EARTH BASED ROCK GLACIERS, AN ANALOG OF MARTIAN FURROWED LANDFORMS.

Spencer DeMar Riley[1,2], Chris Neel[2,3,4], Richard Marston[2,3,4], [1]Department of Geosciences, Weber State University, Ogden, UT 84408, [2]Arkansas-Oklahoma Center for Space and Planetary Sciences, [3]School of Geology, Oklahoma State University, Stillwater, OK 74078, [4]High Alpine Research Project (HARP)

Introduction:

Streams of rock situated in the rocky mountains of Colorado may unlock the mystery of furrowed landforms on Mars. Termed rock glaciers by geomorphologists, these periglacial landforms consist primarily of rock debris cemented by ice. In the process of moving down slope, rock glaciers contort in folds or fractures, which cause them to display a distinctive ridge and furrow topography. The goal in this study is to better understand the origins, the significance, and dynamics of these ridges and furrows in relation to independent site variables such as slope. With this understanding, identifying similar landforms on Mars may be possible.

Rock glaciers can be readily identified on aerial photographs taken of the Earth. It is also possible to map spacing of ridges using the scale of the photograph. Elevation information may then be taken from topographic maps or from photogrammetry to determine slopes. Such a study was performed by Fitzgerald (1994). Fitzgerald discovered through statistical analysis that ridge spacing is correlated with slope and cirque relief.

Modern imagery of Mars obtained by the Mars Global Surveyor spacecraft provides resolution sufficient to resolve ridges on possible Martian rock glaciers (1.39 m). The Mars Orbiter Laser Altimeter (MOLA) also provides us with low resolution (1/64 °) topographic maps of Mars. This resolution, while not adequate for detecting and mapping elevation of individual ridges, can yield a larger scale slope for potential rock glacier landforms, which in turn allows calculation of the average slope.

Study Area:

Mt. Mestas is located at the southeastern end of the Sangre de Cristo Range near La Veta, Colorado. Multiple rock glaciers mantle the slopes of Mt. Mestas. The largest of these on the southeast side was selected for its magnitude, accessibility, and abundance of measurable ridges and furrows. The Mt. Mestas rock glacier is one of the southernmost rock glaciers in the United States, and terminates at an unusually low altitude of 2,575 m. Giardino and Vitek (1988) have classified it as an inactive, ice-cemented, tongue-shaped rock glacier. They claim it was not active during the last glacial period. The presence of pine trees on the rock glacier and sizeable lichen on the surface of the rock glacier comprise evidence of the lack of recent movement.

The mountain is plutonic in origin, and the source rock for the rock glacier is felsite. The fabric of the rock glacier consists of platy clasts of felsite with an average diameter of 0.4 m, but ranging up to about a meter in diameter. As the rock glacier descends from the source area it forms three terraces before terminating in a steep front.

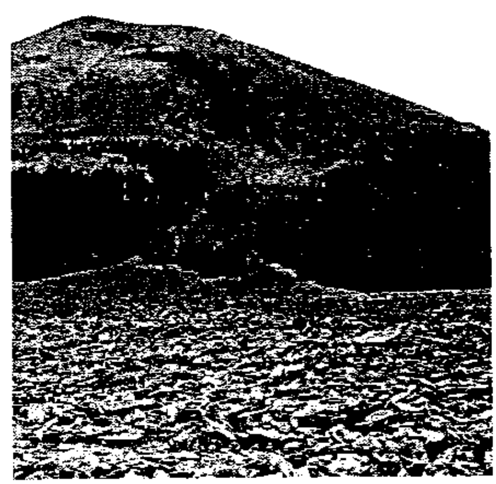

Figure 1 Mt. Mestas rock glacier as seen from the toe.

Data Acquisition:

A longitudinal profile of the Mt. Mestas rock glacier was surveyed using a Topcon Rotating Laser RL-60B and an LS-70B Laser Level. Data points were recorded at the peak of each ridge, and the bottom of every furrow, and in some cases by necessity in between. Intervals of slight or no ridge and furrow activity were surveyed using a compass and measuring tape. Latitude and longitude were obtained using a Garmin Etrex Vista GPS unit and are accurate to within 5 meters. Elevation was recorded using the Garmin Etrex GPS barometric altimeter, and was verified on topographic maps.

The survey line begins at an elevation of 2720.32 m above sea level at a transition of slope, where the first measurable ridge is located (N37 ° 34' 12.6", W105 ° 07'57.2"). The survey line is oriented down the axis of the rock glacier, perpendicular to the center of the transverse ridges. Three ridges in close proximity to the toe of the rock glacier were not recorded because the toe of the rock glacier has been excavated for use in highway construction. The survey line terminates at the toe of the rock glacier (N37 ° 33' 50.9", W105 ° 07' 50.6").

Results and Analysis:

The survey line taken down the axis of the Mt. Mestas rock glacier reveals 30 ridges over a horizontal distance of 735 m. Earlier attempts to correlate ridge spacing and slope by Fitzgerald (1994) consisted of mean ridge spacing over an entire rock glacier. Using this technique, the mean ridge spacing for the Mt. Mestas rock glacier is 24.5 m. Excluding three long sections along the axis that do not contain ridges, and taking an average over the spacing between each of the ridges produces an average of 13.0 m. The ridge spacing ranges from 5.8 m to 26.5 m. The slope taken from ridge top to ridge top ranges from 0.311 to 0.008 (0.46 °-17.2 °). The spacing and slope between pairs of ridges was measured where significant values could be obtained and plotted below.

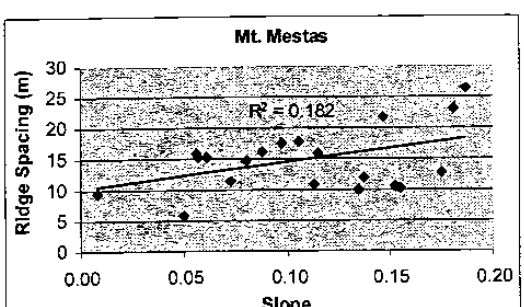

Figure 2 Slope vs. Ridge Spacing

There does appear to be a slight statistical correlation between slope and ridge spacing with little discrimination of ridges included in the analysis. However, it must be acknowledged that additional variables effect the shape and formation of ridges and furrows. Fitzgerald (1994) concluded that multiple aspects of cirque morphology also effect ridge spacing. Periodicity of debris influx may also influence surface morphology. These other variables may account for much of the unexplained variation in ridge spacing when plotted against slope.

Significant changes in slope along the glacier are marked by areas of asymmetrical ridges, and some bunching, which disturbs the ridge spacing. We propose that these areas should not be included in a raw statistical correlation between slope and ridge spacing. After excluding all irregular asymmetrical ridges, and selecting only ridge sets with high symmetry and similar wavelength on uniform slopes, a less distorted correlation was obtained. Problematically, this exclusion of data leaves few data points in ideal situations on this rock glacier, and little relevance to a statistical approach. It would be necessary to gather a larger sampling of different rock glaciers if this approach were to be pursued. Other rock glaciers located on Mt. Mestas would be a good location to gather these data.

Conclusions:

While there appears to be a correlation in this data set and in others, a higher understanding of the relationship between ridge spacing and slope would require a larger detailed data set. Utility of ridge spacing vs. slope on Mars is presently limited to analysis of imagery. Therefore, any relevant deductions about this relationship must be obtainable in this manner. Future research by use of aerial photography over a larger sampling of rock glaciers would be useful for application to Mars.

Acknowledgements:

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