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Martian Valley Networks and Analogue Features on Earth

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1 Introduction

Today, Mars is a very dry, cold and fluvial inactive planet, but different types of fluvial valley networks are still conserved. Longitudinal and dendritic valleys are prevailing representatives. Due to the strong action-related dependency between fluvial activity and climate there must have been other environmental conditions on early Mars. However a fundamental climate change of Mars is still not sufficiently explored and understood.

2 Geological Overview

On Mars most valley networks are located at the southern highlands (Figure 1). It is an area with Noachien age (> 3.7 Ga). Longitudinal valleys have a main occurrence at the highland-lowland-boundary (30°S to 5°N). The dendritic ones occur at the southern flank of Tharsis and Alba Patera. Dendritic patterns belong to the oldest fluvial structures on Mars. The headwater of longitudinal valleys shows a bimodal allocation, most of them between 500 m and 1500 m. It corresponds with 40 % of all headwater sources. The other region is located nearby -1500 m. These are 20 % of all longitudinal headwater sources. Nearly half of dendritic valley networks have their general occurrence between 1000 m and 2000 m, 15 % nearby -2000 m. The slopes have three main directions: 25 % to N, 30 % to NW and 20 % to SE. The whole area in the W and NW of Hellas drain to NW, the south-pole-regions to Agyre and Hellas [1].

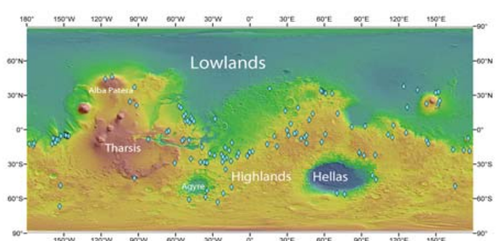

Figure 1: Current status of the distribution of valley networks (blue figures) on Mars.

3 Data base and methods

We focus on selected Martian valley networks by using image data of the High Resolution Stereo Camera (HRSC) on board of the ESA Mars Express Orbiter and Context Camera (CTX) images of the NASA Mars Reconnaissance Orbiter. HRSC digital terrain models (DTM) are used to derive morphometric parameters of valleys and interior channels. The used measurements aim to constrain fluvial discharge rates bye the means of cross sectional parameters. The correlation of the findings combined with results of the crater-size frequency distribution (CSFD), allows interpreting the development and timing of possible flooding events. The resulting data set might give clues to ancient climatic conditions and its influence on the morphology and the discharge rates of the channel systems. Furthermore, in this work we complemented to collect published studies of valley networks on Mars and put the results into a data base. Important specifications and parameters include the location of the valleys.

4.1 Valley networks on Mars

Longitudinal valleys (Figure 2) belong to the longest linear structures on Mars. Their lengths fluctuate from 20 km to 200 km in 9 of 10 cases [2], but lengths of more than 1000 km are represented too. The headwater sources and small tributary valleys originate in alcoves formed by groundwater sapping processes. The discharge course is often controlled by tectonic and topography. The slopes alternate between 0.09° to 2.4°. In general slopes of longitudinal valleys are slighter (0.4° to 0.6°) than slopes of dendritic valleys (0.2° to 0.4°) [1]. The gradient of valley networks on Mars shows steeper slopes as their analogues on Earth [1]. Erosion processes were not fully developed [1]. Two conditions are responsible for this. Either the amount of water was insufficient, or the span of time too short to generate well developed valleys. In contrast to the achievement by lateral erosion, vertical erosion processes were more significant generating this type of channels. Dendritic valleys (Figure 3) show a very different pattern. Most of them have an expansion of not more than some dozen km [3]. They arise in higher located topographic positions (Tharsis) following the relief.

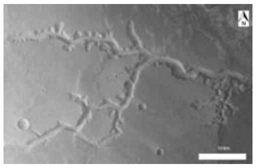
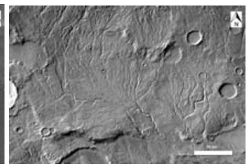

Figure 2 and 3: Nirgal Vallis with tributary valleys. HRSC orbit: h4072_0000 and Warrego Valles drainage pattern. THEMIS daytime infrared mosaic.

The branches of their tributaries confluence downwards. In comparison with longitudinal valleys dendritic ones do not have the width and depth of longitudinal valleys. The magnitude is located below 500 m for their width and 50 m for their depth. In contrast to the valleys formed by sapping erosion and ground water release dendritic patterns obviously were formed by surface runoff after precipitation events [4]. Some valleys (Figure 4a/b) show little incised structures. These interior channels were generated by a flowing agent directly. Proceeding from the assumption that these channels were completely filled with water, we have a term to calculate the minimum amount of discharge to modeling mass bilances.

Figure 4a: Senus Vallis with interior channel. CTX image P02_001670_1746_XN_05S147W, NASA/JPL/MSSS.

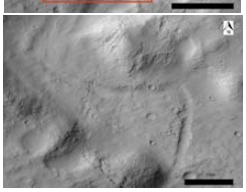

Fig. 4b: Closeup of the interior channel in Senus Vallis. CTX image: P02_001670_1746_XN_05S147W, NASA/JPL/MSSS.

4.2 Terrestrial analogues


Figure 5 and 6: Gully erosion in a sandy tidal creek. [5] and Fish River Canyon. [5]

Over a short period of time small gullies were created at low tide (Figure 5). In the foreground a tidal creek was falling dry. The whole substrate was saturated with water. Due to backward erosion effluent water incised small gullies from the middle part of the picture to the background. The eroded material were transported through the channel and accumulated on the ground of the tidal creek.

The Fish River Canyon (Figure 6) in Namibia shows geomorphological analogies to Senus Vallis, Mars. The incising river generated this type of valley especially by vertical erosion.

5 Conclusions

Mars offers some analogue geomorphological structures reminding on terrestrial fluvial patterns. Terrestrial processes and those on Mars are quite similar in a difference of process dimensions. But in contrast to Earth, most Martian valley networks are non active features since 3.7 Ga. Based on this, we have to investigate geological and geomorphological processes on Earth in order to conclude environmental conditons during Noachian times. Interior channels should give us a chance to estimate a minimum size of discharge rates and water amounts to understand climate conditions on early Mars to clear the question why significant fluvial erosion ceased during the history of Mars.

6 References

[1] Jaumann, J. (2003): Forschungsbericht 2003-20. [2] Carr, M.H. (1995): doi:10.1029/95JE00260. [3] Baker, V.A. et al. (1992): Channels and valley networks, Mars, pp. 493-522. [4] Jaumann, R. et al. (2009): doi:10.1016/j.epsl.2009.09.026. [5] Busche, D., Kempf, J., Stengel, I. (2005): Landschaftsformen der Erde. Bildatlas der Geomorphologie, Darmstadt.