EVIDENCES FOR FLUVIAL AND LACUSTRINE ACTIVITY ON INTERIOR LAYERED DEPOSITS OF VALLES MARINERIS

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Introduction: One of the key questions of the study of Mars is the past or current presence of liquid water. The recent results from rover missions confirm the role of water at the surface of Mars at least during Noachian period [1]. These results are in agreement with all the water-worn features reported until today on Noachian Highlands [2] attesting that water cycle was different than today. However, neither results from rover missions neither geological evidences allow to constrain the duration of this water activity. The debate about a global warm and wet past climate or episodic conditions conducive to liquid water is still active. For the Hesperian period, the indices of water activity are more sporadic leading to exclude global climate conditions favourable to liquid water. However, a recent work [3] reports the occurrence of dense valley networks dated at Hesperian period around and within Valles Marineris whose features could be consistent with warm and wet conditions. The study of this water activity within Valles Marineris is crucial to understand the history of the canyon system. Indeed, Valles Marineris displays many enigmatic sedimentary figures whose formation under warm and wet conditions is controversial because of their age. Some canyons have thick Interior Layered Deposits (ILD). The hypotheses about their origin are so diverse as non-aqueous Aeolian or volcanic origin and aqueous subice volcanism or lacustrine origin [4, 5, 6, 7, 8]. Here, we report evidences of dense valley networks within Valles Marineris connected to a paleolake observed on possible ILD.

Evidences of fluvial activity: Thermal Emission Imaging System (THEMIS) images reveal valley networks within Melas Chasma (Fig. 1a, b). We observe valley networks highly organized to the fifth order attesting of the maturity of the networks. The drainage density of the network is in the same range as terrestrial density studied at same resolution (1.5 km^{-1}). The morphological details reveal an inner channel on some valley floor (Fig. 1c) attesting that stable water has flowed within these valleys and has eroded them. The heads of the valleys are scattered at different altitudes especially along a divide corresponding to a crest line in the topography. The geometry of the networks is correlated to local slope [9] with dendritic pattern in case of slope lower than 1.3° and parallel pattern in case of higher slopes like runoff pattern on Earth. All these features suggest that the network has been supplied by precipitations. The presence of dense and mature valley networks within Melas Chasma attests of climatic conditions auspicious to stable liquid water at the surface and of atmospheric precipitations at least during of several thousands years of Valles Marineris history.

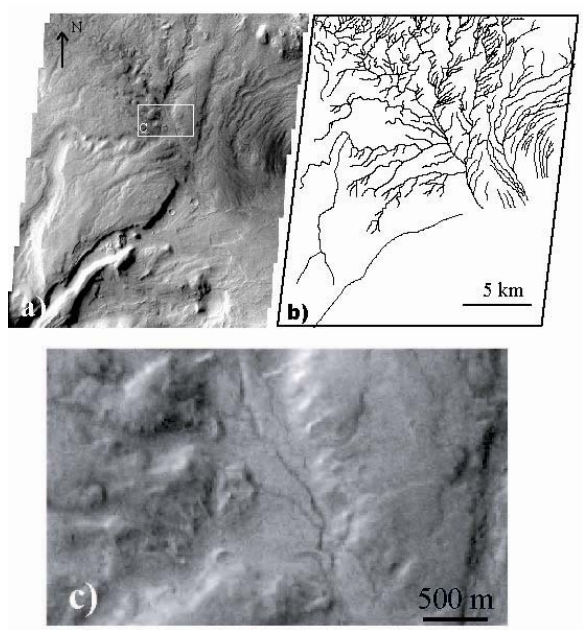

Figure 1: Part of Melas Chasma Valley networks. a) Part of THEMIS image V3249001, b) Valley mapping from THEMIS images (Visible and infrared) and MOC (Mars Orbiter Camera) images, c) Enlargement showing inner channels on valley floor.

Evidences of a paleolake: On the DEM, the outlet the valley network of the Fig.1 corresponds to a completely enclosed depression (Fig. 2a). This enclosed depression is observable in the morphology on day-time THEMIS images (Fig. 1b). The contour of the depression represents a contour line suggesting a water level implying a water volume of 157 km^3. High resolution images show the presence of fans at the outlet of valley networks. In addition, many outcrops of layers are present in the depression. These layers have been studied in detail especially their inclination. The layers have an apparent dip toward the center of the paleolake. The dips are close to 3° on the side of the depression and horizontal at the center of the

depression. Those dips are typical of lacustrine layers [10]. In addition, sedimentary balances have been computed suggesting that the eroded volume from the valley networks is in the same range than the estimated volume of these layers. That suggests that a paleolake existed in relation with the activity of the valley networks. The system has probably lasted several thousand of years in order to deposit the estimated volume of lacustrine sediments.

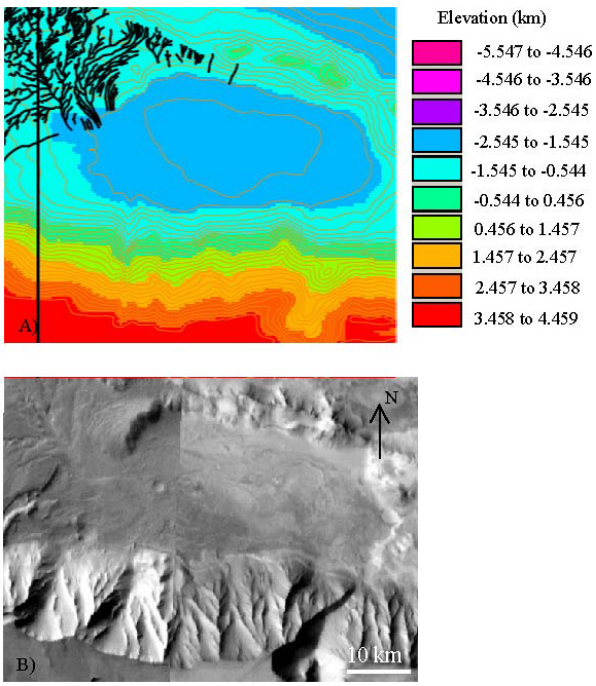

Figure 2: A) Digital Elevation Model (DEM) of the enclosed depression, B) Day-time THEMIS images of the enclosed depression.

Substratum of the landforms: The substratum where valley networks are observed is different from the basaltic wallslopes of Valles Marineris. As shown in Fig. 3, the valleys are located on a 2 kilometer thick and layered geological formation. In this locality, the formation and the valleys are crosscut by grabens attesting of a tectonic activity younger than the fluvial activity. The study in detail of all the outcrops of this formation scattered on the valley networks area also reveals layers over several kilometers with alternation of dark and light toned material. The ILD of Valles Marineris, whose some are located in Melas Chasma have these features. All these observations so suggest that the valleys eroded a remaining ILD of Melas Chasma and that a tectonic activity occurred after the formation and the erosion of the ILD.

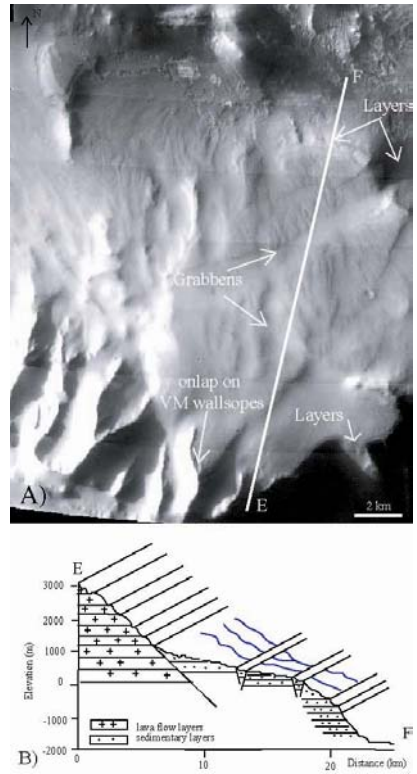

Figure 3: Substratum of valley networks: a) THEMIS Visible image V04747002, b) interpretative 3D diagram of the V04747002 image from the topographic profile EF.

Conclusion: Climatic conditions auspicious to liquid water and precipitations have occurred on Melas Chasma at least during several thousand years forming dense hydrographic networks and a paleolake. These landforms are located on a remaining ILD attesting that liquid water has played a role in the erosion of the ILD. All these results in Melas Chasma dated at Hesperian period demonstrates that an efficient water cycle existed after 3.5 Gy in Valles Marineris able to solve some paradox of the water-related Valles Marineris history.

References: [1] Squyres S. W. et al. (2004), *Science*, 306, 1709-1714 [2] Craddock, R. A. and Howard A. (2002), *JGR*, *107*, doi10.1029/2001JE001505. [3] Mangold N. et al. (2004), *Science*, 305, 78-81. [4] Lucchitta, B. K. et al. (1994), JGR, 99, 3783-3798. [5] McCauley, J. F. et al. (1978), Icarus, 17, 289-327. [6] Nedell, S. et al. (1987), Icarus, 70, 409-441. [7] Chapman, M. G. and K. L. Tanaka (2001), JGR, 106, 10087-10100. [8] Komatsu, G. et al. (2004), PSS, 52, 167-187. [9] Phillips L.F. and Schumm S.A. (1987), *Geology*, 15, 813-816. [10] Sly, P. G., (1994), Blackwell Science, Oxford, 157-191.