ON THE SHAPES AND DIMESIONS OF BRIGHT HALO CRATERS ON THE LUNAR MARIA

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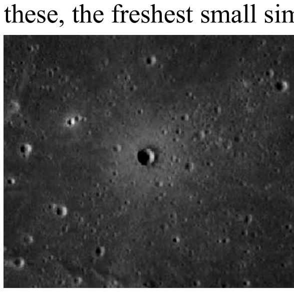
Introduction: Among the millions of impact craters on the Moon there exists a population of small, simple craters distinguished by halos of bright, unweathered ejecta (Fig.1). These craters usually also feature well-defined, unaltered rims and ejecta features (e.g. striations, "herringbone" patterns), blocky ejecta, and a marked scarcity of subsequent, smaller cratering (Fig.2). These features mark these craters as some of the very 'freshest', least-altered craters on the Moon, and their bright ejecta, in particular, also makes them relatively easy to identify, even in large scale (low resolution) imagery. As some of the youngest craters on the Moon, these "bright halo craters" ("BHCs") represent a sub-population of craters in nearly pristine condition, and therefore a baseline for studying the post-impact evolution of the entire lunar simple crater population.

Previous work suggests that these craters are generally both considerably deeper, and closer to parabolic than the vast majority of small simple craters on the Moon [1], characteristics which distinguish them from the far more numerous older and more altered craters. The purpose of this work is to determine the shapes of as many lunar BHCs (D = ~500-7000 m) as possible and use them to develop a shape model for these, the freshest small simple craters on the Moon.



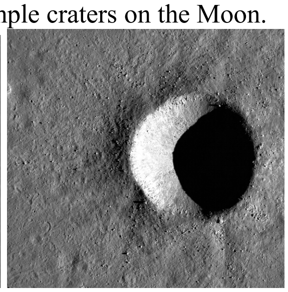


Fig.1 (left): A BHC included in this project. Fig.2 (right): Note the sharp rim, well-defined ejecta features, and blocky ejecta blanket.

Methods: In this work I am using the free shadowfront method (FSM) to determine the craters' shapes [1,2] (other methods lack sufficient coverage and/or are prohitively time consuming for use here). This method uses the length and shape of the shadow within a crater to determine the depth and eccentricity (e) of an approximating conic section (usually a hyperbola). I used the Lunar Orbital Data Explorer (LODE - http://ode.rsl.wustl.edu/moon/) to scan several lunar Mares for BHCs, and used LODE's search capabilities to locate any associated, appropriate Lunar Reconnaissance Orbiter (LRO) narrow angle camera (NAC) imagery of these craters. For an image to be useful, the crater must contain a reasonably smooth, elliptical shadowfront (solar incidence angle (i) between 67° and 83°) whose tip falls within the middle third of the crater (Fig.2), and the 'look angle' must be within 4° of vertical [2].

Results: Ultimately, 65 apparent BHCs were measured using the FSM (Fig.3). Plotting the results on e vs. d/D axes (Fig.4) shows that the preponderance of BHCs are both deeper than d/D = 0.2 and with $1.3 < e < 2.0$, all consistent with the results of [1]. Further examination of craters outside of these limits revealed that at least three of them are not in fact BHCs (Fig.4). The "bright halos" around two of them are due to topographic/illumination effects, while the third is draped by ejecta from a smaller, much younger crater near its rim (Fig.5).

Plotting the remaining 62 BHCs on d vs. D axes (Fig.5) and applying least squares yields the approximate linear relationship between depth and diameter for lunar BHCs:

$$d = 0.254D - 19.9$$

Not unexpectedly, the eccentricity of the BHCs is not as closely related to their diameters as the depth (Fig.7). However certain general limits may be observed. For all diameters, BHCs have eccentricities greater than ~1.3 - thus they are all hyperbolic, not parabolic. For diameters less than about 3.5 km, e averages 1.83 with limits of about $1.3 < e < 2.4$ and standard deviation of σ = 0.26. For larger ones the limits are much more restricted: $1.3 < e < 1.8$. This difference may reflect the different (more rapid) alteration of smaller craters' shapes versus larger ones due to macroscale processes, as opposed to similar rates of surface darkening to their bright halos due to space weathering.

Conclusions: This work begins the process of formulating a better model for the shapes of simple craters on the Moon. Collection of additional BHCs will be ongoing and will be used to refine this model as further results come in. The results used herein may be used to make good estimates of the depths and shapes of certain craters given only the presence of a bright "halo" of ejecta. Continuing work will be addressing the shapes and dimensions of more ordinary simple craters and of secondaries. The results for BHCs should serve as a useful baseline for comparison in this ongoing work.

References: [1]Chappelow (2015), 46th LPSC, abst #1079. [2]Chappelow (2013), *MAPS*, 48, 1863-1872.

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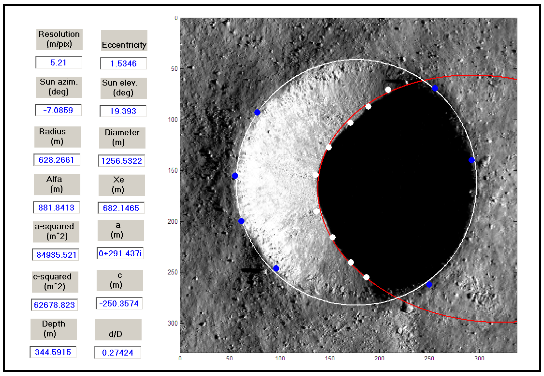


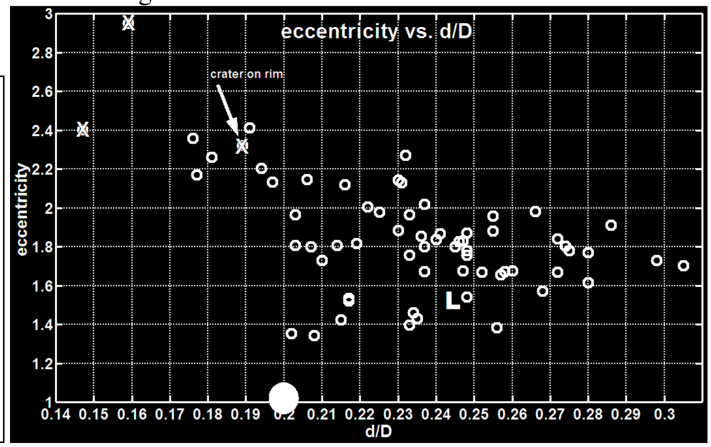
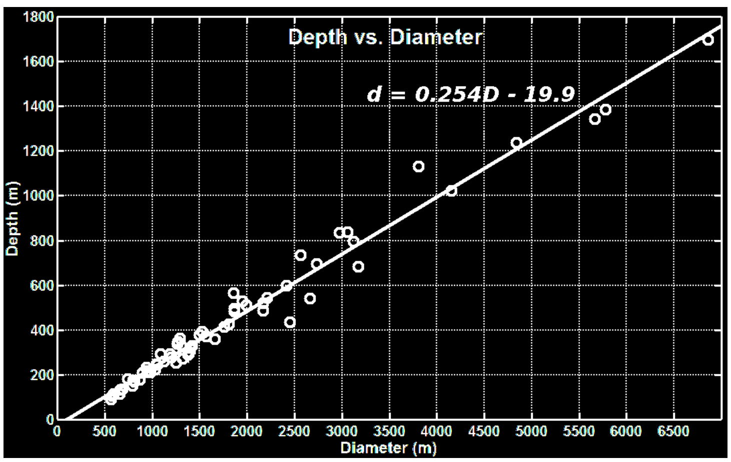


Fig.3 (left): A typical output screen from the FSM program. Note the excursion between the shadowfront and the shadowfront ellipse, due to a slide within the crater. Fig.4 (right): The BHCs plotted on *e* vs. *d*/*D* axes. Linne crater is marked 'L', and the current model for 'bowl-shaped craters' is the blob at bottom. The **X**-ed out craters at upper left and one indicated by arrow were found not to be BHCs but common simple craters disguised as BHCs by topographic effects or later ejecta drapage (Fig.6).



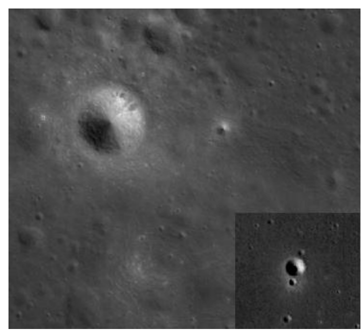


Fig.5 (left): Least squares line fitted to plot of BHCs depth vs. diameter. Fig.6 (right): Two 'outliers' in the data which were re-examined based on their unusual (for BHCs) values of *e* and *d*/*D*. Topographic and illumination effects created the illusion of a bright halo in one case, while in another case (inset) an adjacent smaller crater had mantled it with fresh ejecta.

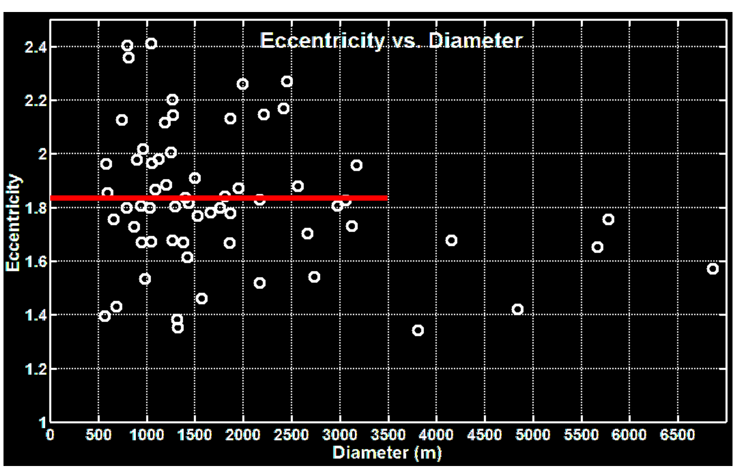


Fig.7: Plot of e vs. D. The average *e* for BHCs smaller than *D* = 3.5 km is indicated in red.