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Dyke swarms associated to domes in Utopia Planitia

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1. Introduction

Utopia basin is an extremely large depressed area, around -4 km in elevation and ~3200 km in diameter, produced by a pre-Noachian impact [1] cantered at 40°N and 105°E. Large enclosed basins, such as Utopia, have been proposed to have contained large standing bodies of water early in Mars history. Utopia also shows evidence of volcanic activity in the Late Noachian to Early Hesperian prior to the resurfacing by Vastitas Borealis Formation material that came with, or caused by, localized rifting processes and the formation of a pervasive wide mound fields [2]. We focused on a specific area of ~ 315 km^2 covered by a coloured CaSSIS image cantered at ~ 30°50'N and 96°40'E. The CaSSIS colour stereo camera of ExoMars/TGO views the surface of Mars with 4 filters in the range 0.4-1.2 µm and a pixel size 4.6 m enhancing geologic mapping potential [3].

2. Observations

In the study area fissures and ridges are visible on the floor units. Despite the large number of structures, we observed a specific regular association between mounds and radially distributed ridge swarms. The mounds showing this peculiarity are located on the low albedo floor unit. They are characterised by central and distal pits, a rough surface, concentric annular features visible in proximity of the pits and a gently convex shape that may appear like pies or domes, depending on the flattening grade. The ridge swarms associated to domes extend up to one to two times the mound's diameter (averagely 500 m). Differently, mounds sitting on the high albedo floor unit display single large craters, sharp and steep flanks and do not show association with ridges in the study area. It is to be noticed that swarms of radial ridges are visible even where no mound is sitting on the central spot of origin.

3. Preliminary Discussions

Due to their morphological traits, we interpret (i) the mounds associated with dykes to be potential mud volcanoes [4] and (ii) the mounds with no radial dykes as tuff rings [5]. Accordingly, we interpret radiating dyke systems and centralized volcanism to have formed under the drive of upwelling of low-density bodies. Additional information about the source geometry can be inferred by the dyke distribution. The ubiquitous radial asset and the absence of inner system of concentric fractures or dykes suggest that the source reservoir must be spherical or prolate (while an oblate geometry is to be rejected) [6]. A hypothesis that well-matches these observations is the local remobilisation (e.g. diapirism) of low-density layers due to large scale volcano-tectonic drives [2]. The presence of radially distributed swarms with no central volcanism could be likewise interpreted in this context as the expression of an early stage of evolution of the same upwelling process [4].

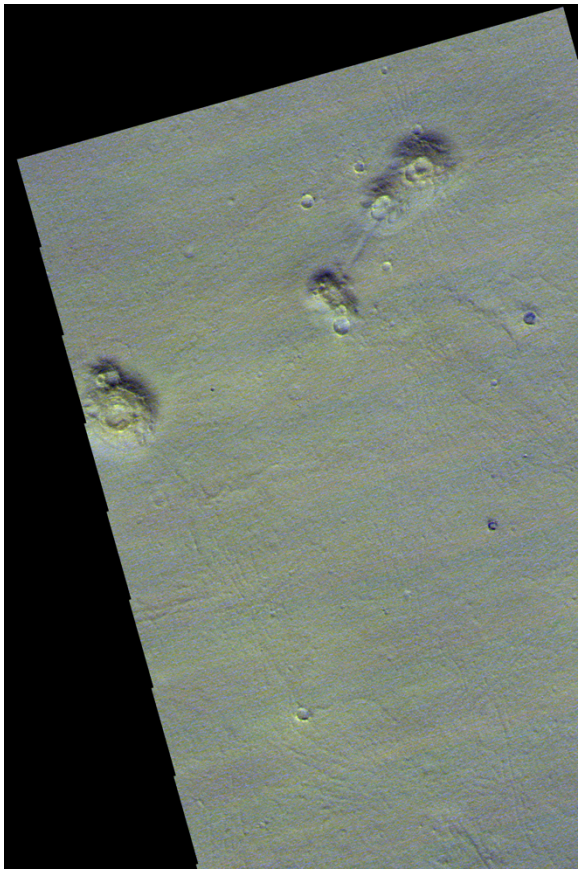
4. Colour variegation

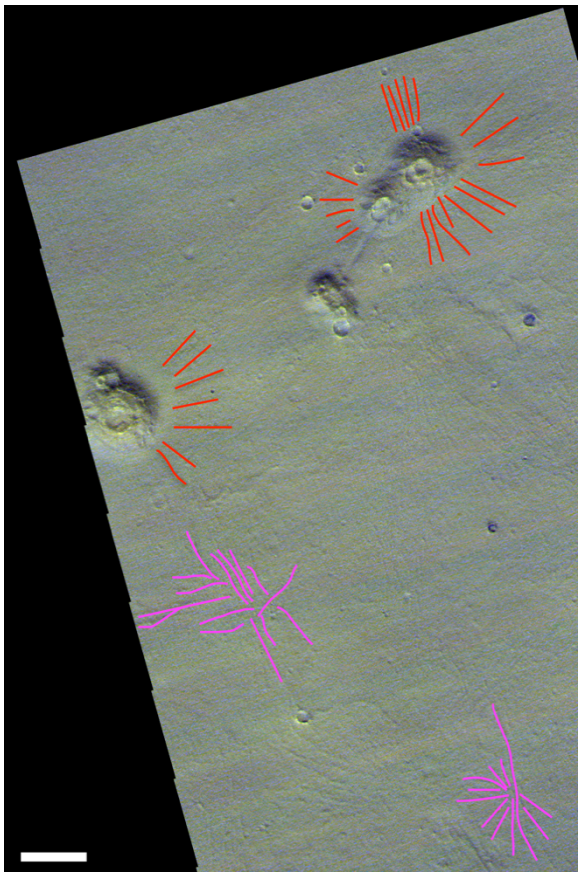
The CaSSIS image covering the study area allows to analyse the colour variegation. We primarily consulted data acquired with the NearIR-Red-Blue filters where differences were neatly visible across the region between yellow and blue portions. Nevertheless we found no correspondence between the high/low albedo units and the colour distribution. Blue spots are mainly present where there is lower topographic relief and some wind stripes are as well visible, thus suggesting that the blue colour could be dictated by larger dust abundance. The fact that no additional colour variegation was present in correspondence of mounds and structures leads to the hypothesis that any pre-existing divergences could have been obliterated by alteration and dust coverage. However albedo variations can be spotted in places in correspondence of the mounds.

5. Issues and Future work

Nevertheless, we recognise discrepancies between the observations and the expected morphology associations. Thus, no certain interpretation can be yet assigned to the newly described domes associated with dyke swarms. The main issues are: (i) topographically positive ridges are usually found associated to magmatic dykes (although endured veins of clastic material cannot be ruled out), while in the study area they surround mounds showing mud volcanoes' key traits; (ii) volcanic domes are similar in shape and dimensions to the ones herein discussed, nevertheless we observe ubiquitously central pits that are not to be expected in the volcanic domes' structure.

Figure 1: Image MY34_004205_149, Utopia Planitia. Interpreted image on the right shows (i) red: radial dykes growing around mud volcanoes and (ii) magenta: swarms of dyke with no volcanic expression in the central position. White bar for scale =1 km.





We accordingly plan to develop further studies to analyse this domes-dykes association which has the potential to be a discriminating parameter for the interpretation of these features.

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