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Plains volcanism in Tharsis, Mars (II): Volumes, rates, and rheology of eruption products

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Abstract

The morphology and topography of volcanic landforms provides critical information to the investigation of their tectonic setting and the physical characteristics (e.g., rheology) of their eruption products. Their investigation is also an important prerequisite for studies of comparative planetology, e.g., the comparison between surface features of the Earth and other planetary bodies. Numerous small and low shield volcanoes on Mars and associated vents and lava flows have previously been compared to terrestrial plains-style volcanism [1,2], which is defined as being an intermediate style between flood basalts and the Hawai´ian shields [3]. This study investigates the topography and morphology of Martian landforms associated with plains volcanism using MOLA, MOC, THEMIS, HRSC, and HiRISE data. Our goal is to estimate the volumes of low shields in Tharsis, and the thickness and the rheologic properties of associated lava flows in adjacent volcanic plains.

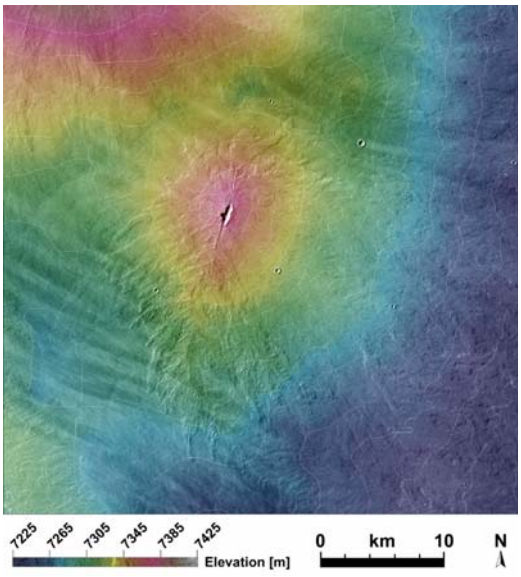

Figure 1 | Small and low shield near Arsia Mons, with well-developed pattern of radial lava flows (center at 4.34°S, 247.4°E; part of HRSC image h0891_0000). The combination of image and topographic data allows to measure volumes and morphometric properties of individual lava flows, a prerequisite to determine their rheology.

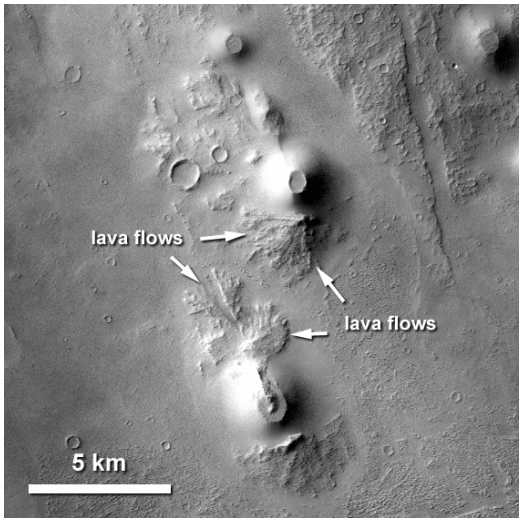

Figure 2 | Cinder cone field and associated lava flows near Biblis Patera (CTX, North is up). The close spatial (and probably genetic) association of cinder cones and lava flows is rarely observed on Mars. The morphometric analysis of such features will help to test predictions of eruption processes on Mars [7] and to get insight into the composition and rheology of magmatic products.

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Methods and data

Topographic data from MOLA and HRSC are used to determine the volumes of low shield edifices (Fig. 1). Lava flow thicknesses are determined applying the method of De Hon [4], originally developed to estimate thicknesses of lunar mare basalts. The diameters of craters which were not buried by later flows are derived from visual inspection and from kinks in crater size-frequency distributions, which are investigated in a companion study [5]. The thicknesses of lava flows can then be combined with absolute ages to derive volcanic resurfacing and eruption rates. Lava flow rheology is analysed in image and topographic data, applying previously established methods [6, and references therein]. Observations of landforms (Fig. 2) yield information about eruption styles and help to infer composition and volatile content of magmatic products. The results will put constraints on models of the magmatic evolution of Tharsis. They will also yield estimates of volcanic outgassing, thereby contributing to decipher the atmospheric evolution of Mars.

References

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