THE RELATIONSHIP BETWEEN LAVA FANS AND TUBES ON OLYMPUS MONS IN THE THARIS REGION, MARS. P.W. Richardson[1], J.E. Bleacher[2], L.S. Glaze[2], S.M. Baloga[3]. [1]Earth and Space Sciences, University of Washington, Seattle, WA, 98195, paulwric@u.washington.edu, [2]Planetary Geodynamics Laboratory, Code 698, NASA GSFC, Greenbelt, MD, 20771, [3]Proxemy Research, Farcroft Lane, Laytonsville, MD, 20715

Introduction: The acquisition of image data from the *Mars Odyssey* THermal EMission Imaging System (THEMIS) and the European Space Agency's *Mars Express* High Resolution Stereo Camera (HRSC) have enabled new observations, and in some cases interpretations, of small volcanic features in the Tharsis region of Mars. While image resolution limitations have traditionally hampered detailed inspection of small-scale (<10 km in diameter) volcanic features on Olympus Mons, these data together provide complete coverage of the volcano at resolutions between 12 and 18 m/pixel. When co-registered with pre-existing, topography data from the Mars Orbiter Laser Altimeter (MOLA), small-scale features such as fans, tubes, ridges, and channels can be mapped, and their characteristics measured. Here we report on a study focused on lava fans on the flank of Olympus Mons.

Background and Approach: Olympus Mons rises 23 km above the surrounding terrain and has a diameter of ~ 600 km [1]. Our mapping encompassed ~ 330,000 km^2, covering both the volcano's main flank and areas beyond the basal scarp where Olympus Mons derived lavas flowed onto the Tharsis plains.

Lava fans are delta-like features displaying lava flow morphologies that radiate down slope from an apex and are thought to represent local eruption points on the flank of Olympus Mons. Multiple hypotheses are proposed to explain the formation of lava fans such as: 1) outlets for lava tube flows [2], 2) small-scale vents occurring along dikes or rift zones [3], or 3) outpourings of lava along thrust faults [4]. Using ArcGIS (by ESRI) to examine HRSC, THEMIS, and MOLA data, we assigned a data point to the apex of all identifiable fans as originally described by *Carr et al.* [2] in order to provide insight into the mechanism of their formation. To test the relationship between fans and tubes, the lava tubes and ridges were traced and their relationships to fans were noted. The objective of this work is to identify fans that are associated with tubes to better enable a focused study of features that might be indicative of rift zone activity.

We also conducted preliminary Nearest Neighbor analyses to the location data for Olympus Mons lava fans. This approach has been shown to provide insight into the formation of volcanic features on the Earth, Moon, and Mars [5,6,7] The statistical techniques are applied to the total population of fans, the individual fans and fan complexes, and the populations of fans that are and are not related to lava tubes. Results could help identify rift zone-related features if present.

Results: Every identifiable fan is considered a localized point of eruption in this study, rootless or not, and was assigned a data point. Fans exhibit a delta-like shape formed by roughly linear boundaries trending from a single apex. The fan is often composed of outpourings of lava that can be traced to a single apex that is the topographic high-point. Small collapse pits and boulder-like features are commonly located at the apex. Fans are typically embayed by younger lava flows which probably obscure their full extent.

The total population of fans is 171. Some fans exhibited adjacent and nested relationships with other fans, together forming a much larger fan complex.

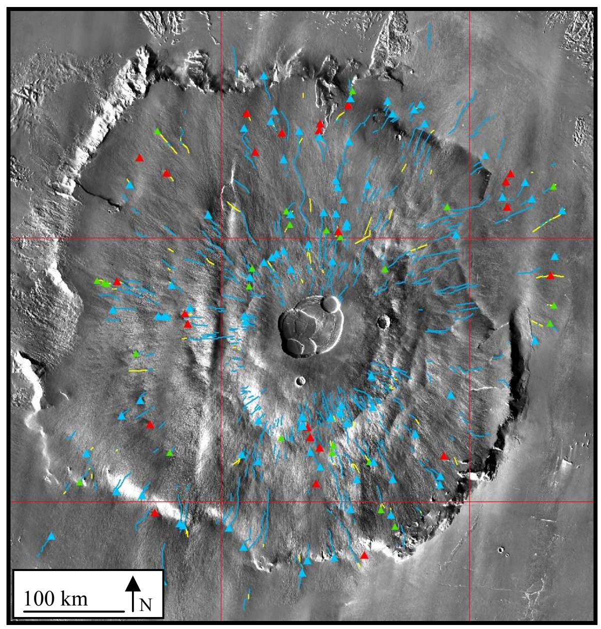

Figure 1: Tubes are shown in blue. Ridges are shown in yellow. Triangles represent fans. Blue triangles represent fans that are tube-related. Green triangles represent fans that are probably tube-related. Red triangles represent fans that are not known to be tube-related.

Fan complexes composed of multiple nested or adjacent fans were also assigned a single point to represent the entire complex in the geographic center of the cluster of apexes. When a cluster is assigned one data point we assume that each individual fan within the cluster was formed during the same event. 112 fans are isolated and the remaining 59 individual fans form a total of 23 fan complexes. In other words, of the total population of 171 individual fans, there are 135 individual fans and fan complexes.

Fans were originally characterized as muted, smooth, mottled, or channeled based on their texture in accordance with [8]. However, this classification scheme was dropped due to the gradational nature of fan textures that are often exhibited within one fan. Larger fans (>10km) often display smooth textures proximally and a channelized or hummocky texture distally. However, we note that muted fans, which are characterized by a muted texture (possibly attributable to burial by younger material) are regionally grouped on the Northwest flank of the volcano nearby areas previously described as possibly being affected by a combination of dust, ash, and or ice deposition [9].

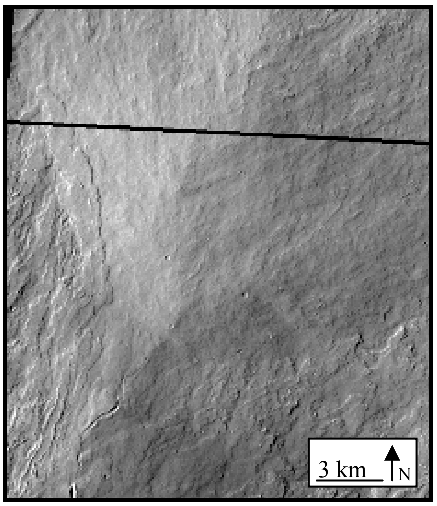

Figure 2: THEMIS VIS(V12162005). Fan associated with lava tube. Mapped as blue triangle in Figure 1.

Lavas that appear to have surged out of a tube and are located up slope from the tube's distal end are considered to be part of the lava tube structure, as mapped by [8]. Morphological characteristics of lava tubes and ridges are well-established [1,8,10,11]. Lava tubes are morphologically expressed as sinuous chains of collapse pits inferred to be skylights sometimes located axial to ridges. Lava tubes display a range of surface textures and are often associated with ridges. Lava tube overflow likely occurred during emplacement and produced smooth to hummocky textures. Fans, even when overlapping a lava tube, do not display a continuation of the tube's structure through the fan's apex, thereby being a unique feature apart from the tube potentially representing a younger event.

Lava tubes and ridges were traced across Olympus Mons [Figure 1]. Of the 135 individual fans and fan complexes, 86 were associated with lava tubes that trend into their apex [Figure 2]. 25 of the remaining fans or fan complexes were located in close proximity down slope of a lava tube that is considered to most likely be associated with the fan. The other 24 fans or fan complexes were not associated with lava tube collapse [Figure 3].

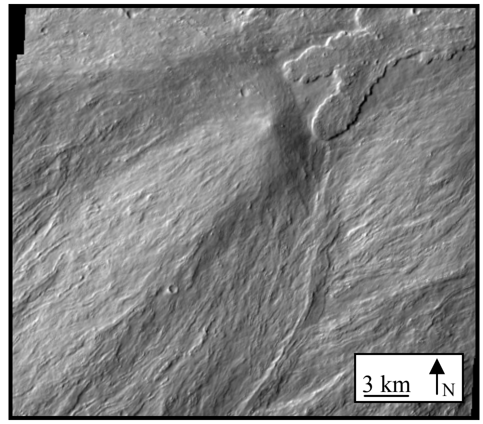

Figure 3: THEMIS VIS(V13535008). Fan not associated with lava tube. Mapped as red triangle in Figure 2. Large tabular flow embays proximal area of fan.

Discussion: 82% of fans are associated with lava tubes, consistent with the results of [8]. The remaining 18% of fans are embayed by younger flows, which possibly buried evidence of lava tubes. Due to the strong association of fans and lava tubes, we conclude that fans are likely the result of lava tube breakouts as originally suggested by [2]. This process could result from lava tube blockage, increases in lava flux, or changes in slope. The hypothesis that fans form along thrust faults is based on the observation that fans are often found at the base of Olympus Mons flank terraces. However, the change in slope associated with terraces could have been the cause of tube breakout events [12]. While many fans are associated with terraces, they are also associated with lava tubes, suggesting that their formation was likely related to a lava tube encountering a slope break. Preliminary Nearest Neighbor results for the full set of 171 fans are not consistent with a random Poisson distribution, suggesting that the full population might represent more than one formation mechanism. The 18% of fans that are not associated with lava tubes are the best candidates for potential rift zone related processes.

References: [1] McGovern P.J. et al. (2004) *JGR,109,* E08008 [2] Carr, M.H. et. al. (1977) JGR, 82, 7S0470 [3] Mouginis-Mark P.J. and Christensen, P.R.(2005), *JGR,110,* E08007 [4] McGovern, P.J. and Solomon, S.C. (1993) JGR, Vol. 98, E12 [5] Glaze, L.S., et al. (2007) GSA, #46-13. [6] Bleacher, J. E. et al. (2008) LPSC 39, #1391. [7] Gregg, T.K.P., & K. Shockey (2008) GSA, # 133-4. [8] Bleacher et al. (2008) JGRE doi:10.1029/2006JE002826. [9] Basilevsky, A.T. et. al. (2005) *Sol. Syst. Res., 39(2),* 85-101. [10] Pupysheva, N.V. et. al. (2006) Vernadksy-Brown Microsymposium. [11] Basilevskaya, G.N. (2006) *Sol. Syst. Res., 40(5*), 408-417. [12] Bleacher (2007) LPSC, abstract 1886.