AUTOMATIC MAPPING OF MARTIAN PHYSIOGRAPHY: APPLICATION TO THARSIS REGION.

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Abstract. Physiographic maps of Mars are created automatically by a computer algorithm using topographic data. Generated maps are polygon-based and GIS compatible; they summarize all relevant topographic features and present them in a handy visual format that is also well suited for further quantitative analysis. The physiographic map of the Tharsis region is created, discussed, and compared to the geologic map of the same region.

Introduction. Surface processes on Mars create unique landforms that are recognized in images by their diagnostic features. To the degree to which such features can be identified by an algorithm parsing the topographic data, they can be used to automate the generation of physiographic maps of Mars. The physiographic map is the thematic map of terrain motifs – scattered patches of Martian surface having similar topographic attributes. Such map, obtained automatically, and thus at a minimum cost, is a valuable exploration tools for further geologic and geomorphic investigations. We present a method for automatic creation of physiographic maps of Mars using topography data given by the MOLA Mission Experiment Gridded Data Record (MEGDR) [1]. In order to demonstrate the abilities of our technique we have utilized it to create a physiographic map of the Tharsis region on Mars.

Methods. Our new mapping technique is a significant improvement on a procedure first proposed in [2]. The original technique uses three topographic attributes – slope gradient, surface texture, and local convexity – to characterize the landscape, and to classify each pixel in a grid representing the study area into one of 16 terrain types. Thus, the physiographic map generated by the original technique is a raster wherein each pixel is assigned a class label in the range from 1 to 16. The disadvantage of a raster map is its "grainy" character caused by the variability of terrain class labels on a scale of a single pixel. In contrast, our new technique yields a polygon-based physiographic map, with terrain labels assigned to units of the landscape significantly larger than a single pixel. In order to create the polygon-based map we first execute the algorithm described in [2] and use its results to calculate a vector of 19 elements for each pixel in the study area. This vector reflects a histogram and "texture" of terrain types within a neighborhood of a given pixel. The vectors corresponding to all pixels in the study area are clustered [3] into a desired number of classes – each class representing a unique topographic motif. The study area is segmented on the basis of the classes yielding a final, polygon-based map.

Results. The Tharsis region on Mars has been mapped using 4km/pixel MEGDR. Fig.1A shows a shaded relief map of the region – a popular tool to visualize topography. Note that due to the large spatial scale of the region the shaded relief lacks information about features occurring on small spatial scale. Fig.1C shows a physiographic map of the Tharsis region created by our algorithm. The physiographic map compresses all important aspects of site's topography into a form that is convenient to visualize and to analyze further. Each terrain class consists of a large number of pixels having similar but not necessarily identical terrain features. The ability to generalize a specific set of features to a broader class is what sets our technique apart from earlier methods. In comparison to the shaded relief map, the physiographic map offers much more information about the site's topography. This is because it is an *annotated* map with the labels that encapsulate knowledge gained by (automatically) processing objective measurements of topographic various features. Fig.1B shows the manually drawn [4] geologic map of the region; there are 43 different geologic units mapped. The geologic map is also an annotated map which offers even more information than the physiographic map because it takes into consideration site's stratigraphy as well as its topography. Visual comparison of Fig.1B and Fig.1C reveals a certain level of correspondence between physiographic and geologic maps, although each terrain class is typically spread amongst several geologic units.

Discussion. A GIS compatible physiographic map of a region on Mars can be created automatically by our computer algorithm. Such map encapsulates all relevant topographic information into a product that can be interpreted both visually and via further computer analysis. Creating such maps is "cheap" because a computer algorithm rather than an analyst is doing all the "behind the scene" analysis. The physiographic map offers a much better summarization of the site's topography than the standard shaded relief map, but it contains less information than a geologic map. Thus, a physiographic map provides a product that is intermediate between the shaded relief map (constructed algorithmically on the basis of rudimentary processing of the topographic data) and the geologic map.

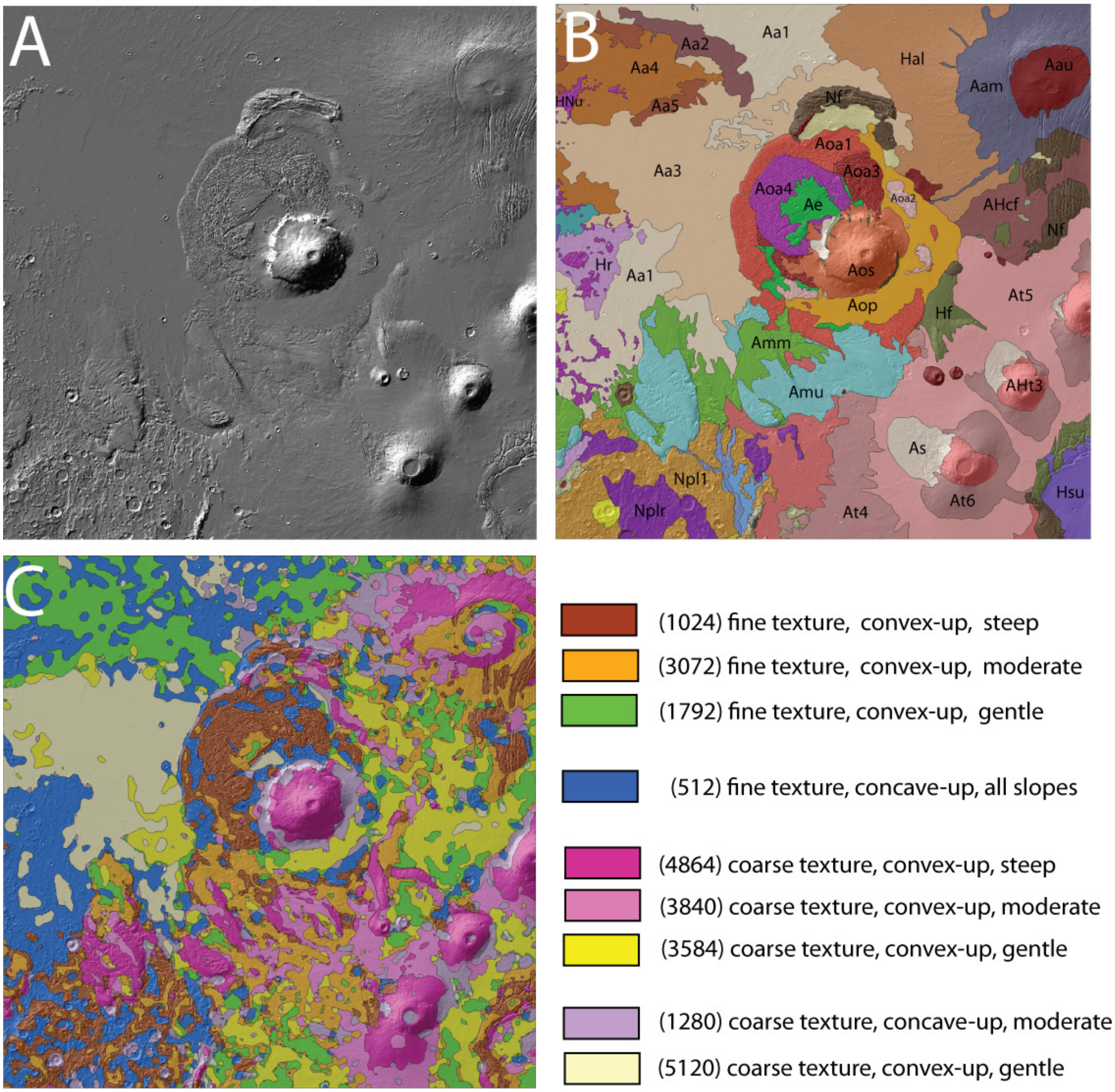

Figure 1. Mapping Tharsis region on Mars. (A) The 1024 x 1024 pixels raster shows shaded relief of the Tharsis region on Mars. (B) Geologic map of the Tharsis region. (C) The physiographic map of the Tharsis region auto-generated by our method. Different colors indicate 9 different terrain classes. The colors have no relation to the colors used by the geologic map. The legend of the 9 terrain classes lists (ID number), predominant texture, predominant convexity, and predominant slope gradient.

Our technique for an automatic creation of physiographic maps is not restricted to Mars; such maps can be generated for any surface for which digital elevation data with sufficient spatial resolution is available. This includes Earth, and will soon include the Moon and the planet Mercury.

References: [1] Smith D. et al. (2003) NASA Planetary Data System, MSG-M-MOLA-5-MEGDR-L3-V1.0 [2] Iwahashi, J., and R.J. Pike (2007) *Geomorphology*, 86, pp. 409-440 [3] Tilton, J.C. (2000) *Disclosure of Invention and New Technology: NASA Case Number GSC 14, 328-1* [4] J Scott, D. H., and K. L. Tanaka (1986) U.S.G.S. Geo. Inv. Series Map I-1802.