Depth and Diameter Relationships of Terrestrial Planet Impact Craters and their Implications to Gravity Scaling: Joseph M. Boyce, Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, Hawaii, 96822, jboyce@higp.hawaii.edu.

We have attempted to estimate the final, post-formation d_r/D function for craters on each of the terrestrial planets using the approach of [1]. In previous studies the "fresh" crater d_r/D function for crater populations was often used as a proxy for this function determined using an empirical approach that fit a curve to an arbitrarily defined population of fresh impact craters. However, the total number of fresh craters and their depth range were chosen independently by each investigator, and as a result varied from study to study [e.g., 2, 3, 4, 5, 6]. Further complicating the issue, the simple/complex crater transition can vary broadly from place to place on the planets [1, 5, 6], consequently, the inadvertent inclusion of craters in this transition when calculating the different segments of the curve affects the slope of their curves. Moreover, the affects of other processes on the morphology of craters larger than ~ 50 km that operate on some planets but not others can also affects crater shape [7].

To address these problems, [1] used only the deepest and morphologically freshest Martian craters to define the global final, post-formation d_r/D function for craters in the diameter range of from 6 – 50 km (binned in geometrically increasing-diameter sizes). They found (consistent with the findings of [5, 6]) that this function was different for the deepest, freshest craters above and below ~ 12 km diameter (well into the complex crater diameter range), and that there is much more uncertainty (i.e., r^2 of the best fit curve) in the function determined for smaller craters because of scatter in the data. [1] found that the function that describes craters > 12 km diameter is $d_r = 0.381\ D^{0.52}$ ($r^2 = 0.98$) (Figure 1). They suggested that the high r^2 value indicates a strong correlation between the two variables, and that other factors such as target properties or gradational processes, have had little effect on crater geometry.

To compare results obtained using this approach with those using the old method, they identified the 4 next deepest fresh craters in each bin and calculated the best-fit fresh crater function and r^2 using progressively 2, 3, 4 and 5 of the freshest craters in each bin. They found that 1) the constant in the function decreased with increasing number of fresh crater/bin (from 0.363, 0.356, 0.333, and 0.315, respectively), 2) the r^2 of each function increased from 0.82 for 5 craters to 0.98 for 1 craters in each bin, and 3) the exponent of the function (i.e., slope of the curve) was nearly constant at ~ 0.52 +/-0.004. They suggested that these relationships indicate use of the old method would result in significant underestimation of the final, post formation depth of craters, and hence conditions that control this parameter.

In addition, [1, 2, 5, 6] found that the deep, fresh craters < 12 km diameter tend to cluster in distinct areas on Mars (such as southern Utopia and Isidis Planitia), while the larger deepest, fresh craters are randomly distributed globally (e.g., the nearest neighbor statistic, R = 1.18 for large pristine crater). We interpret these relationships to indicate that complex craters > 12 km diameter on Mars form with approximately the same d_r/D relationships and as a result suggest that they are insensitive to such variables as target material properties (e.g. strength).

In this study, this method has been applied to the published d_r and D data for the terrestrial planets [1, 8, 9, 10, 11, 12, 13, 14, 15] as well as new d_r/D data for deep crater on the Moon collected using 1:250 M Lunar topographic Orthophoto maps (LTO). While published tabulated d_r/D data were used, where only graphed data were available the DATATHIEF program was employed, or where the data are so densely packed on a graph that they are individually indiscernible the best fit curve was estimated visually. Using the results from this step, the d_r/D functions for both simple and complex craters were calculated for each terrestrial planet (see for example Figure 2). In addition these functions are determined for crater populations well above or below the simple/complex crater transition size in order to avoid the affects of strength and other factors around the transition diameter. As was done by [11], the intersections of the simple and complex crater functions for the deepest, freshest craters are calculated for each planet and compared with the acceleration of gravity (g) for each of the respective planets. This function is plotted in Figure 3 and shows an inverse relationship between the transition diameter and gravity described by $D_{transition} = 199\ g^{-0.60}$ ($r^2 = 0.98$).

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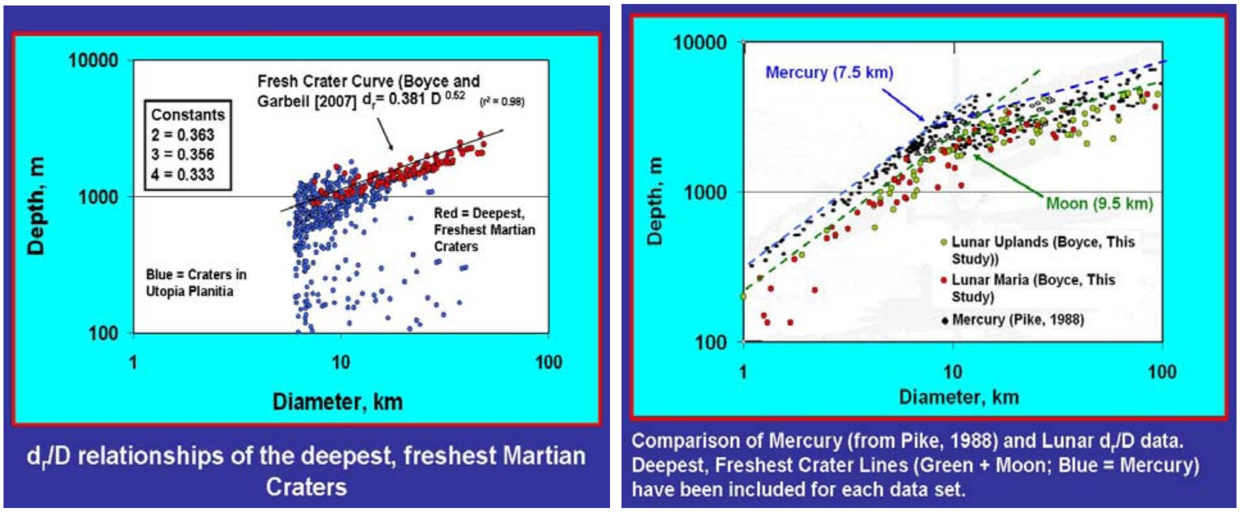

Figure 1. On the left, is a scatter diagram showing d_r/D of the 5 deepest Martian craters (red) > 12 km diameter with craters in the S. Utopia and Isidis Planitia region included (blue). Figure 2, on the right, is a scatter diagram showing d_r/D of deep, fresh Lunar (red and green) and Mercury (black) craters. The best-fit curves are included for the deepest, fresh craters in each size bin.

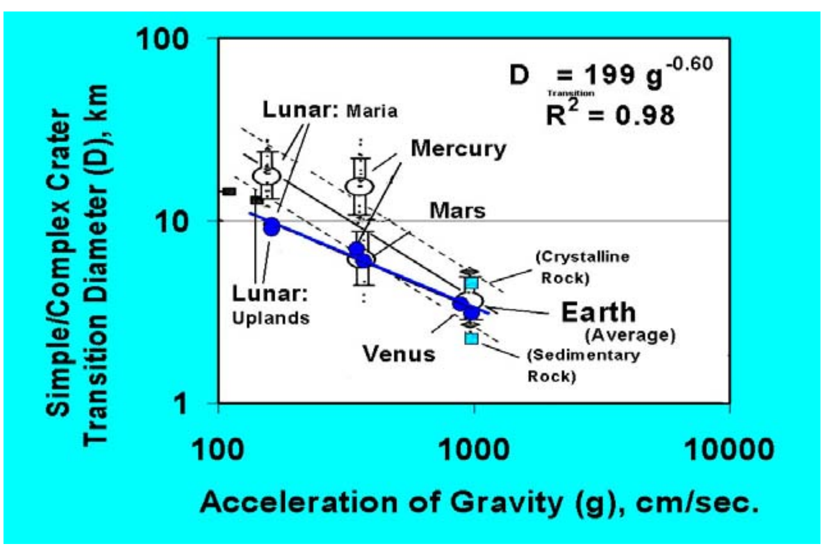

Figure 2. Plots of the simple/complex crater transition for each of the terrestrial planets verses the acceleration of the gravity of those bodies. Data symbols in black are from [11], and data in blue are from this study using the new method for calculation of the simple/complex transition.