Rosetta data reveals more surprises about comet 67P

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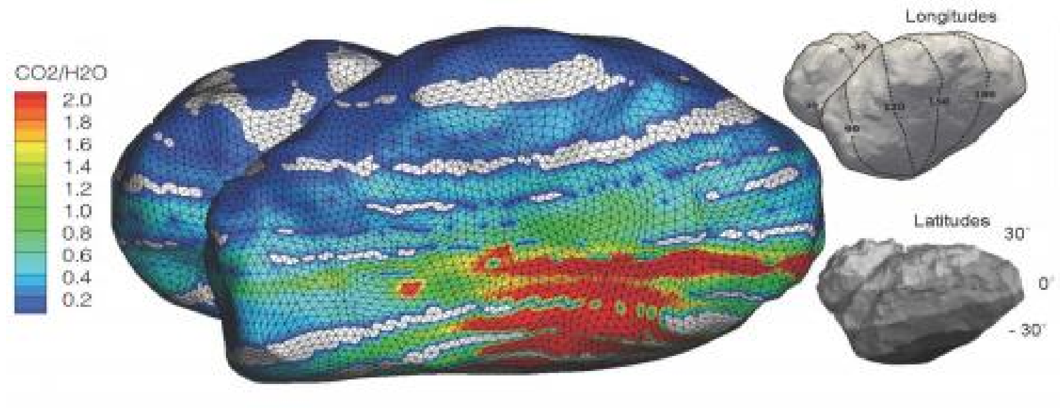

Rosetta scientists measuring the composition of comet 67P's atmosphere or coma discovered that it varies greatly over time. Large fluctuations in composition in a heterogeneous coma indicate day-night and possibly seasonal variations in the major outgassing species: H2O, CO, and CO2. The red region where CO and CO2 dominate is a part of the comet that is poorly illuminated, indicating a complex coma-nucleus relationship where seasonal variations may be driven by temperature differences just below the comet surface. Credit: Shape model credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

As the Rosetta spacecraft orbits comet 67P/Churyumov-Gerasimenko, an international team of scientists have discovered that the comet's atmosphere, or coma, is much less homogenous than expected and comet outgassing varies significantly over time, as reported in a paper published in the Jan. 23, 2015, issue of *Science*.

"If we would have just seen a steady increase of gases as we closed in on the comet, there would be no question about heterogeneity of the nucleus," says Dr. Myrtha Hässig, lead author of the paper titled "Time Variability and Heterogeneity in the Coma of 67P/Churyumov-Gerasimenko" and a postdoctoral researcher at Southwest Research Institute in San Antonio. "Instead we saw spikes in water readings, and a few hours later, a spike in carbon dioxide readings. This variation could be a temperature effect or a seasonal effect, or it could point to the possibility of comet migrations in the early solar system."

"Our whole concept of the variability of volatile release at comets will change based on this paper, which will have significant impact on our understanding of comet formation and evolution," said Dr. Hunter Waite, a program director and planetary scientist at SwRI.

Comets are small solar system bodies with a nucleus composed of ice, dust, and small rocky particle. As comets approach the Sun, they heat up and outgas, displaying visible atmospheres and, often, tails. Comets contain some of the best-preserved material from the formation of our planetary system, offering clues about physical and chemical conditions that existed in the early solar system.

After the European Space Agency Rosetta spacecraft rendezvoused with 67P in August 2014, it made headlines around the world landing a space probe on the comet's surface in November. The lander is now in hibernation, but the Rosetta orbiter continues conducting 11 experiments vital to understanding comets in general and comet 67P specifically, as it approaches the Sun.

"From a telescope, images of a comet's atmosphere suggest that the coma is uniform and does not vary over short periods of hours or days. That's what we were expecting as we approached the comet," said Dr. Stephen Fuselier, a director in the SwRI Space Science and Engineering

Division and the lead U.S. co-investigator for the Rosetta Orbiter Spectrometer for Ion and Neutral Analysis Double Focusing Mass Spectrometer (ROSINA DFMS) instrument. "It was certainly a surprise when we saw time variations from 200 km away. More surprising was that the composition of the coma was also varying by very large amounts. We're taught that comets are made mostly of water ice. For this comet, the coma sometimes contains much more carbon dioxide than water vapor."

The Rosetta mission is providing an opportunity for long-term study of a comet during its sunward approach; the data being discussed are from the initial two-month period of the encounter. Measuring the in situ coma composition at the position of the spacecraft, ROSINA data indicate that the H2O signal is strongest overall; however, there are periods when the CO and CO2 rival that of H2O.

"These large fluctuations in composition in a heterogeneous coma indicate diurnal or day-night and possibly seasonal variations in the major outgassing species," says Hässig. "When I first saw this behavior, I thought something may have been wrong, but after triple-checking the data, we believe 67P has a complex coma-nucleus relationship, with seasonal variations possibly driven by temperature differences just below the comet surface."

The nucleus of 67P consists of two lobes of different sizes, connected by a neck region. This complex, "rubber-ducky" shape likely plays a key role in this variation, as different portions of the nucleus face the Sun during the comet's 12-plus-hour diurnal rotation cycle. If coma composition reflects the composition of the nucleus, variations suggest that the nucleus may have formed by collision of smaller bodies that originated from very different regions of the early solar system. As the comet continues on its 6.5-year journey around the Sun, Rosetta scientists will consider seasonal variations as well.

The ROSINA instrument is led by Principal Investigator Dr. Kathrin Altwegg, a professor at the University of Bern, Switzerland, where Hässig earned her Ph.D. ROSINA, which combines two mass spectrometers with a pressure sensor, was designed, built and calibrated by the University of Bern. The DFMS had hardware contributions from Germany, France, Belgium as well as the University of Michigan and Lockheed Martin in the U.S. The University of Bern operates ROSINA.

More information: "Time variability and heterogeneity in the coma of 67P/Churyumov-Gerasimenko," by M. Hässig et al. *Science*, www.sciencemag.org/lookup/doi/ … 1126/science.aaa0276

Provided by Southwest Research Institute

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