To boldly go where no man has gone before

Rosetta has arrived. After a lengthy voyage through space to the comet 67P/Churyumov-Gerasimenko – affectionately nicknamed Tschuri by the researchers – the space orbiter has now reached its final destination. Also on board are highly complex Empa sensors made of metal ceramics, incorporated into two mass spectrometers.

TEXT: Cornelia Zogg / PICTURES: ESA

Over ten years ago, the space probe Rosetta embarked on its voyage into space with the aim of accompanying the comet for a year and, for the first time, setting a lander (Philae) down on its surface – a major undertaking and the pride and joy of the European Space Agency (ESA). A short while ago, the final brake maneuver was successfully completed, enabling the space probe to inspect and record the target comet 67P/Churyumov-Gerasimenko from all angles. Comets are regarded as primitive masses in our solar system and may have carried water or even simple building blocks for life to Earth. However, many fundamental questions concerning these giant lumps made of dust and ice remain open, which is where Rosetta comes in. The comet's first images from approximately 12,000 kilometers away reveal that Tschuri consists of two lumps that are connected via a "neck", making the comet look like a giant rubber duck.


Target comet "Tschuri"

Empa on board

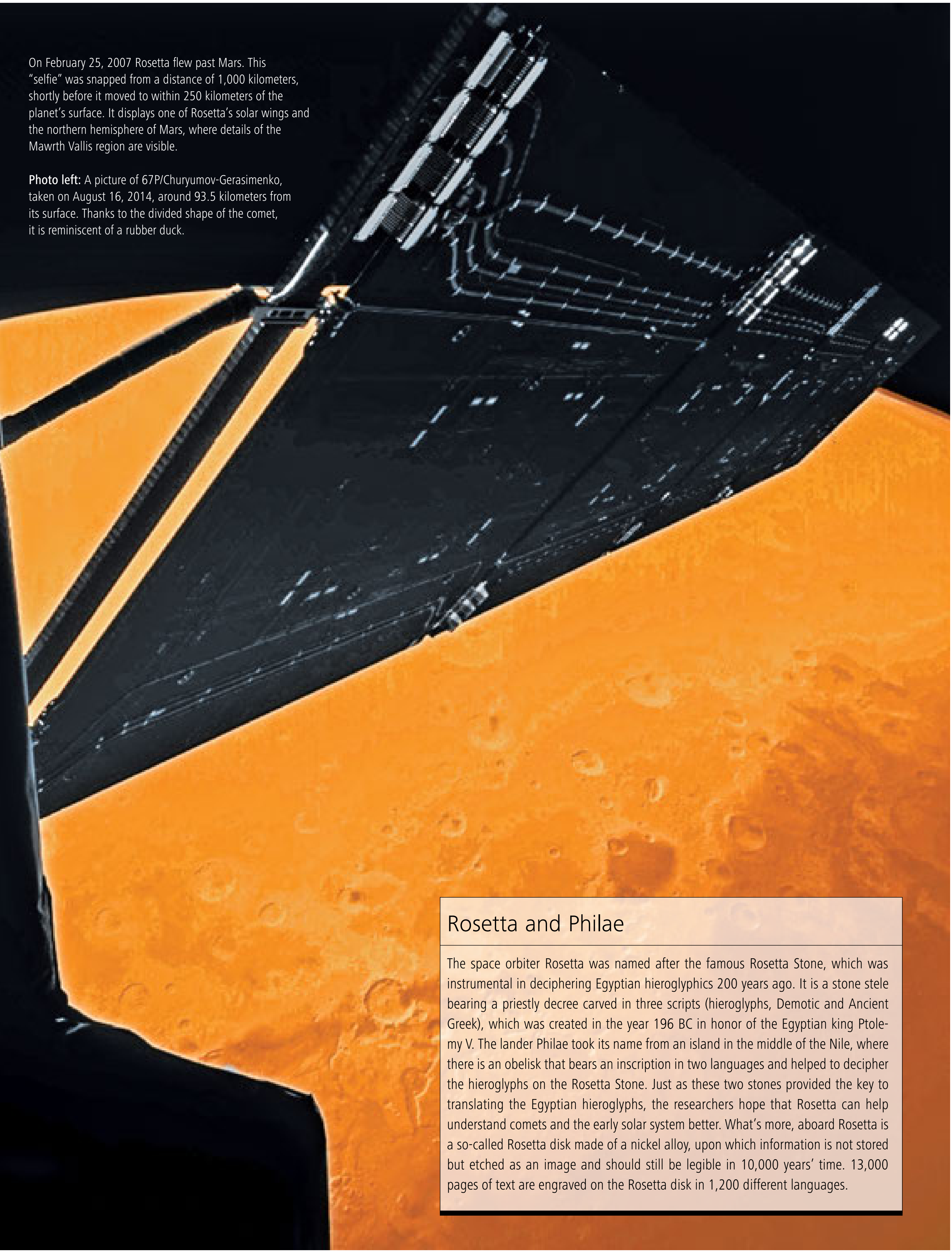
One of the numerous pieces of equipment on Rosetta was developed with Empa's help. The instrument group ROSINA (Rosetta Orbiter Spectrometer for Ion and Neutral Analysis) was developed within a project lead by the University of Berne. It comprises two mass spectrometers, a pressure sensor (which also gages the temperature and velocity of the comet gas) and a data-processing unit. The Berne team brought in Empa, which assumed the development and production of the ion-optic sensors for the two spectrometers. Not only do these need to be light; they also have to withstand the harsh conditions in space.

After the cosmic rendezvous with the comet, ROSINA is supposed to analyze ions and neutral gas particles in the (extremely "thin") atmosphere and the ionosphere of 67P/Churyumov-Gerasimenko. After all, this enables conclusions to be drawn regarding the origin of our solar system. The mass spectrometer DFMS (double focusing mass spectrometer) has two different operating modes: a gas mode to measure neutral gas particles and the ion mode to analyze ionized particles. The time-of-flight mass spectrometer RTOF (reflectron time of flight) enhances the DFMS by increasing the sensitivity of the entire instrument. In the process, the mass is analyzed using the "time-of-flight" technique. The combination of an extremely high mass and temporal resolution enables snapshots of the entire mass range from one to 1,000 amu (atomic mass unit).

Successful process development

The ion-optic structural components for both mass spectrometers were developed and produced by a team lead by Empa engineer Hans Rudolf Elsener. One major challenge was to convert the astrophysicists' ideas and requirements into a multi-functional, "space-worthy" product that satisfied the highest demands: it needed to be ultra-light, mechanically robust, high-voltage-proof and extremely precise. Besides tweaking the design, Elsener developed various processes to combine different substances, such as metals and non-metals (ceramics). For instance, the individual parts were not screwed together, as is normally the case, but rather soldered in a vacuum furnace. In doing so, the materials were combined chemically with the aid of filler materials. This requires a wide range of coatings, all of which need to be tested beforehand. The parts to be joined are in a solid state – only the filler material is melted and either reacts with the coating or base material.

The methods and technologies developed at Empa were quite successful; no wonder then, that other space projects soon followed. Elsener and his team are currently developing a new ion-optic sensor for an even smaller, lighter mass spectrometer for the Russo-Indian moon mission LUNA. And the Empa engineers recently produced equally complex modules and sensors for the joint European and Japanese Mercury mission BepiColombo. //



On February 25, 2007 Rosetta flew past Mars. This "selfie" was snapped from a distance of 1,000 kilometers, shortly before it moved to within 250 kilometers of the planet's surface. It displays one of Rosetta's solar wings and the northern hemisphere of Mars, where details of the Mawrth Vallis region are visible.

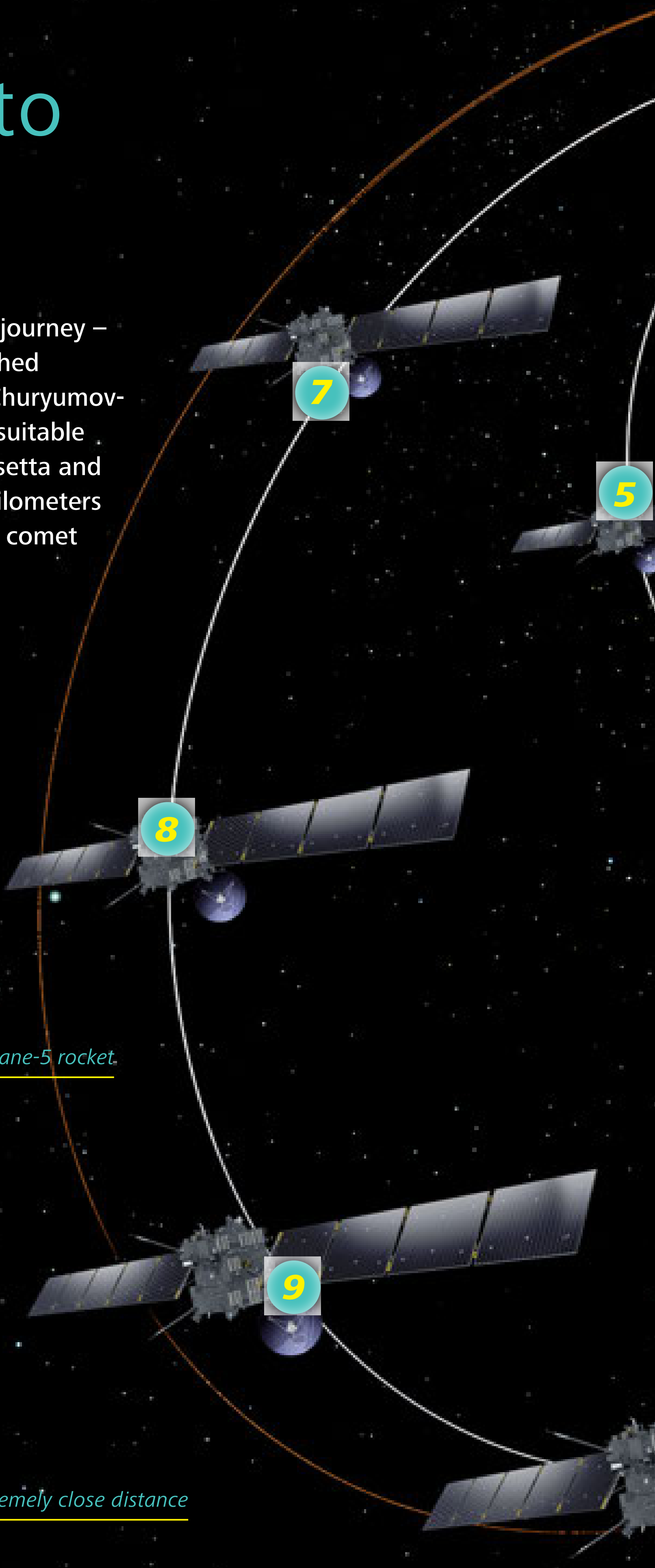
Photo left: A picture of 67P/Churyumov-Gerasimenko, taken on August 16, 2014, around 93.5 kilometers from its surface. Thanks to the divided shape of the comet, it is reminiscent of a rubber duck.

Rosetta and Philae

The space orbiter Rosetta was named after the famous Rosetta Stone, which was instrumental in deciphering Egyptian hieroglyphics 200 years ago. It is a stone stele bearing a priestly decree carved in three scripts (hieroglyphs, Demotic and Ancient Greek), which was created in the year 196 BC in honor of the Egyptian king Ptolemy V. The lander Philae took its name from an island in the middle of the Nile, where there is an obelisk that bears an inscription in two languages and helped to decipher the hieroglyphs on the Rosetta Stone. Just as these two stones provided the key to translating the Egyptian hieroglyphs, the researchers hope that Rosetta can help understand comets and the early solar system better. What's more, aboard Rosetta is a so-called Rosetta disk made of a nickel alloy, upon which information is not stored but etched as an image and should still be legible in 10,000 years' time. 13,000 pages of text are engraved on the Rosetta disk in 1,200 different languages.

A cosmic trip to meet a comet

Rosetta is facing the final phase of a lengthy journey – and has still a way to go. The probe has reached the target comet "Tschuri" – short for "67P/Churyumov-Gerasimenko" – and has already identified a suitable place for its lander Philae to touch down. Rosetta and her comet are currently around 405 million kilometers from the Earth. Rosetta will now shadow the comet for at least another year.



1 *March 2004: Rosetta lifts off into space on board an Ariane-5 rocket*
2 *March 2005: first Earth gravitation thrust*
3 *February 2007: Mars gravitation thrust*
4 *November 2007: second Earth gravitation thrust*
5 *September 2008: flyby past asteroid "Steins"*
6 *November 2009: third Earth gravitation thrust*
7 *July 2010: flyby past asteroid "Lutetia"*
8 *June 2011: Rosetta enters hibernation*
9 *January 2014: Rosetta is awoken*
10 *May 2014: rendezvous maneuver with target comet*
11 *August 2014: arrival at target comet*
12 *November 2014: Philae's landing maneuver*
13 *August 2015: Rosetta and Tschuri fly past sun at an extremely close distance*
14 *December 2015: scheduled end to the mission*

Video
The probe Rosetta has been circling the comet since August 6. This is what its exact flight path looks like.

http://www.esa.int/spaceinvideos/Videos/2014/08/How_to_orbit_a_comet