(21) LUTETIA'S SURFACE COMPOSITION: LESSON LEARNED FROM THE ROSETTA FLYBY.

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Introduction: During the last several years, the asteroid (21) Lutetia was the object of lively discussions among asteroid experts. During the flyby of the Rosetta spacecraft with (21) Lutetia on July 10, 2010, the instruments OSIRIS, VIRTIS, ALICE, and MIRO were turned on to characterize the surface properties of the asteroid. The obtained results have not solved the ambiguity in understanding of Lutetia's surface composition. Barucci et al. [1] have assembled and analysed all the information available from space missions (Rosetta, Herschel and Spitzer) and ground observations collected over the last 30 years to interpret the Lutetia's surface composition.

Rosetta results: During the flyby, Lutetia presented a pole-on aspect and consequently only about 50% of the surface (northern hemisphere) has been observed by Rosetta spacecraft. The images taken by OSIRIS cameras [2] reveal an object with complex geology. The surface is rich in craters, lineaments, landslides, grooves, boulders and unusual features indicating a complex history. Lutetia seems to be a very old object with an irregular shape and with some smooth younger areas. The lifelong bombardment produced several big craters and many different generations of smaller craters. The North Pole, in the Baetica region, is covered by a thick regolith layer, which flows in major landslides, most likely generated by impact-induced seismic activity. Albedo variations on Lutetia surface have been highlighted and are clearly connected to different compositions and morphologies.

The analysis of the spectral data obtained by VIRTIS [3] revealed featureless spectra between 0.5 and 5.0 µm. The UV ALICE imaging spectrometer results report a precipitous drop between 180 and 160 nm. No similar feature has been observed in the UV reflectance of any asteroid and it is particularly difficult to interpret [4] due to the lack of laboratory data at these wavelengths.

A temperature map has been derived that shows good agreement between the values measured by MIRO and VIRTIS [5], [3], [6]. The thermal inertia has been computed and found to be between 20 and 30 $Jm^{-2}K^{-1}s^{-0.5}$ implying a surface covered by a fine regolith, also confirmed by Spitzer and Herschel observations [7], [8]. Using the mass determined by the RSI experiment [9], a bulk density of 3400±300 kg m^{-3} has been determined for Lutetia, which is one of the highest known densities of any asteroid and it is similar to that of the differentiated asteroid (4) Vesta.

Ground observations results: Ground-based observations of Lutetia using many different techniques have been performed over the last 30 years. All available data show that Lutetia's surface composition is particular with respect to other studied asteroids. The surface of Lutetia is most probably composed of a variety of materials similar to chondrites. None of the known meteorites exactly matches all measured Lutetia's properties [1] .

Conclusions: Search for the best meteorite analogue by matching featureless asteroid and meteorite spectra should be taken with caution. The laboratory spectra is very sensitive to geometry of measurements, sample preparation and grain size distribution. Moreover, asteroid albedo and meteorite reflectance can not be compared directly. Recent arguments given by Vernazza et al. [10] in support of enstatite chondrite composition of Lutetia look only one-sided. Their analysis involved only one near-infrared spectrum obtained from ground and an ad hoc comparison of Lutetia's mid-infrared data with the KBr-diluted spectra of enstatite chondrites. They postulated that Lutetia's surface scattering is dominated by the fine-grained components but ignored particle-size effect when compared with carbonaceos chondrites.

In conclusion, Lutetia is likely a remnant of the primordial planetesimal population. Lutetia is an old object (about 3.5 Ga), possibly partially differentiated [11], with a highly complex surface with a peculiar composition, probably constituted by a mixture of "incompatible" types of materials, like carbonaceous and enstatite chondrites, which may have been aggregated by impacts.

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