THE PLANETARY SOCIETY

THE PLANETARY REPORT

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BEYOND HUMAN VISION

TURNING UP THE COLOR ON SATURN'S ICY MOONS

TESTIFYING FOR SCIENCE ✻ VOLATILES ON MERCURY ✻ EXOPLANETS: HONING THE HUNT

CASEY DREIER *is director of advocacy for The Planetary Society.*

A Key Witness for Exploration

Planetary Science Gets Its Day in Congress

ABOVE *On September 10, 2014, Planetary Society President Jim Bell [center] testified before the U.S. House of Representatives Subcommittee on Space about the importance of continued funding for planetary science.*

To hear Jim Bell discuss his Congressional appearance, listen to this episode of *Planetary Radio*: **bit.ly/1m8hWqD**

Read Jim's full written testimony [pdf download]: **bit.ly/1v4yv8G**

THE E-MAIL ARRIVED early on a warm morning during the final days of August. It was from a staff member on the U.S. House of Representatives Subcommittee on Space, writing to let us know that in a week and a half there would be a hearing on the state (and fate) of planetary science and, by the way, would The Planetary Society's president be interested in testifying?

Yes—yes, he would.

Eleven busy days later, Jim Bell arrived in Washington, D.C. to address the uncertain future of planetary science at NASA. As a professional planetary scientist, he understands the major scientific questions of his field inside and out. As president of The Planetary Society, he gets the importance of continued space exploration for society at large. In short, he was a perfect witness for the subcommittee.

The hearing, *Exploring Our Solar System: The ASTEROIDS Act as a Key Step*, took a close look at the recent cuts to NASA's Planetary Science Division initiated by the White House in 2013. It also examined a proposed bill, the American Space Technology for Exploring Resource Opportunities In Deep Space (ASTEROIDS) Act, which would grant ownership rights of natural resources collected in space to private companies.

Jim's testimony focused on two major points:

1. Advances in planetary science depend heavily on planetary exploration missions, and
2. Today's dollars pay for tomorrow's missions.

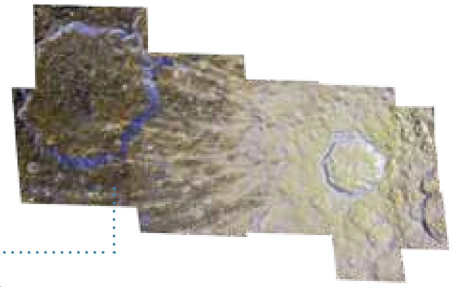
Although planetary science looks strong, it's because the current suite of missions were paid for in the past. The rate of new missions being built today has decreased substantially. As current missions age and end, there will be few replacements ready to continue exploring the solar system. In fact, after 2017, there will be no NASA spacecraft exploring the outer planets or inner planets. Since advances in planetary science depend so heavily on new data from spacecraft, there will be a drop in science activity in these crucial areas. These gaps can be mitigated, Jim argued, by restoring the budget to historical levels as soon as possible.

The congressional representatives on the subcommittee were receptive and they enjoyed seeing samples of the stunning images of our solar system that we provided for the testimony. "We value the planetary science community and the important work they do," said House Science Committee Chairman Lamar Smith (R-TX) in a prepared statement before the hearing. "I hope that [the White House] is paying attention to today's discussion."

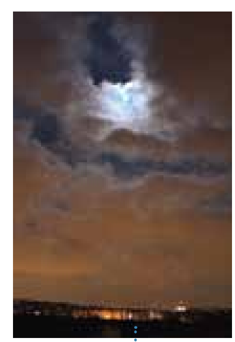
The hearing was a clear sign that The Planetary Society's continued advocacy for the health and future of planetary exploration missions is working. That success is a direct result of our members' efforts to contact their representatives, and their donations in support of our programs. Little known fact: Congress, for the most part, does not pay for its witnesses to travel to D.C. to speak. The Society was able to provide travel for Jim Bell to testify in front of Congress thanks to the generosity of you, our members.

Congress, particularly the House of Representatives, has strongly supported planetary exploration in both its monetary appropriations and policy authorizations. We're building better support in the Senate and in NASA. Our message is getting out there—planetary science is great exploration bang for the buck—and last month's hearing testifies to that.

Photo: Tushar Dayal for The Planetary Society



DEPARTMENTS



ON THE COVER: *Cassini*, like all robotic explorers we launch into deep space, has deepened our understanding of our solar environs in many ways—some anticipated and some not. Dialing up *Cassini*'s infrared, green, and ultraviolet filters draws out details in the surfaces of Saturn's icy moons that we cannot see in natural color wavelengths. This map of Enceladus' far side shows the redepositon of icy dust (pink and yellow) from the "tiger stripe" vents (cyan tinted) at the moon's South Pole.

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Investing in the Future

That's What We Do at The Planetary Society

IN THE COURSE of just about any human undertaking, be it laying out the streets of a city, rotating crops, getting the kids to school on your way to work, or deciding what pitch to throw to the next batter in a baseball game, we want to have a plan. We want to figure out just what we're trying to accomplish and then come up with a way to get it done. Well, ever since I took over here four years ago (I just celebrated my employment anniversary), the Board of Directors and many of you have wanted the Society to have a plan—a strategic plan. Thanks to the diligence of our chief operating officer Jennifer Vaughn and the staff, along with our superb consultant Warren Riley, we have an excellent strategic plan. Look for it soon in mailboxes and on **planetary.org**.

The main goals of the plan are to help us achieve our mission and vision of empowering the world's citizens to advance space science and exploration, so that people everywhere can know the cosmos and our place within it. The team and I have talked the plan and goals through. We feel we can achieve our three-year goals by August 21, 2017, when a total eclipse of the Sun will darken a swath from Northwest to Southeast right across the United States. It will be a big day for the Sun and, we hope, a big day for the Society.

The big idea behind the big ideas is to be even more influential, to promote an even more engaged and enthusiastic citizenry that embraces the importance and optimism of space exploration, so that humankind can look farther and deeper into space, make extraordinary discoveries, and advance our understanding of how we fit into it all. How hard could it be?

To help us grow, we have hired several new people, each of whom is an outstanding addition to the staff. You may already be reading Media Producer Jason Davis' illuminating blog, and you'll soon be enjoying the videos by Merc Boyan, another new media producer. Our executive assistant Whitney Pratz has streamlined everyone's workday, especially Jennifer's. Digital Marketing Manager Karen Hames has improved the performance and the overall look of our e-mail and marketing communications. If you're a Society volunteer, thank you; I'm sure you've been in touch with Kate Howells, our dedicated, Canada-based volunteer network manager. I am delighted that many of you have already heard from our new director of development Richard Chute; he brings valuable wisdom and experience to our operations. Our new director of communications is Erin Greeson; she will make a big difference in how we connect with the world and, especially, with you. As a member, you are the reason we all came to work today.

EUROPA UNITES CAPITOL HILL

Jupiter's moon Europa has gotten a great deal of attention recently, because people in the space industry, and in the government sector that funds exploration, are coming to realize how straightforward it might be to fund a mission out there and look at the plumes that may be streaming through the cracks in Europa's surface—a shell of water ice covering an ocean twice the size of our own. So in July, we held an event on Washington, D.C.'s Capitol Hill to raise awareness of the opportunity, importance, and fundamental awesomeness of such a mission. What if there's something alive out there?

Our own Casey Dreier set the stage. We had wonderful presentations from NASA's Chief Scientist Ellen Stofan and Europa Mission Study Scientist Bob Pappalardo. It was great.

Congressmen John Culberson, Lamar Smith, and Adam Schiff showed up and contributed. Whether or not you're from the United States, this was a remarkable example of how space brings out the best in us. These gentlemen are from different political parties and might often disagree, but here they are like-minded and motivated to make the mission happen.

I wrapped it up with my talk on "P.B. and J." or the Passion, Beauty, and Joy of exploration and discovery. Everyone was impressed by the science, and by the attendance of more than two hundred young staffers, people who want to see NASA take us to this new, exciting place—a place where we will certainly make astonishing discoveries.

VISITING JAXA

I recently made my first trip to Japan and my first visit with our colleagues at the Japanese Aerospace Exploration Agency (JAXA).

I met with Makoto Yoshikawa at JAXA's Institute of Space and Astronautical Science. We discussed the Society and our deeply shared interest in solar sailing. He and his team are as eager as any NASA principal investigator in trying to get a new solar sail mission funded. I got a brief tour of their clean room/final assembly building, which is strikingly similar to others I've visited in the U.S. and Europe. (I guess to get air clean enough for spacecraft assembly, we all have to abide by the same laws of physics.) Especially gratifying, and just plain fun, was meeting with the young engineers who are monitoring Japan's *Interplanetary Kite-craft Accelerated by Radiation Of the Sun (IKAROS)* solar sail (see the July/August 2010 issue of *The Planetary Report*), and planning the next sail mission.

As an engineer raised in the United States, I was struck by how we all are influenced by our cultures. My dad often gave me access to his tools. I remember spending a lot of time measuring things with a metal tape measure. I suspect our LightSail design team did as well. Our sails are deployed with metal ribbon "tape measure" booms. The Japanese engineers, most of whom are quite a bit younger than I am, grew up with origami, the art of folding paper. And sure enough, their solar sail designs involve extraordinary, elegant, and efficient methods of folding and packing the sail material. It's just cool.

As I toured the spacecraft display area in the lobby, where JAXA has models of *Hayabusa*, *IKAROS*, and several other Japanese-built spacecraft, a group of about thirty Japanese students recognized me. I was stunned. Apparently, the "Science Guy" television show makes its way to a sector of the Japanese educational system. I gave each kid a Planetary Society pin. It was wonderful to see the students' enthusiasm on the other side of Earth.

PROGRESS ON *LIGHTSAIL-1*

And finally, I must mention that *LightSail-1* passed its Day-in-the-Life test, showing that the sail can perform its key functions in space. The whole team gathered on the campus of Cal Poly San Luis Obispo to watch it unfurl its sails and pass the major systems test. For a full report on the day's activities (and to watch the sail deploy), go to **bit.ly/1mVgXut**.

People around the world will be able to watch it from here on our planet's surface, as well as in space from its own onboard cameras. It will be a fantastic experience for citizens of the world. Together we can engage people in space exploration; together we can change the world.

Bill Nye

ABOVE *In July, The Planetary Society hosted "The Lure of Europa" on Washington, D.C.'s Capitol Hill. Here, Bill explains the importance of a new mission to the Jovian moon to a crowded room. At his side is the Jet Propulsion Laboratory's Europa Mission Study Scientist Bob Pappalardo.*

Photo: Tushar Dayal for The Planetary Society

HAPPENING ON
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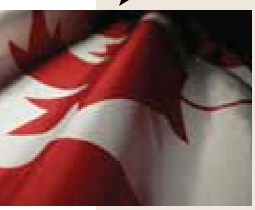
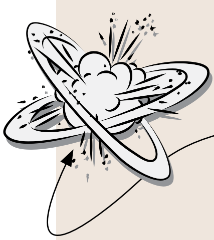


LIVE: WE SEE THEE RISE: THE CANADIAN SPACE PROGRAM
We welcomed 1,600 Canadian space enthusiasts to the University of Toronto in October for our celebration of Canada in space! Guests included Canadian space writer Elizabeth Howell, University of Western Ontario planetary scientist Gordon "Oz" Osinski, and Canadian Space Agency astronaut Jeremy Hansen. **bit.ly/1qjyuqP**

LIVE: *MAVEN* ARRIVES AT MARS!
The United States' latest guest of the Red Planet entered orbit on the evening of September 22, 2014, and the crowd at *Planetary Radio Live* was watching with fingers crossed. **bit.ly/1mztkf5**

MIGUEL ALCUBIERRE, INVENTOR OF WARP DRIVE?
Distinguished physicist Miguel Alcubierre developed the general relativity-based model for warp drive 20 years ago, but he doubts it will ever be a reality. **bit.ly/1wfqH2F**



ALAN STERN AND A BIG MILESTONE ON THE WAY TO PLUTO
New Horizons Principal Investigator Alan Stern discusses passing through Neptune's orbit on August 25, as well as *MAVEN* and a new Uwingu initiative. **bit.ly/1mOGJuJ**

THE SEARCH FOR EXTRATERRESTRIAL POLLUTERS?
Harvard student Henry Lin has led work that determined the soon-to-be-launched James Webb Space Telescope may be able to detect an alien civilization by analyzing pollution in its atmosphere. **bit.ly/VjGRKV**

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ON *PLANETARY.ORG*

BOOK REVIEW
THE NIXON SPACE DOCTRINE John Logsdon's new book shows how the post-*Apollo* era was defined by Richard Nixon. **bit.ly/1yHuLgR**

NEWS
EARLY ARRIVAL Jason Davis figures out why *Orion* is on the launchpad early. **bit.ly/1yCQsPb**

PROJECTS
UNFURLING SAIL Video from *LightSail*'s Day-in-the-Life test. **bit.ly/1mVgXut**

SCIENCE UPDATE
MARS UPDATE Emily Lakdawalla comments on the fourth full drill hole on Mars and speculates on wild rock fractures. **bit.ly/1pCX45Q**

SPACE IMAGERY
AMAZING VIEWS FROM INDIA *Mars Orbiter Mission* delivers on its promise of stunning views of Mars. **bit.ly/1vppB5i**

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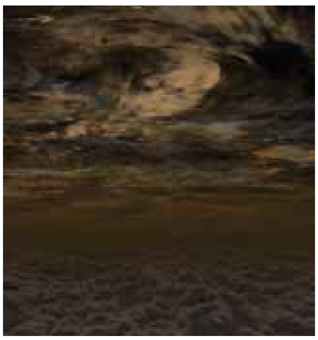
LONG-DISTANCE AUTO MECHANIC Exhaustive detail about *Curiosity*'s wheel damage, its causes, and possible solutions. **bit.ly/1z1mWxt**

LOOKING INTO THE FUTURE
FLYING TO EUROPA Van Kane looks at potential issues for designing a suitable mission to Europa. **bit.ly/1ryyWZp**



ABOVE *Scientists have discovered relatively clear skies, illustrated above, on HAT-P-11b, an exoplanet about the size of Neptune. Until now, all exoplanets observed in this size have been found to have high cloud layers that blocked any detection of molecules in their atmospheres, as depicted below.*

Illustrations: NASA/ESA/R. Hurt, JPL-Caltech

SCIENTISTS HAVE DISCOVERED clear skies and steamy water vapor on a gaseous, Neptune-size planet outside our solar system. The planet is the smallest for which molecules of any kind have been detected.

The planet, HAT-P-11b, is located 120 light-years away in the constellation Cygnus. Unlike Neptune, this planet orbits close to its star—about once every five days. Scientists believe it to be a warm place with a rocky core and gaseous atmosphere.

Clouds in a planet's atmosphere can block the view to underlying molecules that reveal information about the planet's composition and history. Finding clear skies on a Neptune-size world is a good sign that other smaller planets might have similarly good visibility.

In the new study, which was reported in the September 25, 2014 issue of *Nature*, the researchers set out to look at the atmosphere of HAT-P-11b, not knowing if it would contain clouds or not. They used Hubble's Wide Field Camera 3, and a technique called transmission spectroscopy, in which a planet is observed as it crosses in front of its parent star. Starlight filters through the rim of the planet's atmosphere and into a telescope's lens. If molecules such as water vapor are present, they absorb some of the starlight, leaving distinct signatures in the light that reaches the telescope.

Using this strategy, Hubble was able to detect water vapor at HAT-P-11b. The team then used NASA's Kepler and Spitzer telescopes to verify that the water was, indeed, emanating from the planet.

The results from all three telescopes demonstrate that HAT-P-11b is blanketed in water vapor, hydrogen gas, and likely other yet-to-be-identified molecules. The scientists plan to examine more exo-Neptunes in the future and hope to apply the same method to smaller super-Earths—the massive, rocky cousins to our home world with up to ten times the mass.

"The work we are doing now is important for future studies of super-Earths and even smaller planets, because we want to be able to pick out in advance the planets with clear atmospheres that will let us detect molecules," said Caltech's Heather Knutson, a coauthor on the study.

—from NASA

QUESTIONS AND ANSWERS

Q In popular astronomy books and magazines, the Sun is almost invariably depicted as just another bright star in Pluto's dark sky. Are there plans to have *New Horizons* look back and take a picture of the Sun from Pluto's distance?

– Rafael Moro-Aguilar, Madrid, Spain

A Great question! While the Sun is just one of many stars, it's still the brightest star in Pluto's sky by quite a bit. When *New Horizons* passes by Pluto on July 14, 2015, its distance from the Sun will be almost 33 times the distance between Earth and the Sun. The Sun will be over a thousand times dimmer there than it is on Earth, but even that will be too bright for the spacecraft's two imaging instruments: Ralph (its visible and infrared imager/spectrometer), and LORRI (Long Range Reconnaissance Imager). We're worried that taking pictures of the Sun might damage the instruments before the extended mission to fly by Kuiper belt object (KBO) targets takes place. However, after *New Horizons* flies by a KBO, risking these instruments will not matter any more, so we could try it then. We just haven't planned that far out yet—for now, our eyes are on Pluto!

—Amanda Zangari
Southwest Research Institute

PAUL SCHENK *maps icy moons and is a co-investigator on* New Horizons, *and a participating scientist on* Dawn *and* Cassini.

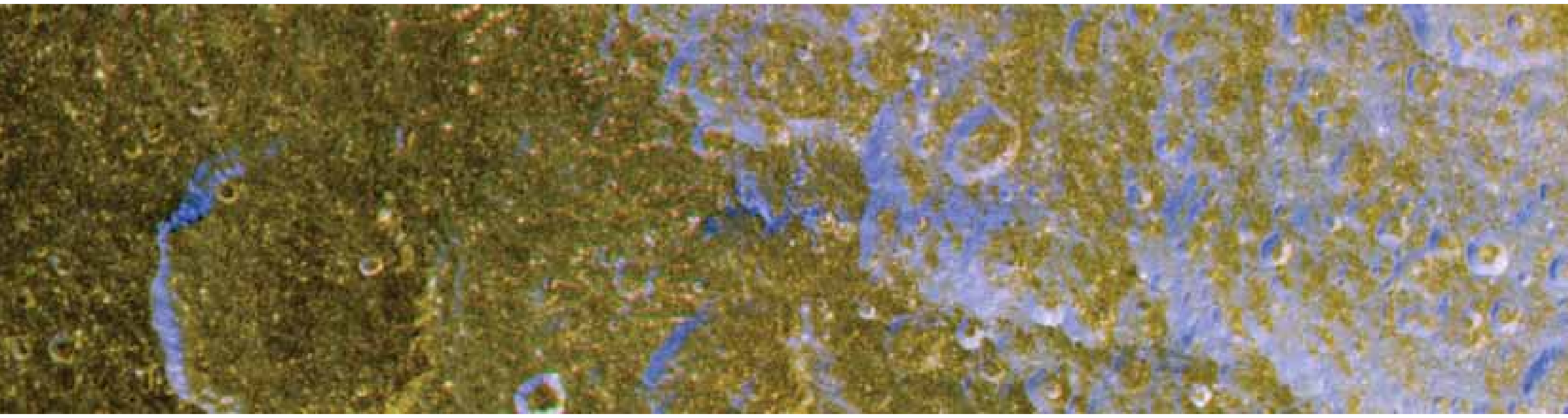
Blue Pearls for Rhea

Color-Mapping Saturn's Icy Moons

THE FIRST FIFTY YEARS of solar system exploration have surprised us with many scientific marvels and insights, but no one, not even the great, pioneering space artist Chesley Bonestall, anticipated the fascinating vistas the planets would reveal. *Mars Reconnaissance Orbiter* and rover images of the Red Planet have a stark beauty all their own, like the Painted Desert in Arizona, and Europa often resembles a Jackson Pollack painting in the right light. Yet it is subtle, majestic, ringed Saturn that has a special place in our imaginations.

Cassini has been streaming stunning images of Saturn to Earth since 2004. While the ringed planet and its large moon Titan have certainly lived up to expectations, many of the planet's icy moons have become unexpected stars in *Cassini*'s show. By turning on the color switch in our mapping process, these little ice worlds have now come into their own.

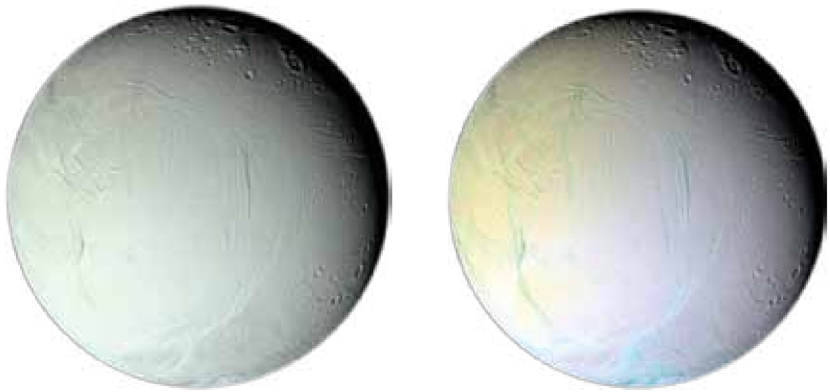
Every planet we map in detail surprises us, and Saturn's moons are no exception. Enceladus, barely measuring 600 kilometers (about 370 miles) across and no larger than Great Britain, has been the star, but Mimas, Tethys, Dione, Rhea, and Iapetus also have not disappointed. The maps and high-resolution mosaics of these moons not only reveal scientific surprises, they bring out the best in these small worlds.



ABOVE *In this* Cassini *mosaic, constructed from infrared (IR), green, and ultraviolet (UV) images, splotches of blue lie scattered along the equator—somewhat like a string of pearls—on Saturn's icy moon Rhea. The blue patches were formed when ring particles in orbit around the moon hit its heavily cratered surface, disrupting its soil. The scene is 650 kilometers (about 400 miles) long.*

FIRST FULL-COLOR MOON MAPS

Global color mapping of Saturn's classic midsize icy moons (those known before the start of the Space Age) is now essentially complete, thanks to ten years of *Cassini*'s orbital operations. *Cassini*'s orbital tour was designed to map these moons piecemeal. Because the Saturnian system is so densely populated, each moon could be visited up-close only a few times. There have been more than twelve targeted encounters with Enceladus but only six with Dione and two with Iapetus, for example. These encounters were at distances of less than 3,000 kilometers (1,860 miles) or so. Thanks to planning by *Cassini* team members such as Cornell University's Paul Helfenstein and Tilmann

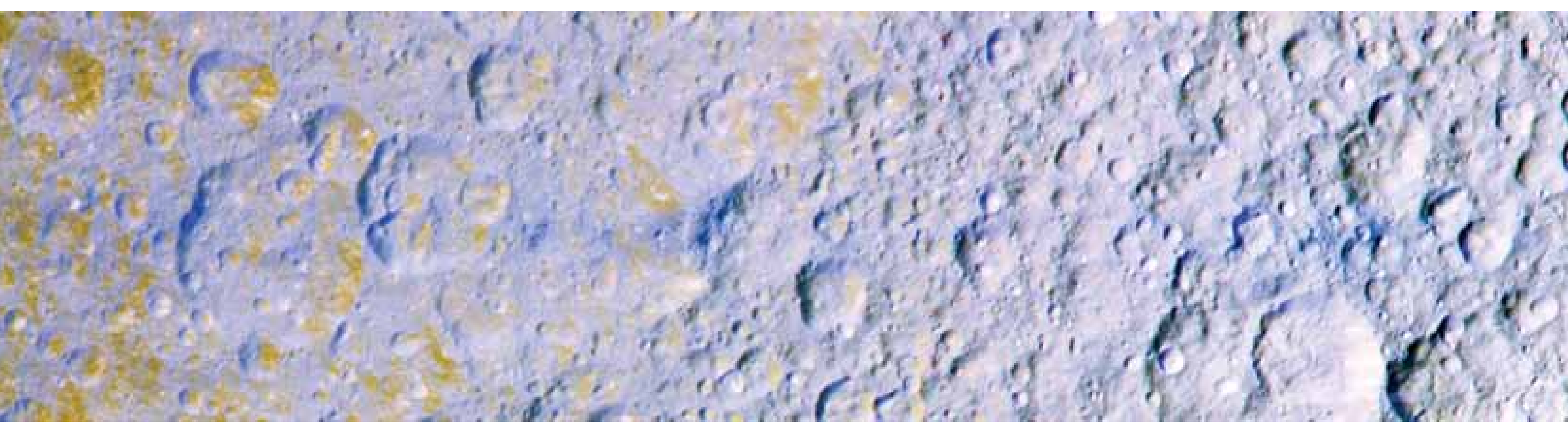


LEFT *Enceladus looks pretty enough in a "natural" color image (left) taken through* Cassini*'s red, green, and blue filters. But if we bump up its colors beyond the range of human vision using those same IR, green, and UV colors (right), interesting things begin to emerge. Not only do the bluish walls of recently formed fractures stand out, but the moon's orange and pink global surface pattern becomes more pronounced. The pink areas are where fine particles falling out from the icy moon's south polar jets are thickest.*

All mosaics and images: NASA/JPL-Caltech/SSI/Paul Schenk, Lunar and Planetary Institute

Denk of Berlin's Free University, the spacecraft returned images from different regions or hemispheres during these encounters, to be reconstructed later. More distant encounters filled in the remaining gaps.

Like most planetary cameras, and unlike imaging spectrometers, the *Cassini* Imaging Science System (ISS) camera acquires each color filter image separately for later transmission to Earth. *Cassini* must also do its mapping in the form of multiple frame mosaics of those areas in view during each encounter. Most of these mosaics were acquired in three colors, and they have now been assembled into the first seamless, high-resolution full-color maps of these bodies. The natural colors of these moons are muted and slightly greenish in cast, but *Cassini* also mapped in a color range extending beyond human vision. Our human color vision ranges from approximately 400 to 700 nanometers in wavelength. The new *Cassini* maps are in the ultraviolet (UV) and near-infrared (IR) range, from 340 to 930 nanometers and sometimes beyond, and it is in this range that the color differences really pop out.

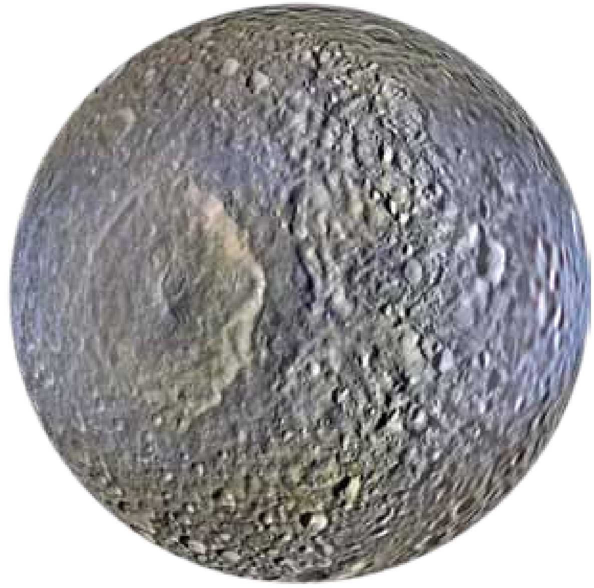


A MOSAIC OF THOUSANDS OF IMAGES

How are such maps produced? Each new map is made from more than a thousand individual images, obtained in four distinct spectral channels, or layers. The first layer is the base map, constructed of hundreds of the highest resolution clear filter images of each body. This filter has the best transparency to light and covers the visible spectral range. Base map resolution depends on the resolution of the majority of the images, which were chosen to highlight feature definition. For Iapetus and Rhea the map resolution is 400 meters, Dione and Tethys 250 meters, and Mimas 200 meters per pixel. At 100 meters, Enceladus has by far the best mapping coverage for any icy satellite. The color images were selected to provide the best color resolution at each wavelength. Ideally, we selected color images acquired at the same time as the base map images.

Rhea

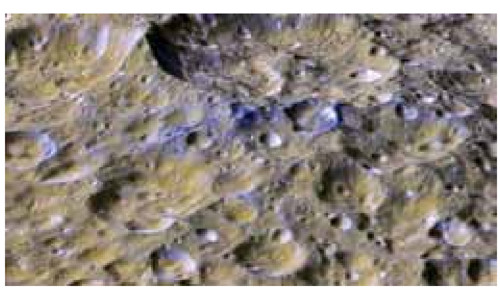
Mimas



ABOVE Cassini's *new color maps of Saturn's icy moons reveal many differences among them. Rhea's surface is divided into dark and brighter sides (the pearls are too small to be seen here). Mimas is dominated by the Herschel impact crater, but its bluish equatorial zone stands out. Tethys, too, is dominated by a big crater but also features a large fracture system (shown here), a bluish equatorial zone (left) similar to Mimas', and a reddish darkening on one side. On bright and dark Iapetus, the equatorial ridge is visible. In the areas between the moon's hemispheres, the ridge is partly ice covered and stands out from the dark material.*

RIGHT *One of Rhea's "blue pearls" is seen up close in this perspective view of its heavily cratered landscape. This* Cassini *IR, Green, and UV mosaic was obtained at a resolution of 130 meters per pixel and is approximately 85 kilometers (about 50 miles) wide.*

Mapping starts as individual clear, IR, green, and UV images are calibrated to remove electronic camera and charge-coupled device (CCD) effects. Each image is then registered into what we call the global control network to properly position it on the surface, re-projected to a common map format, photometrically adjusted to remove the effects of global shading, and then digitally combined to make a global map in each color filter. The three color maps are then merged with the clear base map to make the final map.



NEW DISCOVERIES AND NEW PUZZLES

Although it was always planned to eventually produce global color maps of these moons, the maps and the discoveries they unlocked were results of serendipity. For example, in the process of producing a high-resolution stereo (3-D) mosaic and topographic map of cratered regions on Rhea, I noticed an odd, bluish spot on its equator. More on this interesting feature later, but being curious I wanted to know if there were other such spots on Rhea. Sure enough, a color mosaic to the east showed several more bluish spots, also on the equator. In fact, bluish spots were strung more than halfway along Rhea's equator like an enormous string of bluish pearls! Here was a mystery, one requiring a more complete global map.

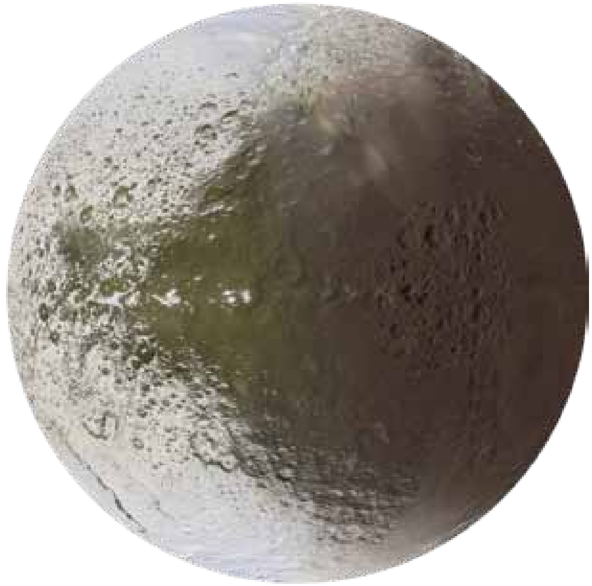
If Rhea has "blue pearls," what about her siblings? The next logical step was to make color maps of all six of the larger airless, icy moons. These maps show that several of the moons have dark, reddish discolorations on their leading and trailing hemispheres, easily understood as discolorations due to E-ring dust and magnetospheric alteration by charged particles, respectively. None of the other moons have the same blue pearls, but Mimas and Tethys have something just as weird: wide bands of bluish to "UV-ish" discoloration along their equators. Broad and diffuse, these bands stretched across their leading hemispheres like giant cummerbunds (like Earth's Moon, Saturn's moons are locked and keep one side facing Saturn and one side facing forward).

Here were some new puzzles revealed

All mosaics and images: NASA/JPL-Caltech/SSI/Paul Schenk, Lunar and Planetary Institute

Tethys

Iapetus



in the color patterns of Saturn's icy moons. I called some of my colleagues, and we set to work figuring out what we were seeing. Chris Paranicus, of Johns Hopkins University's Applied Physics Laboratory, had been using *Cassini*'s Magnetospheric Imaging Instrument (MIMI) to look at the behavior of high-energy electrons trapped in Saturn's magnetic field. He found that they impact the surfaces of these moons in a pattern exactly the same as our equatorial UV color bands on Mimas and Tethys. Three months after this discovery, *Cassini*'s Composite Infrared Spectrometer (CIRS) found that the color patterns also correlate very well with a thermal anomaly, a cold temperature pattern commonly known as the Mimas/Tethys Pac-Man Feature, indicating that the impact of the electrons alters the grain size and compaction of these icy surfaces in observable ways. Here is a classic example of how planetary processes are revealed when we explore with a comprehensive suite of instruments at many wavelengths.

STRINGS OF BLUE PEARLS

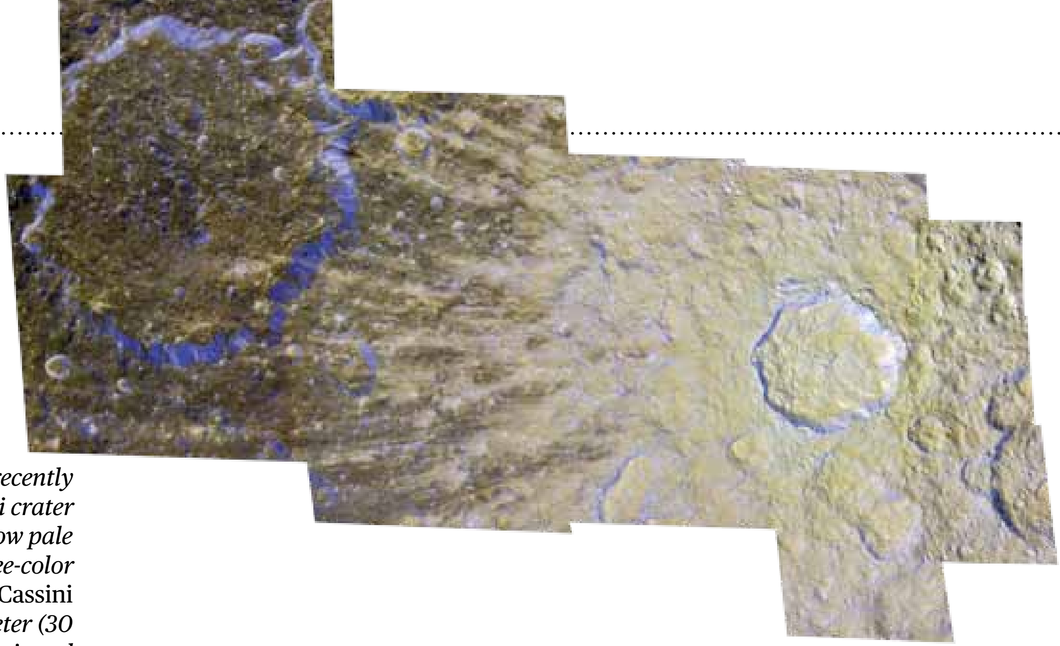
Back to those beautiful blue pearls on Rhea. These small spots form irregular discolorations a few kilometers across along the equator, separated by 50 to 100 kilometers (30 to 60 miles). Curiously, they are always found only on the locally highest spots on the equator. This pattern is similar to another one of *Cassini*'s great discoveries: the 20-kilometer (12 mile)-high topographic ridge on Iapetus, also found only along the equator.

How does a monstrous ridge resemble a faint set of blue spots? The maps show that the ridge on Iapetus is not continuous but broken into isolated knobs and shorter segments along the equator, in roughly the same pattern as what we see on Rhea. The difference between the two is that the ridge on Iapetus has mass and height, while the blue pearls on Rhea are merely discolorations on an otherwise undisturbed surface.

One of the more interesting ideas to explain the ridge on Iapetus, put forward by European Space Agency's Wing-Huen Ip, was

ABOVE *Bright, icy patches lie on the flanks of a 10-kilometer (6.2 mile)-high mountain in this perspective view of Saturn's strange, icy moon Iapetus. These hills are part of the satellite's famous globe-girdling equatorial ridge and mountain system, which probably formed long ago when a dense, orbiting ring system re-accreted back onto its surface. This view is 100 kilometers (62 miles) wide.*

PAUL SCHENK *is a planetary research scientist at the Lunar and Planetary Institute in Houston, Texas, where he studies the cratering, volcanic, and geologic histories of the outer planets' icy moons. He also uses colors, topography data, and high-resolution imaging to map those icy moons. On his days off, he sometimes goes diving wearing an old diving suit and brass helmet and is something of a diving historian. He also flunked out of art school.*



ABOVE *Rhea's recently formed Inktomi crater appears to glow pale yellow in this three-color (IR, green, UV)* Cassini *view. This 50-kilometer (30 mile)-wide crater ejected bright ice over a broad area. The blue-rimmed craters at left are older.*

BELOW LEFT *Bluish ice is visible along the inner walls of Bagdad Sulcus, one of Enceladus' active "tiger stripe" vents. This IR, green, and UV view was obtained at 35 meters-per-pixel resolution and is 30 kilometers (about 19 miles) across. The pinkish area is covered by fine material deposited from the icy jets.*

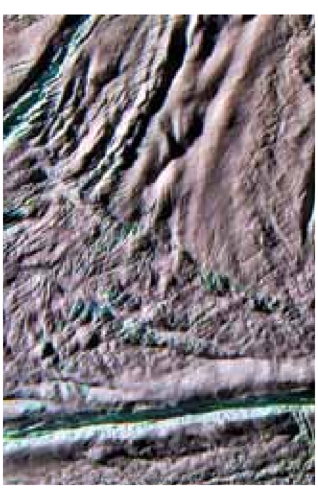
BELOW RIGHT *Temperature maps of Mimas and Tethys from* Cassini's *Composite Infrared Spectrometer show cold areas identical to the bluish regions seen in the global maps on the preceding page.*

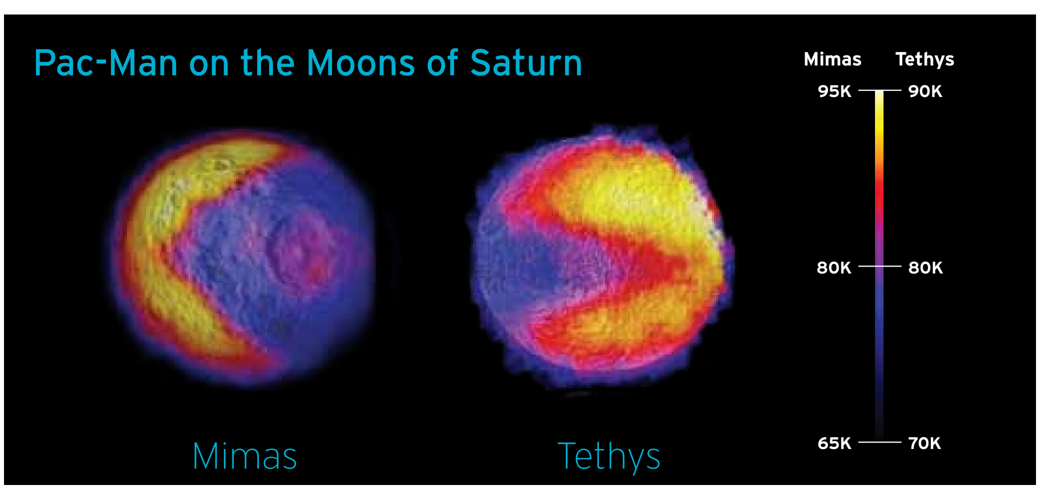
that a ring-like mass of particles formed in orbit around Iapetus, possibly from a large impact event, and that some of this mass re-accreted back onto the surface along the equator. This novel idea was not considered very plausible, or at least very likely, when it was first proposed in 2007. With the discovery of a similar (though much less massive) feature on Rhea, the concept of temporary rings forming around satellites becomes much more plausible, indeed likely, as several of my colleagues have since shown in numerical models. Ringed satellites are another of the profound discoveries of the *Cassini* mission.

How does one construct a ridge from a ring? It's relatively simple. Ring particles orbiting moons of giant planets do not last long but either dissipate into space or slowly (think centuries) spiral in toward the surface. With no atmosphere, the particles eventually hit the surface at very low grazing angles, hitting the first high obstruction that gets in their way. On Rhea, not many particles hit and only the regolith is disturbed, exposing deeper ices. On Iapetus, many millions of tiny particles hit the same obstructions, slowly accumulating a narrow pile of debris along the equator, hence a long set of ridges.

ENCELADUS REPAINTS ITSELF

Enceladus, with its active jets and plumes at the South Pole, always seems to steal the show, and it should be no surprise that Enceladus is the most colorful of Saturn's icy moons. Several factors combine to make this so. First, Enceladus' surface is geologically younger than the other moons and has not had as much time for erosion, which tends to mute geologic colors. Second, the geologic activity on Enceladus results in continual fracturing and exposure of new crust at the





Mimas/Tethys Pac-Man Feature image: NASA/JPL-Caltech/GSFC/SWRI surface. Third, some of the ice-rich, colorful dust from the plumes and jets at the South Pole returns to its surface.

When we looked at the first color maps of Enceladus, they appeared different from the others. There was a global symmetry, with opposite hemispheres redder than the rest of the surface, but the pattern was offset 40 degrees from where we expected it to be. When I showed this map to my colleagues, one of them said, "We have seen this pattern, too."

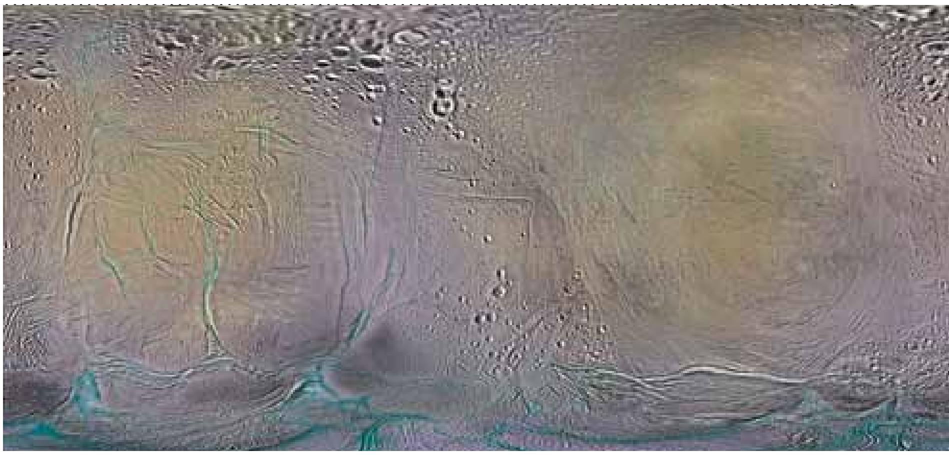
As I was mapping color on Enceladus, Sasha Kempf of the University of Colorado and Jurgen Schmidt of Finland's University of Oulu had been modeling what happens to the dust-sized grains of ice from these plumes. Most of this icy dust escapes to form the giant E-ring around Saturn but some of the dust returns to the surface, mostly in two giant tongue-like extensions from the South Pole that extend northward beyond the equator. Our color map, showing two large areas brighter in the UV spectrum (or bluer) than normal, matched this pattern almost exactly. Here was direct evidence that Enceladus was repainting itself with a kind of extremely fine "snow," with accumulations up to meters or tens of meters in some areas.

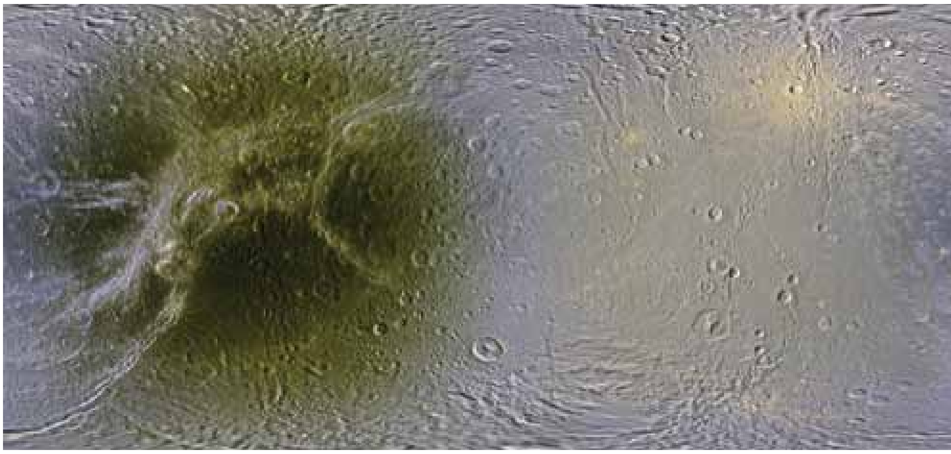
Many other areas on Enceladus show intriguing color complexities related to local geologic history. Tectonically fragmented regions have complex color patterns. The most striking color differences are associated with relatively young, deep fractures. The exposed walls of these fractures are even bluer than the plume dust deposits and perhaps similar to the striking bluish ice we often see in tourist pictures of polar glaciers here on Earth.

INSIGHTS FROM COLOR

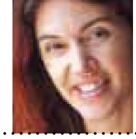
Mapping in color helps us unravel the geologic histories of all the icy moons, including Enceladus, Dione, and the rest of Saturn's family, and has been directly responsible for several interesting discoveries. Color maps with their subtle hues also give us a more realistic sense of what these surfaces look like from a human perspective, and are somehow more intuitively insightful than the grey-tone images and mosaics that are often published. Humans have a strong aesthetic sense of natural beauty, especially on their native planet. Color mapping of planetary surfaces thus helps us leap beyond the scientific information gleaned and provides a unique human look at nature's handiwork. Each of the planetary bodies we have looked at across the solar system, including the moons, has proved to be a unique world with its own inherent geology and native beauty. One can only wonder what we will find when we start exploring the thousands of other planetary bodies being discovered in our galactic neighborhood.

More information about Paul Schenk's icy moons mapping project is available on the Lunar and Planetary Institute's website at lpi.usra.edu/icy_moons.





ABOVE *Global maps of Enceladus (top) and Dione (bottom) show surprising diversity of features. The yellow and pink colors of Enceladus betray the redeposition of ice dust from the jets at its South Pole. Dione, however, is affected by radiation particles altering the backside (left) and turning it dark, broken only by the network of bright fractures. The brighter forward side at right is covered in dust from Saturn's E-ring. The bright splotch on Dione is the young 30-kilometer-wide crater Creusa.*



REBECCA THOMAS *is a PhD research student at The Open University, U.K.*

Missives from *MESSENGER*

New Views of Mercury Reveal a More Volatile-Rich World

ABOVE *The region around Rachmaninoff, a double-ringed impact basin on Mercury, is scientifically intriguing because it shows evidence of hollows (surface features caused by sublimation of volatiles) and explosive volcanism (including the largest such deposit on Mercury, at upper right).*

ONE OF THE MOST EXCITING findings of the *MESSENGER* spacecraft currently orbiting Mercury is evidence that the planet is rich in volatiles (substances that readily change from solid to vapor at low temperatures). For instance, *MESSENGER* has detected higher-than-expected abundances of these substances on the planet's surface, as well as landforms best explained by volatiles escaping from within its crust and mantle.

Prior to *MESSENGER*'s arrival we knew that Mercury has a huge iron core, and the leading hypotheses to explain this implied that the planet would be volatile-depleted. For example, processes in the early solar nebula may have meant that the building blocks for Mercury were iron-rich but volatile-poor. Alternatively, Mercury may have suffered substantial volatile loss shortly after it formed, either in a giant impact or by vaporization in the heat of the hot young Sun, as was recently suggested for dense exoplanets close to their stars.

LEARNING ABOUT THE SURFACE

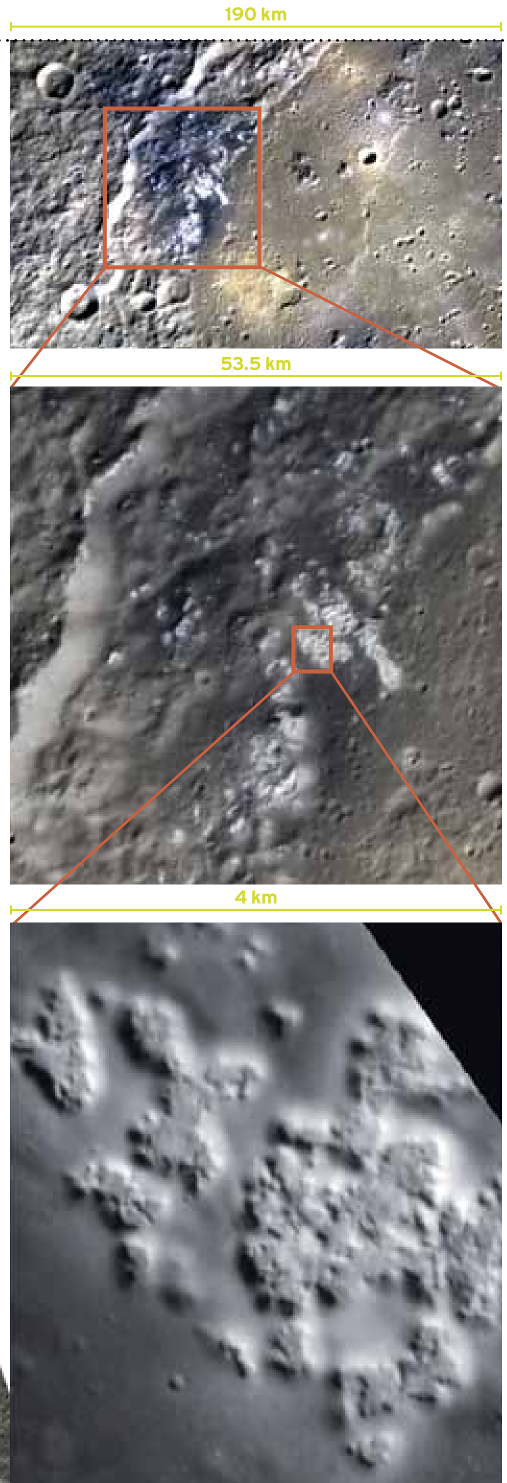
Data gathered by *Mariner 10* in the 1970s and Earth-based radar observations did not challenge these hypotheses to any great degree. The surface looked old and cratered, and though there were indications of volatiles in permanently shadowed craters near the North Pole, they could have been delivered from outside by cometary impact. However, after *MESSENGER* reached Mercury in 2008, made three flybys and then settled into orbit, our view of the innermost planet has had to change radically. *MESSENGER* has sent back a wealth of invaluable data: images of the entire surface at unprecedented resolutions, topographic data from its laser altimeter, and chemical and mineralogical data from its spectrometers. All this has led us to a surprising conclusion: Mercury is neither dead nor dry.

With daytime temperatures exceeding 400 degrees Celsius (750 degrees Fahrenheit), Mercury's surface was never going to be a land of rivers and jungles. All the same, the percentage of volatile elements at its surface is startling. *MESSENGER*'s X-ray and gamma-ray spectrometers have detected ten times the sulfur content of the silicate portion of Earth and a higher potassium-to-thorium ratio than on Mars. This is despite the fact that both sulfur and potassium are relatively volatile. Though it is possible that internal processes have concentrated volatiles at Mercury's surface and the bulk planet's volatile concentration is lower, it certainly does not look like Mercury is highly volatile-depleted.

A GEOLOGICALLY ACTIVE MERCURY

Volatiles are important to me as a planetary geologist because of the positive effect they have on so many of the processes that make a planet geologically active. For example, they lower the melting temperature of rock and favor volcanism, and their presence in the crust enables movement of faults. Additionally, volatiles at the surface lead to all kinds of fascinating geomorphological processes—just look at Mars or Titan—and volatiles in magma can lead to dramatically explosive eruptions.

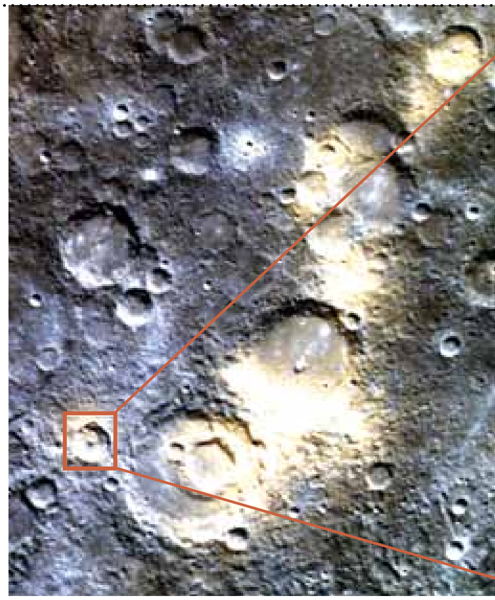
Images: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington

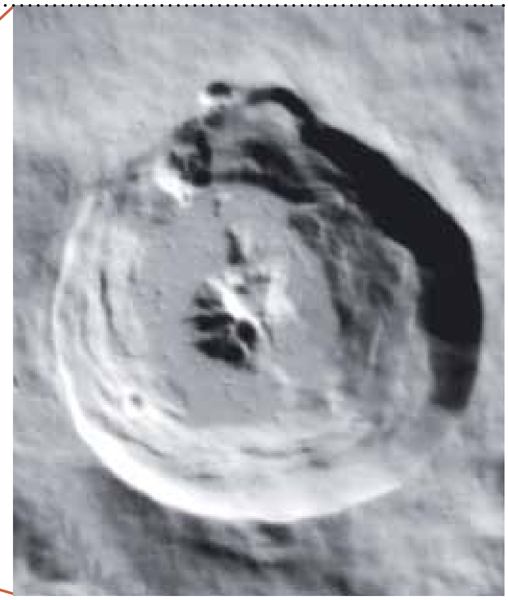


The more we look at Mercury's surface, the more we see confirmation that volatiles are in play there. Its most intriguing (and downright beautiful) surface features are the small, haloed depressions known as "hollows." Clusters of hollows with diameters from one kilometer (0.6 mile) to hundreds of kilometers occur all over the planet's surface, usually in impact craters. They look like the surface has been eaten away, leaving flat-floored depressions about 50 meters deep. Bright, bluish material on their floors and in a halo around them made them stand out even in lower-resolution *Mariner 10* images, and they were initially dubbed Bright Crater Floor Deposits (BCFDs). What is really surprising about hollows is that they look so fresh: their margins are crisp and they are not superposed by impact craters, large or small. Because

LEFT *These high-resolution images of hollows in dark, low reflectance material (LRM) at the rim of Sholem Aleichem crater show their detailed morphology. They have broadly flat floors with some rough blocks, and their margins are very crisp, suggesting that they formed recently in geologic terms.*

BELOW *The impactor that formed Mercury's de Graft crater seems to have exposed dark LRM rock. Sometime after that, hollows formed all over the crater's floor and peak structures, as seen in these magnified views. The hollows' formation was probably due to sublimation of the LRM at the surface and the subsequent loss to space.*





ABOVE *Bright, relatively red deposits form a "line of fire" at the margin of an ancient impact basin, and they surround pits that we believe to be explosive volcanic vents. The close-up shows Kuniyoshi crater, a very young crater southwest of the line. Kuniyoshi's freshness suggests that it, and the explosive volcanism within it, may be less than a billion years old–very young in Mercury terms!*

Images: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington

counting superposed impact craters is our best method of dating planetary surfaces from orbit, this lack of cratering means it is quite possible hollows are forming even now.

So what do hollows have to do with volatiles? The way they cluster to form wide, relatively flat-floored areas makes it improbable that they are the vents of volcanic eruptions, so our best guess is that they form by the loss of volatile material from the planet's surface. Considering the searing temperatures reached at Mercury's daytime, the prime candidate mechanism for their formation is sublimation: volatile elements near the surface are heated, go straight from the solid state to gas, and are lost to the exosphere. The distribution of hollows across the planet's surface does seem to confirm this. Surface regions that receive more heating from the Sun have more hollows than generally cooler areas. Additionally, hollows in those colder areas are more frequently associated with volcanic vents than hollows elsewhere, which may mean heating from within can also provide the energy required for volatile loss in areas where the Sun's heat is less dominant.

This begs the question: if solar heating strips volatiles away from the surface, why do we see fresh hollows? Surely, all the near-surface volatiles should have been lost by now? The answer to this quandary is impact cratering. As mentioned above, most hollows are in impact craters. Craters with hollows are almost always either in the dark substrate known as low reflectance material (LRM) or they expose LRM in their interiors. It seems that LRM is a volatile-bearing rock and that fresh exposures of it result in volatile loss and hollow formation, leaving behind the eye-catching bright material.

How LRM formed in the first place is the next important question. Mercury's crust is very thin, so could it be upper mantle material? Or is it the original crust of Mercury, formed at the dawn of the planet's history? The answer to this is essential for determining whether LRM's high volatile content is a result of a high bulk volatile content within Mercury, or whether it has built up through concentration of volatiles in one particular substrate.

RECENT EXPLOSIVE VOLCANISM

While hollows show a high concentration of volatiles at the surface, our best probe of the planet's interior is volcanism. There has been a lot more volcanic activity on Mercury than we used to think. Lava plains cover 27 percent of the globe, and vents surrounded by bright,

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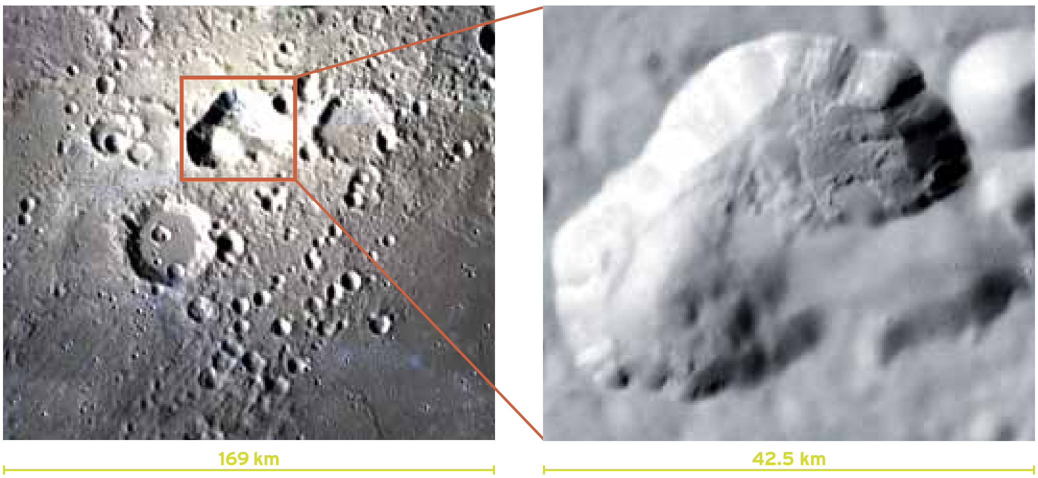
REBECCA THOMAS *is in the final year of her PhD research into the geology of the planet Mercury, making new discoveries about the innermost planet using data from the* MESSENGER *spacecraft. She has also investigated extremely recent flows on the Cerberus Plains of Mars.*



ABOVE *The pyroclastic deposit northeast of Rachmaninoff is the largest on Mercury, spanning 130 kilometers from the center of its vent. It appears that the vent may actually be two or three conjoined volcanic pits, suggesting that the site of eruption moved over time.*

red deposits across the planet seem to be the result of widespread explosive volcanism. What's more, this volcanism was long-lived: large-scale lava plains have been dated up to 3.5 billion years ago, and smaller effusive and explosive eruptions appear to have continued into at least the last 2 billion years, and probably as recently as 1 billion years ago. This is despite the fact that, as a small body with a high surface-area-to-volume ratio, Mercury would be expected to cool faster than a larger planet like Earth, leaving less energy for magma melting. That cooling has also led to global contraction and lithospheric thickening, which hinder magma ascent even if magma is being generated at depth.

As mentioned earlier, volatiles reduce the melting temperature of rock, so the more volatiles are present in Mercury's crust and mantle, the easier it is to melt it. However, the detection of long-lived volcanism alone is not enough to prove there are volatiles at depth in Mercury. Other processes could account for it; for instance, insulation of the planet's interior by a thick outer megaregolith, as has been proposed to explain similarly long-lived volcanism on the Moon. A much better indicator of the presence of volatiles is the widespread occurrence of explosive volcanism. Volcanism becomes explosive when volatiles in the magma or in its environs expand and rip the magma to pieces, spraying out fragments that fall to create pyroclastic deposits. This is what we think the bright, red, diffusely margined deposits around central pits are. At last count, we have found these deposits at 150 locations on Mercury. The deposits can be enormous: the largest, northeast of the Rachmaninoff basin, extends up to 130 kilometers (about 80 miles) from its vent. It takes a very high volatile concentration to eject particles to that distance, at least as much as the concentration present in such eruptions on Earth.

The important question here is where the volatiles are coming from. One option is that they may not begin in the magma at all. When rising magma hits shallow seawater or a lake or aquifer on Earth, violently explosive eruptions can occur. So far, the evidence does not point toward such a strong contribution from nonmagmatic volatiles. Hollows are our clearest indicators of volatiles in the crust, and though explosive volcanism often occurs near them, the scale of eruption does not seem to increase if there are more hollows or if hollows are closer to the vent. While we cannot rule out some incorporation of volatiles from the rock through which the magma rises, the evidence as it stands doesn't point to sudden mixing with a large body of subsurface volatiles.

That leaves the magma itself as the main source of the volatiles, which is exciting because it may indicate that Mercury's mantle is volatile-rich. But here we have to tread carefully. The volatile concentration at the

Image: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington

ABOVE *A bright cluster of hollows etches an area within an unnamed basin on Mercury. This is the only area within the basin in which hollows are found. To the bottom left is part of the peak ring of the basin. This peak ring has been modified by subsequent impacts. This is a high-resolution observation, at 21 meters per pixel, so the full image is about 27 kilometers (about 17 miles) square.*

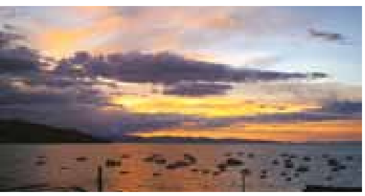
time of eruption isn't necessarily the same as that in the magma at depth—volcanic systems are much more complex than that. On Earth, volatiles often concentrate in magmas during storage in a subsurface magma chamber. Volatile-poor minerals crystallize out first, leaving the remaining melt volatile-enriched. Additionally, the magma can be enriched in volatiles by incorporation of melted volatile-rich wall rock.

The evidence does point to subsurface storage of this kind on Mercury: volcanic vents often form groups or overlap each other, indicating that they originate from one shallow source body from which the site of eruption varied over time. That means that the far-flung pyroclastic deposits do not necessarily indicate incredibly volatile-rich magma at depth. Still, to be concentrated in this way, volatiles did need to be originally present in the magma or its environs, so, as with hollows, explosive volcanism is an excellent sign that Mercury has significant volatile content.

UNDERSTANDING MERCURY'S FORMATION

All this tells us that we need to go back to those proposed formation mechanisms for Mercury and seriously reconsider those that would lead to a volatile-depleted planet. Some theories, such as early vaporization of much of the planet's rocky mantle by the Sun, probably need to be thrown out completely. Others have to be modified to account for what we're now learning about Mercury's composition. For instance, new versions of the giant impact hypothesis have volatiles re-accreting after the impact.

Our understanding of both hollows and explosive volcanism will benefit from the next six months of observations by *MESSENGER*, as it gathers data from lower altitudes before impacting the surface next March. After that we have a lot to look forward to from *BepiColombo*, the joint ESA and JAXA mission that should be arriving at Mercury in 2024. Compositional analyses will be the key to understanding both hollows and explosive volcanism and figuring out what they mean about the planet's bulk volatile content and the processes that have concentrated it. The better we understand Mercury, the better we understand the early history of our solar system as a whole. It's endlessly fascinating how small-scale features on planetary surfaces can give us the answers to some of the biggest questions of all.



Lake Titicaca and a Total Lunar Eclipse

SEPTEMBER 19–OCTOBER 3, 2015

Experience the archeological wonders of Peru and Bolivia on this South American adventure! We'll visit Arequipa and drive up into the Andes to Puno on the shore of Lake Titicaca, situated at 12,507 feet and surrounded by spectacular peaks. We'll visit the Floating Islands and take a hydrofoil across the lake to La Paz, Bolivia where we'll also explore the site of Tiahuanacu (Tiwanaku). We'll enjoy the Total Lunar Eclipse from Lake Titicaca and then wrap up our expedition in Cusco and Machu Picchu!

Total Solar Eclipse: Bali and Sulawesi, Indonesia

FEBRUARY 27–MARCH 13, 2016

Join us in Indonesia to see the Total Solar Eclipse on March 9, 2016! You'll also visit the world's finest orangutan reserve for close looks at these magnificent primates, along with proboscis monkeys, gibbons, and more! The itinerary includes Kadidiri Island, situated in the Togian Islands, Indonesia's finest marine reserve. There, we will snorkel, kayak, and explore its underwater wonderland. The trip will conclude in legendary Bali where we will learn about the Balinese culture, see the monkey forest, visit historic temples, and celebrate our adventure!

To get started on your adventure, go to planetary.org/expedition to download more information.

You can also contact Taunya at Betchart Expeditions to learn more:
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408-252-4910 (International)
800-252-4910 (USA only)
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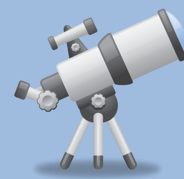
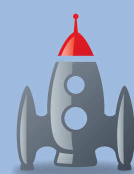


IN THE SKY

A partial solar eclipse is visible October 23 from most of North America. The Geminid meteor shower peaks December 13 and 14. Often the best meteor shower of the year, its 100 meteors per hour may be seen from a dark site. Bright Jupiter is in the pre-dawn east in October, getting higher as the weeks progress. In October, Saturn sinks lower in the early evening southwest as days pass. Reddish Mars stays in the early evening southwest throughout northern autumn.



RANDOM SPACE FACT

With NASA's *MAVEN* spacecraft and India's *Mars Orbiter Mission* both recently successful at entering Martian orbit, there are now seven working spacecraft at Mars, the most ever.

TRIVIA CONTEST

Our March Equinox contest winner is Stefan Maas of Bethesda, Maryland. Congratulations! **THE QUESTION WAS:** What planet in our solar system has the shortest day/rotation period? **THE ANSWER:** Jupiter, at about 10 hours.

Try to win a free year's Planetary Society membership and a Planetary Radio T-shirt by answering this question:

What was the first successful Mars orbiter?

E-mail your answer to *planetaryreport@planetary.org* or mail your answer to *The Planetary Report*, 85 South Grand Avenue, Pasadena, CA 91105. Make sure you include the answer and your name, mailing address, and e-mail address (if you have one). By entering this contest, you are authorizing *The Planetary Report* to publish your name and hometown. Submissions must be received by December 1, 2014. The winner will be chosen by a random drawing from among all the correct entries received.

For a weekly dose of "What's Up?" complete with humor, a weekly trivia contest, and a range of significant space and science fiction guests, listen to *Planetary Radio* at *planetary.org/radio.*

BRUCE BETTS *is director of science and technology for The Planetary Society.*

Honing the Hunt

A New Exoplanet Project, and OSETI Rolls On

USING LASERS TO LOCK DOWN EXOPLANET HUNTING

The Planetary Society is launching a new collaboration with Yale University's exoplanet hunter Debra Fischer and her team. We will support the purchase of an advanced, ultra-stable laser to be used in a complex system they are designing to push radial velocity exoplanet hunting to a whole new level–a level intended to facilitate the discovery of Earth-sized planets around nearby stars.

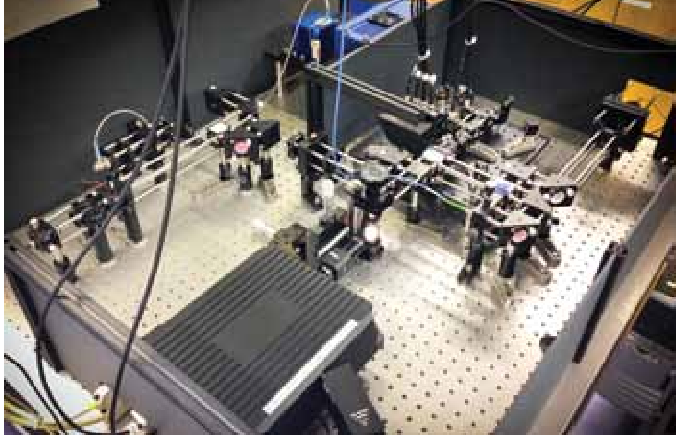
"The search for exoplanets is motivated by the question of whether life exists elsewhere," says Debra. "This drives our interest in the detection of planets that are similar to our own world: rocky planets with the potential for liquid surface water and plate tectonics; worlds that might harbor life that we can recognize."

Finding Earth-size planets around other stars is extremely hard, to say the least. The radial velocity technique measures the tiny wobble induced in a star by a planet's gravitational tug. For an Earth-like planet in a star's habitable zone (where liquid water may be stable on the surface), the wobble is on the order of 10 centimeters per second. Right now, radial velocity precision allows measurements of closer to only 1 meter per second. What is needed to improve precision by that much is a very complex system with many parts. One set of those parts involves calibration: making sure you are measuring the same thing night after night, so that what you record as a specific wavelength in 2014 measures as the same wavelength years from now, allowing you to compare the data and know you are looking at real signals, not just imprecise measurement variations.

"In order to improve the radial velocity method to the precision needed to detect true Earth analogs, a wavelength calibration method is needed that is more precise than anything that currently exists," says team member and Yale postdoctoral fellow Tyler McCracken. "We rely on this calibration to obtain nightly

RIGHT *Yale team member Tyler McCracken poses in front of the 4.3-meter Discovery Channel Telescope at Lowell Observatory's Happy Jack site, close to Flagstaff, Arizona. Debra Fischer and her team will use the telescope to seek out 100 Earth-like planets around other stars.*

Photo: Yale University Exoplanet Group



measurements and map out the wobble of the star over multiple years. This translates to a requirement for wavelength calibration that is stable over decades. Our solution to this problem is to lean on technology developed in other fields (namely atomic, molecular, and optical physics) and to tune their techniques to meet our requirements."

Debra and her team have built a prototype in their lab at Yale. But now they need to upgrade to a more stable, more professional laser to get to the precision they need. That is where The Planetary Society comes in. Once we support the laser, they can integrate it into their system and build a true science instrument, not just a prototype. Once it is thoroughly tested and understood, it will be combined with their other new development, the Extreme Precision Spectrograph (EXPRES) spectrometer (funded by the National Science Foundation), and that whole system and more will be moved to the Discovery Channel's 4.3-meter telescope near Flagstaff, Arizona. There, the search of hundreds of relatively nearby stars for Earth-analog planets will begin.

To learn more about how the calibration system works, go to **bit.ly/TPS-exoplanets**.

BACK ON THE RAILS WITH OSETI

Sometimes the most advanced space observations—such as looking for laser pulse communications from alien civilizations—get interrupted by rather mundane issues. The Optical Search for Extraterrestrial Intelligence (OSETI) project, carried out by Paul Horowitz's group at Harvard University using The Planetary Society All-Sky Optical SETI Telescope, suffered just such a hiccup a while back when the observatory's roof literally ran off the rails.

The telescope is housed inside a simple-looking building that protects it during inclement weather. When conditions are right for observations, the 4-ton roof is rolled back horizontally on metal rails. After years of use, some of the rails were completely worn out, and the roof no longer worked properly. Using big cranes and heavy-duty welding equipment, new rails were installed and the roof now opens and closes, using a lower electrical current than ever before.

This is the only OSETI search that scans the whole sky (visible from Harvard, Massachusetts, that is) and it searches every possible night. The 72-inch telescope and the first generation of its amazing back-end electronics date from 2006, and were funded by Planetary Society members. More recently, the system received a major upgrade to its electronics, designed and implemented by Curtis Mead, who was a graduate student at the time (Curtis has since earned his PhD).

Over the years, the system has also been adapted for completely remote operation. It includes a weather station and remote cameras to ensure the right conditions for observations. Curtis now operates the telescope on a regular basis remotely from California.

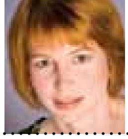
For even more information about our OSETI program, including the recent electronics upgrades, go to **bit.ly/TPS-seti**.

ABOVE *They just wore out from use! One of the broken rails from the moveable roof protecting The Planetary Society All-Sky Optical SETI telescope in Harvard, Massachusetts. The worn-out rails were replaced and the roof is operating better than ever.*

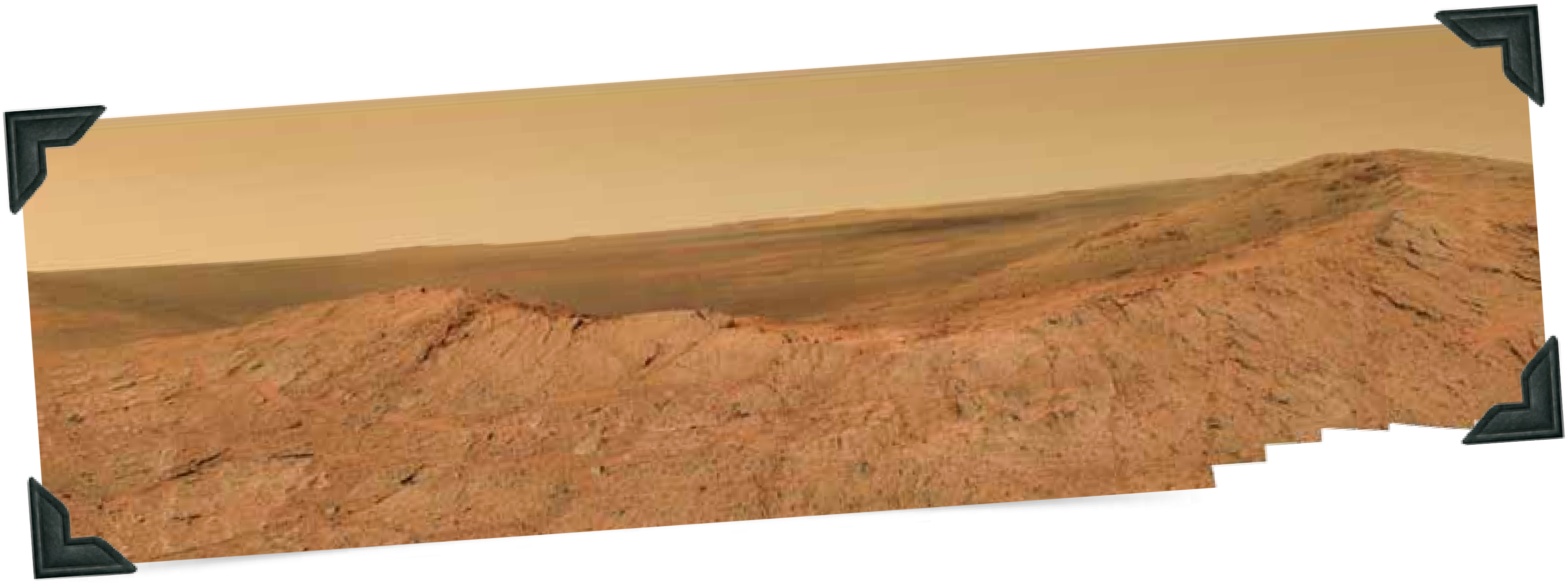
TOP *A prototype of the Exoplanets Laser system sits in the laboratory at Yale University.*

Top photo: Yale University Exoplanet Group; photo at right: Paul Horowitz

Planetary Society members have helped make these projects—and many others—possible! Thank you. *Thanks!*



EMILY STEWART LAKDAWALLA
blogs at planetary.org/blog.



The View from Pillinger Point

THE *OPPORTUNITY* ROVER is now a mountain climber. *Opportunity* spent three years driving 12 kilometers (about seven miles) across the sandy wastes of Mars' Meridiani Planum to reach the rim of Endeavour crater. The rover has spent another three years crawling around the rim of that crater, and is now scaling heights it has never reached before. *Opportunity* took the images that make up this sweeping panorama—across a ridge named Pillinger Point and down into the basin of Endeavour crater—with its Pancam on sols 3663 to 3668 (May 14 to 19, 2014). Pillinger Point is one of several locations along Endeavour's rim where *Mars Reconnaissance Orbiter* spotted hints of clay minerals that might provide clues to a wetter and more clement Martian past.

—*Emily Stewart Lakdawalla*

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MySky

I often read excerpts from *The Planetary Report* to my husband and children, and we enjoy exploring our planetary neighborhood—whether it's pausing to view a bright rainbow at home or watching a meteor shower while on a camping trip. On April 14, 2014 my husband Bill took this photo of Mars and the full Moon over Saint Peter's Basilica in Vatican City. The picture, shot from our hotel room, was taken with a Canon EOS Rebel T2i. At the time, we didn't realize that we were missing the lunar eclipse back in the States! —*Wanda Eyre, Everett, Washington*

WANT TO SHARE YOUR SPACE IMAGE? Send us an e-mail with a jpeg attachment (less than 5 MB) of your image to *planetaryreport@planetary.org*. Please use the subject line "MySky" and include a short caption (such as where you took the image and, if appropriate, with what equipment) and credit line for the image. Please include just one MySky image per submission. Also, be sure to include your name, contact information, and membership number (it's on your membership card and on the mailing label of your magazine). We'd also love to learn more about what is most important to you about being a member of The Planetary Society. Questions? E-mail *planetaryreport@planetary.org*.

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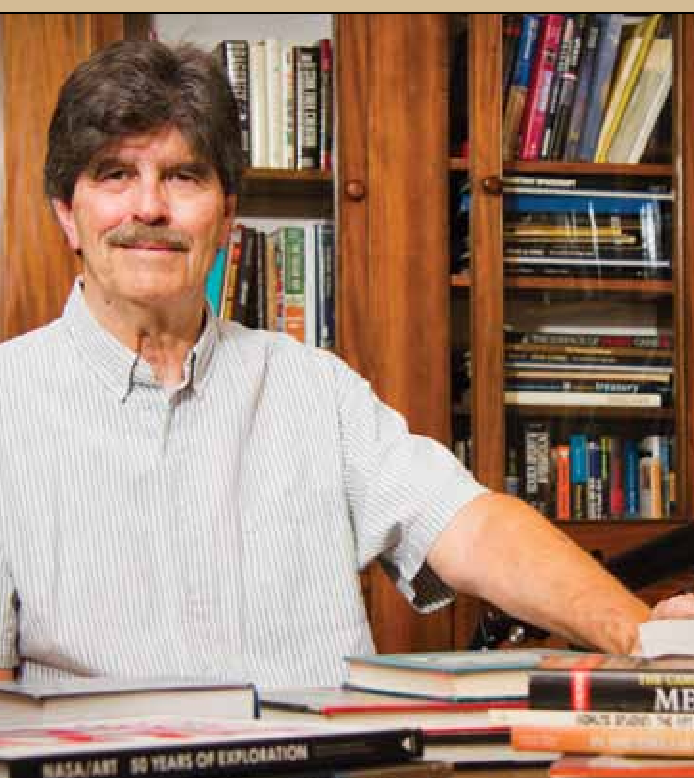

Are you a longtime member? Do you have a special memory related to your membership? If so, please share it with us by e-mailing it to *planetaryreport@planetary.org*.

To donate, volunteer, or give a gift membership, visit us at ***planetary.org***

In November 1980, Dave Hagie responded to an intriguing ad in *Omni* magazine and became one of The Planetary Society's earliest members. Soon afterward he signed on as one of our original volunteers and, from our first little office in Pasadena, began stuffing envelopes. "The first couple of years, between the volunteers and our direct-mail consultants, we sent out about 3.5 million invitations to join The Planetary Society. That helped the organization grow to 100,000 pretty quickly," says Dave.

Dave's interest in the cosmos began in childhood, gazing at the night sky over Kansas City, Missouri. As an adult, his decades-long career as an accountant and field office manager with Pasadena's Parsons Corporation was spent working half-time in Pasadena and half-time abroad, in Korea and all over the Middle East. One thing remained constant, though, and that was his devotion to The Planetary Society.

One of his proudest achievements as a volunteer, he says, was successfully managing the Society's move from 65 North Catalina—our (overstuffed) Pasadena headquarters of 25 years—to our current digs across town. As a longtime member of our New Millennium Committee, Dave also has been a generous and reliable supporter of the Society's work.

We're glad Dave (shown here sorting books in our library) agreed to let us thank him here for his many years of membership, hard work, and financial support. When asked what he'd like to see The Planetary Society achieve in the near future, Dave said, "I want to see us grow to 100,000 members again, like we did in those early years."

With the help of our loyal supporters—people like Dave, and you—we know we can do it.

Photo: Loren A. Roberts for The Planetary Society