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Shallow Fluvial valleys on Alba Patera, Mars from HRSC/MEX analysis: Limited snowmelt episode

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1. Introduction

Alba Patera is the northernmost shield volcano of the Tharsis bulge, on which valley networks have been identified in Viking images. Valleys are mainly distributed on the northern side of volcano, with a parallel to dendritic pattern associated with a very high drainage density of 2.3 km^{-1}, comparable to those observed on Hawaiian volcanoes [1, 2] They are older than sets of normal faults cutting Alba Patera, and dated of the Amazonian Period [3], but the age of the volcano itself (Late Hesperian-Early Amazonian) implies an age for valleys younger than that of classical valley networks formed during early Mars.

These valley networks have been revisited by the HRSC stereo camera enable to generate Digital Elevation Models (DEM) with a spatial gridding of <100 m and a height accuracy of < 20 m. The depth of the deepest valleys detected in the HRSC DEM is around 30 m, whereas most of them are much shallower. Although these valley networks are relatively young in the Mars History, their original morphology is partially smoothened by a dust mantle in high resolution images, but this mantling does not seem to have filled these valleys significantly. Images also confirm that valleys located to the north are likely the result of hydrologic erosion in volcanic ash as proposed previously [2, 4, 5].

Previously unrecognized valley networks have been observed on the eastern and southeastern sides of Alba Patera, where volcanic flows are well developed and less blanketed by dust or ash deposits. They are shallower than northern ones. Although valleys are mantled, imprints of original morphology indicate that liquid water was locally seeping from the front of lava flows. This suggests that liquid water percolation was an active process in this volcanic lithology.

At HiRISE resolution, these valleys are completely buried by fine-grained, ice-rich mantle [6]. No fresh fluvial landforms (channels) is observed inside this mantle. The whole surface of Alba Patera is submitted to periglacial processes (ice sublimation in mantle, and ice accumulation in relatively young impact craters e.g. concentric filled crater) with no evidence for active layer and freeze-thaw cycles.

2. Conclusion

The distribution of valley networks on whole Alba Patera and their pattern suggest that they formed by runoff controlled by topographic slope and lithology. However, 3D characteristics of valleys do not suggest a sustained fluvial activity unlike what we could derive by their 2D properties such as the high drainage density. Episodic snowmelt following snow deposition could be at the origin of these shallow valleys. Melting can be due either to the volcano geothermal activity (valleys possibly formed coevally to volcanic activity), or to transient climatic episodes during the Late Hesperian/Early Amazonian periods that may have been recorded in other locations on Mars. Relationships with ice-rich mantling and age of valleys are not consistent with a melting of this mantling deposited during periods of high obliquity [7] in the recent history of Mars [8].

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