Volatile exposures on the 67P/Churyumov-Gerasimenko nucleus.

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Introduction: Comet 67P/Churyumov-Gerasimenko (hereafter 67P) was extensively studied by the ESA Rosetta/Philae mission during more than two years, from July 2014 to September 2016. Even though the nucleus surface is dominated by dark, carbonaceous and organic-rich material, which originates a red spectrum, ice exposures were observed occasionally on the surface, where they stand out because they are bright and with a blue spectrum, i.e. having a lower spectral slope compared to the average dark terrain.

We present the most extensive catalogue of volatile exposures on comet 67P, built analyzing in a homogenous way the observations of the OSIRIS imaging system onboard Rosetta. We look at the color sequences usually composed of 7-11 filters covering the 250-1000 nm range, at a spatial resolution from a few m/px to 0.1 m/px. To identify the volatiles exposure, we applied the following criteria: a) they should be at least 50% brighter than the comet dark terrain; b) they should have neutral to moderate spectral slope values in the visible range (535 -882 nm); c) they should be larger than 3 pixels.

We identified 603 distinct volatile exposures also called bright spots (BS) distributed in the various morphological terrains of the comet 67P [1]. Icy exposures are more often observed post-perihelion and have typical sub-meter size, with a median areal value of 0.7 m^2. This typical meter-submeter size for the volatile exposures supports the Ciarniello et al. model [2] in which water ice enriched blocks of 0.5-1 m size should be homogeneously distributed in the cometary nucleus embedded in a refractory matrix. This result also indicates that high spatial resolution is mandatory to identify ice on cometary nuclei surfaces.

Bright spots are found isolated or in clusters, with lifetimes ranging from a few minutes-hours, in which case they are very likely frost, to several days-months, in which case they should be considered exposure of the primordial water ice enriched blocks [2]. Several of them are clearly correlated with the cometary activity, being the sources of jets or appearing after an activity event.

The BS spectral slope is much lower than the comet dark terrain, and moreover it evolved toward lower spectral slope values in post-perihelion observations, including several BS having negative spectral slopes, indicating the presence of frost, for the short-lived ones, and of water ice with large grain sizes (> 1000 μm) for those having longer duration.

The minimum duration of the bright spots shows three clusters [1]: an area-independent cluster dominated by short-lifetime frosts; an area-independent cluster with lifetime of 0.5-2 days, probably associated with the seasonal fallout of dehydrated chunks [3]; and an area-dependent cluster with lifetime longer than 2 days consistent with water-driven erosion of the nucleus.

The total surface of exposed water ice is less than 50000 m^2, which is 0.1% of the total 67P nucleus surface. This confirms that the surface of comet 67P is dominated by refractory dark terrains, while exposed ice occupies only a tiny fraction. Moreover, the abundance of volatile exposures is six times less in the small lobe than in the big lobe, adding additional evidence to the hypothesis that comet 67P is composed of two distinct bodies.

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