EPSC Abstracts
Vol. 8, EPSC2013-178-1, 2013
European Planetary Science Congress 2013

Analysis of Fluvial Processes and Mass Balances on Newton Crater's Rim, Mars

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Abstract

Here we present insight into a geologic and geomorphological analysis of valley networks on Newton Crater's rim. We use calculations of discharge rates and functional relations between local fluvial and lacustrine environments to improve the insight into a time featuring of environmental and climate conditions, whose processes need quantitative investigations [1].

1. Introduction

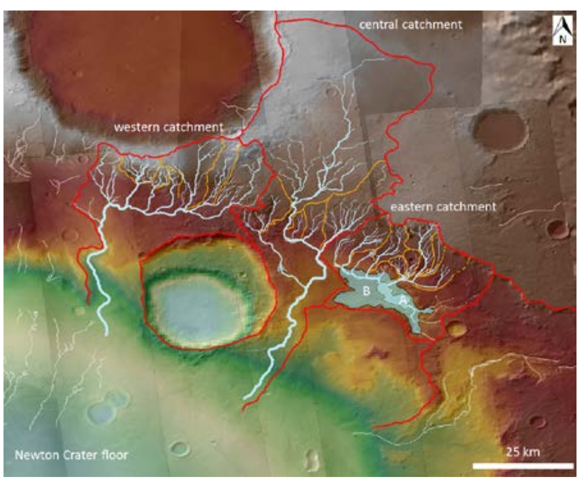

Figure 1: Topographic map of the north-eastern rim of Newton Crater and its main dendritic networks.

The investigated region (Fig. 1) is located in the Southern hemisphere of Noachian-Hesperian-aged highlands at 40°S latitude and 157°W longitude at the north-eastern crater rim of Newton Basin. It spans from nearly 3000 m height down to the more than -1300 m deep Newton Basin.

2. Data and Methods

For this work, we used datasets of the High Resolution Stereo Camera (HRSC) [2] on board the Mars Express Orbiter and Context Camera (CTX) [3] images of the Mars Reconnaissance Orbiter. To obtain morphometric parameters of valley networks HRSC digital terrain models (DTM) [4] were utilized. These are complemented by statistic methods to give estimations and calculations for specific fluvial issues as discharge and runoff production rates. The correlation of the findings combined with results of the crater-size frequency distribution (CSFD) [5], allows interpreting the development and timing of the examined region. The resulting data set might give clues to early Martian climatic conditions and its influence on the morphology and the discharge rates of the identified channel systems.

3. Geology

The entire region of interest shows a heavily fluvial dissected surface. South- and south-west-oriented crater walls exhibit slopes between 2 % and 6 %. They are particularly fluvial dissected by dendritic networks with drainage densities from 0.14 km^{-1} up to 0.3 km^{-1}. CSFD measurements of the surface by dissected dendritic networks yield an age of 3.5 Ga, whereas the age of the crater floor was estimated to be 3.1 Ga [6]. The younger age marks the termination of fluvial activity in that region as these units cover the mouths of the fluvial valleys. Hence, the period of fluvial activity spans a time of at least several 100 Ma. Dendritic networks embody the earliest stage of fluvial activity with surface runoff induced by precipitation (rainfall/snowfall). Reconstruction of topographical watersheds enable to identify three catchment areas (western, central, eastern) with sizes between 1800 km² and 4200 km². At the source region, valley networks occur as dendritic patterns with downwards coalescing branches and slopes ranging from 2% to almost 5%. Between 980 m and 1410 m an enclosed basin was identified in the eastern catchment (Fig. 1). The lack of channel remnants and the abrupt cut of all channels at an elevation of 1150 m imply that this depression could have hosted a lake or at least a standing body of water for a certain time. The measurement of the potential lake volume yields 3.9 km³ and more than 53 km³ for a maximum lake extent. The peak discharge rates (Q in m³/s) are deduced by the width of the channels (W in m) calculated by

$$Q = 1.4\ W^{1.22}\ [7].$$

The estimated discharge rates range between 1000 m³/s and 1250 m³/s for each catchment area. The networks of the western and central area enter Newton's crater floor, whereas the eastern networks drained into the potential lake basin. Their runoff production rates (peak rates) start at around 3 cm/d and possess the upper limit at 5.6 cm/d [8]. Discharge rates of about 1200 m³/s of the individual catchments imply higher rates of surface runoff occurring around Noachian and Early Hesperian times.

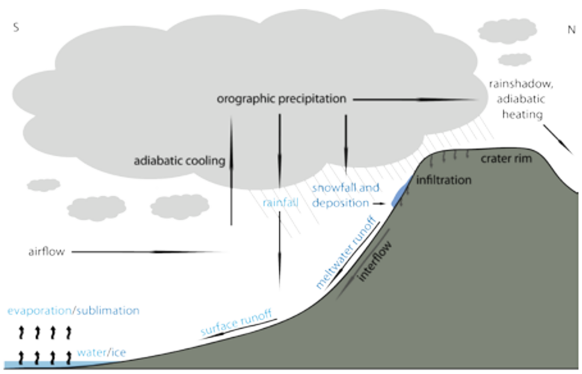

Figure 2: Scheme of a local water circulation of orographic precipitation and surface runoff.

[9] suggest that Newton Basin formerly hosted a huge paleolake. It could have fed the atmosphere with vapour followed by orographic rain- or snowfall and subsequent surface runoff (Fig. 2). Following a cold-climate scenario, precipitation could have accumulated snow deposits on the upper crater wall and rim. During periods of higher obliquity [10] snowmelt and subsequent surface runoff would have led to the formation of the various channel systems.

4. Conclusions

This work shows that Newton Crater's topography caused a local climate system driven by sublimation of a lake and orographic precipitation along Newton's crater rim. The main fluvial activity phases can be dated to Late Noachian/Early Hesperian times.

Acknowledgements

This research has been partly supported by the Helmholtz Association through the research alliance „Planetary Evolution and Life“.

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