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Polygonal Dike Networks in the Medusae Fossae Formation

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1. Introduction

1.1 The Medusae Fossae Formation

The Medusae Fossae Formation (MFF) is a widespread and voluminous formation which covers 2.1 x 10^6 km^2 between 130-230ºE and 12ºS-12ºN [1-3]. As a fine-grained, friable deposit, its surface is dominated by aeolian features such as yardangs [3-5] and a large number of both fresh and indurated transverse aeolian ridges [TARs] [5]. The deposition of the MFF began at the latest in the Hesperian [6], and over time it has been recognized that, by virtue of its fine-grained nature, the MFF may preserve an important record of Martian history, most directly as a result of the burial and exhumation of channels found in the Zephyria region of the formation [7]. In order to better document the occurrence of small-scale features of interest within the MFF, we examined 427 High Resolution Imaging Science Experiment (HiRISE) images spread across the formation, during which the occurrence of features of interest were mapped [8]. HiRISE images were supplemented by Mars Reconnaissance Orbiter Context Imager (CTX), Mars Express High Resolution Stereo Camera (HRSC) and Mars Global Surveyor Mars Orbiter Camera (MOC) images where needed. Here we describe the occurrence and characteristics of several polygonal networks of rectilinear ridges.

1.2 Rectilinear Ridges on Mars

Rectilinear ridges have been recognized in several different areas on Mars. Long, linear to slightly curving or *en echelon* ridges hypothesized to be exhumed magmatic dikes have been found in a variety of environments on Mars [9-13], particularly in formerly glaciated terrains where magma may have been emplaced into an icy substrate. A network of rectilinear ridges was described in detail in an unnamed crater on the dichotomy boundary [14]. These chaotic, intersecting ridges, forming irregular polygons ~1 km across, are hypothesized to be brecciated dikes emplaced during the process of crater formation [14]. A group of intersecting rectilinear ridges, informally known as “Inca City” and seen to be eroding out of the south polar layered deposits, was observed in early MOC images and hypothesized to be lithified duneforms, clastic dikes, or magmatic dikes [15]. More recently, smaller networks of linear ridges (polygons ~25 m across) have been identified in Gale Crater, where they have been attributed to preferential cementation of material due to the circulation of fluids through fracture networks [16].

2. Observations

Rectilinear ridges forming polygonal networks in the MFF were found in seven HiRISE images and one HRSC image in four different locations (Fig. 1). They are notable because of their extremely fine degree of preservation and their complex, lattice-like geometries. Figure 2 shows a wide view of ridges located at the northern tip of Gordii Dorsum. The ridges are significantly darker than the bulk of the Medusae Fossae Formation, from which they appear to be in the process of being exhumed. Unlike the rest of the formation, which erodes by forming streamlined yardangs and small, light colored TARs, the rectilinear ridges tend to erode by shedding dark, meter-scale boulders (Fig. 3), suggesting that they are formed from a material with significantly different properties. Ridges observed at the northern tip and to the east of Gordii Dorsum have dark, sharply defined ridge crests and occur as somewhat isotropic polygonal lattices. The westernmost latticed ridge occurrence exhibits slightly curving ridges with a preferential orientation (convex towards the northwest). The polygons are generally hundreds of meters across: significantly larger (10x) than those observed in Gale Crater [16], and either smaller than or similar in size to those attributed by [14] to brecciated dikes.

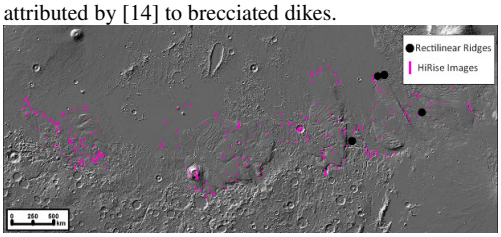

Figure 1. Occurrence of rectilinear ridges compared to HiRISE image distribution.

3. Interpretations

The observed ridges can be characterized on the basis of their color, morphology, and scale. The polygons formed by the ridges are

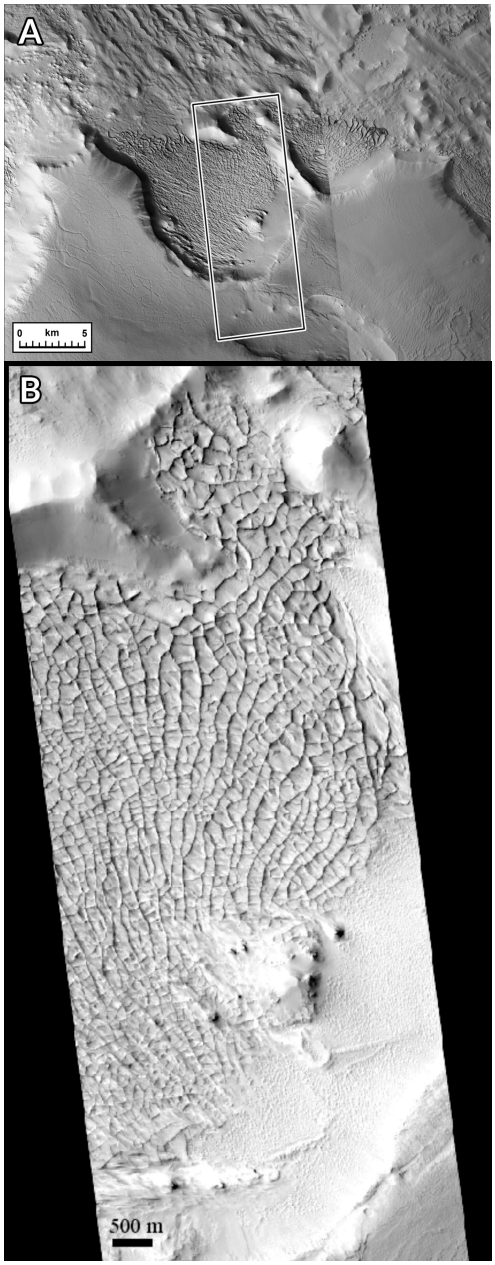

Figure 2. (a) CTX mosaic (P07_003648_1924 & B17_016359_1910) providing context for (b) HiRISE orbit ESP_018548_1910, showing a showing a dense lattice of rectilinear ridges within the MFF.

significantly larger than networks of aeolian bedforms with similar morphologies, which suggests that the ridges are not likely to be indurated dune crests. The patterns made by the ridges are similar to those in Gale Crater [16] but on a much larger scale, which could indicate the past presence of circulating fluids in the substrate. The features that most closely resemble the MFF ridges are the brecciated dikes postulated by [14], though the MFF features are not confined to individual impact craters (Figure 2a). They also tend to be fairly uniform in width. The color and erosion style of these features is similar to nearby lava flows, which could suggest that the ridges are magmatic dikes which have been intruded into the MFF and which are now being exhumed. The northern parts of the MFF are often seen to have both polygonal fracturing and preferentially aligned, arcuate fracturing. This could explain the unique lattice pattern of the ridges if the fresh magma moved upwards along similar pre-existing fracture planes. As either clastic or magmatic dikes, these features would represent the best-preserved examples of exposed dikes observed on Mars to date, and the presence of magmatic material intruded into the MFF could be an indicator for broader volcanic activity across the breadth of the MFF.

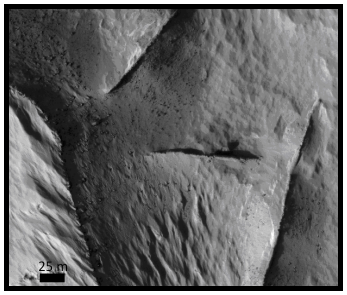

Figure 3. Close-up of linear ridges and boulders.

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