DEPTH TO DIAMETER RELATIONSHIPS OF PRISTINE MARTIAN COMPLEX IMPACT CRATERS: IMPLICATIONS TO CRATER MECHANICS, SURFACE PROPOERTIES AND SURFACE PROCESS STUDIES. Joseph M. Boyce, and Harold Garbeil, Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI. 96822, jboyce@higp.hawaii.edu

Introduction: The goal of this study is to accurately establish the final, post-formation depth (d_r) to diameter (D) function of complex Martian impact craters. Establishment of this function is important because it is a standard for comparisons with d_r/D of more degraded craters. Such comparisons are critical for studies that use crater morphology, for example, to determine the rate and amount of surface degradation, or in crater mechanics studies that use ejecta volume to crater cavity volume comparisons, or to determine the spatial distributions that target strength units and has on their absolute strength values.

Previous studies of Martian crater morphology typically estimated this function empirically by fitting a curve through populations of fresh impact craters [1, 2, 3, 4, 5]. However, we hold that this method is a relatively inaccurate estimator of that function because the craters used are modified from pristine crater shapes and as a result, the method is inadequate for quantitative studies that rely on d_r/D as a measure of crater shape. In addition, some studies have attempted to estimate this function from (and for) regional crater populations, but these populations are too small to produce statistically reliable results (e.g., < 1 fresh crater per 10^6 km^2 > 12 km diameter [6] is expected, far too few for this method). Moreover, regional differences in target material properties can significantly effect the determination of this function (if undetected or ignored), because of the shift in size they cause in the transition diameter between strength and gravity controlled regimes. Finally, this approach is also sensitive to graphical manipulations such as binning characteristics, sample size, and definition of fresh craters. Any of these can significant affect determination of the value of the d_r/D functions.

In an effort to estimate the most accurate d_r/D function as possible and address the above weaknesses, we propose an empirical approach that uses only the most pristine craters (i.e., defined here as craters that typically have well-developed small-scale primary impact features such as secondary crater fields, few superposed craters, and the greatest depth for their size compared with other similar size craters) in our global database (d_r/D data from our 5184 craters database from MOLA shot and DEM data). We use pristine craters in the 7-55 km diameter range to construct a best-fit curve through their d_r/D values. THEMIS, MOC and Viking images were also employed to verify the morphologic classification and degradation state of these craters, however, the large, pristine craters located in the high-latitudes are mantled with a thin deposit [7]. This deposit appears to have had little effect on their depths. To simplify analysis we have excluded craters in Isidis and southern Utopia Planitia because previous mapping [1, 2, 3, 4, 5] has shown these regions contain anomalously deep crater populations. In addition, to aid in detection of other unidentified regions of anomalous target materials, and more accurately estimate the dr/D function, the data have been separated into two groups, i.e., craters with diameters between 7 - 12.99 km (1956 craters) where strength effects are most probable, and craters with diameters between 13 - 55 km (1898 craters) where gravity effects dominate. The bins increase logarithmically in diameter.

Results: The d_r/D of the pristine craters (as defined above) are plotted in Figure 1. These are the basis for our calculation of the approximate final, post-formation d_r/D function for Martian complex craters. The equation of the best-fit line through the pristine complex craters in the 13 - 55 km crater diameter range is $d_r = 376\ D^{0.51}$ ($r^2 = 0.96$), and for 7 - 12.99 km diameter craters it is $d_r = 348\ D^{0.58}$ ($r^2 = 0.62$), while both combined is $d_r = 436\ D^{0.47}$ ($r^2 = 0.95$). Error bars (~ 8-10%) are included and based on measurement error analysis of d_r. The r^2 values indicate that there is little dispersion of the data around these lines suggesting a strong correlation between depth and diameter, especially for large pristine craters. Furthermore, this also suggests little affect from other factors such as target properties or differing amounts of degradation produced by the post-formation operation of surface processes.

To compare these results with those produced using previous approaches we have identified the 3 deepest fresh craters (plus the pristine craters) that fall into the same bin as the pristine craters. These craters are also plotted in Figure 2. The best-fit curve is determined for these points, as well as the d_r/D function and shows that the d_r/D function of fresh craters generally has smaller constants and exponents than the d_r/D function for pristine craters and higher r^2 values. In the size range 7-12.99 km diameter the fresh crater d_r/D function is $d_r = 412\ D^{0.42}$ ($r^2 = 0.37$), and in the 13 - 55 km size range it is $d_r = 321\ D^{0.50}$ ($r^2 = 0.76$), while both combined is $d_r = 382\ D^{0.44}$ ($r^2 = 0.83$). This is not surprising because, by definition, the fresh craters are shallower than pristine craters of the same size so their inclusion insures lower d_r values, as well as a greater dispersion.

The locations of the pristine and fresh craters are plotted in Figure 2. We see the large pristine craters are found throughout the test regions and are approximately randomly distributed (R = ~ 1.18), whereas the smaller size pristine and fresh craters cluster in a few locations (e.g., southern edge of Acidalia/Chryse Planitia, and in the highlands on the southern edge of Isidis basin). This suggests abnormally strong target materials in these cluster regions, which is consistent with previous findings [1, 2, 3, 4]. However, the global scattering of both pristine and fresh craters also suggests the target materials in most regions have nearly the same strength, which indicates that the megaregolith in the Noachian highlands has nearly the same strength as in the younger, less cratered terrain types elsewhere. This unexpected strength of Noachian-age highlands rock may be a result of cementation due to percolation of groundwater through these rocks.

Finally, a comparison of the predicted crater depths based on the dr/D function determined here and those based on fresh craters indicates significantly different initial depths for a given crater size (e.g., a fresh crater 10 km diameter is ~ 200 m shallower than a pristine crater). This means that past studies that use changes in crater depth from the initial depth have significantly underestimated topographic changes since crater formation.

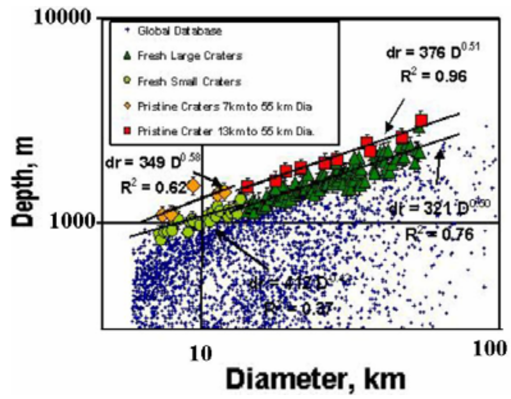

Figure 1

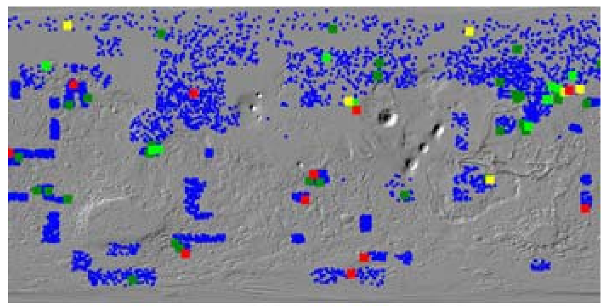

Figure 2

Figure 2. Map of the location of the 5189 craters included in this study. Craters types are color coded consistent with those in Figure 1.

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