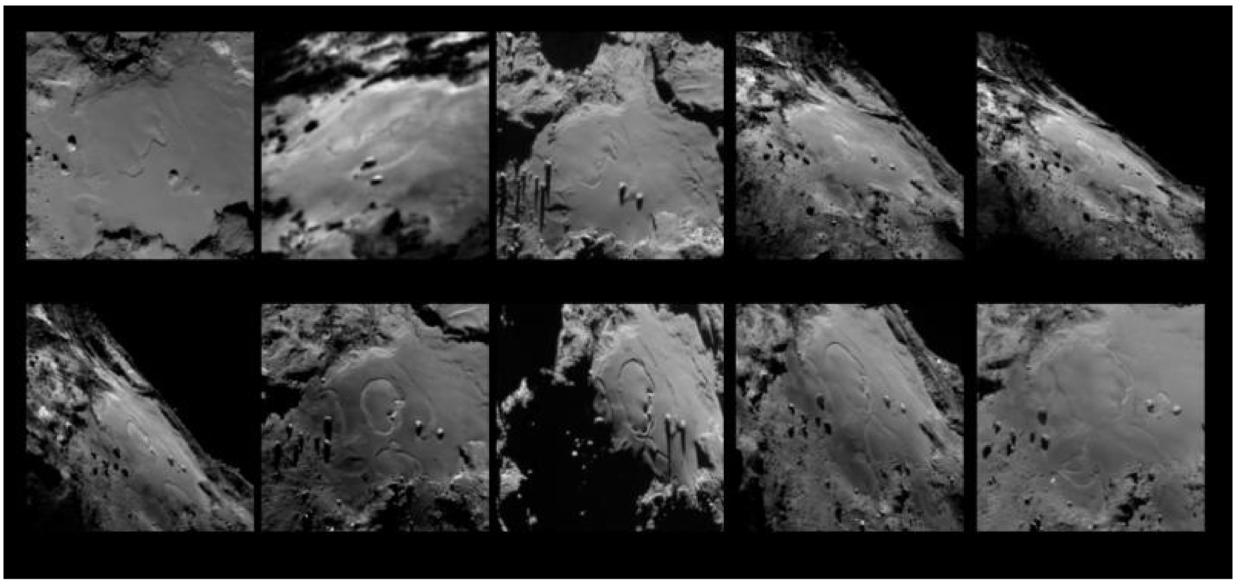
Comet surface changes before Rosetta's eyes

September 22 2015



Sequence of ten images showing changes in the Imhotep region on Comet 67P/Chruymov-Gerasimenko. The images were taken with the OSIRIS narrow-angle camera on Rosetta between 24 May and 11 July 2015. Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

In the months leading to the perihelion of Comet 67P/Churyumov-Gerasimenko, Rosetta scientists have been witnessing dramatic and rapid surface changes on the Imhotep region, as reported in a paper to be published in *Astronomy & Astrophysics*

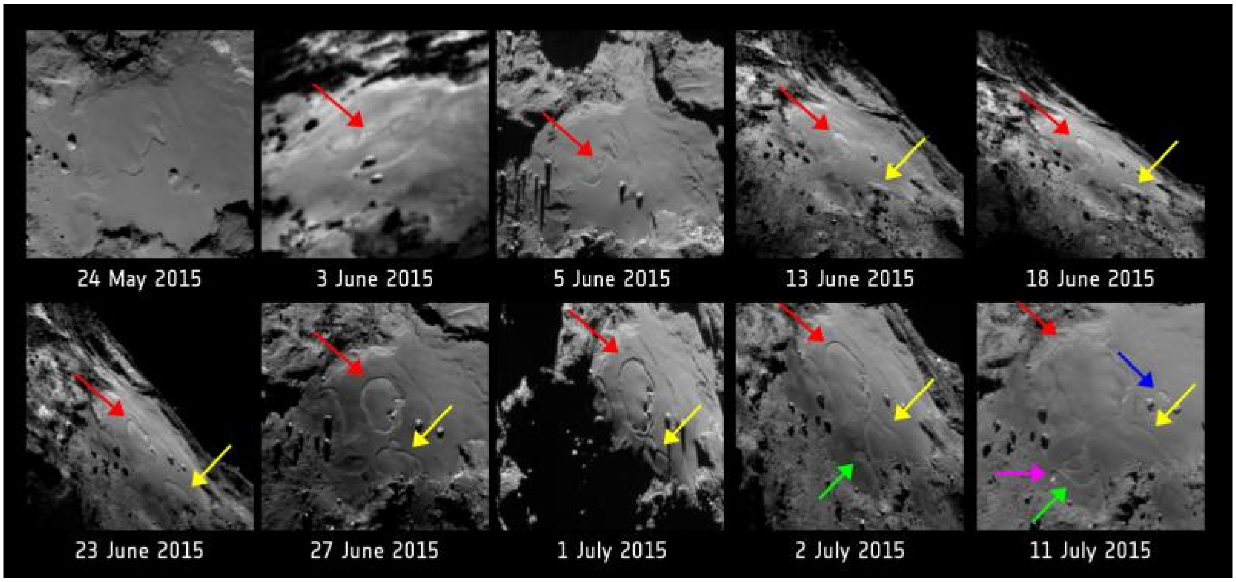
Since arriving at Comet 67P/C-G in August 2014, Rosetta has been witnessing an increase in the activity of the comet, warmed by the ever-closer Sun. A general increase in the outflow of gas and dust has been punctuated by the emergence of jets and dramatic rapid outbursts in the weeks around perihelion, the closest point to the Sun on the comet's orbit, which occurred on 13 August 2015.

But in June 2015, just two months before perihelion, Rosetta scientists started noticing important changes on the surface of the nucleus itself. These very significant alterations have been seen in Imhotep, a region containing smooth terrains covered by fine-grained material as well as large boulders, located on 67P/C-G's large lobe.

"We had been closely monitoring the Imhotep region since August 2014, and as late as May 2015, we had detected no changes down to scales of a tenth of a metre," comments Olivier Groussin, an astronomer at the Laboratoire d'Astrophysique de Marseille, France, OSIRIS Co-Investigator and lead author of the study.

"Then one morning we noticed that something new had happened: the surface of Imhotep had started to change dramatically. The changes kept going on for quite a while."

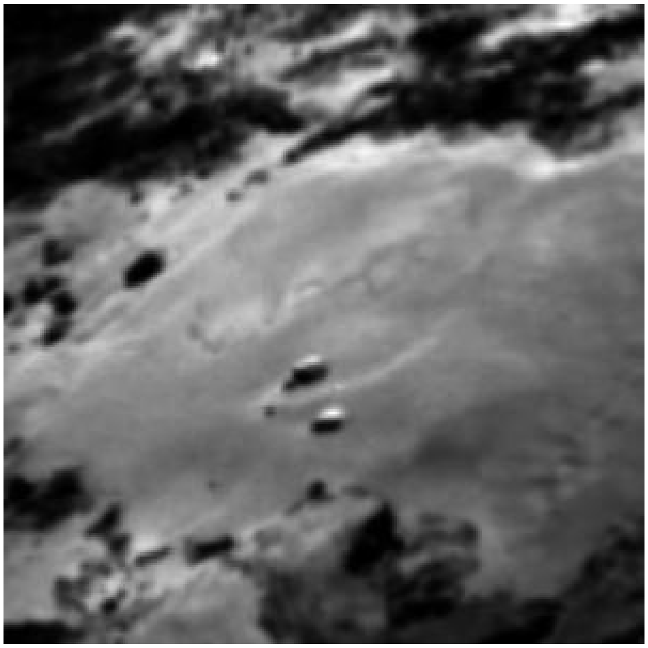
First evidence for a new, roughly round feature in Imhotep was seen in an image taken with Rosetta's OSIRIS narrow-angle camera on 3 June. Subsequent images later in June showed this feature growing in size, and being joined by a second round feature. By 2 July, they had reached diameters of roughly 220 m and 140 m, respectively, and another new feature began to appear.



Annotated version of the sequence of ten images showing changes in the Imhotep region on Comet 67P/Chruymov-Gerasimenko. The images were taken with the OSIRIS narrow-angle camera on Rosetta between 24 May and 11 July 2015. Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

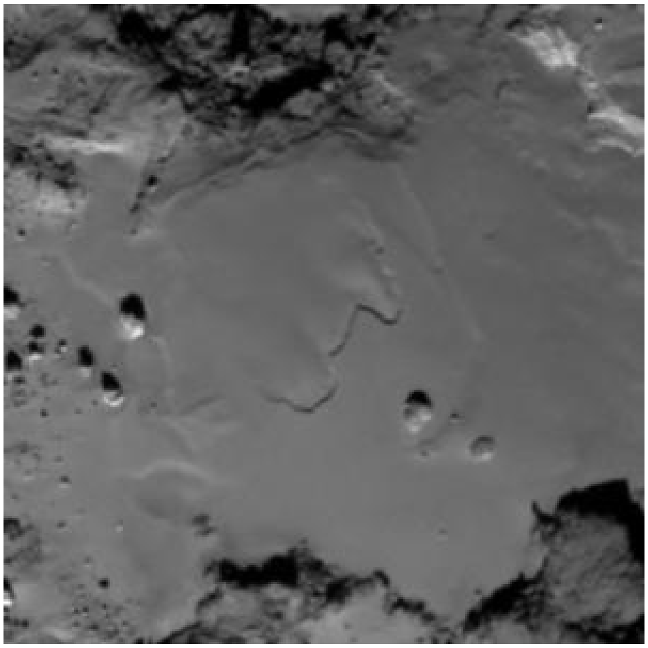
By the time of the last image used in this study, taken on 11 July, these three features had merged into one larger region and yet another two features had appeared.

"These spectacular changes are proceeding extremely rapidly, with the rims of the features expanding by a few tens of centimetres per hour. This highlights the complexity of the physical processes involved," adds Olivier.



The Imhotep region on Comet 67P/C-G on 3 June 2015. Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

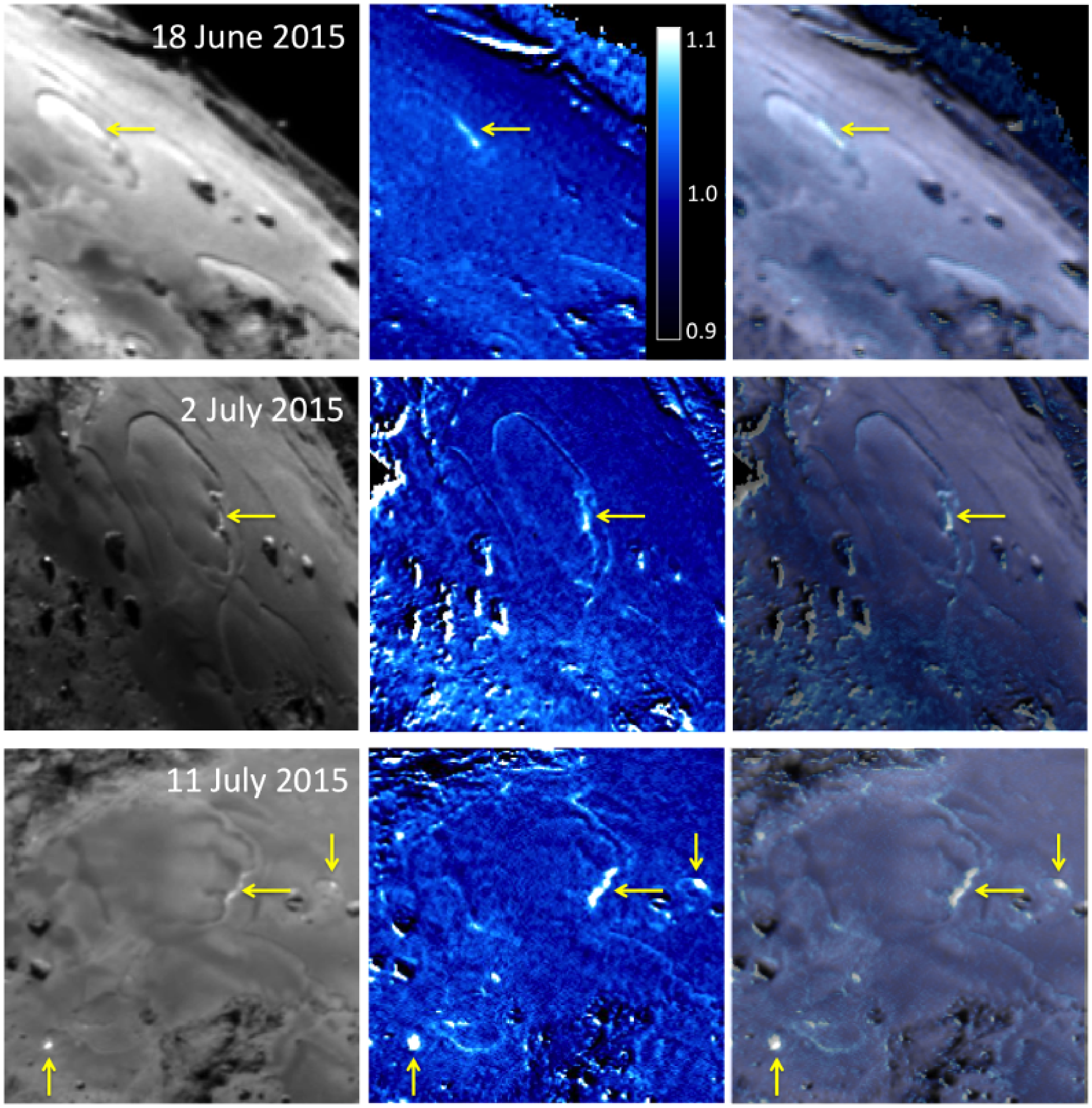
The sublimation of volatile species is clearly an important factor, as colour images of this region reveal the signature of exposed ice on some of the rims of the newly-formed surface features. The rapid rate of expansion is unexpected, however: models of sunlight-driven sublimation would predict erosion rates of just a few centimetres per hour, and thus the scientists believe that additional mechanisms are required to explain the observations.



The Imhotep region on Comet 67P/C-G on 24 May 2015. Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

A simple possibility is that the surface material is very weak, allowing for more rapid erosion, but it is also possible that the crystallisation of amorphous ice or the destabilisation of so-called 'clathrates' (a lattice of one kind of molecule containing other molecules) could liberate energy and thus drive the expansion of the features at faster speeds.

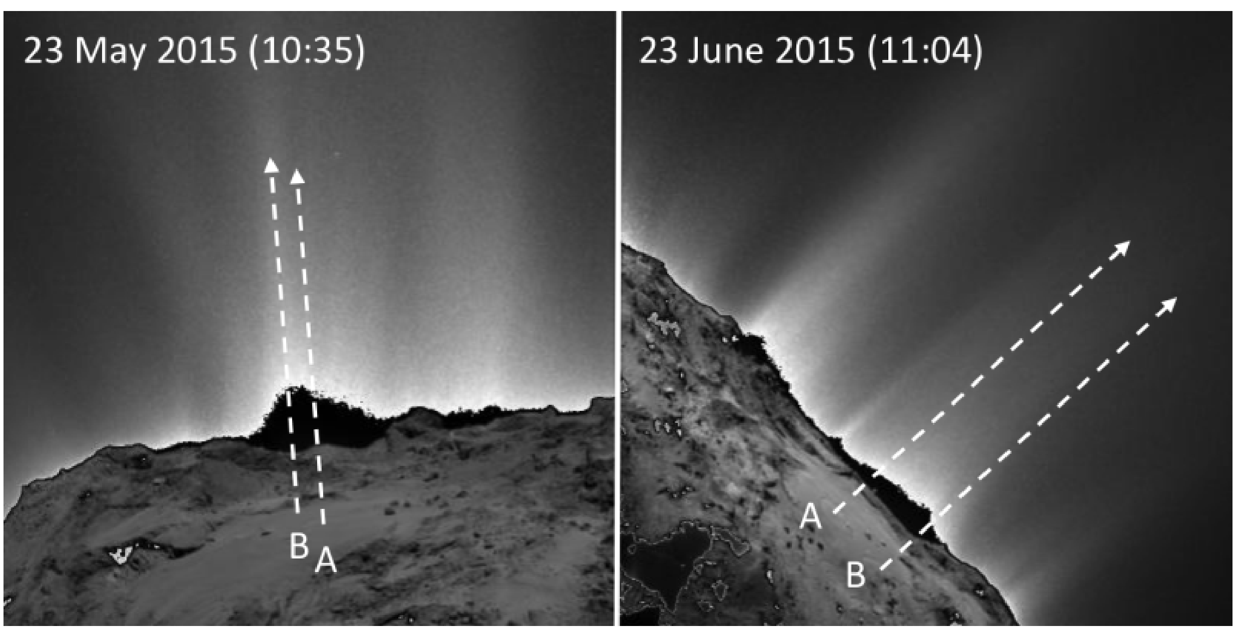
The erosion could be accompanied by increased rates of gas outflow, including H2O, CO2, or CO. The scientists also searched in OSIRIS images for evidence of increased dust rising from Imhotep as the surface morphology evolved, but did not find any.



Colour images of the Imhotep region on Comet 67P/C-G, taken with the OSIRIS narrow-angle camera on Rosetta on 18 June (upper row), 2 July (middle row) and 11 July 2015 (lower row). The first column shows images taken in the orange filter (649 nanometres); the second column shows the ratio between images taken with the blue filter (481 nanometres) and the orange filter for the 18 June and 2 July images, and the ratio between images taken with the blue and the red (701 nanometres) filters for the 11 July image; the third column shows a composite obtained by combining the images in the previous two columns. The yellow arrows indicate some of the new features that were detected on Imhotep. These colour images show that some patches on the surface of the comet reflect orange/red light less effectively and blue light more effectively than their surroundings. They appear as white in the central column, where the colour ratio is shown. This indicates the presence of frozen water ice at or just below the surface of these patches. Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

While it is unlikely that many small (micron-sized) dust particles were released as the features formed and expanded, it is possible that the same amount of mass was released in a smaller number of larger (millimetre-sized) particles, which would produce less reflected light and thus be harder to detect with OSIRIS.

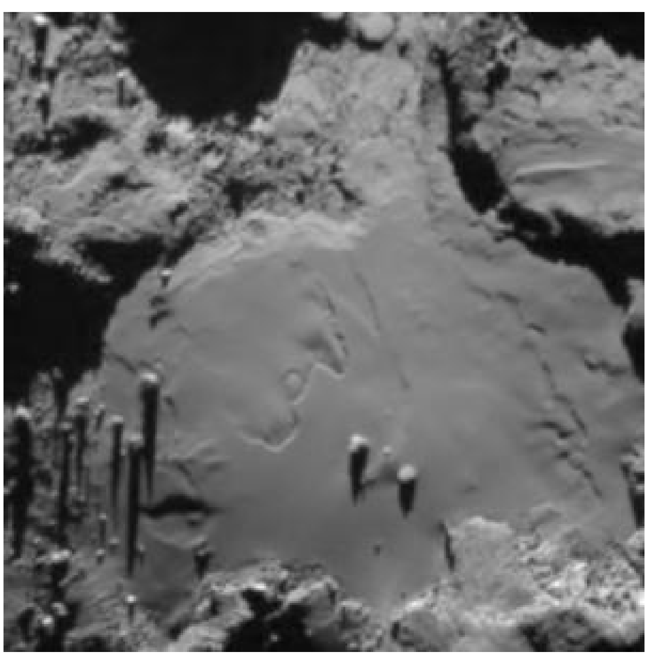
In addition, a significant fraction of the dust released may have immediately fallen back to the surface, accumulating at the base of the expanding rims.



Activity seen above the Imhotep region with the OSIRIS narrow-angle camera on Rosetta on 23 May 2015 (left), before significant morphological changes were seen in this region, and on 23 June 2015 (right), after the changes had begun to appear. (Times are in UT.) The positions of the first two new features that were seen in Imhotep are marked with A and B. The white arrows indicate the direction along which an increase of activity would have been seen in the case of jets lifting from the newly arisen features. Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

Although the scientists were initially surprised to see such significant changes taking place on smooth terrains such as those seen in Imhotep, the location of this region close to the comet's equator guarantees that it receives large amounts of sunlight.

"We are looking forward to combining our OSIRIS observations with data from other instruments on Rosetta, to piece together the origin of these curious features," concludes Olivier.



The Imhotep region on Comet 67P/C-G on 5 June 2015. Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

More information: "Temporal morphological changes in the Imhotep region of comet 67P/Churyumov-Gerasimenko," *A&A*, Received: 21 July 2015 / Accepted: 08 September 2015 DOI: dx.doi.org/10.1051/0004-6361/201527020

Provided by European Space Agency

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