TOPOGRAPHY OF VALLEY NETWORKS ON MARS: COMPARISON BETWEEN MOLA AND HRSC DTM

V. Ansan[1] , N. Mangold[1], Ph. Masson[1], G. Neukum[2] and the HRSC co-Investigator team. Lab. IDES-CNRS, bât. 509, CNRS and Université Paris-Sud, 91405 ORSAY, France, [3] DLR, Berlin, Germany, Contact: veronique.ansan@u-psud.fr, nicolas.mangold@u-psud.fr

Introduction: Since visible images have been acquired by Viking orbiter in 1976, valley networks have been mainly identified in the heavily cratered uplands dated Noachian (>3.5 Gyr). Valley networks on Mars have been the subject of considerable debates about their formation processes since three decades [1-5]. MOLA altimetric data gives the possibility to study the geometry and topography of valley networks at spatial resolution of typically 500m -1 km [e.g. 6]. This resolution is sufficient to map large valleys but not small tributaries that we can map on high resolution imagery. The Mars Express High Resolution Stereo Camera (HRSC) allows us to exctract DTM from stereoscopic images with typical spatial resolution of 50 m or better, but vertical resolution not as good as that of MOLA, typically 20 to 100 m depending on terrains roughness and image quality. In this study we compare the organization of valley networks in two regions (Aeolis region and West Echus Chasma plateau) using both DTMs (MOLA and HRSC) and manual mapping in order to quantify the difference of geometry between these two datasets.

Valley networks in Aeolis region: This region is characterized by densely cratered terrains dated of the Noachian period [7, 8]. The terrains between large craters are incised by valley networks. HRSC acquired some images with a spatial resolution ranging from 10 m to 40 m in 5 stereo bands and 4 color channels in Aeolis region. These images show that the densely cratered terrain has been modified by numerous valley networks. For example, the nadir images of 228 and 241 orbits, centered at 157.355°E and 30.576°S (Fig. 1) displays a set of valley networks with a mature organisation (dendritic pattern with high bifurcation ratio) similar to that of terrestrial valley network in temperate climatic zones. These valley networks have large drainage basins and a high density drainage.

The DTMs generated from stereo images give quantitative information about the morphometry of valleys. Using the triplet of images (nadir and two stereos ones), we generated by DLR's software [9] a DTM with a spatial resolution of 22.4m/pixel and a height accuracy of 20m, which highly improves the topography of this area previously observed by MOLA data.

We used a hydrologic analysis (DNR hydromod) included in ARCVIEW GIS [10] to extract the valley networks from MOLA and HRSC DTMs (Fig. 1). MOLA drainage density gives between 0.1 and 0.2 km^{-1} with Strahler order of 3 whereas HRSC DTM gives between 0.1 and 0.3 km^{-1} with Strahler's order of 4. With manual mapping from nadir HRSC images at 22.4m/pixel, the drainage density is between 0.1 and 0.5 km^{-1} with Strahler order of 5 (Fig. 1). HRSC DTM gives thus a strong improvement in the drainage characterization compared to MOLA, but still not sufficient to reproduce manual mapping.

Valley networks in Echus region: This region is located at the North of Valles Marineris. On the plateau at the west of Echus Chasma canyon (278-281°E, 0-5°N), valley networks show similar fluvial dendritic pattern. These valleys were identified from their difference of thermal properties on THEMIS images [11]. HRSC provides the possibility to look in detail to their morphology and geometry with the spatial resolution at ~20 m/pixel (Fig. 2). Valleys in Echus area are not restricted to the locations where they have been observed through THEMIS images [11]. They extend over more than 200 km along Echus Chasma western plateau.

MOLA topography enable us to detect only a few valleys in this region with depth of about 100 m. This is mainly due to the widths of valleys: valleys less than 500 m wide can not be detected on MOLA DEM despite the excellent vertical resolution. The HRSC DTM at spatial resolution of 50m gives slightly better results by detecting most valleys deeper than 30 m. For example, a drainage basin included in an old filled impact crater shows an organisation of 2 Strahler's order at MOLA scale, 3 orders for HRSC DTM and 4 for HRSC nadir image mapping. We detect 3 times more valleys with HRSC DTM than with MOLA data. The detection of valley networks is thus much better for from MOLA and HRSC DTM but it is nevertheless far to be comparable with the manual mapping which able to see the smallest tributaries. With the manual mapping, these valley networks display a mature dendritic pattern with high bifurcation ratio [12, 13] ranging from 3 to 5.

Conclusion: Compared to MOLA, HRSC DTMs improve the quantification of valley networks properties such as drainage densities and aspect ratios, showing that the manual mapping of valleys with previous Viking or THEMIS images were justified. Nevertheless, mapping from HRSC images show that the manual mapping is still better than any automatic method and will continue to be useful to characterize valleys, at least in 2D. The two studied regions enable us to compare a Noachian (Aeolis) and a Hesperian (Echus plateau) networks. The comparison shows that the West Echus plateau younger drainages are much more shallow with less incision than in Aeolis, despite that the drainage densities is higher and their maturity is large. This difference is probably the effect of three parameters: (1) Noachian terrains are not as well preserved as late episodes of activity on freshly formed Hesperian rocks, possibly explaining small tributaries are missing over Noachian terrains, (2) the duration of Noachian networks might be longer to explain the larger incision of valleys, (3) the bedrock composition is uncertain and might be different. Such automatic studies will be continued over larger area to be statistically valid and improve our understanding of Martian valley networks.

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Figure 1. Extract of HRSC image (orbit 228) located in Aeolis region. Numerous dendritic valley networks incised Noachian densely cratered terrains.