SOURCE REGIONS AND MULTIPLE WATER RELEASE EVENTS IN VALLEY NETWORKS OF THE LIBYA MONTES REGION ON MARS

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Introduction: Martian valley networks have been cited as the best evidence that Mars maintained flow of liquid water across its surface. Although internal structures associated with a fluvial origin within valleys such as inner channels, terraces, slip-off and undercut slopes are extremely rare on Mars (Carr and Malin, 2000) such features can be identified in high-resolution imagery (e.g. Malin and Edgett, 2001; Jaumann et al., 2005). However, besides internal features the source regions are an important indicator for the flow processes in Martian valleys because they define the drainage area and thus constrain the amount of available water for eroding the valley network. Furthermore, the morphology of the source regions and their topographic characteristics provide information about the origin of the water. On Mars valley networks are thought to have been formed by retreating erosion where the water is supplied from the sub-surface. However, the mechanisms that are responsible for the release of ground water are poorly understood. The three-dimensional highly resolved data of the High Resolution Stereo Camera (HRSC) on the Mars Express Mission (Jaumann et al., 2007) allow the detailed examination of valley network source regions.

Western Libya Montes: A valley network in the western Libya Montes region from 1.4° N to 3.5° N and 81.6° E to 82.5°E originates at a highland mountain region and drains down to Isidis Planitia over a distance of about 400 km. Midstream the valley network splits into a shorter eastern and a longer western part (Fig. 1). Most of its distance the western valley exhibits an interior channel that allowsus to constrain discharge and erosion budgets (Jaumann et al., 2005). The basic valley was formed in the Noachian/Hesperian period between 3.7 and 3.3 billion years ago but also operates into the Amazonian. However, discharge and erosion budgets restrict the erosion time to a few million years in total, indicating single episodic events rather than continuous flow over long periods of time (Jaumann et al., 2005).

Source Region: Whereas the source region of the eastern part of the valley is dominated by a dendritic dissected drainage area within very old geologic units (Fig. 2), the style of the western valley catchments is different. There the source region of the valley is covered by a series of lava flows. Even the upstream part of the western valley is covered by lava flows that overflow the original interior channel. Within this part of the valley a younger interior channel cuts the lava flow (Fig.3) indicating multiple flow events. Tributaries are rare, short and not dendritically arranged in this area. The valley system emanates directly from a lava plain and cascades down over

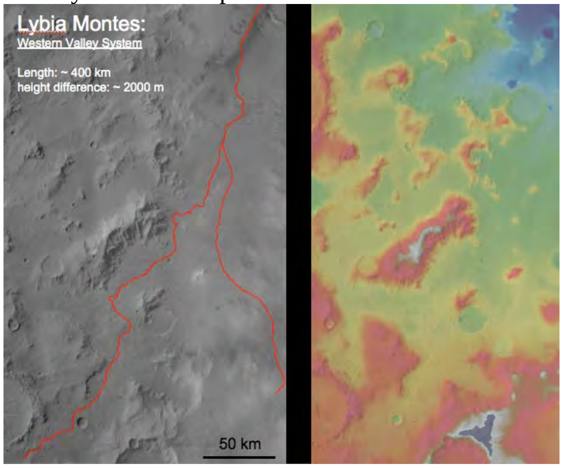

Fig. 1: Western Libya Montes valley system (left: HRSC nadir image; right: MOLA, blue to white indicates – 5000m to 3000m).

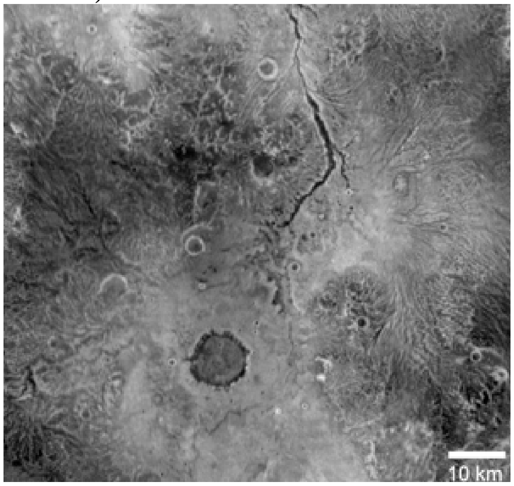

Fig. 2: Dendritic pattern of the eastern branch of the western Libya Montes valley system (THEMIS nighttime IR image).

old highland materials for a distance of about 20 km and a height difference of 700 m (Fig. 3). The staggered cascades have slopes of 6°. This is high compared to the overall valley slope of 0.1° small compared with waterfalls on Earth. However if we consider slope reduction by erosional undercut and collapse, this remaining slope will coincide with former cataracts.

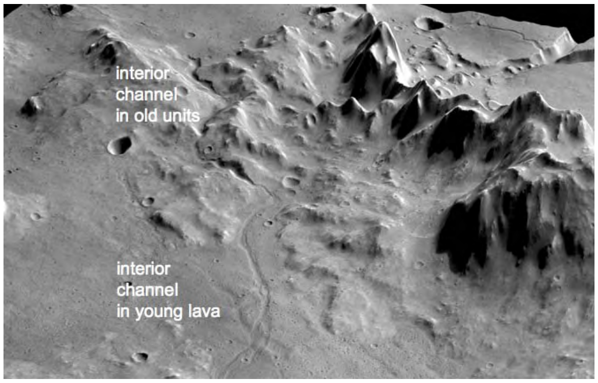

Fig. 3: Source region of the western Libya Montes valley system. The valley emanates abrupt at the end of a lava flow, cascades down the boundary of old highland materials and incises into younger lava flow (HRSC stereo image).

Although we cannot exclude an early period of precipitation, as indicated by the dendritic pattern of the eastern branch, most of the western valley has been formed by retreating erosion caused by subsurface water release. The close correlation of valley erosional structures and lava emplacement indicate a volcanically triggered water release mechanism either by hydrothermally driven expulsion of groundwater or more likely by melting and mobilizing ground ice due to heat induced by lava.

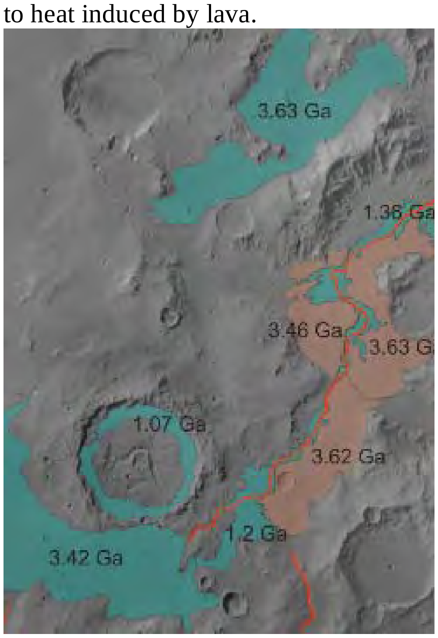

Fig. 4: Ages of different surface units in the western Libya Montes valley source region as derived from crater frequency measurements.

Stratigraphic Sequences: The analysis of stratigraphic sequences in the western branch of the valley system in terms of crater frequency measurements (Hartmann and Neukum, 2001; Ivanov 2001) indicates a series of subsequent volcano-fluvial events (Fig. 4, 5). In the Noachian < 3.7 Ga, Isidis rim material (Nm, Nplh) was initially fluvially eroded and erosional debris (Hd1) was deposited (Jaumann et al., 2005). In the Hesperian (3.5 to 3.4 Ga), volcanic activity (Hs1) triggered water release followed by deposition of fluvial sediments (Hd2) 3.35 Ga ago (Jaumann et al., 2005). In the Amazonian volcanic activity occurred during the period 1.4 to 1.1 Ga ago with lava flows (As2 and As3) and related fluvial activity as indicated by the interior channel in Fig. 3, which cut the lavas of unit As3.

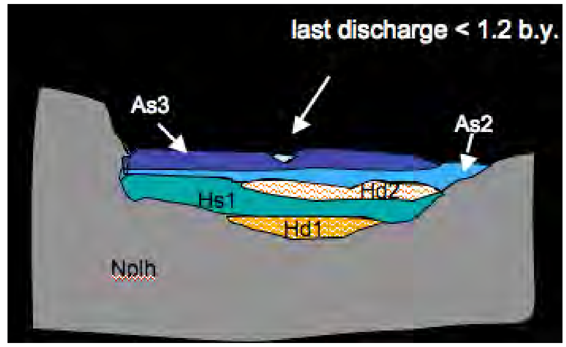

Fig. 5: Stratigraphic sequence of volcano-fluvial events in the western Libya Montes. For explanation see text.

The interior channel dissecting lava flow As3 might have been the last fluvial event in this region. According to discharge analyses discussed in Jaumann et al., (2005), the amount of water released within this Amazonian aged interior channel is estimated to about 400 m^3/s. This is an order of magnitude less than the discharges measured for the early Hesperian period in the same region (Jaumann et al., 2005).

Summary: The western Libya Montes valley was episodically active for about 2 billion years with major episodes in the Noachian (> 3.7 Ga), the Hesperian (3.5 to 3.4 Ga) and the Amazonian (1.4 to 1.1 Ga). Whereas precipitation may have dominated the fluvial activity during the Noachian as indicated by the dendritic drainage pattern in the older eastern branch, the Hesperian and Amazonian fluvial activities were triggered by volcanic processes such as ground ice melting or hydrothermal water release. The Hesperian discharge rate of 4800 m^3/s indicates fast erosion of the valley that might have been cut down within a million years (Jaumann et al., 2005). This suggest rather episodic than sustained flows, which is consistent with the observation of volcanically related water release processes.

References: *Carr, M. H., and M. C. Malin, Icarus, 146, 366–386, (2000); Hartmann, W.K. and Neukum, G., Space Sci. Rev., 96, 165-194, (2001); Ivanov, B.A., Space Sci. Rev., 96, 87-1044, (2001); Jaumann, R., et al., GRL 32, L16203, (2005); Jaumann. et al, Planet. Space Sci. in press (2007); Malin, M.C., and Edgett, K.S., JGR 106, E10, 23429-23570, (2000).*