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Post-impact Processes on Rhea: Analysis of Crater Modification from Topographic Data

Michelle Kirchoff (1), Betzaida Aponte-Hernandez (2), Edgard Rivera-Valentín (2), and Paul Schenk (2). (1) Southwest Research Institute, Boulder, CO, USA (kirchoff@boulder.swri.edu) (2) Lunar and Planetary Institute, Universities Space Research Association, Houston, TX, USA

Abstract

Better understanding of past surface modification processes experienced by Saturn's mid-sized moons, such as thermal episodes, infill, or impact-induced seismic shaking, is gained from analyzing crater diameters, depths, and wall slopes. We report on new such measurements on Rhea from topographic data and investigation of their relationships. We find a significant correlation of depth-to-diameter ratio with wall slope, which is most consistent with crustal heating and/or seismic shaking being the dominant post-impact processes on Rhea.

1. Introduction

Cassini ISS images have been used to create topographic maps of the saturnian satellites using photoclinometry, stereo, and shadow length [4]. Measurements of crater diameter (D), depth (d), and wall slope (α) using this data can improve our understanding of past heating events experienced by the mid-sized moons (MSMs) (e.g., [5]), along with other modification processes, such as infill (most likely by ejecta) or impact-induced seismic alteration [e.g., 2]. Studies on icy moons [e.g., 5] have found a smaller mean d/D value (~0.1) than computed for fresh lunar craters (~0.2) [e.g., 3], likely indicating either post-impact processes or differences in target mechanical properties. We expand on previous work [1] to gain new insight into the post-impact processes that have modified craters on Rhea.

2. Methods

Topographic maps are derived from Cassini ISS high resolution images at 0.18 km/pixel. Thus, the minimum crater examined is D~4 km (~20 pixels across) resulting in 744 craters analyzed (max D~110 km). We use tools in ISIS3 QVIEW to measure the D and d of each crater. Four profiles, separated by 90° in azimuth extended at least one crater radius in length, are extracted. For each profile, diameters are measured from rim to rim, and the depths from rim to lowest topographic point. A crater's D and d are then computed as the average of profile measurements. A crater's wall slope (α) is calculated by finding the least squares fit (LSF) slope (β) of the topography from the rim to crater floor, such that $\alpha = \tan^{-1}\beta$ with resulting error derived from the 90% confidence interval. Crater morphology for D<30 km craters is determined using both the topographic maps and high resolution Cassini ISS images.

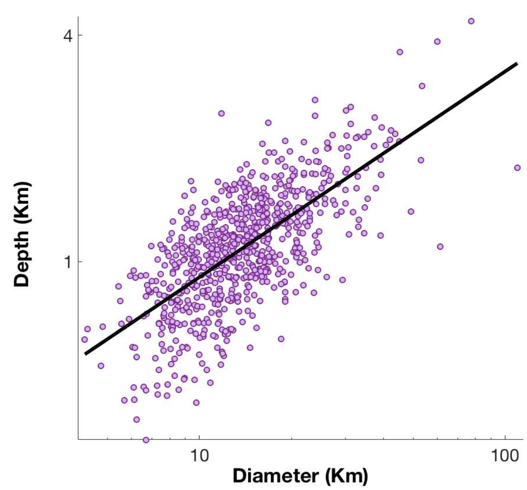

Figure 1: Log crater rim-to-rim diameters versus log rim-to-floor depths with LSF line.

3. Results

In Fig. 1 we plot each crater D and corresponding d. The LSF slope is 0.55 ± 0.04, statistically similar to the value found by [5] of 0.49 ± 0.02 (90% confidence using t test). Transitions in cratering regimes are not observed in our data; however, our min and max D are near the transition diameters for simple-to-complex (~4.5 km [5]) and complex-to-basin (~96 km [5]). Fig. 2 plots d/D vs. α, and the LSF indicates a linear correlation exists. Several craters, however, fall beyond the 90% confidence interval, suggesting these craters are likely affected by different processes than those following the general trend. Finally, Fig. 3 shows ratio of the number of simple to complex craters in 1 km bins with Poisson errors. An LSF fit to the data suggests a declining trend in the relative number of simple craters as diameter increases. However, simple craters do seem to occur up to D~20 km implying the transition occurs over a range. These results are in agreement with previous studies [e.g., 5].

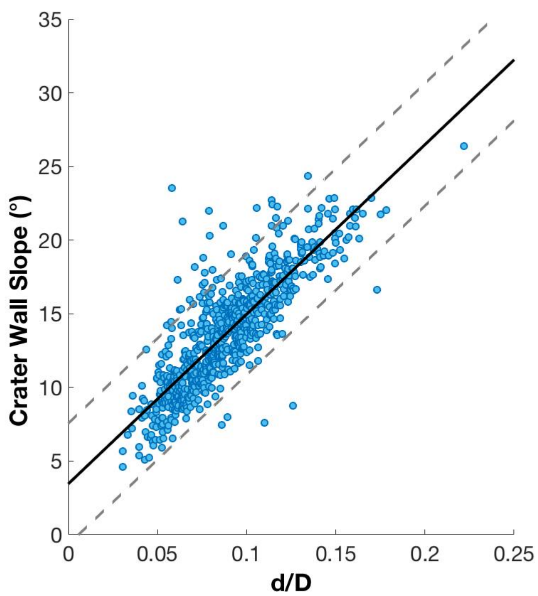

Figure 2: Depth-to-diameter ratio (d/D) versus wall slope with LSF line and 90% confidence intervals.

4. Implications for Post-impact Processes on Rhea

The d/D values appear significantly correlated with α (Fig. 2). Therefore, we suggest that post-impact processes, such as crustal heating or impact-induced seismic shaking, which nearly simultaneously relax a crater's d/D and α, are prevalent on Rhea. Crater infill, which changes d/D, but not α, may explain the craters that fall above 90% confidence interval. One suggestion for the craters that fall below the 90% interval, where α has been reduced more than d/D, is that something is different during the formation process, such as forming in a unique terrain.

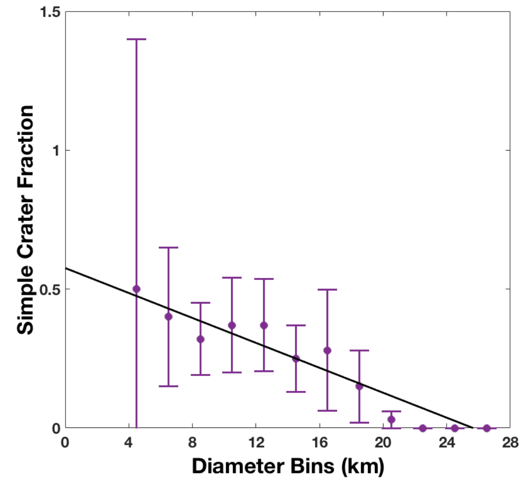

Figure 3: Ratio of the number of simple to complex craters in 1 km bins with Poisson errors and LSF line.

Acknowledgements

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