

Volcanic Features on the Syria-Thaumasia Block, Mars: Implications for Ancient Martian Volcanology

L. Xiao^{1,2}, M. Smith², J. Huang¹, Q. He¹, N. Petford³, D.A. Williams⁴, J.G. Liu⁵, and R. Greeley⁴. ¹Faculty of Earth Science, China University of Geosciences, Wuhan, 430074, China (longxiao@cug.edu.cn), ²Centre for Earth and Environmental Sciences Research, Kingston University, Kingston-Upon-Thames, KT1 2EE London, ³School of Conservation Sciences, Bournemouth University, BH12 5BB, UK ⁴School of Earth and Space Exploration, Arizona State University, Tempe, 85287, AZ, ⁵Department of Earth Science & Engineering, Imperial College London, SW7 2AZ, UK

1. Introduction: The Syria-Thaumasia block (STB) is located in the center of the Tharsis bulge at an altitude of 6 to 8 km above Mars datum. Its origin is unclear [1]. Syria Planum was previously recognized as a center for the tectonic activity of Tharsis, but not as a major locus for volcanic activity, despite its centrality over the bulge. [2] mapped most of the region, and suggested that there is extensive volcanism in Syria Planum, Thaumasia Planum and Thaumasia Highland. Very recently, [3] identified a swarm of tens of coalesced shallow volcanic edifices in Syria Planum. We have identified other volcanic features in the STB, such as small volcanoes, lava flows, and wrinkle ridges that have not been previously reported. These apparently Noachian and Early Hesperian age volcanic features are indicators of ancient martian volcanology and would provide us with clues to better understand martian early thermal history.

2. Approach: We carefully mapped volcanic features, including small shield volcanoes and wrinkle ridged plains in Syria Planum, Solis Planum, Thaumasia Planum and Thaumasia Highland within the Syria-Thaumasia Block (STB) as well as possible small volcanoes outside the STB, based on visual interpretation of MOLA, THEMIS, HIRISE and HRSC data.

3. Results: Volcanic features in the STB area can be grouped into four types:

Small volcanoes (swarms) at northwestern Syria Planum

More than fifty apparently Hesperian aged small volcanoes have been recognized in northwestern Syria Planum (Fig. 1), which is 1000-1500m above the southeastern basin. These small shield volcanoes are typically 10-30km in diameter and 100-250m high. Volcanoes to the north are symmetric and have steeper slope than those volcanoes to the southeast. Generally, there are few volcanoes beyond the northwestern Syria plateau.

Lava flows between Syria and Solis Planum

Controlled by topography, extensive lava flows appears to flow toward the southeast from northwestern Syria Planum to Solis Planum (Fig. 2). These lava flows are superimposed on NE-trending wrinkle ridges at the southeastern Solis Planum and cease at its rim, a topographic high. Most recognized lava flows extend over 200km long, and can be traced to up 1000km. Lobate and channel-fed flows can also be seen, although dust has covered most of the northern region and made detailed flow features indistinguishable.

Wrinkle ridges in Solis Planum and Thaumasia Planum

Wrinkle ridges in Solis and Thaumasia Planum are different in their spacing and orientation. One set of parallel wrinkle ridges are in Solis and Sinai planum (Fig. 3), while ridge networks are seen in Thaumasia Planum and Melas Fossae. The latter networks consist of dominated NNE-trending ridges that locally intersect with NW-NWW-trending ridges (Fig.3). There is a straight EW-trending linear feature, which is not morphologically similar to wrinkle ridges but more like a dike.

Old small volcanoes within and outside the STB

Eleven small volcanoes in the Noachian Coprates Rise and Thaumasia Highlands have been identified [2] and more than thirty similar small volcanoes were mapped in Thaumasia Fossae and to the southwest on the southern cratered highlands, outside the STB. All of them have diameters ranging from 50 to 80km, and 1500-2000m high. They are randomly distributed in the heavily crated highlands. These edifices are heavily cut by radial channels, suggesting the edifices are original shields or cones. Two of them are shown in Fig 4.

4. Discussion

The four types of volcanic features are spatially distributed from west Syria Planum to east Thaumasia. These features are also major volcanic types on Mars [2,3]. It is therefore an excellent area for studying martian volcanism and volcanology, particularly from the Noachian to Hesperian time. Volcanoes formed in Noachian have totally different surface features from

those in Hesperian. Noachian volcanic edifices are mostly resurfaced by impact craters and channels, while Hesperian ones have smooth surfaces. This variation in cratering suggests that no significant modification, e.g., by rainfall or surface water flow, occurred after Noachian time, consistent with [1].

Volcanism on the southland of the STB is unclear because of the heavily cratered, degraded surface. It is generally accepted that there is plain volcanism, but most ridged highlands have a Hesperian age. Noachian volcanic edifices are poorly studied, with the exception of larger structures in the Hellas basin [4] and Tharsis rise. Our study reveals the presence of Noachian small shield structures of generally similar size. Considering their random distribution, we consider that they may represent original volcanic edifices on Mars' surface in Noachian time. These small volcanoes, along with those fissure eruptions, generated lava flows and pyroclastic deposits that covered this part of Mars' surface. It is also possible that there were large numbers of volcanoes with 50-100km diameters and 2km elevations during early Noachian times. This possibility is currently under investigation.

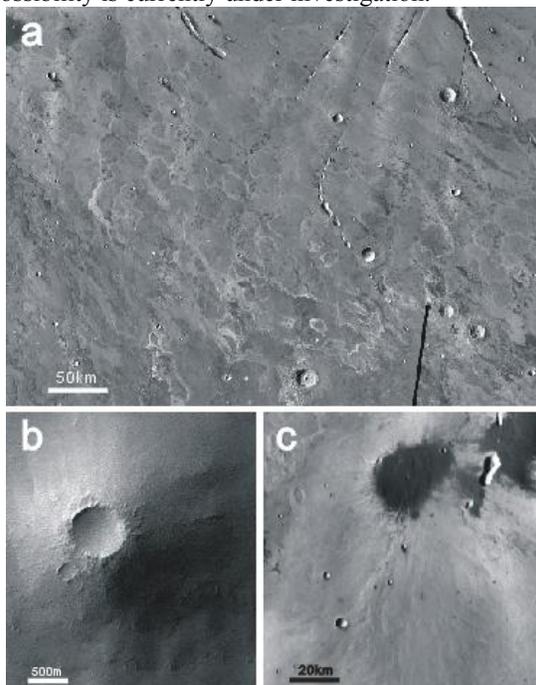


Figure 1. (a), small shield volcanoes outlined by light rims on the upper left. The southwest are lava flows originated from these volcanoes (THEMIS, center at 260.6°E , -17°N); (b), a small dusty shield volcano (4 km diameter, 150m high, 257.5°E , center at -12.8°N) at northern Syria planum; (c), an asymmetric shield volcano (80km diameter, 500m high, center at 255.8°E , -24.9°N). Its top is covered by fine dust. Lava flows toward southwest and extend hundreds of kilometers.

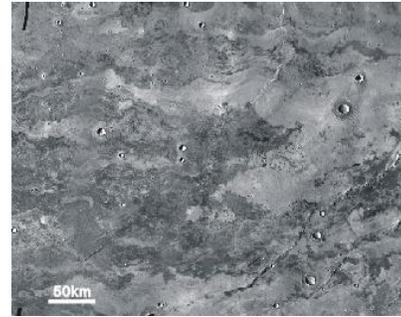


Figure 2. Lava flow features in Solis Planum (THEMIS, center at 273.4°E , -24.9°N).

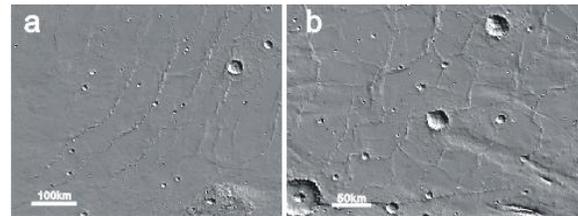


Figure 3. Wrinkle ridges at Sinai Planum (a, MOLA, image 500km wide, center at 278.4°E , -24.45°N) and Thaumasia Planum (b, MOLA, image 350km wide, center at 293°E -25.6°N). Note that they have different style. Wrinkle ridges on young Sinai Planum are parallel distributed, while a network style wrinkle ridges are seen on the old Thaumasia Planum.

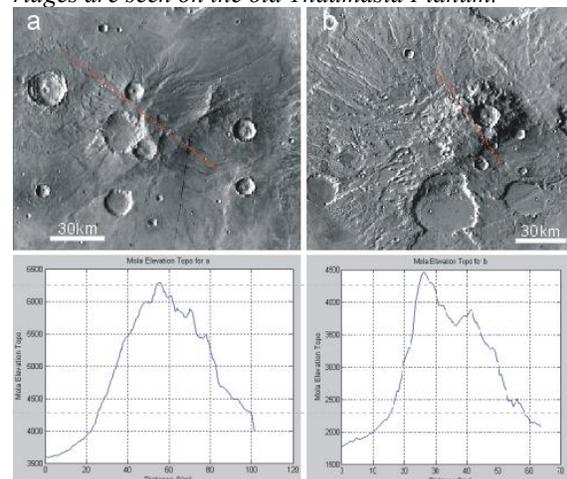


Figure 4. (a), a volcano at Corates Rise which is numbered 13 by [2] (center at 300.4°E , -17.95°N); (b), a remnant shield volcano at 215.31°E , -34.69°N , out of the STB and within southern cratered highland.

References:

- [1] Carr M. (2006) *The Surface of Mars*, Camb.[2] Dohm, J.M. and Tanaka K.L. (1999) *Planetary and Space Science*, 47, 411-431.[3] Baptista et al. (2008), *JGR*, 113, E09010, doi:10.1029/2007JE002945.[4] Williams D. et al. (2008), *PSS*, in press.