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A global study of the bright features observed on comet 67P/Churyumov-Gerasimenko during the Rosetta mission

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Abstract

During the course of the Rosetta mission, its OSIRIS (Optical, Spectroscopic and Infrared Remote Imaging System) [1] scientific cameras revealed exposed bright features on the nucleus of the Jupiter-family comet 67P/Churyumov-Gerasimenko (hereafter 67P). These have been attributed to the presence of H_2O ice based on their spectrophotometric properties [2],[3], [4], [5]. In this context, we report a comprehensive study of exposed bright features observed by OSIRIS instrument during Rosetta's time spent at 67P. We catalogue such features from early August 2014 up to the end of September 2016, taking into account their morphology and temporal evolution as the heliocentric distance of the comet varied. The objective of this study is to better constrain the morphologies of these bright features, introduce potential triggers for their appearance and monitor their temporal evolution in the event of the availability of multi-filter observations.

Depending on the morphologies and potential formation scenarios of the studied features, we divide them into 5 categories as follows.

1. Isolated patches on smooth terrain
2. Isolated patches close to irregular structures
3. Patches resting on boulders
4. Cluster of features
5. Frost

Results & Discussion

Generally, these bright features are preferably located in equatorial regions of the cometary nucleus. The majority of them are concentrated in the range of -30° to +30° of latitudes as evidenced in the map in Fig.1, where red dots correspond to the locations of features attributed to H_2O ice and the blue dot corresponds to the CO_2 ice. The locations of 10 of the H_2O ice features and the CO_2 ice feature hitherto studied are also included therein for the sake of completeness of the map [3],[6],[7].

We find that the isolated patches located on smooth terrain are not directly influenced by shadows whereas on the contrary, isolated patches close to irregular structures often find themselves under shadows. In our analysis of temporal evolution of bright features, we find lifetimes in the order of few weeks and several months for the former and the latter respectively. This indicates that the patches on smooth terrain sublimate away faster than their counterparts. We suggest that both these feature types are created due to surface erosion dominated by the cometary activity towards the perihelion passage of the comet. Then, there have been a number of bright features observed resting on the surface of boulders throughout the course of the Rosetta's observations of 67P. We are able to correlate 2 of them with cometary activity sources. These include an outburst during the perihelion passage that would have modified the local terrain resulting in exposed subsurface icy material in the Khonsu region, and a displacement of a boulder in the Bes region. For the latter we observe that after the displacement, some bright material has appeared on its surface, which was absent beforehand when it was at its original location. Although we are not able to trace any kind of activity for other patches resting on boulders probably due to the absence of observations during the transient activity time, supported by the above 2 cases, it is rational to mention that they are correlated to sources of cometary activity. Furthermore, there have been several observations of clusters of bright features, individually smaller in size compared to the aforementioned features. These clusters have mostly been observed in the pre-perihelion period and they are located near to cliff structures.

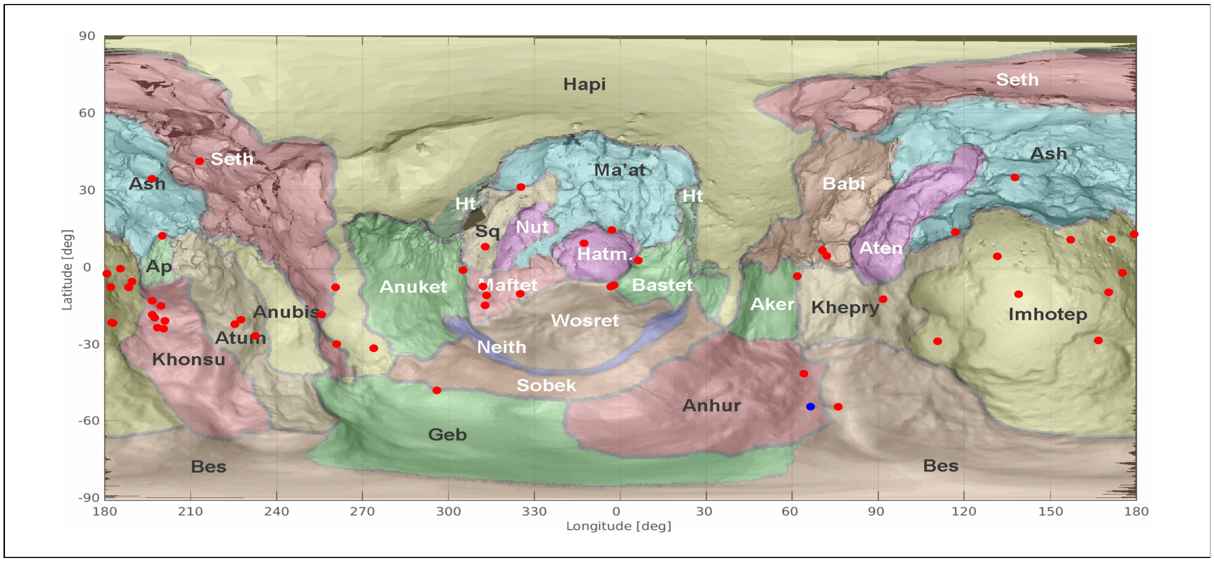

Figure 1: Map of bright features observed on 67P.

structures. Therefore they could be related to cliff collapse events, where the resulting debris expose water ice contained and preserved inside since their formation. Despite the fact that such a cluster could include numerous smaller bright features, it is noteworthy that we consider the cluster in its entirety as a single unit feature in our catalogue.

Frost has been observed since September 2014 (~3.36 AU inbound) [8] to the perihelion passage (1.24 AU) and has been continuously observed towards the end of the mission (~3.8 AU outbound). This frost could be observed at the morning of the comet, where the sun light returns after about 12 hours. Gradually the shadows cast by different morphological structures get shorter as the sun moves towards the local zenith, revealing the frost formed over the cometary night due to condensation of water ice already sublimated previously [9]. Frost is observable for few minutes as it rapidly sublimates away. This process keeps continuing as long as the solar irradiation is strong enough to sublimate the frost and once the comet is beyond the snowline of the solar system, the frost becomes ice as there would not be further sublimation. This diurnal cycle of water got more pronounced as 67P got closer to its perihelion, leading to greater water production rates, as the incident solar radiation increased following the inverse square law. During 67P's perihelion passage, frost was ephemerally visible on a given location cast by shadows.

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