MORPHOMETRIC CHARACTERIZATION OF SMALL IMPACT CRATER MODIFICATION ON MARS

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Introduction: The present work forms part of an ongoing project to assemble a large database of morphometric parameters measured from simple impact craters on Mars [1-3]. These parameters characterize crater *shape* (as opposed to just depth/diameter) with the goal of identifying statistically significant regional differences and the signature of specific surface processes in different environments.

Crater database: Up to now, our work has focused on a database of approximately 7,500 simple primary craters with diameters between 500 m and the simple/complex transition (database A [1]), and a database of 1,300 globally-distributed craters (database B [3]). In the former case, craters were selected from stereo-pair CTX images in Amazonis Planitia, Terra Sabaea, and Sinai Planum. These regions were chosen to represent (a) young, relatively strong targets, (b) older, regolith-dominated surfaces, and (c) an intermediate case, respectively.

We are in the process of expanding this database to encompass over 35,000 simple craters from the Robbins and Hynek (2012) catalog [4] with a diameter between D ~ 1 km and the simple-complex transition diameter. These craters occur in over 100,000 cropped CTX-derived DEMs, implying that there are on average between 2 and 3 DEMs per crater. The use of multiple DEMs to extract morphometric parameter values will provide a useful estimate of the precision of our measurements. Approximately 2/3 of these occur between +/- 30° latitude: these low-latitude craters are the focus of this study.

To prepare these DEMs for morphometric analysis, it is necessary after cropping to locate the crater centers, owing to spatial offsets introduced in the stereo model production step. This is accomplished using a Hough transform of slope maps to identify circular features of approximately the cataloged crater size. As a quality control step, human operators are needed to confirm that the crater was correctly identified and to map the correct crater in cases where the program has misidentified.

As part of this work, we will assign qualitative attributes to each crater by visual inspection to identify additional factors relating to initial shape and modification. Several attributes, such as distinctive hallmarks of flooding by volcanic flows, significant modification by ice-related processes, and association with clusters of probable secondaries, will be used to remove craters that are not primary and not modified by dry, long-acting surface processes (e.g. wind, thermomechanical weathering, soil creep, and mass wasting).

DEMs: CTX stereo pairs were identified in accordance with the parameter limits described in [5], and were generated for image pairs containing the craters in our study using the Ames Stereo Pipeline [6]. DEMs were then post-processed according to the procedure outlined in [7].

Parameter measurements: Among the parameters we measure are "length scales of steepening" (a.k.a. "steepening lengths"), defined as the distances over which transitions in slope and curvature occur along radial topographic profiles of the upper and lower crater cavity. An automated process has been developed for finding the radial distance between points of interest (POIs) along elevation profiles extending from the center to 1.25R, where R is the azimuthally-averaged radius. These points include the point of Most Negative Curvature (MNC, identical to the topographic rim in well-preserved craters), and positions where fractions of the maximum radial slope are first reached while moving centerward or outward. Each "steepening length" is measured in non-overlapping radial profiles and averaged; the uncertainty of this mean value is estimated from the variation between profiles in a single crater. We characterize the modification sequence by finding the dependence of morphometric parameters such as steepening length upon (a) each other and (b) crater depth/diameter. An additional goal of this work is to estimate rates of modification by fitting diffusion-model profiles to measured radial profiles in consultation with crater number densities, as in [8].

Results: To date, our work suggests that morphometric parameters describing crater rims are largely decoupled from those describing cavity shape, as expected in the case where cavity evolution is dominated by sedimentary infill. An example of this is shown in Figure 1 for craters having D > 1 km in database A [9]. Clear relationships between cavity parameters, or relationships between parameters describing the rim, may be clearly expressed at a regional scale (assuming rates of sedimentation are approximately uniform). Such relationships are also likely to exhibit a dependence on crater size. An examination of the regional modification sequence, as characterized in this way, will be possible using the expanded database that is currently being assembled.

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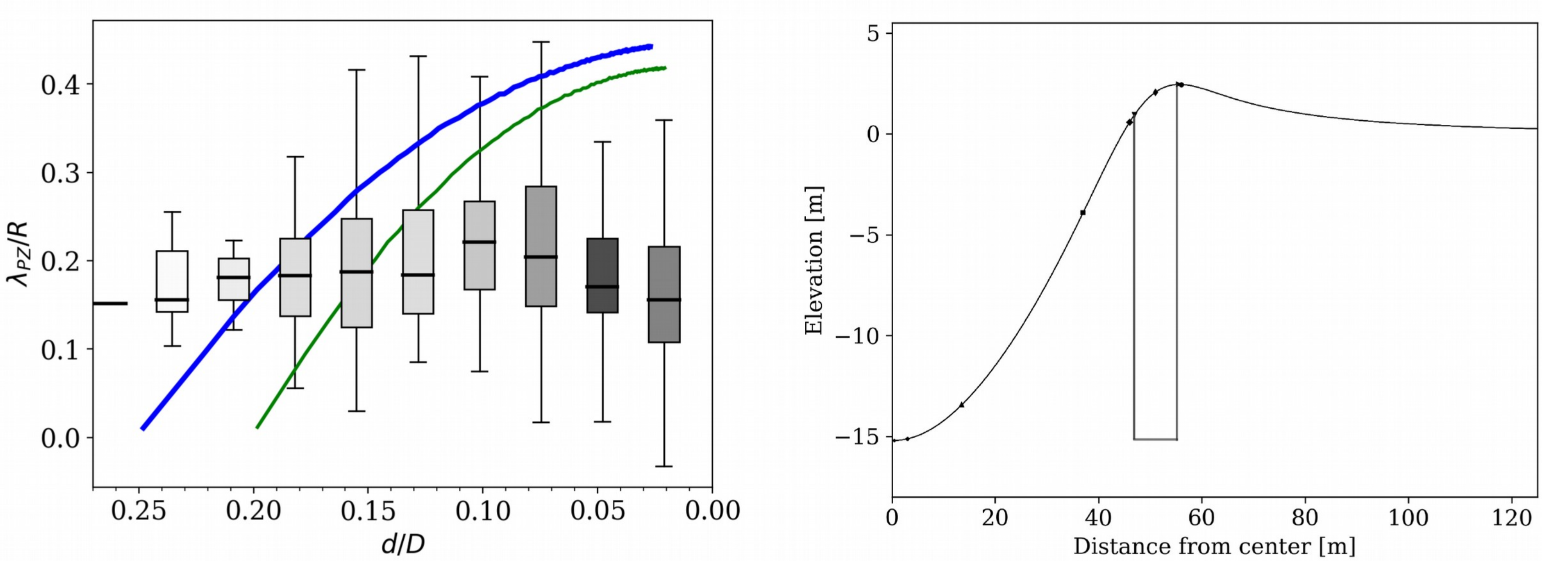

Figure 1: Left: Rim steepening length vs. rim-to-rim diameter / rim-to-floor depth for *N* = 506 craters in database A with D > 1 km. Blue and green curves show expected result for initially sharp-rimmed paraboloid craters whose evolution is driven by linear topographic diffusion (as expected for airless worlds like the Moon). Right: model profile illustrating the steepening length (the distance between the two vertical lines) plotted on the y axis at left, defined as the fractional radial distance between the position where wall slope decreases to 50% of its maximum value, to the rim (where it becomes 0). This is a measure of the rounding of crater rim walls. The box-whisker plot at left shows that crater rims are largely independent of cavity aspect ratio, as expected in the case where cavity evolution is dominated by sediment infilling [9].