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Spectrophotometric investigation of the layered structure of comet 67P/Churyumov-Gerasimenko

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Abstract

ESA's Rosetta OSIRIS cameras [1] acquired high resolution images in the NUV-VIS-NIR wavelengths range that allowed the definition of a pervasive layered structure for comet 67P/Churyumov-Gerasimenko [2]. The measurement of the different orientation of the morphological terraces allowed the construction of a three-dimensional ellipsoid-based model (Ellipsoidal Model, EM) defining the structural level of any point of the 67P nucleus in terms of elevation [3]. The model highlights thus that different regions are exposed at different structural elevation. Therefore, a spectrophotometric investigation has been performed on outcropping consolidated materials in order to define possible differences between stacks of layers.

1. Introduction

The images acquired by the OSIRIS cameras allowed to describe a cometary body with a bi-lobed shape [4] characterized by several morphological features [5-6-7-8]. In particular, the morphological terraces, present in ordered sets, can be interpreted as the surface expression of over-imposed layers characterized by discontinuity surfaces and defining an inner stratification. The different orientation of the terraces and cuestas has been derived and used by [2] to obtain geological cross-sections that allowed to define the presence of a nearly continuous stratification. The calculation of the angular deviations, namely the differences between the perpendicular to the fitting planes and the local gravity vector fields, both for the entire comet as well as for the two distinct lobes, unequivocally confirms the presence of an onion-like stratification that independently envelopes each lobe. Furthermore, by measuring the orientation of a large number of terraces and mesas scattered on both lobes, [3] reconstructed a three-dimensional geometrical model (EM) based on a number of concentric ellipsoidal shells. That model can reproduce the inner layering of the cometary nucleus and accurately predict the intersection of layers with the topography. Therefore, the EM can be used to define the position, namely the structural elevation, of any point on the cometary surface as a distance from the structural centre of the reference lobe. Concerning the two distinct lobes, it is thus possible to identify regions, or areas, localized at different structural elevations relatively to the EM. This is the starting point of the spectrophotometric analysis performed.

2. Methods

For the spectrophotometric investigation of the two lobes, two OSIRIS-NAC sequences of post-perihelion images per lobe were selected. Those sequences cover the maximum number of available filters and have similar spatial resolutions and phase angles. According to the EM, the framed regions are located at different structural elevations, with the innermost and outermost layers corresponding respectively to Imhotep and Apis regions for the big lobe (BL) and to Wosret and Bastet regions for the small lobe (SL). The sequences were then converted to reflectance and photometrically corrected using the Akimov photometric model [9, and reference therein] in order to obtain multispectral images. For each dataset, a geomorphological map was realized in order to easily distinguish outcropping consolidated materials from deposits. A two-classes supervised classification was firstly used to mask the fine material deposits, obtaining datasets constituted exclusively by outcropping materials and relative coarse deposits, which can be considered autochthonous materials. On masked multispectral images a supervised classification was then applied on the basis of the structural elevation in order to verify if layers located at different elevations display different spectral characteristics.

3. Results

The spatial distribution of the obtained classes highlights a dependence on the structural elevation defined by the EM. In particular, outcropping materials located at different elevations are characterized by a different brightness, with the outermost classes that result darker than the innermost ones. On the contrary, once normalized to the green wavelength (535.7 nm), reflectance values of all the classes display no substantial differences.

4. Conclusions

The obtained results are congruent between the BL and SL: the spectral dichotomy observed between layers located at different structural elevations can be mainly due to differences in the composition and/or textural properties of the cometary nucleus [10].

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