SeVoco

Semi-volatiles in a comet

DURATION
15/12/2019 - 15/03/2024

BUDGET
241 777€

PROJECT DESCRIPTION

Comets are considered to be the most pristine bodies in our solar system. The study of comets can therefore provide information on the chemical composition of the protoplanetary disk (4.6 billion years ago) and on the role of comets in the evolution of the solar system.

A comet can be seen as an icy dirt ball describing an elliptical orbit around the Sun. As a comet approaches the Sun, the icy dirt ball (nucleus) gets heated and its ices progressively sublimate to form a tenuous comet atmosphere (gas coma). Smaller grains are dragged along with the gas flow, while larger rocks and boulders fall back to or remain on the surface. The envelope of free grains around the nucleus forms the dust coma (see Figure 1). The grains that are released from the nucleus contain volatile and refractory material. As a function of time and grain temperature, volatile material is progressively lost from the grains and added to the cometary atmosphere until only the refractory grain material remains. A bluish comet ion tail is created as the coma gas is photochemically excited by solar UV radiation. The yellowish comet dust tail is caused by sunlight reflected off the particles in the dust coma, which further spreads as the smaller grains are pushed away from the Sun by radiation pressure

Rosetta, ESA's comet chaser, has studied comet 67P/Churyumov-Gerasimenko (67P in short) for over 2 years and provided a wealth of information on the nucleus and its topography, the gas coma, the dust environment, and the comet-solar wind interaction. However, a specific group of cometary constituents referred to as *semi-volatile* species has remained elusive because none of Rosetta's instruments was specifically designed to measure them. As the name implies, semi-volatile species have a lower volatility, which causes them to be released more slowly from the nucleus and grains compared to more volatile species like H2O, CO2 and O2 (See Figure 2). At this time, very little is known about these species and their importance relative to the volatile and refractory reservoirs. As such, their role in solar system formation and evolution is unclear. We intend to learn more about these species in the SeVoCo project.

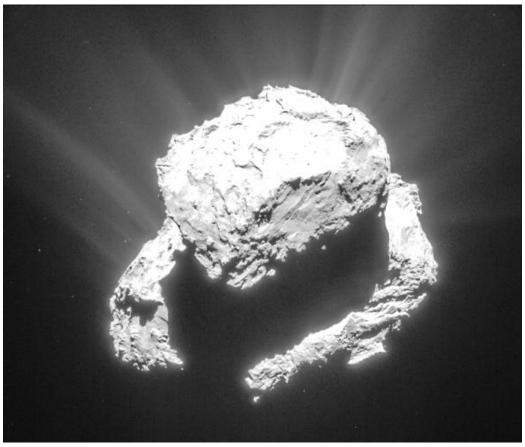

Figure 1: Comet 67P on 9 March 2015 from a distance of 71.9 km. Many dust jets can be seen against the dark backdrop. Credits: ESA/Rosetta/NAVCAM – CC BY-SA IGO 3.0

As semi-volatile species are progressively released from grains, their abundance in the gas coma relative to the abundance of volatile species (mostly directly released from the nucleus) will increase as a function of distance from the comet. This knowledge can be applied to identify semi-volatile species in the gas coma. We can therefore indirectly learn more about semi-volatile compounds from the gas composition measurements of 67P obtained at various distances from the comet with the ROSINA/DFMS sensor. We will use this approach to identify semi-volatile species in the gas coma.

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Semi-volatile species typically have a low abundance in the gas phase, so extra care must be taken during DFMS data treatment so that all instrumental effects are adequately corrected for. We will use data analysis software developed to treat DFMS data for the complete Rosetta mission in a consistent manner. Since a lot of parameters are constantly changing during the measurements, in-situ DFMS measurements are not easy to interpret. To disentangle the effects of all these parameters, we will rely on our available coma model for the behavior of the refractory, semi-volatile and volatile components in the comet atmosphere. By comparing model and observations, we can identify semi-volatile species and obtain insight into how semi-volatile species are released into the comet atmosphere. The sum of all identified semi-volatiles will provide a first estimation (a lower bound) of the total semi-volatile mass and its importance relative to the volatiles and refractories.

Available ground-based observations for 67P will be used to constrain the ultimate fate of the semi-volatiles as they are photochemically processed after their release in the comet atmosphere. Identifying possible species with delayed release (i.e. for which a distributed source is important) for 67P prepares us to study them during the next 67P perihelion passage in 2021, which will actually occur under better conditions for observation from Earth than the 2015 passage.

To summarize, SeVoCo will further expand the general knowledge on the atmosphere of comets and of comet 67P in particular. It will present a lower bound on the relative importance of semi-volatile species in the coma. If the results imply that this largely unknown group of cometary species is an important contributor to the coma, future space missions to comets should be equipped with instruments specifically developed to examine these semi-volatile compounds in greater detail.

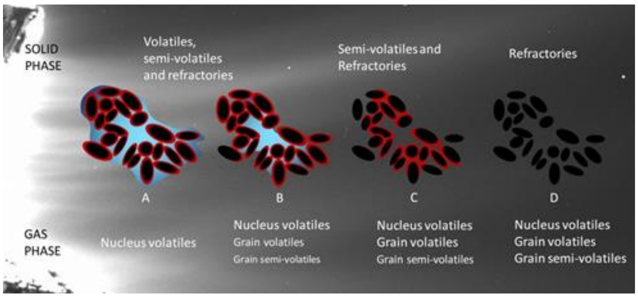

Figure 2: Schematic representation of cometary dust grain and coma evolution after nucleus release. Volatile species given in blue, semi-volatile species in red and refractories (non-volatiles) in black

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