SMALL MARTIAN SHIELD VOLCANOES AND TERRESTRIAL ANALOGUES.

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Introduction: A number of terrestrial analog studies have focused on characterizing individual lava flows [e.g., 3, 6-7]. Morphometric and compositional information from these features can be used to infer the rheological properties of similar lava flows, the timing and duration of the eruptions episodes, the depth of the magma chambers [2, 12-14], and even the eruptive and emplacement history of the larger shield volcanoes found on Mars [e.g. 8]. Another common volcanic feature are small shield volcanoes, which are small constructional feature formed by the eruption of lava flows from a central vent [9]. Small shield volcanoes have been found on Mars [1-2], Venus [3], the Moon [4], and possibly even Titan [5]. They represent important stages in the volcanic evolution of a planet's surface and can also provide clues regarding the composition and rheology of the magma, timing and duration of volcanism, and potentially the lithosphere conditions. Small shield volcanoes have been described as a relatively late volcanic feature formed during the waning stages of plains-style volcanism [e.g. 10]. On Mars, this type of volcanism may result from a magmatic occurrence that occurs near larger plumes [1, 10].

Currently we are collecting field observations, Global Positioning System (GPS) measurements, and remote sensing data of small, parasitic shield volcanoes and their related lava flows located on the flanks of Kilauea Volcano, Hawaii, and on the rift zones on Iceland. These features provide us with the opportunity to characterize the textural and morphologic variability of flow field surfaces and provide a means to generate surface unit maps that represent local flow emplacement processes and constrain flow field development. Our analyses suggest that an understanding of the lithospheric characteristics and temperature fields in volcanic regions dominated by shield volcanoes is crucial to correctly interpret the development of these regions.

Small Shield Volcanoes On Mars: Small shield volcanoes are found in a variety of places on Mars. Syria Planum shield volcanoes represent a late-stage volcanic episode that began with the formation of long lava flows [2]. This complex and multi-staged volcanic system is probably related to the formation of the main Tharsis volcanic province, which is generally younger than Syria Planum [e.g.11]. On Syria Planum, the volcanic eruptions may have ceased in the early Hesperian [2]. The formation of small shield volcanoes continued in the Tharsis region as these features and related fissure vents have been mapped in the vicinity or within the caldera floors of the Tharsis Montes [12-14]. In addition, small-vent fields in the eastern Tharsis province have been described as the result of late Amazonian volcanism associated more or less directly with the Tharsis Montes [12].

Rheological evidences for the Syria Planum small shields, like the presence of channels or irregular volcanoes' borders [2], allowed us to conclude that these shields were formed during a relatively more vigorous volcanic phase, with the creation of pyroclastic deposits [2]. A previous steadier phase is inferred by the presence of tube-fed flows adjacent to these shields [2]. These repeated phases [8, 15] may be explained given the characteristics of the Martian lithosphere.

Lithospheric Influences: We hypothesized that the small shield volcanoes and the variety of volcanic eruptions that occurred on Syria Planum are intrinsically related to the particularly thicker crust of this region [2]. Syria Planum is characterized by a thick crust associated with a thin lithosphere at the time of the magmatic activity, which possibly has resulted in relatively shallower magma sources [2]. As a consequence, the maximum height for the possible volcanic constructs in this region was more limited than in the other regions of the Tharsis plateau. As it is suggested by [16] the development of this thicker crust may explain the incomplete development of a larger volcano at this location by the end of the volcanism, which then continued in the western Tharsis region. As stated by most of the thermochemical models for the Martian lithosphere, the crust is less conductive than the mantle, thus impeding a preferential ascension of magma. The fact that plains-style volcanism on Mars is peripheral to large shields (or found inside calderas or other summit regions after an extended eruptive phase) supports the idea of small batch magmatism, strongly constrained by the local lithospheric characteristics. On Earth, on the flanks of Kilauea and on Iceland, there are good analogues to these shield volcanoes formed in the surroundings of more extended volcanic systems.

Small Shield Volcanoes On The Earth: There are many similarities between these Martian features and the parasitic shield volcanoes found on Kilauea and in Iceland. Specifically, parasitic shield eruptions on Kilauea contribute significantly to the growth of the volcano and they are closely associated with lava tube systems and long duration eruptions [17]. Of the 15 parasitic shields on Kilauea [18] three formed in historical times, including Mauna Iki (1919-1920), Mauna Ulu (1969-1974) and Kupanaiaba (986-1992).

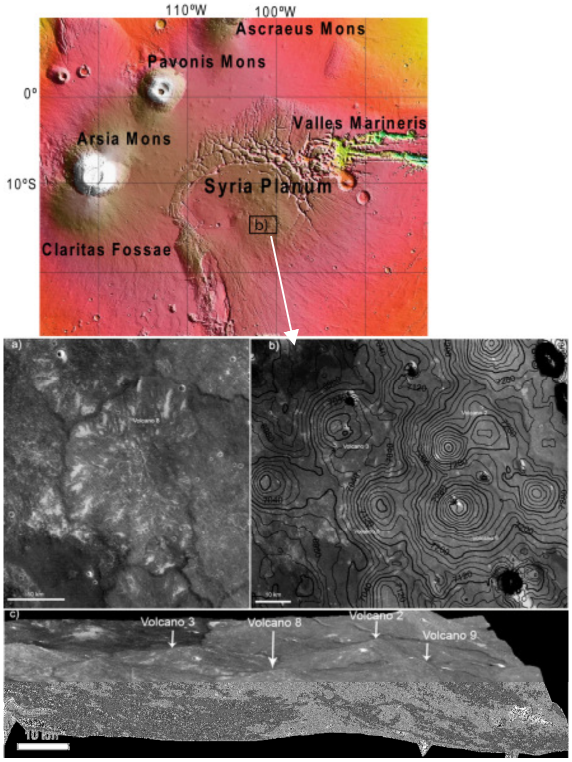

Figure 1. Top: Shaded relief map from MOLA 1/128º DEM. The black rectangle delineates the HRSC mosaic of Figures 1 a–c) from Syria Planum. A) Shield volcano seen by HRSC, where a small vent is visible on the top. B) HRSC image superimposed on MOLA data where the contour lines (spaced of 20 m) delineate some volcanic shields. C) The field of coalesced shield volcanoes is represented in a 3D picture, with 10X vertical exaggeration.

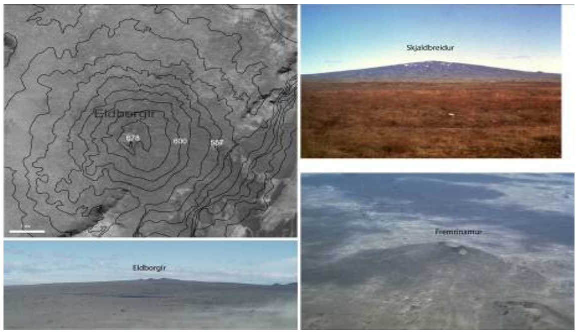

Figure 2. Icelandic small shield volcanoes. On the left is Eldborgir. Left-top) SPOT 5 satellite image with 20 m height contour intervals. Left-bottom) Surface photograph showing a summit high of 200 m and a diameter of ~1000 m. Eldborgir is located in the south of Iceland in a periglacial cold desert area. On the right side are Skjaldbreidur (top) and Fremrinamur (bottom).

The relationship between activity at the summit of Kilauea and it flanks provides important information about the magma conduit system within the volcano. Similar small shield volcanoes are also found in Iceland including 24 that have formed since the last interglacial period [19]. These features are located on median slopes of 2.7° (from 0.6° to 8°), have a median height of 60 m (from 12 m to 520 m), and a median diameter of 3.6 km (from 500 m to 11 km). Like those found in Hawaii, these features form as fluid lavas erupts along rift regions. The small shields found in Syria Planum are comparable in size and shape [2]. In Figures 1 and 2 we present a comparison to the Eldborgir shield volcano (also called Lambahraun), which formed 6000 years ago from a single long-duration eruption. This 10 km-diameter volcano has a mean slope of 2° with a summit vent. Its shape is not purely conical as it formed over pre-existing, non-flat topography. Several Icelandic cones have slopes less than 2° or more, such as Strandarheiði with a slope of 0.6° [19], which is comparable to those of Syria Planum, with a median slope of 0.5º [2].

Conclusions: We analyzed the lithosphere characteristics of Syria Planum and Tharsis, and concluded that thicker crust roots may be in the origin of a longstanding volcanism on Tharsis, which is normally marked by the presence of small shield volcanoes and vents on the flanks of important volcanic provinces [16]. On the Earth, the local heat increase during the formation of later-stages volcanic provinces may be strongly due to the presence of tubes in the lavas. A quantitative analyses of the formation, distribution and length of lava tubes on later stage volcanic provinces, like those referred for Iceland and Hawaii, may be of extreme importance on the characterization of known analogues for Martian plain-style volcanic structures.

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