MORPHOMETRIC CHARACTERIZATION AND COMPARISON AMONG THE THARSIS MONTES-RELATED LOW SHIELD AND FISSURE VENT FIELDS.

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Introduction: The Tharsis province is a volcanic-tectonic rise that spans >4,500 km across the western hemisphere of Mars. It is composed of an array of volcanic features including seven partly buried shield volcanoes, lava plains, and clusters of small vents [1-4], and a variety of tectonic features [5,6]. Mars Orbiter Laser Altimeter (MOLA) data showed that low shields and fissure vents are more abundant across this province than originally thought from *Mariner* and *Viking* images [7]. Recent studies utilizing MOLA, Thermal Emission Imaging System (THEMIS), and High Resolution Stereo Camera (HRSC) data have characterized small-vents in the Tempe Mareotis, Syria Planum, and Eastern Tharsis province areas [8-18], often comparing these features to the Snake River Plain, Idaho, which is the type locale for plains-style volcanism [19]. The objective of this study was to characterize similar fields of low shields and fissure vents on the Tharsis Montes (Arsia Mons, Pavonis Mons, and Ascraeus Mons from southwest to northeast), which are located northwest of the topographic center of the Tharsis province [20].

Background and Approach: Lava flow structures were characterized and their abundances and stratigraphic relationships were estimated based on lava flow mapping of HRSC and THEMIS images covering a central north-south transect of each of the Tharsis Montes [21,22]. Fissure vents were described as linear trenches generally a few to tens of km long that are associated with adjacent channel-, tube-, and sheet-fed flow fields. A fissure is generally associated with a slight rise, in some cases showing rims up to 100 m in height, which are likely composed of spatter or cinders. Low shields are typified by a rise with a central peak and are also associated with a combination of channel-, tube-, and sheet-fed flows, building a small edifice up to 35 km across (when not embayed by younger flows) and 100 to 200 m high.

This project built upon the previous lava flow mapping of the Tharsis Montes by examining THEMIS images and the MOLA 128 pix/degree gridded data product beyond the extent of the HRSC-based mapping, enabling a more accurate estimate of the abundance of small-vent structures associated with these large shields (Figure 1). Just as analysis of MOLA data showed new small volcanic vents that went undetected in previous image analyses, mapping conducted on HRSC and THEMIS data show additional vents, which are often older and heavily embayed structures, thereby displaying little to no trace in the topographic data. We determined the median slopes, orientations, and estimated volumes of small vents within each small-vent field for comparison among the Tharsis Montes, as well as with other fields of small volcanic vents identified throughout the Tharsis province [2,7-18].

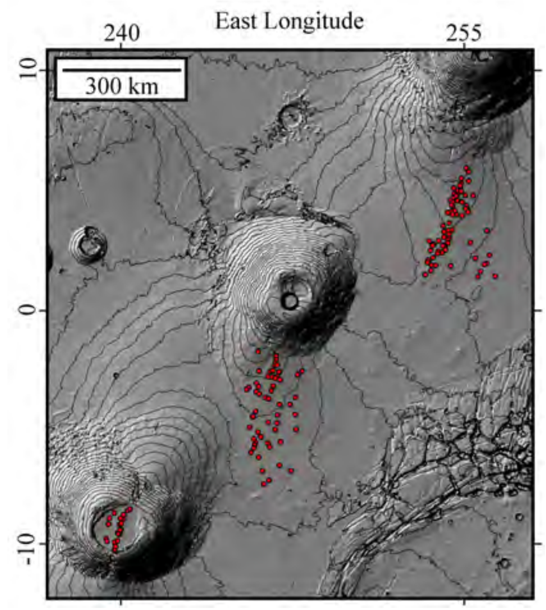

Figure 1. MOLA shaded relief image (derived from the 128 pix/degree gridded data product) showing the location of the Tharsis Montes-related small-vents in red. Contour lines represent 500 m change in elevation. North is towards the top of the image, and light illumination is from the left. The large shield volcanoes are Arsia Mons, Pavonis Mons, and Ascraeus Mons from the southwest to northeast.

Arsia Mons: A series of vents were recognized in the summit caldera of Arsia Mons from analysis of Viking images [23,24], which were later briefly described using MOLA data [25,26]. We identified 18 low shields and 4 fissures with a maximum density of 0.006 vents/km^2. The vents comprise at least one lineament trending N20˚-25˚E, generally parallel to the Arsia Mons southwest rift zone. A possible second, older lineament is located to the west of the primary chain of vents with a similar orientation. Fissure vents are embayed by flows from the low shields and are not easily recognized in the MOLA data. Fissure vents trend N5˚W to N5˚E while some elongate low shield vents trend N5˚-20˚W suggesting a change in vent orientation with time from due north to northwest. Low shield median slopes are <1˚.

Pavonis Mons: A small-vent field at Pavonis Mons is located to the south of the main shield and includes 44 low shields and 11 fissure vents with a maximum density of 0.007 vents/km^2. Similar to the relationship observed at Arsia Mons, fissure vents are heavily embayed by low shields and their flows. The vents roughly define two lineaments that transition from N5˚E closer to the main flank to N15˚E at over 200 km from the main flank. Individual fissure vent orientations also show a transition in orientation from N20˚-40˚E near the main flank to N70˚-80˚E at over 200 km from the main flank. Low shield widths range from several kilometers (when embayed) up to several tens of kilometers. Several low shields display an increase in slope near the summit, with values as high as 5˚, while other low shields display little to no proximal steepening. However, all low shields display median slopes of <1˚. Unembayed low shield volumes are roughly 1.1 x 10^{11} km^3. However, this value is likely to be a minimum estimate if the more extensive flow fields that cover the rest of the field were also erupted from these vents.

Ascraeus Mons: Similar to Pavonis Mons, the small-vent field at Ascraeus Mons is also located to the south of the main flank and includes 31 low shields and 40 fissure vents with a maximum density of 0.009 vents/km^2. Unlike the relationship seen at Pavonis Mons, fissure vents are not consistently younger than low shields in this region. The vents define one prominent lineament along which nearly all the vents in this area are located. The lineament, which produces a topographic ridge that is easily detected in the topographic contours (Figure 1), trends N5˚E at ~120 km from the main flank to N20˚E at ~300 km from the main flank. Fissure orientations range from N5˚E to N30˚E but do not show a transition with distance from the main flank. Although some low shield flank slopes range up to 3˚-4˚, median slopes are consistently <1˚.

Summary and Conclusions: All three of the Tharsis Montes appear to have experienced plains-style volcanism associated with their most recent volcanic activity. However, when compared, the small-vent fields display several trends. Perhaps most notable is an increase in small vent abundance to the northeast (Arsia to Pavonis to Ascraeus) from 22 to 55 to 71. The increased vent abundance is associated with a decrease in low shield-to-fissure vent ratios from 4.5 to 4.0 to 0.7 to the northeast and an increase in vent density. The distribution of vents transitions to the northeast as well. At Arsia Mons all small vents are located within the summit caldera. At Pavonis Mons the small-vents are spread throughout an area of ~42,000 km^2, beginning at a distance of ~120 km from the summit caldera. 85% of the Ascraeus Mons small vents are tightly clustered along a lineament with an area of ~16,000 km^2, beginning at a distance of ~270 km from the summit caldera.

The Tharsis Montes-related small-vent fields appear to differ from other small-vent fields in the Tharsis province in that they form lineaments, which appear to be directly related to larger shield volcanoes. Because development of each small-vent field appears to have occurred synonymously with major rift apron eruptions at each of the Tharsis Montes, differences between the fields should provide insight into the style of rift zone development at the larger shield volcanoes. The abundance and density of small vents, and the distance from the main volcano at which small vent development was taking place, increases from Arsia Mons to Ascraeus Mons. If low shields and fissure vents form as the result of small individual batches of magma as suggested for other Tharsis province small vents [10-17], it appears that Tharsis Montes-related small batches of magma increased in abundance and degree of dispersal away from the main vent from Arsia Mons to Ascraeus Mons.

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