SYRTIS MAJOR PLANUM (MARS): A TYPE EXAMPLE OR A SPECIAL CASE OF A LARGE IGNEOUS PROVINCE. P. Fawdon[*1,2], M. R. Balme[1], C. Vye-Brown[3], D. A. Rothery[1], C. J. Jordan[4]. [1]Department of Physical Sciences, The Open University, Walton Hall, Milton Keynes, UK. MK7 6AA; (peter.fawdon@open.ac.uk), [2]Birkbeck, University of London, Malet St, London WC1E 7HX [3]British Geological Survey, Murchison House, West Mains Road, Edinburgh, UK. EH9 3LA, [4]British Geological Survey, Nicker Hill Keyworth, Nottingham UK. NG12 5GG

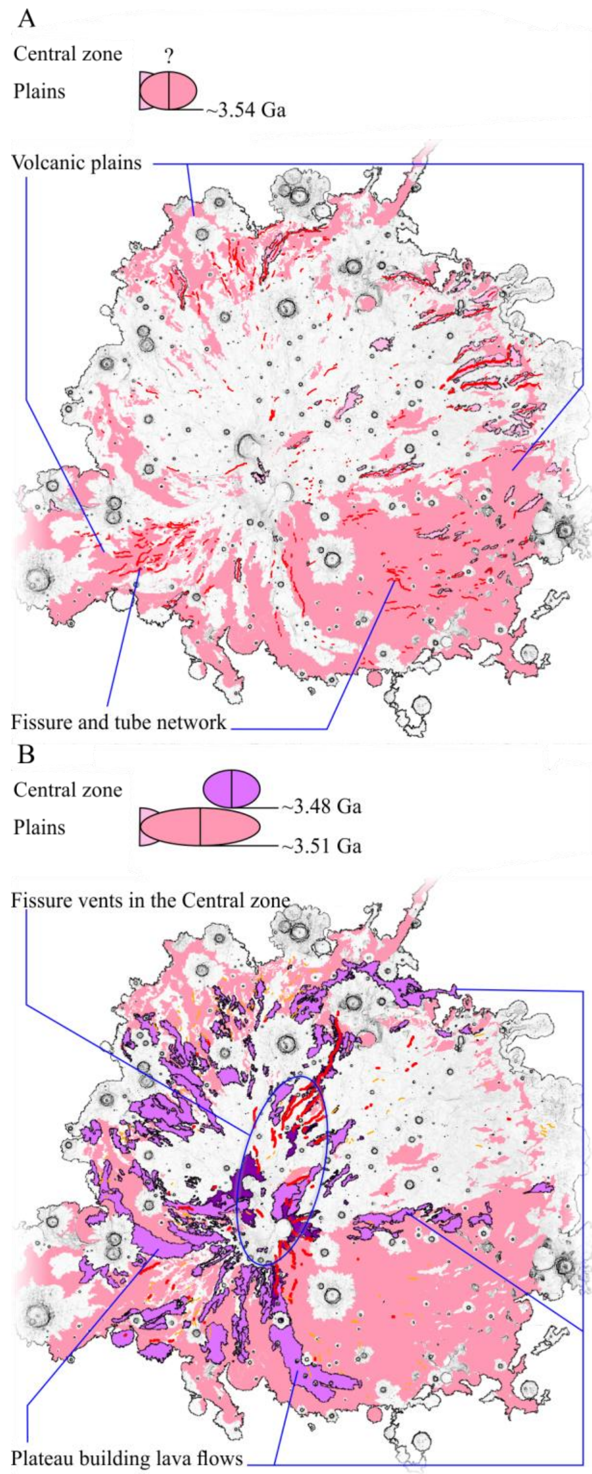
Syrtis Major Planum (SMP), a Hesperian-aged (~3.0 – 3.7 Ga), volcanic plains volcano, can offer insight into the architectural and stratigraphic development of ancient Large Igneous Provinces (LIP) on a Mars-like planets.

At SMP it is possible to study in plan-view the development of the volcanic plains which make up a substantial proportion of the martian and terrestrial crust. SMP differs from LIP's on the Moon, which represent a more formative stage of planetary evolution, in that it formed later in the planet's history. It also offers a different perspective to that of the Earth, where tectonic and erosional processing limit the understanding of LIPs to predominantly cross-sectional and geochemical perspectives. Importantly, SMP formed after the major period of fluvial and impact erosion on Mars but, unlike the older portions of Tharsis, it has not since been overlain by shield-forming volcanism. Consequently, SMP retains a wealth of detailed morphological and geographic information about the formation of volcanic plains that is not readily observed at other sites.

SMP itself covers ~3 % of the martian surface. It is located on the edge of the Noachian highlands, on the rim of the Isidis basin [1]. SMP consists of a gently sloping 'shield' of lava plains 1100 km wide, estimated to have a mean thickness of only ~500 m [2]. At the center of the lava plain is the central caldera complex containing the Nili and Meroe Patera calderas. These have hosted high silica composition magmas [3,4], a hydrothermal system, and possibly ignimbrite deposits [5].

We have mapped all of SMP using a THEMIS (100 meters/pixel) baselayer, supplemented by CTX (6 meters/pixel) data where available. Using these observations, and drawing on literature, we report on (1) the geological history of the main constructional phase of SMP, and (2) examples of the volcanic architecture that make up SMP. Drawing on these observations we ask: should SMP be considered a type-example for LIPs on terrestrial planets, or is it a unique case in the history of ancient Mars?

Geologic history: Based on our mapping and stratigraphy, plus crater size frequency distribution model ages and observations in the literature, the major constructional phase of SMP can be divided into three stages, all between ~3.6 Ga to ~3.2 Ga.



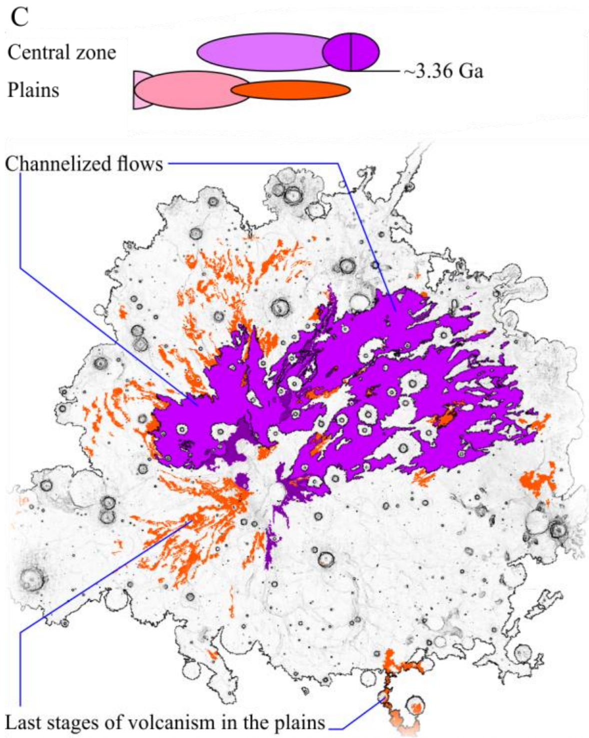


Figure 1: *The distribution, development and timing of lava emplacement in the constructive history of SMP divided into three stages and split between the central and plains areas. (A) Lava plains (**light pink**) emplaced from vent ridges (red). (B). Effusion becomes dominated by the central region forming plateaus like flows up to 350 km long (**Pink**) that are less likely to be overlain by lava plains. (C) Aa flows (**purple**) emanate from the north and central fissure zones and from late stage fissures in the lava plains (**orange**).*

In the first phase (Figure 1a), the lava plains were formed by thin lava flows, erupted from long fissures and distributed by narrow channels. Initial emplacement was both across the plains and in the central region of SMP.

Over time, the relative importance of effusion changed to become dominated by effusion from vents in the central zone, producing an increasing proportion of giant pāhoehoe flows interleaved with, and then overlying, the lava plains, emplacement was from three central fissure vent zones on a north-south alignment (Figure 1b).

Towards the end of the major constructional phase, the style of lava flow changed again. Flows became progressively shorter, and had a channel and levee structure typical of ʻa´ā lava. By this time, the distribution of effusion was then dominated by the central and northern central Fissure zones (Figure 1c). However, occasional eruptions still occurred from long narrow fissure in the lava plains. Finally, the maturing magma reservoir erupted to form Nili Patera at the northern end of the Central Caldera Complex [5].

Since the end of this major constructional phase in SMP's history the landforms recording its evolution have remained preserved due to the tectonic stability and Mars' cold, dry, low erosion environment.

Implications: From our mapping, we conclude that the evolution of SMP can be explained by the waxing and waning of a mantle plume interacting with the underlying Noachian crust. This interaction has led to the distinctive morphology of the volcanic shield [1,2], the explosive formation of the calderas [5], and the range of compositions observed within the central caldera complex [3,4].

The physiography of SMP is distinct from more voluminous, giant shield-forming styles of volcanism on Mars [6], but it is similar to older plateaus southwest of Hellas (e.g. Melea Planum) and Hesperian plains (e.g. Hesperia Planum).

The low relief of SMP, and its relatively short life span after being initially emplaced through a relatively thick crust, combined with the observed variety of compositions of lavas erupted and variations in the proportions of these different types, makes SMP unusual for Mars. One might expect Mars to have had only a narrow window when short duration mantle upwelling events could have occurred, because of its rapid planetary cooling. However, SMP is strikingly similar to LIP's on Earth where the planetary cooling regime has permitted relatively short duration mantle upwelling throughout time its geological history.

The origins of LIPs tell us about melting in the crust and mantle on terrestrial planets. Understanding their emplacement tells us about their environmental impact. On Earth, the impact has generally been negative on in terms of habitability, due to associations with rapid climatic change following LIP emplacement. Conversely, the climatic effects of LIPs on Mars may have been positive in terms of habitability; replenishing the Hesperian atmosphere with Water and CO_2 [7]. Furthermore, long lasting LIP volcanism also has the potential to maintain habitable enclaves for isolated colonies of life protected from the inhospitable surface in the warmed subsurface.

In conclusion SMP may be unusual for Mars but it also records, plan view, a complete example of LIP volcanic architecture on a terrestrial planet.

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