BEST-FIT BIAXIAL ELLIPSOID SHAPE OF (4) VESTA, CRATER DETECTION FROM DIGITAL TOPOGRAPHY AND COMPARISON WITH MARTIAN, LUNAR AND MERCURIAN CRATERS.

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Summary: Based on the entire digital topography, the best-fit biaxial ellipsoid was determined. Using a crater detection algorithm (CDA), the catalogue with 8749 craters was created. Additionally, craters were compared with Martian, Lunar, and Mercurian craters.

Introduction: For Mars, the Moon, Phobos, Venus, Earth and Mercury, catalogues with 132843 [1], 78287 [2], 9224 [3], 345 [4], 24 [5] and 6622 [6] craters, respectively, have been developed. For Mars, the Moon and Mercury, in order to compare corresponding topographic-cross-profiles of craters, two conditions have been fulfilled: (1) the catalogues are complete enough; and (2) a digital topography is available in sufficient resolution. It was found that for Lunar craters depth/diameter ratio and height of a crater rim is approximately twice larger than for Martian craters [1], while an average Mercurian crater is shallower than an average Lunar crater, but less shallow than an average Martian crater of the same size [6]. Recently, Vestan topography has become available thanks to the Dawn mission [7]. This was an opportunity for this work, to: (1) compute the best-fit biaxial ellipsoid of Vesta; (2) use a CDA in order to detect craters from Vestan topography; (3) create the catalogue of these craters; and (4) compare their topographic-cross-profiles with Martian, Lunar and Mercurian craters.

Datasets and Methods: Datasets used and methods developed are as follows:

Vestan topography. The highest available resolution of 11521x23041 pixels has been used. According to the 250 km radius sphere, the lowest elevation is -38063 m and the highest elevation is 42823 m. The topography was resampled to 1/64° resolution (11520x23040 pixels). The Claudia Planetocentric coordinate system has been used (IAU longitudes increased with 210°, while latitudes are the same).

Determination of a best-fit biaxial ellipsoid: A biaxial ellipsoid was chosen as a shape model, instead of a general ellipsoid, based on an assumption that centrifugal force during protoplanet creation is the major cause of current Vesta's shape. An iterative approach has been developed, which increases/decreases major/minor ellipsoid axis, as long as the further optimization is possible. For the optimization criteria, it was chosen to minimize the deviations between absolute elevations and the surface of ellipsoid.

Crater detection algorithm. In the previous work, a topography-based CDA has been developed [8] and improved using a specially developed interpolation method [1]. This makes the CDA suitable for the detection of craters only a few pixels in diameter.

Manual verification of detections. Each crater-candidate proposed by the CDA was manually verified in order to ensure that each crater from the resulting catalogue has double confirmation that it is a crater indeed. False detections were deleted, while true detections were added to the catalogue. In the case of true detection, coordinates and radius have been additionally corrected within ±1 pixel accuracy.

Results: The preliminary results are as follows:

The best-fit biaxial ellipsoid: For the given resolution of ±1 meter, the determined best-fit biaxial ellipsoid is 278.624 km (equatorial radius, r_e) · 220.872 km (polar radius, r_p). These values are comparable to the best-fit general ellipsoid (285.3 · 277.7 · 223.8 km) and the biaxial ellipsoid (285 · 285 · 229 km), computed by the others [9].

Processed Vestan topography. The elevation values relative to the best-fit biaxial ellipsoid were computed, shown in Fig. 1. The lowest elevation is -17401 m and the highest elevation is 21626 m.

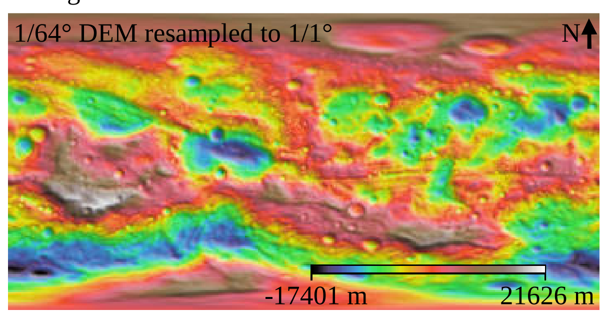

Figure 1: Processed Vestan topography.

Crater detections. The CDA from the previous work [8][1] successfully detects the craters from Vestan topography. The results are similar to the previous detections from diverse lunar and planetary bodies.

Assembled catalogue. The main phases of the work on the new catalogue of Vestan craters are shown in Fig. 2. A part of the resulting catalogue is shown in Fig. 3. It contains 8749 craters, and for craters larger than 4 km in diameter, it is mostly complete.

Topographic-cross-profiles. The CDA has been used in order to extract average topographic-cross-profiles, the 2D representations of 3D craters' shapes. Comparison with Martian, Lunar and Mercurian craters are shown in Fig. 4.

Conclusion: The flattening $(1-r_p/r_e)$ and eccentricity $(1-(r_p/r_e)^2)^{0.5}$ of Vesta are ~0.21 and ~0.61, respectively. The CDA from the previous work [8][1] can successfully detect and analyze craters using available Vestan topography. An average Martian, Lunar and Mercurian crater is shallower than an average Vestan crater of the same size. In the future work, the plan is to extend the catalogue with craters catalogued by others [10], in order to be even more complete.

References: [1] Salamunićcar G. et al. (2012) *Planet. and Space Sci.*, *60*, 236-247. [2] Salamunićcar G. et al. (accepted) *Adv. Space Res.*, 1-15, doi: 10.1016/j.asr.2013.06.024. [3] Salamunićcar G. et al. (accepted) *Adv. Space Res.*, 1-12, doi: 10.1016/j.asr.2013.11.006. [4] Salamunićcar G. and Lončarić S. (2012) *LPS XLIII*, Abstract #1159. [5] Salamunićcar G. and Lončarić S. (2012) *COSPAR 39*, Abstract #A3.1-0061-12. [6] Salamunićcar G. (2013) *LPS XLIV*, Abstract #1866. [7] Russell C. T. et al. (2012) *Science*, *336*, 684-686. [8] Salamunićcar G. and Lončarić S. (2010) *Trans. Geosci. Remote Sens.*, *48*, 2317-2329. [9] Preusker F. et al. (2014) *Vesta in the Light of Dawn: First Exploration of a Protoplanet in the Asteroid Belt*, Abstract #2027. [10] Marchi S. et al. (2012) *LPS XLIII*, Abstract #1617.

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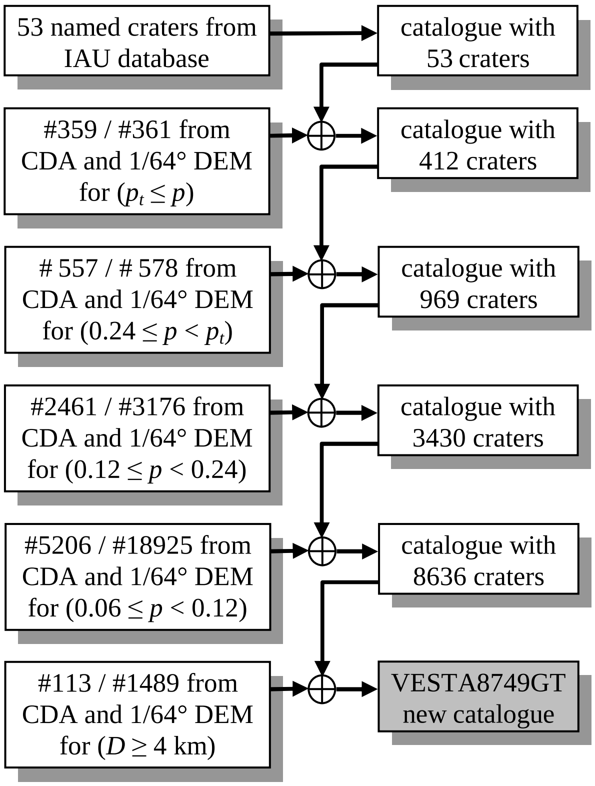

Figure 2: The main phases of the work on the new catalogue of Vestan craters (#*n* / #*m* means *m* candidates and *n* previously uncatalogued craters; p_t = 0.39068145 – the maximum of *Q* curve computed using the MA130301GT catalogue of Martian craters).

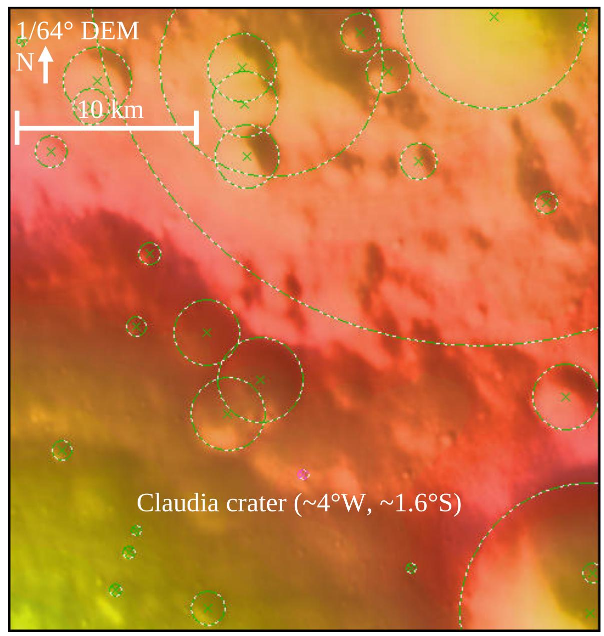

Figure 3: A part of the VESTA8749GT catalogue.

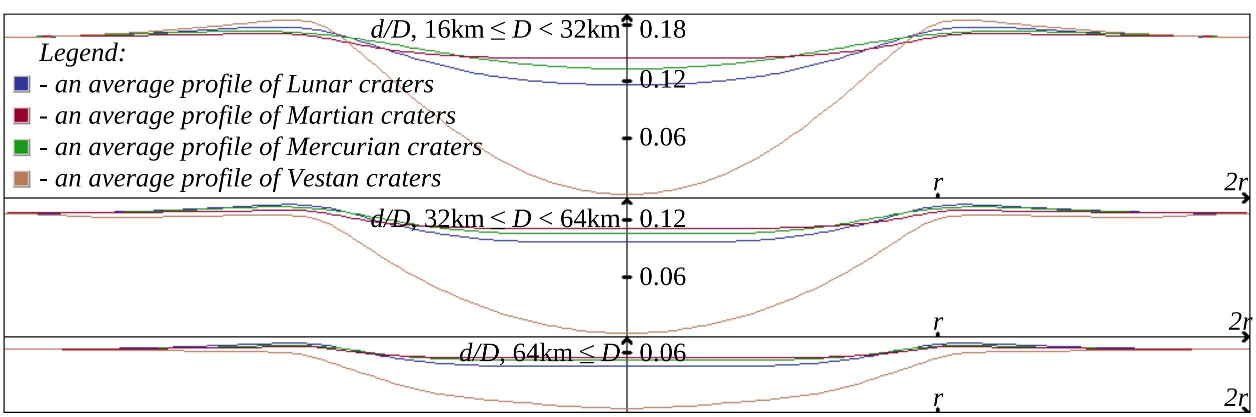

Figure 4: Average topographic-cross-profiles of Lunar, Martian, Mercurian and Vestan craters, for 3 groups regarding their diameter (16km ≤ *D* < 32km – top, 32km ≤ *D* < 64km – middle, 64km ≤ *D* – bottom).