Plains volcanism on Mars: ages and rheology of lavas. E. Hauber[1], P. Brož[2], and F. Jagert[3], [1]Institut für Planetenforschung, DLR, Berlin, Germany, Ernst.Hauber@dlr.de, [2]Charles University in Prague, Faculty of Sciences, Czech Republic, [3]Ruhr-Universität Bochum, Geographisches Institut, Germany.

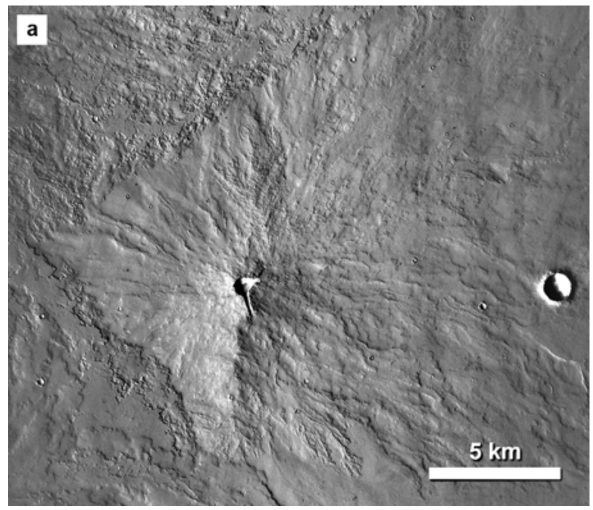
Introduction: Plain-style volcanism [1] is widespread in the Tharsis and Elysium volcanic provinces on Mars, [2,3]. Detailed images and topographic data reveal the morphology and topography of clusters of low shields and associated lava flows. The landforms of plains volcanism on Mars have all well-known terrestrial analogues in basaltic volcanic regions, such as Hawaii, Iceland, and in particular the Snake River Plains [4]. The very gentle flank slopes (<1°) indicate low-viscosity lavas [4-6], and topographic investigations hint at emplacement times for the low shields in the order of a few hundred to a few thousand years [7]. Emplacement itself was characterized by complex interactions between ascending magma bodies and tectonic structures of various ages [8]. Despite these recent studies, the chronology of plains volcanism was only poorly constrained, with a few exceptions of regionally limited studies [e.g., 6].

Here we report on our absolute age determinations of plains volcanism on Mars, as derived from crater counts. We also present results on the rheologic properties of lava flows, inferred from morphometric measurements of lava flows.

Data and Tools: Crater counts were performed with the software tools *CraterTools* (crater counting; see [9]) and *Craterstats* (analysis of crater statistics; see [10]), developed at FU Berlin. We used images of the Context Camera Investigation (CTX) on Mars Reconnaissance Orbiter [11], which are ideally suited for this purpose due to their good contrast, high resolution (5-6 m/pixel), and wide coverage (swath width ~30 km). Morphometric properties of lava flows were determined from single shots of the Mars Orbiter Laser Altimeter (MOLA) [12], which were superposed on CTX images in a GIS environment.

Methods: Representative surface areas for age determination were mapped in CTX images (Fig. 1a). Several low shields in each shield cluster were dated by crater counts. The goal was to derive absolute ages for a given shield, but also to determine whether the shields within one shield cluster formed at roughly the same time or over a prolonged period, and whether the clusters have comparable ages or not. The results are key to determine the history of late-stage volcanism in Tharsis and, therefore, help to put constraints on models of the endogenic evolution of Mars. The crater size-frequency distribution of the shield in Fig. 1a is shown in Fig. 1b. Using the production function coefficients of Ivanov [12] and the impact-cratering chronology model coefficients of Hartmann and Neukum [13], we get an absolute model age of ~44 Ma for this example.

We analyzed lava flow rheology applying established methods [14, and references therein]. Assumptions on certain parameters (e.g., magma density, Grätz number) followed earlier studies for better comparison. We analyzed 8 lava flows in 3 shield clusters, both on the flanks of low shields and associated with fissure eruptions (SE of Olympus Mons, Ceraunius Fossae, SE of Pavonis Mons) (Fig. 2).



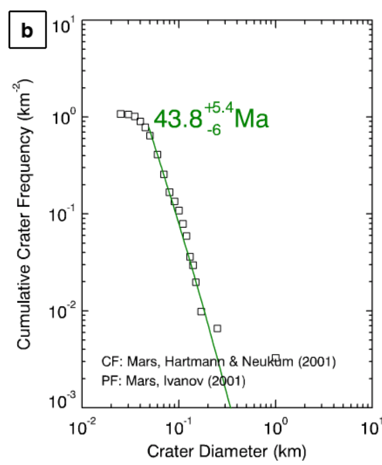


Fig. 1. (a) Low shield in Tharsis (CTX image). Note the radial pattern of lava flows emerging from the vent structure. (b) Cumulative histogram of crater size-frequency distribution, with derived model age.

Results: We determined the ages of 60 shield volcanoes and lava flows in Tharsis. The ages within a given shield cluster are similar among themselves, with a smaller spread in the age distribution in the younger clusters (Fig. 3). This smaller spread in younger clusters was expected, since the inherent systematic error of the method is within a factor of about

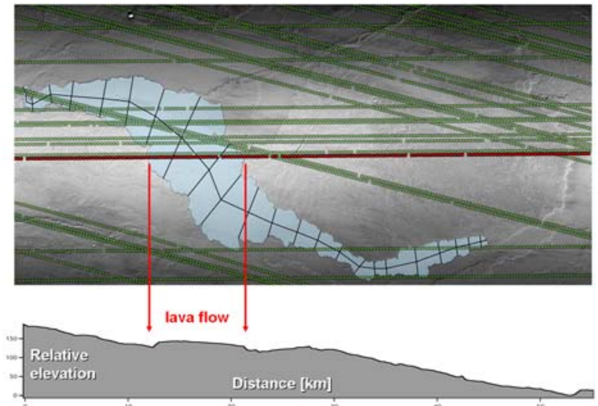


Fig. 2. *(above)* Lava flow (blue shading) mapped in CTX image and superposed single MOLA shots (green and red dots). *(below)* Topographic profile derived from selected MOLA shots (red dots in upper panel). Due to the precise co-registration, the lava flow can easily be identified in the MOLA track and the height can be measured accurately.

two for an assigned absolute age, and there is an average statistical error in the range of 20%-30% for ages <3 Ga [15]. The spatial distribution of ages is shown in Fig. 4. Most clusters have ages <100 Ma. Shields in Tempe Terra are older, with ages of a few hundred million years. The oldest cluster is located in Syria Planum (ca. 1.3 Ga - 2.9 Ga).

Our analysis of the rheologic properties of lava flows confirms previous reports that yield strength and viscosities are low [5,6]. Average yield strengths are 120 – 240 Pa (for a lava density of 2500 kg m^{-3}) and 130 – 270 Pa (for 2800 kg m^{-3}). Effusion rates vary between a few hundred m^3s^{-1} and 2500 m^3s^{-1}. Viscosities range from 800 – 5800 Pa s (2500 kg m^{-3}) and 900 - 6500 Pa s (2800 kg m^{-3}). These results apply to lava flows both on the flanks of the low shields and in the adjacent plains, possibly suggesting a genetic link.

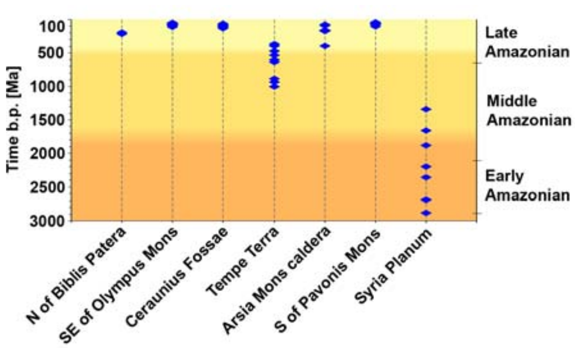


Fig. 3. Ages of shields in 7 clusters in Tharsis.

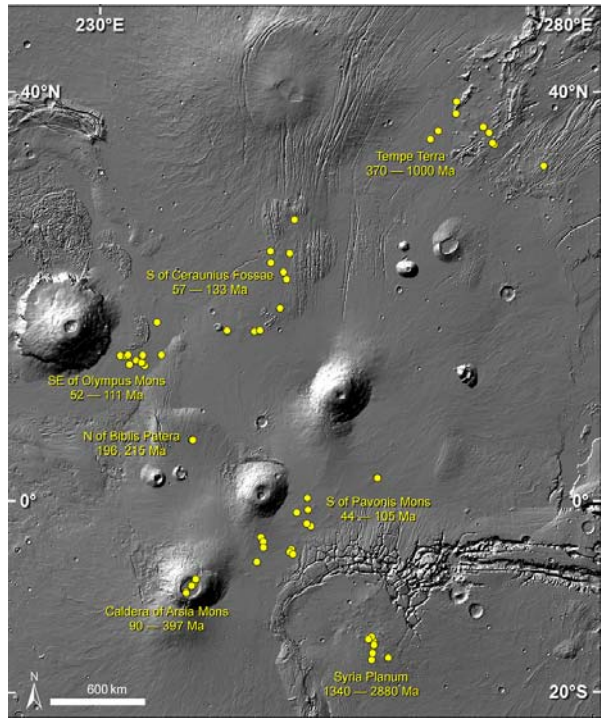


Fig. 4. Ages of low shields in Tharsis.

Summary: Late Amazonian volcanism is more widespread in Tharsis than previously recognized. Based on the results shown in Fig. 3 it appears possible that Mars is volcanologically not dead yet. Rheologic analyses of these late eruption products imply low viscosity lavas. Ongoing work investigates the volumes of erupted products and implications for the outgassing history and atmospheric evolution of Mars.

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