ORIGIN AND EVOLUTION OF LONG LOBATE LAVA FLOWS ON SYRIA PLANUM, MARS

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Introduction: On Mars, long lava flows have been described as the first volcanic stage at the formation of a plains-style volcanic region (e.g. [1]). They have been identified and described on the eastern flanks of the Tharsis Montes (e.g.[2 - 4]), as well as on Tempe Terra [5] and Syria Planum [6]. This type of volcanism have been described as a consequence of magmatism near larger magmatic provinces near-plume or post-plume (e.g. [1], [7]). On the Earth, the plains-style volcanic provinces are characterized by three main phases (e.g. [7 - 8]); 1st: vent-elongated fissures, where flows follow the topography; 2nd: low shield volcanoes form on slightly higher slopes; 3rd: final volcanic resurfacing forming steeper slopes with a lower extrusive rate. The fact that plains-style volcanism on Syria Planum is peripheral to the large Tharsis Montes (located at the topographic summit after an extended eruptive phase) supports the idea of small batch magmatism under lithospheric conditions [8].

Volcano A Description: The Syria Planum region reveals an original pattern of volcanic features distinct from the other areas over the Tharsis bulge; a large volcano (Figure 1) (described as volcano A in [6]) was identified west of a swarm of small shield volcanoes [6]. An extensive field of lava flows, identified between approximately 15º-19ºS and 105º- 102ºW, covers an area of approximately 100,000 km^2. Through the study of HRSC and THEMIS IR-day and IR-night images, we can identify elongated and lobate shapes for these flows with preferential NW to SE orientation, following the regional slope. Using THEMIS and MOLA data, we observe that these lava flows erupted from an isolated volcano – Volcano A - on the northeast of Syria Planum [6]. The summit cone of volcano A is about 40 km in diameter, and it lies at an elevation of approximately 6.7 km (Figure 1). This volcano is located outside of a HRSC mosaic, although THEMIS and a HIRISE image enables its study. On Figure 1 is shown a MOLA profile from "a" to "b". From the center of volcano A to the side "a", the slope is about 1.4º while from the center to the side "b" the slope decreases to 0.7º, to the side where the lava flows extend downslope. Post-flow tectonic deformation is detected on the volcano's western flank. In Figure 1 it is of note that the flanks facing east are considerably smoother than the western flanks.

Regional Geology: Syria Planum formation was described by [6] as the result of successive magmatic and tectonic events. From the Early to the Late Hesperian period we have: I) extensional field stress that produced grabens; II) eruption of volcano A resulting in lavas that spread all over Syria Planum. Volcano A has similar characteristics to the Tharsis Montes, such as the same effusion rate (see [6]), except that it did not grow as high as the Tharsis Montes. Previous work [6] concluded that these lava flows are likely to be basaltic to andesitic in composition, similar to Martian Montes lava flows; III) tectonic deformation of the emplaced lava flows by the formation of several fractured patterns such as NE-SW en-echelon faults, troughs and adjacent grabens; IV) new episodes of volcanic activity, forming a coalesced swarm of small shields that bury preexisting faults.

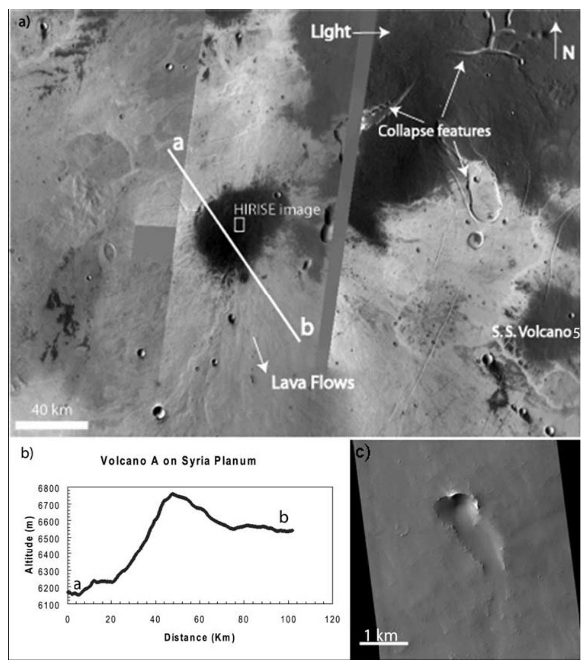

Figure 1. a) At the center of this THEMIS mosaic is volcano A, which is the eruptive center of extended lobate-shapde lava flows. The caldera is about 40 km wide. At bottom right is shield volcano 5. At top right several collapse features are evident. The profile a-b is shown in b). c) HIRISE image (PSP_001840_1660) showing a volcanic vent, with about 700 m width, on the top of volcano A.

Tectonic Deformation: In the Syria Plunum area at least 4 tectonic episodes are identified, distinguishable by their different directions and patterns (see Figure 2). First, NW-SE faults typically a few kilometers wide and hundreds of kilometers long were identified. These fractures exhibit a very dense network of faults defining many small grabens, which are covered by lava flows related to volcano A to the Northwest. These grabens might correspond to the most primitive tectonic pattern that affected the bedrock. Syria Planum was the center of tectonic activity before the emplacement of the volcanic plains at the surface. Such older faults were observed in Claritas Fossae and north of Noctis Labyrinthus [6]. Presumably, those faults underlie the present surface and can exhibit control on the area's volcanism. Second, volcano A's lava flows have been intersected by faults, mainly oriented NE/SW, in the northern region of Syria Planum (Figure 2). We determined that these fractures are hundreds of km long and approximately some tens of meters in depth. They are much more scattered and less densely distributed than the NW-SE-oriented faults found to the south. Third, in the southern and eastern regions of Syria Planum, next to the NW-SE oriented grabens, there are fissures some hundreds of meters wide (Figure 2). This activity thus clearly postdates the lava flows of volcano A, and therefore the NW-SE faults that are buried beneath the lava flows. We interpret these faults and related activity to have resulted from a reactivation of the ancient NW-SE fractures, possibly as a consequence of volcanic activity. Finally, several collapsed features were also identified in the vicinity of volcano A (see Figure 1). These collapse features postdate all the different terrains of Syria Planum, affecting the small shields at their northern boundary.

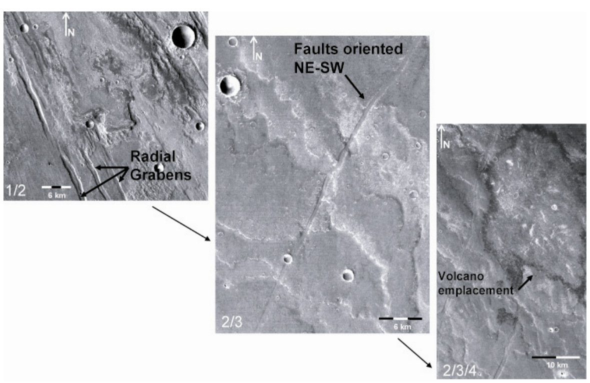

Figure 2. Chronologic relationship between the 4 magmato-tectonic phases from the early to the late Hesperian period in Syria Planum and described in in this work.Preliminary crater counts show ages from the Hesperian period.

Dating: Craters larger than 250 m in diameter were counted and classified over lava flow surfaces of 20,945 km^2 and using the method described in [9]. We determined 0.0025 ± 0.0003 craters/km^2 for the lava flows. These counts correspond to ages of approximately 3.6 Gy for the lava flows from volcano A. According to the error bars, these ages are not significantly different from those determined for the shield volcanoes [6], suggesting that the period of time between the formation of volcano A and the small shields was limited (3.6 Ga and ~3.4 Ga, respectively).

Chronology of volcanic and tectonic episodes: According to Figure 2, the geological episodes can be chronologically described as follows; Phase 1: Formation of the grabens, with a few on the order of 4 kilometers width, and dated to the Late Noachian to Early Hesperian epoch [10]. Phase 2: Formation of volcano A in the Early Hesperian, which partially covers the grabens of phase 1, but are not cut by these grabens. Phase 3: Lava flows from Volcano A are cut by NE-SW faulting event of Early Hesperian age. In some areas the faults may serve as conduits for magma eruptions that postdate the lava flows from volcano A. In that case phase 3 and 4 are almost contemporaneous. Phase 4: A swarm of shield volcanoes (formed during the Hesperian period) are superimposed on these lava flows. Also, at least three volcanic shields are clearly superimposed on lava flows from volcano A (see one in Figure 2). Phase 5: Few depressions formed by collapse might signify the last episode of activity, perhaps generated by the Noctis Labyrinthus opening in, or after, at the Late Hesperian.

Conclusions:. Volcano A is the origin of long lobate lava flows (>200 km) resulting from high effusion rates (see [6]), similar to Martian Montes lava flows. The small shield volcanoes and the extensive lava flows of volcano A appear to be structurally different and chronologically distinct. In comparison with the long lava flows, the small shield volcanoes imply a lower volcanic eruption volume that was subsequent to the flows from volcano A. The Syria Planum small shield volcanoes might signify a later-stage activity that once began with the emplacement of volcano A. Volcano A might have never reached the stage to enable the construction of a larger Mons-style construct at this location.

References: [1] Keszthelyi and Thordarson, (2000) *JGR*, **105**, E6, 15027-15050. [2] Bleacher et al. (2007) *JGR*, **112**, E4, doi: 10.1029/2006JE002873. [3]Mouginis-Mark and Rowland (2008) *Icarus*, **198**, 1, doi: 10.1016/j.icarus.2008.06.015. [4] Garry et al. (2007) *JGR,* **112**, E8, doi: 10.1016/j.icarus.2008.06.015. [5] Hauber et al. (2002) *EGU XXVII*, #4846. [6] Baptista et al. (2008) *JGR,* **113**, E9. [7] Sakimoto et al. (2003) *Sixth Int. Mars Conf.*, #3197. [8] Wilson and Head III (1994) *Rev. Geophys.*, **32**, no. 3, p. 221-263. [9] Hartmann and Neukum (2001) *Sp. Sci. Rev.,* **96**, p. 165-194. [10] Tanaka and Davis (1988) *JGR,* **93**, doi: 10.1029/JB093iB12p14893.