ERUPTION STYLES OF SMALL MARTIAN SHIELD VOLCANOES AND INDICATIONS OF POST-FLOW TECTONIC DEFORMATION ON SYRIA PLANUM, FROM MOLA, TES, AND THEMIS DATA.

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Introduction: Syria Planum, near the center uplift of the Tharsis Bulge, is characterized by hundreds of small, coalesced shield volcanoes and lava flows. As such, it is the largest field of plains-style volcanic shields on Mars [1], and its total volume is nearly 20% that of Olympus Mons [2]. Some preliminary studies have considered the general eruptive center attributes [3] and the stress regimes related to the magmatic plumbing [4]. The Syria Planum shields and lava flows are part of a global correlation between volcanic topography and eruption styles [5] driven by magmatic composition and volatiles [6,7]. Recent terrestrial quantitative field studies [6,7,8] suggest that new martian data may allow us to use higher-resolution topography, image, and composition data to better constrain eruption styles and post-eruption deformation. Accordingly, in this study we use topographic, compositional, and image data from the Mars Orbiter Laser Altimeter (MOLA), the Thermal Emission Spectrometer (TES), and the Thermal Emission Imaging System (THEMIS) to constrain the small shield volcano eruption style, eruption volume, and post-eruption regional tectonic deformation.

Data and Analysis:

Shield Morphology: Fig. 1 shows the locations of shield volcanoes and lava flows, on MOLA shaded relief topography, considered for this study. We use 256 pix/deg (230 m/pix) gridded MOLA data in conjunction with the IDL-based program *Gridview* [9] to systematically measure topographic attributes of shields and flows such as the basal diameter, height or length, volume, area, local slopes, summit crater dimensions, and other parameters.

We find that, topographically, Syria Planum volcanoes are very similar to terrestrial basaltic shields in the Eastern Snake River Plain (ESRP); both plains locations contain flow fields with multiple eruptive vents, fissures, coalescing shields, radial flow patterns, summit craters, low shield flank slopes, and possibly large tube flows – all characteristics of basaltic plains volcanism [10]. The Syria Planum volcano flank slopes range from 0.1˚-1.6˚, with an average of ~ 0.7˚. Basal diameters range from 10-35 km, with an average of ~ 20 km. In comparison, the average ESRP volcano flank slopes are less than 5˚, and basal diameters range from 5-25 km [11]. We find that volcanoes on Syria Planum do not show the full range of shield morphologies visible elsewhere on Mars; they lack steepened summit slopes and summit caps. This suggests that the Syria Planum eruption style is relatively non-explosive compared to other martian volcanic fields [6], which is consistent with our observations of gentle summit slopes, small summit craters, minimal apparent local volcanic mantling deposits (possible explosive eruptive products), and abundant evidence for quieter effusive activity. While the small edifices fit into global topographic trends [12], we see no local trends in latitude, flank slopes, volumes, areas, or summit craters.

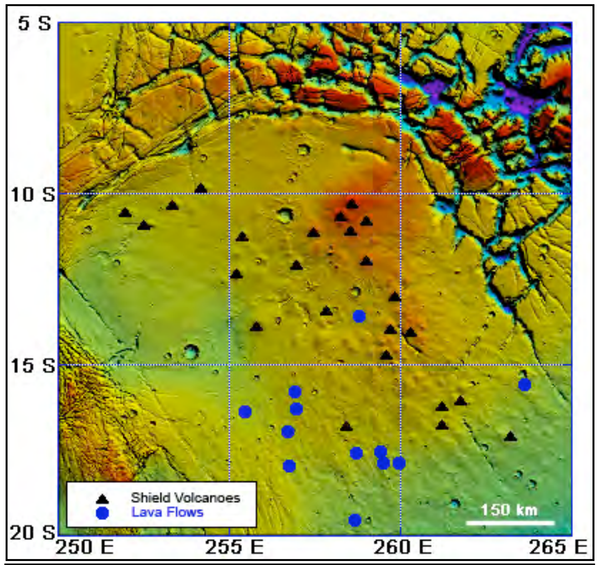

Figure 1. MOLA shaded-relief topographic map of Syia Planum with measured shield volcano and lava flow locations.

Edifice and Flow Volumes: The summit and higher-elevation regions of Syria Planum are dominated by coalesced shield volcanoes and local slopes of 0.1˚. On the lower flanks, where local slopes increase to 0.3˚, we find a transition from shields to large lava flows, however, the eruptive volumes apparently do not change. Fig. 2 shows measured shield and flow volumes. Shield volumes range from 64-1057 km^3, with most edifices at a few hundred cubic kilometers. Similarly, we measured the volumes of Syria Planum lava flows to be 34-339 km^3, with most flow volumes at a few hundred cubic kilometers. These comparable shield and flow volumes suggest either a common magma source, or very similar monogenetic magma source generation and ascent conditions, however, there are a handful of intriguing and notable exceptions to the cluster of typical volumes shown in fig. 2. A second smaller subset of shields have volumes in ~800-1000 km^3 range. Temporal or spatial shifts in local magmatic plumbing or magma rise conditions might explain the volume dichotomy. While we do consider spatial vent distribution or regional superposition relationships, we do not see an initial relationship explaining the volume dichotomy in the preliminary data. When available, surface chemical compositions may provide insight to the volcano differences. Unfortunately, TES data studies [13,14] show primarily dusty surfaces on Syria Planum, with only limited local exposure of the "basaltic" and "basaltic andesite - andesite" surface composition types [15, 16].

Post-Flow Tectonic Deformation: When we consider the topographic attributes of the Syria Planum lava flows, it is often readily apparent that current slope gradients do not match observed flow directions (i.e., see Fig. 3 [and also 17]). Using MOLA topography, we measure along-flow vectors and local current slope gradient vectors. The flow directions and local slope directions vary by as much as 54˚, with an average deviation of ~ 30˚. The spatial distribution of vector differences defines a regional topographic trough that must be the result of post-flow tectonic deformation. Fig. 3 shows a part of this newly defined deformation axis, which is approximately radial to the regional Tharsis Bulge. We expect further measurements to better define the location and extent of these deformation features.

Conclusions: Syria Planum has topographic attributes of a major plains volcanism province superimposed on a large volcanic/tectonic rise. Many of the fissures, coalescing shields, radial flow patterns, and summit craters are newly-visible in MOLA and THEMIS data. We find that the eruption style is relatively non-explosive compared to other martian volcanic fields. While there is a regional transition from shields to large flows, we find that the flow volumes are similar to the shield volumes, which suggests either a common magma source, or similar magma generation and ascent conditions. Finally, a significant fraction of the lava flows in this study does not conform to the local topographic gradient. Our mapped distribution of the difference between the original and current slopes defines a regional topographic trough directly attributal to post-flow tectonic deformation.

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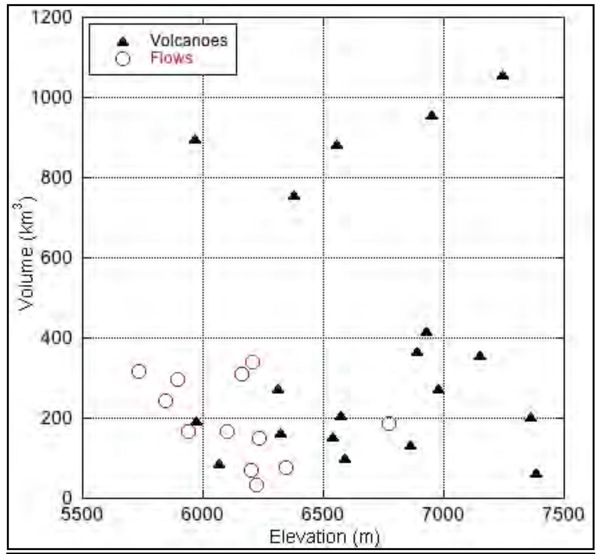

Figure 2. Lava flow and shield volume versus elevation.

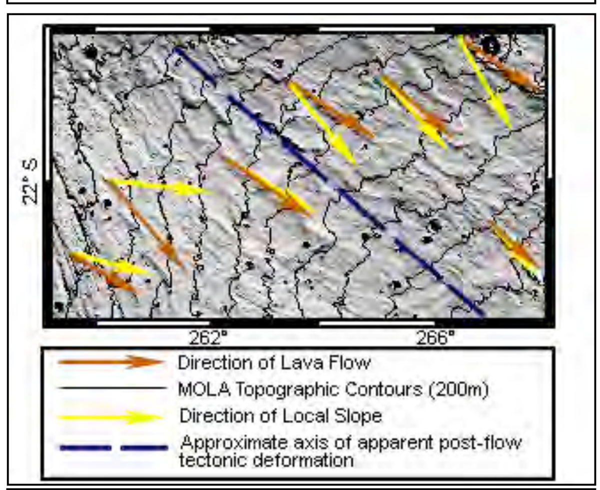

Figure 3. MOLA shaded relief topography for a portion of Syria Planum showing lava flow vectors, current slope gradient vectors, and the mapped axis of apparent post-flow tectonic deformation.