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Hydrocode simulations of few Lutetia craters

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Abstract

The flyby of the Rosetta spacecraft at the asteroid Lutetia on July 2011 returned images of about half body with the maximum resolution of 60 m/px. A series of features have been observed, among them 2 impact structures are particularly interesting-depth: the largest crater, called Massilia, with its 57 km of diameter, and, nearby, a 24 km crater located within a crater cluster in the Polar region and younger than the others.

Both craters have been modeled by means of the iSALE hydrocode, finding that the projectiles had diameters of 3.8 km and 8 km for the 24 and 57 km craters, respectively. The principal aim of our analysis is to determine the projectile dimensions, allowing to set stringent constraints on the collisional history of Lutetia, and its internal structure. In fact, the large dimensions of these craters pose challenging questions concerning the size of the impactor and the frequency of such events.

1. Introduction

The ROSETTA spacecraft passed the Main Belt asteroid Lutetia on July 10th, 2010. The imaging system OSIRIS on board took high resolution images of the asteroid surface revealing a very complex object, endowed with a variety of both small scale and major features, pointing to a long and highly complex history [1].

The surface morphology is dominated by different populations of impact craters, whose dimensions span from few hundreds of meters to a few tens of kilometers. In particular, one impact structure, named *Massilia*, with its 57 km of diameter has a size comparable to the radius of the asteroid. This crater, located near the terminator of the high resolution images, is deformed by grooves and pit-chains, indicating modifications that took place during and/or after its initial formation [1]. The asymmetry is mainly due to the fact that part of the wall is lacking. In addition, adjacent to Massilia's rim, a cluster of craters, named *North Pole Craters Cluster* (NPCC), stands out for the presence of a possibly young crater with remarkable dimensions (diameter~24 km, referred hereafter as *NPCC-24*). This crater appears to be asymmetric too, while its interior is dominated by a great variety of deposits, among which smooth and fine deposits with boulders produced by the excavation of shattered bedrock.

2. Model Set Up

The numerical modeling of the impact structures was performed through iSALE shock physics code (e.g., [2], [3], [4]) that is well validated with laboratory experiments and with other hydrocodes ([5]).
To model both the impact events generating Massilia and NPCC-24, we consider the same model setup. The global shape of Lutetia was obtained by combining the stereo-photoclinometry on OSIRIS images and the inversion of photometric light curves and contours of adaptive-optics images ([6], [7]). The overall asteroid's dimensions are (126 ± 1) × (103 ± 1) × (95 ± 13) km^3 along the principal axes of inertia [1]. In the model we have assumed the asteroid a sphere with a radius of 50 km, made by dunite.
The projectiles are assumed to be made by dunite hitting the surface with a vertical velocity of 4.3 km/s.

Finally, a high-resolution digital terrain model (DTM), derived by stereo-photogrammetric analysis of OSIRIS NAC images [8], was used for the derivation of DTM profiles.

3. Results

3.1 Massilia

The DTM profile shows the Massilia crater with a diameter of 57 km and a depth of 4.5 km. To better reproduce these values, we adopted a 8 km-diameter projectile. The final model crater results to be 55 km in diameter and 4.5 in depth.
This impact gave rise to a series of fractures involved the upper layer of the asteroid and the overall body, but did not completely shatter Lutetia. The most damaged region involved is the one up to 15 km below the crater floor.
According to this modeling analysis and the current main belt impact rate suggests that such an impact occur every ~18 Gyr, therefore the impact is likely to have occurred relatively early in the Solar System history when the collisional environment in the asteroid belt was more intense.

3.2 NPCC-24

The NPCC-24 crater dimensions obtained from the DTM profile are 24 km and 4 km, respectively as diameter and depth. To reproduce these values, we adopted a 3.8 km-diameter projectile.
According to the current main belt impact rate, the projectile dimensions suggest that such an impact occur every ~3.8 Gyr.

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