ADVANCED CRATER SIZE SCALING LAWS THROUGH HYDROCODE SIMULATIONS.

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Introduction: To relate the size of a given crater with the kinetic energy of the impactor is a fundamental question that is been addressed primarily by laboratory cratering experiments [e.g. 1]. The resulting crater size after the impact of the projectile of given mass and velocity strongly depends on the gravity and the properties of the target. So-called π-group scaling [e.g. 2] is probably the most successful approach to relate small-scale laboratory cratering experiments with natural craters on different planetary targets in different gravity conditions. The well-established set of equations is calibrated by laboratory experiments in dry and wet sand [1,3] for gravity dominated craters and in cohesive rocks [1,4] for strength dominated craters. In order to investigate a much broader range of target properties, impact velocities, and gravity conditions we use hydrocode simulations of impact cratering. Recent advances in material models [5,6] now allow for studying crater formation in competent rocks in the gravity regime, systematic analysis of the effect of porosity, dry friction, and cohesion on crater size [7], and the investigation of how the impact angle [8] and velocity [9] affect crater size.

Numerical Experiments: We conducted a suite of numerical experiments of crater formation over a large range of impact diameters *L* in different target configurations of competent rock and granular materials including also layered targets. We use two slightly different variants of the SALE code, SALEB [10] and iSALE [6 and reference in there]. To model the material behavior during crater formation we use ANEOS and Tillotson EOS coupled with a porosity compaction model [6,11,12] and a brittle-ductile failure and damage model [5]. Note we model only the transient crater formation. Subsequent collapse resulting in complex final crater morphologies is not covered by this study.

Results: Fig. 1 shows an example of a series of numerical cratering experiments in three different target lithologies. The gravity-scaled size π_2 is plotted vs. scaled crater diameter π_D. The brown triangles represent crater formation in a granular material (e.g. dry sand, regolith) characterized by the coefficient of friction and porosity. As expected all points plot along a line (power-law) in a double-logarithmic diagram. The blue squares represent numerical cratering experiments in competent rock. For impactors smaller than *L*=5 m (π_2=1E-7) crater size becomes independent of gravity and crater size scales with the cohesion. The turquoise circles represent numerical cratering experiments in a layered target consisting of (1) a 50m granular material layer, (2) a 1000m transition layer, where porosity decreases and cohesion increases, and (3) competent rock. For very large impactors the data points approach the scaling line for competent rock (blue) as the upper two layers are too thin in comparison to the impactor diameter *L* to have a significant effect on crater formation. For smaller impactors the data points fall exactly on the brown line as the crater are only formed in the upper layer.

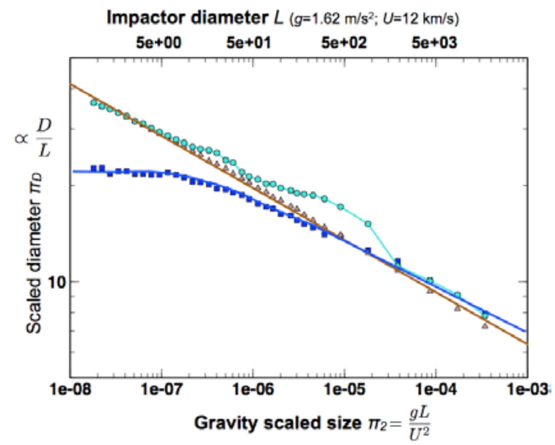

Fig. 1 Gravity-scaled size p2 vs. scaled crater diameter for three different target configurations (see text).

Concussion: Crater scaling is significantly affected by target properties. Layers of different lithologies cause deviations from classical power-law scaling. Surprisingly, crater diameter increases when crater depth reaches down to the boundary between softer and stronger material and/or porous to nonporous lithologies (see bumps in turquoise line).

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