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The Experimental Projectile Impact Chamber (EPIC) at Centro de Astrobiología, Spain: Reproducibility and verification of scaling relations.

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Abstract

The Experimental Projectile Impact Chamber (EPIC) consists of a 20.5mm caliber, compressed gas gun and a 7m wide test bed. It is possible to vary the projectile size and density, the velocity up to about 500m/s, the impact angle, and the target composition. The EPIC is especially designed for the analysis of impacts into unconsolidated and liquid targets, i.e. allowing the use of gravity scaling. The general objective with the EPIC is to analyze the cratering and modification processes at wet-target (e.g. marine) impacts.

We have carried out 14 shots into dry sand targets with two projectile compositions (light and weak; heavy and strong), at two impact angles, at three impact velocities, and in both quarter-space and half-space geometries. We recorded the impacts with a high-speed camera and compared the results with numerical simulations using iSALE.

The evaluation demonstrated that there are noticeable differences between the results from the two projectile types, but that the crater dimensions are consistent with scaling laws based on other impact experiments [1]. This proves the usefulness of the EPIC in the analysis of natural impacts.

1. Introduction

The EPIC consists of a 7m wide, funnel-shaped test bed, and a 20.5mm caliber compressed N_2 gun. The test bed can be filled with any type of target material, but is especially designed for wet target experiments. Experiments are done under 1Atm pressure. The gun launches projectiles of any material and dimensions <20mm (smaller diameters using sabots), and at any angle from vertical to near horizontal. The impact velocity is controlled by gas pressure and projectile mass and is of the order of a few hundreds of meters per second. The transient crater in dry sand is about 30cm wide, whereas it is expected to be about 50cm wide in water. The relatively large (compared to conventional gas-gun) craters and the combination of quarter-space (QS) and half-space (HS) geometries allow the detailed study of the dynamics of cratering motions during the stages of crater excavation and modification (e.g. water resurge). These observations provide valuable validation data for numerical models and provide dynamical insight to aid interpretation in field studies.

2. Aim of Study and Methods

We use numerical simulation (iSALE) to evaluate the effects of varying projectile velocity, projectile mass, and impact angle on crater dimensions for 14 impact experiments into sand of mainly medium/coarse fraction. The projectile velocities range from 273m/s to 377m/s and are above the speed of sound in dry sand, i.e. about 200m/s. We use two projectile compositions (20mm, 5.7g delrin, disrupts upon impact; 20mm, 16.3g Al_2O_3, survives the impact), and two different impact angles (90˚ and 53˚ over the horizontal plane). Nine of the experiments are QS using a camera tank with a 45mm thick glass window to reduce energy loss by vibrations. Five experiments are done in HS geometry as reference. The cratering is documented with high-speed camera.

3. Results and Discussion

The cratering process observed in the QS impacts fit well to the numerical simulations after doubling of the projectile mass (i.e. impact energy) used as input in the numerical modeling (Fig. 1). This is expected for an ideal situation with no energy loss due to vibration of the glass window. This shows that the EPIC QS experiments are a reasonable approximation for half-space experiments. QS has the benefit over HS in that cratering and modification material motions are more easily visualized. The transient crater (TC) and final crater (FC) dimensions for both QS and HS combined with the numerical simulations show that the experimental craters follow established scaling relations [i.e. 1] (Fig. 2).

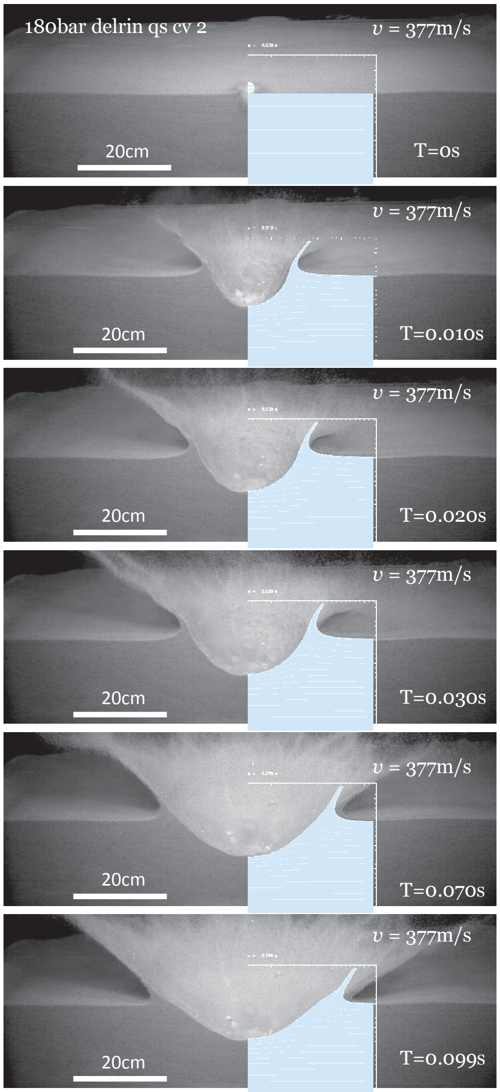

Figure 1. Crater growth during impact of a QS delrin projectile into dry sand. Results from numerical simulation overlaid on contemporaneous snap-shots from the EPIC experiment.

The analysis also showed that the TCs from stronger/heavier projectiles (Al_2O_3) are larger, but also relatively deeper than for the lighter/weaker delrin. However, more extensive slumping of the Al_2O_3 craters gives same depth/width relation of the FC. Oblique TC from delrin has steeper uprange side vs. steeper downrange side than for Al_2O_3. The reason for this and its implication to natural impacts needs further analysis. However, slumping in the oblique craters leads to similar FC shape as for equivalent vertical impacts. This is most evident for Al_2O_3, possibly due to the relatively deeper craters enhancing the slumping.

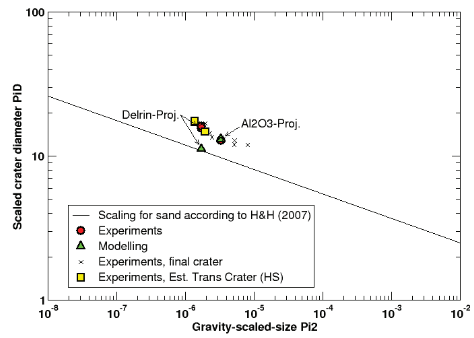

Figure 2. The experimental and numerical results plotted on the scaling graph by [1].

4. Conclusion

The EPIC provides a useful tool for the analysis of cratering and modification processes when using unconsolidated target materials that obey gravity scaling.

Acknowledgements

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References

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