EPSC Abstracts
Vol. 5, EPSC2010-340, 2010
European Planetary Science Congress 2010

Rosetta/OSIRIS Observations of the Surface Geomorphology of 21 Lutetia

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Abstract

Expected observations by the OSIRIS imaging system on Rosetta and their importance for geomorphological investigations of 21 Lutetia are described.

1. Introduction

The Rosetta spacecraft will perform a fly-by of the asteroid, 21 Lutetia, on 10 July 2010. The closest approach (CA) distance will be 3000 km. The scientific imaging system, OSIRIS[1], will be acquiring images throughout the fly-by through both its narrow-angle (NAC) and wide-angle (WAC) cameras. The highest spatial scale in the NAC is expected to be 56 m px^{-1} (slightly higher spatial scale than the Galileo SSI at 243 Ida[2]) with WAC images being lower resolution by a factor of 5. Ground-based observations have indicated that Lutetia has a geometric albedo of 0.208±0.025, an effective diameter of 98.3±5.9 km [3], an axial ratio of around 1.8 and a rotation period of 8.1655 h [4]. Accounting for the spectral slope, [3] have refuted the original idea that Lutetia was C-type and an M-type categorization is now suggested although mid-infrared spectra still show similarity to CO3-types [5]. The asteroid will be slightly smaller than the NAC field of view (FOV) if viewed end-on but slightly larger than the FOV if the spacecraft is orthogonal to the long axis. The object should be continuously within the FOV of the WAC.

In this work, we will describe and analyse the surface features of 21 Lutetia and discuss their implications for the structure and geological evolution of the asteroid. We will also compare these observations to other small bodies visited by spacecraft including 253 Mathilde, 243 Ida, and 433 Eros.

2. Expected Observations

The relatively distant fly-by will allow rather complete coverage of one hemisphere. The asteroid will be 100 px across CA-1 h. However, at this time, the spacecraft will be close to zero phase. Hence, any geomorphological interpretation from these early data will have to be based upon limb profiles. The phase angle will reach 30° around CA-4 min. From this time through to CA, a series of images with multiple filters will be acquired in both NAC and WAC. These images (40) will provide the main data set for geomorphological analysis. The OSIRIS colour filters have been extensively calibrated in-flight. These will provide photo-metrically accurate colour ratio maps which have been shown to be of importance for the study of geological units on small bodies such as Phobos and Deimos [5].

Rosetta reaches a phase angle of 90° at CA+1 min. From this point onwards, the observations will provide stronger evidence of topographic relief albeit at decreasing resolution.

3. Expected Results and Potential Comparisons with Other Data Sets

It is to be expected that the surface of Lutetia will be dominated by impact craters. But the influence of these impact craters on the object will be of major interest. The shape of 253 Mathilde was moulded by 4 impact craters which were equal to or greater in diameter than the mean radius of the asteroid itself. Being in the gravity-regime, impacts on small bodies are not affected by the target material and depth/diameter ratios of around 0.2 (or slightly smaller) have been observed. The failure of impacts of this magnitude to disturb or damage the rest of the object has been suggested as evidence for a high porosity which scatters the shock of the impacts and reduces the transmission of seismic energy [e.g. 6]. On the other hand, Phobos shows grooves and lineations which have been interpreted as fractures resulting from the Stickney impact [7] although there are alternative explanations. Other small bodies appear to be intermediate between these two extremes with 243 Ida showing small grooves [2] and 433 Eros and Deimos showing evidence of downslope motion (talus) which might be indicative of destabilization through seismic activity [8,9].

At Lutetia, OSIRIS will need to establish the sizes and depths of major impact features and determine the existence of any phenomena which can be related to the resulting seismic activity.

Ejecta distributions on small bodies remain a complicated topic. Ejecta blocks have been recorded on Ida [10] and Eros [11] while crater rays have been seen in association with a small, apparently fresh, impact crater on Phobos [5]. The resolution of OSIRIS is unlikely to be adequate to address this issue effectively at Lutetia except where blocks combine to form larger structures such as crater rays. On the other hand, crater ejecta might also be studied by their influence (e.g. ponding) on the depths of surrounding older craters [12, 13]. The wide range of phase angles for the OSIRIS observations should be beneficial for such a study.

Surface manifestation of interior structure is typically difficult because of masking by a thick layer of regolith. However, the observations from Eros of the 18 km Rahe Dorsum with its thrust fault morphology [14] suggest that a detailed search for such structures on Lutetia would be warranted.

It is to be expected that even subtle colour differences on Lutetia will be identified by OSIRIS. The importance of colour ratio mapping to identify emplacement of geological units on small bodies has been shown in [5] and will be exploited in the data analysis.

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