MARTIAN VALLEY NETWORKS AND ASSOCIATED FLUVIAL FEATURES AS SEEN BY THE MARS EXPRESS HIGH RESOLUTION STEREO CAMERA.

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Introduction: Our objective is to characterize the internal structure of valley networks based on small-scale features that are related to fluvial processes. In order to map the features we used the data of ESA's Mars Express High Resolution Stereo Camera (HRSC) [1]. As HRSC is a stereo camera the three-dimensional structure of small inner valley features can be resolved providing quantitative information on transport rates and mass balances. Although the age differences between the valley floors and the surroundings are large and therefore stand for low average erosion rates, the estimated discharges indicate higher erosion activities and therefore shorter periods for the valley formation, which may be caused by episodic flooding events.

Background: Martian valley networks have been cited as the best evidence that Mars maintained flow of liquid water across the surface [e.g. 2]. However, internal structures associated with a fluvial origin within valleys like inner channels, terraces, slip-off and undercut slopes are extremely rare on Mars [3, 4, 5, 6]. So far only a small part of the Martian surface has been covered with high-resolution imagery and this may explain the lack of those features in valleys. Nevertheless these features, if present would prove sustained flow on the surface.

Approach: HRSC-images cover large areas of the Lybia Montes and Xanthe Terra Region and reveal structures like inner channels, terraces and slip-off and undercut slopes. The Mars Express High Resolution Stereo Camera (HRSC) is a multiple line scanner capable of resolving, at 250 km periapsis height, features as small as 10 m/pixel [1]. A typical HRSC scene is 5000 pixels wide and 100000 pixels long covering about 10^5 km^2 with a spatial resolution between 10 m and 30 m in 5 stereo bands and 4 color channels. This provides insight in large areas of the interior of valley network within a single image. As HRSC is a stereo imager, the topography can be measured with height accuracies comparable to the spatial resolution.

Results: In High Resolution Stereo Camera (HRSC) images of the Mars Express Mission a 130 km long inner channel is identified within a 400 km long valley in the Lybia Montes. In Figure 1 a segment of the inner channel incised in a narrow valley at 3°N, 82°E. Based on HRSC stereo information we were able to determine the depth of this inner structure (Figure 2) and thus we could estimate the discharge in the inner channel.With maximum bankfull discharge rates of 10^4 m^3/s [7] this channel is comparable to terrestrial rivers like the Mississippi and Amazon. Using the valley depth in connection with the ages of the floor, as derived from crater statistics, an average erosion rate of <1µm/a is deduced. Based on crater counts the development of the valley began 3.7 Gyr ago and lasted 350 Myr. However it is unclear, whether it was formed continuously or through isolated flooding events. The eroded valley volume amounts to 460 km^3. Taking the maximum bankfull discharge it would require 4 x 10^4 days to erode the valley, which would be consistent with a flooding event every few thousand years. On the other hand, if we assume only 5% bankfull discharge it need about a million years to dig the valley [7]. Thus, even with shallow flow, the valley network would have been eroded much faster than indicated by the average erosion rate. Therefore episodic flooding events are more reasonable than sustained flow conditions in order to form the valley network in Lybia Montes.

Nanedi Valles in the Xanthe Terra Region, contains a series of features interpreted to have formed by surface flow of water including meanders, slip-off and undercut slopes (Figure 3 arrows A, B), terraces and inner channels. Slip-off and undercut slopes as develop in the meanders (Figure 3) are the most prominent examples for fluvial erosion. The topographic data of HRSC allows determining the depth and width of Nanedi Valles and to create a cross section profile of the meander with slip-off and undercut slopes (Figure 3). The valley in this region is about 500 m deep and 4.5 km wide. The undercut slope can clearly be identified in the profile (Figure 4) due to a steeper slope. Several terraces, which have been developed on the slip-off slope, are developed.

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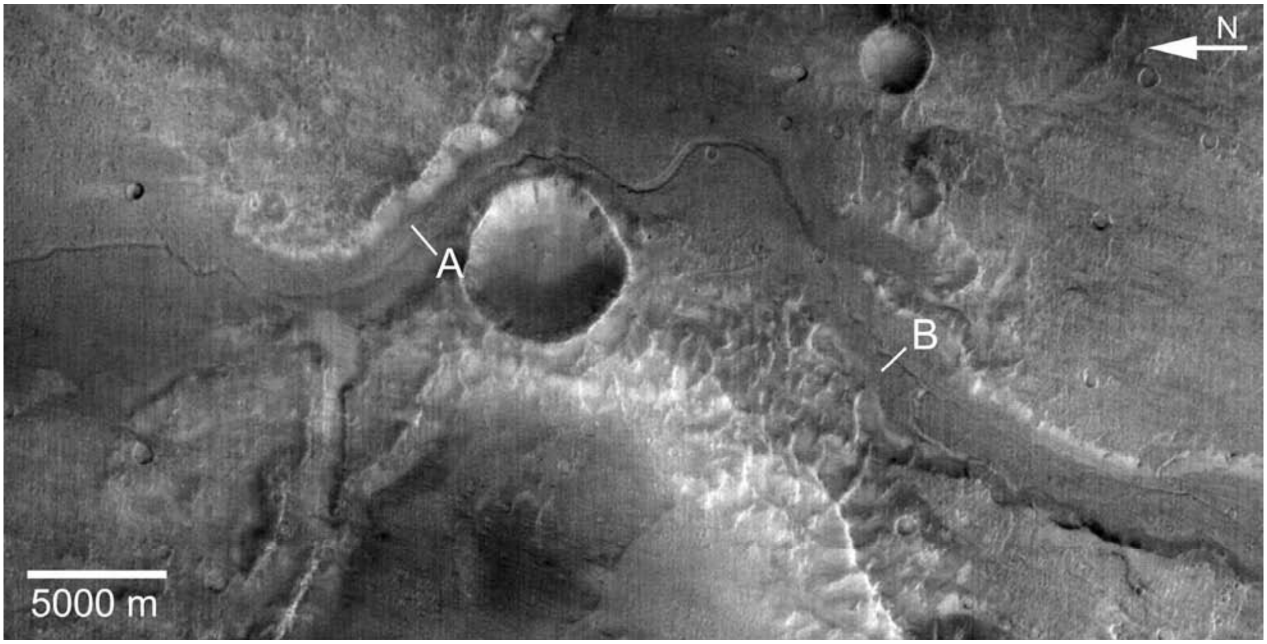

Figure 1. Part of the inner channel in the Lybia Montes (Orbit 47).

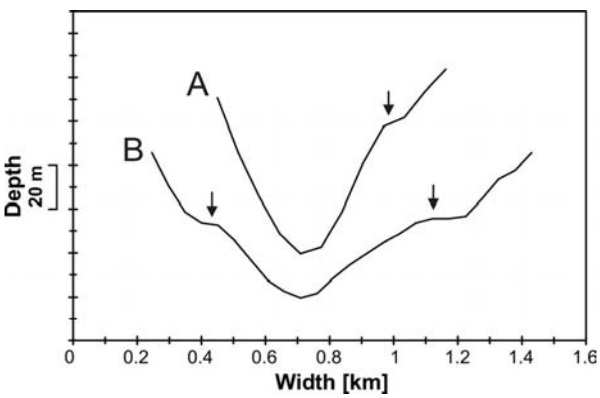

Figure 2. Cross sections of the inner channel (s. Fig. 1).

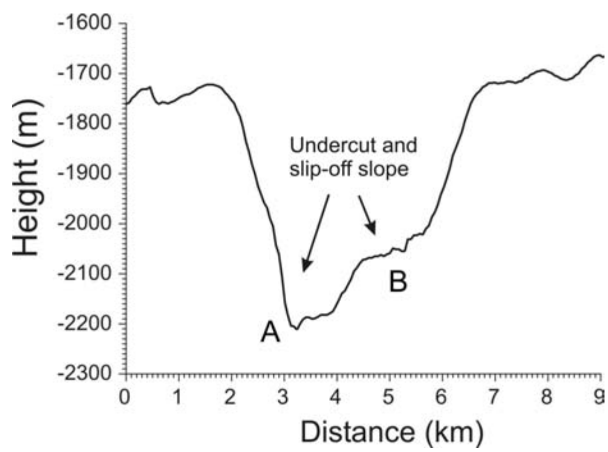

Figure 4. Cross section of Nanedi Vallis (s. Fig. 3).

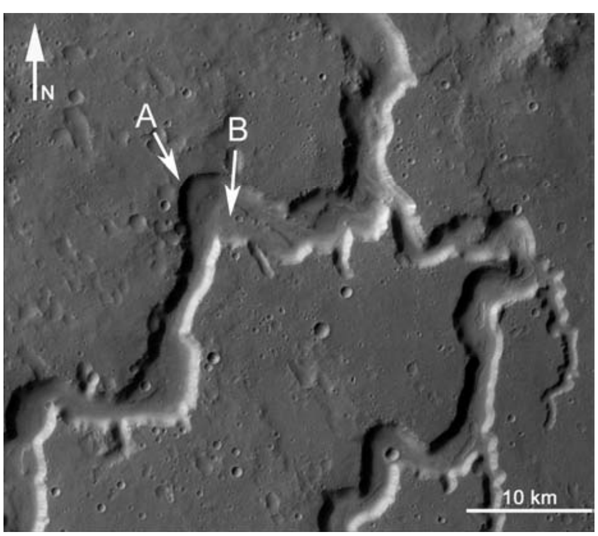

Figure 3. Part of the Nanedi Valles in the Xanthe Terra Region, at 7°N, 312°E (Orbit 905). Undercut (A) and slip-off slopes (B) are marked.