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First analysis of the size-frequency distribution of boulders $\geq$ 7m on comet 67P

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Abstract.

Images of the surface of comet 67P Churyumov-Gerasimenko taken by the OSIRIS camera on board the Rosetta spacecraft have been used to study the statistical distribution and morphological properties of both cluster and isolated roundish structures ('boulders') scattered all over the

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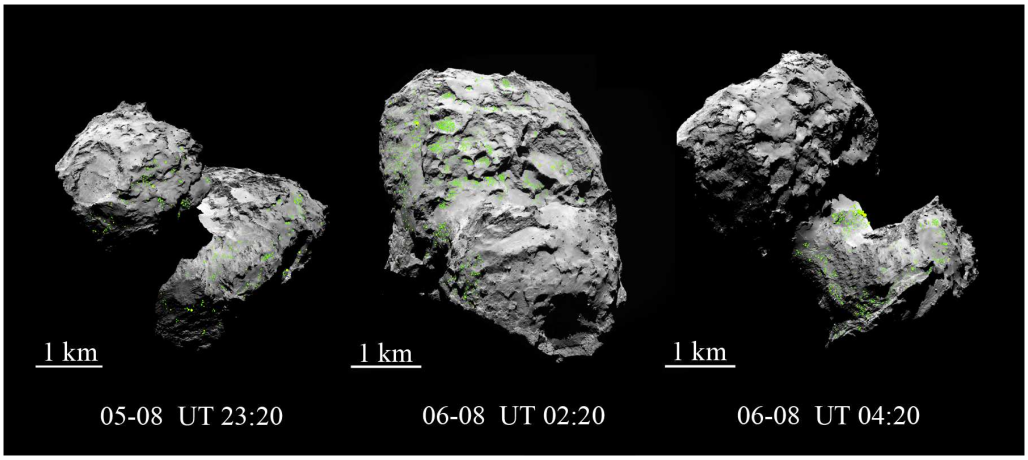

Fig. 1. Three images of 67P showing the spatial distribution of the ≥ 7 m boulders on the illuminated side of 67P (75% of the total surface, equivalent to 36.4 km^2), derived from NAC images taken on Aug 5-6, 2014.

surface. We used NAC images taken on Aug 5-6, 2014, at a distance between 131.45 - 109.76 km, with a spatial resolution ranging from 2.44 - 2.03 m/px (Fig. 1). Such data cover a full rotation of 67P, providing the first ever full size frequency distribution coverage of boulders ≥ 7m visible on a cometary illuminated side.

Boulders are ubiquitous on the head, neck, and body of 67P (Thomas et al. 2015). The initial count of 4 976 boulders was reduced to 3 546 for statistical purposes taking into consideration only those with a diameter larger than 7 m (Pajola et al. 2015).

Of the discarded 1 430 smaller boulders, 602 fall in the 6-7 m bin, 587 are between 5 and 6 m, 222 between 4 and 5 m, and the remaining 19 are inside the 3-4 m bin. The cumulative boulder size-frequency distribution per km^2 of the entire illuminated side of the comet was then derived by considering the surface area of the comet shape model of 67P, which is 36.4 km^2 (Sierks et al. 2015). The resulting plot is presented in Fig. 2: the power-law index value is -3.6 +0.2/-0.3. Such global power-law index suggests that 67P is mostly dominated by boulders that formed during gravitational events triggered by sublimation and/or thermal fracturing causing regressive erosion, as indicated in Pajola et al. (2015). Local boulder fields showing different size-frequency distributions may reflect different origins such as collapses/pit formation with subsequent escape of high-pressure volatiles and consequent high fracturing or evolution of the original material formed during collapsing or gravitational events, but consequently altered by continuous and high sublimation.

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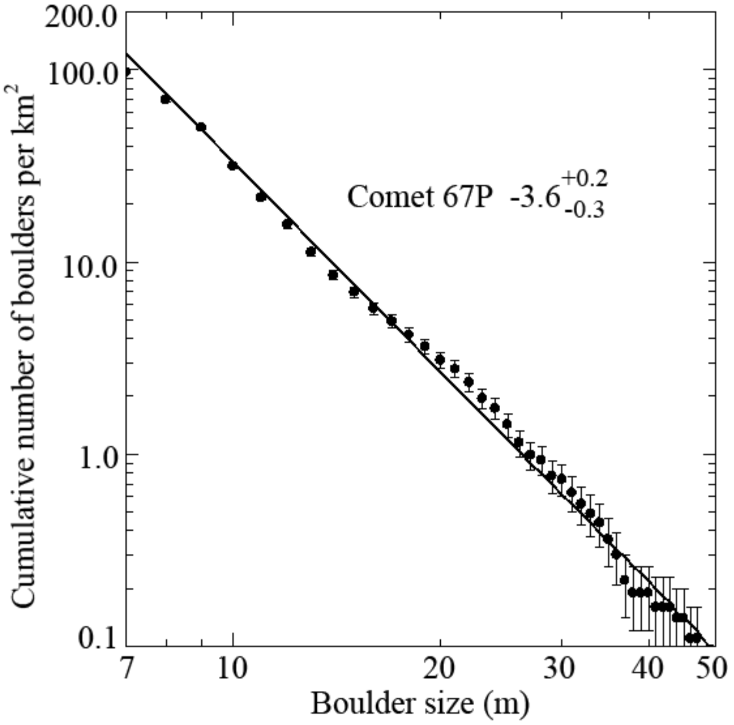

Fig. 2. Cumulative size-frequency distribution of boulders ≥ 7 m per km^2 over the illuminated surface of 67P. Vertical error bars indicate the root of the cumulative number of counting boulders (as from Michikami et al. 2008) divided by the illuminated area of 67P. The continuous line is a fitted regression line to the data, and the power-law index of the size distribution is -3.6 +0.2/-0.3. The bin size is 1 m.

We made use of the Arcgis 10.2 software together with IDL, Matlab, and R software to perform the presented analysis.

References

Michikami, T., Nakamura, A.M., Hirata, N., et al. 2008, Earth, Planets, and Space, 60, 13
Pajola, M., Vincent, J.-B., Guttler, C., et al. 2015, A&A, 583, 37
Sierks, H., Barbieri, C., Lamy, P., et al. 2015, Science, 347, a1044
Thomas, N., Sierks, H., Barbieri, C., et al. 2015, Science, 347, a0440