Cavity shape of large lunar impact features. Charles J. Byrne, Image Again**,** 39 Brandywine Way, Middletown, NJ 07748, charles.byrne@verizon.net.

Introduction: The shape of the apparent crater of an impact feature is sometimes described as a paraboloid. The radial profiles of several large lunar impact features have been examined and they are found to be better approximated with a negative cosine curve [1, 2, 3].

Alternate models of cavities: The radial profile of a paraboloid, normalized in both radius and diameter, is:

$$Z = -1 + R\text{^}2$$

where *Z* is the depth of the cavity, normalized on the *true depth* [4] at the center (assuming no central peak, as is the case with the features reported here). *R* is the radius, normalized on half the *apparent diameter* [4] of the cavity (measured at the intercept of the apparent crater with the target surface).

The radial profile of a negative cosine is given by:

$$Z = -Cos(2 \cdot R/\pi)$$

where *Z* and *R* are normalized as above.

The two models are compared in Figure 1.

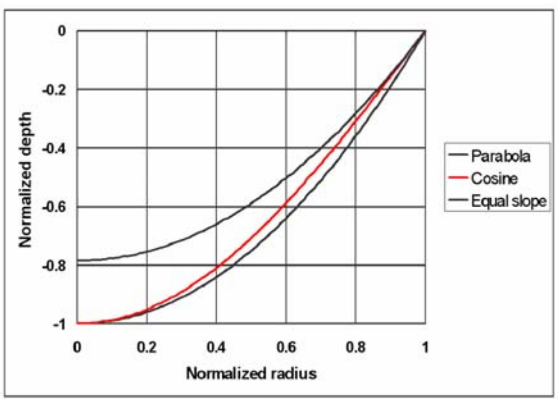

Figure 1: The negative cosine curve compared with a parabola.

The difference between the two models is small if they are each normalized in both radius and depth. However, if only the slope near the rim can be measured, fitting a parabola to that slope will result in an underestimate of the true depth by 21%. This slope is the best available measure of true depth when there is subsequent fill by mare or ejecta from nearby features. Therefore, this difference is important.

Figure 2 shows how well the negative cosine fits the cavity of impact features when the cavity is well-exposed, has no internal rings, and has little fill by mare or ejecta.

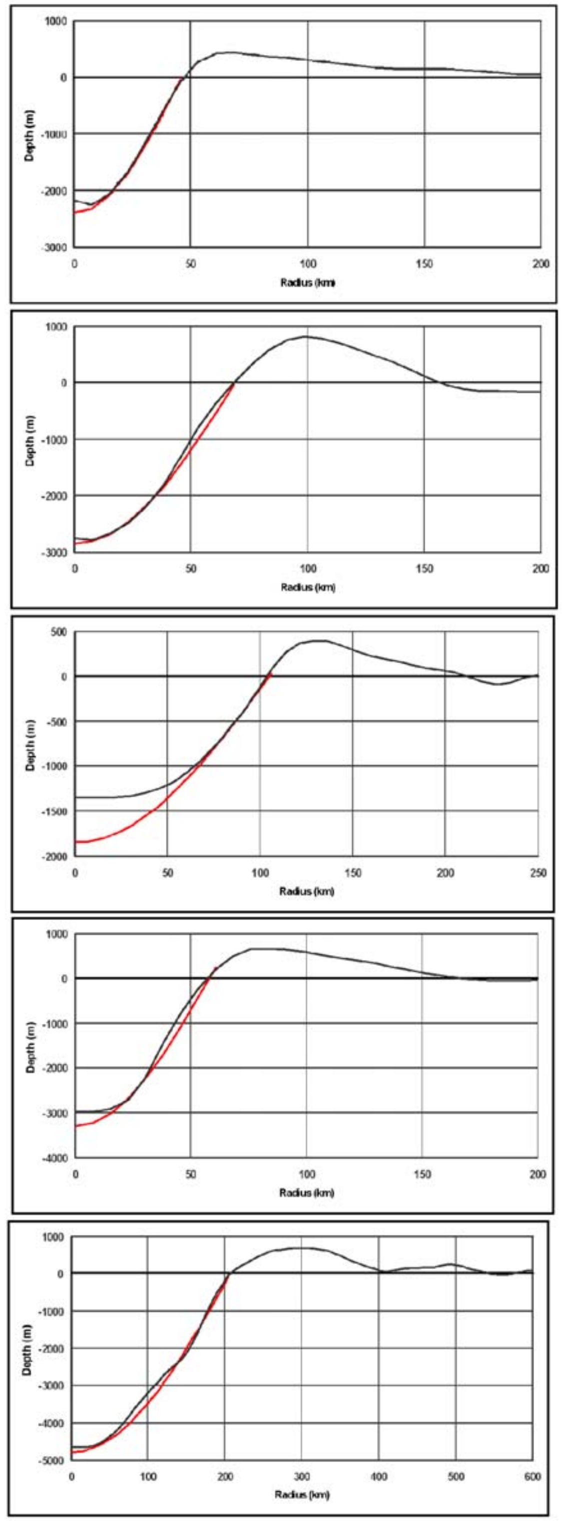

Figure 2: Radial profiles of (from the top) Copernicuse, Hilbert, Grimaldi, Langrenus, and the Moscoviense Basin. The red lines are negative cosine curves.

These radial profiles were calculated from Topogrd2, the quarter-degree digital elevation map derived from the Clementine LIDAR instrument [5]. They have had the estimated elevation, slope, and curvature of the pre-impact target surface removed by subtraction [1,2, 3].

Internal Rings: When internal rings are present, a negative cosine is a good estimate of the envelope of the radial profile, as shown in Figure 3. It still relates the true depth to the slope near the rim.

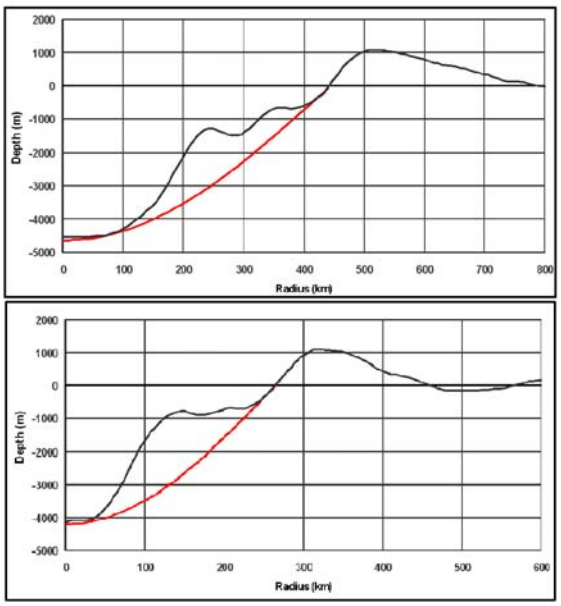

Figure 3: Radial profiles of the Orientale and Freundlich-Sharanov Basins (from the top). The red lines are negative cosine curves.

Application: The negative cosine curve can be used to estimate the depth of a cavity when it is filled with mare, so long as the slope near the rim is exposed. An example of such a procedure is shown in Figure 4.

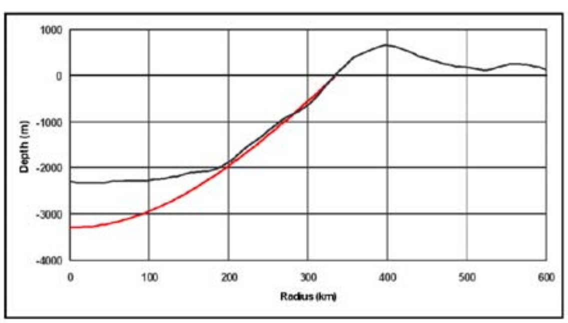

Figure 4: Radial profile of the Crisium Basin. The red line is the estimated radial profile (a negative cosine curve) before the extensive mare flooding.

Figure 4 can be used to estimate the apparent depth of the Crisium Basin as 3300 meters and the central depth of the fill (mare covering ejecta from the Imbium Basin) as 1000 meters. The same method has been used to estimate the apparent depths of the South Pole-Aitken Basin and the Near Side Megabasin [2, 3].

Volume of partial fill: The volume of fill V_f in an apparent crater with a negative cosine radial profile, no inner rings, and a normalized fill level of Z_f is:

$$V_f = -\left(4/\pi\right)\int_{-1}^{Z_f}\left(arcCos(Z)\right)^2 \cdot dZ$$

Figure 5 shows the computed normalized volume of fill. If the fill rises to the original target surface, the normalized volume is 1.4534. Note that the curve of Figure 5 is valid only for fill that is below the level of the estimated target surface, not for fill that floods the rim. To find the volume of fill of a specific crater, multiply the normalized volume by $R_A{}^2 d_T$.

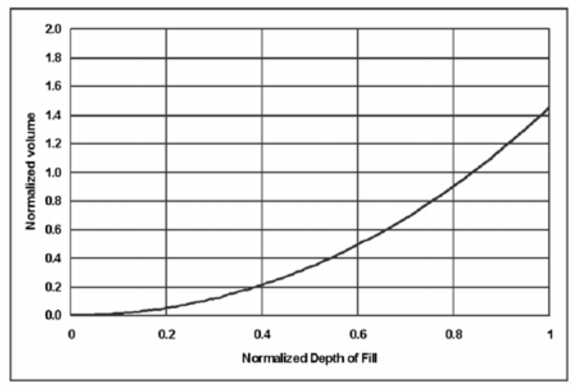

Figure 5: The normalized volume of fill within an apparent crater with a radial profile of a negative cosine.

Summary: For lunar impact features, at least those of more than 100 km in diameter, a negative cosine curve is a good approximation to the radial profile or envelope of the radial profile of the apparent crater before mare fill. This provides a method for estimating the true depth (depth shortly after impact and collapse of the transient crater) even when there has been subsequent fill of the cavities by mare or the ejecta of other features.

If there is isostatic compensation before mare fill, all vertical dimensions of the crater will be reduced, approximately proportionately.

References:

[1] Byrne, C.J., Radial profiles of lunar basins, LPSC XXXVII, Abstract 1900, 2006. [2] Byrne, C.J., A large basin on the near side of the Moon, Earth, Moon, and Planets, 2008. [3\ Byrne, C.J., *The Far Side of the Moon: A Photographic Guide*, Springer, New York, 2008. [4] E.P. Turtle, E. Pierazzo, G.S. Collins, G.R. Osinski, H.J. Melosh, J.V. Morgan, W.U. Reimold, Impact structures: what does crater diameter mean? Geological Society of America, Special Paper 384: 1-24 (2005). [5] Zuber, M.T., Smith, D. E., Neumann, G. A., Topogrd2, web site of the University of Washington in St. Louis, http//wufs.wustl.edu/geodata/clem1-gravity-topo-v1/, 2004