PLANETARY SCIENCE INSTITUTE

NEWSLETTER

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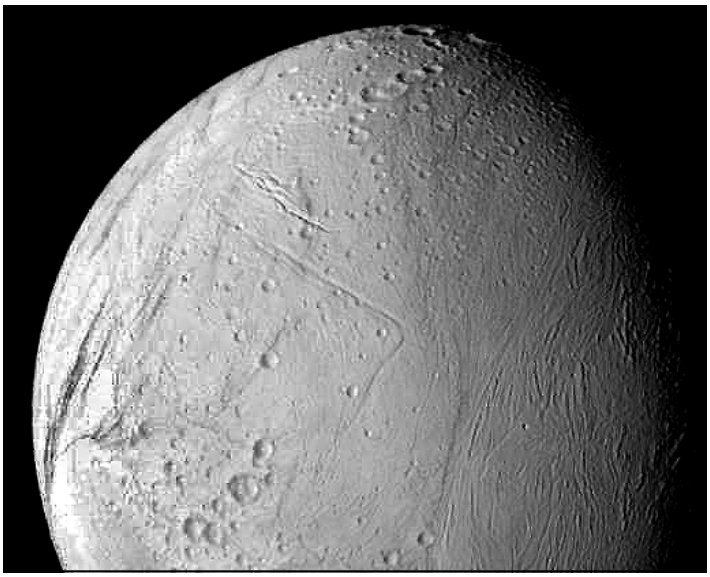
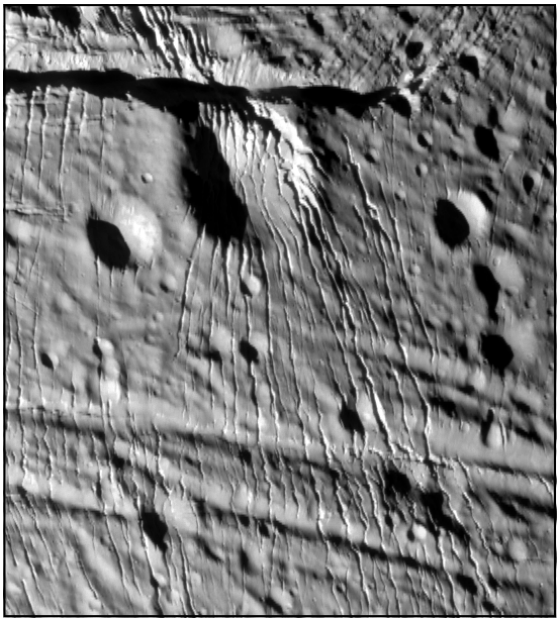
A Challenge from Saturn's Moon, Enceladus

By William K. Hartmann



Enceladus's surface shows old, cratered areas at top and left, and is made of bright ice. In the center are younger plains that seem to have been resurfaced by less-cratered, fresher ice, possibly by water eruptions through swarms of fractures.



Intense fractures can be seen in this area of Enceladus, roughly 90 km (60 miles) wide. Older fractures, running left to right, have wide, softened rims and have been cut by numbers of later craters. Other fractures, running top to bottom, are sharp and narrow, and seem to be the most recent features in the area.

The Cassini space probe, now orbiting Saturn, continues to return fascinating images of the diverse moons of Saturn. One of these is a small world, Enceladus, 500 km (312 miles) across, about one seventh the size of our moon. Spectra show that the surface is composed of clean, bright, frozen water — the most reflective surface known in the solar system.

PSI has little current research about the surface properties of such exotic moons in the outer solar system, but the Cassini images of Enceladus exemplify the opportunity for PSI to extend our research to those distant realms. The important point is these satellites are not just geologically dead iceballs, but show tremendous geologic and geophysical variety, from the active volcanoes of Jupiter's moon Io, to crater-saturated ice-moons such as Saturn's Rhea.

In the image above left, Enceladus seems to have been partly resurfaced, probably when deep fractures broke up old surface regions and allowed eruptions of interior water that froze into new plains. Spectacular examples of such fractures are shown in the close-up, above right. Enceladus thus serves as an important "missing link" between Jupiter's moon Ganymede, where a few fractured swaths cut through old cratered terrain, and Europa, where the whole world has been resurfaced by fresh ice, too young to have many impact craters. Enceladus has both extremes.

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Inside this issue:

Enceladus *(continued from front page)*

What's going on inside such worlds? A 500-km iceball is too small to have much internal heat of its own – so what provides the energy to drive geologic activity over a long time, from old surfaces hit by many impacts to young surfaces too recent to have much impact scarring? The leading idea is tidal forces: complex gravitational effects in which attractions of other moons cause a particular moon to move closer or further from its planet, causing slight tidal stretching, or flexing, of the moon itself. Internal friction from this flexing heats the moon, much like a tennis ball warms up from friction if you keep flexing it. It is known that this kind of tidal heating provides the energy that keeps volcanoes erupting on Jupiter's moon Io. The problem is that most calculations suggest Enceladus does not get quite enough tidal flexing or heating to melt its interior and allow the resurfacing we see. In short, there's an intriguing mystery here.

The close-up image indicates the potential for using Enceladus to learn how the resurfacing works. Many of the craters seem to postdate old, eroded, soft-edge fractures; however, most of the craters themselves are broken by a younger generation of sharply defined fractures. That suggests that the fracturing has come, surprisingly, in cycles.

The images show how study of the geologic structure and the cratering – nature's handy process of stamping cookie-cutter circles on planets at a uniform rate – can clarify the deep internal processes that shape planetary surfaces. PSI is a leader in studying impact and cratering phenomena, and using them to clarify geological evolution of worlds in the inner solar system. Perhaps soon we will be able to extend our work beyond Mars and the asteroid belt into the outer solar system. Assuming that NASA's funding for basic research continues, PSI may be able to tap into Outer Planet Data Analysis Programs to pursue such studies. Enceladus offers us that challenge.

More Cassini images are available at this UA-based website: http://cyclops.lpl.arizona.edu/ir_index_main.php

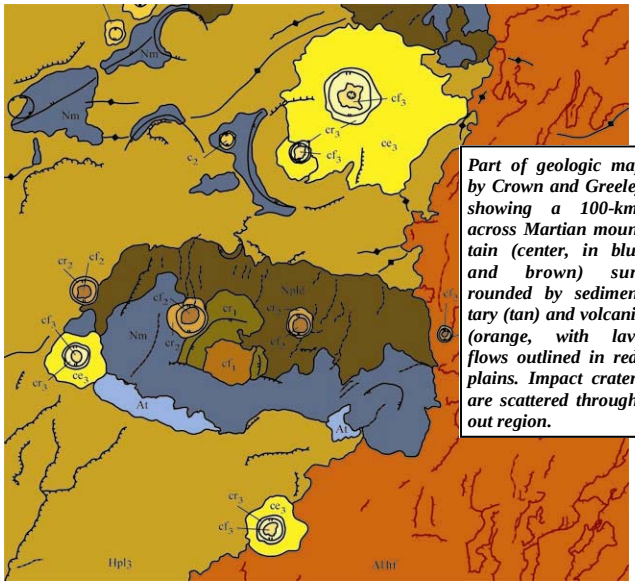
PSI Planetary Mappers go to Washington

By David A. Crown

PSI scientists Les Bleamaster, Frank Chuang, and David Crown traveled to Washington, D.C., in late June to attend and present research results at the annual Planetary Geologic Mappers Meeting, hosted this year by the Center for Earth and Planetary Studies of the National Air and Space Museum. The Planetary Geologic Mapping Program is a joint NASA/U.S. Geological Survey effort. Research projects are selected for support by NASA's Planetary Geology and Geophysics Program based on their scientific value and appropriateness for mapping. The Astrogeology Team at USGS-Flagstaff provides coordination and support for the program, including generation of base maps and relevant databases for each investigation, editorial assistance in scientific peer review and adherence to USGS cartographic standards, and pre-press preparation and printing of maps in the USGS Scientific Investigations Map Series. The mapping program historically has included investigations of Mercury, the Moon, Venus, Mars, and the Galilean satellites. At present, most projects are part of the systematic mapping of Venus at 1:5,000,000 scale using Magellan radar data, or local (1:500,000) to regional (1:5,000,000) scale mapping of Mars using a combination of Viking Orbiter images and new Mars Global Surveyor and Mars Odyssey datasets.

The PSI group is presently working on mapping two regions on the surface of Mars that will contribute to our understanding of martian geologic history, in particular the role of water in various geological processes through time. Crown and Chuang are mapping a traverse across the lowland-highland boundary at the northern margin of Arabia Terra in the Deuteronilus Mensae region. The boundary here is thought to mark the shoreline of an ancient northern ocean first proposed by Tim Parker of the Jet Propulsion Laboratory and colleagues. Key objectives are to understand the formation of prominent debris aprons and lineated valley fill deposits that cover the lowland surfaces and whose emplacement may have been facilitated by ice filling pore spaces and gaps between rocky debris. Bleamaster and Crown are mapping the eastern edge of Hellas basin where the extensive canyon systems of Dao and Harmakis Valles may have deposited ice and debris on the basin floor. Their recent work, along with 2004 summer intern Lida Teneva of Franklin and Marshall College, has resulted in the identification of layered deposits along the basin's eastern margin, which appear to be a large depositional shelf with an ice-rich substrate, possibly denoting high stands of ancient lakes on the basin floor. With colleagues David Williams and Ron Greeley (Arizona State University) and Laszlo Keszthelyi (USGS), Crown is also participating in a new global geologic mapping project of Jupiter's moon Io, using datasets from both Voyager and Galileo.

PSI scientists have participated in the Planetary Geologic Mapping Program for many years. David Crown first became involved through a Voyager-based mapping study of Io in preparation for the Galileo mission and his Ph.D. research on Martian volcanoes at Arizona State University in the late 1980s; he has conducted a series of mapping investigations of Mars since then, as well as a mapping investigation of Guinevere Planitia on Venus. Les Bleamaster recently published a 1:5,000,000 geologic map of the Ovda Regio Quadrangle of Venus, an outgrowth of his Ph.D. research at Southern Methodist University.



Part of geologic map by Crown and Greeley showing a 100-km-across Martian mountain (center, in blue and brown) surrounded by sedimentary (tan) and volcanic (orange, with lava flows outlined in red) plains. Impact craters are scattered throughout region.

PSI Welcomes Faith Vilas

This spring, Dr. Faith Vilas joined PSI as an Affiliate Senior Scientist. She is currently at NASA's Johnson Space Center (since 1984) where she leads the Planetary Astronomy Group. Faith is internationally recognized as one of the leading ground-based observers studying asteroids, and has been appointed the new director of the MMT Observatory (MMTO), located thirty miles south of Tucson in the Santa Rita Range of the Coronado National Forest. MMTO is one of the finest astronomy facilities in the world, combining a 6.5-meter (21-foot) telescope with a vast array of powerful observing instruments; it is a joint venture of the Smithsonian Institution and the University of Arizona. Faith will assume the directorship of MMTO in December, 2005.

Faith received her BA in Astronomy from Wellesley College in 1973 and her MS in Earth & Planetary Sciences from M.I.T. in 1975, after which she worked as a research assistant/computer center manager at the Cerro Tololo Inter-American Observatory in Chile, and associate scientist for Lockheed, re-analyzing orbital x-ray fluorescence data from Apollos 15 and 16.

Faith earned her doctorate in Planetary Sciences from University of Arizona in 1984, where she did her thesis on compositional trends in outer-belt asteroids. Also in 1984 she was a part of the team that discovered Neptune's rings. Faith subsequently laid the groundwork for our understanding of the role of water throughout the asteroid belt, identifying diagnostic spectroscopic features. She is a member of the Hayabusa science team – a Japanese sample return mission – arriving at near-Earth asteroid Itokawa in September 2005 and returning samples in July 2007.

In addition to her science activities, Faith has led a flight project for orbital debris detection and mitigation, ran the Discovery program at NASA Headquarters, and was elected Chair of the Division for Planetary Sciences of the American Astronomical Society. She is also a paramedic, pilot, and one of the founders of an animal rescue adoption nonprofit near Houston.

Faith has had long-standing collaborations with PSI scientists in the areas of early solar system conditions and asteroid studies. She has also agreed to be a PSI mentor.

Mark Sykes, PSI's Director, said, "We look forward to benefiting from Faith's knowledge and experience, developing closer ties between PSI and the MMTO, and having fun developing new ideas for science investigations."

When Penguins Fly in Tucson!

By Steve Kortenkamp

On April 26, PSI took delivery of our long-awaited computer cluster. The new high-performance cluster is a cornerstone of our fledgling Center for Interdisciplinary Research and was purchased with funding from our recently awarded NSF equipment grant (see Frank Chuang's article in the Spring 2005 PSI newsletter).

The new cluster will aid PSI scientists in their research in such areas as asteroid impacts, planet formation, and solar system dynamics, to name a few. Accounts on the cluster are available to all PSI researchers. (To request an account, email James Ward at james@psi.edu.)

The cluster was built by Penguin Computing of San Francisco, CA, and arrived encased in a massive black cabinet (the monolith in the images at right). Much to our dismay the 1000-pound monster was taller than the doorways into PSI's West Wing, where our computer room is now located. After an "all hands on deck" call was issued, we were able to rotate, wrestle, and ultimately roll the beast through the doorways and down the hall to the computer room. No sooner had we powered up our new computer cluster than we discovered its first "bugs" — a dozen little penguins had stowed away for a better home in Tucson. Fortunately for them, we keep the computer room nice and chilly.

"Uh oh! The door's too small!" Many hands were required to wrestle the new computer cluster — a massive monolith — into the office. Steve Kortenkamp and the PSI crew worked carefully for hours moving it into place.

PSI "movers" holding the "bugs." From left front: Mark Everett, David Tarico, Steve Kortenkamp and Dave Lien; standing: Stu Weidenschilling, Frank Chuang and James Ward. Bravo!

Pasquale Tricarico, Another New Face at PSI

Pasquale Tricarico joined PSI as an Associate Research Scientist in May, moving from Washington State University, where he had spent the last two years as a Postdoctoral Research Associate in Astrophysics. His current research interests include the realization of distributed computing systems for Near-Earth Objects impact hazard monitoring, NEO deflection methods, dynamical stability of minor planets in the solar system and of Earth-like planets in extra-solar planetary systems, and mission design and optimization.

He has a research background in celestial mechanics and extensive experience in computer programming, numerical analysis, computer simulations, and data analysis. He is the author of ORSA (http://orsa.sf.net), the Orbit Reconstruction, Simulation and Analysis software tool for scientific-grade celestial mechanics computations. This software allows one to accurately simulate asteroids, comets, artificial satellites, solar and extra-solar planetary systems. It also provides a coherent physical environment, fast and accurate numerical algorithms, a graphical user interface, and is distributed under an open source license.

Pasquale received his Ph.D. in Physics from Padova University (Italy) in 2003, working under the guidance of Prof. Francesco Marzari on the dynamical stability of Trojan asteroids in the solar system. This research focused on the application of the Laskar's Frequency Map Analysis method to different asteroidal populations. This analysis method has successfully been applied to describe the dynamics of Jupiter Trojans, to explain the apparent absence of Trojan asteroids in Saturn's and Uranus's orbit, and also to study the dynamics of Neptune Trojans.

Welcome aboard, Pasquale!

New Books from PSI Authors, Hartmann and Levy

Workman Publishing Co., New York, has just released a third edition of ***The Grand Tour: A Traveler's Guide to the Solar System.*** This is a heavily illustrated popular science book by artist Ron Miller and PSI's Bill Hartmann, with text primarily by Bill. The book includes several hundred color illustrations, mostly digital artwork of planets, moons, asteroids and comets by Ron, paintings by Bill, and additional spacecraft photography.

The first two editions were highly successful; over 100,000 copies were sold and the book was published in several translations in foreign countries. These original editions were illustrated solely with paintings; however, there has been an interesting evolution in astronomical art in that many illustrators, including Ron Miller, now use computer imagery almost entirely. Bill reports that "a concern was whether the new digital images and the paintings would work together, but we're pretty happy with the result."

The book is not only updated with information about planetary science, but includes completely new sections on the origin of the solar system and on extra-solar planetary systems. It's a great introduction to planetary exploration for readers of all ages.

PSI Board Chair David H. Levy has two new books coming out this fall. One is titled ***David Levy's Guide to Variable Star Observing*** published by Cambridge University Press. The second book is ***Deep Sky Objects: The Best and Brightest from 40 years of Comet Chasing*** from Prometheus Books and is about the objects he has spotted and which have come his way during the last 40 years of his personal search for comets. Be on the lookout for these great new reads by our own PSI authors.

Note: several books by Hartmann and Levy — including this latest by Hartmann — are available through our new PSI Bookshop (see order form enclosed).

Painting by Bill Hartmann shows a comet nucleus with double-lobe structure approaching the early Earth. Some researchers believe such comets provided some of the Earth's water, in the form of cometary ice. (Image copyright W.K. Hartmann.)

Digital artwork by Ron Miller shows a view of Saturn's rings as seen from Saturn's cloud tops at sunset. Miller has included halo phenomena generated in ice crystal clouds (see article by Dave Lien, Spring 2005 PSI Newsletter). (Image copyright Ron Miller.)

Director's Notes

PSI scientists from around the country, and a few from overseas, will be gathering in Tucson for our PSI retreat on August 22nd and 23rd at Hacienda del Sol Guest Ranch Resort. This is an annual event at which we share our science and discuss future directions for the Institute. I am expecting a lot of exciting reports on expeditions to remote locations around the globe, the search for evidence of the most ancient life on Earth, the formation of planets around other stars, the latest discoveries on Mars, missions to asteroids and planets, planning for the expansion of human exploration to the Moon and Mars, and much more. PSI education and public outreach activities are also going to be highlighted.

If you are a *Friend of PSI*, (or if not see below to become a new *Friend of PSI*) you are welcome to attend our science and education sessions, meet our scientists and staff, and see the wide range of science and other activities that you help support. You are also invited to attend our banquet on Monday August 22 at Janos' J-Bar Grill. Banquet tickets are $25 per person, and tickets must be purchased by July 29th; there will be a cash bar. Just contact Chris Holmberg at chris@psi.edu (or 520-622-6300 ext 10) to purchase banquet tickets; we will also send you an agenda if you want to attend the science sessions.

We would like to welcome David Levy as the new Chair of the PSI Board of Trustees. David is the science editor for *Parade* magazine and is seen often on public television giving interviews and explaining current science events. He is well-known as one of the top comet hunters in history, with twenty-one comets bearing his name. The most famous of these is Shoemaker-Levy 9, which had broken up into a "string of pearls" before putting on a big show as the fragments impacted Jupiter in 1996. You may meet David and the other members of the Board at the retreat and banquet.

Looking forward to seeing you there!

Mark V. Sykes
July 2005

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The ***Friends of PSI*** are people like you — excited by the new worlds revealed in our exploration of the solar system and beyond, seeing the Earth as a planet for the first time, and wanting to participate in the expansion of human presence beyond the Earth. PSI scientists are active participants in this adventure. They travel to remote and dangerous regions on Earth to study processes found on other planets as well. They participate in missions to the Moon, Mars, Saturn, and asteroids. They model the formation of the solar system and how planets can grow around other stars. They identify the location and nature of space resources to sustain the expansion of permanent human presence on the Moon, Mars, and beyond.

PSI scientists are helping to create the next generation of explorers, and reaching out to the public through lectures, books, and art. Please join us in this adventure by becoming a *Friend of PSI* and renewing your membership annually.

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All of the benefits of *Supporter* plus an autographed multicolor print of an original painting by W. K. Hartmann, or a signed copy of *A Traveler's Guide to Mars*, Bill's beautiful and fascinating overview of modern Mars research, illustrated by detailed photographs from the Mars Global Surveyor mission.

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