ON ORIENTATIONS OF MARTIAN VALLEY NETWORKS. T. F. Stepinski[1] and W. Luo[2], [1]Department of Geography, University of Cincinnati, Cincinnati, OH 45221-0131, stepintz@uc.edu. [2]Department of Geography, Northern Illinois University, DeKalb, IL 60115, wluo@niu.edu.

Introduction: Formulation of the specific scenario for formation of Martian valley networks (VN) is elusive as the observational evidence is ambivalent. Recent works [1,2] aimed at updating global inventory of VN aim at reducing this ambivalence. Utilizing results of [1] and recent assessment [3] of factors controlling precipitation on early Mars, we have linked [4] formation of VN with existence of northern ocean. Here we follow up on this linkage by analyzing distribution of VN orientations relative to the distribution of terrain slopes. It is expected [5] that large scale features of Noachian terrain were in place before formation of VN. Terrain erosion associated with the formation of VN has not been significant enough to alter the large-baseline slopes of the Noachian terrain. Thus, in general, distribution of VN orientations should follow distribution of slopes on the Noachian terrain. However, according to a hypothesis [3,4], precipitation, ultimately responsible for carving VN, was delivered by transfer of water vapor from the northern ocean. This opens up a possibility that northern slopes received disproportionately large amount of precipitation leading to a higher number of VN with northern orientations. In order to check this hypothesis we compare a distribution of VN orientations with a distribution of large-baseline slopes on the Noachian terrain

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Distribution of VN orientations: VN downstream azimuths have been calculated as one of the attributes in the automatically generated global dataset of VN [1], but has not been analyzed until now. MOLA-based raster with resolution of 128 pixels/degree was used to compile this dataset. The azimuths of VN were calculated in two different ways: (1) by using the outlet and the upstream end of valley's main stream, and (2) by using the outlet and a point on the network located farthest from the outlet. Both methods yield very similar distributions. Here we utilize the azimuths calculated using the method #2 as a measure of VN orientations. Distribution of VN orientations was examined for a subset of the dataset fulfilling the following conditions: (a) relatively large VN with contributing area > 1000 km^2, (b) VN located on Noachian terrain, (c) VN located in the area of high dissection density. Our dataset contain 1998 such VN. Their locations are shown on Fig.1 (top) and the distribution of their orientations is shown on Fig.1 (bottom).

Note that VN shown in Fig.1 are linear features although they are difficult to see as such given a limited image resolution.

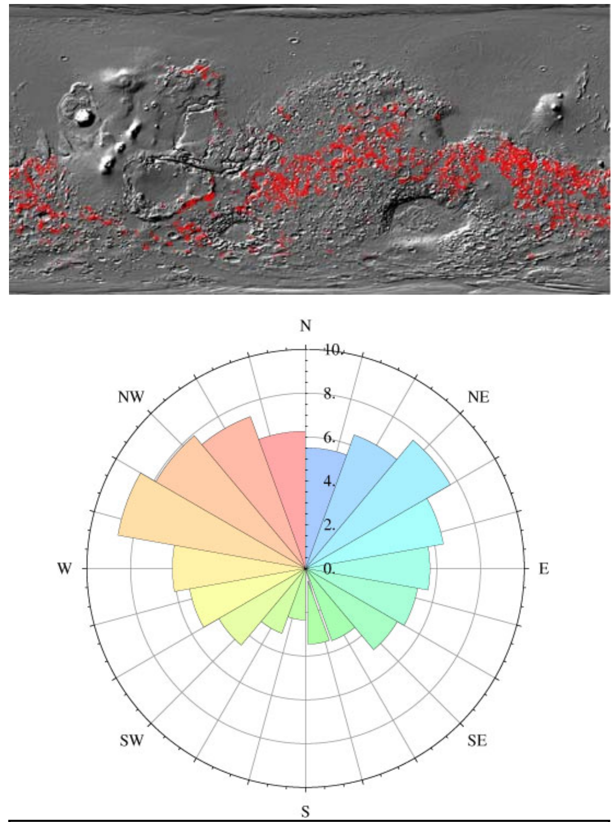
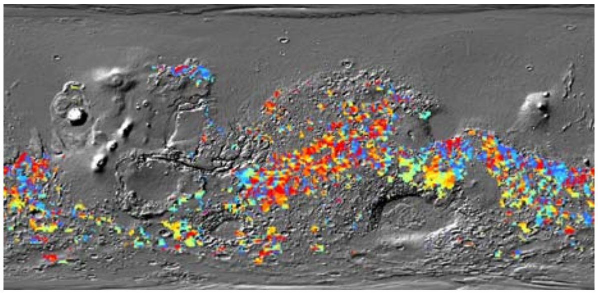


Figure 1: (Top) Location of VN utilized in our analysis. (Bottom) Histogram of orientation of these VN.

Distribution of orientation of terrain slopes: Distribution of orientation of terrain slopes depends on baseline length used to calculate a slope. Ideally, the baseline should be equal to the size of the network and thus it should vary from location to location. For simplicity, we calculate terrain slope on the basis of (almost) constant baseline. Terrain orientation is calculated as azimuth of direction of steepest descent calculated from coarse resolution elevation grid. We use 1 degree/pixel elevation grid that corresponds to ~60 km baseline length on the equator. Distribution of terrain orientations is relatively stable to changes (within the same order of magnitude) in the baseline length. We have restricted the spatial extent of our calculation to a region located in the Noachian and corresponding to high dissection density. Fig.2 (top) shows a map of terrain orientation. The entities shown on Fig. 2 are 1 degree pixels colored according to their orientations (azimuths); the legend is incorporated into Fig.2 (bottom). Fig.2 (bottom) shows a histogram of terrain orientations labeled to colors corresponding to the map.



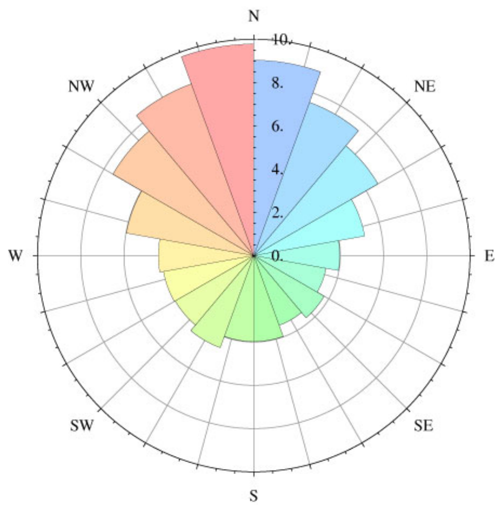


Figure 2: (Top) Map of terrain orientations calculated using 1 degree/pixel elevation grid. (Bottom) Histogram of terrain orientations.

Discussion: Histogram of terrain orientation clearly shows that dissected Noachian surface (see colored portion of the entire Martian surface on Fig. 2) slopes predominantly in northerly directions. About 60% of slopes have azimuths within $\pm 80^o$ from the north direction, whereas only 30% of slopes have azimuths within $\pm 80^o$ from the south direction. The remaining 10% of slopes have easterly or westerly azimuths. Within the slopes having northerly directions there is a systematic increase in the frequency of slopes with progressively more northerly directions with almost 19% of all slopes having azimuths within $\pm 20^o$ from the north direction. This reflects the large scale topography of Mars with Noachian highlands sloping toward the dichotomy boundary and the northern plains.

Histogram of VN orientation (Fig. 1) also shows a bias toward northerly directions with 56% of VN having azimuths between within $\pm 80^o$ from the north direction and 32% of VN having azimuths within $\pm 80^o$ from the south direction. However, distribution of azimuths of VN having northerly directions differ from distribution of azimuths of slopes having northerly component. Whereas azimuths of slopes are biased toward true north, azimuths of VN are more broadly distributed and somewhat biased toward NE and NW directions.

We explain this discrepancy between the two distributions by the process of VN formation via runoff erosion. By analogy to terrestrial streams, the runoff follows the local steepest descent path. The network that forms as a result of runoff process has an overall direction that reflects all local slopes in the catchment area. This direction does not follow directly the azimuth of the large scale slope, but rather is offset from it due to a diffusive character of local slopes pointing in many different directions. In order to quantitatively show that distribution of VN azimuths follows from the distribution of small scale slopes, a random-walk-like calculations needs to be performed which is beyond the scope of this contribution.

Conclusion: A comparison between distribution of VN azimuths and distribution of long baseline slope azimuths reveals that the two are consistent if diffusion of VN azimuths from a predominant regional slope is taken into account. We definitively concluded that azimuths of VN are not more biased toward north than the azimuths of slopes. This does not refute a hypothesis that moisture ultimately responsible for carving VN was delivered from the north. The moisture could be delivered at altitude high enough so the precipitation was even and independent from slope direction. In addition, even though the source of the moisture was to the north the predominant wind could not be strictly from the north. More analysis is necessary to study this issue in details.

References: [1] Luo, W. & Stepinski, T.F., JGR-Planets 114, E11010 (2009). [2] Hynek, B.M, Beach, m., & Hoke, M.R.T., JGR-Planets, 115, E09008 (2010), [3] Richardson, M.I. and Soto, A., in 2nd Workshop on Mars Valley Networks, 62-65, (2008). [4] Stepinski, T.F. & Luo, W. 41st LPSC, #1350, 2010. [5] Phillips, R.J. et al., Science, 291, 2587-2591, 2001