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The salt of the comet

Under the leadership of astrophysicist Kathrin Altwegg, Bernese researchers have found an explanation for why very little nitrogen could previously be accounted for in the nebulous covering of comets: the building block for life predominantly occurs in the form of ammonium salts, the occurrence of which could not previously be measured. The salts may be a further indication that comet impacts may have made life on Earth possible in the first place.

More than 30 years ago, the European comet mission Giotto flew past Halley's comet. The Bernese ion mass spectrometer IMS, led by Prof. em. Hans Balsiger, was on board. A key finding from the measurements taken by this instrument was that there appeared to be a lack of nitrogen in Halley's coma – the nebulous covering of comets which forms when a comet passes close to the sun. Although nitrogen (N) was discovered in the form of ammonia (NH_3) and hydrocyanic acid (HCN), the incidence was far removed from the expected cosmic incidence. More than 30 years later, researchers have solved this mystery thanks to a happy accident. This is a result of the analysis of data from the Bernese mass spectrometer ROSINA, which collected data on the comet 67P/Churyumov-Gerasimenko, called Chury for short, on board the ESA space probe Rosetta (see info box below).

Risky flight through the comet Chury's dust cloud

Less than a month before the end of the Rosetta mission, the space probe was just 1.9 km above the surface of Chury as it flew through a dust cloud from the comet. This resulted in a direct impact of dust in the ion source of the mass spectrometer ROSINA-DFMS (*Rosetta Orbiter Sensor for Ion and Neutral Analysis-Double Focusing Mass Spectrometer*), led by the University of Bern. Kathrin Altwegg, lead researcher on ROSINA and co-author of the new study published today in the prestigious journal *Nature Astronomy*, says: "This dust almost destroyed our instrument and confused Rosetta's position control."

Thanks to the flight through the dust cloud, it was possible to detect substances which normally remain in the cold environment of the comet on the dust particles and therefore cannot be measured. The amount of particles, some of which had never before been measured on a comet, was astonishing. In particular, the incidence of ammonia, the chemical compound of nitrogen and hydrogen with the formula NH_3, was suddenly many times greater. "We came up with the idea that

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the incidence of ammonia in the ROSINA data could potentially be traced back to the occurrence of ammonium salts," explains Altwegg. "As a salt, ammonia has a much higher evaporation temperature than ice and is therefore mostly present in the form of a solid in the cold environment of a comet. It has not been possible to measure these solids either through remote sensing with telescopes or on the spot until now."

Ammonium salt and its role in the emergence of life

Extensive laboratory work was needed in order to prove the presence of these salts in cometary ice. "The ROSINA team has found traces of five different ammonium salts: ammonium chloride, ammonium cyanide, ammonium cyanate, ammonium formate and ammonium acetate," says the chemist on the ROSINA team and co-author of the current study, Dr. Nora Hänni. "Until now, the apparent absence of nitrogen on comets was a mystery. Our study now shows that it is very probable that nitrogen is present on comets, namely in the form of ammonium salts," Hänni continues.

The ammonium salts discovered include several astrobiologically relevant molecules which may result in the development of urea, amino acids, adenine and nucleotides. Kathrin Altwegg says: "This is definitely a further indication that comet impacts may be linked with the emergence of life on Earth."

Publication details:

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Blog article by Kathrin Altwegg about the publication:

https://astronomycommunity.nature.com/channels/1490-behind-the-paper

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The European Space Agency ESA

Europe has been active in space travel and space exploration since the start of the space age. The European Space Agency ESA, in which participating states pool and coordinate their activities, was founded in 1975. Switzerland was among the ten founding members of the ESA; today it comprises 22 member states. Bernese researchers were appointed to ESA's advisory commissions very early on thanks to their proven expertise. Therefore, they also have an influence on which space projects and missions are chosen from the proposals submitted by the scientific community.

More information

Rosetta mission

The mass spectrometer ROSINA was a key experiment undertaken by the Rosetta mission. For over two years, the Rosetta probe carried out a detailed examination of the comet 67P/Churyumov-Gerasimenko, called Chury for short, and in the course of this even landed a landing module on the surface of a comet for the first time ever. The mass spectrometer ROSINA (Rosetta Orbiter Spectrometer for Ion and Neutral Analysis) was developed, built, tested and telecommanded on the comet under the direction of the University of Bern. It was possible to determine many components of Chury's atmosphere – many of which for the first time on a comet. Thus, ROSINA made a significant contribution to the acquisition of new insight into the origin of our solar system. The mission's active phase came to a close in 2016 with the Rosetta probe's controlled crash on the surface of the comet Chury. However, since then, over 2 million data sets from ROSINA are still being evaluated in Bern and being made available to researchers across the world.

More information

Bernese space exploration: With the world's elite since the first moon landing

When the second man, "Buzz" Aldrin, stepped out of the lunar module on July 21, 1969, the first thing he did was to unfurl the Bernese solar wind sail and plant it into the ground on the moon, even before the American flag. This Solarwind Composition experiment (SWC) which was planned and analyzed by Prof. Dr. Johannes Geiss and his team from the Physics Institute of the University of Bern was the first great highlight in the history of Bernese space exploration.

Bernese space exploration has been working with the world's elite since then. The resulting numbers are impressive: Instruments flew into the upper atmosphere and ionosphere with rockets 25 times (1967-1993), 9 times into the stratosphere on balloon flights (1991-2008), over 30 instruments flew on space probes, and with CHEOPS the University of Bern shares responsibility with the ESA for a whole mission.

The successful work of the Department of Space Research and Planetary Sciences (WP) from the Physics Institute of the University of Bern was consolidated by the foundation of a university competence center, the Center for Space and Habitability (CSH). The Swiss National Fund also awarded the University of Bern the national research focus (NFS) PlanetS , which it manages together with the University of Geneva.