The manner in which the depth of excavation of large scale lunar impacts increases with increasing crater diameter is unknown. Laboratory impact cratering experiments show that the depth/diameter ratio of an impact crater is at a maximum near the conclusion of the excavation stage of crater formation (5). This intermediate stage crater geometry is termed the initial crater cavity in this report. Subsequently, fallback will decrease crater depth, while dilation or "rebound" of basement materials and rim slumping will simultaneously decrease crater depth and increase crater diameter. The net effect of these modification processes is to decrease the depth/diameter ratio of the initial crater cavity.

Estimates of the depth of excavation of the initial cavities of large lunar craters are complicated by the pervasiveness of these modification processes. Several investigators have estimated the excavation depth of basin-sized impacts by extrapolating the nearly constant depth/diameter relationships observed for small fresh lunar craters (D <15 km) which do not appear to have experienced extensive modification (e.g. 4, 10). Such estimates assume that the depth of the initial cavity increases proportionally with increasing cavity diameter in such a manner that the depth/diameter ratio of the initial cavity is approximately the same for craters of all size. In this theory of proportional cavity growth the marked discontinuity in crater depth/diameter ratios observed at D=15 km is interpreted to be the result of an increase in the ability of modification processes to reshape the geometry of the initial crater cavity (e.g. 7, 8). Other investigators have proposed that the depth/diameter ratio of the initial crater cavity decreases with increasing crater size. In this theory of variable cavity growth the shallowness of large lunar craters is interpreted to be the result of changes in the geometry of the initial cavity in addition to modification processes (1, 2, 6, 9).

Fresh intermediate-sized craters (15 km <D< 100 km) are characterized by terraced rims (which vary in width from 10% to 30% of the rim crest radius), flat floors and central peaks. Rim slumping in the latter stages of crater formation appears to have translated large portions of the rim of the initial crater cavity downward into the apparent crater. In this study topographic trends of exterior crater deposits have been extrapolated inward, past the crater rim in order to model the rim configuration of the initial crater cavity prior to slumping. As shown in Figure 1, this inward extrapolation is continued until an initial cavity radius and rim height is achieved which corresponds to the rim height/diameter ratio observed for small lunar craters. The reconstructed rim of the initial crater cavity modeled by the extrapolated exterior surface provides a boundary condition which can be used to restore slumped portions of the cavity rim to their inferred initial positions (Fig.2). By assuming a parabolic shape for the initial crater cavity (a=2 in Fig.2; ref.3) it is possible to estimate the initial cavity depth after restoring a portion of floor material to its inferred pre-slump position. Thus it is first assumed that the initial cavity does grow proportionally in order to determine
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the initial cavity radius on the basis of the rim height/diameter relationship observed for small craters (Fig.1), and then by restoring terrace and floor material to their inferred initial positions an initial cavity depth is determined (Fig.2). The model cavity depth/diameter ratio inferred is then compared to the depth/diameter relationship observed for small lunar craters. The results (a) constitute a test of the internal consistency of the proportional cavity growth theory, and (b) determine if rim slumping alone can account for the change in apparent crater depth/diameter ratios observed at D=15 km.

The natural variability in radial topographic trends makes it necessary to apply the above procedure to exterior crater topography along several azimuthal directions at an individual crater in order to infer an approximate average rim height, depth and diameter for the initial crater cavity. This technique is sensitive to phenomena that perturb the exterior topography surrounding the initial cavity such as: (a) post-formation mantling produced by igneous activity or ballistic sedimentation, or (b) differential tilting of segments of the crater rim produced by slumping in the latter stages of crater formation or by post-formation rim deformation due to isostatic rebound of the crater floor.

Application of this technique to the crater Taruntius (D=58 km) illustrates its sensitivity to variable exterior crater topography. Taruntius is characterized by an anomalously small depth/diameter ratio, an extensive series of cracks and fractures which crosscut the crater floor, and variable rim topography (rim elevations differ by up to 1 km of local relief). Extrapolation of exterior topographic trends along several azimuthal directions yield initial cavity diameter estimates which range from 32 km-52 km indicating variable enlargement of the initial cavity by factors of approximately 1.5-1.1. The circularity of the crater rim and the relative symmetry of topography within the crater suggest that such highly variable amounts of slumping did not occur. Rather the variable rim topography, possibly produced by variable pre-impact topography or post-impact rim deformation, has made it impossible to infer an average rim height and diameter for the initial crater cavity.

The extrapolation procedure has been more successful when applied to fresh-appearing craters formed on relatively flat mare surfaces. Cavity enlargement due to slumping has been calculated to range from factors of 1.05-1.15 for the craters Dawes, Diophantes, Delisle, and Lambert up to factors of 1.2-1.5 for certain portions of the rims of Cauchy, Timocharis, and Aristarchus. Estimates of the initial cavity depth for the craters Cauchy, Delisle, Lambert, Timocharis, and Aristarchus do not generally agree with initial cavity depths predicted by the extrapolated depth/diameter trend of small lunar craters. Rather the majority of inferred cavity depths are less than depths predicted by the small crater depth/diameter ratios. This indicates that rim slumping alone cannot account for the morphometric discontinuity in crater depth and rim height observed at D=15 km. Therefore, either proportional growth of the initial cavity does not occur with increasing crater size (1,2, 6,9), or other modification processes become relatively more significant in reshaping the initial cavity.
Figure 1. Exterior topographic trends are extrapolated to point where inferred initial cavity rim height/diameter corresponds to extrapolated small crater data. Figure 2. Floor and wall material is restored to original, pre-slump position permitting an estimate of initial cavity depth.