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TRANSIENT WATER ICE ON COMET 67P/CHURYMOV-GERASIMENKO

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Introduction: The Visible InfraRed Thermal Imaging Spectrometer, VIRTIS [1] onboard ESA's Rosetta mission started to observe the nucleus of the 67P/Churyumov-Gerasimenko in August 2014. The instrument is composed by two units. VIRTIS-M, the mapping unit of the instrument, relies on a Shafer-Offner optical design and performs imaging spectroscopy in the 0.25-5.1 µm spectral range across 864 channels resulting in a spectral sampling of 1.8 nm/band for wavelengths below 1 µm and 9.7 nm/band between 1-5 µm. The instrument has a 3.7 deg FOV and uses 256 samples with an IFOV of 250 µrad [1]. VIRTIS-H is the high spectral resolution unit, operating between 2-5 µm and it is mainly devoted to the coma study.

Data: Comet 67P/Churyumov-Gerasimenko was observed to be moderately active very far from the perihelion by Rosetta mission, that collected high spatial and spectral resolution data of the comet from VIRTIS [1]. Here we analize the VIRTIS data acquired in the period August-September 2014 (3.6-3.3 AU from the Sun), with a ground spatial resolution varying between 7.5-25 m/pixel, and covering a spectral range of 0.35-5.0 µm.

Results: The first reflectance spectra, taken in different areas over the illuminated regions of the comet's nucleus, show the presence of a broad absorption band at 2.9-3.6 µm, attributed to organic compounds [2]. The same spectra showed the absence of pure water ice absorption bands, indicating an upper limit of about 1% on the water ice abundance at that resolution [2]. Those early data were acquired with a resolution of about 15-30 m/pixel.

In the following observations, VIRTIS acquired data of the "neck" region with a better spatial resolution. In some specific areas of the neck, VIRTIS observed spectral variations moving from the illuminated pixels to the shadowed areas, with a progressive change of the band around 3-µm. This feature shows a clear shape change with a broadening, a shift towards shorter wavelengths and a strong increase of the depth. The characteristics of the spectra showing the stronger 3-µm band indicate the presence of water ice in addition to the organic material present on the comet surface.

Fig.1 shows the region of the neck where the ice signature has been observed, and fig. 2 shows the two spectra taken from the same region, one very close to the shadow and one on the well illuminated area.

The two spectra show a clear difference in the 3-µm spectral range (fig.2). The strong 3-µm ice band is clearly present in all the pixels located at the border of the shadow and it progressevly disappears going far from the shadow. The same regions has been seen at different comet rotations and the same phenomenon has been observed: a stronger 3-µm ice band close to the shadows.

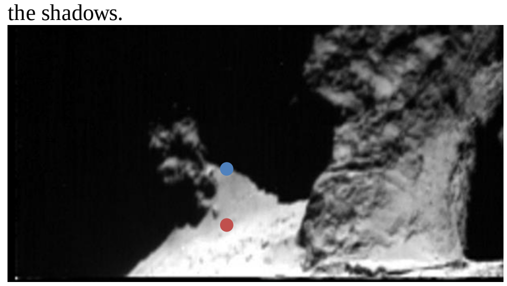

Fig.1. VIRTIS monochromatic image at 0.7-µm of the neck region of 67P. The colored dots indicate the zones from which the spectra in Fig.2 are taken.

The analysis done indicates that the maximum quantity of ice is found very close to the shadows in all the observations, even if the pixels in shadows are different in each image. The observations suggest that the ice is not constant but it depends on the thermophysical condition of the comet surface. The spectra show also different thermal emissions: the spectra with stronger 3-µm band are also charcterized by smaller thermal emissions. A clear anti-correlation trend of ice abundance with temperature is seen in this region of the neck, suggesting that the water ice feature is present only when the temperature is low enough to permit the stability of water ice on comet surface. Thus, we are looking at a process that implies sublimation and condensation of water going from illuminated to not illuminated points.

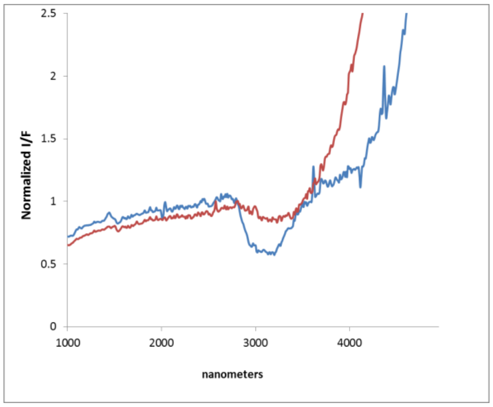

Fig.2 Two spectra taken from the region in fig.1. The red and the blue spectra correspond, respectevely, to the red and blue spots in fig.1.

Two possible mechanisms for the condensation of water ice in the comet unilluminated area can be considered: the condensation of coma material (emitted gas and icy grains) onto cold spots on the nucleus [3] or condensation in the colder external layers of gas coming from subsurface sources [4,5]. Both the mechanisms can be responsible for the phenomenon we see.

Conclusion: Ice has been observed on other cometary surfaces [6] as patches of pure ice mixed with the non-ice component of the surface. In case of comet 9P/Tempel 1, these ice patches were not directly linked with the comet gas activity and the main sources of gases were indicated in the comet interior. On comet 67P, VIRTIS observes surface ice mixed with a non-ice organic rich component, in a region were the localized water activity occurs [7]. Moreover, the ice signature is variable with time and illumination conditions suggesting a cyclic process of sublimation-condensation of water ice on the comet surface.

The cyclic replenishment of ice, due to the light/dark changes, in the first comet layers can be the key for the strong local activity seen from the comet neck.

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