CLASSIFICATION OF CURVILINEAR RIDGES IN THE NILOSYRTIS HIGHLANDS OF MARS. E. K. Ebinger and J. F. Mustard, Brown University Department of Earth, Environmental, and Planetary Sciences, Providence, RI 20912, Ethan_Ebinger@brown.edu

Introduction: Over 10,000 curvilinear ridges, hundreds of meters to a hundred kilometers in length and meters wide, are exposed in the Nilosyrtis Highlands on Mars. A subset of these ridges have been investigated by other researchers [e.g. Head and Mustard, 2004; Mustard et al., 2009; Ivanov et al., 2011; Saper and Mustard, 2013] and may be of impact, volcanic, tectonic, glacial, hydrothermal or fluvial origin. In this study we expand on the work done by by Saper and Mustard [1] regarding the ridges and their orientations in Nili Fossae. We have mapped the characteristics, orientations, elevations, and geologic contexts of over 12,000 ridges to test hypotheses for their formation. Here we summarize the mapped ridges, ridge networks and features, then we discuss hypotheses for their formation.

Methodology: The area Northwest of Nili Fossae, from approximately 27°N-33°N and 65°E-73°E was mapped for this study. Using CTX [Malin et al., 2007] for the majority of the mapping, and supplemented by HiRISE data [McEwen et al., 2007], ridges were digitized in ArcMap, and orientations were calculated in MatLab. Criteria for identification and classification of ridges initially followed that of Saper and Mustard [2013] but were refined with our mapping and showed there were more types of ridges present in the region. These ridges are discussed below.

Results: A total of 12,568 ridges were mapped over a 230,000 km^2 area. From this mapping we define six categories:

Dense networks of polygonal ridges. Erosionally exposed polygonal networks of ridges are typically found over a range of elevations and are commonly found in phyllosilicate-bearing basement rock that is capped by an olivine-rich volcanic unit [2,3]).. These ridges are the most common type (41% of ridges). They are on average < 500 m in length, approximately 20 m in width, and show no preferred orientation for the entire data base (Figure 1a). These ridges intersect, forming polygonal patterns. The ridges often contain knobs/mounds along their length and also at intersections between two or more ridges. The ridges are most similar to those identified by [1].

Long, Anastamosing Ridges. Long, branching ridges that are commonly found around Huo Hsing Vallis, but only represent 2% of total ridges (Figure 1b). Cross-cut by the negative relief of the remnant fluvial valley, these positive relief features are 20-50 m wide and tend to be oriented at 20° and 135° from North. Typically several to a hundred km in length, the longer ridges can appear as aligned segments with small gaps between segments.. Ridges branch off at < 90° angles. Ridges sometimes split and continue parallel to each other for a few hundred m to a few km.

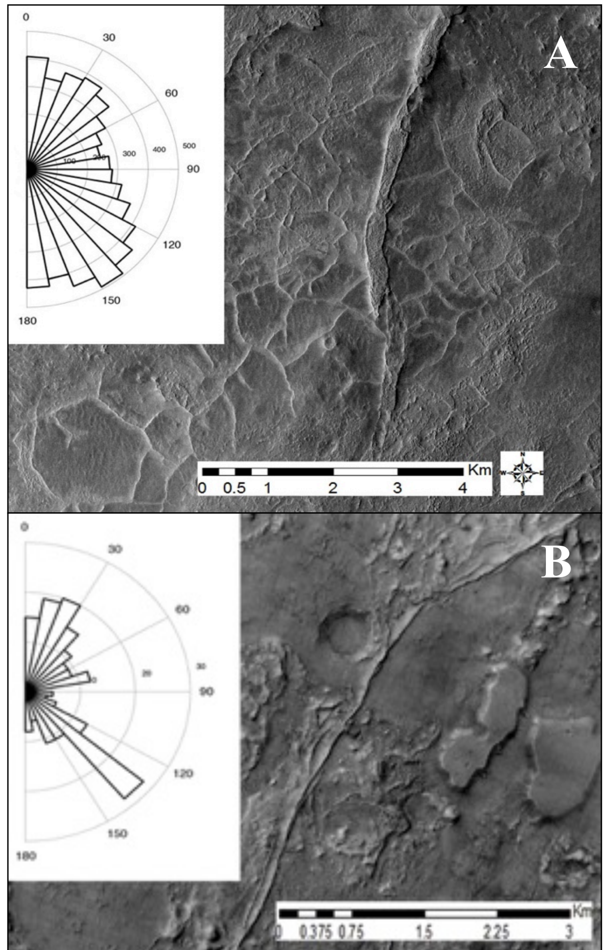

Figure 1: A) Dense, polygonal ridges exposed at 31.972°N, 67.345°E, and **B)** long, anastomosing ridges at 26.467°N, 66.624°E, with rose diagrams of orientations for all ridges of that type.

Short, Anastamosing Ridges. Characteristically similar to the long, anastamosing ridges, but on a much smaller length scale and oriented predominantly at 125° from North. Not continuous along length, these ridges can extend up to 10 km. However, they are also 20-50 m wide and cross-cut by fluvial channels, and only 2% of total ridges.

Dike-like Ridges. Parallel, en echelon, and/or radially oriented ridges that vary in width (20-200m) along their length and tend be oriented 150° from North (Figure 2). Width is typically <100 m but show more variablility than the other ridge types, and in segments with increased width, called bulges, and the position of the bulges often marks a branch point or ridge intersedtion. The ridge segments are commonly linear with low curvature and no networks forming polygonal or lattice-like patterns. The ridges are also cross-cut by fluvial features, and represent 5% of total ridges.

Linear Ridges. Although similar in length and width to the short, anastomosing ridges (1000 m long and 20-50 m wide), these ridges differ because they are quite straight and form few intersections with little curvature evident in the exposed segments. Occasionally erosional knobs are found along their length, but unlike the other types the ridge does not branch at these knobs/mounds. Linear ridges are oriented at 145° from North and are found all over, including in outcrops of other ridge types, although usually isolated and only 7% of total ridges. Commonly the ridges are not as well defined as the other classes but can be interpolated between gaps.

The Other Ridges. Many of the mapped ridges did not fall into one of the aforementioned categories (43% of ridges) or had characteristics pertaining to more than one and thus were not categorized. These ridges display a wide range of morphological features but distinctive characteristics to further subdivide these ridges have not been identified. Orientations calculated for these ridges are complicated and require further analysis. One ridge type not present within the study area are the boxwork structure ridges, such as those identified in Gale Crater, and to the southeast in the NE Syrtis Region [4, 5]. Boxwork structures are smaller than the observed ridges, and exhibit a distinctive polygonal morphology.

It is also important to note that very few ridges were found north of 31°N, likely because of the obscuration of the surface by the well-studied latitude dependent mantle (e.g. [6]).

Conclusions: Different types of ridges are present within the Nilosyrtis region of Mars. Some outcrop in networks, forming polygonal structures, while others are highly unassociated with other ridge features. Based on their morphology we can propose possible formation mechanisms. The dense networks of polygonal ridges are likely erosionally exposed impact-related fractures, faults, or deformation bands that hardened relative to the host rock [1]. Similarly, hypothesized formation mechanisms for the linear ridges includes fluid-filled fractures and faults that hardened relative to the host rock. Due to their length and dendritic nature, possible formation mechanisms for both long and short anastomosing ridges could be eskers or inverted river channels [7,8]. The dike-like ridges match the characteristics observed by Head and Mustard, 2006 [9] and Lambert, 1981 [10] for volcanic and/or breccia dikes, respectively, insinuating that these ridges formed from magmatic or fluid fracture fill and mineralization.

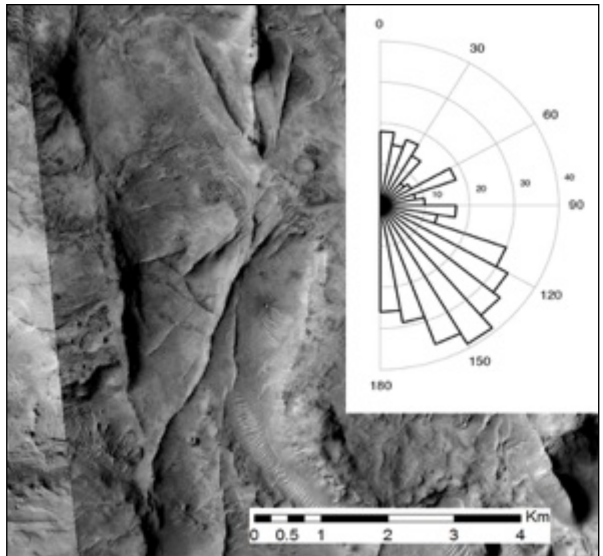

Figure 2: Dike-like ridges exposed at 28.214°N, 68.590°E, with rose diagrams of orientations for all ridges.

Further studies will be conducted to achieve more quantitative results, and a more complete analysis of ridge formation hypotheses will be presented at the meeting. Heights of ridges will be mapped using HiRISE DEMs, and spectra of the ridges and their associated host unit (a phyllosilicate-bearing basement rock [1,2,3]) will be collected and analyzed once a favorable CRISM image is taken.

References: [1] Saper L.M. and Mustard J.F. (2013) *Geophysical Research Letters 40.2, 245-249* [2] Mustard J.F. et al. (2009) *Journal of Geophysical Research 114* [3] Mustard J.F. et al. (2007) *Journal of Geophysical Research 112* [4] Siebach K.L. and Grotzinger J.P. (2014) *J. Geophys. Res. Planets, 119, 189–198* [5] Quinn D.P. and Ehlmann B.L. (2014) *LPSC XLV, Abstract #2312* [6] Mustard. et al. (2001) *Nature 412, 411-414* [7] Anderson R.S. and Anderson S.P. (2010) *Geomorphology: The Mechanics and Chemistry of Landscapes, p.260-263* [8] Weitz C.M. et al. (2008) *Geophys. Res. Letters 35, L19202* [9] Head J.W. and Mustard J.F. (2006) *Meteoritics & Planetary Science 41.10, 1675-1690* [10] Lambert P. (1981) *Multi-ring Basins, Proc. Lunar Planet. Sci. 12A, 59-78*

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