GLOBAL, COMPUTER-GENERATED MAP OF VALLEY NETWORKS ON MARS.

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Abstract: The new, global map of valley networks on Mars has been created entirely by a computer algorithm parsing topographic data. This new map represents the update to a current global map of valleys compiled by Carr. Dependencies between dissection density and its potential controlling factors are derived and discussed.

Introduction: Martian valley networks (hereafter referred to as VN) are geomorphic features on Mars exhibiting some visual resemblance to terrestrial river systems. Analysis of spatial distribution of drainage on Mars requires a global, sufficiently detailed map of VN. The existing global map was drawn by Carr [1,2] using Viking-based images covering ±65 of latitude. The Carr map contains ~ 348,024 km of networks; taken globally it depicts an immature drainage heavily concentrated in the southern highlands. The newer, higher resolution or higher quality global mosaics of Mars reveal existence of many valleys not depicted in Carr's map. Therefore, construction of a new, more comprehensive global map of VN is in order. Recent advances in machine extraction of geomorphic features from topographic data [3] make it feasible to derive VN map automatically – by computer parsing of the MOLA topographic data [4]. Here we use such an automated approach to construct a planet-wide map of VN to serve as an update to Carr's map.

Methods: The core technology underpinning our mapping method has been described in [3]. The algorithm detects incisions directly from terrain morphology making an accurate mapping of regions with highly variable density of dissection possible. The valleys are mapped only where they are "seen" by an algorithm without resorting to any particular model of dissection. The emphasis on mapping rather than modeling the location of VN is what distinguishes our method from previous applications of computer algorithms to delineate the VN [5,6]. To obtain a global map of VN we subdivided the entire surface of Mars into overlapping tiles having size of 10^o by 10^o each. This subdivision is necessitated by the size of the global topographic grid (46080 x 22528 pixels) that is too large to be processed in its entirety. The overlapping buffer (having width of 100 km) between adjacent tiles prevents mapping incomplete fragments of the valleys that would be cut by boundaries between non-overlapping tiles. The valleys are identified and measured at each tile separately and the results from individual tiles are concatenated into a single database from which duplicate valleys, which are present due to buffering, are eliminated yielding the final map.

Results: Computer generated database consists of 23,569 "objects." Due to the limited quality of the topographic data, and the disjoined character of the VN, not all objects in the database represent a single network; often what is interpreted in an image as a single network is represented in the database by several objects. The total length of all VN in the database is 1,002,364 km, a significant increase over what has been mapped by Carr. The best method to visualize the spatial distribution of dissection on a planetary scale is through a map of continuous [3,7] dissection density (D). A global map of actual VN lacks details and does not reflect quantitatively spatial variations in density of dissection. Values of D are calculated at the pixel level and do not require subdivision of Martian surface into individual watersheds. A global map of D has enough resolution to depict local variations in density of dissection. Fig.1 shows the map of D as calculated from our database of VN. The legend to Fig.1 shows a full range of the D values, but eliminating outliers, the effective range of D values is 0-0.12 km^{-1}. Similar calculations for Earth, using topographic data of compatible resolution, yields values of D in the range of 0-0.32 km^{-1}. The distribution of dissection on Mars as revealed by the new map does not differ from what was revealed by Carr's map; Noachian highlands are predominant locations of the dissected areas. However, we find more valleys resulting in higher values of D.

In order to search for an explanation for observed distribution of dissection on Mars we have calculated zonal statistics of D with respect to elevation, latitude, local slope, and crater density. The result of the zonal statistics calculation is a function showing a dependence of D (averaged over the entire zone) on a variable of interest. Fig.2 summarizes the results of zonal statistics calculations. As expected, D is higher in regions characterized by higher slopes. The dependence of D on latitude reveals that highest level of dissection is found in the equatorial regions; the dissection density drops off toward the poles. The relatively high dissection is found at elevations ranging from -5000 m to 2500 m (low-to-medium on Fig.2); the higher regions are characterized by lower values of D. Finally, dissection density is proportional to crater density – regions with more craters are more densely dissected. We have also estimated depths of valleys and their dependence on latitude; valleys become shallower toward the south pole.

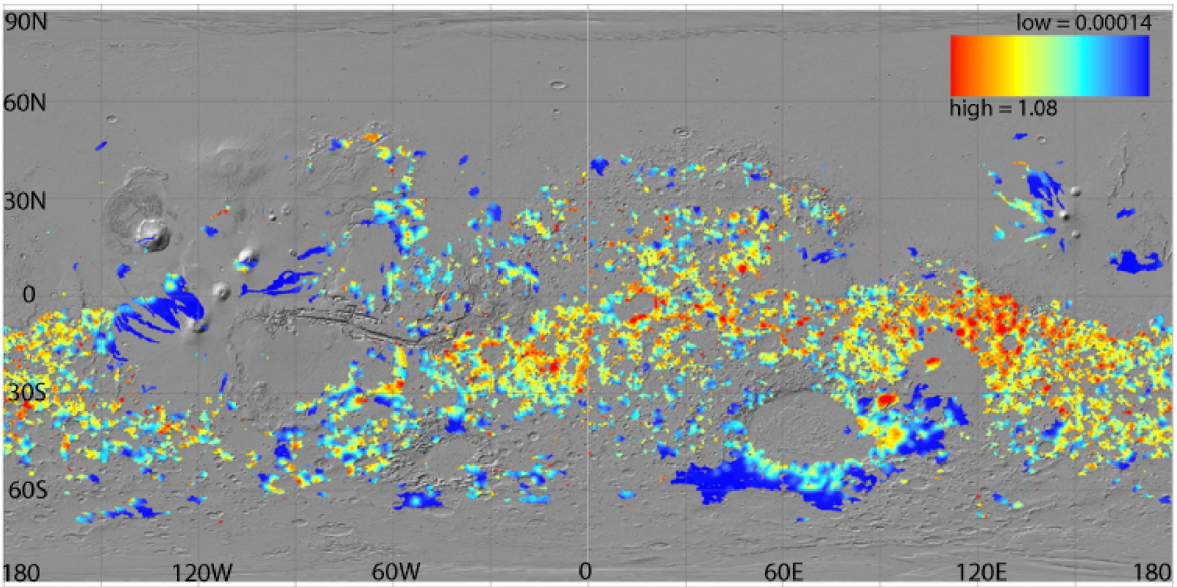

Figure 1. Global map of dissection density (D) on Mars constructed on the basis of the new, computer-generated database of VN. Blue-to-red gradient corresponds to low-to-high values of D. The gray areas correspond to regions for which D is not defined.

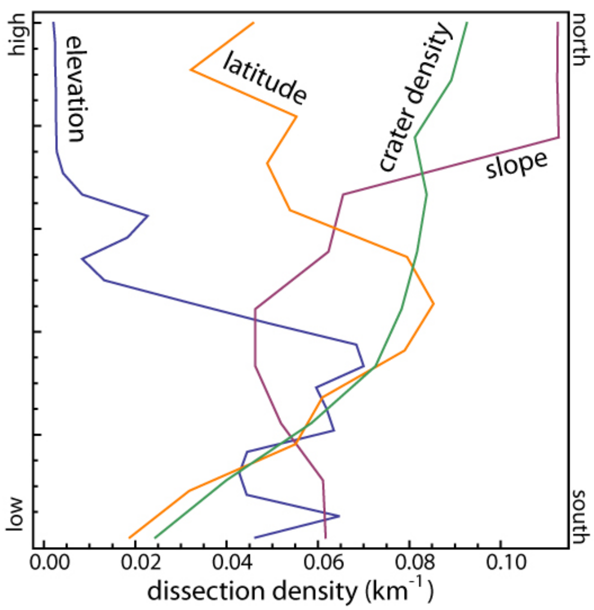

Figure 2. Dependence of D on four potential controlling factors.

Discussion. A global map of dissection can now be constructed by means of computer parsing of digital elevation models. This new technique was used to update Carr's map of VN on Mars. The new map offers an opportunity to test hypothesis of VN formation from a global perspective. The spatial distribution of D and zonal statistics point to the impact cratering as an ultimate source of VN. We hypothesize that impacts cause a series of alterations to an otherwise cold and dry global climate. These climatic diversions create episodic and short-lived precipitation events and groundwater sapping activities that are responsible for the patchy character of VN. They also explain mixed and inconclusive geomorphic evidence and observed lack of maturity [8] in the development of VN.

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