3D STUDY OF LUTETIA LINEAMENTS: NEW CLUES TO UNDERSTAND THE ASTEROID ORIGIN.

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Introduction: The Scientific Imaging System for *Rosetta*, OSIRIS (Optical, Spectroscopic, and Infrared Remote Imaging System) on 10 July 2010 acquired an imaging sequence of asteroid 21 Lutetia which allowed a detailed study of the asteroid surface. The images show significant surface features like craters, lineaments, landslides, scarps, and boulders, which indicate a complex geological history [1]. On the basis of topographic boundaries, overlapping relationships, crater density, surface texture, and lineament pervasiveness, 8 different regions have been detected [2]. However, one of the most striking aspect of Lutetia is the huge number of observed lineaments. They intensely pervade the oldest units (Noricum and Achaia regions) but they do not interest the youngest one (Baetica region). Several categories of features has been observed, like: (i) troughs (graben), that are generally 1 km wide possibly result of extension due to tensile stress, (ii) faults, which are linear and articulated with splays; (iii) isolated steep scarps, often separating different surface textures, and finally (iv) ridges that are major structural features associated to topographic high. These lineaments are generally more than 50 km long and seem to form systems [1]. Moreover, in the different stratigraphic regions of the asteroid, the lineaments show a preferred orientation but in all regions there are lineaments which cross or do not follow the local preferred orientation [1].

3D mapping of Lutetia lineaments: On a non-spherical body it is not obvious to determine the relationship occurring between the different lineaments. Actually, lineations that appear to be similarly oriented on different asteroid facets could have no correlation at all or, the other way round, lineaments with different orientations could be of the same system [3]. Therefore, some other method besides visual observation is necessary to determine if surface lineations are organized in systems. In this context, the mapping of the lineations on Lutetia shape model has permitted to obtain a three-dimensional view of these structures and has allowed a better understanding of their effective orientation.

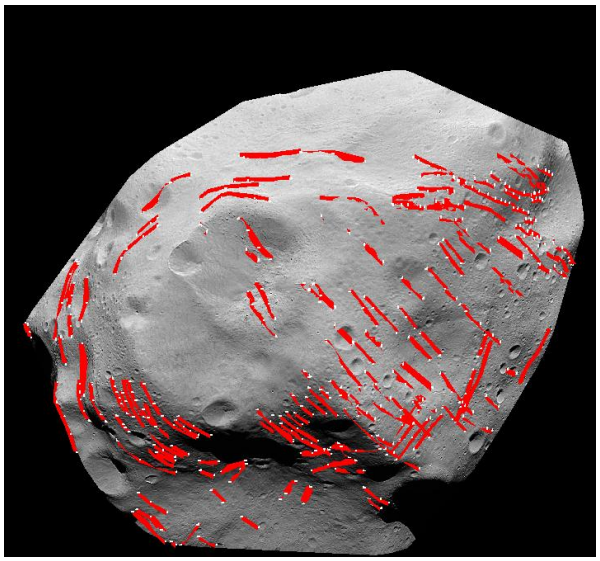

Fig.1 3D mapping of Lutetia lineaments in GOCAD. Lineaments (in red) have been drawn onto the asteroid shape model.

This 3D-study is essential to gain new clues on the origin of these features and to understand if surface lineations are representative of the internal asteroid structure, yielding information about the nature and history of Lutetia.

To accomplish the 3D-mapping of lineaments we employed a shape model of the northern sector of Lutetia [4] imported into GOCAD environment, a software usually adopted by oil companies for real 3D geological reconstructions of subsurface structures [5]. An OSIRIS image (N20100710T154241240ID30F22) at the highest resolution available (68 m/pixel) has been subsequently co-registered with the model (Fig.1). Because the lineations were mapped directly onto the shape model they have a three-dimensional component and can be interpolated to define planes cutting through the asteroid (Fig.2). Then the planes have been plotted in a stereographic projection. Finally, we compared the poles of the planes in order to determine if they were similarly oriented and related to the major craters of the asteroid.

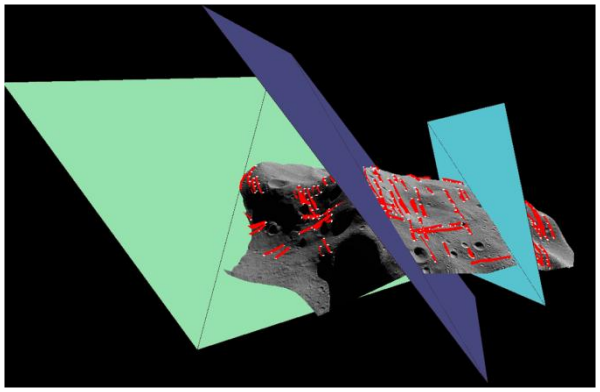

Fig.2 Example of three planes fitting the lineaments and cutting through the asteroid.

Results: We detected several structures concentric with respect to the North Pole Crater Cluster suggesting that these lineaments were originated by these impact events. Moreover, a considerable number of lineaments with the same orientation has been observed. In particular, two main sets have been detected (1st set: Dip ~40° Dip direction ~250°; 2nd set: Dip ~70° Dip direction ~220°). However, these systems show no obviously correlation with any impact events present on the surface. By contrast, the morphology of some major craters seems to be affected by the structural control of pre-existent planes of weakness. This opens new questions on the origin of these features and, in turn, on the internal structure and origin of Lutetia. Although we cannot completely exclude that these iso-oriented lineaments originated from an impact event occurring in the non-visible southern hemisphere, our results suggest that these lineaments pre-existed all major crater on the asteroid surface. Therefore, Lutetia could be a fragment of a bigger parent body affected by impact events that created most of the lineament fabrics OSIRIS observed on its surface. With the destruction of the parent body, the Lutetia fragment retains the history of the bigger body fracturing in its structural fabric.

References: [1] Thomas et al. (2012) *Planet.Space Sci.*, *66*, 96-124. [2] Massironi et al. (2012) *Planet. Space Sci.*, *66*, 125-136. [3] Buczkowski et al., (2007) *Icarus*, *193*, 39-52. [4] Debei et al. (2012) *Planet. Space Sci.*, *77*, 64-72. [5] Mallet, (1992) *NATO-ASI, Math. and Phys. Sciences, 354*, Kluwer Academic Publishers, Dordrecht, 123-141.