IMPACTS OF HEMISPHERICAL GRANULAR TARGETS: IMPLICATIONS FOR GLOBAL IMPACTS.

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Introduction: As impact excavation diameters subtend a nontrivial fraction of a planetary body, both the excavation process and ejecta emplacement may depart from the classical description of impacts into a planar surface. Hemispherical particulate targets were impacted at the NASA-Ames Vertical Gun Range in order to trace the evolution of the ejecta curtain and to document the effects of slope and surface curvature on crater shape and cratering efficiency.

Experiments: The cratering process in low-strength granular sand targets have been extensively studied over the last two decades. Unfortunately such targets have such little strength that hemispherical surfaces are difficult to construct without a bonding agent that results in spallation and an ejecta curtain with only a few large fragments. Compacted pumice has been used successfully for a variety of studies (1,2) and possesses sufficient shear strength to maintain steep slopes while behaving as a reasonably low-strength particulate material upon impact. Hemispherical targets were constructed by compressing pumice with a mold on a pumice base. The pumice base minimized unwanted effects produced by shock reflections from materials with contrasting strength. Both 0.318 cm and 0.635 cm velocities aluminum spheres impacted the hemispheres with 1.9-2.3 km/s. In addition, a ledge was created in two experiments in order to examine the effects of slope on the ejecta plume.

Results: Four significant findings can be cited. First, the ejecta plume maintains an angle of about 45^{o} from the local surface during most of crater excavation. Consequently, the ejecta plume appears to decrease with respect to the horizontal on a curved surface or changes dramatically as it crosses a stepped surface. Second, the ejecta curtain after excavation maintains an approximate constant angle with respect to the horizontal. As a result, the ejecta curtain meets the surface at increasingly steeper angles away from the point of impact (Figure 1). Third, cratering efficiency (displaced mass/projecticle mass) in a hemispherical target is greater than a plane-surface crater but approximately matches the plane surface case if the displaced mass above the chord from rim-to-rim (apparent rim) is ignored. Fourth, the diameter/depth ratio referenced to the pre-impact curved surface is greater than the ratio for planar surface impact.

Discussion: The uniformly downward-directed gravity vector in the experiment is unlike the radially inward vector for a planetary body. Previous experiments at high (3) and low (4) gravitational fields suggest that the gravity vector does not modify the cratering flow field but only limits crater growth. Consequently, the experiments may have a direct bearing on excavation and shape and efficiency of craters whose diameters subtend a significant fraction of planetary curvature. Moreover, it is believed that during excavation, the ejection angle (and therefore plume angle) near the surface is approximately constant. The experiments indicate that the ejecta curtain after excavation meets the curved surface at increasing angles, and the effect of a radially inward gravity vector can be examined by theoretically modeling the ejecta curtain under laboratory and planetary conditions. The cratering flowfield follows the approach in (5) where ejection velocity decreases a $(X/R)^{-3}$ with X/R representing the fractional stage of growth of a crater with final apparent radius, R. Additionally, the crater is assumed to grow as $(X/R)^{4}$ over most of its late stages. Although such a model does not provide an accurate description throughout the entire growth of a crater, it suffices for comparing the contrasting laboratory and planetary gravitational fields. Figure 2 reveals that the effect of the inward-direct g-field increases the angle between the surface and ejecta curtain. For the Moon, the ejecta curtain becomes vertical at a distance of nearly 1200 km for a relatively small crater (D< 200km). A basin-size impact (D~ 600km) requires shifting the curve laterally, thereby preserving the constant ejection angle, with respect to the surface, and results in a vertical ejecta curtain at a distance of about 1400 km.

<u>Implications</u>: The experiments suggest that basin-size impacts or large craters on small bodies may be shallower than their counterparts on a planar surface but may have displaced a larger relative mass. Moreover, the increased ejecta curtain angle with distance may result in a change in ejecta emplacement style with distance. Although the ejecta curtain is vertical, ejecta within the curtain impact the surface at 45° and the time between first and last arrival within the curtain increases. This increased interaction time as the ejecta curtain density decreases should result in a more chaotic style of emplacement, perhaps accounting for the transition in ejecta facies surrounding the Imbrium basin noted in (6).

(1) Schultz, P.H. and Gault, D.E. (1985) <u>J. Geophys. Res.</u>, <u>90</u>, 3701-3732. (2) Schultz, P.H. and Gault, D.E. (1984) <u>Lunar and Planetary Science XV</u>, 732-733. (3) Schmidt, R.M. (1984) <u>Lunar and Planetary Science XV</u>, 722-723. (4) Gault, D.E. and Wedekind, J. (1977) In <u>Impact and Explosion Cratering</u> (Roddy <u>et al.</u>, eds), p. 1231-1244, Pergamon, NY. (5) Schultz, P.H. and Gault, D.E. (1979) <u>J. Geophys. Res.</u> <u>84</u>, 7669-7687. (6) Spudis, P.D. (1985) Workshop Apollo 15, Lunar and Planetary Institute, Houston, TX.

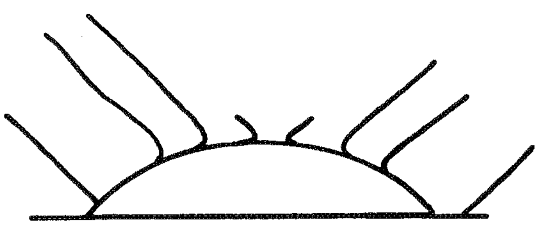

Figure 1. Evolution of ejecta curtain at 2.5, 62, 125, and 188 ms for a 2.3 km/s impact into a hemispherical target of compacted pumice with a diameter of 37 cm.

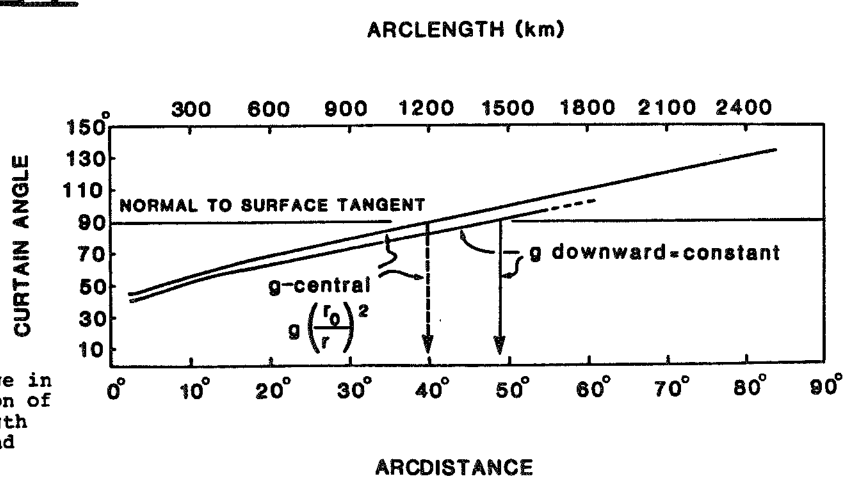

Figure 2. Comparison of the change in ejecta curtain angle as a function of arcdistance (degrees) and arclength (Moon) for planar (g downward) and planetary (g inward) cases.