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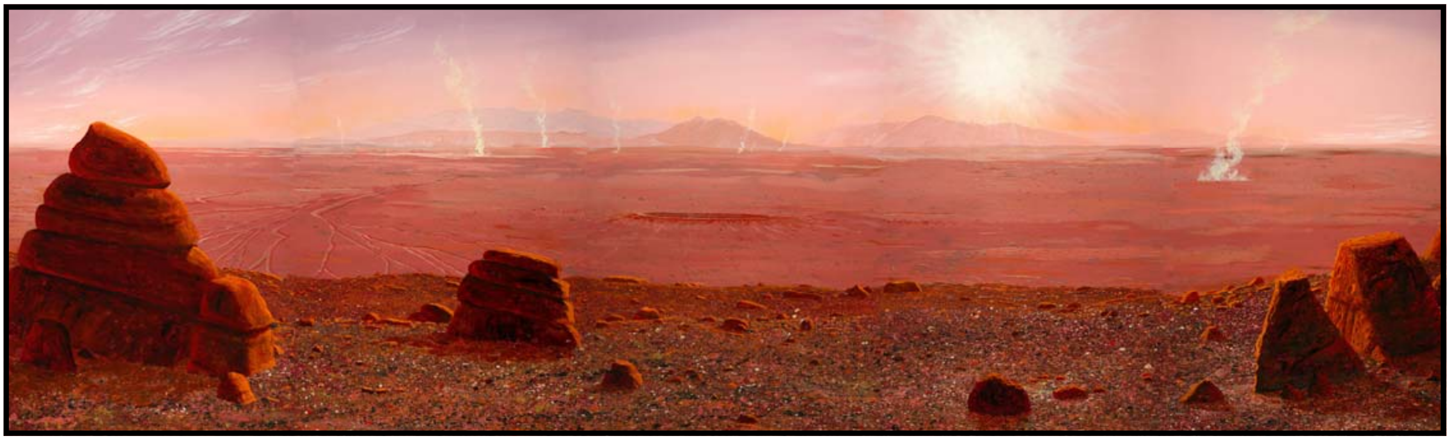


Mural Mirrors Mars: ***Mural by W. K. Hartmann shows dust devils in Gusev-like crater on Mars. Article on page 2.***

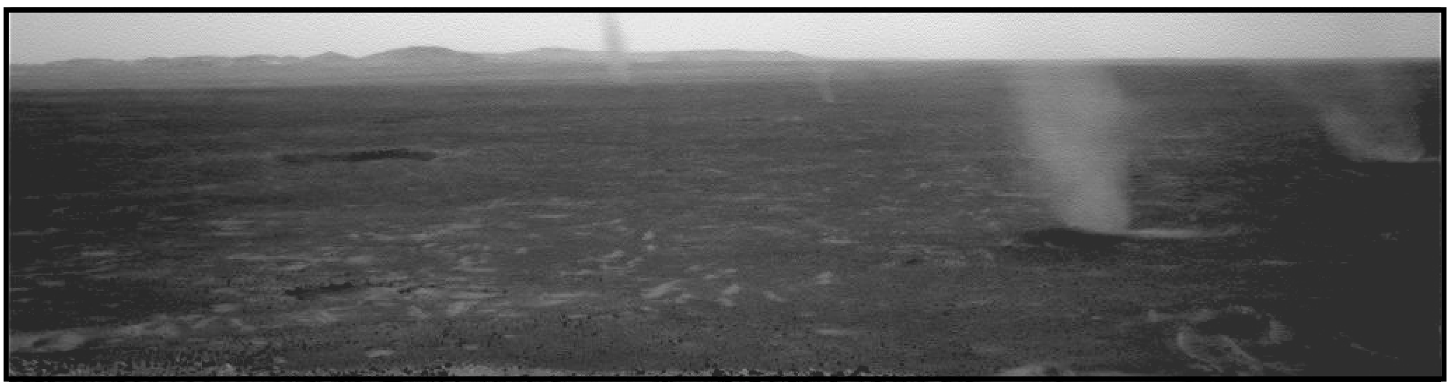


Image credit: Mosaic of Spirit rover navigation camera images, NASA/JPL

Dust Devils on Mars *by Matt Balme*

The spectacular black and white image above, showing dust devils whirling across Gusev crater on the Martian surface, was taken by NASA's Mars Exploration Rover Spirit on the 568th Martian day, or sol, of the mission. Familiar to Arizona dwellers, dust devils are small whirlwinds, driven by heating of the ground by strong sunlight, that become visible as they pick up dust and sand in their path. Although they are most common in hot, desert environments, they can occur anywhere the sun causes the ground to heat up more quickly than the lower atmosphere — even if the actual temperatures are freezing cold! In fact, dust devils have even been observed in the Canadian Arctic and, as shown here, also in Mars' thin, frigid atmosphere.

Martian dust devils were first detected in the late 1970s on Viking orbiter photos that showed dust clouds casting long shadows. The shadows indicated that the clouds were in the form of tall columns, i.e., dust devils. In the late 1990s, high-resolution Mars Global Surveyor images

Continued page 2

Inside this issue:

Dust Devils on Mars *(continued from front page)*

revealed not only dust devils, but the winding tracks they left behind across the Martian surface. These tracks are almost always darker than the surrounding terrain, although rare "bright" tracks have been seen. The process by which these tracks form is unknown — the simplest explanation is removal of bright dust from a darker substrate — alternatively, the tracks might represent a "roughening" of the surface material by the passing dust devil, rather than removal of a distinct layer.

Dust devils might play a much larger role on Mars' climate than they do on Earth's. They tend to be much bigger, and recent computer models of the atmosphere have shown they might be the main mechanism for lifting fine dust into the Martian sky. Dust devils might also pose a hazard to future exploration of the red planet, so they are not mere scientific curiosities, but an active and possibly dangerous part of the Martian climate system.

Dust devils have been a focus of my PSI Research Scientist work for some years now. I have chased dust devils in Nevada with PSI Associate Research Scientist Steve Metzger, simulated dust devils in the laboratory using the Arizona State University vortex generator apparatus, studied dust devils and their effects on the surface of Mars using spacecraft images, and modeled the way dust devils lift dust with Axel Hagermann of the Open University in England. Also, I have recently written "Dust Devils on Earth and Mars," an invited *Reviews of Geophysics* paper surveying more than a hundred years of scientific studies of dust devils.

Further studies of dust devils are planned at PSI, and I intend to submit a research proposal to NASA this year to study the formation mechanisms of dust devils using field studies in Nevada and Arizona. ◻

Mural Mirrors Mars *by William K. Hartmann*

Speaking of Martian dust devils, part of my outreach activities as a PSI Senior Scientist and Board of Trustees member is to continue painting astronomical scenes, and a recent commission featured these ghostly dust columns wending their way across Mars (see painting on front page). The commission came from Ted Buttner and Rosemary Chang, who have also supported science displays in Oakland's Chabot Science Center, where I installed an earlier mural.

The dust devil mural was for a wall in their new, environmentally friendly "Earth House" home. The painting was done in five panels, 40x60 inches each, to reduce transportation and logistical problems. The finished mural is 5 feet tall and over 16 feet long. I started with the view from the hillside Earth house, and transformed it into a panorama from a Martian hill, looking across a plain toward the sun. Based on views of dust devils from Martian orbit and from the Spirit rover, and my own observations of dust devils in Arizona, the mural includes a number of distant dust columns.

In 2005, I began the mural in my back yard, spattering paint across the foreground to simulate Martian regolith gravels. The front page shows the panorama after images of the five panels were integrated in Adobe Photoshop.

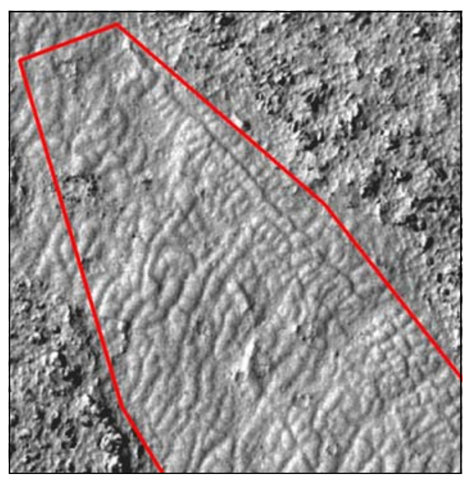
PSI is supported mostly by grants from NASA and other agencies, but federal funds come with significant restrictions; for example, excluding real estate purchases. Buttner and Chang are also PSI donors whose gifts along with donations from others give PSI much more flexibility to build the long-term future of our organization. We at PSI value our supporters! ◻

A Possible Breakthrough in Crater-dating of Mars (Part 1) *by William K. Hartmann*

Since the 1970s, PSI has developed a technique for dating planetary surface features, using counts of accumulated impact craters (per unit area) on the various geological formations. The method has had success predicting ages of rocks from broad lava regions of the Moon and Mars, but in the last few years new issues have emerged. Originally, we dealt with kilometer-scale craters on both the Moon and Mars. As seen in this image, Mars orbiters have photographed smaller and smaller details on Mars, and we've attempted to use craters as small as 20 meters across to get dates on small landforms such as individual lava flows and glacier-like features.

Since 2003, the method has attracted increasing fire, because of uncertainties in the formation rate of small craters in the diameter range of about 1 m to 100 m. Some researchers suggested our numbers might be off by a factor of 2000! A breakthrough occurred in December 2006, when Mars Global Surveyor researchers reported discovery of new, 10-20 meter-scale craters formed on Mars in the last seven years. The exciting thing for our PSI group – as the MGS researchers mentioned in their paper – is that the rate of formation they measured was within a factor 2 or 3 of what the PSI team has been using for that size crater. If this work is right, it guarantees that small craters *can* be used to get accurate dates for small Martian landforms, and it indicates that our age estimates are approximately right, to within an order of magnitude, even for small, individual formations on Mars. ◻

In the next PSI Newsletter: How the new results support recent theories of dramatic climate change cycles on Mars.



A football-field-sized region of Mars illustrates the crater-counting technique. We outlined a flat region in red that has polygon textures suggesting freeze-thaw cycles (similar to Arctic terrain on Earth). Crater counts were done in the red area. The region is so young (< 10 My?) that very few craters can be found, although a crater about 1.5 meters across appears at the bottom edge, right center. (Image credit Mars Reconnaissance Orbiter/ HiRise UA, TRA_000854_1855_RED)

Samarasinha Moves from NOAO to PSI

Nalin Samarasinha has been a PSI Senior Scientist for the last two years, but just moved his office to PSI headquarters last March. His research is focused on comets and other small bodies of the solar system.

Originally from Colombo, Sri Lanka, Nalin completed his undergraduate studies at the University of Colombo where he majored in Physics and obtained first-class honors. He moved to the United States for his graduate studies, and fulfilled the requirements for his Astronomy PhD in 1992 under the guidance of Dr. Mike A'Hearn at the University of Maryland, College Park. As part of his dissertation work he showed unambiguously that comet Halley rotates in a non-principal-axis spin state, known in layman's terms as a tumbling motion. Comet Halley is the first small body to be discovered in a non-principal-axis spin state.

Also in 1992, Nalin moved to Tucson, to work with Dr. Mike Belton who was then an astronomer at the National Optical Astronomy Observatory (NOAO). In his stint as a postdoctoral researcher at NOAO, Nalin continued his studies on comets. Among his many investigations were numerical studies to understand the long-term evolution of cometary rotational states due to activity of cometary nuclei. Later, still at NOAO, he began applying for NASA funding as a Principal Investigator and continued his collaborations with his then-NOAO colleagues, Mike Belton and Beatrice Mueller. He also collaborates with many other colleagues in the USA and elsewhere.

In addition to rotational studies of comets, his research interests include interpretation of coma morphologies and dynamical studies of other small bodies of the solar system. In 2000, using numerical modeling, he explained how coma morphology due to a wide jet is fundamentally different from that due to a narrow jet. With that, he provided a self-consistent explanation for the behavior of coma morphology of comet Hale-Bopp, which had been a mystery for comet scientists. His work has helped in the accurate interpretation of coma morphology and kinematics of gas and dust features in the coma of any comet.

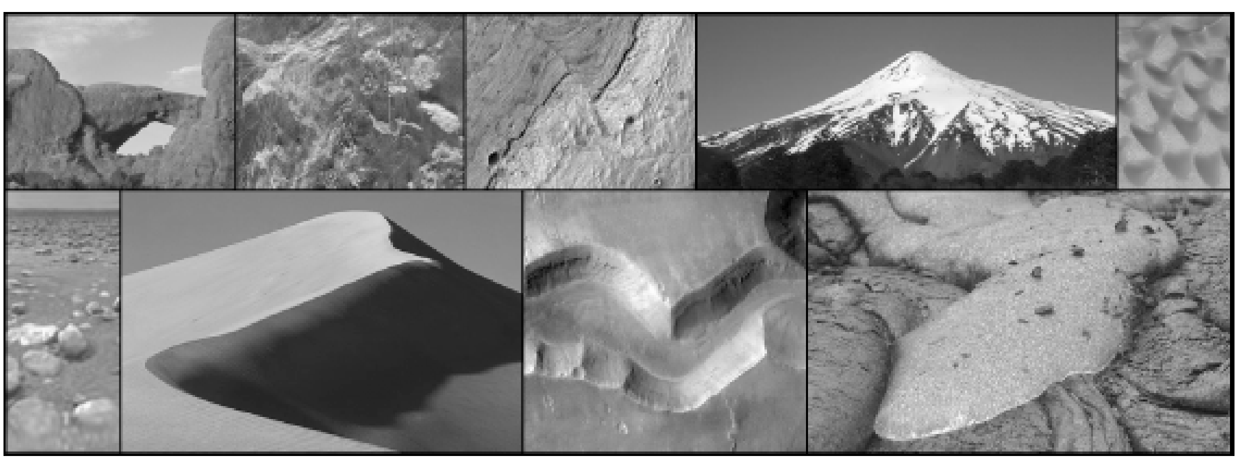
Two years ago, Nalin joined the scientific staff of PSI while concurrently holding a soft money position at NOAO. Now he submits all his funding proposals through PSI. His current research projects involve spin studies of comets and asteroids and morphological analyses of comets and he is optimistic about collaborating with other PSI scientists. In addition to his astronomical research, he values and actively participates in education and public outreach activities, the most recent being a public talk on the 2007 Astronomy Day (April 21) at the Kitt Peak Observatory Visitor Center.

In his spare time (if there is such a thing) he likes to follow cricket matches, read about what is going on around the world, and cook spicy foods. He and his wife, Ganga, are the parents of lovely twin daughters, Surani and Ruvini, who will soon be high school students.

Welcome to PSI, Nalin!

IAG Planetary Geomorphology Working Group

by Mary Bourke (Coordinator, IAG Working Group on Planetary Geomorphology)



The International Association of Geomorphologists (IAG) has a new working group on Planetary Geomorphology: http://www.geomorph.org/wg/wgplg.html . Our focus is to encourage stronger collaboration between Earth scientists and those who study geomorphology on other planetary bodies. In addition, we want to promote the inclusion of planetary geomorphology in school and university curricula. We have launched a web site, http://www.psi.edu/pgwg/, hosted by the Planetary Science Institute in Tucson, to facilitate the dissemination of information on planetary geomorphology including reading lists, upcoming meetings, and eventually, annotated images of planetary landforms for use in lectures.

The web site is a community resource and all suggestions for content are welcome. ▫

Paul Abell: All About NEOs and Hockey

Paul Abell joined PSI in April, 2005, while he was a National Research Council Postdoctoral Associate at the NASA Johnson Space Center (JSC) in Houston, Texas, and is one of PSI's offsite scientists. He is currently a Research Scientist in the Astromaterials Research and Exploration Science (ARES) Directorate at JSC, where he studies Near-Earth Objects (NEOs).

Paul was born in Leeds, England, and when he was two his family immigrated via ship to the tiny village of Wawanesa, Manitoba, Canada (estimated population 500). During his formative years, the long, cold winter nights and small-town atmosphere were perfect for hours of stargazing and watching the northern lights. Paul decided to attend Colgate University, NY, so that he would not have to give up his beloved cold weather, small-town surroundings, and hockey. After his first observational astronomy class, Paul was hooked and decided to major in Astronomy/Physics, receiving his Bachelor's degree a few years later.

Paul earned a Master's degree in Space Studies from the University of North Dakota in Grand Forks — yet another small town with cold weather and, of course, hockey! While there, he met two very important people in his life: his future wife, Amy Sisson, and Chuck Wood (fellow PSI scientist), the Chair of the Space Studies Department. Chuck's infectious enthusiasm for NEOs and planetary science in general helped convince Paul to continue his graduate studies.

Still following the cold weather hockey trail, Paul moved back to upstate New York to obtain a Ph.D. from Rensselaer Polytechnic Institute where he completed his doctoral dissertation on the compositional studies of NEOs. Shortly after graduation, Paul joined Faith Vilas (another fellow PSI scientist) for his postdoctoral work as a National Research Council Associate at NASA JSC. Paul also joined Faith on the Hayabusa Science Team, where they have been aiding the Japanese in the analysis of data collected by the Hayabusa spacecraft of near-Earth asteroid (25143) Itokawa.

Paul near the summit of Mauna Kea, Hawaii, during a cold telescope observing run in January, 2006. His home away from home, the NASA Infrared Telescope Facility (IRTF), is in the background.

Paul's professional interests involve ground-based studies of NEOs via visible and near-infrared spectroscopy to determine the physical characteristics of asteroids and comets. He is also participating in the development of future spacecraft missions to NEOs for sample return, and is a supporter of improving public outreach and education concerning NEOs and their associated risks and benefits. When Paul is not in the lab, he enjoys the company of Amy and their cats, attending the ballet and symphony, playing miniature war games, drinking Islay single malt whiskies, and reading and watching science fiction. Unfortunately, now that they live in Houston, cold weather and hockey are a little harder to come by.

PSI is glad to have you aboard, Paul!

Director's Notes

We invest in infrastructure so that we can continue to grow and increase our efficiency and capability. The success of PSI scientists in recent years has resulted in a rapid growth in computer resources that finally tapped the power and cooling capacity of our computer room. Over the past three months we have learned a great deal about things like *three-phase power* and *tonnage of cooling* in order to properly size our needs. Finally, the contractors have left and we can now double, and possibly triple, our current computer usage. Since computational power is increasing while using less electricity and generating less heat, our future capability will be even greater.

The importance of infrastructure also extends to our solar system exploration program. Knowledge is the return that taxpayers earn for their investment in the expensive spacecraft we send to Mercury, Mars, Pluto and elsewhere. Understanding how these planets and other objects work gives us a broader understanding of our universe and a more detailed understanding of how our own planet works. Similar physics is applied to all. This knowledge is derived from NASA's data analysis programs and the basic research programs that provide the context for that analysis. At a time when the volume and diversity of data coming back from our space missions have been skyrocketing, these research and data analysis programs have been slashed by 25% over the past 18 months to cover funding shortfalls in the Moon-Mars program. They have yet to recover. The return per dollar on investment is shrinking to the point where support for further investment in NASA missions can be rightly challenged. This is not a good thing.

It has been suggested at NASA Headquarters that the next opportunity for small Discovery and Mars Scout missions be skipped to create a funding wedge for a new $1.5 billion Flagship mission to the outer solar system. It would be better to use that money to fix the research and data analysis programs for the next decade and grow them by a modest amount. Then, with a solid foundation ensuring good benefit, we could more credibly go to Congress and ask for new money for a new large mission to gain even more knowledge.

Mark V. Sykes
June, 2007

PSI Scientists Await Dawn Launch

by Mark V. Sykes

The NASA Dawn Discovery Mission is scheduled to launch on July 7, 2007, aboard a Delta II rocket from Launch Complex 17-B at Cape Canaveral, Florida. Using ion propulsion, it will be the first multiple-rendezvous space mission. Its targets are the two largest asteroids between Mars and Jupiter. Dawn will arrive at the smaller of the two, Vesta, in October, 2011, for a six-month stay, mapping and studying its surface and composition. Vesta largely melted early in its history, forming a metallic core. Volcanism has covered its surface with basaltic lavas. An ancient, large impact excavated a nearly hemispheric crater covering its south pole. The debris from this impact created a large asteroid family from which about four percent of meteorites falling to Earth today originated.

Dawn will depart Vesta in April, 2012, arriving at the small planet Ceres in February, 2015. Unlike Vesta, which contains essentially no water, Ceres formed further from the Sun and contains substantial amounts of water. Models suggest that Ceres has a subsurface ocean, which raises the question of whether life could have developed there over the age of the solar system. Its surface is covered with clay minerals, indicating long interaction between water and minerals. Hubble Space Telescope observations reveal a very smooth, oblate object with no obvious craters or other topography, suggesting that Ceres has segregated into a rocky core covered by an ice-rich mantle.

PSI scientists have been involved with the Dawn mission since its inception. PSI Senior Scientist Bill Feldman and I are Co-Investigators of the mission. Feldman is one of the principal designers of the Gamma-Ray Neutron Spectrometer (GRaND), which will measure the elemental composition of Vesta and Ceres. We are both members of the Dawn Science Team.

PSI Associate Research Scientist Pasquale Tricarico has been supporting Dawn mission planning by developing software that allows the science team to simulate spacecraft trajectories as it orbits both Vesta and Ceres, allowing individuals to select different gravity models, orientations, and operating altitudes in order to gain experience in detailed survey planning under a variety of conditions, many of which will be unknown until target arrival. He is also working on predictions for flyby targets as Dawn moves through the asteroid belt.

PSI Postdoctoral Research Scientist Matt Chamberlain and I have been making observations of Vesta and Ceres using groundbased telescopes operating in the mid-infrared, submillimeter and millimeter wavelengths in Arizona, Hawaii, and Australia in collaboration with Amy Lovell (Agnes Scott College) and Bobby Bus (Infrared Telescope Facility). These observations are providing new insights into the thermal properties of the surfaces of these bodies, allowing for better planning of observations by Dawn, and the targeting of specific areas showing unusual properties that have yet to be understood.

Dawn will be providing new knowledge about two objects that were essentially frozen at very early stages of their planetary evolution, each taking a different path — one dry (Vesta), the other wet (Ceres). Ceres grew large enough for its gravity to maintain a round shape, making it the smallest known planet.

Dawn is a long mission, and given its trajectory through the asteroid belt, it is hoped that there will also be numerous opportunities to explore other objects as it flies past. PSI scientists are looking forward to an exciting eight years. □

At Astrotech, near the Kennedy Space Center in Florida, two Dutch technicians examine the Dawn spacecraft after deployment of the solar panels on one side, as Dawn is prepared for launch. Photo credit: NASA/George Shelton (KSC-07PD-1268A).

Third child for Matt & Yen Chamberlain!

Welcome to the world, Zane Chamberlain! Seen here at two weeks of age, Zane was born May 16th, weighing 8 lbs. 2 oz. and measuring 19 1/2" long. Won't be long before he is chasing siblings Keira and Corey down the halls of PSI. Well done, Yen and Matt; he is adorable!

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1700 E. Fort Lowell Road, Suite 106
Tucson, AZ 85719-2395
Phone: 520/622-6300
Fax: 520/622-8060
www.psi.edu

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