Geomorphological Analysis of Mass Balances of Martian Valley Networks in Western Terra Sirenum

A. Petau[1], D. Tirsch[1] and R. Jaumann[1,2]
[1]Institute of Planetary Research Berlin (DLR), Germany (Andreas.Petau@dlr.de), [2]Free University of Berlin

Introduction: In recent years, there has been a great deal of interest in Martian valley networks. Especially when [1] and how and among witch circumstances they have been formed [2] has been discussed up to now. On the whole, at what time Martian valley networks have been generated and that water might has been the forming agent is pretty certain now. A substantial amount of research by a lot of studies is published about that issue. However, a central question that needs to be addressed in this context is, how much water was required to create valley networks on early Mars. The intention of this study focuses on a geologic and geomorphological analysis of valley networks in the Western part of Terra Sirenum presenting calculations of discharge, transportation and erosion rates to improve the insight in a time there must have been other environmental and climate conditions, whose processes are still not sufficiently explored and understood.

Methods: For this work a number of image data were used, including the High Resolution Stereo Camera (HRSC) [3] on board of the ESA Mars Express Orbiter and Context Camera (CTX) images of the NASA Mars Reconnaissance Orbiter. To optain morphometric parameters of valley networks HRSC digital terrain models (DTM) [3] were utilized. These are complemented by using statistic methods to give estimations and calculations for specific potamologic issues. The correlation of the findings combined with results of the crater-size frequency distribution (CSFD) [3] , allows interpreting the development and timing of the examined region. The succeeding data set might give suggestions to early Martian climatic conditions and its influence on the morphology and the discharge rates of the identified channel systems.

Observations: The investigated region (Figure 1) is situated in the Southern hemisphere of Nochien-Hesperian-aged highlands between S37,5° to S39,5° latitude and W157,5° to W155° longitude close to the northeastern crater rim of Newton Basin. It surmounts from nearly 2950 m down into the more than -1300 m deep Newton Basin. The complete investigation area shows a trichotomy of a strong fluvial dissected surface on the south- and south-west-oriented slopes: (1) at the crater rim of a large impact crater in the western region, (2) at the plateau surface area in the eastern part and (3) in the central region of a quasi more or less trough-shaped surface. All of these features indicate a lot of well received drainage areas of dendritic patterns with prestine watersheds in the upper parts of the fluvial systems. Ultimately, the lower ones unified the extensive drainage tributaries to drain them off into the absolut erosion base level, into Newton Basin.

Discussion: By using the crater-size frequency distribution analysis this research suggests an epirogenetic evolution of fluvial activity around 3,7 Ga. All identified valley networks arise on basaltic surfaces of Noachien-Hesperien-age and discharge in the Basin of Newton crater with an equal age. The whole region is dissected into three main drainage areas: an Eastern, a Western and a central one. The Eastern (Figure 2) part consists of three geomorphological main units: the main watershed of an even high plateau with a well developed sharp edge interrupted by weak eroded segments, its steep escarpment followed by the extended area characterized by lower slopes and largely preserved dendritic valley network patterns within local watershed separating them. The Western unit features two main units: the crater rim as the main watershed for the whole area of the big crater in the North and its associated drainage areas with their associated local watersheds. This rim subserves as the Eastern main watershed for the central drainage area unit as well. The Western strong eroded segment of the previously mentioned high plateau determine the main watershed for the ancient fluvial activty. The results may be interpret as follows: The areas with the highest capacity of fluvial erosion are correlated with the steepest slope in the drainage system. The higher the declivity the efficient the vertical erosion and the deeper the channel incision. In the central region a deep valley was incised by vertical erosion. The dendritic extension is reduced, ceases at last and the channels were concentrated to one main outlet channel controlled by tectonic as seen in the example of the valley segment in the central region (Figure 3), witch shows rectangular in contrast to the dendric structures upstream. In this part the discharge *(Q in m³/s)* had an amout of 591 m³/s by using the channel width *(W in m)* 142 m in the Irwin-calculation equation [4].

$$Q = 1.4\, W^{1.22}$$

By an assumed sedimentary amount of 44 % [3] the rate of transport is calculated with 260 m³/s.

Using and conversing the equation of Irwin for calculating the extension of the drainage area *(A in km²)*,

$$Q = 57 A^{0.33}$$

the extension of the central drainage area might have had an extension of approximately 1196 km². That allowed to estimate an erosion rate at this point of 6856 m/1000 years considering a value of 44 %. In this way, this work in comparision with other works [5] give us an regional overview of fluvial mass balances for the whole investigated area at local places, where a less eroded surface allows the measuring of the channel width of each well preserved channels. The calculations help us to interpret the situation around 3,7 Ga in a quantitative way, especially for the time limit of multi-phase processes as seen in the Eastern drainage area suggesting that repeated events of fluvial erosion must had taken place and how much water was required.

References: [1] Carr, M.H., Clow, G.D. (1981) *Icarus 48*, 91-117.; Fassett, C.I., Head III, J.W. (2008b) *Icarus 198*, 37-56. [2] Pieri, D.C. (1980) *NASA Tech. Memo 81979*, 1-160.; Craddock, R.A., Howard, A.D. (2002) *J. Geophys. Res. 110.*, doi: 10.1029/2001JE001505.; Hynek, B.M., Phillips, R.J. (2003) *Geology 31*, 757-760. [3] Jaumann, R. et al. (2009) *Earth and Planet. Sci Lett.*, doi: 10.1016/j.epsl.2009.09.026. [4] Howard, A.D., Moore, J.M., Irwin III, R.P.(2005) *J. Geophys. Res. 110*. E12S14. [5] Irwin III, R.P., Craddock, R.A., Howard, A.D. (2005) *Geology 33*, 489-492.

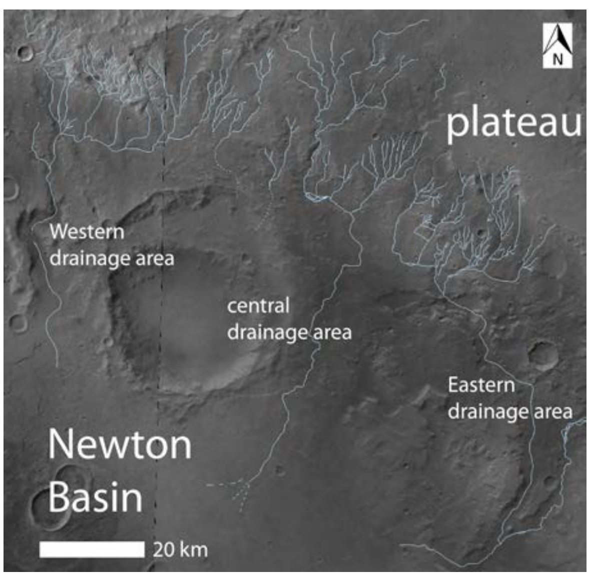

Figure 1: Western Terra Sirenum, HRSC Orbit h6479_0000, HRSC Orbit h8604_0000.

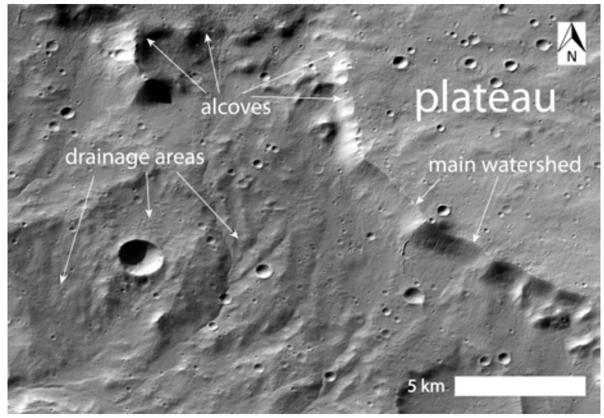

Figure 2: Eastern unit, P17_007591_1394_XN_40S155W, CTX NASA./JPL/MSSS.

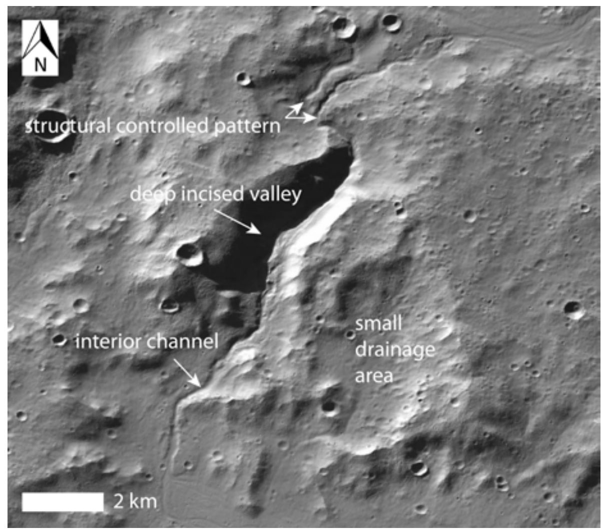

Figure 3: Central unit, P18_008092_1393_XN_40S156W, CTX NASA/JPL/MSSS.