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Surface changes on comet 67P/Churyumov-Gerasimenko: How do comets evolve with time?

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Abstract

The Rosetta mission spent nearly two years orbiting comet 67P/Churyumov-Gerasimenko allowing it to observe how the comet's surface changed with time. During the Dec 2014–Jun 2016 period, numerous remarkable, yet localized, changes were observed [1–4]. These changes included collapsing cliffs, moving boulders, growing fractures, and peculiar transient surface changes on smooth deposits. The localized changes suggest compositional or physical heterogeneity. However, their scale has not resulted in significant alterations to the comet's landscape. This suggests that most of the major landforms were created early in the comet's current orbital configuration, or earlier if the comet had a larger volatile inventory, particularly of CO/CO_2 ices, or contained amorphous ice, which could trigger activity at larger distances from the Sun.

1. Introduction

During the Dec 2014–Jun 2016 period, numerous remarkable, yet localized, changes were observed using OSIRIS [5] images. Here, we present the most significant events that have occurred.

2. Erosion

Erosion on the surface of the comet appears to begin as in-situ weathering of consolidated surfaces, which acts to weaken these materials causing their fragmentation. This effect is evident in a number of locations as collapsing cliffs. So far, we have observed at least three such events. Two of them on the large lobe [1,2], one of which was also found to be associated with a large outburst [2], and another in

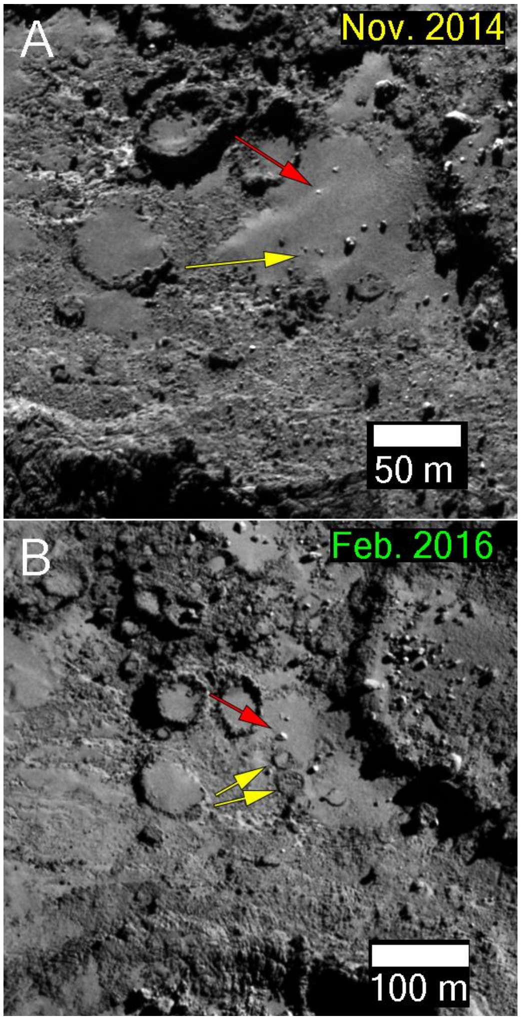

Figure 1: Evidence for erosion on 67P. Smooth materials were removed (> 3 m-thick) exposing underlying features.

the southern neck region. We have also observed extension of a large pre-existing >500 m-long fracture running through the northern neck, whose timing appears to be consistent with changes in the orbital period of the comet and possible evolution of orbital-induced stress in the neck region [e.g., 6]. We also observe movements of large boulder, particularly the displacement of a ~30 m-wide boulder for a distance of ~140 m in the equatorial regions. We have also observed indicators of erosional transport of unconsolidated materials on the surface resulting in the exhumation of previously covered surfaces (Fig. 1).

3. Transient changes

We have observed unique morphological transient changes in the smooth unconsolidated materials that appear to gradually fade away with time or simply stop evolving. These changes are marked by the appearance and/or receding of shallow scarps that tend to exhibit brightening in the rims preceding, and usually persistent during, the changes. Spectrophotometric analysis of these brightened rims is consistent with exposure of ground ice (not frost). Finally, starting in Mar. 2015, numerous patches on the surface of dust-covered terrains underwent textural changes marked by increase in surface roughness to form "honeycomb"-like features [4]. Similar to other seasonal changes, these features have faded substantially in post-perihelion images.

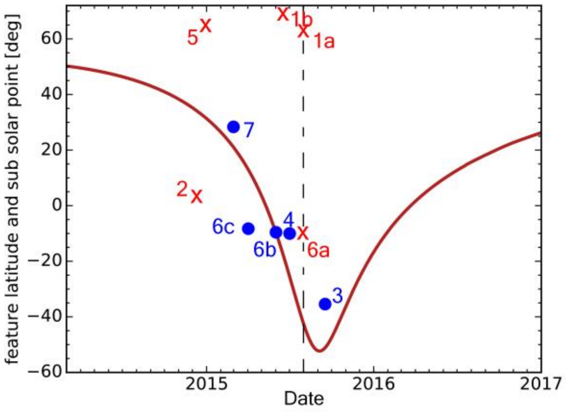

Figure 2: Changes vs. sub solar point. Most events appear to be driven by insolation (blue) with few exceptions (in red). (1) Cliff collapses, (2) Neck fracture evolution, (3) Boulder movement in equatorial region, (4) Erosion (Fig. 1), (5–7) transient changes in smooth materials. Dashed line marks perihelion.

4. Summary and Conclusions

The significant, yet localized, changes in the comet's landscape especially during perihelion suggest that changes to the surface of comets occur on a seasonal scale. Surface changes have mostly occurred around perihelion when the comet was around 2–3 AU. Most changes occur at or close to the sub-solar point, suggesting they are insolation-driven. However, no major changes to the comet's landscape have occurred that have significantly altered its shape or major landforms, even in the southern hemisphere where lower resolution, yet adequate data is available from May 2015. Given that the comet has only spent <10 orbits in its current close configuration since 1959 [7], it is possible that earlier perihelion passages were substantially more active. Alternatively, the comet's landscape may have been shaped up at an earlier period of the comet's lifetime if it had a larger volatile inventory, particularly of CO/CO2 ices or underwent large-scale crystallization of amorphous ice, possibly during its centaur phase [8].

References

[1] El-Maarry M. R. et al. (2017), Science 355. 1392–1395, DOI: 10.1126/science.aak9384.

[2] Pajola, M. et al. (2017), Nature Astronomy 1. DOI:10.1038/s41550-017-0092.

[3] Groussin, O. et al., (2015), Astr. & Astrophy. 583, A-36

[4] Hu X. et al, (), Seasonal erosion and restoration of the dust cover on comet 67P/Churyumov-Gerasimenko as observed by Rosetta/OSIRIS. Astr. & Astrophy. Accepted.

[5] Keller, H. U. et al. (2007), Space Sci. Rev. 128, 433–506.

[6] Hirabayashi, M. et al. (2016). Nature 534, doi:10.1038/nature17670 (2016).

[7] Belyaev, N. et al. (1986), Catalogue of Short-Period Comets, Slovak Academy of Sciences, Astronomical Institute, Bratislava.

[8] Jewitt, D. (2009). Astonom. J. 137, 4296–4312.