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Numerical modelling of Linné crater

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Abstract

Linné is a 2.2-km crater located at 27.7°N 11.8°E, near the western edge of Mare Serenitatis. Recent high resolution data of LROC has revealed that is an inverted truncated cone, despite it has been addressed as a perfect bowl-shaped simple crater.

Our aim is to investigate via numerical modelling the formation of this crater, to shed some lights in the impact cratering process in light of the new data discoveries.

1. Introduction

Observed for the first time at the beginning of the 19th century, Linné crater is one of the best example of simple fresh crater on the Moon.

It has been usually addressed in the impact literature to evince the “simple-crater” category: in fact, it is a bowl-shaped cavity, surrounded by a circular raised rim and bright ejecta deposit. Its interior is a parabolic-like without central flat floor, with a slope that is steepest near the rim and smoothly decreases towards the crater’s center (e.g., [6]).

However, the recent high-resolution data collected by Lunar Reconnaissance Orbiter Camera (LROC) onboard the NASA spacecraft Lunar Reconnaissance Orbiter (LRO) [9] are pointing to an inverted truncated cone shape for the crater [4].

The investigation of this Linné crater becomes hence of great importance to unravel the physics underlying the impact process.

2. iSALE shock code

Numerical modelling is performed through iSALE shock physics code. The original was developed by [1] for simulating single-material Newtonian-fluid flow, by using either, or a combination, of the Lagrangian and Eulerian descriptions. Since the 1990s, iSALE has been modified to include extensions, correction and enhancements. These modifications include an elasto-plastic constitutive model, fragmentation models, various equations of state (EoS), and multiple materials ([2]; [5]; [7]), whereas the most recent advance was the implementation of a novel porosity compaction model, the ε-α-model [11]. In addition, the code is well tested against laboratory experiments at low and high strain-rates [11] and other hydrocodes [8].

3. Results and Discussion

In this work, we will present the preliminary results about the numerical modelling of Linné crater.

We consider granite as material to represent the target, because it has density similar to the lunar bulk density measured by GRAIL (e.g., [10]). The same material is used to simulate the projectile, for its similar density to porous asteroid and for the convenience of reducing the number of different materials in the model (e.g., [3]).

We adopt 15 km/s for the velocity and we assume a vertical impact, due to the axisymmetric nature of the model.

We are carrying out simulations to constrain the projectile diameters and the shape of the Linné cavity, by comparing the model results with LROC NAC DTM [4].

We found that the inverted truncated cone shape of Linné may be ascribed to a high fracturing of the target material (Fig. 1). For comparison, the adoption of a less fractured target leads to a bowl shaped cavity (Fig. 2). In the two cases, the projectile diameter is of 150 and 200 m, respectively. Similar results are obtained if using basalt instead of granite.

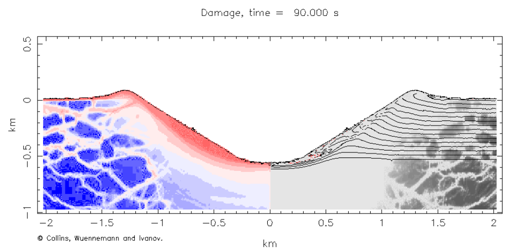

Figure 1: Total Plastic Strain (TPS) vs. Damage plot, when simulating highly fractured target material. The amount of damage is shown on a grey scale, while the TPS contours are illustrated for the same cross section in a colour scale, where red corresponding to the maximum deformation while blue means no deformation.

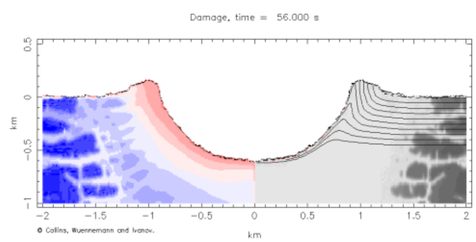

Figure 2: TPS vs. Damage plot, when a less fractured target material is assumed. The colour legend is the same as above.

6. Summary and Conclusions

Crater Linné is a well preserved impact crater, located in NW Mare Serenitatis. The expected bowl-shape for this crater cavity is failed against the new LRO data, which pointed to a inverted-truncated cone. The preliminary numerical modelling investigations led us to suggest that the observed shape cavity may be ascribed to the highly fractured target material, instead of the post-impact modification.

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