THE EXPERIMENTAL PROJECTILE IMPACT CHAMBER (EPIC), SPAIN.

J. Ormö[1], I. Melero Asensio[1,2] , K. Housen[3], K. Wünnemann[4], D. Elbeshausen[4,5], and G. Collins[6]
[1]Centro de Astrobiologia (INTA-CSIC), Torrejon de Ardoz, 28850, Spain, ormoj@cab.inta-csic.es., [2]Department of Geophysics, Faculty of Physics, Universidad Complutense de Madrid, Madrid 28040, Spain (present address), [3]Applied Physics, The Boeing Co, Seattle, WA 98124, [4]Museum für Naturkunde, Leibniz Institute for Evolution and Biodiversity Science, Invalidenstr. 43, 10115 Berlin, Germany, [5]Autodesk GmbH, Försterweg 3, 14482 Potsdam, Germany (present address), [6]Impact and Astromaterials Research Centre, Dept. Earth Science and Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, United Kingdom.

Introduction: The geomorphology of an impact crater may reflect the target environment, e.g. if liquid water was available at the time of impact. The Experimental Projectile Impact Chamber (EPIC) at the Centro de astrobiología, Spain, is specially designed for the study of processes related to wet-target (e.g., 'marine') impacts. It includes a 7-m wide, funnel-shaped test bed (Fig. 1), a 20.5-mm caliber compressed N_2 gas gun, and a camera tank (Fig. 2). The target can be unconsolidated or liquid. The gas gun can launch 20 mm projectiles of various solid materials under ambient atmospheric pressure and at various angles from the horizontal. The EPIC complements observational data from natural impact craters and numerical simulation (here the iSALE code [e.g., 1,2,3]) with the objective to understand how impact craters can reveal information on environments of importance for life.

Aim of study: The EPIC is primarily developed for wet-target impact experiments, which for the relatively large crater dimensions and the variability of parameters such as impact angle allowed by the system, are rare in literature. However, all experiments in this study performed in unconsolidated dry sand target in order to first demonstrate if EPIC experiments are consistent with previous experimental work and natural impact events within the widely-used pi-group scaling framework [e.g., 4]. We also use the experiments as ground truth for the validation of numerical impact models.

Methods: Projectile impacts were performed into single layer (i.e., homogeneous) dry beach sand targets with two different projectile materials; ceramic Al_2O_3 (max. velocity 290 m/s) and Delrin (max. velocity 410 m/s) in which the basic parameters velocity, projectile density and strength, and impact angle could be varied. 23 shots used a quarter-space setting (19 normal, 4 at 53° from horizontal) and 14 were in a half-space setting (13 normal, 1 at 53°). The experimental results were compared with 2-D numerical simulation of vertical impact, and 3-D simulation for oblique impact using the iSALE code [e.g., 1,2,3] with input parameters that replicated the experiments (i.e., impact angle, velocity, target and projectile properties). The results were then plotted in nondimensional form [4] to evaluate their reproducibility and consistency with pi-scaling [e.g. 5].

Fig. 1. The large test bed. Man on left for scale.

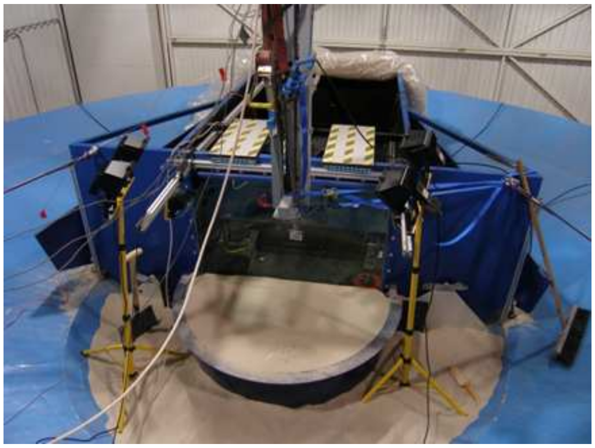

Fig. 2. The camera tank for quarter-space experiments mounted inside the large test bed.

Results and Discussion: Differences were seen between the non-disruptive Al_2O_3 and the disruptive Delrin projectiles in transient crater development; The transient craters from the Al_2O_3 projectiles are larger, but also relatively deeper than for the Delrin. However, more extensive slumping of the craters from the Al_2O_3 shots results in the same depth-diameter relationship of the final crater as for the Delrin shots. The transient craters from oblique Delrin impacts have a steeper uprange side whereas those from the oblique Al_2O_3 impacts have a steeper downrange side. It seems the oblique Delrin impacts are in this aspect more similar to the transient crater shape during large oblique natural impacts. However, slumping in the oblique craters produced in this study eventually leads to similar final crater shapes as for equivalent vertical impacts.

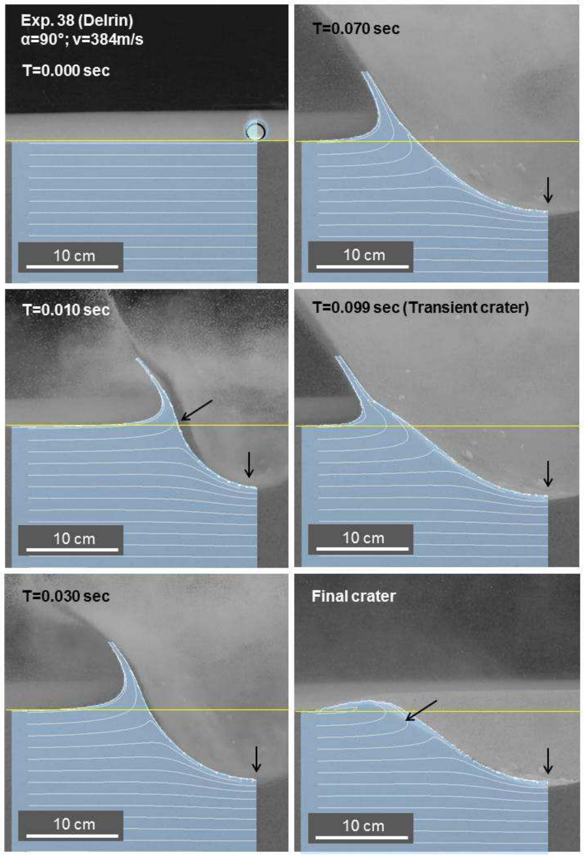

Fig. 3. Comparison between Delrin projectile impact experiment and numerical simulation (blue overlay). Black arrows indicate places with discrepancies between experiment and model. Black circle in the first frame at time (T) 0 seconds illustrate the dimensions of the Delrin projectile whereas the size-compensated projectile used in the simulation is shown in pale blue. Horizontal yellow line indicates the target surface.

We also successfully validated numerical models of vertical and oblique impacts in sand against the experimental results, as well as demonstrated that the EPIC quarter-space experiments are a reasonable approximation for half-space experiments as well as the numerical simulations after adjusting (i.e. doubling) the projectile mass used as input in the numerical modeling (Fig. 3). Quarter-space experiments have the benefit over half-space experiments in that cratering and modification material motions are more easily visualized and quantified. The final crater dimensions, when plotted in scaled form, agree well with the results of other studies of impacts into granular materials (Fig. 4). Therefore, the EPIC results generally follow the established scaling for sand targets. Altogether, the combined evaluation of experiments and numerical simulations support the usefulness of the EPIC in impact cratering studies.

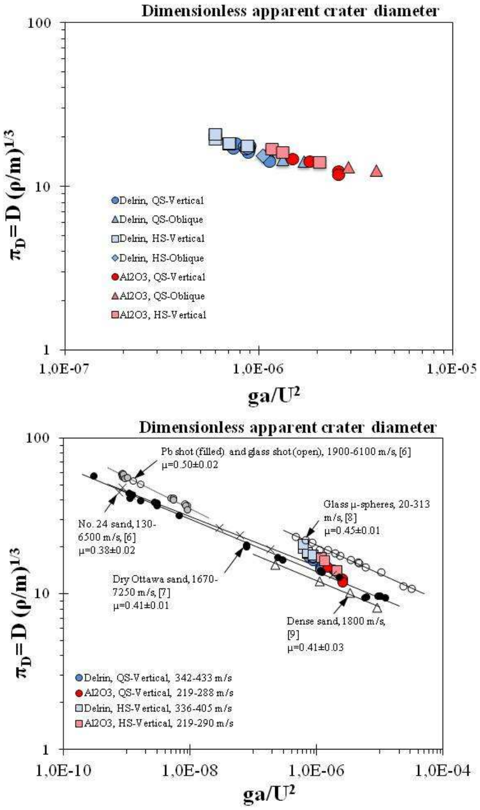

Fig. 4. (Top) Present results plotted in nondimensional form. (Bottom) Comparison of present results with other data for granular materials. The diameter used here is the apparent crater diameter.

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References: [1] Amsden A. A, et al. (1980) LA-8095. Los Alamos, NM: Los Alamos National Laboratory. [2] Wünnemann K., et al. (2006) *Icarus, 180*, 514-527. [3] Elbeshausen D. (2009) *Icarus, 204(2),* 716–731. [4] Holsapple K. A. and Housen K. R. (2007) *Icarus 187*, 345-356. [5] Holsapple K.A. (1993) *An. Rev. Earth & Planet. Sci., 21*, 333-373. [6] Schultz P. H. and Gault D.E. (1985) *JGR*, *90*, 3701-3732. [7] Schmidt R.M. (1980), *Proc. Lunar Planet. Sci. Conf. 11th, Vol 3*, 2099-2128. [8] Yamamoto S., et al. (2006) *Icarus*, *183*, 215-224. [9] Housen K.R., et al. (2015) *Icarus* (In prep).