Planetary Science Institute

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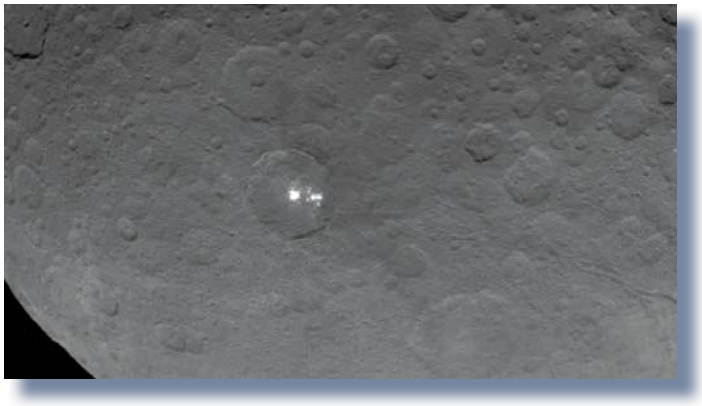
Ceres – Mysterious Spots, and More *by Mark V. Sykes*

Ceres gets more and more interesting the closer the Dawn spacecraft gets to its surface. The originally identified "white spot" has resolved into a complex of smaller well-defined bright spots (image below) that continue to raise the question of their origin. Thermal models of Ceres interior predicted the present existence of a subsurface ocean persisting over the age of the Solar System. Could the white spots be evidence of cryovolcanism (icy volcanoes) by which such an interior ocean connects to the surface, bringing into question the exciting prospect of whether life evolved in the dark of Ceres interior?

The bright spots might offer an opportunity to see if any life emerges onto the surface of Ceres, only to perish imbedded in a bed of bright evaporites left when heavily mineralized water sublimes. One could imagine scooping up a cup of this material, looking for evidence of dead bugs and perhaps the most important discovery in human history.



NASA's Dawn mission captures an image of the brightest white spots on the surface of Ceres on May 16, 2015, from an altitude of 7200 km.

There are other possible causes for the white spots. On Earth, impacts can drive hydrothermal activity for tens of thousands of years. The white spots could be the residuum of water emerging onto the surface in the course of such an event. Perhaps the white spots are large subterranean deposits of bright material excavated by an impact or revealed by mass wasting processes?

In the image above, the surface of Ceres reveals additional interesting features such as non-circular and polygonal craters that may indicate tectonic boundaries (cracks?) beneath the surface. There are also many linear features with different orientations that may indicate subsurface tectonism (crustal movements) or fractures driven by impacts from outside the image above.

Now we are also seeing mountains (in the image below). Are these cryovolcanos? Are they pingo-like (mounds of icy earth) structures driven by expanding ice over many orbits? Are they remnant fragments of a plate of ice driven vertically?

NASA's Dawn mission discovers a mountain that inspires comparisons with a pyramid. Image obtained on May 4, 2015, from an altitude of 13,600 km. *(Images: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA)*

We are exploring a new world and trying to map our knowledge from other worlds, such as Earth, Mars, and icy Saturnian satellites, onto Ceres. But Ceres will have its own unique signatures. After all, it is the closest ice-rich dwarf planet to the Sun at slightly less than twice the distance of Mars. The next icy worlds are the Galilean (around Jupiter) and Saturnian satellites. Ceres' "warmth" and potential interior processes means that ice may be more plastic and dynamic both in the past and today. In the left image, the resolution of the image is 700 meters per pixel. When data reaches its lowest altitude of 325 km this December, we will be seeing its surface 20 times sharper. Some questions may be answered, but it is guaranteed that more will arise. Already I am hoping we will have an opportunity to go back!

Mark Sykes is a Co-Investigator on the NASA Dawn mission to Vesta and Ceres which is managed by NASA's Jet Propulsion Laboratory for NASA's Science Mission Directorate. See more images of Ceres at http://www.psi.edu/news/ceresopnav1 .

Inside this issue:

Meet Michelle Minitti

Michelle Minitti says she was "thrilled and honored" to join PSI as a Senior Scientist in December 2012. A project on black holes in the third grade ignited her love of space, a passion that propelled her throughout her education and continues to inspire her professional career. From third grade on, Michelle wanted nothing more than to be an astronaut. Her parents, Bob and Kathy Minitti, supported her by finding numerous summer science and engineering camps to attend—including Space Camp! A high school teacher, Frank "Doc" Zinke, sparked Michelle's interest in chemistry, leading her to select materials science and engineering as a college major.

In 1991, supported by a Flinn Foundation scholarship, Michelle attended the University of Arizona, much to the chagrin of her father, an Arizona State University (ASU) alumnus. In what became a turning point in her life, she took elective planetary science classes with Robert Strom and Randy Jokipii. Michelle discovered that the materials she learned about in her engineering classes – such as forsterite, anorthite, enstatite – were not just names of chemical compounds, but the building blocks of planets. Thus, she realized she could combine her interest in engineering with her love of space. Further elective geology classes and a transformative summer internship with the NASA Academy program at Goddard Space Flight Center (thanks to the Arizona Space Grant program!) cemented Michelle's desire to switch her graduate studies to geology.

In 1995, Jan Tullis and Mac Rutherford of Brown University bravely welcomed this engineering major (with almost no geology background) into the graduate program at the Department of Geological Sciences. Michelle worked with Mac in his experimental petrology lab and was greeted with many interesting and timely problems to work on courtesy of the burgeoning Mars exploration program with Mars Pathfinder and Mars Global Surveyor (MGS). Through high temperature and pressure laboratory experiments, Michelle investigated formation mechanisms for the "sulfur-free rock," a novel (at that time) rock chemistry measured by Mars Pathfinder, and linkages between the Martian meteorites and the lithologies detected by the Thermal Emission Spectrometer (TES) on MGS.

After receiving her Ph.D. in 2000, she became a postdoctoral researcher at the Geophysical Laboratory of the Carnegie Institution for Science. From there, she gained a NASA Astrobiology Institute postdoc position at ASU (to her father's delight). With Laurie Leshin as her advisor, Michelle delved farther into a problem she started researching at Brown: the effects of impact shock on water and hydrogen isotopes in nominally-hydrous phases found within the Martian meteorites, providing insight into the water-poor nature of the Martian meteorite phases.

In 2003, Michelle continued working with Leshin by transitioning to a faculty research associate position within ASU's Center for Meteorite Studies (CMS), the largest university-based collection of meteorites in the world. When Leshin was hired by Goddard Space Flight Center in 2005, she recommended Michelle for the Interim Director position. As Interim and, eventually, Assistant Director to Meenakshi Wadhwa of CMS, Michelle worked with the wonderfully effective CMS staff to design and implement new laboratory, museum, collections and storage spaces; develop education and public outreach activities and materials; and build the collection through new acquisitions.

At CMS, Michelle continued her research focused on interpreting the rich Mars datasets from MGS, the Mars Reconnaissance Orbiter, and the Mars Exploration Rovers using laboratory-synthesized samples and terrestrial analogues. Her work raised the attention of Ken Edgett of Malin Space Science Systems and future PSI colleague R. Aileen Yingst, who were preparing a "hand lens" camera proposal for the upcoming Mars Science Laboratory (MSL) mission. Michelle joined the team in 2004 and the camera, the Mars Hand Lens Imager (MAHLI), began its successful study of Mars after MSL's Curiosity rover landed in Gale crater in 2012.

Since the landing, Michelle has worked enthusiastically on the operation of MAHLI and the Mars Descent Imager (MARDI), in addition to analyzing and interpreting the datasets collected by these two cameras. She particularly enjoys that her MSL work incorporates her two backgrounds: engineering and science.

Image acquired by MAHLI on May 3, 2015 (Sol 794 of the MSL mission) of a target named "Bigfork". The sedimentary rock exhibits alternating layers of resistant and recessive material, the origin of which is a subject of active study by the MSL science team. The field of view is 5 cm across; the loose grains sitting on the outcrop layers are sand-sized. Credit: NASA/JPL/MSSS

From her home office in Kensington, MD (i.e., the kitchen table), her two children, Sydney (10) and Zachary (6), participate in the Mars exploration adventure, listening to planning meetings and choosing names for rock targets for Curiosity to study. "That such family exploration can occur is enabled by the wonderful flexibility of PSI!" she said.

We are thrilled and honored that Michelle joined PSI!

Frontpage masthead : At the southern edge of the rich Virgo cluster of galaxies, Messier 104, also called the Sombrero galaxy, is one of the most famous objects in the sky. Credit: NASA's Hubble Space Telescope.

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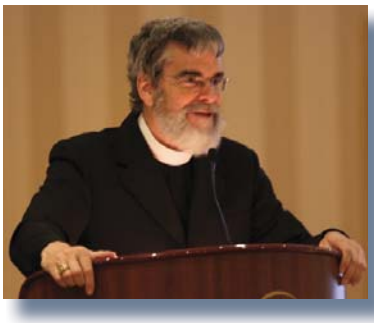
Chris Holmberg, Editor and Writer
Alan Fischer, Writer and Photographer
Special thanks to Gil Esquerdo, Dianne Janis, Emily Joseph, Carol Neese, and Elaine Owens

The *Friends of PSI* Annual Fundraising Gala



The 2015 PSI fundraising gala took place April 1st at the Hilton El Conquistador Resort north of Tucson. The event offered our loyal supporters--*The Friends of PSI*--a splendid banquet, dozens of raffle items, and a fascinating keynote speaker, Brother Guy Consolmagno (above). Brother Guy entertained us with a talk entitled "Adventures of a Vatican Planetary Scientist" as he looked back at some of the odder places his career in planetary science has taken him over the past 40 years.

Both scientist and theologian, Brother Guy brings an interesting perspective to the world of Planetary Science. Known as the Pope's Astronomer, he received the prestigious Carl Sagan Medal, the first clergyman to be so honored.

Keynote speaker — and longtime colleague to many PSI scientists — Brother Guy Consolmagno presented a slideshow including numerous vintage photographs. This one behind him depicts early Vatican astronomers. *Photographs by Alan Fischer.*

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From CODAC, l-r, Nora Navarro Hernandez, Kristine Hall, Ramon Navarro, CODAC CEO Dennis Regnier (back to camera) and Dana Regnier.

L-r: Bob Breault, Lynne Wood Dusenberry, Bruce Dusenberry, and Judi Breault.

Robert and Katherine Ramirez, Vantage West Credit Union.

Margrethe and Bill Feldman (PSI), and Tim Swindle (UA).

Christina Gage and Josh Acuna from Keegan, Linscott & Kenon.

Tarik Sultan, of Wolf and Sultan, and his daughter Bianca.

Bob and Judi Breault peruse the many enticing raffle items.

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 1, 2015 to May 31, 2015

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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

The Lunar and Planetary Science Conference held every March in The Woodlands, Texas, is the meeting most heavily attended by PSI scientists. It is always great to see our PSI colleagues from around the country and world, as well as alumni! This year nearly 60 people attended our dinner at the meeting. Needless to say, attendance continues to grow!

PSI Director Mark Sykes (in green) surrounded by PSI scientists and staff at the 2015 LPSC meeting in Houston.

This year we brought our CFO, Bruce Barnett, and Project Controller, Anthony Villari, to the meeting so they could have some face time with our distributed family and answer questions, field suggestions for improving support, and help with project planning. This was very useful for people and we will continue to bring administrative and financial staff to this meeting in future.

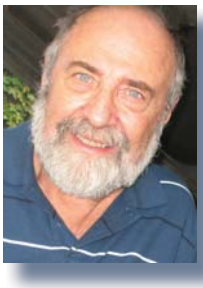
We are continuing to add people at a steady pace from all career stages. It is a constant stream of energy into the Institute!

We are also evolving. As I have mentioned in the past, PSI has a greater than average fraction of female PhDs. The demographics of planetary science is about 25% women. At PSI, it is about 45%. At our current pace of applicants, I expect within a couple of years that PSI will become the first hard-science institution of our size to have a majority of scientists who are women.

I would also note that within the overlapping cohorts of men and women at PSI that women have higher average salaries (it's within one-sigma, but hey) and they are on average more successful in their grant writing. It is amazing what can happen when there is a level playing field!

Mark V. Sykes
June 2015

PSI Staff News



Nelson: Outstanding Volunteer

PSI Senior Scientist **Robert Nelson** was recognized by the Board of Mt. San Antonio College, Walnut, CA, for his extensive contributions as a volunteer research scientist in earth science and astronomy. Since 2010, "Dr. Bob" has volunteered his time to work with students on high-level research projects, and has generously provided access to over $250,000 worth of scientific equipment allowing the College to establish a research laboratory.

In addition to volunteering his time, Bob recruits other scientists to assist Mt. SAC students in conducting advanced-level research projects. Many of the students have won monetary awards and scholarships as a result of the research they have conducted under his mentoring. The Mt. SAC Board credits Bob with helping their students secure admission to top four-year universities.

The Board of the college was duly impressed with Bob's contributions, and so are we at PSI! Congratulations, Bob!

Betty Pierazzo Honored With Lunar Crater

Elisabetta "Betty" Pierazzo, a leading expert in the modeling of impact crater formation throughout the Solar System, has been honored by having an impact crater on the Moon named for her.

The 9-kilometer diameter crater is located on the far side of the Moon. Bright rays of ejected material extend more than 450 kilometers from the crater rim, suggesting that the crater was formed by a relatively recent impact event. The newly appointed "Pierazzo Crater" provides an important data point toward testing the various theories for how impact melt is emplaced.

Pierazzo Crater is a timely commemoration of Betty as it marks four years since she lost her heroic battle with cancer.

In addition to impact crater formation, Pierazzo was an expert on the astrobiological and environmental effects of impacts on Earth and Mars. At the time of her death in 2011, she was a Senior Scientist at PSI.

Betty Pierazzo on the rim of Meteor Crater in 2009 being interviewed for the National Geographic channel program, "Known Universe."

For images of Pierazzo Crater, visit http://www.psi.edu/news/craterbetty .

Pierazzo International Student Travel Award

At this year's Lunar and Planetary Science Conference in Houston, PSI Director Mark Sykes (left) presented the 2015 Pierazzo International Student Travel Award to Edgar Steenstra from the University of Amsterdam.

The award was created in honor of PSI Scientist Elisabetta Pierazzo to allow two students each year to attend science meetings.

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Mars Opportunity Image Similar to '08 Sonoran Wilderness Painting by PSI's Hartmann

Jim Rice, PSI Senior Scientist and NASA Mars Exploration Rover (MER) Geology Team Leader on Opportunity rover, brought the International Space Station (ISS) crew and Opportunity together in a unique way this year. He enlisted the help of his good friend, Terry Virts, ISS Expedition 43 Commander, in choosing targets on Mars for the robotic geologist to investigate. The astronauts onboard ISS viewed Opportunity's Navcam images to determine which Martian rocks to sample. The astronauts in space and scientists on Earth both thought this was a wonderful arrangement.

The area that caught the attention of scientists recently is the Spirit of St. Louis crater (left) featuring a hillock of rocks called Lindbergh Mound. The origin of the small, shallow crater (80 ft wide), whether by impact or other, is unknown as yet.

The image is strikingly similar to a painting (above) done by PSI co-founder Bill Hartmann in 2008. Bill, known for space paintings as well as science papers, painted this landscape in the Sierra el Rosario volcanic mountain complex, protruding from the "Gran Desierto" dunes just south of the Arizona border in northwest Sonora, Mexico. The on-site painting shows an outcrop of basalt lava with strikingly red sunrise light on the background dunes.

A benefit of PSI's home location in the Sonoran Desert is that parallels to Martian geology are all around us!

The mosaic from Opportunity rover is composed of false color images using Pancam's 753 nm, 535 nm, and 432 nm filters. These filters are used to enhance the many striking but subtle color differences between the rocks and soils in the scene. Opportunity image courtesy NASA. Painting courtesy William K. Hartmann. The painting is on display in the PSI "West Wing" conference room, Tucson. Both images cropped to create comparable compositions.