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Geomorphological Study of Fluvial Environments in Terra Sirenum, Mars

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1. Introduction

In recent years, there has been a great deal of interest in valley networks on Mars. 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 [1, 2, 3]. The intention of this study concentrates on a geologic and geomorphological analysis of valley networks in Terra Sirenum with the focus of its eastern unit of the investigated area. We present calculations of discharge rates, statistic calculations and functional relations between fluvial and lacustrine environments on Mars to improve the insight into a time featuring other environmental and climate conditions, whose processes are still not sufficiently explored and understood.

2. Geologic Overview

The investigated region (Figure 1) is located in the Southern hemisphere of Noachian-Hesperian-aged highlands between 37.5°S to 39.5°S latitude and 157.5°W to 155.0°W longitude close to the northeastern crater rim of Newton Basin. It surmounts from nearly 3000 m down into the more than -1300 m deep Newton Basin. The study is focused on the northeastern crater rim of Newton Basin.

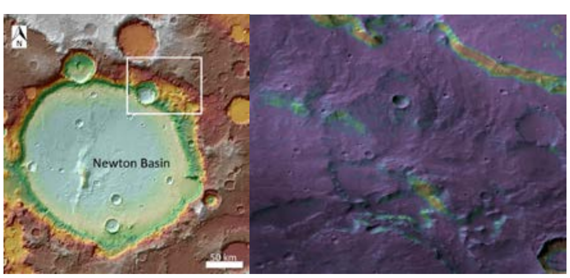

Fig.1 and Fig. 2: (Fig. 1) Investigation area within the white square at the northeastern rim of Newton Basin. (Fig. 2) Slope map (aerial perspective to north) of the eastern part of the area with the characteristic of a step-and-plain shaped surface. Steepest slopes are showed in a green to brown, less steep sections in a violet colour.

3. Data and Methods

For this work a number of image data were used, including datasets of the High Resolution Stereo Camera (HRSC) [4] on board of the ESA Mars Express Orbiter and Context Camera (CTX) images of the NASA Mars Reconnaissance Orbiter. To obtain morphometric parameters of valley networks HRSC digital terrain models (DTM) [4] were utilized. These are complemented by using statistic methods to give estimations and calculations for specific potamological issues. The correlation of the findings combined with results of the crater-size frequency distribution (CSFD) [4], 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.

4. Discussion

The complete investigation area shows a trichotomy of a heavily fluvial dissected surface on the south- and south-west-oriented slopes of the rim of Newton Basin (Figure 2). Due to the crater rim the regional slopes down to the erosion basis show very high gradients. They are mainly characterized by step-and-plain profiles presumably triggered by the collapse of Newton Basin´s flanks after the impact followed by fluvial erosion.

Moreover, we have identified a western, a central and an eastern unit presenting extended valley networks, each system with a stream order of 5 (Figure 3). At the source region, valley networks occur as dendritic patterns with downwards coalescing branches. They are enclosed by very well preserved main watersheds and local watersheds, partly destroyed by subsequent erosion events. Downstream the branches of the dendritic patterns confluence into one main channel for each valley system.

In the eastern unit we were able to identify an enclosed basin between 980 m and 1410 m altitude.

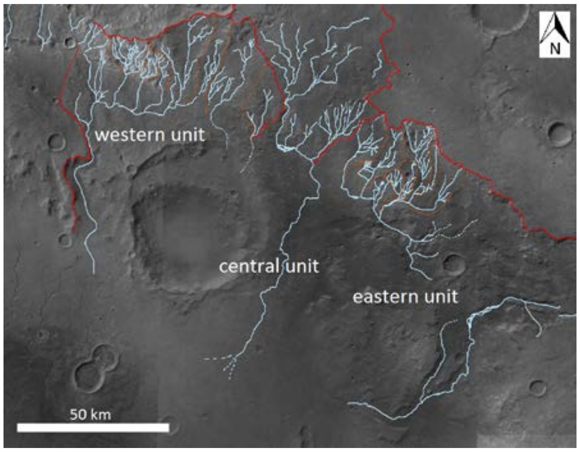

Fig. 3: The area is divided into three units: western, central and eastern unit. The separation is controlled by main watersheds (red) and local watersheds (orange), HRSC orbits h6479_0000 and h8604_0000.

That one must has been delivered particularly with water by the main dendritic valley system of the eastern unit and some inflow from east, southeast and south of that basin (Figure 4).

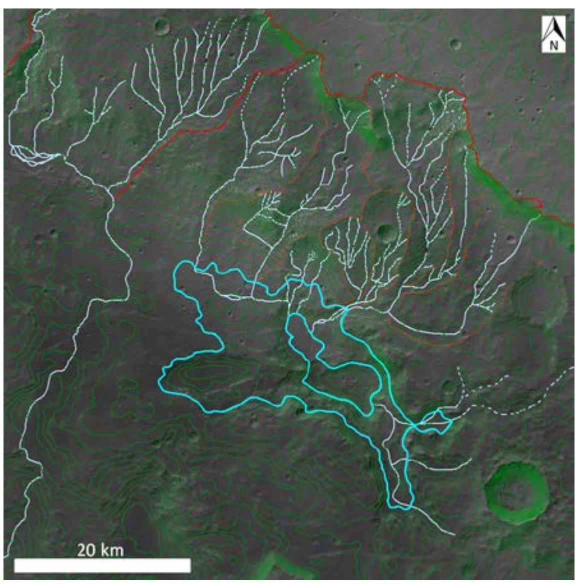

Fig. 4: Eastern unit. Dendritic valley network system discharges into a basin. The outer blue frame shows the highest basin rim in 1410 m altitude, the inner blue frame the rim of a possible stagnant water body in 1150 m altitude, HRSC orbit h8604_0000.

Due to the missing channel remnants from the bottom in 980 m up to 1150 m altitude, we can assume that there could have been a lake or at least a body of stagnant water for a time. By using the HRSC-DTMs we calculated the lake´s volume of 3.9 km^3 and the discharge rate (Q in m^3/s) derived from the interior channel width (W in m) by the help of the empirical equation

$$Q = 1.4\, W^{1.22} \text{ [5].}$$

The discharge of the whole eastern fluvial system is about 2400 m^3/s. In the case that a singular runoff event has formed the surface the basin would be filled in a time of some weeks. For the case that the basin was completely filled up to its rim in 1410 m the required time for a complete fill circled around 200 days. It is important to underline the data suggest only values for the situation of a surface runoff into a basin regardless of interflow or (deferred) infiltration into the crust.

The aim of the study is to give an insight into the geomorphological and hydrological situation of a fluvial-response-system, its functional relation and development at the Noachian-Hesperian-boundary with the help of discharge rates, erosion rates and statistical analysis.

Acknowledgements

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