EPSC Abstracts
Vol. 8, EPSC2013-204, 2013
European Planetary Science Congress 2013
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The volcanic and tectonic evolution of Syrtis Major

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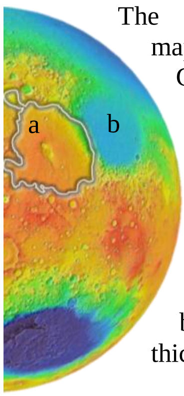
1. Introduction



The Syrtis Major Planum, originally mapped as unit Hs in the Greely and Guest 1987 map [1], is a low-angle basaltic shield volcano (Figure 1). Greeley and Guest suggested it is Hesperian (3.7 – 3.0 Ga) age, but recent work suggests a wider range of formation ages [2]. The edifice is a 1500 km by 1100 km (~1 % of the martian surface) basaltic lava plain with a total lava thickness of ~500 m..

Figure 1(above): Syrtis Major Planum (a) Isidis basin (b) on colourised MOLA topography.

At the center of the edifice there is a 1500 m depression containing two distinct central calderas believed to contain evolved volcanic products [3]. Additionally, extensional and compressional fault systems, orientated concentrically and radially from the central caldera complex, dissect the flanks. Syrtis Major has not been holistically investigated since a summary of MGS data in 2004 [4]. Other works have focused on different aspects of its evolution.

2. Surveys conducted

We present a summary of our developing understanding of the volcano tectonic history of the Syrtis Major Planum and discuss the mechanism and implications of the range and distribution of observed features. From our ongoing mapping and dividing of the unit Hs we find the following landforms and stratigraphy:

2.1 Volcanic features

We categorize lava flows into three types. [A] Narrow flows 1-6 km wide, 5-30 m thick with flow field lengths of up to 300 km. These flows are distributed both radially with respect to the central

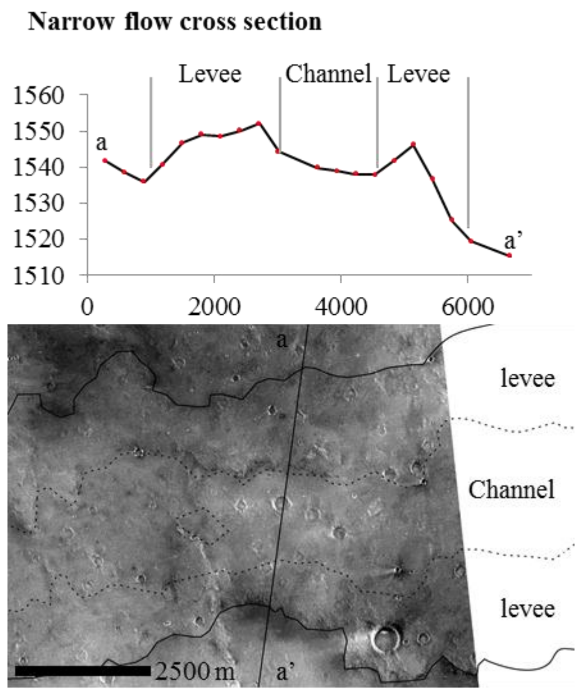


Figure 2: Narrow lava flow with medial channel; (a) cross-section MOLA points (b) CTX image; B18_016839_1901_XN_10N290W

caldera complex (in all but the south eastern quadrant) and in slope controlled orientations impinging into the Isidis rim in the east and north-east quadrants. Many of these simple and complex lava flows commonly display a topographic depression running along the flow axis throughout the majority of the observed length. This depression can be hard to distinguish in the relatively poor imagery but is clear in MOLA PEDR data (Figure 2). [B] Broad flows 20-90 km wide, 60-100 m high with flow fields that are 200 to 500 km in length. These flows are stratigraphically beneath the narrow flows or are on the northern, southern and western margins of the Planum. [C] Rare lavas with distinct night/day thermal properties and characteristic surface roughness. These have been seen to cross-cut Hesperian impact ejecta.

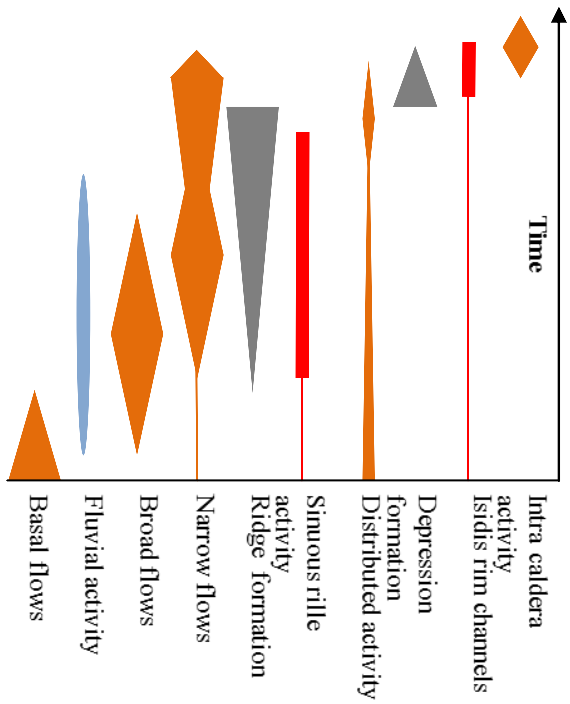


Figure 3: Sketch showing the observed stratigraphic relationship on Syrtis Major Planum.

2.2 Tectonic features

The wrinkle ridges observed on Syrtis Major are interpreted to be compressional fault systems. A survey of these features has been carried out to ascertain the component of shortening radial to the central caldera complex. A simple model of thrust faulting developed from [5] was used to calculate the strain from the height difference across the ridge profile. Total shortening was between 0.5% in the NW and 2% in the SE, here, the distance compensated for by faulting was 2.25 Km.

2.3 Channel features

There are two morphologies of channels on Syrtis Major. Firstly; sinuous channels similar to the Arnus Vallis [6]. These are 100s of km in length, 200-1000m wide, with depths of <100m. Channels of this type are cross-cut by wrinkle ridges, are associated with both broad and narrow flows and predate caldera formation. Secondly; channels which form part of contributory networks and which are perpendicular to local slope. Such features have previously been ascribed to a fluvial genesis [7]; we concur with this and expand the range of observations.

3. Discussion

These observations show both the diversity of volcanology within Syrtis Major Planum, and the coeval tectonic and erosional development. The distribution of observed features demonstrates an evolution of volcanism and a complex history of tectonic interaction characterized by the relationships in (figure 3). We propose the following evolutionary sequence: Initial volcanism was plains-forming in style, with now-obscured vents distributed across the extent of Syrtis Major. Subsequently, lava emplacement was spatially focused, and central caldera complex developed. Caldera-centric volcanic activity initially consisted of broad massive flows hosting lava channels similar in character to the Arnus Vallis [6]. This emplacement style then developed into a period dominated by narrow flow forming eruptions fed from both the caldera and a magma transport system. During the formation of the caldera depression, a maximum of 2 km of subsidence took place. It is at this time the wrink1e ridge formation took place, crosscutting the previously emplaced lava flows. Since the caldera collapse event, eruptions have been limited to smaller flows on the rim of the Isidis Plantia, persistent small events distributed across the planum, which may have continued throughout its history, and the doming, rifting and formation of small cones within the central caldera craters.

These observations suggest a more complicated history than previously thought. Our ongoing work aims to de-convolve the sequence and nature of these events.

References

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