MORPHOMETRIC ANALYSES OF MARTIAN HIGHLAND IMPACT CRATERS;

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The mechanisms responsible for degrading highland impact craters on Mars have remained a long-standing mystery. Leighton et al. [1] recognized that martian craters are in widely different degrees of preservation, and it was presumed, ages. Based on historical and spacecraft observations of aeolian activity, Hartmann [2] suggested that loose crater ejecta had been removed and redistributed. Alternatively, Jones [3] and Chapman and Jones [4] suggested that water was the major erosive agent during an early martian crater obliteration event. Based on Viking data, Arvidson et al. [5] suggested volcanism as yet another possible process responsible for crater degradation. In recent years a number of other investigators have supported various aeolian mechanisms to explain martian crater degradation [6, 7, 8]. However, based on the range in crater morphology, the timing of degradation, and the estimated amount of erosion, we believe that only a combination of processes can explain the record of resurfacing evidenced by the highland craters [9, 10]. Because the geologic materials which contain degraded impact craters are the oldest exposed units on the planet, the morphology of these craters represents the results of the earliest processes operating on Mars. Obviously both aeolian and fluvial processes have occurred, but which process is principally responsible for martian highland crater degradation? The answer has importance for understanding the martian atmospheric and climatic history, the history of water and aeolian material on Mars, the nature of the highland units, and in assessing the possibility of life having developed on Mars. Because it appears that crater morphometry is highly dependent upon geologic unit [11, 12], we have constrained our initial analysis to dissected materials (Npld) in the Margaritifer Sinus region. Using radiometrically-calibrated (red filter), moderate resolution (~200 m/pixel) Viking orbiter images, we measured the morphometry of 264 fresh impact craters using the photoclinometric algorithm written for the Planetary Image Cartography System [13]. These measurements are important for establishing a basis for comparison with degraded impact craters. Although we have measured ~4 times the number of complex craters reported by Pike and Davis [14] and restricted the work to dissected highlands materials, our results fall within their 95% confidence interval (Figure 1). Measurements of 28 impact craters in various degrees of degradation are also presented. Depth to diameter ratios suggest that larger diameter craters are proportionally shallower than smaller diameter craters (Figure 2). The low correlation coefficient for the rim height versus diameter measurements ($r = 0.029$) is most likely due to the inclusion of craters with widely different states of preservation in the data set.

The most puzzling relationship defined by these preliminary analyses is that between depth and diameter for degraded impact craters (Figure 2). The depth-diameter relationship for degraded craters compared with that for fresh craters should either have (a) a parallel slope, which would be expected if the craters were uniformly modified by degradation operating independent of crater size, or (b) have a steeper slope, which would indicate that the smaller diameter craters were infilled faster than the larger diameter craters. However, the best-fit curve for degraded craters is shallower than that of fresh craters, which suggests that the larger diameter craters have been infilled to a greater extent than the smaller diameter craters, or were proportionally not as deep to begin with. This relation is probably a function of both size and age of the craters. Larger diameter craters require greater amounts of infilling to become eradicated. Future work will categorize degraded impact craters to distinguish trends in morphometric relationships and to better constrain the modes of crater modification.

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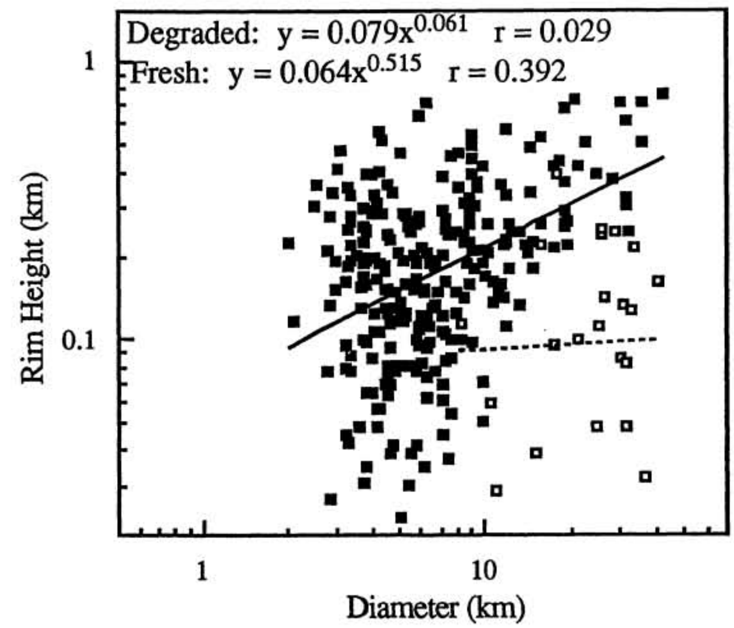

Figure 1. Height of rim above surrounding terrain as a function of crater diameter for 264 fresh impact craters (solid squares) and 28 degraded impact craters (open squares) in the Margaritifer Sinus region of Mars. Despite the low correlation coefficient (r), the equation for fresh crater rim heights (solid line) falls within the 95%-confidence interval defined by Pike and Davis [14]. (Note: This figure is at the same size and scale as Pike and Davis' [14] Figure 1 for ease in comparison.)

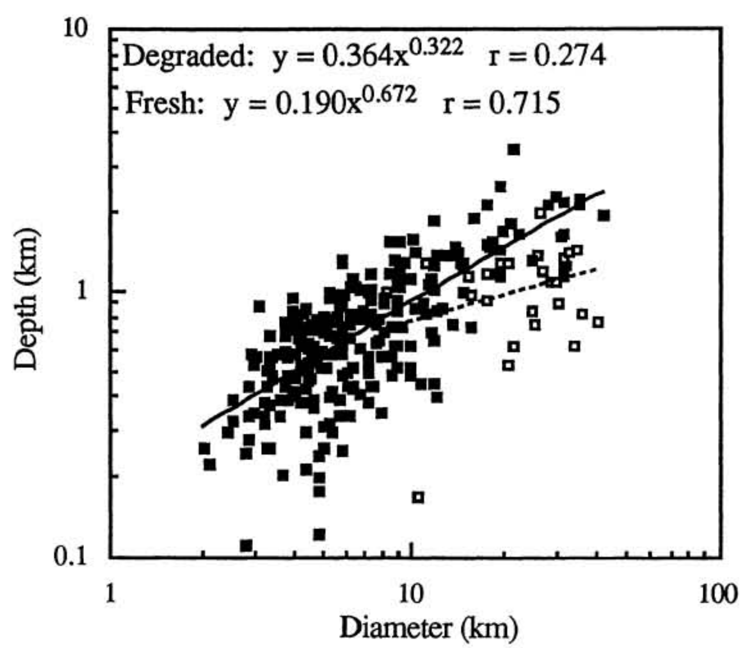

Figure 2. Depth of crater as a function of diameter. The equation defining degraded impact craters (dashed line) suggests that larger diameter craters have been infilled to a greater extent than the smaller diameter impact craters. The amount of infilling suggested by the degraded craters appears to be a complex function of both crater size and age.

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