A SURVEY OF VOLCANICALLY EMPLACED RILLES ON MARS. S. I. Peters[1]. [1]Department of Earth and Climate Sciences – Middlebury College, Middlebury, VT 05753. Corresponding email: seanp@middlebury.edu

Introduction: Sinuous channels of volcanic origin (e.g., sinuous rilles, canali) have been observed on Venus, the Moon, and Mars [1,2,3,4]. These enigmatic landforms are morphologically distinct from channelized lava flows, typically with topographically negative source regions, a nebulous formation mechanism (constructive vs. destructive), long, sinuous channels, definitive channel walls, and nebulous deposits [1–4]. Sinuous rilles, in particular, are generally interpreted to have eroded the preexisting landscape, although the method of erosion (i.e., mechanical or thermal) remains controversial [1–4]. On Venus, the presence of channels (e.g., canali) that are long, meandering and sometimes branching has been documented [1–3]. While some of these channels are morphologically similar to lunar sinuous rilles, others have terrestrial and Martian counterparts and much remains unknown about their formation due to the data limitations [1–4]. *Hurwitz* et al. [2013] conducted a comprehensive global survey of sinuous rilles on the Moon cataloging and characterizing over 200 sinuous rilles. Their observations contributed to a better understanding of rille formation and constrained the volcanic evolution of the lunar surface.

On Mars, volcanism has also been a widespread process both spatially and temporarily [5]. Understanding the surface evolution of Mars is impossible without considering the contribution of volcanism. Mars hosts large central volcanoes, innumerable lava flows, low shields, cones, and ancient calderas [5,6]. Rilles have also been observed, primarily in proximity to large central volcanoes [6]. However, a global analysis of the distribution, morphology, and characterization of Martian volcanic rilles has not been conducted. Unlike the moon, Mars has a thin atmosphere and its surface been subjected to the long-term effects of erosion and degradation by wind, glaciers, the cryosphere, liquid water on the surface, and geologically recent volcanism. A plethora of high-resolution image data in conjunction with high spatial resolution topographic data provides an ample opportunity to conduct a survey of smaller scale volcanic features.

In this preliminary work, I have conducted a global survey of the Martian surface in order to catalog suspected volcanically emplaced rilles (a word typically reserved for lunar features). In order to differentiate from the numerous water and lava channels observed on Mars, I have opted to use the term 'volcanically emplaced rilles' to delineate these features – with long, meandering, sinuous, or straight lengths and clearly defined channels and channel walls – suspected of having been primarily emplaced by the eruption and propagation of lava. Typically, unlike typical lava channels on Mars, these features lack large or observable levees, are much narrower, may have structural controls or emanate from tectonic features, and suggest incision into the underlying strata. While some of the observed features have been previously identified as 'sinuous rilles' other features may have morphologic counterparts on other planets that may differ by definition. The volcanically emplaced rilles have been characterized by location and morphologic and morphometric analyses are ongoing. Their distribution and characteristics should further elucidate the volcanic history of Mars, their formation mechanism, provide geologic context, and perhaps contribute to comparative planetology.

Methods: The study was/will be conducted in these steps: 1) initial identification of candidate features; 2) ranking of candidate features by confidence score; 3) morphological analyses and possible re- and sub-classification of features; and 4) placing the features in geologic and geospatial context of the Martian geologic timescale.

1 – The initial identification for candidates in this study was conducted using THEMIS daytime IR (~100 m/px) from 60° N to 60° S. After the initial survey, I utilized image data from CTX (~5-6m/px) and HiRISE (~0.5m/px) for further classification.

2 – Due to various aspects of degradation and in order to account for other plausible formation mechanisms, the observed landforms were assigned a confidence score from 1 to 5, with 1 demonstrating the feature was very unlikely volcanically emplaced and a 5 meaning a volcanic origin was very likely. The assigned confidence score was based on morphology (e.g., comparison to previously observed rilles and degree of degradation), geographic context (e.g., proximity to volcanic or non-volcanic processes), and alternative hypotheses for formation based on the preceding criteria.

3 – I will conduct topographic and morphometric analyses using MOLA (~463m/px) and HRSC DTMs (~50-70m/px) in JMARS in order to measure lengths, widths, depth, slope, and sinuosity. Qualitative morphology was ascertained using CTX and HiRISE.

4 – Once a subset of landforms that can be identified as volcanically emplaced has been obtained and characterized, the features will be placed within the context of Martian geologic history and surface evolution using existing 'geologic' maps and their relationships to other regional landforms.

Using the above methods, I aim to produce the following:
1 – *A global catalog of volcanically emplaced rilles.*
2 – *Morphologic analyses of volcanic emplaced rilles*.
3 – *A reconstructive history of the formation, emplacement, and evolution of volcanically emplaced rilles on Mars*.

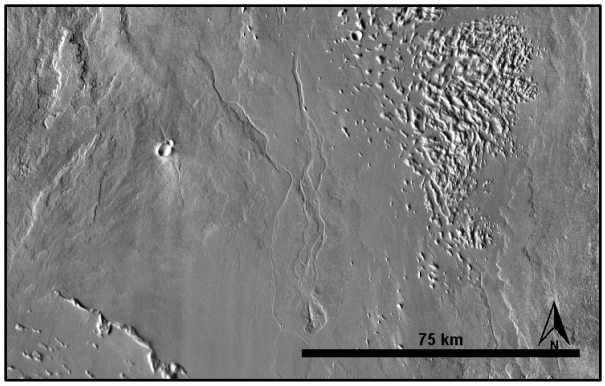

Figure 1: Example of volcanically emplaced rille candidates in Tharsis near Olympus Mons (THEMIS IR Daytime). These features have confidence rankings of 4. The left feature is 86 km in length while the right feature is 198 km in length. Lava flows have modified these features to the north meaning the measured lengths are minimal values.

Preliminary Observations: An initial survey found ~500 rille-like features, but further review continues to whittle down the number of those likely emplaced due to volcanism. 64 features have been assigned a confidence score. A total of 19 features representing likely volcanically emplaced rilles (those with confidence rankings >3) have been observed to date and all have had their lengths measured. The number of volcanically emplaced rilles is expected to increase as the study progresses but remain much lower than ~500.

Distribution. The observed landforms stretch across the Martian surface, but are unsurprisingly concentrated around volcanic centers. The state of degradation of some regions (e.g., Circum-Hellas Volcanic Province or Tyrrhena Planum) may make classification and characterization challenging.

Morphology. Some rilles are more sinuous than others. Tectonic and structural control is evident in some features, especially those in the Tharsis Volcanic Province. The observation of landforms with similar morphologies may allow for grouping based on morphology which could suggest a formation or alteration mechanism (Fig. 2). Some rilles emanate from fractures while over originate from subcircular depressions (Fig 1 & 2).

Of the rilles that have been measured (n=19) and that are likely volcanically emplaced (confidence internals 4 and 5), lengths range from 45–458 km, with a median length of 118 km.

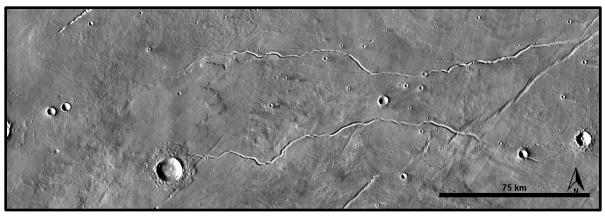

Figure 2: Another example of two rille candidates also located in Tharsis (THEMIS IR Daytime). Top and bottom feature have confidence rankings of 4 and 5, respectively. Top feature is 218 km in length while bottom feature is 236 km in length. Large impact craters have destroyed some of the features resulting in measure lengths that are absolute minima.

Preliminary Discussion: Our preliminary results suggest that Mars has produced volcanically emplaced rilles within a variety of geologic contexts.

Distribution. Features with the highest likelihood of volcanic origins are located in or near volcanic regions and provinces. This is partly an observation bias as the difficulty in determining a volcanic origin is increased in areas with active surface processes, which promote degradation and erosion. As such, so far, these features have been identified in areas with generally younger surface ages (i.e., Amazonian, <3 G.a.).

Morphology. Preliminary observations suggest that those rilles and rille-like features away from volcanic centers are more degraded due to dynamic surface processes. Furthermore, some of the features exhibit obvious structural control which can make them appear unusually linear. Some features have been overprinted by impact carters and volcanism, which can hinder analysis. These features display lengths on the order of those observed on the Moon and Venus.

Formation and Geologic Context. Those features exhibiting a high likelihood of volcanic origin tend to occur in volcanic provinces and regions. Many are observed on the aprons of the Tharsis Montes, for instance.

Ongoing and Future Work: Continued identification of features, assignment of confidence scores, and morphologic analyses.

References: [1] Komatsu, G. and Baker, V.R. (1992) *Int. Colloq. Venus*, 60 – 61. [2] Komatsu, G. and Baker, V.R. (1994) *Geology*, 22(1), 67 – 70. [3] Baker, V.R., et al. (1992) *J. Geophys. Res.,* 97 (E8), 13,421 – 13,444. [4] Hurwitz, D.M. et al. (2013) *Planet. Space Sci*., 79-80, 1 – 38. [5] Werner, S.C. (2009) *Icarus*, 201, 44–68. [6] Plescia, J.B. (2004) J. Geophys. Res., 109, doi: 10.1029/2002JE002031.

Acknowledgements: Special thanks to Dr. Erika L. Rader (UIdaho) for productive feedback on this abstract.