Lunar and Planetary Information
# BULLETIN

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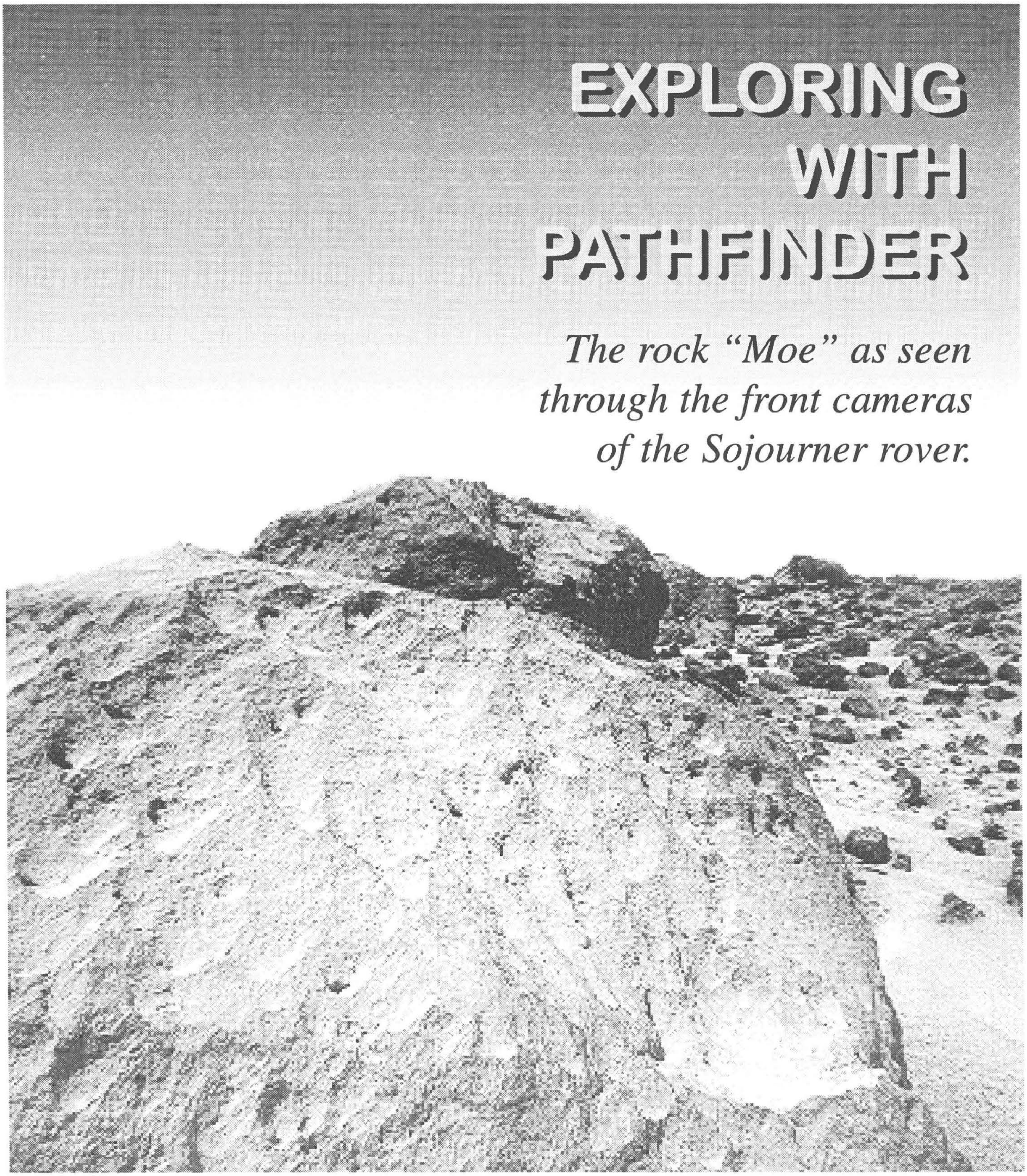
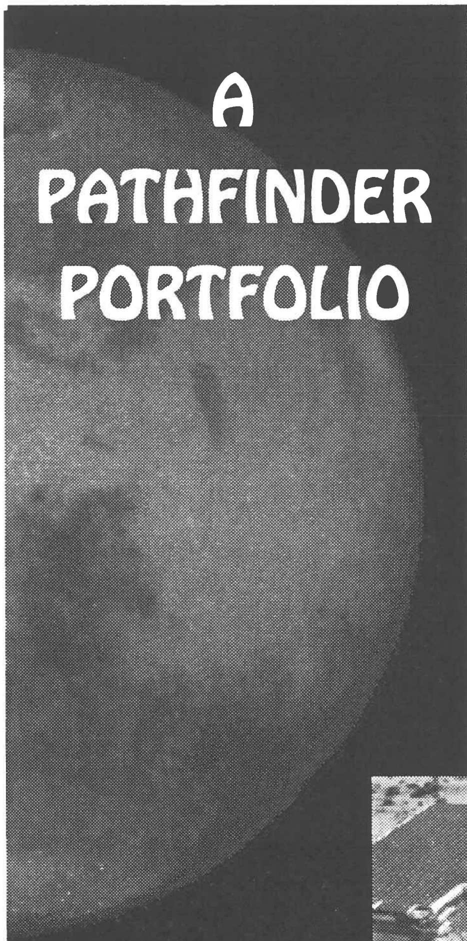
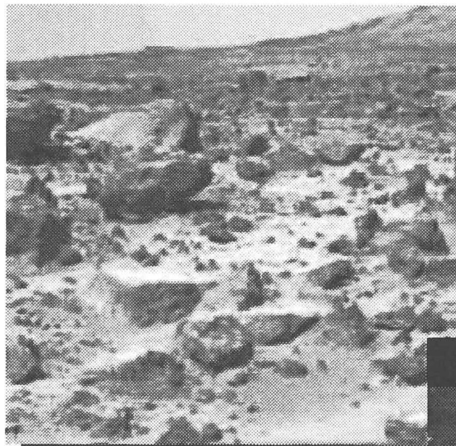


# EXPLORING WITH PATHFINDER

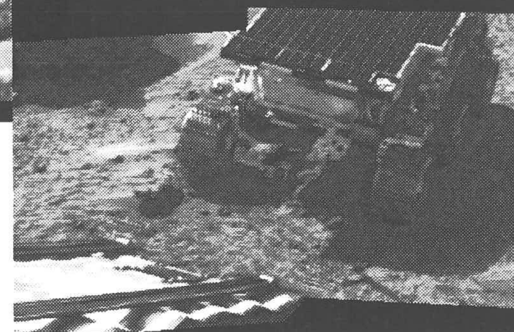
*The rock "Moe" as seen through the front cameras of the Sojourner rover.*

# A PATHFINDER PORTFOLIO

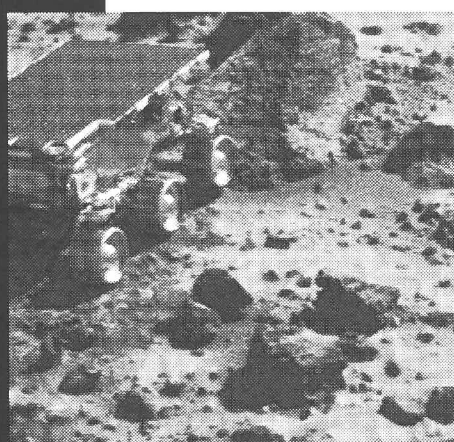




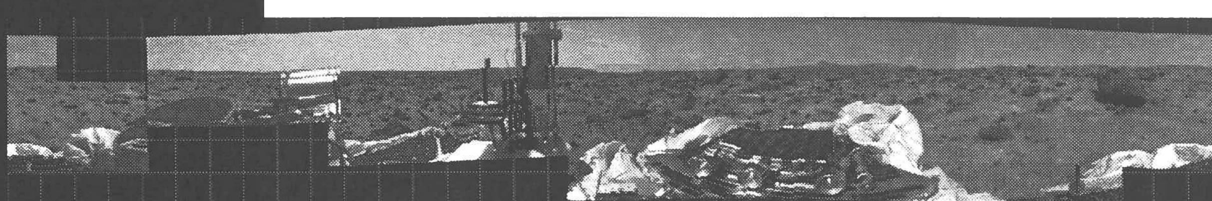
*Return to Mars. One of the first images from the Pathfinder lander camera shows a boulder-strewn landscape presumably created by ancient floodwaters coursing through Ares Valles.*



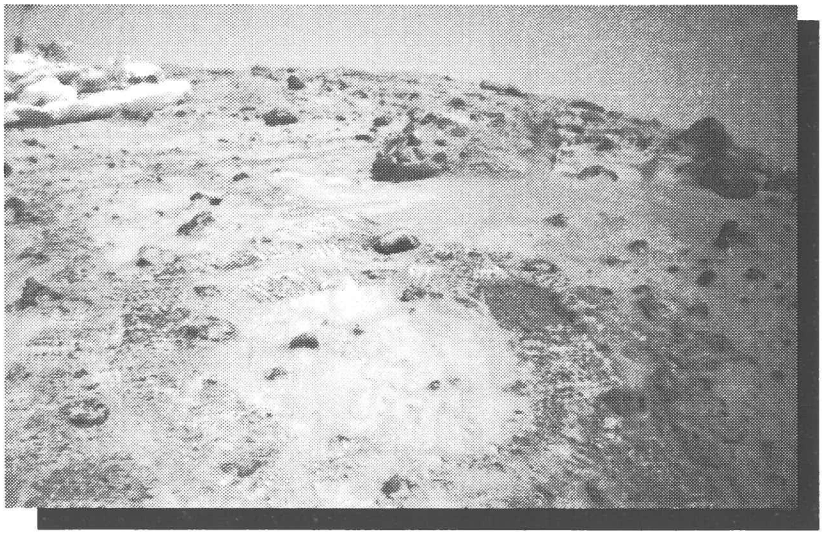
*"Six wheels on soil!" was the jubilant caption that appeared with this image on the Mars Pathfinder Web site. The image was taken by the IMP camera on July 5 following Sojourner's descent down the rear rover deployment ramp. The microrover's seven-month journey from Earth to Mars is complete. The soil beneath Sojourner (with tracks visible behind the right rear wheel) was to be the first target of the Alpha Proton X-Ray Spectrometer.*



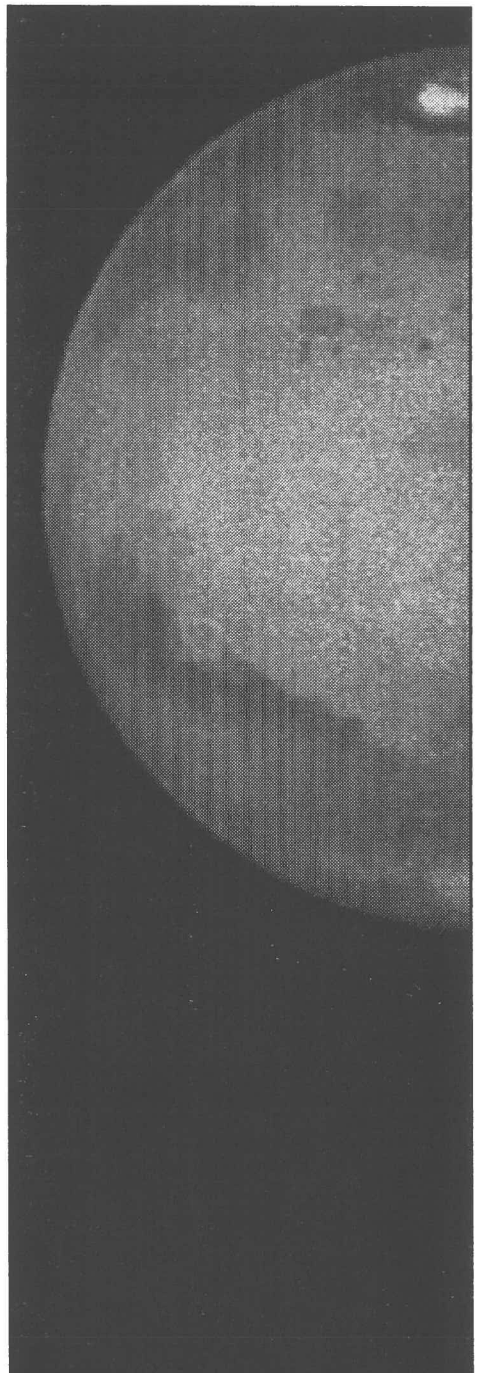
*On its 37th day on Mars, Sojourner places the Alpha Proton X-Ray Spectrometer against a rock dubbed Wedge.*

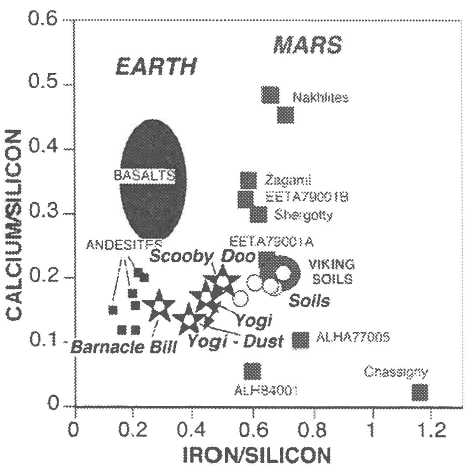


*This 360° photomosaic was taken by the IMP camera on July 4. The lander in the foreground was named the Sagan Memorial Station in honor of the late scientist. All three lander petals are fully deployed. The Sojourner microrover is shown in its stowed position. Metallic cylinders at either end of Sojourner are the rover deployment ramps. Visible at the rear end (right) of the rover is the Alpha Proton X-Ray Spectrometer. Components of the high gain-antenna (dark, circular object and bright, metallic object) are to the right of the center petal. The black post, bull's-eye rings, and small shaded blocks in the far right portion of the image are calibration targets.*



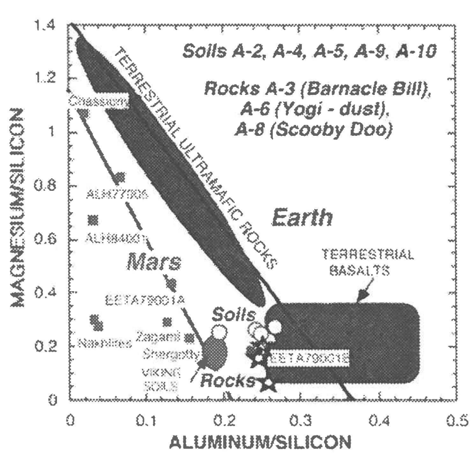
*The rover looks back at the lander and captures an image of its tracks in the dune-like surface.*






*(Left) Preliminary rock and soil analyses. In this diagram, preliminary Alpha Proton X-Ray Spectrometer analyses of soils (small circles) extend the range of Viking soil analyses. Rock analyses are indicated by stars. The analysis of Yogi appears to be contaminated by dust adhering to the rock's surface. The rock composition can be estimated by subtracting a portion of dust; the resulting Yogi composition is very similar to that of Barnacle Bill (assuming 50% dust having the composition of drift analysis A-5 and using a linear mixing model to subtract the dust, which is only strictly valid if the dust, where present, is thicker than the APXS penetration depth). Barnacle Bill is also contaminated by dust, but to a lesser extent.*

*(Right) Preliminary X-ray data illustrates chemical differences between terrestrial rocks and meteorites inferred to have come from Mars. The martian meteorites (as well as Viking soil analyses) all plot to the left of the fields for Earth rocks. Pathfinder APXS analyses of rocks (stars) and soils (small circles) appear to plot in the gap between these previously defined fields, although they are similar to at least one basaltic meteorite. The other two stars represent the compositions of Barnacle Bill and Yogi.*




Images and data are from the Pathfinder Web site (or mirrors) that can be reached at http://mpfwww.jpl.nasa.gov. Educators can obtain a set of Mars Pathfinder images as well as a poster with classroom activities by contacting NASA CORE at 440-774-1051, ext. 249 or 293, or via e-mail to nasaco@leeca8.leeca.ohio.gov. See also the Web site at http://spacelink.nasa.gov/CORE.

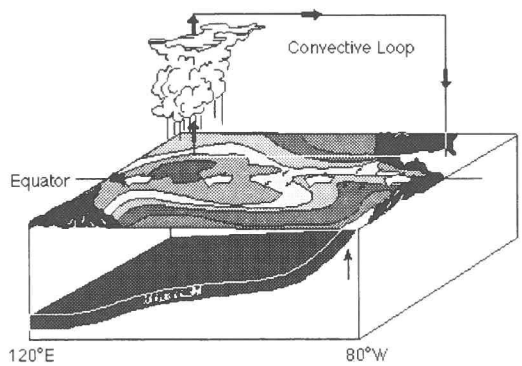
# NEWS FROM SPACE

## COMPLEMENTARY SATELLITE MEASUREMENTS SUGGEST EL NIÑO IS BREWING AGAIN

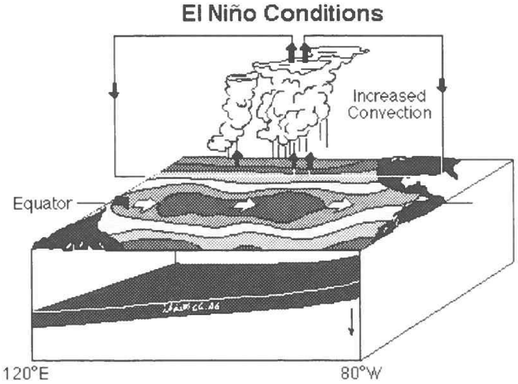
Simultaneous ocean measurements taken by two orbiting NASA science instruments suggest that another weather-disrupting El Niño may be developing in the Pacific Ocean, with the potential of affecting global weather patterns next winter.

Sea-surface height measurements taken by the radar altimeter onboard the joint U.S.-French TOPEX/POSEIDON satellite and wind data collected by the NASA Scatterometer on Japan's Advanced Earth Observing Satellite (ADEOS) are being used together for the first time to diagnose changing oceanographic and atmospheric conditions in the tropical Pacific Ocean.

Normal Conditions




El Niño Conditions




The El Niño phenomenon is thought to be triggered when steady westward-blowing trade winds weaken and even reverse direction. This wind shift allows the large mass of warm water normally located near Australia to move eastward along the equator until it reaches the coast of South America. This displaced pool of unusually warm water affects where rain clouds form and, consequently, alters the typical atmospheric jet stream patterns around the world. The change in the wind strength and direction also impacts global weather patterns.

"NSCAT has observed two episodes of the reversal of the trade winds in the western Pacific, one at the end of December and one at the end of February. Both generated warm water masses, called Kelvin waves, that traveled across the Pacific and were measured by TOPEX/POSEIDON," said Lee-Lueng Fu, TOPEX/POSEIDON project scientist at the Jet Propulsion Laboratory. "Kelvin waves are often a precursor to a warm state of the tropical Pacific, sometimes leading to an El Niño. Whether an El Niño event will occur cannot be determined by just examining the satellite data. A computer model that couples ocean-atmosphere data, like the one used by the National Oceanic and Atmospheric Administration (NOAA), is a necessary tool to issue scientifically based predictions. Now, for the first time, both TOPEX/POSEIDON and NSCAT are observing and providing the best, near real-time view of global ocean winds and sea level ever obtained. These observations will help NOAA's model to predict the occurrence of El Niño."

NOAA has issued an advisory about the early indications of El Niño conditions. A number of El Niño forecast activities supported by NOAA indicate the likelihood of a moderate or strong El Niño in late 1997. The forecast model operated at NOAA's National Centers for Environmental Prediction (NCEP) used data collected by the TOPEX/POSEIDON satellite.

"The use of TOPEX/POSEIDON data clearly improved our forecast for the winter of 1996-1997," said Ants Leetmaa, chief scientist at NCEP. "We currently use the data continuously for our operational ocean analyses and El Niño forecasts. The use of this data set enabled a clearer picture to be developed of the multi-year evolution of ocean conditions in the tropical Pacific that have resulted in the onset of the current warm episode. We have not yet had a chance to utilize the NSCAT data in the models but we anticipate that its use also will improve our forecast system."

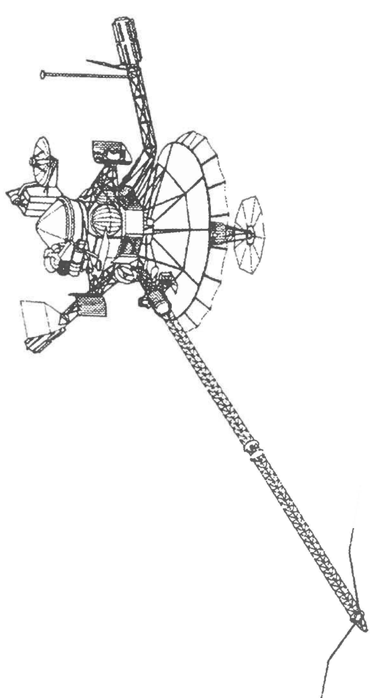
"Since the beginning of the instrument's operation in September 1996, NSCAT has observed stronger than normal easterly winds in the central and western tropical Pacific, which might have piled up warm water in the west as indicated by the higher than normal sea level and sea surface temperature," said W. Timothy Liu, NSCAT project scientist at JPL. "This is usually a precursor of subsequent anomalous warming in the east. Kelvin waves moving across the Pacific do not necessarily mean El Niño, but we are studying how these seasonal phenomena like Kelvin waves are related to events like El Niño that occur over several years.

Unfortunately, NSCAT and other instruments including a Total Ozone Mapping Spectrometer were lost to scientists when the ADEOS satellite failed and was declared irrecoverable by NASDA, the Japanese space agency, on June 30 this year. "The data we have obtained to date are extremely valuable," said Jim Graf, NSCAT project manager at JPL. "If we knew we were limited to just nine months of data, we would have chosen the period we actually got. We obtained coverage over the summer and winter monsoon seasons and what may be the onset of an El Niño. Perhaps the largest loss is the discontinuity of the long-term data set, which is being used to understand interannual and decadal variations in our climate."

El Niño, a Spanish term for a "boy child," is so called because the warm current first appeared off the coast of South America around Christmas. Past El Niño events have caused unusually heavy rain and flooding in California, unseasonably mild winters in the Eastern United States and severe droughts in Australia, Africa and Indonesia. El Niño episodes usually occur approximately every two to seven years.

The following Internet sites can be accessed for more information:
TOPEX/POSEIDON: http://podaac.jpl.nasa.gov/topex
NSCAT: http://winds.jpl.nasa.gov
NCEP: http://nic.fb4.noaa.gov:80/products/analysis_monitoring/enso_advisory/index.html

## GALILEO DATA SHEDS LIGHT ON PROBE FINDINGS



Jupiter has both wet and dry regions, just as Earth has tropics and deserts, according to new images and data from the Galileo spacecraft. The data may explain why Galileo's atmospheric probe found much less water than scientists had anticipated when it dropped into the Jovian atmosphere in December 1995. "We had suspected that the probe landed in the 'Sahara Desert of Jupiter," said Andrew Ingersoll, a professor at the California Institute of Technology and member of the Galileo science team. "But the new data show there is moisture in the surrounding areas. Jupiter is not as dry overall as we thought."

The probe apparently entered a clearing in the clouds — a dry spot through which deeper, warmer layers can be seen. By studying various areas, including those resembling the probe entry site, the Galileo orbiter has helped scientists understand the probe results. In fact, the air around a dry spot has 100 times more water than the dry spot itself, according to Robert Carlson of the Jet Propulsion Laboratory, principal investigator for the imaging spectrometer instrument onboard Galileo.

Such dry spots cover less than 1% of the atmosphere and appear to be regions where the winds converge and create a giant downdraft, according to Caltech graduate student Ashwin Vasavada. In fact, the water content of the giant, gaseous planet varies at least as much as the moisture varies from place to place on Earth.

"Winds rise from the deep atmosphere and lose water and ammonia," explained Glenn Orton, a Galileo interdisciplinary scientist at JPL and Photopolarimeter-Radiometer co-investigator. "At the top, when they converge and drop back down, nothing is left to condense back into clouds, and a dry clearing is created. These dry spots may grow and diminish, but they recur in the same places, possibly because of the circulation patterns on Jupiter."

Ingersoll said the dry spots are found in a northern hemisphere band at 5–7° latitude. When the Galileo probe was released near the tops of the clouds, it found dry air underneath. But at other locations, the weather might be rather Earth-like.

In the months since the probe's descent, Galileo mission scientists have debated whether the dry conditions it encountered were due to the downdraft concept, or whether Jupiter's water had somehow been concentrated deep in the gas planet's interior as it formed and evolved four billion years ago. "There was a cosmochemical explanation and a meteorological explanation, and our latest analysis clearly favors the idea that the dry spots are a consequence of weather-related activity," Ingersoll said. "Fifty miles below the cloud tops, we could expect thunderstorms, lightning, and rain. But in contrast to Earth, individual jovian storms and weather systems sometimes last for months, years, or even centuries. The Great Red Spot, for example, has existed for at least the 300 years that we've been aware of it."

Despite the relatively warm temperatures and the presence of water on Jupiter, Ingersoll said it is "highly unlikely" that the planet could sustain life in its thick, gaseous environment without any solid surface. He expressed the opinion that any jovian life forms would have to hover, and "while we might imagine an advanced life form that could adapt, prebiotic compounds would not survive in that environment and, therefore, evolution could not take place there."

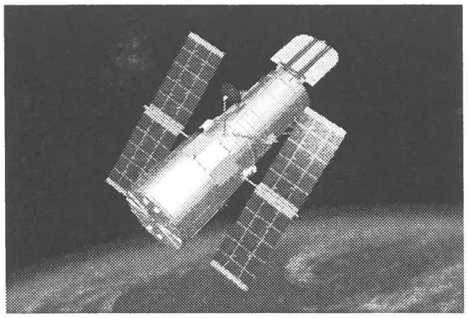
The latest data from Galileo also shed new light on the auroras that glow in a narrow ring around the Jupiter's poles. The auroras are created when charged particles collide with atmospheric particles, causing them to light up. New images show the nightside aurora for the first time.

Scott Bolton of JPL, co-investigator for the Galileo plasma and plasma wave instruments, said the latest findings show "Jupiter's auroras are a lot like the auroras we see on Earth as the northern lights. However, we now know that the auroral arc on Jupiter is thin and patchy, and we can also estimate its altitude is between 300 and 600 kilometers."

These auroras had previously been viewed in ultraviolet light by the Hubble Space Telescope, and in infrared light by Earth-based telescopes, but Galileo was able to capture images of the auroras in visible light and from a closer vantage point.

Images and other data received from Galileo are posted on the Galileo home page on the World Wide Web at: http://www.jpl.nasa.gov/galileo.

### HUBBLE SEES RAPID WEATHER CHANGES ON MARS, NEW DUST ACTIVITY



Astronomers using the Hubble Space Telescope to track weather on Mars, and how it might affect the Pathfinder landing site in Ares Vallis, reported July 15 that a large dust storm seen south of the site only 12 days earlier had dissipated. However, a new dust storm has appeared in the polar region, about 2000 kilometers (1200 miles) due north of Pathfinder. The researchers conclude that Pathfinder landed during a period when rapid changes in the regional distributions of dust and clouds were taking place on Mars.

Hubble pictures taken with the Wide Field Planetary Camera 2 recorded remarkable daily changes in the behavior of dust and water-ice clouds on the red planet as followed over a three-day period, from July 9 to 11. The variability seen in just three consecutive days of Mars observations shows that weather changes are very rapid — possibly chaotic — so it may be impractical to make an accurate weather forecast for Mars, say researchers. "Mars never ceases to amaze us," says Steve Lee of the University of Colorado at Boulder.

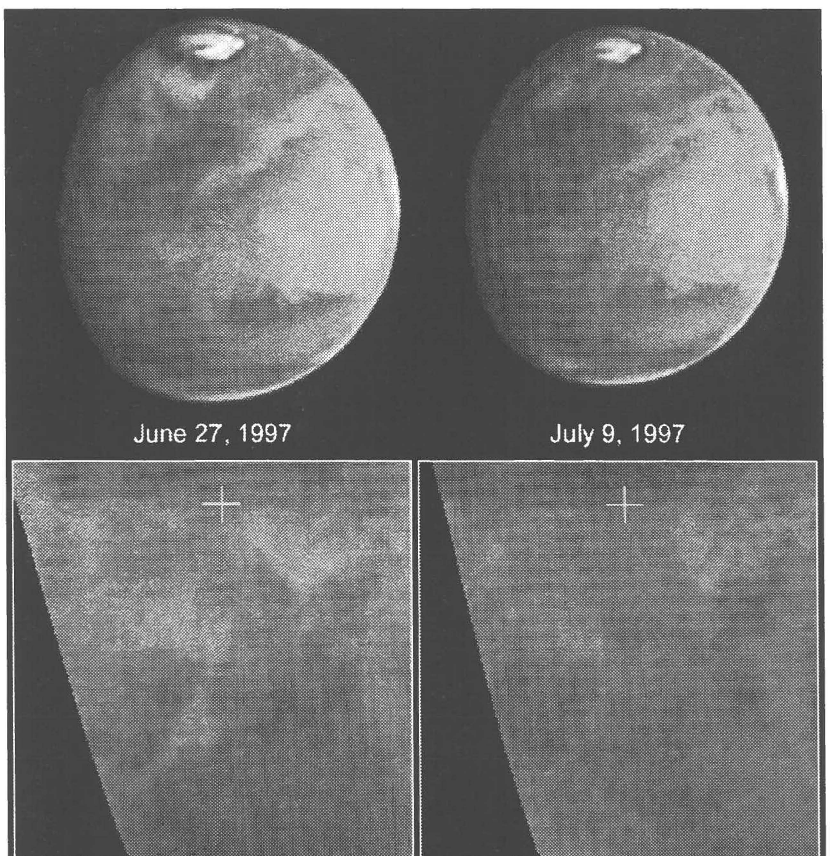
The team suggests that the dust seen in the skies over Pathfinder may have diffused toward the landing site from the now dissipated dust storm in Valles Marineris. The newly erupted 600-mile-long dust streamer coming off the northern polar cap and extending southward may also be sending dust toward the Pathfinder landing site.

The Hubble Mars Team consists of Phil James and Mike Wolff (University of Toledo), Steve Lee (University of Colorado), Todd Clancy (Space Science Institute), and James Bell III (Cornell University.)

## DECAY OF A MARTIAN DUST STORM

NASA Hubble Space Telescope images of Mars, taken on June 27, 1997 (left) and July 11, 1997 (right), document the dissipation of a large dust storm during the 12 days separating the two observations.

The images were taken to monitor the weather conditions near Ares Vallis, the site where NASA's Pathfinder spacecraft landed on July 4. Maps of the equatorial region were constructed from the images and are shown at the bottom of the figure; a green cross marks the Pathfinder landing site. (All images are oriented with north to the top.)



**Mars • Pathfinder Landing Site**
PRC97-24a • ST ScI OPO • July 15, 1997
S. Lee (Univ. Colorado), P. James (Univ. Toledo), M. Wolff (Univ. Toledo) and NASA

These two sets of observations show a number of dramatic changes in the planet's atmosphere. At about the 7 o'clock position on the June 27 image, the eastern end of the Valles Marineris canyon system is just coming into daylight and can be seen to be filled with yellowish dust. The dust appears to be confined to the canyons, which can be as much as 8 kilometers deep and hundreds of kilometers wide. Estimates of the quantity of dust involved in this storm indicate that 96% of the incoming sunlight is being blocked from reaching the surface by the dust clouds. Note that on the July 9 image, the dust storm appears to be subsiding; it is estimated that the dust quantity in most of the visible canyon system has dropped to only 10% to 20% of that seen on June 27.

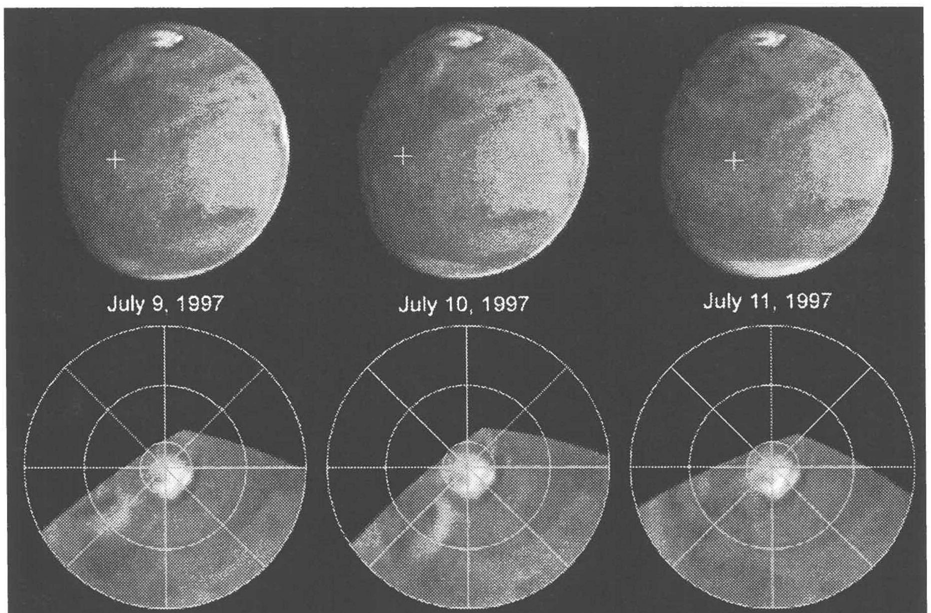
However, on July 9 a streamer of dust is visible in the North polar region, extending about 1200 kilometers southward from the dark sand dunes surrounding the polar ice cap; diffuse dust is visible over much of Acidalia, the dark region to the north of the Pathfinder landing site. The extent of clouds visible across the planet has also changed considerably between the two dates. Just to the west (left) of the July 9 dust streamer, a very bright area of water-ice clouds is seen; this area was considerably cloudier on June 27.

These images dramatically show that atmospheric conditions can change rapidly on Mars. Observations such as these will continue to be made over the next several months, allowing the detailed surface observations made by Pathfinder to be placed into the broader context of the global images available from HST.

### RAPID WEATHER CHANGES OBSERVED ON MARS

NASA Hubble Space Telescope images of Mars, obtained over three consecutive days between July 9 and 11, 1997, dramatically show that the behavior of dust and water-ice clouds exhibit substantial daily variations. The full-disk images are shown along the top (Pathfinder landing site marked by the green crosses), and maps of the north polar region are shown along the bottom. (The maps are oriented with 0° longitude to the bottom, and extend from 40° N latitude to the pole; latitude circles are shown at 40°, 60°, and 80°, and lines of longitude are shown every 45°.) About 24 hours separates each of the images.

The polar maps document the movement of bright water-ice clouds as they are seen to progress eastward, perhaps driven by a passing weather front on Mars. Between July 9 and 10, the polar cloud seen near 60° N latitude is measured to have moved about 550 kilometers eastward over a period of about 24 hours, corresponding to a velocity of about 22 kilometers/hour. The cloud has dissipated considerably by July 11.




Mars • July 1997
PRC97-24b • ST ScI OPO • July 15, 1997
S. Lee (Univ. Colorado), P. James (Univ. Toledo), T. Clancy (Space Science Inst.) and NASA

Clouds in the southern hemisphere seem to thicken considerably over this three-day period as well. The bluish south polar hood, composed of water-ice clouds, is seen along the bottom of the images. We cannot see the south polar cap, since the north polar cap is tilted toward us during this season and the south cap is in winter darkness.

On the July 9 image and map, a streamer of dust is visible in the north polar region, extending about 1200 kilometers southward from the dark sand dunes surrounding the polar ice cap; diffuse dust is visible over much of Acidalia, the dark region to the north of the Pathfinder landing site. This dust cloud is apparently diffusing with time, as it seems to become less distinct in each successive image. This dust storm may be supplying some of the dust seen overhead by the Pathfinder spacecraft.

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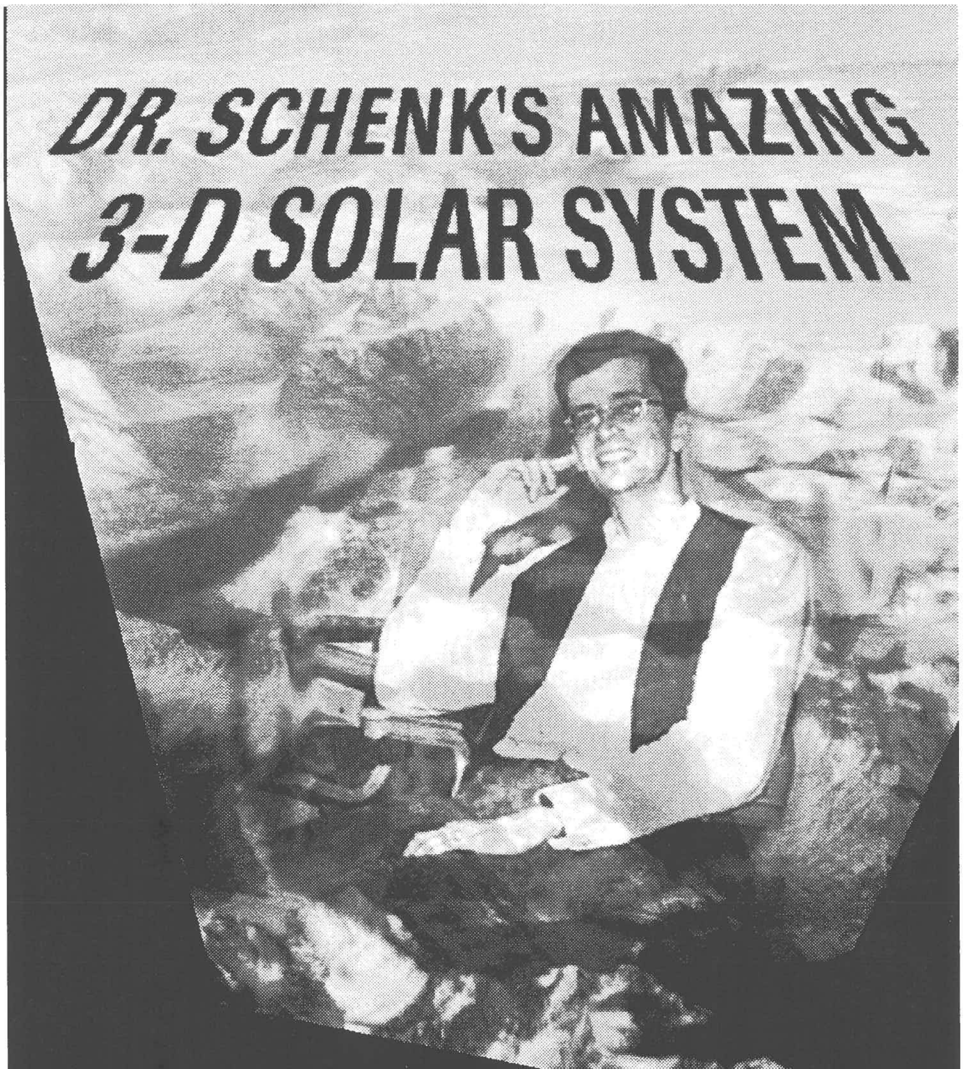
# DR. SCHENK'S AMAZING 3-D SOLAR SYSTEM



*"It gives you a very different perspective on what other planets look like. One can actually sense how rugged the mountains are and how deep the craters are."*

*—by Brian Anderson*

Just as invention is often born of necessity, the *3-D Tour of the Solar System* sprang from the seed of one man's frustration with a specific scientific problem.

"I wanted to know how deep the craters were on the icy satellites," said Paul Schenk, the senior author of the CD-ROM recently released by the Lunar and Planetary Institute. "The methods that were available were kind of primitive, and I thought it would be a real big help if we had stereo images so I could measure the features directly."

Soon afterward, Schenk came across some stereo images of Uranus' satellite Miranda and realized a valuable scientific resource may have remained untapped.

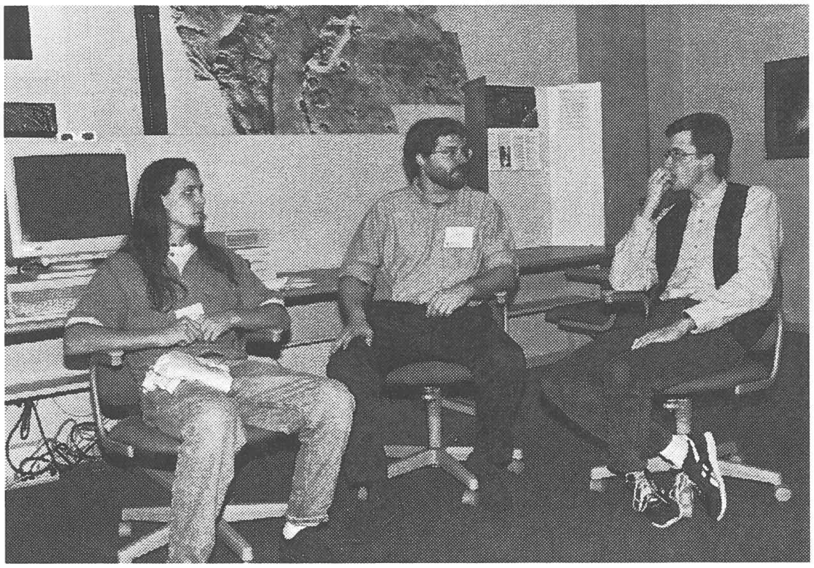
"I began to investigate whether there were any unused stereo images in the Voyager dataset," Schenk said. "I found out that most of the outer planets had stereo coverage, which surprised me. Once I had that, it was natural to extend it to the rest of the solar system."

After discovering a wealth of viable stereo images, Schenk and co-authors David Gwynn and James Tutor began the arduous process of sifting through the datasets of various missions to select representative images of the nine planets, their satellites, and the asteroid belt. Most of the stereo pairs, save for some dedicated stereo images taken on Apollo and Magellan missions, had to be constructed using existing orbital photographs.

"I think this has been the first chance anybody has had to explore these images," Schenk said. "A few people had looked at a few examples, such as Miranda, but I think a lot of people just assumed there was no useful stereo coverage."

Over a period of about a year, Schenk and his coworkers processed, cleaned up, and reprojected the selected original images to create optimum stereo pairs. ("Your mind would just explode if you saw the originals," Schenk explained.) In addition, for many of the images, the scientists compiled data sheets of relevant factors such as spacecraft altitude, image width, and stereo baseline.

"We were all surprised by the amount of work that was involved," Schenk said.



*From left to right, James Tutor, David Gwynn, and Paul Schenk.*

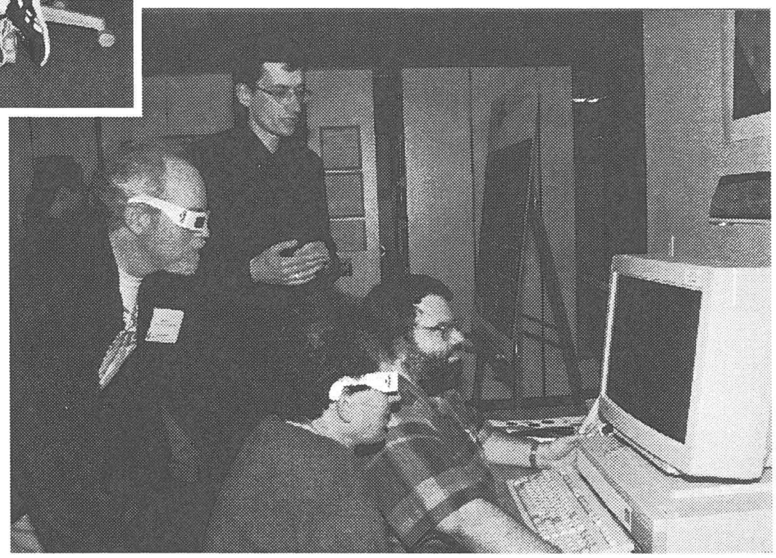
The resulting product, the first collection of true stereo images from the solar system, contains more than 150 images. The images are viewed using red-green 3-D glasses (included with the CD) and highlight important geological features such as impact craters, volcanos, and faults, in keeping with Schenk's original focus.

"It gives you a very different perspective on what other planets look like. One can actually sense how rugged the mountains are and how deep the craters are," Schenk said. "We tried to put in several examples of all the prominent features on planets. It's a useful way of illustrating specific geological features and the deposits and structures that are associated with them."

Some of the stereo pairs reveal dramatic geological features not visible in standard photographic images. Many of the volcanos on the outer satellites turned out to be flatter than expected, for example, and images of Ra Patera on Io revealed a connection between a lava flow and a high plateau east of the volcano.

"This wasn't detected at all with the standard images," Schenk said.

Although 3-D vision in one sense emulates the depth perception of human eyesight, the stereo images on the *3-D Tour* are exaggerated to show vertical relief and geological detail. Whereas human eyes are separated by only a few inches, Schenk tried to select images that were spaced apart at distances equal to or greater than the altitude at which they were taken. Essentially, these images give a "giant's eye" view of terrain, revealing features in striking stereo detail that would not be apparent in normal orbital views.



*Paul Schenk observes as participants at the 28th Lunar and Planetary Science Conference explore the solar system in 3-D.*

"If you were in orbit, you wouldn't be able to tell anything about these features," Schenk said.

Schenk, who earned a Ph.D. in planetary sciences in 1988 and joined LPI's scientific staff in 1991, notes that geologists have long relied on stereo images for gauging distances on Earth and that NASA continues to use the technology for navigational purposes in rover operations such as Pathfinder. He believes stereo imaging will play an increasingly important role in studying the icy satellites and Mars, and he hopes to focus his own research in that direction.

"I plan to use the stereo images to actually map the topography of the icy satellites, which hasn't been done, focusing on Io and Ganymede. Those are the first on the list, then Mars. Some of this has been done on Mars, but it hasn't been done everywhere."

In addition to pursuing his own research interests in the coming years, Schenk will oversee the production of future editions of the 3-D CD-ROM, including an interactive multimedia version for younger audiences that is already in the works.

"I definitely have plans to do more such products and to make them bigger and better," Schenk said.

The *3-D Tour of the Solar System* can be sampled on the LPI Web site at http://cass.jsc.nasa.gov/lpi.html. The CD can be ordered using the form on page 10 of this *Bulletin.*

*(Mr. Anderson is a member of the Publications and Program Services Department staff at the LPI.)*

# NEW IN PRINT

These publications are available from the publisher listed or may be ordered through local bookstores.

*REVIEW*

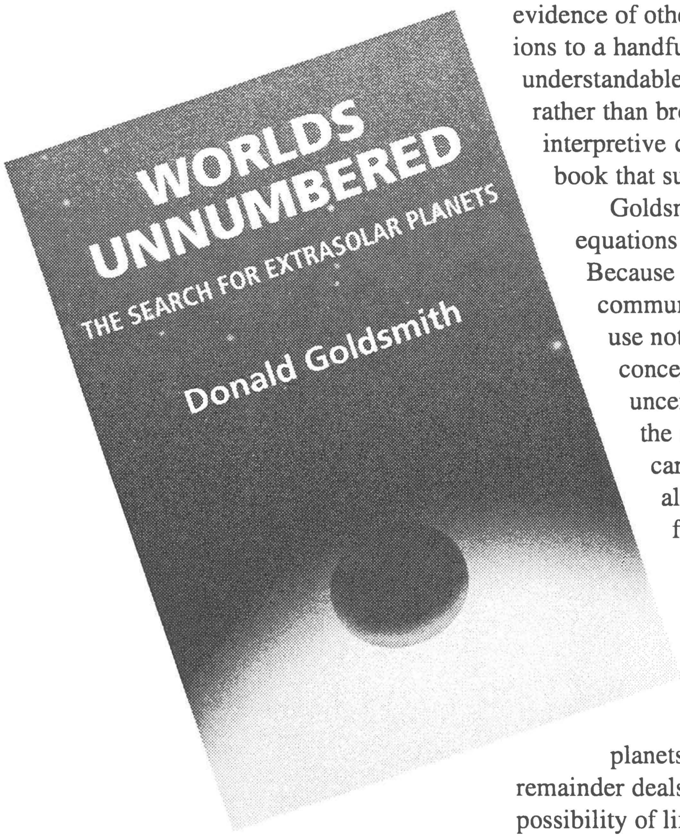
## Worlds Unnumbered
## The Search for Extrasolar Planets

by Donald Goldsmith

University Science Books, Sausalito, California, 1997, 256 pp.

Black and white and color photographs and illustrations. Hardcover. $28.50.

The past few years have been truly exceptional for space science. Observations using the Hubble Space Telescope have permitted a glimpse of the universe at a time roughly one billion years after its creation, a time when many astronomers expected to see galaxies in the earliest phases of their lives. Instead, they observed galaxies similar to their modern-day counterparts, along with a hint that galaxies may form by assembly of subgalaxy-sized clusters of stars. Detailed studies of a meteorite that appears to have come from Mars gave rise to an interpretation that the meteorite contained signs of past life on the Red Planet. And astronomers who have long sought evidence of other planetary systems were finally able to detect substellar mass companions to a handful of nearby stars. The enthusiasm that greeted these detections is understandable; however, more work is needed before their interpretation as planets, rather than brown dwarfs or a new class of object, can be validated. The need for interpretive caution notwithstanding, Donald Goldsmith has written a 200-plus-page book that summarizes some, but not all, of the new observations.




Goldsmith's book is intended for a nonprofessional audience. There are no equations and only a few technically oriented illustrations appear in the book. Because such a book does not rely upon the usual trappings that scientists use to communicate with each other about the technical aspects of their work, it must use not only vivid, but useful and correct analogies to convey technical concepts. A book of this nature should be factually correct, and where there is uncertainty, it should convey that unashamedly. Books such as this are often the connection between the professionals and the public and as such they carry a responsibility to portray accurately what we know. They should also portray those things that we do not know in just that light, without falling prey to the temptation to pass on to the public unproven interpretations of experiments or observations. The public should be allowed to share in the process of debate that scientists engage in as they do their work. This book fails on several counts; the most critical failing is discussed at the end of this review.

While one might assume from the title that the book deals solely with the search for other planetary systems (or for extrasolar planets), only about half the book covers that aspect of the story. Much of the remainder deals with questions of life elsewhere in the solar system as well as the possibility of life outside the solar system. This aspect of the book offers a brief, Reader's Digest tour of the many profound and complicated aspects of the question of life. These are both important and exciting topics that have been discussed in greater detail in other works of this kind, some of which are listed in the *Further Reading* section near the back of the book. Chapter 8 is entitled "Can we Find Life on Extrasolar Planets?," which might lead the reader to expect a discussion of the possible signatures of life that are believed to provide reasonable presumptive evidence that life exists on a planet (much as the *Galileo* spacecraft viewed the Earth from space and detected those molecules in the Earth's atmosphere that are the consequence of abundant life on this planet). Instead, the chapter is about UFOs and alien abductions.

# NEW IN PRINT

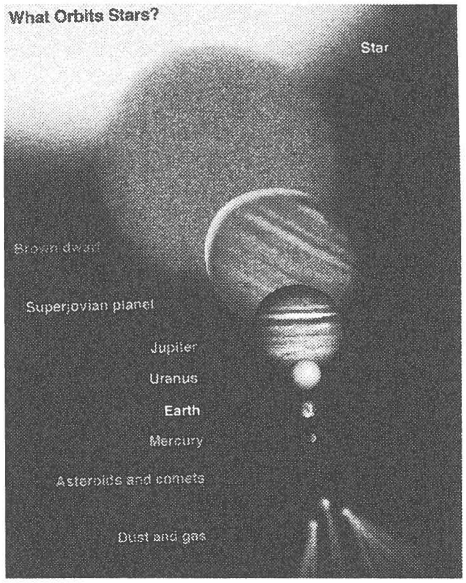



*Plate 14*

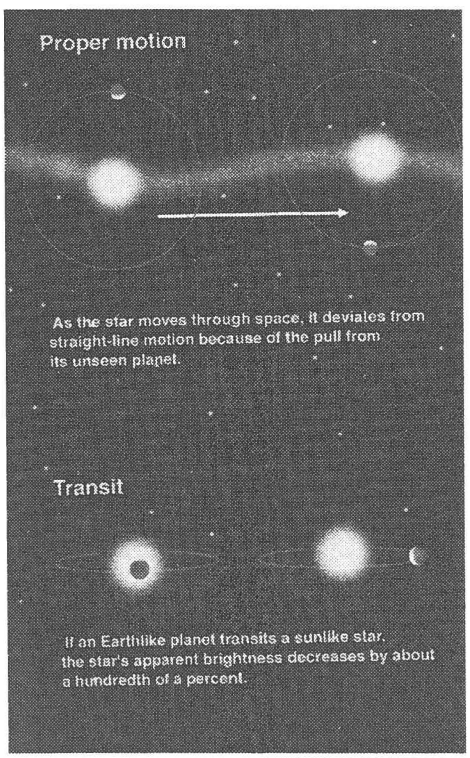



*Plate 21*

The discussion about finding life is a small part of Chapter 9 entitled "Future Searches for Extrasolar Planets."

The book benefits from the artwork of Jon Lomberg. His imagery provides an informative depiction of detection techniques (e.g., color plate 21) as well as a view, through the eyes of an artist, of the landscape of new worlds (e.g., the companions to a pulsar). Color plate 14 is a nice depiction of the range of objects that might revolve around stars, ranging from brown dwarfs to gas and dust. There is a technical error in that the art conveys a sense that the more massive an object, the bigger it is. This is true for matter under "normal" circumstances (e.g., planets), but is not true when matter becomes degenerate. If an object has no internal energy source and is only slightly more massive than Jupiter, at that point it actually gets physically smaller the more massive it is. This is a minor point and not the fault of the artist.

The material is a bit loose on explanatory analogies at various places in the text. For example, the narrative on page 11 about an inebriated golfer confusing a baseball for a golf ball is a poor demonstration of the orbital mechanics that underlies the motion of a star that is caused by the presence of a companion. Use of a hammer thrower, or a rotating seesaw, would have been far more effective and accurate in portraying the underlying physics of the situation.

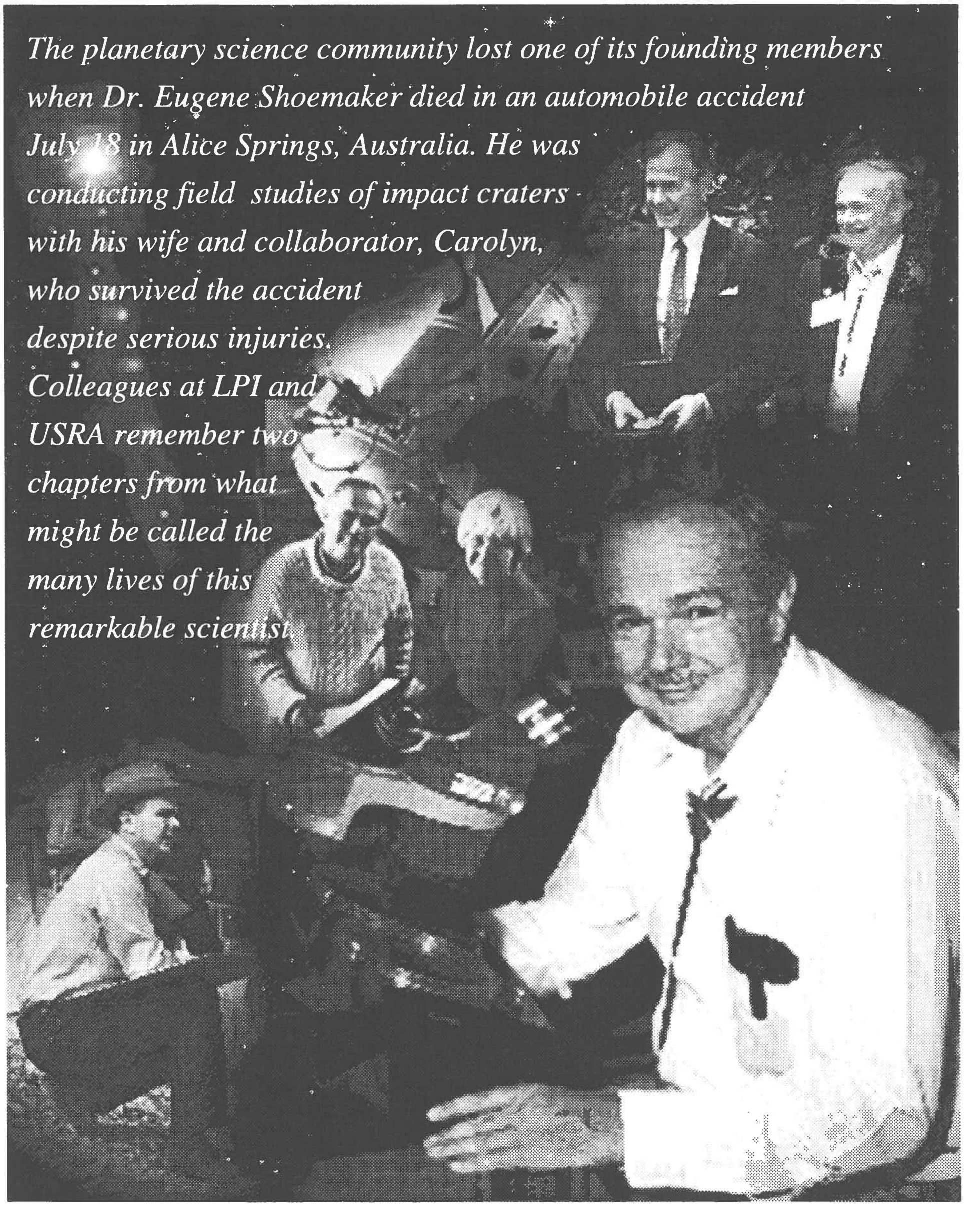
I found the style of the book to be a bit choppy. For example, in the aforementioned Chapter 8, page 181, there is a heading "How to Find Civilizations Around Other Stars" that has below it a single paragraph of text. That is followed by "Interstellar Spaceships," which commands two paragraphs of text. This is admittedly a matter of personal taste, but I would have preferred a smoother, more integrated style of writing. This same style is evident in the presentation of the color plates. They are not located generally near the relevant text, but rather lumped into two clusters of plates. This lessens the impact and information transfer that the imagery could provide.

The enthusiasm that greeted the first interpretation of companions around other stars as planets is understandable, and indeed that interpretation may turn out to be correct for some, maybe even all, of these objects. But that interpretation may also be totally incorrect for many, perhaps all, of these companions. Indeed, there is recent evidence that there may be no companion to the star 51 Pegasi. Also, the book includes no mention of a number of detections that have occurred during this time that may be critical to the interpretation of all the newly discovered companions.

The scientific process of clarifying the true nature of these companions is exciting and offers an excellent example of how science works. The opportunity to portray that dynamic is lost in this book as it accepts the early interpretations uncritically, and worse, passes them on as "fact" to the lay public.

The title of the book derives from a line in Pope's *An Essay on Man*. I close with a quote from Pope's *Essay on Criticism*: "A little learning is a dangerous thing, drink deep, or taste not the Pierian spring." This advice is for readers of *Unnumbered Worlds,* as well as a reminder for practicing scientists.

*—by David C. Black*
*(Dr. Black is Director of the Lunar and Planetary Institute.)*




# Gene Shoemaker 1928–1997

## A Mover and Shaker

*— Jack Sevier*

I can't think of anyone who has left a more indelible mark on planetary science than Gene Shoemaker. He was in it at the beginning when it was the domain of astronomers, and he was in it at the end when all but Pluto had become the property of the planetary scientists with their techniques of photogeology, geologic mapping, cratering analyses, and all the rest of the things that he helped to invent. His 40-plus years in the space program spanned Ranger, Surveyor, Lunar Orbiter, Apollo, Viking, Voyager, Clementine — and he was still going strong at the end with Earth-crossing asteroids and who knows what else.

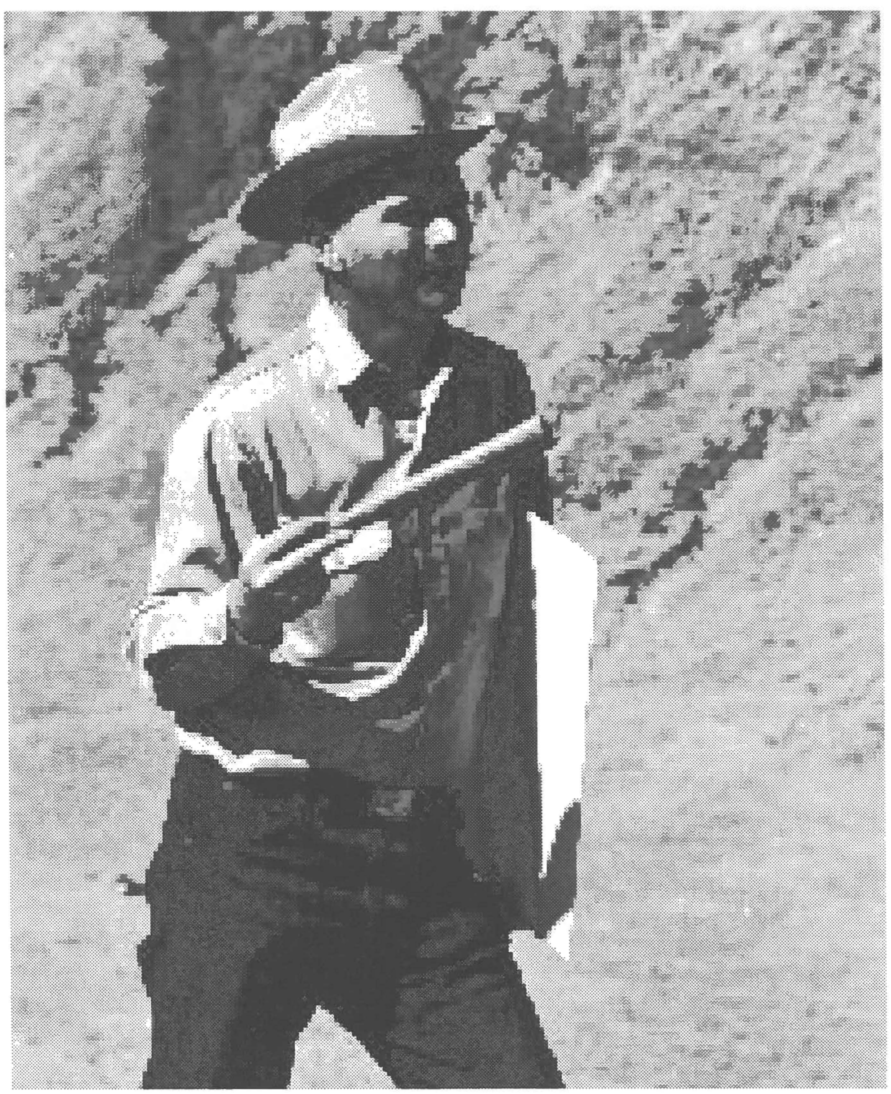
Gene was not just a first-rate geologist, but he was one of those movers and shakers as well. In his 1993 book, *To a Rocky Moon,* Don Wilhelms called it "wooing and selling" (p. 57), but it means the same thing: the ability to persuade the naysayers that your point of view is the correct one and should therefore prevail. The naysayers in the early days of Apollo (circa 1962) were the engineers and managers intent on meeting President Kennedy's simply stated objective of landing men on the Moon and returning them safely to Earth before the end of the decade. Embracing science was not part of the bargain and, worse, it would interfere with the difficult task at hand. However, during a one-year detail from USGS to NASA Headquarters in 1962, Gene was able at least to bring about a partial thaw in the antiscience attitude, and the Manned Space Science Division was established, not that it was terribly influential at first, but at least the foot was in the door.

At about the same time that Gene was wooing and selling at NASA Headquarters, the original Langley space contingent was moving to Houston to the newly established Manned Spacecraft Center (MSC) in a variety of rented office buildings on and around the Gulf Freeway. The Apollo Spacecraft Program Office (ASPO) was one of those MSC elements, and I was one of their young engineers working in the Integration Division. Among other things that needed integrating were the mission requirements with the spacecraft capabilities (neither of which were locked in at this early date). This included things like the mission timeline, landing site characteristics, lunar surface activities, and a host of other considerations. The folks in Shoemaker's Astrogeology Branch (which had moved to Flagstaff by then and some of whom were detailed to Houston to teach geology to the astronauts) seemed to be the best informed concerning many of the scientific aspects of lunar mission planning. More and more I found myself working with them and sharing their desire to get the most science out of the missions, consistent with the real world constraints (although we didn't always agree on the real-world). For example, on one of my first visits to Flagstaff, Gene showed me their mission control center from which they were expecting (hoping?) to conduct the lunar surface operations once MCC-Houston had transferred control to MCC-Flagstaff. They had conducted simulations from there with simulated astronauts located a few miles away in the Sunset Crater area.

A great idea, but not one that NASA was ever going to be ready for. Later they practiced the same thing with real astronauts, but from MCC-Houston and with several communication layers between the Field Geology team in the back room and the astronauts at Sunset Crater.

Gene had managed to accomplish a great deal toward making science an essential element of the Apollo program, but I know it wasn't enough to satisfy him. Although Apollo 11 was an unqualified success from anyone's point of view, Gene wanted the follow-on missions, if there were to be any, to have science as their focus, not just as a by-product. In October 1969, three months after Apollo 11 and one month before Apollo 12, in a public meeting at Caltech, he announced his intent to resign as leader of the Field Geology Team the following March and return to Caltech as chairman of the Division of Geological Sciences. At this same meeting he took the opportunity to chastise NASA for its lack of interest in doing real science. According to Wilhelms (*To a Rocky Moon*, p. 235), "Shoemaker foresaw that NASA simply wanted to use up its remaining spacecraft as fast as possible without making the major changes needed to exploit Apollo scientifically."

At the time, I thought Gene had been rather harsh with NASA, particularly when I later learned that he was already past due to return to his Caltech commitment and had probably intended to do so whatever he thought about NASA and how they were handling the Apollo Program. At any rate, he had caused quite a stir — one that was difficult for NASA to ignore, although there were those who argued that NASA had won the Moon race and should quit while it was ahead. The events that followed confirm that, whatever his motives in raising a fuss, and whatever reasons NASA had in response, Gene achieved his aim. The decision was made soon thereafter that the Apollo flights would not only continue, but, as soon as practicable, the Lunar Module would be upgraded to permit longer staytime and a greater payload capability; a Lunar Roving Vehicle would be built to provide increased mobility beyond what an astronaut could do on foot; a Scientific Instrument Module (SIM) bay would be added to the Service Module for collecting remote sensing data from lunar orbit; additional lunar surface scientific instruments would be built to do things like measuring heat flow, seismic activity, and surface electrical properties, and the Portable Life Support System (PLSS) would be upgraded to extend the extravehicular capability to seven hours compared to the four-hour limit on the early missions.



These were all brought on line for the "J" missions (Apollo 15, 16, and 17) and contributed immeasurably to our understanding of the Moon. Gene had gone on to other things by this time, but the people he had trained and influenced saw to it that the Lunar Exploration Program got the very most science that could be achieved from what Gene had begun. He brought the same dogged determination to every other planetary program in which he was involved and, for that matter, everything else he did, and we (and planetary science) are much the better for it.

*(Mr. Sevier is Director of the Universities Space Research Association's Division of Educational Programs and Deputy Director of its Division of Space Life Sciences.)*

## Gene Shoemaker Remembered: An appreciation

*—Paul D. Spudis*

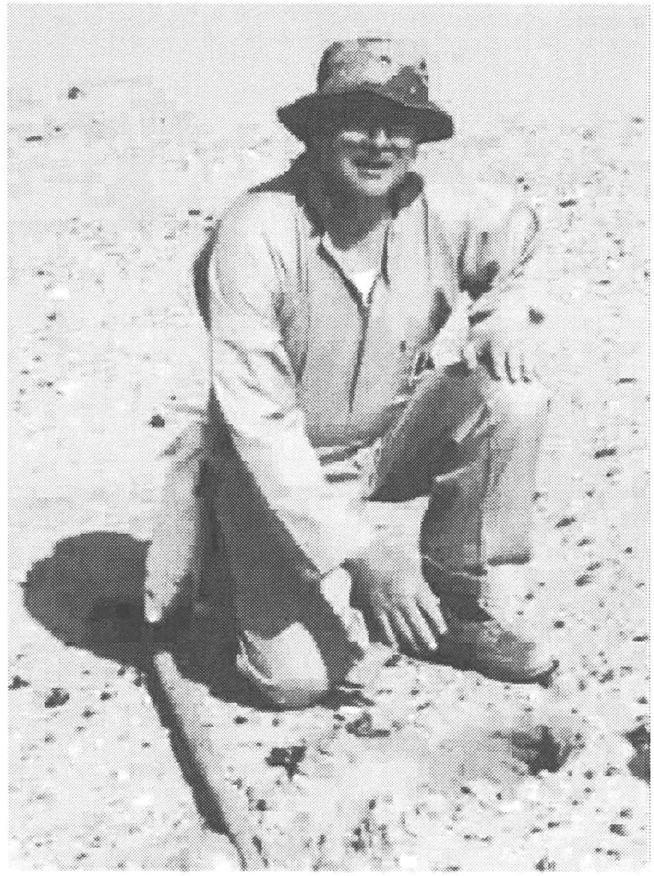
Strange it seems to me that I worked at the Branch of Astrogeology of the U.S. Geological Survey in Flagstaff for over 10 years, but the only chance I ever got to work closely with Gene was after I left the

Survey, in conjunction with the Clementine mission.

When I first came to the USGS in 1980, Gene was on sabbatical at Caltech. My first real encounter with him was at one of the Lunar and Planetary Science Conferences, where he went out of his way to welcome me into the Branch and encourage my studies of the Moon. At the time, interest in lunar science was considered eccentric, to put it mildly, as everyone knew that future NASA planetary missions were to be conducted somewhere else. Gene never looked at it that way. His initial interest in planetary science was focused on the Moon and he never wavered in his tremendous devotion to it. Moreover, he and I had both shared the youthful dream of doing field geology on the Moon ourselves. He encouraged me to continue my lunar work as it was his firm belief that much was left to be done.

During my time at Flagstaff, Gene and I seldom had the opportunity to talk at length, but I found out how much he valued what I did during a Branch meeting. In these annual dog-and-pony shows, each Branch member was expected to get up and present a summary of their work, outlining new results from the past year. After giving my spiel about the importance of lunar science, I had to endure the usual remarks from several associates about the value of the Moon — it was "old hat," all the important problems had been solved, it was time to "move on." Gene got up and proceeded to remind everyone about the scientific importance of the Moon. He heartily endorsed my efforts, meager as they were, to integrate information from Apollo sample studies and regional geology of the Moon determined by photogeology and remote sensing. Gene's immense scientific prestige ensured that such work was taken seriously, and I have little doubt that, without his ringing endorsement, lunar science may well have been abandoned by the Branch.

In 1990, I had an opportunity to leave the USGS and go to Washington DC on temporary assignment, to work on the now-defunct Space Exploration Initiative (SEI). Gene strongly encouraged me to take this assignment. It was his belief that ambitious human exploration of the Moon and Mars could revitalize a floundering space program. I think Gene remembered



his tenure at NASA Headquarters in the early 1960s, when his presence close to the center of things was largely responsible for both the geological orientation of the Apollo program and its extraordinary scientific productivity, neither of which was a foregone conclusion. (For a detailed recounting of this fascinating story, including the crucial role played in it by Shoemaker at a critical time, read the excellent history, *To A Rocky Moon,* by Don Wilhelms, University of Arizona Press, 1993.) In a distinct minority within the scientific community, Gene believed that scientific exploration was a key aspect of human space flight and that people in space had important and unique abilities that robots could not match.

Although the attempt to start SEI was unsuccessful, from this synthesis group came acquaintances, contacts, and personal networking, resulting in a close-knit group of space enthusiasts, eager to work together on a return to the Moon. By a fortuitous coincidence, Gene and I found ourselves working together on a concept for a small, inexpensive mission to the Moon and an asteroid — the Clementine mission. Clementine was envisioned principally as a demonstration in space of certain key technologies developed as part of the Strategic Defense Initiative (SDI), but the concept of gathering unique scientific data with it originated largely from Stu Nozette during a bar conversation with friends. Stu brought Gene into the Clementine discussion very early because Gene was a recognized authority on asteroid science. Gene quickly came to realize that a very productive, low-cost mission was possible with the SDI hardware. I became involved in the mission through my work with Stu on the synthesis group, in particular, after the idea arose to use the Moon as an scientific target in addition to the asteroid.

In January 1992, we held a short meeting about the Clementine mission in Crystal City, Virginia. The night before this meeting, Gene and I had dinner, where we caught up on old times and spun war stories about life in Washington. I was

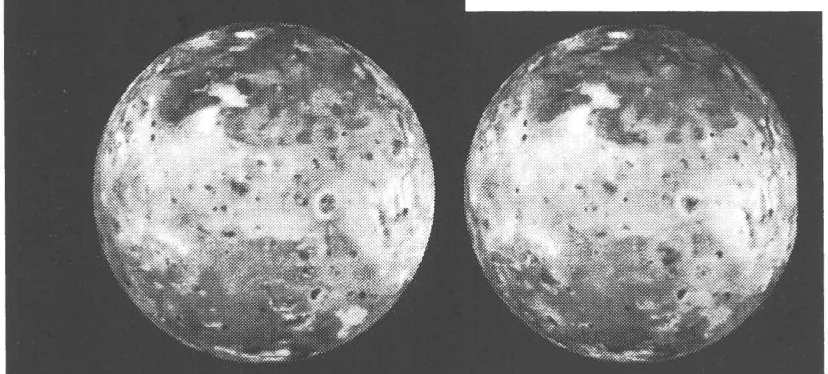
*Continued on page 22*

# 1997 LPI UNDERGRADUATE SUMMER INTERN PROJECTS

*For the 21st year, the LPI Summer Intern Program offered undergraduates the opportunity to take part in real planetary science research projects at the LPI and Johnson Space Center. The 1997 internships were completed between June 9 and August 15. Information about participating in the 1998 program will be posted on the LPI Web site in the fall of 1997 (http://cass.jsc.nasa.gov/lpi.html).*

**ROSS BEYER, University of Illinois**
**ADVISOR:** Deborah Domingue, Lunar and Planetary Institute

"Correlation Between Volcanic Activity and Temporal Variability of the Satellite Io." The IUE spacecraft made observations of the galilean satellites for over a decade with the long wavelength prime (LWP) and long wavelength redundant (LWR) cameras. As spacecraft instruments were better understood, the calibration software for IUE's observations has been updated and refined. All LWP observations have been reprocessed using the new software, and reprocessing of LWR images has begun. Initial comparisons of spectra taken between 1984 and 1986 to spectra taken in 1995 show spatial and temporal variability on all four of the satellites.



This project will study Io in greater depth to correlate volcanic activity with temporal surface variability. In addition, IUE spectra will be compared to laboratory spectra of materials whose absorption bands have been detected. Spectral mixing models (such as those developed by Hapke in 1981, 1984, and 1986) will be applied to the laboratory data to attempt to match observed spectra of Io. Understanding how Io's surface materials are mixed will give insight to the geological processes altering the satellite's surface. Io's surface also varies from area to area, so this study will investigate whether this variability is caused by differences in the amount of mixing of surface materials or whether it is caused by different aereal units of each material.

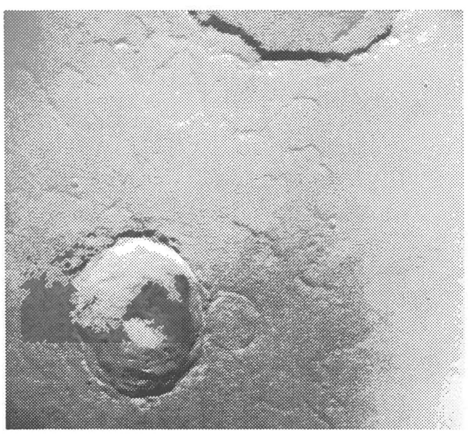
The intern will correlate temporal changes with known areas of volcanic activity and will chronicle the activity of these volcanic areas from IR observations in the literature. Then, using the laboratory spectra supplied by Wagner et al. (1987), the student will compare observed spectra of Io to attempt to model mixing within Io's regolith. The laboratory dataset includes reflectance spectra of terrestrial, lunar, and meteoritic powders and frosts, and software to model mixing is currently being written.

**PAUL COX, LeTourneau University**
**ADVISOR:** Michael B. Duke, Lunar and Planetary Institute

"Theoretical and Experimental Investigation of Regolith/Ice Interactions in Lunar Cold Traps." In this project the intern will develop models of increasing complexity that describe the range of possible configurations of ice deposits at the lunar south pole. The intern will review previous work modeling the accumulation of ice in permanent lunar cold traps and the effects of micrometeoroid and meteoroid impact on ice, regolith, and ice/regolith mixtures. A mathematical modeling approach will be defined using various assumptions about ice accumulation rate and regolith turnover due to impact gardening and experiments that demonstrate critical parameters will be designed.

**TANYA DI VALENTIN, University of Ottawa**
**ADVISOR:** Michael E. Zolensky, NASA/Johnson Space Center

"Characterization of Iron-Nickel Sulfides Formed in the Solar Nebula." Sulfur is an important element, found in all galactic environments. The most common sulfur-containing minerals are Fe and Fe-Ni sulfides, which is the only group of minerals found in all extraterrestrial samples. There is a huge number of different sulfide minerals, but each has its own well-determined stability conditions. This means that, if we can determine which sulfides are present in a given sample, we can establish important physical-chemical constraints on the early solar system, giving us a better view of processes like planet formation and subsequent evolution. For this study, we will use an electron beam to determine the compositions of sulfides in the most primitive extraterrestrial material available: cometary and asteroidal particles collected in Earth's stratosphere called chondritic interplanetary dust particles (IDPs) and type 3 ordinary chondrites, and laboratory-produced analog materials. The small grain size of these sulfides (generally 15–50 nanometers across) will make transmission electron microscope analysis necessary here. The situation is easier for the type 3 chondritic meteorites for which scanning electron microscope and electron microprobe analyses will suffice. We have obtained artificially produced sulfides from experimental studies performed by Dante Lauretta and Bruce Fegley, our collaborators at Washington University. These samples result from the first realistic attempt to duplicate sulfide growth in the solar nebula in the laboratory, and promise a lot of surprises. We will analyze these samples by a combination of SEM and TEM techniques.



**RYAN EWING, The Colorado College**
**ADVISORS:** Paul Schenk, Steven Clifford, Allan Treiman, Lunar and Planetary Institute

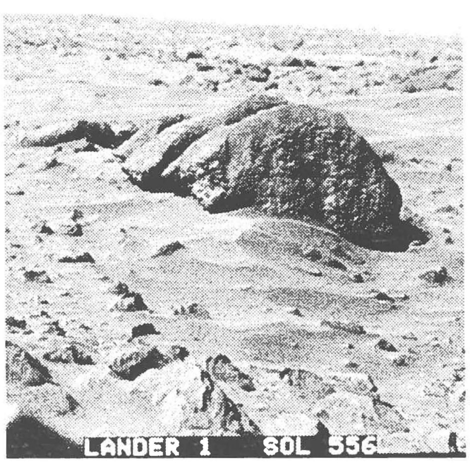
"Stereo Topography of Mass-Wasting Deposits on Mars." Mars has a variety of unusual geologic landforms, including splosh craters, terrain softening, debris aprons, and other mass-wasting phenomena. Some of these features suggest water- or ice-rich rock or regolith. We ultimately seek to understand the role of subsurface water on Mars in the formation of these features. The goal of this project will involve making the first topographic measurements of some of those features formed by mass-wasting in order to determine local surface slope, surface profiles, and material thickness, all of which are unknown. Simple analytical models, pending more sophisticated modeling efforts, may be used to ascertain if these deposits are unusual mechanically, testing the idea that these deposits are water-rich. Two sites in Nilosyrtis Mensae have been selected as candidate features that can be mapped topographically. The intern will be responsible for selecting other sites to examine additional types of mass-wasting deposits. The intern will run a stereo autocorrelation program to generate stereo digital elevation models over target sites, using these to measure slope of deposit and scarp face and to calculate volumes. Simple mechanical models may be applied to these results to make a preliminary assessment of rheologic properties.

**NANCY K. FORSBERG, Hofstra University**
**ADVISORS:** Robert R. Herrick, Benjamin Bussey, Lunar and Planetary Institute

"The Effects of Impact Angle on the Shape of Lunar Craters." Using stereo photogrammetry techniques, the intern will generate and analyze high-resolution topography of selected lunar craters to determine the effects of impact angle on crater shape. A number of laboratory experiments have shown that different impact angles produce distinctive patterns in the ejecta blanket, and these patterns have been observed around craters on the Moon and the other terrestrial planets. These experiments also showed systematic changes in crater shape, but a lack of high-resolution topographic data for smaller fresh craters has prevented testing whether the laboratory shapes are mimicked by actual craters. The Clementine mission collected stereo imagery at approximately 100 meters resolution for roughly one-third of the lunar surface. This is sufficient resolution to generate digital elevation models (DEMs) of topography with a few hundred meters horizontal resolution. Using a combination of manual and automatic matching techniques to find corresponding points on the stereo pairs, the student will generate DEMs for about 10 fresh lunar craters that are approximately 15 kilometers in diameter. Based on the pattern of ejecta, the craters are chosen to represent a range of impact angles at a single crater diameter. The 15 kilometer diameter is chosen so the craters are large enough for features to be easily resolvable in the DEMs but small enough to minimize the effects on crater shape from the modification stage associated with complex crater formation. The resulting DEMs will be analyzed for systematic variation in crater shape and rim height within and among the selected craters, and comparisons will be made with the laboratory data.

**CATHERINE ROSS GRAHAM, Brown University**
**ADVISOR:** David S. McKay, NASA Johnson Space Center

"Scanning Electron Microscope Studies of Carbonate Precipitates." A major goal of the exploration of Mars is to determine whether life has developed there. Recent data on martian meteorite ALH84001 reveal complex zoned carbonates that may be associated with martian microbial activity. The summer project will consist of a Scanning Electron Microscope (SEM) study of selected carbonates formed by precipitation at low temperatures in natural and laboratory environments on Earth. The objective is to try to understand the processes by which bacteria may play a role in the nucleation and growth of these carbonates and to determine whether they leave distinctive signs or fingerprints that can be found within or on the carbonate precipitates. We currently have a variety of appropriate terrestrial samples and plan to get more by summer. The intern project is to study representative samples of each of these materials with the scanning electron microscope (possibly supplemented by TEM studies of selected samples) and to characterize the morphology and chemistry of the carbonate precipitates and associated phases. Some samples will be selectively etched to reveal internal features. The project will also include a literature search on carbonates formed in recent natural environments. Results will contribute to investigations of possible life on Mars by providing new data on possible analogs and by developing new techniques for studying these materials. Important findings will also be incorporated into advanced planning for Mars robotic exploration and the landing site selection process for future missions.




**KAREN JAGER, Pomona College**
**ADVISOR:** Carlton C. Allen, Lockheed Martin Engineering & Science Co.

"Martian Surface Material Simulant." NASA is developing a simulant of the surface material of Mars to be used for testing analytical instruments, engineering designs, and spacesuits, as well as for museums and classrooms. An important part of this effort involves characterizing the simulant and comparing it to our current understanding of the martian surface. The intern will be a key participant in this effort, characterizing splits of the simulant by a wide variety of analytical techniques. The results will be compiled into a technical paper on which the intern will be a co-author.

**MUTSUMI KOMATSU, University of Tokyo, Tokyo**
**ADVISOR:** Arch Reid, Lunar and Planetary Institute

"Prior's Rules and the LL Chondrites." The range of textures and of mineral and bulk compositions within the LL chondrites has been interpreted as representative of a progressive metamorphic sequence (LL3–LL6) within a series of meteorites of near-constant bulk composition. Prior's Rules for the ordinary chondrites refer to the relationship that with decreasing metal content there is a corresponding increase in Ni content of the metal and in FeO content of the ferromagnesian silicates. The variability in ordinary chondrites is thus representative of a range of oxidation states (and oxygen contents) within an essentially constant bulk composition.

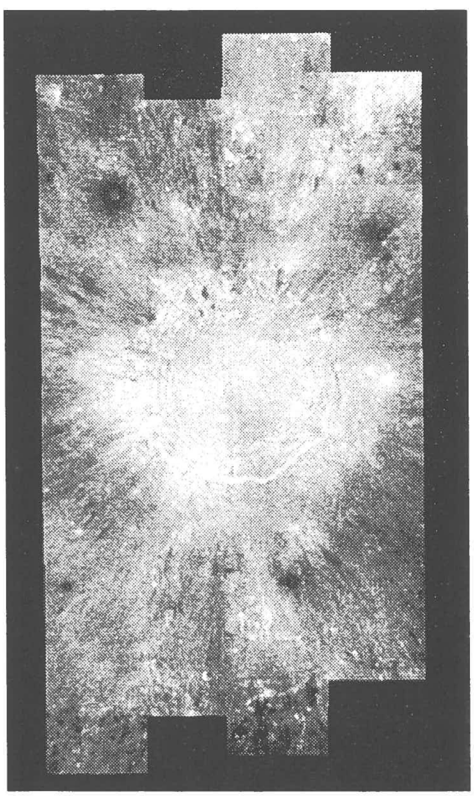
The project will use mineral composition data and mineral abundance data within individual LL chondrites to test whether Prior's Rules apply *within* the LL chondrite group. Polished thin sections from the Antarctic Meteorite Collection at JSC will provide the materials for the study, and these samples will be analyzed using electron microprobe facilities at JSC. These data will also be used to determine whether the metamorphic sequence LL4–LL6 is a sequence representing progressive annealing at successively higher temperatures, whether within each of the metamorphic types (4, 5, 6) there are progressive sequential differences, and the extent to which the type 4 to type 6 sequence is one of progressive oxidation, as suggested by McSween and Labotka (1993).

**KACPER KORNET, Warsaw University**
**ADVISOR:** Tomasz Stepinski, Lunar and Planetary Institute

"From Dust to Planetesimals — Global Evolution of Rocky Solids in the Solar Nebula." It is currently thought that planets formed from the accumulation of solid matter entrained in the solar nebula. This project concentrates on modeling this part of the accumulation process that starts from small particles suspended in the gaseous nebula and ends when most of the solid material aggregates into 1–10-km-sized planetesimals. The result of the project should be a theoretically derived surface density distribution of deposited rocky solids, a quantity that can also be inferred from the present-day planetary distribution of masses. The goal of the project is to determine whether theoretical models of the solar nebula can account for the large-scale architecture of the solar system.

**SARAH KATHRYN NOBLE, University of Minnesota**
**ADVISOR:** Gary E. Lofgren, NASA Johnson Space Center

"Experimental and Petrographic Study of Recycling in the Solar Nebula and the Origin of Chondrules." Chondrules form in the solar nebula during events that process the earliest materials that now comprise the materials in our solar system. Understanding the formation of chondrules gives insight into the physical processes taking place in the nebula. Recent work on chondrule formation suggests that nebular processes are more complicated than previously thought, involving a more complex set of recycling and aggregation processes among previously formed chondrules, chondrule fragments, and other components present in the nebula. These aggregates are chondrule precursors and have implications for determining chondrule composition and the ultimate processing of nebular materials. Work on this project will concentrate on analysis of experiments on the aggregation and partial-melting processes that form chondrules.



**MATTHEW PRITCHARD, University of Chicago**
**ADVISOR:** Walter S. Kiefer, Lunar and Planetary Institute

"The Effects of Lithospheric Rheology on Mantle Convection on Mars." An important issue in martian geophysics is the effect that the planet's lithosphere has on the gravity and topography produced by mantle convection. A purely elastic lithosphere will act to resist convective uplift, whereas in a more realistic visco-elastic lithosphere, viscous flow will relax elastic stresses over time, allowing a greater degree of convective uplift. The intern will assess the interaction between elastic and viscous processes in the martian lithosphere, leading to an improved understanding of how mantle convection affects the planet's topography and gravity.

**BRADLEY THOMSON, Harvey Mudd College**
**ADVISORS:** Paul D. Spudis, Benjamin Bussey, Lunar and Planetary Institute

"Geological Models of Lunar Impact Craters from Clementine Data." Multispectral and topographic data from the *Clementine* spacecraft allow us to map the composition of

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## Gene Shoemaker

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spellbound as Gene described to me his concept of the lunar phase of the Clementine mission. He had calculated the profile, orbit parameters, and mapping strategy for the lunar phase of the mission and sketched it out on a dinner napkin. Two years later, almost to the day, Clementine left Vandenberg Air Force Base for the Moon, following very nearly the exact mission profile Gene had envisioned on a plane ride years before.

During the operational phase of Clementine, the science team lived near the Batcave, our mission control center in Alexandria, Virginia. Gene worked tirelessly for long hours with the rest of the team, carefully scrutinizing the new lunar data and trying to understand some of the amazing new results. I remember in particular his ebullience when Eric Eliason (USGS, Flagstaff) had finished a mosaic of over 1500 images of the south polar region. Gene was struck immediately by the presence of a large zone of darkness near the pole and we spent many hours debating the possibility of a lunar "cold trap," a concept proposed many years ago as the place to search for lunar volatiles. Stu Nozette came up with the idea to use the onboard radio transmitter of Clementine to improvise a bistatic radar experiment to look for possible ice deposits. Although I had never been particularly interested in the problem of volatiles and the environment of the poles of the Moon, Gene's contagious enthusiasm once again won over a new convert. It turns out that Gene may well have been right to be so excited — our detection of ice deposits awaits confirmation by the neutron spectrometer to be flown on the upcoming Lunar Prospector mission.

It's hard to believe that we have lost Gene. He was an irreplaceable asset to the planetary science program. Always encouraging to his peers and especially younger scientists, his breadth of vision and interests were truly remarkable. He attacked and solved some of the most intractable scientific problems with infectious and joyous enthusiasm. I consider myself fortunate for having had the all-too-short opportunity of knowing and working with him. I shall miss him.

*(Dr. Spudis is a staff scientist at LPI.)*

**Photos courtesy of the U.S. Geological Survey, Flagstaff, Arizona. For additional information and remembrances of Gene Shoemaker, see the USGS Web site at http://wwwflag.wr.usgs.gov/USGSFlag/Space/Shoemaker/.**

*Jurgen H. Rahe*

An improbable event on the evening of June 18, 1997 led to the death of Dr. Jurgen Rahe. It would be easy to comment here on the many things that Jurgen did for NASA generally, and for planetary science specifically. Signs of his programmatic leadership and professionalism are evident in the current vitality of the Solar System Exploration program. It is, however, another aspect of Jurgen that I recall most vividly and treasure most deeply — his humanity.

Jurgen's humanity was manifested in many ways. It came through clearly in his all-too-human enthusiasm and dedication to understanding the universe in which we live, exploring our planetary system, and discovering and studying planetary systems around other stars. This was not a programmatic enthusiasm, but a tangible expression of a passion, a flame that burned behind the veil of his calm demeanor.

His humanity was also expressed through his interactions with others. I have known few people who cared so deeply for his coworkers and for people generally. Because of the role that the Institute has with NASA, interactions between Jurgen and many members of the staff here were frequent. His concern for them, and his appreciation for their efforts whether large or small, touched us all. He went to great lengths to help people, to find ways to make their tasks or life a bit easier.

I miss Jurgen, but this message is not one of sadness. It is one of thanks. Thanks for his friendship, and for his humanity. It is up to each of us as individuals, and working collectively, to carry on the flame that was within Jurgen, to use it to shed light on the unknown.

*— David C. Black, LPI*

## 1997 SUMMER INTERN PROGRAM

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various lunar landforms. Impact craters are of particular interest because they excavate and expose interior portions of the Moon that would otherwise remain unseen. Craters of various sizes probe different levels of the crust and a systematic study of several individual craters should make it possible to reconstruct the three-dimensional geological structure of a region of the Moon.

In this project the intern will use *Clementine* multicolor image data to make compositional maps of the surface materials associated with several large impact craters, including Copernicus (97 kilometers diameter, 9°N, 21°W). In addition, the intern will use special stereo image coverage obtained by the *Clementine* spacecraft to make a digital terrain model (DTM) of each crater. These DTMs will be compared to previously compiled topographic maps and other DTMs for accuracy, as well as coordinated with the global topographic map provided by the *Clementine* laser altimetry. The stereo DTMs and the multispectral, compositional data will be merged into geological block models of the crust for at least two, and as many more as can be completed, regions of the Moon. From these data, the three-dimensional nature of a region of the lunar crust will be deduced. The project will involve digital image processing, geological mapping, and interpretation of remotely sensed compositional data.

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Pam Thompson, Editor

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Phone: 281-486-2175, fax: 281-486-2162
E-mail: thompson@lpi.jsc.nasa.gov

# CALENDAR 1997–98

## OCTOBER

### 14–15
**Advanced Cosmic Ray Composition Experiment for the Space Station (ACCESS),** Houston, Texas. Contact: Thomas L. Wilson, NASA Johnson Space Center Mail Code-SN3, Houston TX 77058. Phone: 281-483-2147; fax: 281-483-5347.
E-mail: twilson@ems.jsc.nasa.gov

## NOVEMBER

### 3–6
**International Workshop on Planetary Sciences,** Rio de Janeiro, Brazil. Contact: Fax: 5521-580-7181.
E-mail: lazzaro@on.br

### 4–7
**High Energy Astrophysics Division (HEAD) of the American Astronomical Society,** Estes Park, Colorado. Contact: John Vallerga, Eureka Scientific. Phone: 510-530-1688.
E-mail: eureka@netcom.com
WWW: http://www.eurekasci.com

### 11–14
**International Conference on Isotopes in the Solar System,** Ahmedabad, India. Contact: J. N. Goswami, Physical Research Laboratory, Ahmedabad 380 009, India. Phone: 91-70-462129; fax: 91-79-6560502.
E-mail: isotope@prl.ernet.in

### 17–19
**Search for Extra-Solar Planets with the VLT/VLTI,** Garching bei München, Germany. Contact: Christina Stoffer, European Southern Observatory, Karl-Schwarzschild Strasse-2, D-85748 Garching bei München, Germany. Phone: 49-89-32006229; fax: 49-89-32006480.
E-mail: gwiedema@eso.org
WWW: http://www.eso.org/xtrasol/

### 18–19
**In Situ Resource Utilization (ISRU II) Technical Interchange Meeting,** Houston, Texas. Contact: Stephen J. Hoffman, Science Applications International Corporation. Phone: 281-244-3827.
E-mail: hoffman@snmail.jsc.nasa.gov

## DECEMBER

### 3–5
**American Astronautical Society National Conference and 44th Annual Meeting—Space Exploration: Innovative Approaches,** Pasadena, California. Contact: AAS. Phone: 703-866-0020; fax: 703-866-3526.
E-mail: 74673.724@compuserve.com

### 8–12
**American Geophysical Union Fall Meeting,** San Francisco, California. Contact: American Geophysical Union, 2000 Florida Avenue NW. Washington DC 20009-1277. Phone: 202-462-6900.
E-mail: webmaster@kosmos.agu.org
WWW: http://www.agu.org

### 1998

## FEBRUARY

### 2–5
**First International Conference on Comet Hale-Bopp,** Puerto de la Cruz, Tenerife, Spain. Contact: Richard West, European Southern Observatory, Karl-Schwarzschild Strasse-2, D-85748 Garching bei München, Germany. Phone: 49-89-32006276; fax: 49-89-3202362.
E-mail: werst@eso.org
WWW: http://www.eso.org/outreach/info-events/hale-bopp/hbitp98.html

## MARCH

### 16–20
**29th Annual Lunar and Planetary Science Conference,** Houston, Texas. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 281-486-2166; fax: 281-486-2160.
E-mail: simmons@lpi.jsc.nasa.gov

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Paul Schenk's 3-D Solar System

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