Impacts on a differentiated Lutetia

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Differentiated Lutetia ?

Is (21)Lutetia differentiated ? This question is highly debated since ESA's spacecraft Rosetta flew by the asteroid on the 10th of July 2010. High resolution images form the OSIRIS camera system (Sierks, et al., 2011) and mass estimation from RSI experiment (Pätzold, et al., 2011) lead to a density of 3400 $\mathrm{kg/m^3}$, larger that what is normally expected for an asteroid. This number is an average for the whole body, and 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. Whether Lutetia is fully differentiated down to the level of forming an iron core or only partially with some inner "islands" enriched in irons is not known yet. The possibility has been investigated by Weiss, et al. (2011) and it appears that Lutetia is on the edge 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.

Past investigations

So far no mineralogic evidence has been found to support or invalidate this theory. However this is not so surprising, given the fact that the surface of Lutetia has experienced many modifications and is covered in a thick layer of regolith more or less homogenous across all the observed regions of the asteroid. Vincent, et al. (2011) took a different approach to investigate this problem. They reconstructed 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.

The ongoing work

This study follows the work by Weiss and Vincent, and looks at the differentiation from the point of view of the morphology of the largest crater observed on Lutetia. Massilia crater (Fig. 1, left panel) is 60 km wide and about 5 km deep. It is covered in fine regolith which can flow down the crater flanks following small impacts (Vincent, et al., 2012). The shape of the crater is far from a simple bowl shape and displays some peculiar asymmetries (Fig. 1, right panel). The slopes along the flanks are not constant and the overall morphology cannot be reproduced by an impact on material of constant density (Cremonese, et al., 2011). The shape of the crater can be due to intrinsic failures preexisting in the original body, allowing the material to be ejected preferentially along certain directions, or it can reflect the differentiation. Using the iSALE hydrocode (Amsden, et al., 1980; Ivanov, et al., 1997; Wünnemann, et al., 2006) we try to reproduce this crater and put some constrains on the density and layering of the first 5 to 10 km of the surface which can be responsible for the crater morphology. In a second step we study how the damage pattern propagates inside the body for different possible inner structure. This will be used to understand better the formation and distribution of grooves across the surface, and whether they are linked to the Massilia crater or not.

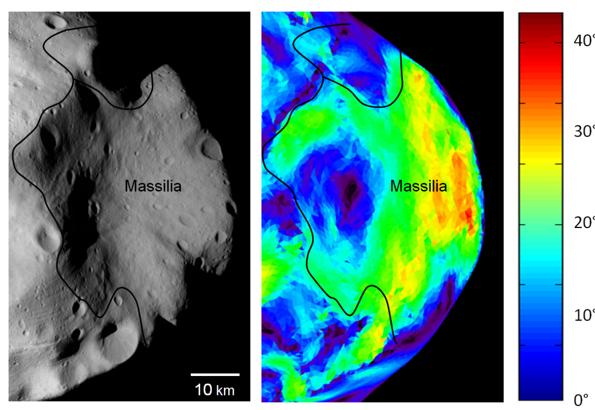

Figure 1: View of the Narnonensis region showing the distribution of slopes inside the Massilia crater. Slopes on the flanks of this crater are among the highest on Lutetia. They are measured with respect to the local gravity vector.

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