SHAPE DISTRIBUTION OF FRESH MARTIAN IMPACT CRATERS FROM HIGH-RESOLUTION DEMs
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In this paper we present the shape distribution of fresh, simple martian impact craters (20 m < D < 5 km) using high-resolution digital elevation models (DEMs) derived from images acquired by the HiRISE camera on the Mars Reconnaissance Orbiter (MRO) [1]. In particular, we present the distribution of morphometric quantities used to characterize 3-D crater shape, measured from 62 crater DEMs generated using the NASA Ames Stereo Pipeline 2.0 (ASP) [2]. In this abstract we show the diameter-normalized variation of the crater rim in elevation and radius as a function of crater diameter. That is, we have measured how fresh crater rims depart from radial symmetry as a function of crater size.

Motivation. Previous studies have focused on the shape distribution of large craters (D > 1 km) using 2-D images or 3-D elevation models derived from stereo imagery and laser altimetry [3,4,5]. The present study examines fresh, simple impact craters, a subset of which belong to the range of crater sizes in which target strength variations can have a significant influence on crater shape. The goals of this work are to (a) help constrain models of crater formation by supplying the distribution of crater shapes that occur in nature; (b) illuminate the effects of different geological target materials on crater shape; (c) characterize the mean "initial" shape of small craters in order to estimate the effects of modification in a variety of martian surface environments.

Methods. The resolution of our DEMs is ~1 m/pixel for the smallest craters (D < 200 m), ranging up to ~20 m/pixel for the largest craters in this study (D = 5 km). Fresh craters were identified as having a maximum rim-to-floor depth (d) to rim-diameter (D) ratio exceeding 0.2 (i.e. $d_{max}/D > 0.2$). A subset of our ASP models were compared with publicly-released USGS DEMs generated using the SOCET SET software, finding comparable d/D ratios (agreement within 1 to 5%). Although the stereo correlation algorithm used by ASP does not find elevations for all positions on the crater flanks and cavity walls, crater rims are highly distinctive features that are easily recognized, so that high-fidelity elevation estimates are usually obtained for the entire rim circumference.

We measure the distribution of morphometric parameters to characterize the shape of crater walls, flanks, cavity- and rim planforms. The 3-D rim trace is obtained by finding the maximum elevation of radial elevation profiles. In this abstract we present the distribution of three properties of the 3-D rim trace: (a) the rim radial deviation, (b) the rim height deviation, and (c) the dominant harmonic of the rim planform.

The rim radial deviation (σ_R*) is defined as the standard deviation of the radius crater R (measured for all profile azimuths) normalized by the mean radius. Rim radial deviation measures the departure from radial symmetry, and is large for highly "polygonal" crater rim planforms. The rim-height deviation is a measure of the departure from a uniform rim elevation (a flat rim). The dominant planform harmonic (above n=1) is the largest harmonic in the Fourier decomposition of the rim planform (e.g., if the dominant harmonic is n = 4, the crater is primarily square-shaped) [6].

Results. The dependence of rim radial deviation on crater diameter is given by $\sigma_R^* \sim D^{-n}$ for n = 0.30 ± 0.03, and is plotted in Fig. 1. Crater rim outlines become more irregular (less circular) with decreasing size, and the dependence is not significantly different from what we have measured for a population of heavily modified craters. This inverse dependence is significantly shallower than was measured previously for fresh craters in 2-D imagery [7]. The dependence of rim height deviation on crater diameter is given by $\sigma_h^* \sim D^{-n}$ for n = 0.22 ± 0.03, and is plotted in Fig. 2. That is, the variation in rim height as a fraction of crater diameter increases with decreasing crater size. In populations of modified craters we find that the inverse correlation between σ_h and D is less pronounced.

Finally, the distribution of dominant harmonics is plotted in Fig. 3. As expected, most craters are dominated by the "elongation" n=2 harmonic, followed by decreasing numbers of craters dominated by harmonics of higher order until n=7, with the exception of n = 5 (pentagonal craters). Future work will characterize how variations in geological target materials influence the relative frequency with which craters of different shapes are formed, and how modification processes change this shape distribution.

References: [1] McEwen, A. et al., *Icarus* 2010; [2] Moratto, Z., et al., *LPSC 41*, 2010; [3] Robins, S & B. Hynek, *J. Geophys. Res.* 2012; [4] Stewart, S. & G. Valiant, *Meteor. & Planet. Sci. 2006;* [5] Garvin, J. et al., *Icarus* 2000; [6] Eppler et al., *GSA Bull.* 1983; [7] Watters & Zuber, *LPSC 40*, 2009.

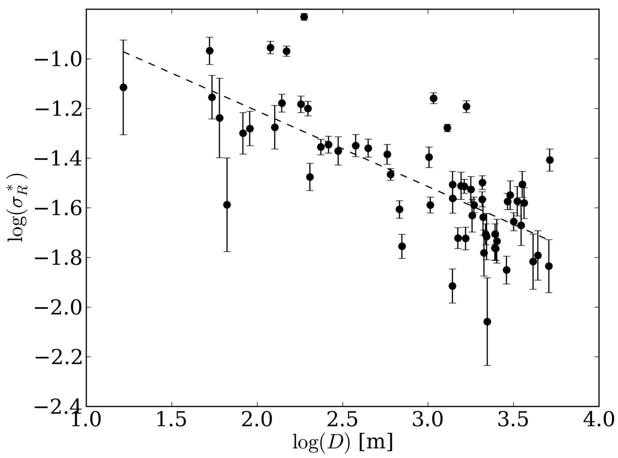

Fig. 1: Rim radial deviation versus crater diameter for 62 fresh martian impact craters: standard deviation of rim radius (normalized by mean crater radius) versus log D for crater diameter D measured in meters. We find that the variation in rim radius decreases with increasing crater size as: σR* ~ D-n for n = 0.30 ± 0.03. Error bars indicate grid resolution as a relative uncertainty in log(σR*).

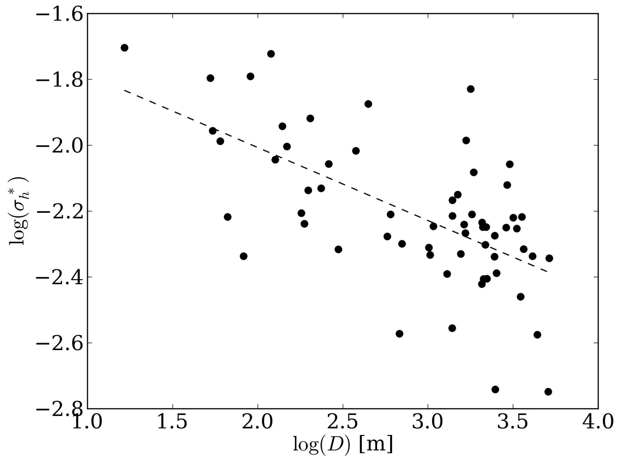

Fig. 2: Rim height deviation versus crater diameter for 62 fresh martian impact craters (dmax/D > 0.2): standard deviation of rim elevation (normalized by crater diameter) versus log D for crater diameter D measured in meters. We find that the variation in rim height decreases with increasing crater size as: σh* ~ D-n for n = 0.22 ± 0.03.

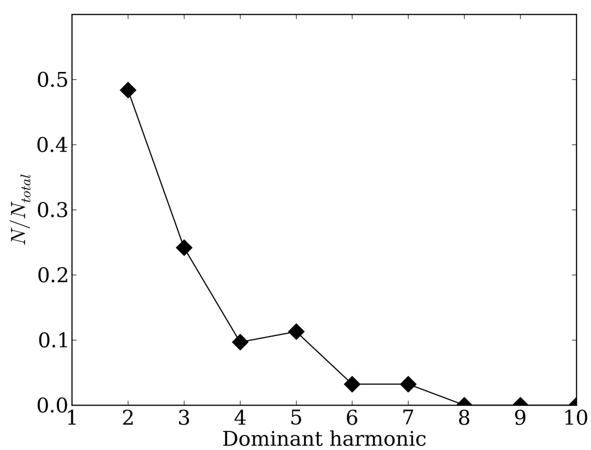

Fig. 3: Fraction N/N_{total} of craters dominated by harmonics n = 2 through n = 10 in the Fourier decomposition of crater rim planforms: e.g., about ten percent of craters are primarily square-shaped (N/N_{total} = 0.1 for n = 4; N_{total} = 62).