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Hydrocode modeling of the largest impact crater on Lutetia, a key to the inner structure of the asteroid

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Abstract

The question whether the asteroid (21)Lutetia is differentiated or not is highly debated since ESA's spacecraft Rosetta flew by the asteroid on the 10^{th} of July 2010. High resolution images from the OSIRIS camera system [1] and mass estimation from RSI experiment [2] lead to an average density of 3400 $\mathrm{kg/m^3}$, larger than what is normally expected for an asteroid (see [3] for typical densities). As we know the surface to be very porous (density 2400 $\mathrm{kg/m^3}$) for the first kilometers we expect much denser layers below, and some level of differentiation. So far no mineralogical evidence has been found to support or invalidate this hypothesis.

The possibility has been investigated by many authors. The study of [4] showed that Lutetia is at the limit of differentiation. From what we know of this asteroid, only minor differences in its initial composition and location in the accretion disk would shift the balance towards a differentiated body or not. [5] investigated this problem by reconstructing the gravity field of Lutetia assuming different possible inner structures (no, partial, and full differentiation) and studied how the resulting gravity pattern on the surface would be compatible with the observed avalanches and other granular flows. They found that most of the visible flows require a gravity field that is more in agreement with a differentiated Lutetia, although this evidence is very tenuous.

We tested the inner structure scenarios (Fig.1) proposed by [5] by performing impact simulations using iSALE hydrocode [6, 7, 8]. The same code is used by [9] to investigate the shape of two craters on Lutetia but without considering explicitly the influence of differentiation. We used our model to put some constraints on the density and layering of the first 5 to 10 km surface layer which can be responsible for the crater morphology [10]. We also discussed qualitatively the effects of different interior models on the shape (Fig.2) of the largest crater Massilia (∼55 km in diameter, ∼5 km in depth) observed on Lutetia. This current study is the continuation of the previously presented work. We compare now all morphological parameters of the craters obtained from our simulations with the real ones derived from the shape model produced by [11]. We look in details at the topographic profiles, diameter and depth, and the slopes distributions in the crater flanks, for several realistic interior models.

References

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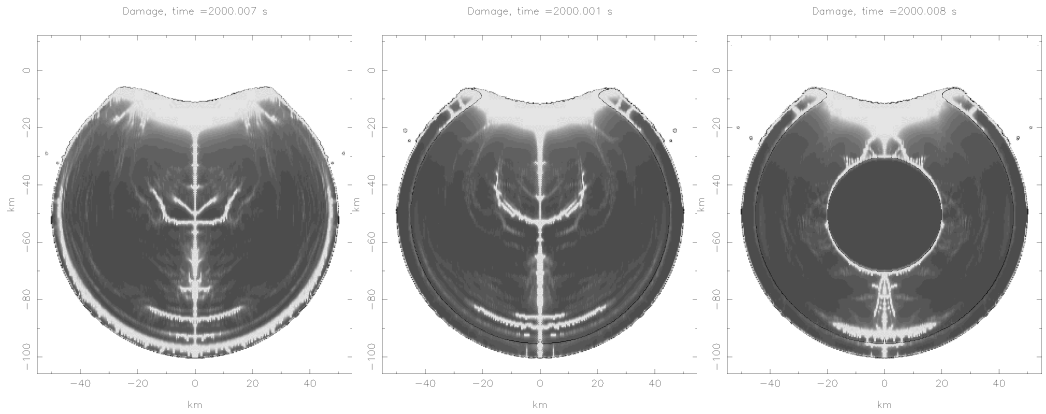
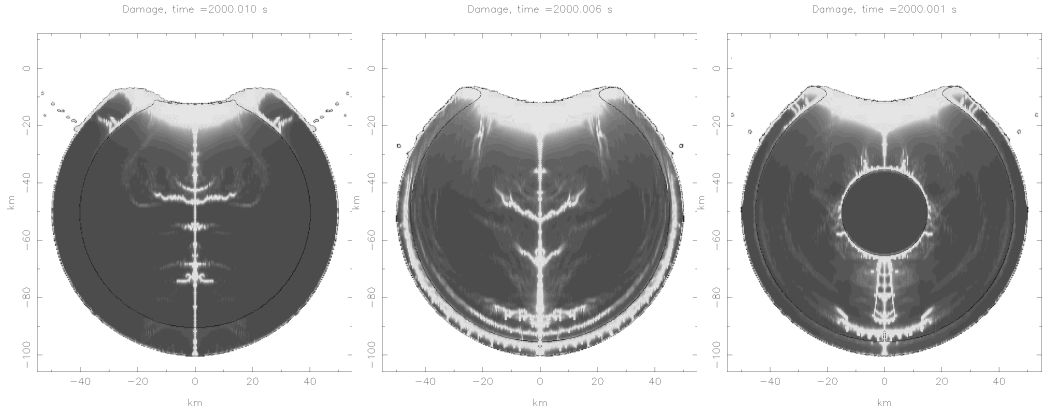


(a) No surface layers (b) 30% porous 5km surface (c) 30% porous 5km surface and 20km core



(d) 30% porous 10km surface (e) 5km surface with gradient in porosity (f) 30% porous 5km surface and 20km core

Figure 1: Crater shape and damage patterns for different interior models.

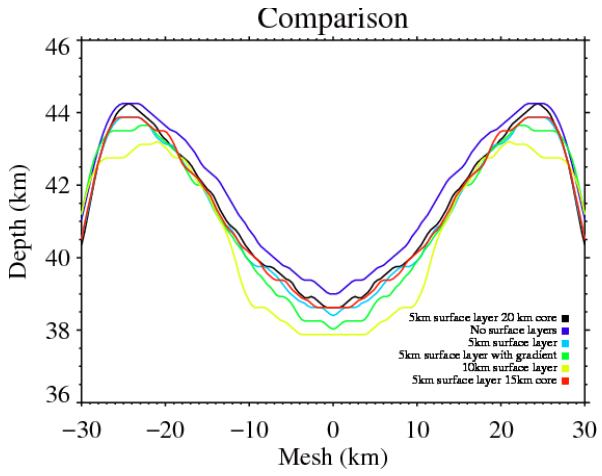


Figure 2: Comparison of the crater profiles in different models.