Planetary Science Institute

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Rosetta Orbiter to Reach Comet after 10-Year Voyage

PSI Scientist Robert Gaskell on the Mission Team

by Alan Fischer and Chris Holmberg

Following a 10-year-long journey, the European Space Agency's Rosetta spacecraft is set to become the first ever to orbit a comet and land a probe on its nucleus. It is scheduled to rendezvous with Comet 67P/Churyumov-Gerasimenko (67P/CG) in August and soft-land an exploratory probe on the comet's surface in November.

The probe is named after the Rosetta Stone, an ancient Egyptian tablet featuring three different scripts. The lander is named after the Nile island Philae where an obelisk with inscriptions was discovered. A comparison of the hieroglyphs on the Rosetta Stone with the inscriptions on the obelisk was the key to deciphering the ancient Egyptian writing system. In a similar fashion, it is hoped that the Rosetta spacecraft will provide a better understanding of comets and the early Solar System.

The mission has already obtained the first images taken from a comet's surface and will provide the first analysis of a comet's composition by drilling into the surface. The probe will travel with the comet as it approaches the Sun and document the changes that occur as the frozen body is transformed by the warmth of the Sun.

PSI Senior Scientist Robert W. Gaskell is working on Rosetta and answers questions about the mission:

Q. Bob, what is your role on the Rosetta mission?
A. I will be building the shape model for the comet and detailed 3D maps of the potential landing sites for the Philae lander. Each of these maps will cover a 1 km x 1 km area of the surface at 40 cm/pixel, a resolution only possible with the stereophotoclinometry (SPC) techniques I have developed over the last 25 years.

To accomplish this I will be using data from the Rosetta/OSIRIS cameras that include a wide-angle context camera and a narrow-angle camera for detail. I will also be able to use images from the navigation camera, and we hope to have access to panoram-

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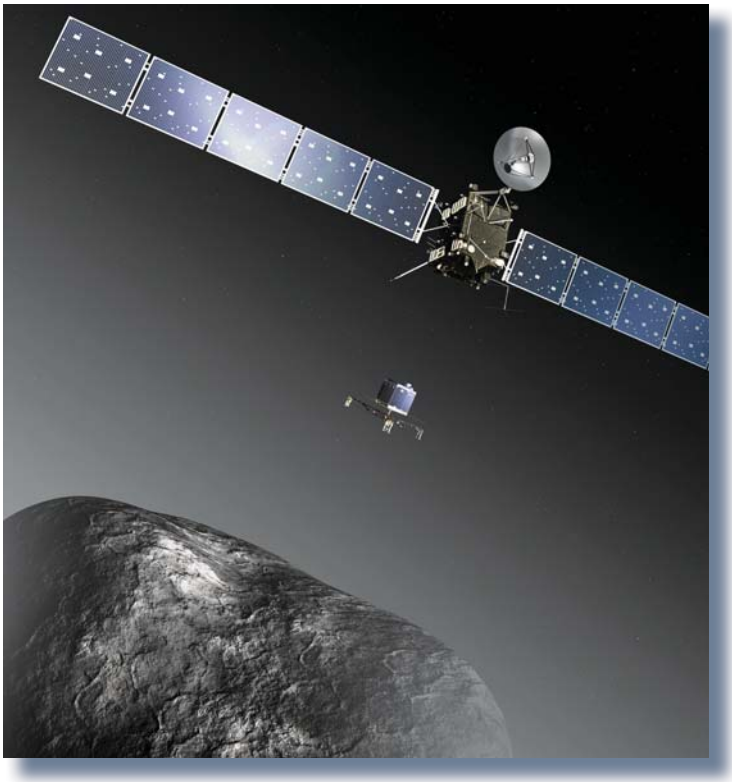
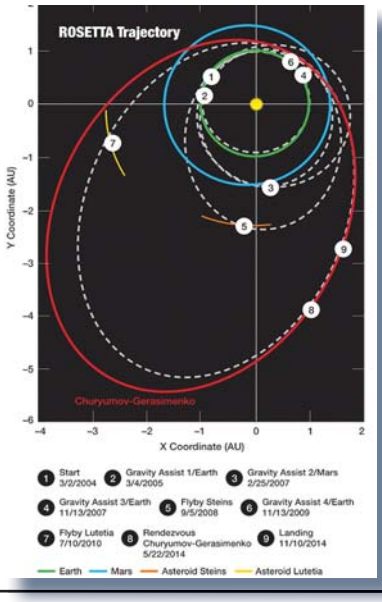


Artist's impression of the Rosetta orbiter at comet 67P/Churyumov–Gerasimenko. The Rosetta spacecraft measures 105 feet (32 meters) across including the solar arrays, while the comet nucleus is thought to be about 2.5 miles (4 kilometers) wide. The image is not to scale.

Photo: ESA; Photo: ESA/Cluster; Image: ESA/NASA - SOHO/LASCO



This graph shows Rosetta's progression from its launch in 2004 to the gravity-assisted orbital maneuvers around Earth in 2005, 2007 and 2009 (green line), and Mars in 2007 (blue line) that accelerated its journey through the inner Solar System on its way to comet 67/P.

Gravity assists save fuel and speed up the spacecraft. This path allowed two bonus flybys of asteroids Steins in 2008 (red line) and Lutetia in 2010 (yellow line).

Rosetta's probe Philae is projected to land on the comet 67/P Churyumov–Gerasimenko on Nov. 10, 2014.

Image credit: ESA

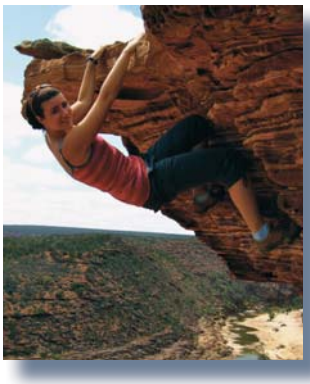
Introducing Haley Sapers

Haley Sapers joined PSI this spring as an Associate Research Scientist. Originally from Edmonton, Alberta, Canada, Haley completed her Ph.D. in Planetary Science (geology) at the Centre for Planetary Science and Exploration, Western University, London, Ontario in 2012.

Haley in the electron microscope clean lab at Pheasant Memorial Laboratory, ISEI, Okayama University, Misasa, Japan.

Her Ph.D. thesis explored biogenicity using combinations of high-resolution geochemical techniques to characterize the first putative trace fossils preserved in meteorite impact glass. By studying biogenicity Haley aims to better understand the unique properties of living organisms and life processes to investigate the earliest life on Earth and to better interpret evidence for life on planets such as Mars. Haley completed her Bachelor of Science Combined Honors at Carleton University in Ottawa, Ontario, Canada, in Biology (microbial ecology) and Geology (geochronology).

Being an avid field scientist, she has spent time on remote reefs off the coast of Punta Frances, south of mainland Cuba; three field seasons studying the Ries impact structure in Germany; the Rochechouart impact structure in France; and the Sudbury impact structure in Canada. She completed a year-long internship with the Australian Centre for Astrobiology traveling to Akaroola, Flindlers Ranges, in the South Australian desert to conduct microbial diversity surveys in Paralana Hot Spring, an extreme radioactive hot spring system.



Haley Sapers climbing in Exmouth, Western Australia.

Haley completed a NASA Planetary Biology Internship at Ames doing theoretical research on single cell biosenors. And she did a summer internship through the Japan Society for the Promotion of Science at Okayama University's Institute for Study of the Earth's Interior, running geochemical analysis of Ries impact glasses at the Pheasant Memorial Laboratory, one of two facilities designed to handle and analyze Hayabusa samples returned from Itokawa, a near-Earth asteroid.

Currently, Haley is investigating microbe-mineral interactions at the micron–submicron scale to better understand the potential habitability of environments created by meteorite impacts both on early Earth and other rocky bodies in the Solar System.

Fascinated with patterns and processes at the submicron scale, Haley specializes in high-resolution techniques and is most at home in front of an electron microprobe. Haley was also a successful Principal Investigator on several shifts at the Canadian Light Source, a major synchrotron facility.

Active in education and outreach, Haley has given several invited public lectures at teaching workshops in Canada and Brazil. She is a member of Virtual Researchers On Call, a digital service connecting scientists and classrooms across Canada. She mentors high school and undergraduate students both in a classroom setting and at scientific conferences, and teaches science and math skills to at-risk elementary students. Haley has also participated in two analogue sample return missions run by Western University and the Canadian Space Agency.

When she is not glued to an electron microscope or a synchrotron, Haley enjoys distance running and SCUBA diving in the summer and alpine skiing and snowshoeing in the winter. She is an avid stained glass artist and knits everything from hyperbolic planes to nudibranchs.

We are delighted to welcome Haley to PSI!

Rosetta to Reach Comet *(Continued from front page)*

ic images from the lander. PSI Research Scientist Eric E. Palmer has developed a technique for finding the probe's location on the surface using topograghic maps made of orbital images and the sort of panoramas Philae will provide.

Q. How long have you been involved with the mission?
A. I have been involved with the mission since 2008, when I went to Marseille for three weeks to build a model of the asteroid Steins following Rosetta's September 2008 fly-by. I returned for three weeks in 2010 to analyze data from the fly-by of asteroid Lutetia.

The Rosetta spacecraft flew by the asteroid Steins in 2008. *(Credit: ESA)*

Asteroid Lutetia as seen by Rosetta in 2010. *(Credit : ESA)*

In preparation for Rosetta's arrival at comet 67P/CG, I have been testing my software using simulated comet images for the difficult task of creating a shape model of the comet. This has been challenging since the simulated comet is not simply rotating, but has a significant wobble as well. I have been able to not only construct the shape, but to solve for the rotation as well.

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Frontpage masthead is an artist rendition of our Solar System. *Not to scale Credit: NASA*

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Chris Holmberg, Editor and Writer
Alan Fischer, Writer and Photographer
Special thanks to Gil Esquerdo, Dianne Janis, Emily Joseph, Carol Neese, and Elaine Owens

The *Friends of PSI* Annual Fundraising Gala

On April 30, PSI's 2014 fundraising gala was held at the Westward Look Resort in Tucson. The banquet hall was filled with our terrific supporters— the *Friends of PSI*—who enjoyed a festive evening featuring a wide variety of raffle treasures, a splendid banquet, and an interesting art-meets-science talk given by PSI Senior Scientist and artist William K. Hartmann entitled "Exploring Mars by Geology Hammer & Paintbrush." Thanks to all our attendees and sponsors, the event was a social and fundraising success!

Bill Hartmann, PSI Senior Scientist and resident artist, giving his art-meets-science presentation (above) and discussing his paintings with our dinner guests (at right).

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** Denotes PSI Board of Trustees*

Richard Ramirez, of Vantage West Credit Union, on left, with PSI Senior Scientist David A. Crown.

L-r: Diana Alexander, Karin Yohem, and Joe Alexander (PSI Board member) with PSI Senior Scientist Bill Hartmann.

Above, Sara Green and Grace Sultan, with the Wolf and Sultan host table.

Pat Roberts with her husband Leon Byrd from The Mahoney Group.

Raquel Blanco with National Bank of Arizona and guest Jordan Munic.

PSI Director Mark Sykes and guests perusing exciting raffle items.

FRIENDS of PSI UPDATE

The Planetary Science Institute wishes to acknowledge our new and renewing *Friends of PSI* for supporting planetary exploration as well as our educational programs here on Earth.
March 16, 2014, to May 31, 2014:

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Tarik Sultan (Wolf and Sultan)

Thank you!

Friends of PSI Benefits

Join the ***Friends of PSI*** and receive the following benefits and gifts:

- PSI's quarterly newsletter filled with information on the latest discoveries, new research, and happenings at PSI
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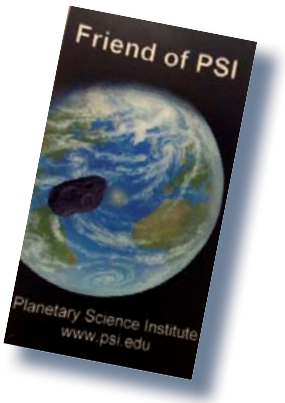

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- Amazon is donating a percentage of every purchase made on its site to a nonprofit of one's choice. To participate, enter Amazon through the ***AmazonSmile*** portal and indicate that PSI is your nonprofit entity for this donation.
- Check out the online store on our PSI website. The store offers a wide variety of PSI logo items such as t-shirts, water bottles, field bags, baby bibs, and much more.

Director's Note: *What is our future in space?*

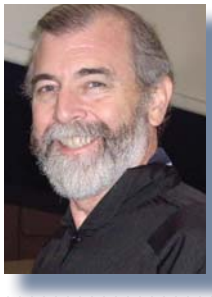
A recent study by the National Research Council says the ultimate goal is to send humans to Mars and that recent plans of the administration to send humans to an asteroid or capture and return a small asteroid back to lunar orbit as a target for human exploration do not advance that ultimate goal. OK, I must admit that I refer to the Asteroid Return Mission (ARM) as the Asteroid Rodeo Mission.

Should we go back to the Moon first? Given that a human-to-Mars mission is estimated to cost $1 trillion, is it reasonable to expect NASA's budget will be bumped up from $18 billion to almost $50 billion a year for the next 30 years? Clearly, the future of human space flight is pretty murky, but there is a strong desire to go somewhere beyond low-Earth orbit where we have been for more than forty years. Wherever we end up going and doing, we need to learn as much as possible about our potential targets, what we can do there, and how we can benefit from it.

PSI has a large contingent of people studying Mars, understanding its geology and history and its potential for life in the past and even today. They are actively involved with the Curiosity and Opportunity rovers and orbital assets. They explore far flung areas of Earth to better understand the processes they observe on Mars.

The Moon continues to be an object of high interest, and our scientists work on understanding its formation, evolution, and the record of our early Solar System preserved on its surface. We have even developed a system to navigate around the surface of the Moon in the absence of communication with Earth (useful for the far-side). Near-Earth asteroids may yet be a target for human exploration. They can take much less energy to get to than the surface of the Moon, and PSI scientists are working to identify and characterize those targets and figure out how resources they provide might support the infrastructure needed to expand human activity in space to the Moon, Mars, and even further distances.

In the meantime, the work we do in the inner Solar System as well as the outer Solar System and planetary systems around other stars needs to be supported. We are grateful to our friends in the public and in government (and particularly our *Friends of PSI*!) who sustain the work of PSI and the planetary science community.



It is the foundation of our growing basic knowledge that allows us to seriously contemplate more ambitious dreams in both human and robotic exploration!

Mark V. Sykes
July 2014

PSI Staff News

Hartmann Elected to IAA

In early June, PSI Senior Scientist **William K. Hartmann** received a diploma certifying his election as a member of the International Academy of Astronautics, based in Paris. Bill is seen here with the certificate in his PSI office, surrounded by just a few of his landscape paintings.

Asteroids Named for Three PSI Scientists

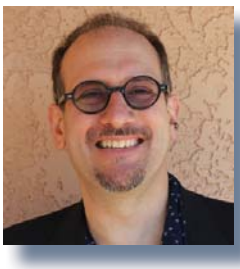
PSI Research Scientists Lucille Le Corre, Eric E. Palmer, and Senior Scientist Thomas H. Prettyman have each been honored by having an asteroid named after them:

(9285) Le Corre —**Lucille Le Corre's** work includes creating combined geologic and composition maps of planetary satellite and asteroid surfaces using radar, stectroscopic and imaging data.

(24412) Ericpalmer — **Eric E. Palmer'**s research focuses on the presence and stability of water and other volatile compounds on asteroid and planetary satellite surfaces, and their detection through spectroscopic techniques.

(24994) Prettyman — **Thomas H. Prettyman** led the gamma ray and neutron detector investigation on the Dawn mission to Vesta, revealing *in situ* a composition consistent with the HED meteorite class as well as an unexpected presence of hydrogen.

Grinspoon Named to IAGETH Board



PSI Senior Scientist **David Grinspoon** has been named a member of the Senior Advisory Board of the International Association for Geoethics (IAGETH).

The IAGETH Senior Advisory Board (ISAB) is comprised of a prestigious group of internationally recognized experts from different regions and geoscientific disciplines. Although ISAB members don't have specific functional tasks in the working of the IAGETH, they act as a "think tank" and offer observations, guidance, and advice and provide unique perspectives and insights on certain issues.

A son born to Naoyuki (Yuki) Yamashita

PSI Postdoctoral Research Scientist **Yuki Yamashita's** first child, Mizuki, was born on May 2, 2014, weighing 6 lb 11 oz. He was named after the dogwood tree, which has a hard trunk and blooms in May in Japan. Yuki admitted that he has never been so happy and so tired!

Welcome to planet Earth, Mizuki!

Congratulations to our scientists!

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Rosetta to Reach Comet *Interview with Gaskell cont'd from pg. 2*

Despite these preparations, we now suspect that 67P/CG will be rotating nicely about a single axis, making my job much, much easier.

Q. With whom are you working?
A. I am supported by the Max Planck Institute and by the Laboratoire d'Astrophysique de Marseille (LAM) where I will be working. I will be joined there by PSI Research Scientist Eric Palmer, and Coralie Jackman from KinetX in preparation for the OSIRIS-REx mission, and by Naru Hirata from the University of Aizu in Japan who is preparing to use my software for the Hayabusa 2 mission.

Q. What are some of the scientific goals of the Rosetta mission?
A. Comets are well known to be made up of pristine material from the birth of the Solar System. The volatiles (mostly H_2O and CO_2) in the comet disappear over time as the comet passes close to the Sun. We will be able to see this happening as Rosetta watches from overhead and Philae observes from the ground. 67P/CG should have plenty of volatiles left. It wasn't until 1840, when the comet passed close to Jupiter, that its orbit was changed to bring it close enough to the Sun to lose material to outgassing.

Q. Why was comet 67P/Churyumov-Gerasimenko selected?
A. Of the many comets that might have been chosen, only a few satisfied the mission's requirements. First, the comet had to have been observed over several orbits of the Sun and had to be outgassing. Second, the comet's orbit had to be near the same plane as Earth's, making it easier to reach and survey. Finally, the comet had to be in the inner Solar System, headed toward the Sun during the Rosetta mission timeline. The perfect target was 46P/Wirtanen, but Rosetta's launch was delayed and the comet missed its chance. Thus its understudy, 67P/CG, was selected in its place.

Q. Tell us about the big event coming up for Rosetta.
A. In November, the Philae lander will detach itself from Rosetta, extend its three legs and drift slowly down to the surface of the comet. Upon touching down, it will fire a harpoon into the ground to secure itself to the comet. The lander carries twelve instruments to make measurements as the surface becomes active under the Sun's influence. What impacts me the most will be the panoramic cameras that will let me see these changes and their effects on the surface. Early October will be a very busy time for me, when I will be constructing the maps from images taken between September 29 and October 8.

Q. What are some of the scientific findings that have come out of your work on Rosetta?
A. One of the most exciting possibilities is the determination of changes in the surface during the comet's close approach to the Sun. It is expected that meters worth of material will be blown off the surface, leaving a landscape that may have changed significantly. These changes should be clearly visible in the 40 cm resolution "before" and "after" maps I will be preparing.

Stay tuned for new findings from Rosetta later this year!

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