EPSC Abstracts
Vol. 8, EPSC2013-646, 2013
European Planetary Science Congress 2013

Is the morphological characterization of valley networks on Earth portable to Mars?

R. Koenders, R.C. Lindenberg and M.Menenti Department of Geoscience and Remote Sensing, Delft University of Technology, The Netherlands (R.Koenders@TUDelft.nl)

Abstract

The climate under which the Martian valley networks formed is still under debate, was it wet or dry, cold or warm. The morphology of the valley networks on Mars shows similarities to those of river networks on Earth. Climate has an influence on the morphology of river networks on Earth. The volume of sediment, the volume of water, and source of water—groundwater or rainfall—are influenced by climate. To compare different watersheds we characterize the watersheds using a limited number of key parameters. The parameters considered here are: volume of erosion, outlet channel and/or valley dimension, slopes, evolution of channel cross-section downstream. We consider four regions, two on Earth and two on Mars, identify the genetic processes, and give time duration constraints.

1. Introduction

The climate under which the Martian valley networks formed is still under debate, was it wet or dry, cold or warm. It is currently analysed whether the Martian valley networks were shaped by rainfall or groundwater. Identifying the genetic process of Martian channel networks as either rainfall or groundwater, gives a strong indication of the past Martian climate [1].

The morphology of the valley networks on Mars shows some clear similarities to those of river networks on Earth. The morphology of valley networks on Earth is influenced by two main categories. 1) The physical attributes of the surroundings, i.e. the erosional properties of the subsurface, slopes of the watershed. And 2) the attributes of the erosional process involved, i.e. the amount of sediment, available amount of water, and the source of the water: groundwater or rainfall. The erosional processes are linked to the climate, sediment flow is controlled by plant growth and ice formation and the amount of water depends on the circulation of water in the atmosphere [2].

In our research we identify a number of morphological parameters that identify the attributes of the erosional processes: volume of erosion, outlet channel and/or valley dimension, slopes, evolution of channel cross-section downstream.

Most of the previous studies have looked at large scale valley networks due to the resolution constraints of the data used (MOLA) [3]. Looking at smaller valley networks brings certain parameters (such as Hack's law) closer to terrestrial values. Both on Earth and on Mars we employ digital elevation models with similar resolutions of $30-50$m per pixel. For Earth we use the ASTER GDEM dataprocut, for Mars we use the High Resolution Stereo Camera (HRSC) processed DEMs.

2. Regions

In the research described here we compare two terrestrial and two Martian valley networks. The two terrestrial networks can be considered Mars analogues, one is shaped by rainfall, the other by groundwater processes. On Mars we have identified two valley networks that are hypothesized to have the same distinction in genetic process.

The Río Colorado is a river that ends in the Altiplano endorheic basin of Salar de Uyuni in Bolivia [4]. It is a system that is predominantly fed by rainfall, which has very little vegetation. The climate is very dry ($130mm$ of average rainfall, $1300mm$ of average precipitation potential), with a short-duration wet-season and a prolonged dry season.

The Qattara depression in the Sahara desert in Egypt is a large paleo-endorheic basin that was groundwater fed. Like on Mars there are many paleo channels visible which give us a good alternative to look at Martian channel morphology.

The Warrego Valles system on Mars shows much resemblance with terrestrial valley networks. One of the hypothesis for the formation process of the system is that the valley networks formed under the influence of an atmospheric water cycle, in a series of erosion events [5].

Figure 1 shows the Eberswalde crater (33W, 24S) is part of the heavily cratered "southern highlands" of Mars. The crater formed during the early Noachian (±4Ga). It was subsequently covered by debris from the Holden crater to the south. A theory of origin for the water is that it is linked to the formation of the Holden crater, whereby the terrain mantled by the hot ejecta blanket was heated up, releasing underground ice deposits [6].

3. Parameters

In our research we identify a number of morphological parameters that identify the attributes of the erosional processes: volume of erosion, outlet channel and/or valley dimension, slopes, evolution of channel cross-section downstream. In order to extract these parameters we use a combined approach of automatic extraction [7] and manual methods.

The volume of erosion we estimate using a number of methods that depend on the local morphology. In the Eberswalde Delta and the Salar de Uyuni delta there are clear lower limits to the volume from the sediments deposited in the deltas. In other circumstances we identify an estimate of the local surface before erosion, by subtracting the current surface we have an order of magnitude for the amount of material eroded away.

The cross-section of the outlet channel gives a good constraint on the maximum amount of water discharge, Q, that a channel can endure.

The slopes of the channels in the watershed, and of the entire watershed give an indication of the amount of erosion that takes place, and how well sediment is transported [8].

The width of the channels in terrestrial valley networks formed by rainfall show increases downstream. The few terrestrial valley networks that are predominantly groundwater fed show a constant width as the channel is followed downstream.

4. Summary

Studies have shown that terrestrial and Martian valley networks show similarities in their morphology. We analyse the morphology of two terrestrial and two Martian valley networks. Using models that describe the time duration required to form the valley networks [8] we analyse the timing of these. In combination with a model of the genetic processes involved in the formation of these valley networks we provide new insights in the climatic conditions on Mars at the time.

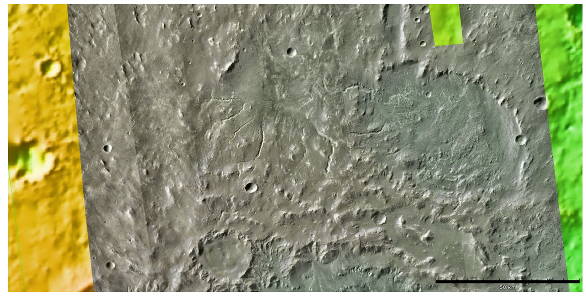

Figure 1: A mosaic of the Eberswalde upstream watershed and delta created using various datasources (CTX, MOLA) in JMars.

References

[1] Stepinski, T. F., and A. P. Stepinski (2005), Morphology of drainage basins as an indicator of climate on early mars, *J. Geophys. Res.*, *110*(E12S12).

[2] Stepinski, T. F., and S. Coradetti (2004), Comparing morphologies of drainage basins on mars and earth using integral-geometry and neural maps, *Geophysical Research Letters*, *31*(15).

[3] Penido, J. C., C. I. Fassett, and S. M. Som (2012), Scaling relationships and concavity of small valley networks on mars, *Planetary and Space Science*.

[4] Donselaar, M., M. Cuevas Gozalo, and S. Moyano (2012), Avulsion processes at the terminus of low-gradient semi-arid fluvial systems: Lessons from the Río Colorado, Altiplano endorheic basin, Bolivia, *Sedimentary Geology*.

[5] V. Ansan and N. Mangold (2006), New observations of Warrego Valles. Mars: Evidence for precipitation and surface runoff, *Planet. Space Sci.*, 54, 219 - 242.

[6] Mangold, N., E. S. Kite, M. G. Kleinhans, H. Newsom, V. Ansan, E. Hauber, E. Kraal, C. Quantin, and K. Tanaka (2012), The Origin and Timing of Fluvial Activity at Eberswalde Crater, Mars. *Icarus*

[7] Koenders, R. and Lindenbergh, R.C. and Storms, J. E. A. and Geleynse, N. and Menenti, M. (Under Review), Identification of channel pixels in digital elevation models using continuous multiscale curvature, *J. Geophys. Res.: Earth Surface*.

[8] Forzoni, A., G. de Jager, and J. Storms (2011), An integrated source-to-sink model simulating sediment flux through a river system and fluvio-deltaic stratigraphy, in *EGU General Assembly, Vienna, Austria*.