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Preliminary geomorphometric analysis of selected Martian scoria cone-like features using high-resolution DTMs

Fanni Vörös [a, *], Balázs Székely [b]

[a] *Doctoral School of Earth Sciences, ELTE Eötvös Loránd University, Pázmány P. sétány 1/C, H-1117 Budapest, Hungary, vorosfanni@map.elte.hu*

[b] *Department of Geophysics and Space Science, ELTE Eötvös Loránd University, Pázmány P. sétány 1/C, H-1117 Budapest, Hungary, balazs.szekely@ttk.elte.hu*

* Corresponding author

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Abstract:

Compared to Earth, the surface erosion activity of Mars is extremely low, so the age of the landscape is typically orders of magnitudes greater; it has attracted the interest since the beginning of space exploration. Because much of the planet's geological history left its traces on the surface and are still visible, Martian geomorphology may provide even deeper insight into the early evolution of the planet than it did in terrestrial geomorphology (Golombek & Bridges, 2000). These observations, as well as the fact that presumably most of the geological processes seen on Earth took place on Mars, the planet provides a great opportunity to study geomorphometric processes on a comparative basis. The morphometric techniques used for terrestrial cinder cones can be mostly applied to their extraterrestrial counterparts (Wood 1979, Brož et al., 2015), assuming the availability of higher resolution DTMs (Digital Terrain Models). With the development of technology, we get an increasingly accurate picture of the surface and geology of Mars (Mars Trek), so not only the physical appearance (proportions) of the forms on its surface can be examined, but this property can be grouped according to other aspects (e.g., age-shape or age-lithology). Such studies have been performed several times on terrestrial volcanic cones, but so far smaller-scale Martian cones do not abound in the same analysis. In the case of Martian scoria cones, the most examined parameters are cone height – cone width ratio, a crater width, crater depth, and slope (Brož et al., 2015, Brož & Hauber, 2011).

In our current project we also examined these parameters, but we focus here on detecting their (a)symmetry. The cones to be examined were selected based on the aforementioned publications; six scoria cones were designated from four different areas – Valles Marineris (three cones), Aetheria Region, Tharsis Region, and Pavonis Mons. Although DTMs are already available for certain areas of Mars, the available were unsuitable for detailed investigation for the studied areas. Thus, we used HiRISE stereo image pairs for processing. HiRISE (High-Resolution Imaging Science Experiment) is a high-resolution camera from the Mars Reconnaissance Orbiter spacecraft. Its 50-centimeter-diameter mirrored telescope is the largest camera mounted on the spacecraft, with which it can take images with a resolution of 30 cm from the orbit around Mars. Its sensor works in three bands, Blue-Green, Red, and Near Infrared (NIR). For the processing of these image pairs (creating DEMs, orthoprojected images, 3D models) NASA Ames Stereo Pipeline can be used supplemented with USGS (United States Geological Survey) ISIS data (because of non-terrestrial images). About the exact processing e.g. Tao et al., 2018 wrote. The result of the time- and machine-intensive processing is an approx. 30 cm resolution terrain model. The following stereo images were used: Valles Marineris (4) - *ESP_033986_1670* and *ESP_034131_1670*, Tharsis Region (1) - *PSP_008262_1855* and *ESP_0426652_1855*, Pavonis Mons - *PSP_002671_1790* and *ESP_011413_1790*, Aetheria Region (1) - *ESP_043896_2055* and *ESP_044885_2055*, Valles Marineris (5) - *ESP_033986_1670* and *ESP_034131_1670* and Valles Marineris (3) - *ESP_033986_1670* and *ESP_034131_1670*.

The easiest way to examine the symmetry of a roughly or in principle circularly symmetric geometric shape is to look at the radial distance from the assumed center of symmetry at a given distance. The polar coordinate transformation (PCT) (Székely & Karátson, 2004) is perfectly suitable for such calculations. The essence of the method is that it "spreads" the shapes originally depicted from above (in this case volcanoes) in the following way: in the original data set is in a Cartesian coordinate system. In contrast, in the polar coordinate system, the same points can be characterized by a distance from a given center (r [m]) and an azimuth angle (φ [°]). For this reason, it is important to determine the center of each scoria cone as accurately as possible, because in the polar coordinate system it will also be the reference point. In Figure 1, the PCT figures of the six scoria cones are presented the insets in the top left corner show their location on Mars and a 3D model of the cone is inserted in the top right corner for each cone. The three cones in the first column are each asymmetric in some way: cones in Valles Marineris (4) and Tharsis Region (1) have some kind of elongation in the north-west direction (in the PCT image ~ (–30°) – (–45°)). The one in Pavonis Mons area is a beautiful example of scoria cones with craters. The crater rim that collapsed in the western direction also easily recognizable in the PCT figure, at ca. –100°. In the second column, three symmetric cones are shown. This symmetry appears as a pattern relatively parallel to

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the azimuth axis. The advantage of this visualization technique is then evident: symmetric shapes appear like parallel features, whereas (non-circular) asymmetry is enhanced.

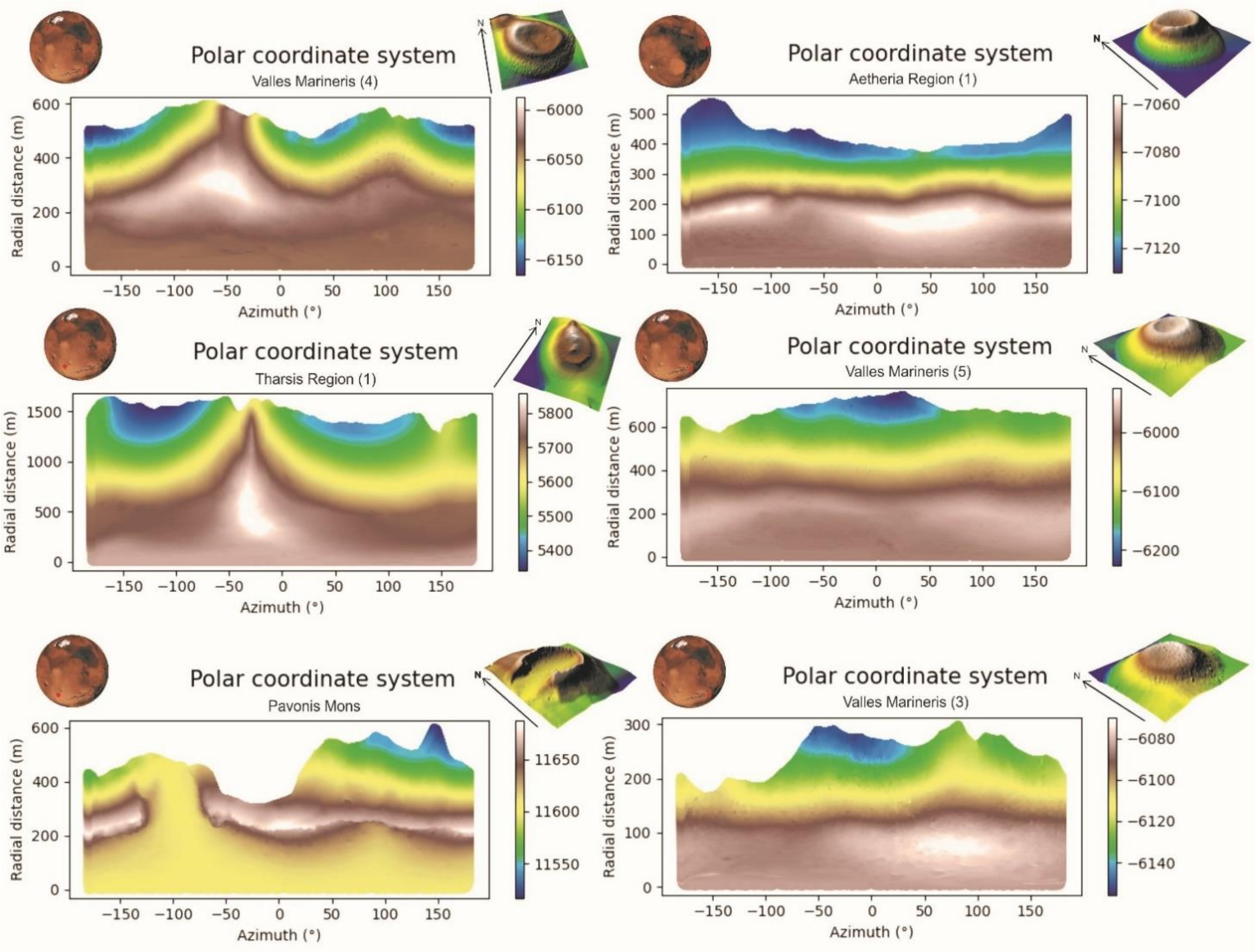

Figure 1. Polar coordinate transformation figures of the selected six cones.

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