ANALYSIS OF VALLEY NETWORKS ON VALLES MARINERIS PLATEAU USING HRSC/MEX DATA

N. Mangold[1], Ph. Masson[1], V. Ansan[1], C. Quantin[2], G. Neukum[3] and the HRSC co-Investigator team. Lab. IDES-CNRS, bât. 509, CNRS and Université Paris-Sud, 91405 ORSAY, France, [2]Lab. des Sciences de la Terre, UCB et ENS Lyon, France, [3] DLR, Berlin, Germany, Contact: mangold@geol.u-psud.fr

Introduction: Valley networks on Mars have been the subject of considerable debates since three decades [1-5]. They have been first attributed to fluvial processes under conditions 3.5 Gy ago that were warmer than the present cold climate. However, many other hypothesis like geothermal activity, subglacial melting or sapping processes have been proposed because valleys are often poorly dendritic. HRSC data give a wide range of tools to study fluvial valleys on Mars from high resolution images to DTM extracted from stereoscopic images.

West Echus plateau valleys:
Dendritic patterns similar to ancient fluvial valleys in deserts are visible on the orbit 97 (Fig. 1) at the west of Echus Chasma canyon (278-281°E, 0-5°N). These valleys were identified from their difference of thermal properties on THEMIS images [6]. HRSC provides the possibility to look in detail to their morphology and geometry with the nadir resolution at 13 m/pixel (Fig. 1). The contrast in albedo on this image is high with valleys best visible in the center of figure. At this place, close views inside valleys confirms their filling by wind blown material locally exhibiting sand dunes. The valleys at the southwestern edge are less visible likely because of the presence of a thin dust mantle. The dust mantle seems thicker in the northeastern part of figure 1a and on the whole HRSC image northerly with no landforms visible. Nevertheless, a strong image enhancement allows us to distinguish buried landforms under this mantling (Fig. 1b), especially short valleys that are perpendicular to the apparent slope. They may have formed in the same way than the other more dendritic valleys. Valleys in Echus area are thus not restricted to the locations where they have been observed through THEMIS images [6]. They extend over more than 200 km along Echus Chasma western plateau (Fig. 1c).
Valleys on figure 1b are less dendritic than on figure 1a but small tributaries branching on main rivers are visible on the left part of the image. The order of the valley system, i.e. the number of connections from the smallest tributary to the main river [7-8], is of 2 to 3 for these valleys whereas it reaches 5 for those of figure 1a. The drainage density, i.e. the ratio between the total length of valleys and the area of the watershed [7], permits to evaluate the level of maturity. The highest drainage system reaches a density of 1.4 km-1 mapped at 13 m/pixel resolution. This is the second highest drainage density on Mars after Alba Patera volcano and it is similar to terrestrial values of valleys on Hawaiian volcanoes [9]. Nevertheless, it is only 40% higher than the same drainage mapped with THEMIS at 100 m/pixel resolution although the drop in scale would suggest a much larger difference. This limitation in the drainage density is likely an effect of the surface degradation by eolian processes which have deleted the smallest tributaries. On the other hand, only few valleys are detected on the 200 m/pixel resolution HRSC DTM. This shows that they are shallow pristine landforms even if they could have been originally deeper and filled later by sand. All of the characteristics of the dendritic valleys are similar to terrestrial features of surface runoff due to atmospheric precipitations.

Inverted channels on Juventae Chasma plateau:
The Juventae Chasma western plateau displays linear curved features visible on MOC, THEMIS and HRSC images (Fig. 2). Their shape of few tens of meter large and few meters high would suggest that they correspond to the erosional relics of ancient channels by erosion like terrestrial inverted channels. The apparent direction of the ancient flows fits with the topography, thus to the north and outward canyon shoulder. On Earth, inverted channels can form by subaerial flows or subglacial flows, and are then named eskers or tunnel valley. The geometry of eskeres is different from subaerial inverted channels. The mapping of Juventae plateau landforms shows that their geometry correspond more to dendritic valleys formed by surface runoff rather than anastomosed systems forming subglacial valleys and subsequent eskers. Their occurrence in the region of Valles Marineris is an additional clue in favor of a climate favorable to runoff formation on the plateau.

Conclusion: Valleys observed in the Valles Marineris plateau display dendritic shape and morphometric characteristics of terrestrial river systems. They can be dated to the Late Hesperian epoch from chronological relationships. Surface runoff in the Late Hesperian epoch could correspond either to a progressive transitional climate after the warmer Noachian epoch [10] or to episodic warmer periods like those which could be related to the increase in atmospheric water vapor due to the outburst of outflow channels [11]. HRSC data will permit to considerably improved the current knowledge of valley networks on Mars.

References: [1] Carr, M. H. and Chuang, F. C., (1997). *JGR*, 102, 9145-9152. [2] Baker, V. R. and Partridge, R. C., (1986). *JGR*, 91, 3561-3572. [3] Gulick, V. C., (2001). *Geomorphology,* 37, 241-268. [4] Cabrol, N. A. and Grin, E. A., (2001). *Geomorphology*, 37, 269-287. [5] Pieri, D. C. (1980). *Science*, 210, 895-897. [6] Mangold N. et al., Science, 2th july 2004. [7] Horton, R. E., Erosional development of streams and their drainage basins: hydrophysical approach to quantitative morphology, *Geol. Soc. Am Bull..*, 82, 1355-1376, 1945. [8] Leopold, L. B., M. G. Wolman and J. P. Miller, Fluvial processes in geomorphology, Dover pub, 1992, 520 pp. [9] Gulick and Baker, JGR, 1990 [10] Craddock, R. A. and A. D. Howard, The case for rainfall on a warm, wet early Mars, *J. Geophys. Res*., 107, E11, 21, 2002. [11] Baker, V. R. et al., Ancient ocean, ice sheets and the hydrological cycle on Mars, *Nature*, 352, 589-594, 1991.

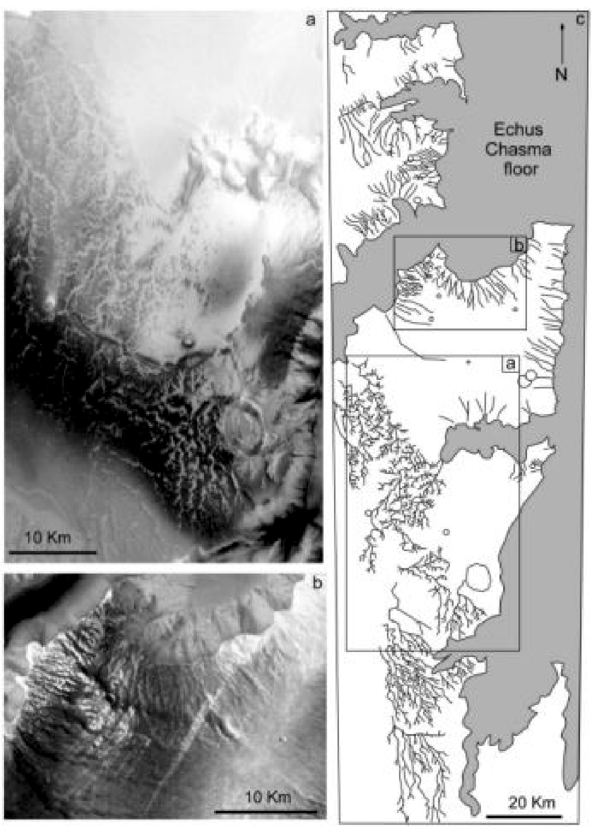

Fig. 1: HRSC image (orbit 97) of West Echus Chasma plateau. (a) Nadir image of dendritic valleys. (b) Nadir image of strongly enhanced image displaying small valleys at canyons border. (c) Map of all valleys observed on orbit 97.

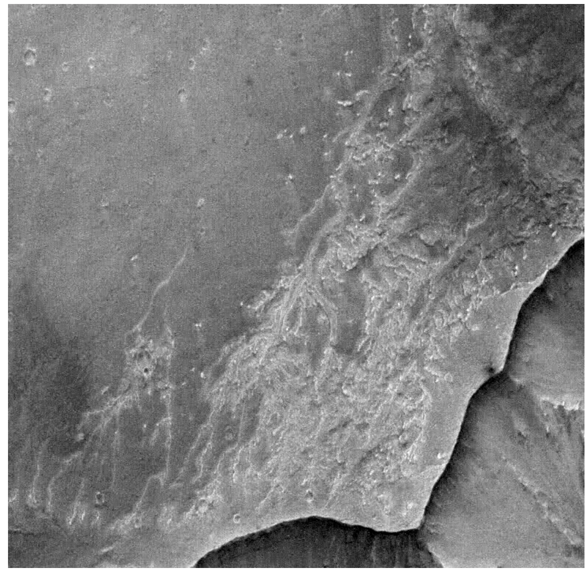

Fig. 2: HRSC image (orbit 243). Inverted features interpreted as inverted channels. The image is 15 km large.