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Surface compositional variation on the comet 67P/Churyumov-Gerasimenko by OSIRIS data

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Abstract

Since the Rosetta mission arrived at the comet 67P/Churyumov-Gerasimenko (67/P C-G) on July 2014, the comet nucleus has been mapped by both OSIRIS (Optical, Spectroscopic, and Infrared Remote Imaging System, [1]) NAC (Narrow Angle Camera) and WAC (Wide Angle Camera) acquiring a huge quantity of surface's images at different wavelength bands, under variable illumination conditions and spatial resolution, and producing the most detailed maps at the highest spatial resolution of a comet nucleus surface.

67/P C-G's nucleus shows an irregular bi-lobed shape of complex morphology with terrains showing intricate features [2, 3] and a heterogeneity surface at different scales.

1. Introduction

The Narrow Angle Camera (NAC) was designed to study the nucleus with eleven large band filters at different wavelengths from the ultraviolet (269 nm) to the near-infrared (989 nm), while the Wide Angle Camera (WAC) is devoted to the study of gaseous species in the coma with a set of eleven narrow band filters ranging from the ultraviolet to visible.

The OSIRIS imaging system has been the first instrument with the capability to map a comet surface at high resolution with its filters and reached a maximum resolution of 11 cm during the closest fly by on February 14, 2015 at a distance of ~ 6 km from the nucleus surface.

Our analysis is carried out on images obtained with different filters at close sequences. Due to the time necessary to switch filters and acquire new images, the images of a colour series are taken at intervals of about 15 seconds. As during this time the comet rotates and the spacecraft moves onto its trajectory, the co-registered images acquired through the different filters are corrected by illumination [4] and the reflectance spectro-photometry and spectral map are extracted.

2. Results

Global colour images of the nucleus reveal a generally dark surface with geometric albedo of 6.5±0.2% at 649 nm and surface albedo variations up to ~ 30% [4].

The images taken at beginning of August when the spacecraft was at about 100 km from the comet at different rotational phases were analysed and the spectral slope were computed for each pixel of the surface in the 535-882 nm range [4].
Three groups of terrains have been identified based on the spectral slopes: i) group 1 with low spectral slope (comprise between 11 and 14%/(100 nm) and higher albedo. This group includes Hathor, Hapi, Babi, partial Seth regions and a portion of the Ma'at region ; ii) group 2 with average spectral slope (between 14 and 18%/(100 nm) and including Anuket, Serqet, regions and partially Ma'at, Ash ; iii) group 3 with high spectral slope (above 18%/(100

nm) which includes Apis region, Hatmehit depression (small lobe) and partially several other regions. The three groups are distributed everywhere in the nucleus, with no evident distinction between the small and large lobe. Spectral variations have been also observed by the VIRTIS imaging spectrometer in the visible and near-infrared (up to 5 μm) range [5].

To better investigate the surface colour variations, we analyse the same images [4] with the G-mode multivariate statistics [6]. The G-mode method is a unsupervised statistical classification method that allows the user to obtain an automatic clustering of a statistical sample of homogeneous taxonomic groups with no a priori grouping criteria and taking into account the instrumental errors in measuring each variable. The method also gives indications of the relative importance of the variables in separating the groups [6, 7, 8] and allows to investigate the existence of the finer structures on the samples. G-mode statistics were applied to the images taken on August 6 at a phase angle of 50° with a surface resolution of about 2m/px. The G-mode were applied on the images corrected by illumination conditions derived by SPG shape model [9] using 7 NAC filters from 480 nm (Blue filter) to 989 nm (IR filter).

Local variations are also present at small scale with higher or lower albedo value and clear differences of spectral-photometry properties. The variations are connected with surface composition and rugosity characteristics. Pommerol et al. [10] reported over one hundred meter-sized bright spots in different regions. The bright spots are clustered or isolated, but in general at low insolation. Their albedo is much higher and the spectra are significantly bluer than surrounding area. These observations are associated to the presence of H_2O ice [10] and confirmed by VIRTIS [11]. Spectral photometric variations are found in many different regions and also on the portion of the red Imhotep region observed during the closest fly-by of 14 February 2015. It's well known that spectral slope can change also with the refractory particle size, but the detected variation is not always associated to the surface morphology.

The surface of comet 67P/C-G is highly complex. Both comet lobes show evidence of regions of the surface covered by different layers of dust. These dusty areas are present on many regions of the nucleus surface including areas with evidence of transport of materials [12] for which detailed spectro-photometric analysis is needed.

3. Conclusion

The heterogeneity of the nucleus is evident from the spectro-photometric properties. Compositional interpretation is difficult on the basis of only photometric filters in the NAC NUV-IR range, due to the limited spectral range and to the fact that the comet surface is composed by an overlap of different components, but we detect a clear evidence of the compositional variability.

The majority of the surface shows a red visible spectral slope which can be associated to the presence of organic components confirmed also by the detection of the broad absorption feature at 3.2 μm band detected by VIRTIS [5, 13, 14] with random bluer areas plus the large region of Hapi where a presence of exposed H_2O ice has been invoked.
The results obtained by OSIRIS data will be presented and compared with those of VIRTIS.

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