PREDICTED EFFECTS OF SURFACE PROCESSES ON MARTIAN IMPACT CRATER DEPTH/DIAMETER RELATIONSHIPS: Joseph M Boyce, Peter Mouginis-Mark, and Harold Garbeil; all from Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI, 96822.

Introduction: In the past, most Mars crater morphology studies concentrated on the planimetric shape of the craters [e.g., 1 thru 7], but the acquisition of high quality topographic data from MOLA has allowed three-dimensional analysis of those craters [e.g., 8, 9]. One of the most useful morphologic parameters is the crater depth (d) and diameter (D) relationship. This parameter is sensitive to the effects of surface processes, and includes the largest dimensions of the craters and as such is least sensitive to measurement error. While individual MOLA profiles can provide accurate d/D measurements for individual small craters (sub-kilometer, in some cases), MOLA gridded DIM data provide the only practical means to determine d/D for whole populations of craters. However, because of the irregular spacing of the MOLA ground tracks, only the diameters of craters larger than about 5-6 km can be measured with reasonable accuracy. This size normally ensures both accurate morphologic measurements and enough craters to provide statistically meaningful values for analysis of morphologic trends in regional crater populations.

Although d/D has been used as an indicator of surface processes, a systematic discussion of how to interpret observed Martian crater d/D relationships in terms of the processes responsible for their modification has yet to be presented. In this abstract, we describe, in general terms, the characteristic of d/D relationships (where depth is measured from the crater rim to its floor {dr}, and the relief between the crater floor and the surrounding terrain {ds}) produced by different surface processes on Mars. It should be kept in mind that surface processes that modify crater shapes and produce characteristic changes to the d/D relationship on Mars fall under either gradation (erosion, transport, and deposition of surface materials by wind, water, gravity, impacts and ice) or volcanic processes [9, 10, 11, 12]. We will discuss each of the major processes and their predicted effects on the d/D of Martian craters.

Discussion: Erosion on Mars by wind, water, gravity, or impact craters (small impact erosion) generally results in decreases in the crater depth and rim height, while causing insignificant increases in crater diameter. Consequently, the d/D ratio of craters of any given crater size will decrease due to the effects of erosion, with the magnitude of the decrease inversely proportional to crater diameter (i.e., small craters shallow more rapidly than large craters) and directly proportional to erosion rates. As a result, erosion by these agents will steepen d/D distribution curves and produce a range in the distribution of depths with the smallest craters showing the greatest spread in depths. Changes to the rate of erosion and/or crater production (generally assumed to be constant after about 3.8 billion years ago) will be expressed as non-uniformity in distribution of the range of crater depth (for a given diameter) in the d/D plots. For example, episodically and significantly fluctuations in the rate of erosion (e.g., such as times of dramatic climate change) should produce gaps or concentrations of data on d/D plots along lines whose slopes are related to age of the fluctuations.

In areas where subsurface ice is abundant, viscous creep can be an important process in modifying the shapes of craters [13]. Because relaxation time decreases as crater diameter increases and increases as viscosity decreases, materials in the rims of large craters will creep proportionally faster than in small craters and the topography of craters in ice-rich materials will soften faster than in craters in dry rock [14]. As a result, the slope of the d/D curve for crater populations in areas that contain abundant subsurface ice will decrease and the range of depth of large craters will increase as creep occurs.

Partial burial of a crater population blanketed by regional scale volcanic or sedimentary deposits produce unique and diagnostic changes to d/D relationships. For example, deposits produced by volcanic flooding or settlement of sediment from the air or standing water generally form a plain having the same elevation inside and outside the craters. Craters with rims lower than the thickness of the deposit will be completely buried, while craters whose rims are higher than its thickness will protrude above the surface of the deposit. As a result, the depth of craters measured relative to the height of their rims (dr) typically increases with increased diameter but are shallower by the thickness of the deposit. In contrast, the depth of craters as measured relative to the surrounding terrain will be zero, independent of diameter, because the surface of the deposit is about the same elevation (at least initially) both inside and outside of the crater. In addition, compaction or deflation of such deposits often occurs soon after emplacement. This will result in the formation of ghost craters (faint topographic outlines of the buried craters whose rims were nearly as high as the thickness of the deposit).

Target material properties can also have a significant effect on the d/D of craters. In d/D plots, significant effects of target material properties can be identified for an area by comparing the d/D of fresh craters in that area with the fresh crater curve [15] for that range of latitudes. If they are essentially the same then it is likely that target materials in that area behave similarly to those of the globally average on Mars. It is also essential that high-resolution images be used to examine the fresh craters in the study areas to determine if they have been affected by younger geologic events [16, 17].

Conclusions: Mars has had a dynamic geologic history involving surface processes that effect impact crater morphology in predictable ways. This abstract has outlined some of those and how to interpret d/D relationship in order to detect major types of surface processes. This information can be used as a basis for interpretation of d/D data and provide valuable information about the geologic history of Mars.

References:

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