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Color and Space Weathering on Lutetia

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1. Introduction

During the flyby in 2010, the OSIRIS camera onboard Rosetta acquired hundreds of high-resolution images of asteroid Lutetia's surface through a range of narrow-band filters. While Lutetia appears very bland in the visible wavelength range, UV color variations were tentatively identified in the Baetica crater cluster (Fig. 1) [1]. As Lutetia remains a poorly understood asteroid, such color variations may provide clues to the nature of its surface. We take the analysis one step further and study color and albedo variability at a much higher spatial resolution than before.

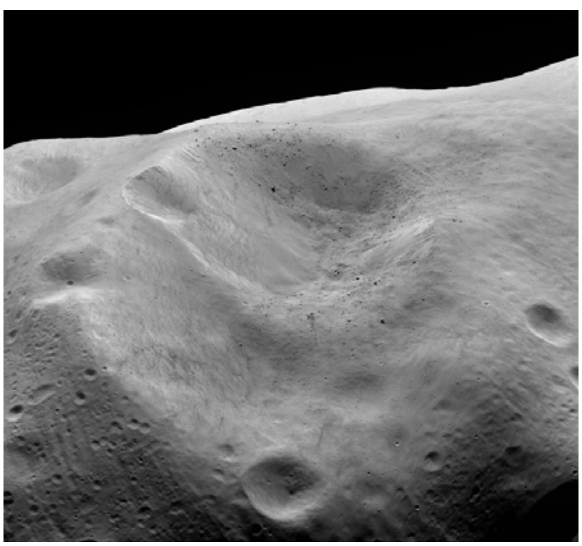

Figure 1: The crater complex in the Baetica region in which color variations were tentatively identified [1].

2. Method

We concentrate our analysis on sets of images in which the images were taken through a sequence of color filters in rapid succession, such that the changes in phase angle and distance to the asteroid are small within the set. We orthorectify the images using the shape model and improved orientation data (orbit position and pointing) that were derived by stereo-photogrammetric analysis [2]. We compensate for the effects of illumination and local topography by photometrically correcting the images. Alternatively, we apply a principal component analysis (PCA) to isolate subtle color variations by eliminating apparent brightness variations due to topography and albedo.

3. Color variations

First we photometrically correct the images with the Hapke model [3]. We find that subtle color variations are associated with the Baetica region (Fig. 2), where the interior of the central crater has an orange tint and a major landslide (*Danuvius Labes*) appears blue.

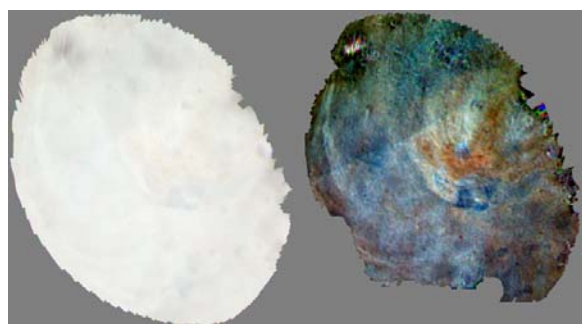

Figure 2: Color composites of the Baetica crater complex. At left a composite of the absolute reflectance, at right a composite of photometrically corrected images (contrast enhanced).

With the PCA we can separate brightness from color variations. The former are isolated in the first principal component whereas the latter are isolated in the higher components (Fig. 3). The associated eigenvectors show us the spectral nature of the dominant color variations. The PCA confirms that the bottom part of the crater cluster is the site of a major landslide that is bluer and darker than average. The top part of the cluster is redder and brighter than average with streaks of material that are oriented radially to the cluster center. We identify these streaks as crater rays.

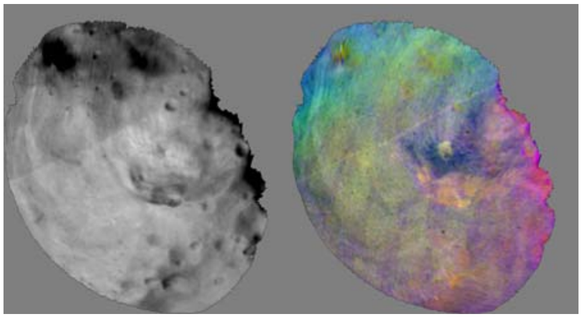

Figure 3: Principal component analysis of a color cube acquired at low phase angle. At left the first principal component, at right a color composite of components 2, 3, and 4.

We interpret the color and albedo variability in terms of the degree of soil maturation, or space weathering, where bright and blue equals fresh and dark and red equals mature. We envision the following scenario: An impact created the central crater and covered the crater floor with a reddish material of either endogenous or exogenous origin. The large landslide postdates the impact and has exposed blue, fresh material.

4. Summary

We analyze subtle color and albedo variations on the surface of asteroid Lutetia as seen by the Rosetta OSIRIS camera. We employ various techniques like photometric correction and principal component analysis. The variations can at least partly be explained in terms of space weathering.

References

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