EPSC Abstracts
Vol. 8, EPSC2013-1007, 2013
European Planetary Science Congress 2013

Experimental analysis of concentric craters in targets with layers of different density: Clues to target influence on gravity dominated craters.

J. Ormö (1), K. R. Housen (2), K. Wünnemann (3), D. Elbeshausen (3), I. Melero-Asensio (1), G.S. Collins (4) and A. P. Rossi (5). (1) Centro de Astrobiologia (INTA-CSIC), 28850 Torrejon de Ardoz, Spain (ormoj@cab.inta-csic.es), (2) Applied Physics, MS 2T-50, The Boeing Co, P.O. Box 3999, Seattle WA 98124, (3) Museum für Naturkunde, Invalidenstrasse 43, 10115 Berlin, Germany, (4) Imperial College London, South Kensington Campus, SW7 2AZ, London, United Kingdom (5) Department of Earth and Space Sciences, Jacobs University Bremen, College Ring 1, 28759 Bremen, Germany.

Abstract

Concentric impact craters have generally been considered to be a consequence of a target with layers of different strength. However, there are many terrestrial and Martian examples with dimensions well above the strength/gravity transition. We use 1G and 150G impact experiments to investigate what target properties that may influence gravity dominated cratering.

1. Introduction

The target influence on the cratering process depends on the ratio of target strength to the lithostatic stress, which in turn depends on gravity, target density, and crater diameter. When this ratio is large, the crater size is determined by target strength and when it is small, it is determined by gravity. Small, strength controlled concentric craters, i.e. craters with a wide outer crater developed in a weaker near-surface target layer, and with a deeper nested crater in the more rigid substrate, have proved useful to determine lunar regolith thickness. However, concentric shapes occur also at much larger gravity controlled craters of reasons still unknown (Fig. 1).

Even though strength can be considered of less importance for gravity dominated craters, there will still be differences in the density and the wave speed between the weaker upper layer and the rigid substrate. The product of these two factors is the mechanical impedance of a material. Possibly, for large gravity controlled craters, differing impedances of two layers could result in reflection of the shock, with a reduction of the energy transferred into the basement. We are here investigating these effects with the use of laboratory impact experiments.

Fig. 1. Martian example of concentric crater formed in the gravity regime. HiRISE image PSP_001348_1770_RED.

2. Methods

At this point we have conducted a single, half-space experiment on the Boeing geotechnic centrifuge, Seattle, USA (Fig. 2). A polyethylene cylinder (1.2 cm length and diameter, 1.8 km/s) impacted the target at nearly normal incidence under an acceleration of 150G, which simulates the lithostatic stress and corresponding shear strength of a 1G crater that is 150 times larger in size. The target consisted of a 0.5 cm layer of dry quartz sand (1.5 g/cm^3) on top of dense chromite sand (3.8 g/cm^3). Our experiments at Centro de Astrobiología (CAB) utilize the compressed N_2 cannon of the Experimental Projectile Impact Chamber (EPIC) (Fig. 2). The experiments have been done in quarter-space setting with the gun shooting a 20 mm diameter delrin projectile at about 420 m/s along a 45 mm thick armored glass window into a target made up of a layer of dry beach sand (1.56 g/cm^3) covering a substrate made up of iron grit sand (4.44 g/cm^3) of similar grain size and cohesion. We conducted shots at 8, 11, and 19 mm dry sand layer thicknesses.

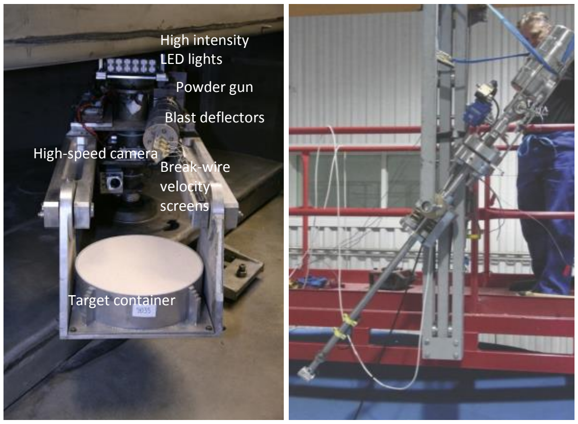

Fig. 2. The equipment used in the experiments. Left, the centrifuge gun at Boeing. Right, the EPIC gun at CAB, here installed for oblique shot.

3. Results and discussion

The shot with the centrifuge setup generated a distinct concentric final crater (Fig. 3). Ejecta from the chromite sand can be seen around the periphery of the inner crater. The 1G shots showed a concentric development (i.e. separate ejecta curtains), but the concentric morphology of the final craters is less distinct as for the 150G shot (Fig. 4) of reasons to be further investigated. Nevertheless, it is obvious from the experiments that the concentric crater growth may be related to differences in layer densities and/or wavespeed, which is of importance for large-scale, gravity dominated cratering, and not only strength differences as hitherto commonly assumed. However, it is yet too early to tell how our experiments scale to natural craters, it depends on whether a point source applies or not. At present, we have only a few data points and we are working on the scaling relations to relate the 1G experiments with those done in the centrifuge, and to larger scale events.

Acknowledgements

J. Ormö is supported by grants AYA2008-03467 /ESP and AYA2011-24780/ESP from the Spanish Ministry of Economy and Competitiveness, and project 90449201 “Concentric Impact Structures in the Palaeozoic (CISP)” from the Swedish Research Council (Vetenskapsrådet). HiRISE image credit: NASA/JPL-Caltech/Univ. of Arizona.

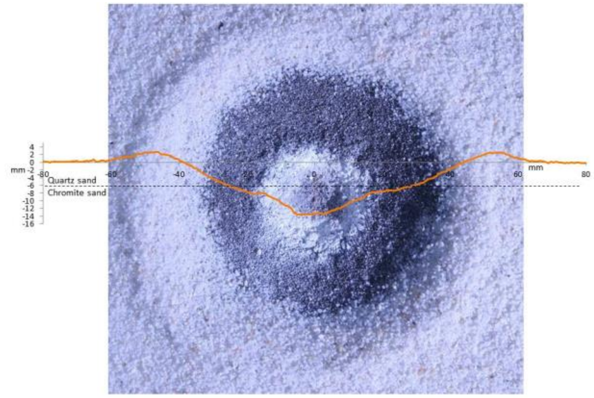

Fig. 3. Concentric crater generated at 150G with the Boeing centrifuge gun.

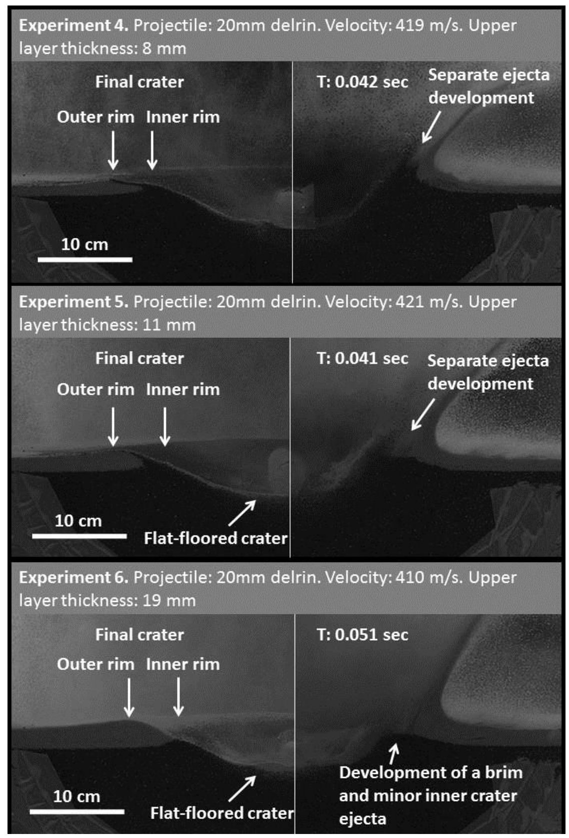

Fig. 4. Snapshots from three experiments with the EPIC gun at CAB. The frames are separated along the projectile trajectory.