MORPHOMETRY AND MORPHOLOGY OF LUNAR CRATERS ON SLOPES. J.B. Plescia[1] , O. Barnouin[1], J.L.B. Anderson[2], and M.J. Cintala[3]. [1]Applied Physics Lab, Johns Hopkins University, Laurel, MD 20723, [2]Department of Geoscience, Winona State Univ., Winona, MN 55987. [3]Code XI3, NASA JSC, Houston, TX 77058.

Introduction: Impact craters often form on sloping surfaces. This results in a crater shape that is asymmetric (typically the longest axis is down-slope), an offset of the deepest part of the floor from the center and an asymmetric distribution of ejecta (concentrated in the downslope direction). On the Moon, such craters form on the margins of highland massifs, the central peaks of large complex craters, and on the interior walls and exterior rims of larger impact craters. Craters on sloped surfaces have also been observed on asteroids (e.g., Kahukura crater on Ceres [1]).

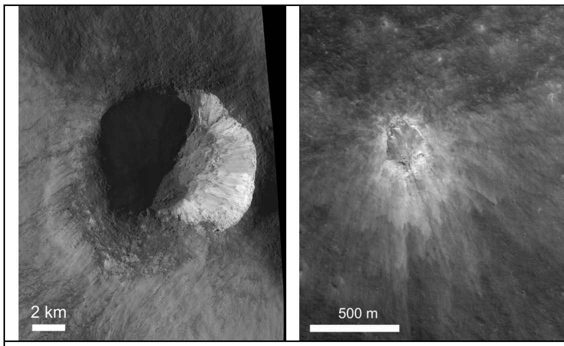

Figure 1. (left) Crater formed on the rim of Gibbs crater. Floor is coated with melt which overtops the downslope rim. Regional slope of inner wall of Gibbs is 28° (right) Crater formed on the central peak Hatanaka. Regional slope of 29°.

It is clear that the topography of the target is influencing the excavation and deposition of material. The issue is the extent to which the value of the target slope and target properties influences the asymmetry. Here we focus on the morphologic and morphometric aspects of such craters, which in turn provides constrains on modeling and experiments. Dechant et al. [2, this volume] examine the problem with laboratory experiments – impacts into sloping targets.

Morphology: Craters formed on sloping surfaces are asymmetric in both plan view and cross section. Typically, the crater has a larger diameter in the downslope direction than in the cross-slope direction. The up slope margin of the crater is often defined simply by a break in slope (an inward facing scarp rather than a raised rim). The down-slope margin can be characterized by a rounded rim (the shape of which may reflect the rheologic properties of the target material) rather than a sharp rim. The lateral margins of such craters resemble those formed on level surfaces. The floor of the crater is asymmetric with the deepest portion being offset downslope from the presumed point of impact.

The asymmetry in the shape resulting from impact into a sloping surface has been demonstrated in laboratory experiments [3-4]. During excavation, material is ejected from the interior resulting in an oversteepened up-slope wall. Material cascades down the inner wall piling up on the crater floor and displacing the deepest point downslope. On the down-slope side, material overtops the down-slope rim and moves farther downslope with the result that a rounded rim is formed. It is unclear whether material from the upper wall actually transits the floor.

Figure 2. Asymmetric crater formed in loose sand with a 20° slope. Note the offset location of the floor, rounded downslope rim and lack of a significant raised rim on the upslope margin.

Morphometry: To examine the extent to which the absolute value of the slope controls the morphology, the dimensions of a suite of lunar craters was examined. Crater diameters (long-axis) ranged 10 km to 50 m. In general, only the lateral dimensions could be measured. For large km-scale craters, a topographic profile could be derived from the LOLA/WAC DTM. For small craters, vertical dimensions could not be determined without an LROC NAC DTM. Regional slopes were derived from the LOLA/WAC DTM.

Figure 3 illustrates the ratio of the distance from the upslope margin to the deepest portion of the floor divided by the overall downslope diameter of the crater as a function of the slope on which the crater formed. Figure 4 illustrates the ratio of the down-slope diameter to the cross slope diameter against the target slope.

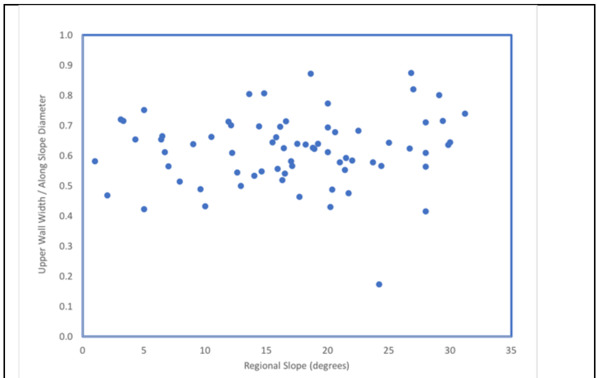

Figure 3. Ratio of width of upslope wall to total down-slope diameter vs. target slope.

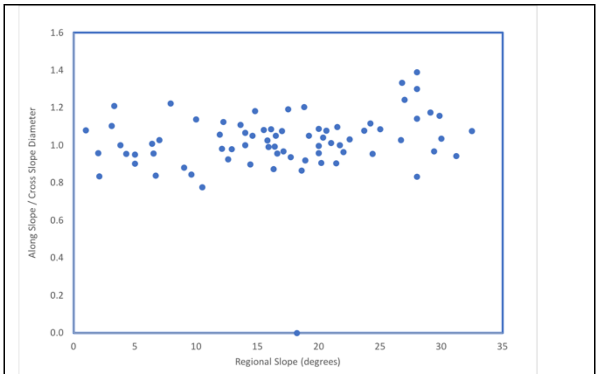

Figure 4. Ratio of down-slope diameter to cross-slope diameter vs. target slope.

The data illustrated in Figures 3 and 4 demonstrate that the slope angle does not exert significant influence on the dimensional aspects of the crater. Slopes as shallow as a few degrees (<5°) will result in an asymmetric crater. Although there is a large amount of scatter in the data, it appears that dimensional ratios are independent of the slope.

Future Work: Existing global DEMS have insufficient resolution to determine the depth of the craters and the angle of the interior walls. LROC NAC DEMS however, offer the resolution to examine the vertical morphometric properties of the small lunar craters.

These data represent craters on a range of target environments: highland massifs, central peaks, and the interior and exterior walls of larger craters. We have not yet examined the extent to which different targets (i.e., different material properties) influence the dimensions.

Conclusions: Craters formed on sloping surfaces on the Moon result in asymmetric morphology and morphometry. The crater exhibits an asymmetry along an axis oriented downslope through the center of the crater. Steep slopes are not necessary; slopes as low as a few degrees exhibit such craters on the Moon. The actual magnitude of the slope seems to have little influence on the lateral morphometric parameters.

References: [1] Dechant, L.E., et al. (2019) this volume. [2] Stephan, K., et al. (2019) *Icarus, 318*, 56-74. [3] Aschauer, J., and Kenkmann, T. (2017) I*carus, 290*, 89-95. [4] Hayahi, K., and Sumita, I. (2017) I*carus, 291*, 160-173.