IDENTIFICATION AND SURVEY OF MARTIAN LAVA INFLATIONARY FEATURES.

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Introduction

Lava inflationary features are positive topographic features commonly found on terrestrial basaltic flows that form when a thickened and rigid crust develops on top of a still-fluid lava interior. When the pressure builds up within the fluid core, a small region of crust may be uplifted, forming a dome with distinct clefts where the crust deformed in a brittle manner [1-4]. Although there is still debate about the details of the exact process of formation and how to quantitatively interpret feature morphology and size with respect to lava flow dynamics and characteristics [3,4], these features yield a useful qualitative connection between observable surface morphology of a lava field and subsurface/past lava dynamics. For example, maps of these features can be connected to the location of lava tubes and regions of transient locally-high pressure; studies have done this for some terrestrial [4-7] and Martian flows [4,6,8-10].

Prior studies have generally discussed inflationary features within one individual field. This has made it difficult to get a general sense of the size and distribution of these features and to compare between fields, due to overall lack of data (a field may yield as few as tens of clear features) and potential differences in identification metrics/image characteristics. Additionally, the sparse data make larger-comparison studies between features found on Earth and Mars yet unreasonable.

In this study, we aim to generate a reasonably comprehensive and global survey of Martian inflationary features. To accomplish this, we first created a simple flowchart for the identification of inflationary features on Mars within remote images. The study primarily focuses on images acquired by the High Resolution Imaging Science Experiment (HiRISE [11]) onboard the Mars Reconnaissance Orbiter (MRO) as features of interest are often ~10m in diameter (with identifying features few meters in width) and thus are not adequately visible in lower-resolution images.

Using the identification flowchart, different inflationary features have been mapped within a few lava fields on Mars that contained previously identified tumuli [6-10]. We are now expanding outwards, conducting further detailed surveys within promising lava fields. The goal is to then complete a broader survey.

For each identified inflationary feature, a description, location, and size are noted within a database. This database, once containing adequate numbers of features from a range of Martian fields, will aid in the more uniform definition/identification of these features and in the comparison of feature morphology and spatial distribution between flows within a single field, between fields, and between planets.

The Features

Tumuli (Figure 1) are circular to elliptical raised surfaces with distinct cleft systems. The majority of tumuli display a main axial cleft running along the long axis as well as several lesser clefts that branch off from the main one. These clefts can form a zigzag-type or star shape. Occasionally, the clefts display lava squeeze-ups, where magmastatic pressure below the crust pushed still fluid lava up through the clefts. Squeeze-ups display an upwardly convex top surface. Tumuli may also display marginal or circumferential clefts, where the cleft systems develop around the edges of the formation, leaving a portion of relatively smooth, horizontal crust at the top of the formation.

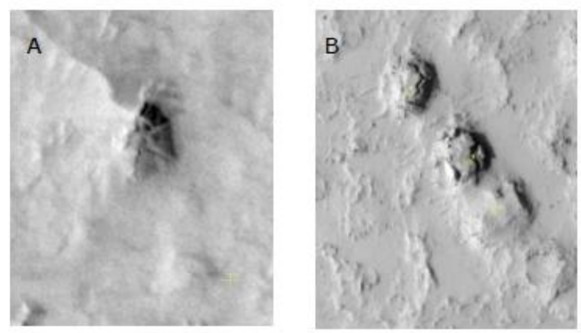

Figure 1. *Tumuli in Elysium Planitia, Mars. Illumination is from the left in the HiRISE image PSP_002542_1765 (3S, 168E). All tumuli are ~10m across. A) This feature displays clear radial clefting in a star-shaped pattern. B) The top tumulus is slightly elongate and displays an axial cleft system. The second feature is more circular and displays axial cleft system. Towards the bottom right, there is the impression of a couple other collinear less-defined/possibly deflated features.*

Lava rises are generally larger features than tumuli, and are more rectangular and elongate in nature, have a flat and smooth top, and are marked by steep circumferential clefts or tilted plates.

Deflated lava-rises and tumuli (Figure 1) are likely inflation formations that were drained, causing the uplifted crust to collapse. These features may have raised edges, but contain a central pit with walls similar in layout to the cleft systems.

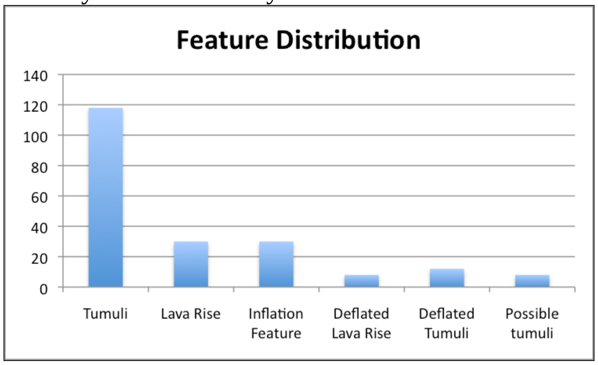

Figure 2. *Distribution of feature types from a sample of 250 features identified in HiRISE image PSP_002542_1765.*

Analysis

As our database of observations grows, we will begin statistical studies that compare various groups of features. For example, we plan to compare sizes of different types of inflationary features and features found within different flows. We will look for consistent scaling differences that can be linked to lava rheologies, flow age and location, or apparent crust thickness. Additionally, we will compare terrestrial distributions with Martian results, which perhaps can illuminate how gravity and atmospheric differences may influence lava eruption, flow dynamics, and crustal development. Initial studies suggest that Martian tumuli are roughly twice as large (in diameter) as Hawaiian [4] and Mt. Etna [6] tumuli.

We also will look at nearest-neighbor analysis of the spatial distribution of inflationary features to attempt to understand how feature distribution relates to subsurface flow patterns and the evolution of those patterns. Prior studies of this type with Martian data indicate a high degree of clustering, which suggest formation through a highly ordered/localized process [7,8]; preliminary results based on our observations are consistent with these results.

Acknowledgements

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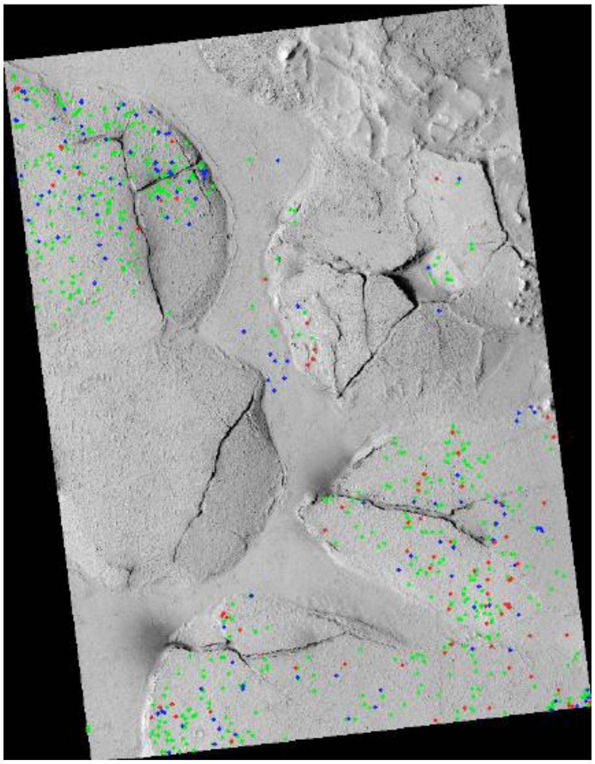

Figure 3. *A nearest-neighbor analysis was done for tumuli (green), lava rises (blue), and other inflation features (red) within PSP_002542_1765 to evaluate the degree to which these features are clustered (vs. randomly distributed). The two lobes in the bottom-right corner had comparable degrees of cluster, consistent with evidence (visible in the CTX image) that they are part of the same flow. The top-left lobe exhibits a higher degree of clustering and is from a different flow. Further work is needed to understand why different flows have different amounts of clustering and why some flows contain tumuli and others (like the lower-half of the top-left lobe) do not.*

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