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The Payun-Matru lava field: a source of analogues for Martian long lava flows

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The Payun Matru Volcanic complex is a Quaternary fissural structure belonging to the back-arc extensional area of the Andes in the Mendoza Province (Argentina). The eastern portion of the volcanic structure is covered by a basaltic field of pahoehoe lava flows advanced over more than 180 km from the fissural feeding vents that are aligned with a E-W fault system (Carbonilla fault). Thanks to their widespread extension, these flows represent some of the largest lava flows in the world and the Pampas Onduladas flow can be considered the longest sub-aerial individual lava flow on the Earth surface [1,2]. These gigantic flows propagated over the nearly flat surface of the Pampean foreland, moving on a 0.3° slope. The very low viscosity of the olivine basalt lavas, coupled with the inflation process and an extensive system of lava tubes are the most probable explanation for their considerable length. The inflation process likely develop under a steady flow rate sustained for a long time [3]. A thin viscoelastic crust, built up at an early stage, is later inflated by the underlying fluid core, which remains hot and fluid thanks to the thermal-shield effect of the crust. The crust is progressively thickened by accretion from below and spreading is due to the continuous creation of new inflated lobes, which develop at the front of the flow. Certain morphological features are considered to be "fingerprints" of inflation [4, 5, 6]; these include tumuli, lava rises, lava lobes and ridges. All these morphologies are present in the more widespread Payun Matru lava flows that, where they form extensive sheetflows, can reach a maximum thickness of more than 20 meters. After the emplacement of the major flows, a second eruptive cycle involved the Payun Matru volcanic structure. During this stage thick and channelized flows of andesitic and dacitic lavas, accompanied the formation of two trachitic and trachiandesitic strato-volcanoes (Payun Matru and Payun Liso) culminated with the Payun Matru summit caldera development [7]. Finally a new phase of basaltic volcanism developed from Carbonilla Fault and was associated again with pahoehoe lavas and, at the final stage, by very long "aa" lava flows characterized by spectacular channel-levees systems. Hence, the Payun Matru lava field shows a multiplicity of flow surface morphologies linked to different lava types and related emplacement mechanisms, therefore it can represent an outstanding analogue of several Martian flows. In addition, the understanding of propagation processes of Payun Matru exceptionally widespread flows can give important clues in the comprehension of emplacement mechanisms of the long flows on Mars. Remote sensing data used to map and observe the Payun Matru can be compared with data acquired by similar instruments from various scientific missions to Mars. Mars Global Surveyor's Mars Orbiter Camera (MOC) data has been used to observe the morphology of the Martian lava flows with a resolution of about 10 meters per pixel in order to compare them with the Payn Matru lava flows. The Mars Orbiter Laser Altimeter (MOLA) was used to investigate the topographic environment over which flows propagated, whereas HRSC data are needed to possibly determine flow thickness and morphological variability. Arsia Mons lava field that includes the longest flows on Mars [8] shows many analogues of the Payun Matru lava flows since it is mainly characterized by sheet-flows with uniform ridged surface texture locally showing features like lava rises and lava tubes. In particular the extensive flow field in Daedalia Planum, at about 300 km south-west of Arsia Mons, is characterized by lobes reaching several kilometeres in length, although the slope of the region is generally minor of 0,5° [9]. Therefore it is very likely that inflation is the main emplacement process of these long flows. The presence of tumuli and lava ridges, detected in several areas of the lava field, seems to support this hypothesis. According to this view some linear features at the flow surface can be interpreted as squeeze-ups. They can be generated by vertical growth and fracturing of the sealing crust followed by effusion of hot lava continuously injected beneath the flow surface. In addition some lava tubes were also detected thanks to several aligned pits produced by partial tube collapse. Tumuli are certainly one of the most representative features of inflation mechanism [5], but their unambiguous detection is very difficult for the inadequate resolution of the available images. Nonetheless some tumuli like features has been already detected by Glaze and co-workers (2005) [10] in the regions surroundings Elysium Mons and in this work we have detect similar features in the Tharsis region, at Ascraeus Mons lava field. Finally Zephyria and Elysium Planitia show particular platy flows that can be compared with flat topped lava rise found on Payun flows. In addition in Zephyria flows as well in the

Payun ones elongated narrow ridges can be observed near the border of the sheetflow and especially near the isolated pre-existent hills surrounded by the lava flow. Their spatial arrangements suggests that they originated from lateral compression inside the visco-elastic deformation of lava crust under the influence of the above mentioned obstacles. In this case these features should correspond to pressure ridges in the sense of MacDonald (1972) [11]. All these examples suggest that inflation. spreading mechanism is present also for some Martian flows. By contrast, the Olympus Mons slopes are mainly covered by lava flows with lobes, tubes (often partially collapsed) and numerous channels that are very similar to channelized flows developed from Carbonilla Fault during the last eruption cycles of Payun Matru complex.

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