Colors of a comet

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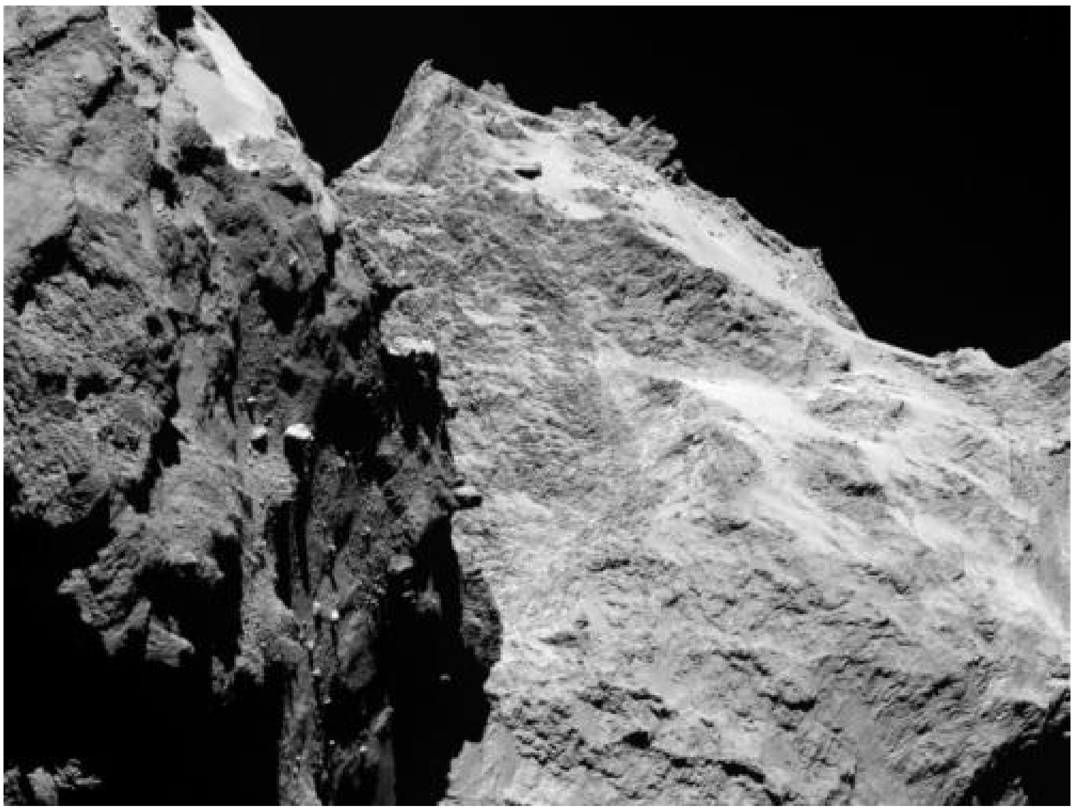

Jagged cliffs and prominent boulders: In this image, several of 67P’s very different surface structures become visible. The left part of the images shows the comet’s “back”, while the right is the back of its “head”. The image was taken by OSIRIS, Rosetta’s scientific imaging system, on September 5th, 2014 from a distance of 62 kilometers. One pixel corresponds to 1.1 meters. Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

OSIRIS, the scientific imaging system of ESA's Rosetta mission to comet 67P/Churyumov-Gerasimenko, shows a surface with subtle, but significant color variations.

To the naked eye comet 67P/Churyumov-Gerasimenko, destination and by now longtime companion of ESA's Rosetta spacecraft, is rather unremarkably colored: black as a piece of coal all over. However, with the help of OSIRIS, Rosetta's onboard scientific imaging system, scientists can make visible subtle, yet comprehensive differences in surface reflectivity. The newest analysis, presented today at the annual meeting of the Division for Planetary Sciences (DPS) of the American Astronomical Society (AAS) in National Harbor (Maryland, USA), thus paints a much more diverse picture of 67P. Not only is the neck region between the comet's two lobes apparently richer in frozen water than surrounding areas. OSIRIS data also show the body to be covered by a porous layer of fine grains and suggest the presence of frozen sulfur dioxide.

Cometary nuclei and other primitive bodies populating the outer regions of the solar system commonly reflect red light slightly more effectively than light of other wavelengths. The effect is believed to be one of the results of space weathering. Images obtained during and shortly after Rosetta's approach phase in July and August of last year with different color filters have now been extensively analyzed and confirm this effect also for 67P.

"Like most cometary nuclei, 67P's reflectivity spectrum is rather smooth and featureless," says OSIRIS team member Sonia Fornasier from the LESIA-Observatoire de Paris/University of Paris Diderot in France, who presented the new results today. Characteristic fingerprints of certain chemical compounds, so-called absorption bands, cannot be found in the wavelengths sampled by OSIRIS—except for a feature centered around 290 nanometers. "This feature lies in the ultraviolet range where instrument calibrations tend to be tricky and need still to be confirmed," says Fornasier. If the feature proves to be real, it is compatible with the presence of frozen sulfur dioxide on the comet's surface," she adds. The gaseous products of sulfur dioxide have been detected in several cometary comae including 67P.

Many of the OSIRIS images analyzed in the new study offer a high spatial resolution of up to almost one meter per pixel. Rosetta can therefore observe differences in surface reflectivity in far greater detail than previous cometary missions. "Using the reflectivity in different wavelengths as a criterion, we were able to identify three different groups of terrains on 67P," Fornasier sums up the extensive analyzes. All three terrains occur on both the comet's lobes, but are often clustered in certain regions. These sometimes, but not always roughly coincide with the 25 different morphological regions so far identified on the comet's surface.

For example, terrain with a slightly suppressed reflectivity of red light can be found mainly in the regions Hapi, Hathor, and in parts of Seth. "Especially the Hapi region on the comet's neck is slightly more bluish than other regions," says Fornasier. This points to a higher abundance of frozen water, as recently confirmed by measurements of the VIRTIS instrument. Terrain reflecting red light most efficiently is concentrated around the Imhotep depression on the large lobe and around the Hatmehit depression on the small lobe.

"The three groups of terrain we identified are not correlated to a particular morphology that may expose material from deeper inside the nucleus," says Fornasier. Therefore, the reflectivity variations of the surface do not show evidence of vertical diversity in the nucleus composition, at least for the first tens of meters.

Apart from composition, reflectivity data can also give insights into the fine structure of surface material. "Between July and August 2014, the

Sun, the comet, and Rosetta were often arranged in very different observing geometries. This can change the amount of light reaching the OSIRIS camera and allows inferences on surface structure," Fornasier explains the basic idea behind this type of analysis. When all three bodies were almost aligned, the measured reflectivity proved to be high. With increasing deviations from this geometry, the surface showed itself darker and darker.

This phenomenon referred to as an opposition surge is known from other bodies in the solar system such as the Moon. It is due to a combination of back scattering and shadow hiding processes in the particulate medium. "Studying this behavior in detail allows us to understand photometric properties of the surface material," says Fornasier.

Again, 67P proves to resemble its cometary siblings such as Wild 2 and Tempel 1 which were visited by previous space missions. Data modeling indicates that the surface is covered by a porous layer of regolith with grains that reflect light in a back scattering manner. The inferred value of porosity of 87 percent is compatible with fractal aggregates which are believed to be the best analogs of cometary dust.

ESA's Rosetta spacecraft arrived at comet 67P/Churyumov-Gerasimenko in August, 2014 after a ten year journey through space. Since then, it has been orbiting the comet at distances varying between six and several hundreds of kilometers. On 12 November, 2014 Rosetta deployed a lander to the comet's surface.

More information: "Spectrophotometric Properties of the Nucleus of Comet 67P/Churyumov-Gerasimenko from the OSIRIS Instrument Onboard the ROSETTA Spacecraft," S. Fornasier et al., 2015 October 30, *Astronomy & Astrophysics* dx.doi.org/10.1051/0004-6361/201525901

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