Planetary and Space Science 85 (2013) 220–231

Contents lists available at ScienceDirect

Planetary and Space Science

journal homepage: www.elsevier.com/locate/pss

An unnamed fluvial valley system formed under different climates at Xanthe Terra, Mars

Akos Kereszturi *

Konkoly Thege Miklos Astronomical Institute (Astrophysical and Geochemical Laboratory), Research Centre for Astronomy and Earth Sciences, H-1121 Budapest, Konkoly Thege Miklos 15-17, Hungary

ARTICLE INFO

Article history:
Received 29 March 2013
Received in revised form
13 June 2013
Accepted 16 June 2013
Available online 21 June 2013

Keywords:
Mars
Water
Fluvial channels
Climate change

ABSTRACT

Analyzing an unnamed fluvial system (at 5.2N 301.4E) in Xanthe Terra on Mars for the first time, the following chronology could be reconstructed. The first period of the fluvial erosion of the area produced channels with higher drainage density than later events, but some resurfacing after this period erased these early, probably interconnected tributary systems and left behind only separate channel sections with eroded appearance. In the second period of fluvial erosion three deep and obvious channels were formed. In a third period, the main inlet to the terminal crater was eroded even more heavily. The last two episodes produced two different, characteristic cross sectional and longitudinal profiles: (1) narrow, shallow and nearly straight profiles, and (2) a wider, deeper and somewhat convex shaped profile. These two profile shapes resemble to other fluvial systems' in the Xanthe Terra region. The existence of these two different types of channel morphology suggests the change in the erosional process could be at least regional and probably related to the change of fluvial erosion's style on Mars forced by climatic changes.

1. Introduction

The origin of numerous valleys and channels on Mars can vary, as surface runoff (Craddock and Howard, 2002; Irwin and Howard, 2002) and subsurface sapping (Carr, 1981; Carr and Malin, 2000; Goldspiel and Squyres, 2000; Grant, 2000) could contribute in their formation. Beside the unclear origin, paleodischarge values (Irwin et al., 2005a) and other characteristics, including the duration of their active period (Kereszturi, 2012) are also poorly constrained. Detailed analysis of certain ancient fluvial systems could give insight into these characteristics, and as a result such studies are of high importance as it was seen in several earlier studies (Erkeling et al., 2012; Mangold et al., 2012). Aside from the identification of the processes worked at ancient fluvial systems, which provides information on their origin, analyzing several of these systems and putting them into global context, and, such analysis supports the general reconstruction of the changing role of fluvial erosion in the geological history of Mars (Moore et al., 2012; Pearsons et al., 2012).

This work investigates a channel system with two open lake basins and a sedimentary fan. The analysis is connected to the author's earlier investigation of fluvial landforms in Xanthe Terra (Kereszturi, 2005, 2010). This area of Mars is covered partly with ancient undulating Noachian aged surfaces (Scott and Tanaka, 1986) and early Hesperian aged lava flows (Crumpler, 1997) with many craters (Rotto and Tanaka 1995). The region is dissected by various ages of fluvial structures, including smaller and older valleys formed during the Noachian, and large outflow valleys formed mostly during the Hesperian (Nelson and Greeley, 1999). Various sedimentary units (Hauber et al., 2008) suggest that fluvial sedimentary transport played an important role in shaping the terrain. In this work a small channel system was analyzed that terminates in a 36 km diameter unnamed impact crater at 5.2°N 301.4°E, located to the south of this crater, roughly between 5°N and 4°N and 301.2°E and 302.0°E. The general overview of the channel system can be red in the Results section.

2. Methods

During the analysis of the channels the author carried out the following: (1) morphological survey of the area, (2) topographic analysis of cross-sectional and longitudinal profiles, (3) crater size frequency distribution analysis for age estimation. To survey the morphology, HRSC images acquired by the Mars Express (MEX) (Chicarro et al., 2004; Jaumann et al., 2007; Neukum et al., 2009), and CTX as well as HiRISE images acquired by the Mars Reconnaissance Orbiter (MRO) spacecrafts (McEwen et al., 2007; Malin et al., 2007) were used. To analyze channel morphometry the following numerical parameters were measured: depth, width, and longitudinal slope angle. For the topographic analysis partly

* Tel.: +36 6303437876; fax: +36 12790429.
E-mail addresses: kru@mcse.hu, kereszturiakos@gmail.com, kereszturi.akos@csfk.mta.hu

0032-0633/$ - see front matter
http://dx.doi.org/10.1016/j.pss.2013.06.007

MOLA data were used (Smith et al., 1999) with IAU2000 planetocentric coordinates, referenced to the latest Mars gravity model, as well as HRSC based DTMs (Digital Terrain Models) (Dumke et al., 2008; Jaumann et al., 2007; Gwinner et al., 2010) with 200 m spatial resolution.

The estimated radial accuracy of the topographic data from MOLA is 30–40 cm and dominated by long-wavelength orbital uncertainties of Mars Global Surveyor probe, but here only the height differences of neighbouring data points were used that made the error substantially smaller. The precision of MOLA measurement approaches 30 cm on smooth level surfaces and increases to about 20 m on slope, where HRSC based DTMs provide more accurate results. Beyond the errors in the database, the manual pointing also causes uncertainties. In the case of height determination, the horizontal distance of 200–300 m between the neighbouring MOLA shots also influences the used height values on steep terrain. The geometric accuracy of HRSC DTM varies with terrain characteristics, and the measured standard deviation against MOLA tracks is around 20 m (Heipke et al., 2007). All of the numerical values served as basis for statistical analysis only.

Regarding the nomenclature, valleys (enlarged by various processes and were not totally filled by liquid water) and riverbeds (were total filled by water at maximal discharge) are difficult to distinguish at the analyzed area, so in this paper the channel term was used to cover both structures.

3. Results

South of an unnamed impact crater at 5.2°N 301.4°E an ancient fluvial channel system is visible, where two main branches join forming a third section. The lower (northern) reach of the channel gets wider and deeper as it approaches the large crater where it terminates (called terminal crater hereafter). At the southern part of the crater bottom a fan shaped depositional structure is visible. For the easy identification of the channel segments the author marked the western tributary at the upper reach with letter A, the eastern tributary at the upper reach with letter B, while downwards (northwards) where these two joins with letter C (Fig. 1). These three sections together are called main channels hereafter.

At the analyzed area the channels dissect a plain with variable crater density (altogether 1313 craters were counted at 425 km^2). Many areas do not appear affected by the fluvial erosion next to this channel system, although eroded, fragmented, channel like pattern can be seen at many locations (indicated with dashed lines in Fig. 1). Dunes are present almost exclusively in the depression of the main channels. Two oval shaped open-lake basins (Lake E and Lake W hereafter) could be identified along A and B branches nearly halfway between their stating point and the termination. These ancient open lake basins have respective inlet and outlet channels. A few locations along the A and B channels are either eroded or heavily mantled, but further to the north they continue their track and are present again as deep elongated depressions. Based on the morphological analysis of the terrain, substantially more and strongly eroded tributaries could have been initially present, which are difficult to firmly identify. These channel fragments are marked by dashed lines in Fig. 1. The bottom of the A, B and C channels is covered with dunes at many locations and on the steep valley walls debris slopes are present with smooth appearance.

In the following more detailed morphological observations are described, together with inset images of the corresponding area. First some characteristics of the incision are presented, together with general findings. Second also general observations are listed using infrared images, thirdly the buried/eroded parts are characterized, and fourthly a bank-like strange structure is overviewed.

Small, 5 × 5 km sized insets of CTX P03_002247_1847 image is visible in Fig. 2 that display characteristic examples of the different

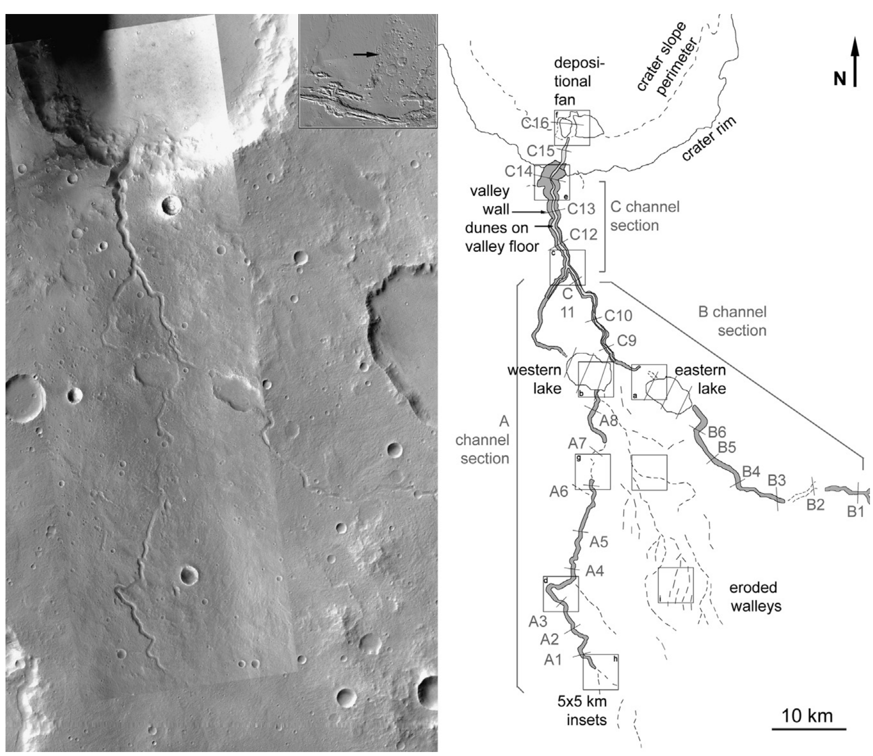

Fig. 1. Overview of the analyzed terrain on images (left) with a small inset (top) showing the location of the analyzed terrain relatively to Valles Marineris, and simple morphological map of the same area (right). Channel sections A, B and C mark the different parts and branches of the system. Small lines crossing perpendicularly these main channels with a letter plus a number (A1, A2…) are locations of cross-sectional profiles. Dashed lines show possibly heavily eroded channel sections, the small 5 × 5 km boxes are visible in magnified version in Fig. 2. The background is H1032 HRSC image, overlain by the CTX P03_002247_1847 image.