EFFECTS OF LIMITING CONTAINER DIAMETER ON CRATER MORPHOMETRY IN LABORATORY IMPACT EXPERIMENTS. M. D. Mouser[1], M. J. Cintala[2], C. J. Cline II[3], [1]Amentum, NASA Johnson Space Center, Astromaterials Research and Exploration Science, [2]NASA Johnson Space Center, Astromaterials Research and Exploration Science, Mail Code XI3, [3]NASA Johnson Space Center, Astromaterials Research and Exploration Science, Mail Code XI5, Houston, TX, 77058 (megan.d.mouser@nasa.gov)

Introduction: Laboratory impact experiments provide a mechanism to test and understand impact events that affect every planetary object in our Solar System. Impact experiments have been conducted on a wide variety of mediums (e.g., sand, ice, solid rock, regolith simulant [1–4]) in a variety of container sizes, depending on the laboratory. While the specific parameters of each impact experiment vary greatly from impacting medium, projectile type and size, speed, etc., there has not been any in depth analysis of the effects that limiting container dimensions might have on the resulting subsurface flow field and ultimately the crater structure. Here we asses the effects of container diameter by conducting a series of cratering experiments on five different container sizes. The results of this study will be informative to the impact community such that closer consideration will be taken regarding the selection of container size to insure the most high quality results with less interference from the boundary conditions.

Methods: To explore the effects that different container sizes have on final crater shape and kinetics, five different sized containers were used. Each bucket had approximately the same depth (12.1 cm) but varied in diameter (Table 1). For reference, S7 is the standard container size used in the Experimental Impact Laboratory (EIL) at NASA Johnson Space Center.

Sepratech silica sand (0.3-0.5 mm grain size) was used as the impacting medium in the containers. Sand has been standard in impact cratering experiments [e.g., 4–6] and thus a good proxy for this experimental impact method development study. Each container was filled with sand without additional compaction, and the top smoothed to a flat surface. Once the container was prepared, a pre-shot scan was taken of the flat surface with the Peel2 3D scanner.

Each experiment used a 3/16" aluminum projectile that was accelerated to 2 km/s in the vertical gun in the EIL. The Ejection Velocity Measurement System (EVMS) was used to capture quantitative data on ejection position, speed, and angle of ejected particles. This system uses a camera set up with a long exposure imaged the ejecta for a total of 1.6 seconds, capturing an image of the ejected particles with the use of a vertically oriented strobed laser sheet.

After the completion of the experiment, the container was scanned again with the Peel2 3D scanner, collecting the post-impact surface. The scans of the pre- and post-impact surfaces are used to assess crater properties such as diameter, depth, and volume, as well as create topographic maps and cross sections of the crater with an open source point-cloud software called CloudCompare [7].

Results: Five experiments were completed, one on each container size. Each experiment was conducted using the same process as detailed in the methods to facilitate a direct comparison between craters. The physical properties of the craters, e.g., diameter, depth, are listed in Table 1. These parameters were determined by taking five measurements and using the average to account for any possible asymmetries in the crater shape.

Container	Container Diameter (cm)	Crater Depth (mm)	Crater Diameter (mm)
L1	31.3	42.01 (3.52)	186.91 (1.83)
S7	26.2	43.31 (3.31)	184.82 (3.47)
TB	22.8	42.17 (0.52)	187.05 (3.83)
LB	20.8	42.91 (7.24)	184.16 (2.04)
E	17.8	43.91 (0.22)	177.94 (1.40)

Table 1. Crater depths and diameters for each experiment (1σ standard deviation in parentheses).

Discussion: Upon analysis of the experiments, several interesting observations were made. First, the craters formed in the sand at this velocity resulted in crater diameters that were almost the same size as the smallest bucket size (~17.7 mm and 17.8 mm, respectively). There was some variability in the crater diameters for all experiments, but the outlier was clearly the smallest bucket, E. The crater depths did not appear to be affected by the container size, as they were relatively similar to each other.

Another interesting feature of the craters was an increase in the convexity of the crater walls with decreasing bucket size. Figure 1a-b show crater profiles of the largest and smallest buckets, with a dashed line showing straight line drawn from the crater rim to the crater floor, with the shaded region showing the area difference from the line to the actual crater wall. The curvature of the crater wall is much more apparent in the smallest bucket size when compared to the largest.

This difference was quantified by finding the area of the shaded region for each experiment to see if there was a consistent trend. Figure 1c shows the area under the crater walls for each container and the associated trend of increasing area with decreasing container size. More experiments are planned at different velocities to further asses this feature.

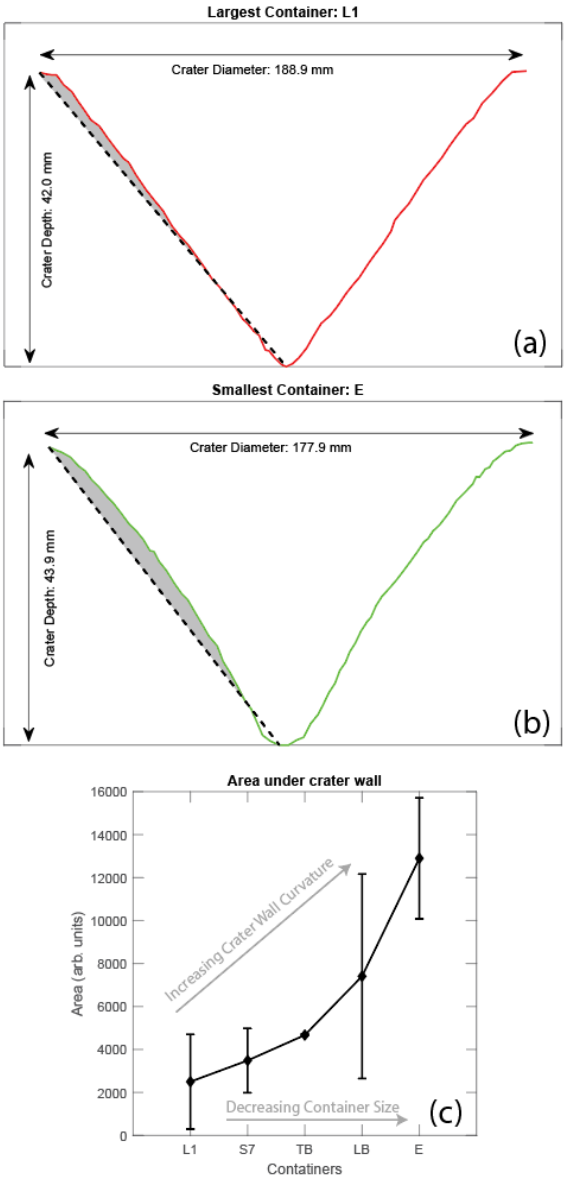


Figure 1. Cross sections of the largest (a) and smallest (b) containers tested in this study. The shaded region shows the area calculated under the curve. (c) The difference of the area under crater walls, due to increasing wall curvature, for each experiment. Errorbars show 1σ standard deviation.

An initial examination of the EVMS images suggests a difference in ejecta particle trajectories, particularly when directly comparing the images created from shots into the smallest container size to those from the larger container. Qualitatively, these differences are highlighted by the position of the ejecta curtain at a fixed time after the impact. By design, the strobing sequence of the laser incorporates a time of quiescence that separates a higher frequency flashing rate soon after impact, and a slower flash rate later in the ejection process. Given the same timing sequence was used in all shots, the position of this illumination gap in the images can be used as a fiducial marker. Pending quantitative assessment of launch position, angle, and speed of individual particles, it can be observed that ejecta particles from the shots into the smallest bucket have a higher speed for the same normalized launch position in comparison to the largest bucket.

Conclusions: The results from this study indicate that container size does have a measurable effect on the experimental formation of a crater in sand. Specifically, an observed increasingly convex nature of the crater wall with decreasing container size, thus creating an artificial shape of the crater itself via an experimentally controlled parameter. This is an important note for future cratering experiments to ensure accuracy of the results and proper applicability to natural systems. Additionally, the ejected particles from the impact event appear to have different kinetics when the crater wall grows too close to the edge of the container.

Next steps for this work are to continue EVMS analysis of the current set of experiments and to conduct the next series of experiments at a different velocity (e.g., 1–3 km/s). Further experimental exploration will include changing the floor depth of the container, i.e., creating a shallower impacting environment to see how not only container diameter affects the crater formation, but how container depth may influence it as well.

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