meter resolution of the terrestrial DTMs, a preferential orientation towards the southwest was observed (Fig. 3). The preferential orientation of 5 northern hemisphere patterned ground sites on Mars was found to be towards the southeast (Fig. 3). The southwest orientations of the terrestrial patterned ground sites were observed to be nearly parallel to the southerly slope (16.21º) of the site in Utah and perpendicular to the prevailing northwesterly slope (16.73º) of the site in Iceland. The slope of the Martian sites were generally more level, ranging from 2º to 9º, with slope directions towards the northwest, northeast, southeast, and southwest. The surface roughness of the terrestrial and Martian sites were also examined [13], however the ASP-generated DTMs were not able to resolve surface roughness values consistently.

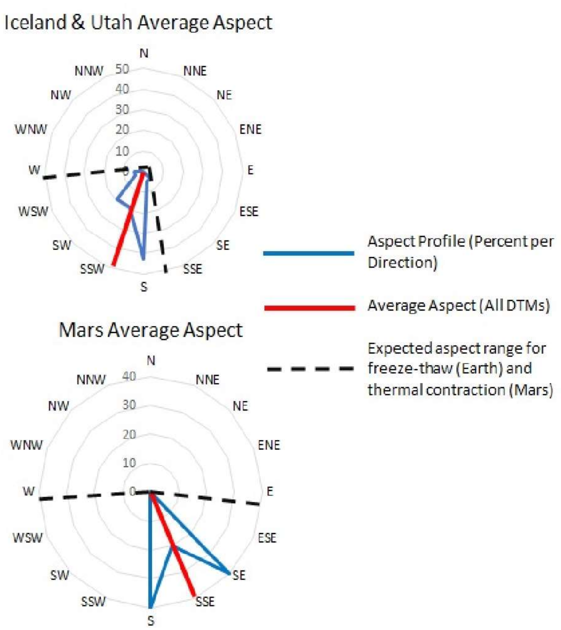


Figure 3. *- Rose diagrams representing the average micromorphological aspect orientation derived from Martian and relic terrestrial patterned ground DTMs.*

Discussion: The southwest orientation of the terrestrial patterned ground sites is interpreted to be a dual-dependency governed by the sun's daily path across the southern sky and the peak diurnal heating that typically occurs during the early afternoon in the southwestern sky. We hypothesize that during warmer months of the year, subfreezing morning and nocturnal temperatures paired with afternoon heating above the freezing point results in preferential permafrost melt on the southwest-facing slope of individual rocks in addition to the broader face of each feature, resulting in a slump towards the southwest. The influence of rocks on ice-table topology was noted at the *Phoenix* landing site as a result of the present-day climate, indicating feature aspect resulting from sustained, recurring freeze-thaw cycles could occur and under the right conditions remain preserved. As this preferred aspect orientation has been preserved in relic features under more dynamic terrestrial weathering regimes, we predict that finding similar afternoon-facing orientations preserved within patterned ground on Mars could point towards freeze-thaw occurring during a warmer climate resulting from a recent period of high-obliquity. An initial analysis of northern hemisphere sites on Mars has not found a prominent southwest aspect orientation.

Conclusion: Feature aspect and orientation can serve as a diagnostic variable for assessing the formation mechanism of patterned ground on Mars. Aspect orientations towards the southwest of relic terrestrial patterned ground suggest the existence of a sensitive solar-temperature dual-dependency during warmer months when melting of near-surface permafrost can occur during the afternoon. A similar solar-temperature dual dependency was not observed at the selected Martian sites, however feature orientation towards the south-southeast supports thermal contraction occurring via the flux between subfreezing nocturnal and diurnal temperatures that presently occur on Mars.

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