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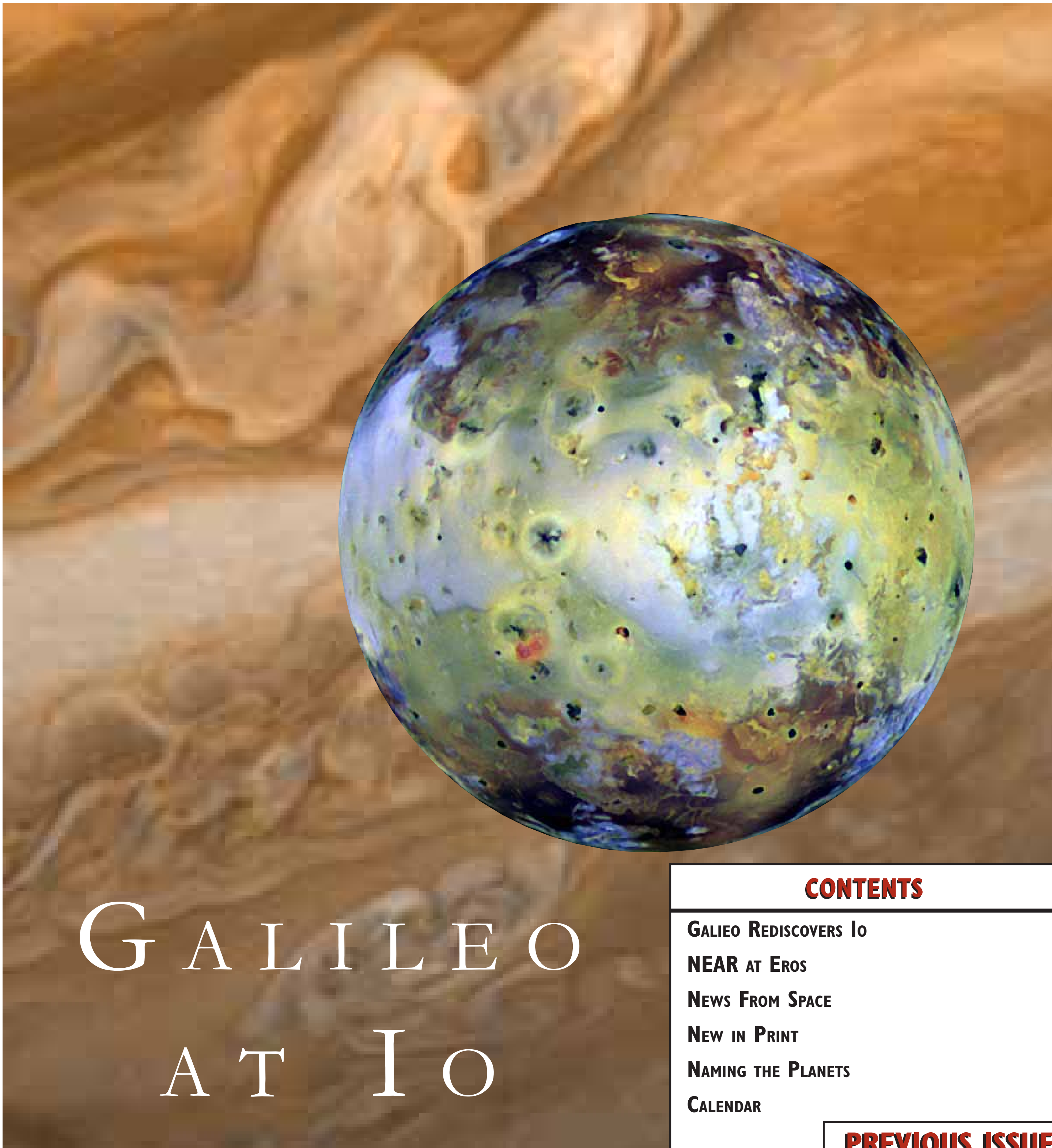

GALILEO AT IO

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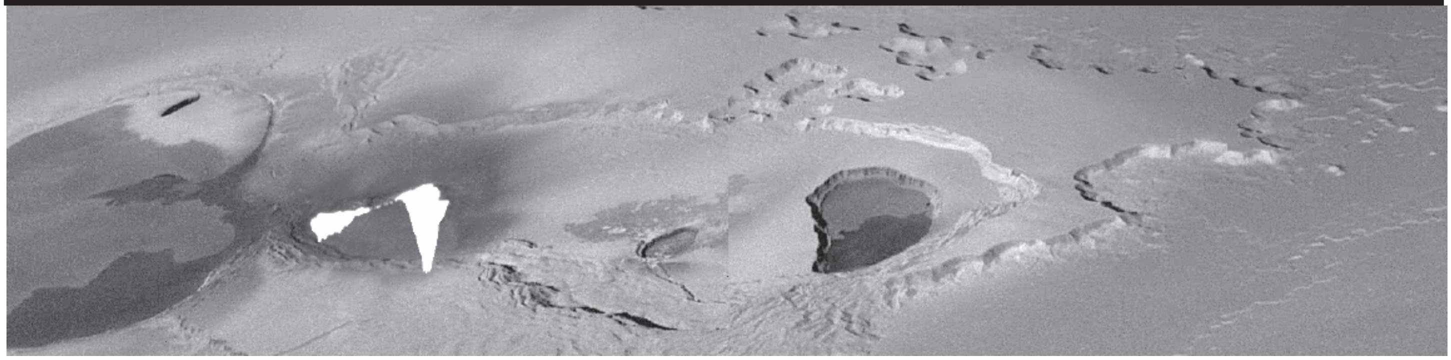
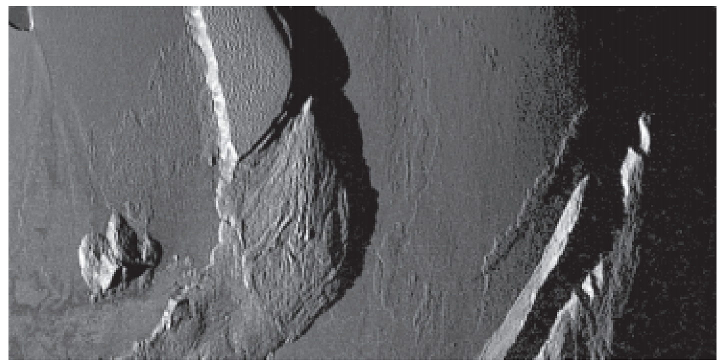
PREVIOUS ISSUES

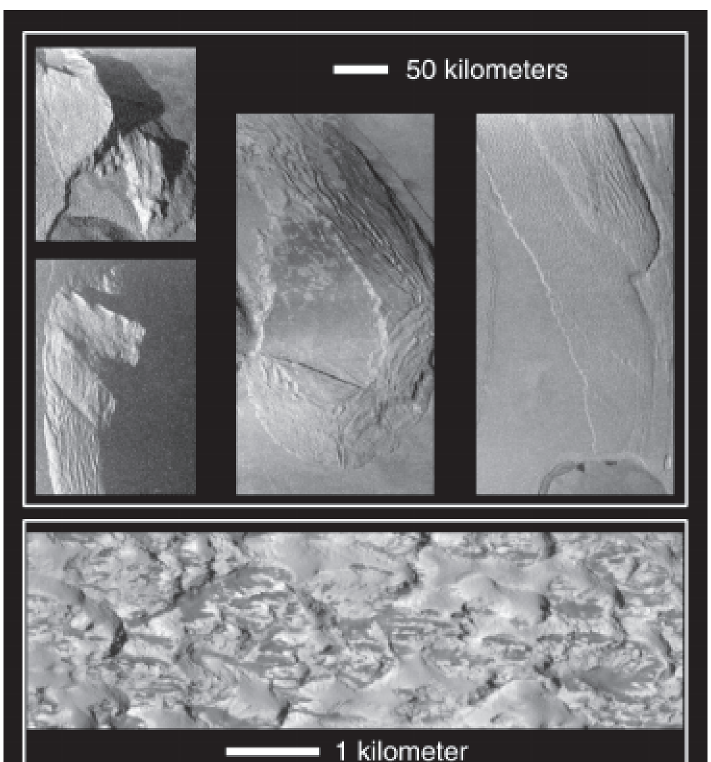
Galileo rediscovers Io



(Top) This mosaic of images collected by NASA's Galileo spacecraft on November 25, 1999, shows a fountain of lava spewing above the surface of Jupiter's moon Io. The active lava was bright enough to cause what the camera team describes as "bleeding" in Galileo's camera, caused when the camera's detector is so overloaded by the brightness of the target that electrons spill down across the detector. This shows up as a white blur in the image. This is the first time an active lava flow has been imaged on another planet. There also appear to be additional hot areas below this line, suggesting that hot lava is flowing away from the fissure. Initial estimates of the lava temperature indicate that it is well above 1000 K (1300°C) and might even be hotter than 1600 K (2400°C). Also of interest is the flat-topped mesa on the right. The scalloped margins are typical of a process geologists call "sapping," which occurs when erosion is caused by a fluid escaping from the base of a cliff.



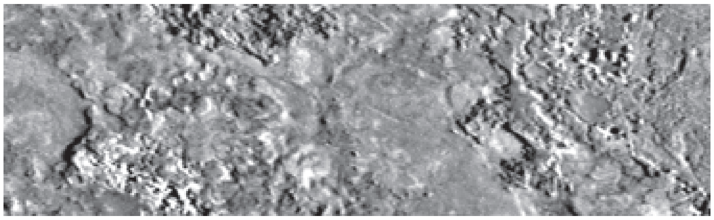
(Above) This image taken by NASA's Galileo spacecraft during its close flyby of Jupiter's moon Io on November 25, 1999, shows some of the curious mountains found there. The Sun illuminates the scene from the left, and because it is setting, the Sun exaggerates the shadows cast by the mountains. By measuring the lengths of these shadows, Galileo scientists can estimate the height of the mountains. The mountain just left of the middle of the picture is 4 kilometers high and the small peak to the lower left is 1.6 kilometers high. These mountains seem to be in the process of collapsing. Huge landslides have left piles of debris at the bases of the mountains.



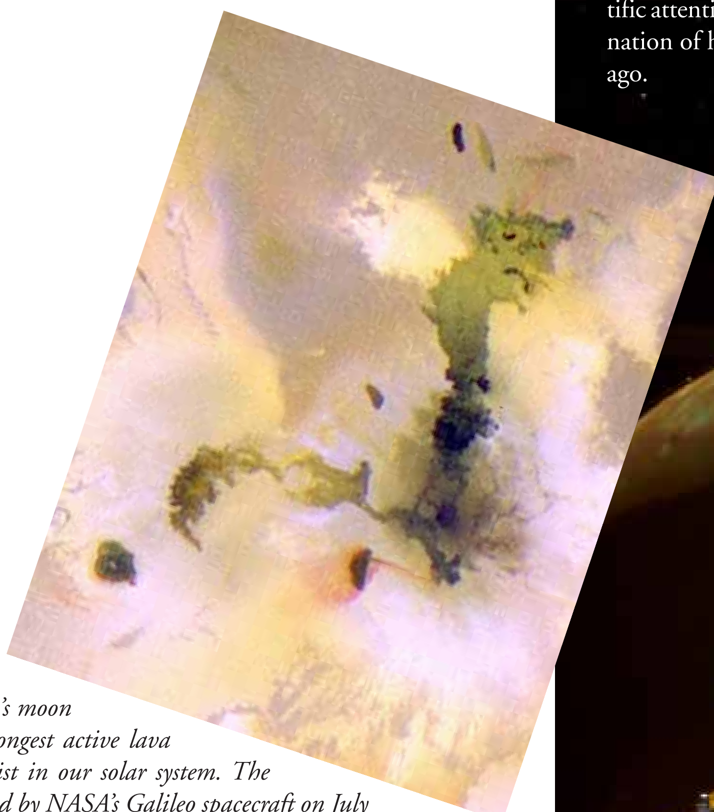
(Left) Unusual mountains on Jupiter's moon Io are shown in these images that were captured by NASA's Galileo spacecraft during its close Io flyby on October 10, 1999. The top four pictures show four different mountains at resolutions of about 500 meters per picture element. The bottom picture is a closeup of another mountain. It is also one of the highest-resolution images ever obtained of Io, with a resolution of 9 meters per picture element. The lower-resolution images show a range of mountain structures from angular peaks on the left to gentler plateaus, surrounded by very gently sloping debris aprons on the right. Galileo scientists believe that these images illustrate the deterioration of Ionian mountains. If this is the case, it means that the more angular mountains on the left are younger than the rounded mountains on the right. Almost all the mountains exhibit ridges parallel to their margins. These ridges indicate material is moving down the sides of the mountains due to gravity.

New views of an old moon

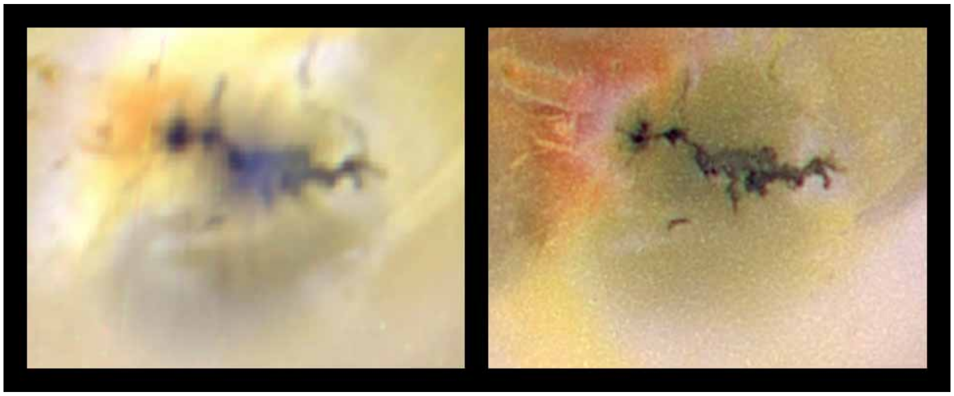
In a year marked by two disappointing losses of unmanned planetary orbiters, *Galileo* emerged as NASA's quiet triumph, a steady workhorse of an orbiter that continued to exceed expectations. Although the spacecraft had been returning data and images for several years since first arriving at Jupiter in 1995, the views *Galileo* captured of Io last year yielded some of the most dramatic images of a planetary body ever captured. Among other findings, *Galileo* returned images of collapsing mountains, active volcanos, and gas plumes on Io. Data returns and analysis will continue for years. In the meantime, the images have refocused public and scientific attention on a distant moon that first captured the imagination of history's most famous astronomer some 400 years ago.



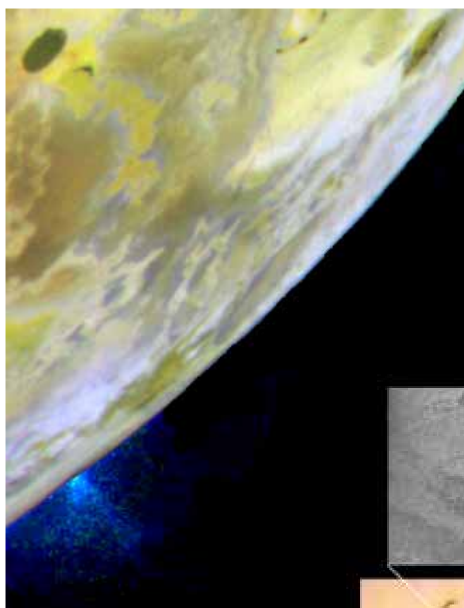
(Above) The highest-resolution image ever of Jupiter's volcanic moon Io, this black and white image was taken by NASA's Galileo spacecraft on October 10, 1999, from an altitude of 617 kilometers. It shows an area about 7.2 kilometers long and 2.2 kilometers wide. Features as small as 9 meters can be discerned, providing a resolution that is 50 times better the previous best, taken by the Voyager spacecraft in 1979. This new image targeted lava flows that erupted from the volcano Pillan. A complex mix of smooth and rough areas can be seen with clusters of pits and domes, many of which are the size of houses. Galileo scientists estimate that the cliff on the left side of the image ranges from 3 to 10 meters high.



(Center) This pair of volcanic features on Jupiter's moon Io represents the longest active lava flow known to exist in our solar system. The image was obtained by NASA's Galileo spacecraft on July 3, 1999. The volcanic features, Amirani (right side of image) and Maui (to the left, just below the center of the image), were originally thought to be two separate volcanos. However, Galileo images have shown that Maui is actually the active front of a lava flow that has extended westward from a vent at Amirani for more than 250 kilometers. Observations by Galileo's near-infrared mapping spectrometer show a hot spot at Maui, so the lava must still be flowing. Other flows extend northward from the Amirani vent. White plume deposits encircle the Amirani vent and are likely to be sulfur-dioxide-rich vapors that have escaped at the vent, frozen, and then snowed out onto the ground. Amirani-Maui is more than 250 kilometers long.

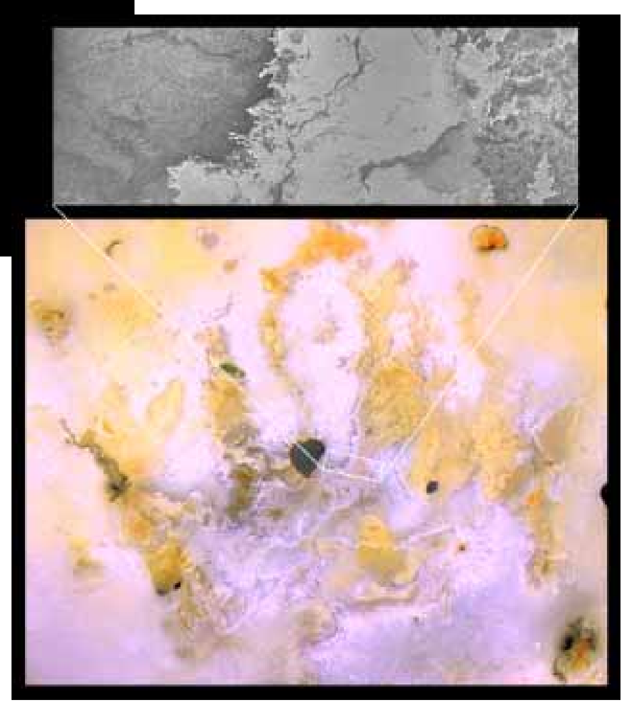


(Above) *A volcano named Zamama on Jupiter's moon Io has recently changed in appearance as seen in this pair of images of Io acquired by NASA's Galileo spacecraft as it approached Io in preparation for a close flyby. The false-color images use the near-infrared, green, and violet filters of the spacecraft's camera. The image on the left was acquired in March 1998 during Galileo's fourteenth orbit and the image on the right was collected in July 1999. Zamama formed during the time period between the flybys of NASA's Voyager spacecraft in 1979 and Galileo's first images of Io taken in 1996. Based on these images, Galileo scientists suspect that the dark lava is erupting from a crack in the ground. The most dramatic difference between these two images is that the volcanic plume that was active in March 1998 and earlier had stopped erupting by July 1999. The rising core of the umbrella-shaped plume can be seen in the 1998 image as a bluish spot in the center of the dark lava.*



(Center) *A plume of gas and particles is ejected some 100 kilometers (about 60 miles) above the surface of Jupiter's volcanic moon Io in this color image, recently taken by NASA's Galileo spacecraft. The plume is erupting from near the location of a plume first observed by the Voyager spacecraft in 1979 and named Masubi. However, during the course of the Galileo tour of Jupiter and its moons, a plume has appeared at different locations within the Masubi region. This color image is the same as the previously released false-color mosaic of Io, but with special processing to enhance the visibility of the plume. The images were taken on July 3, 1999, at a distance of about 130,000 kilometers.*

(Bottom right) *This image of Jupiter's moon Io, taken by NASA's Galileo spacecraft on November 25, 1999, shows a bright lava flow with a distinct dark channel in the middle. The serrated margins are characteristic of fluid lava that is able to work its way into every available nook and crevice. What is unusual about this lava flow is its bright color — most lava flows on Io and the other planets are dark. This leads Galileo scientists to speculate that these lava flows are composed of sulfur, rather than silicate rock. The lava flow appears to emanate from a caldera named Emakong, which is just beyond the left edge of the picture. The image covers an area approximately 120 by 40 kilometers.*



These images and other images and data received from *Galileo* are posted on the Jet Propulsion Laboratory's *Galileo* mission home page at http://galileo.jpl.nasa.gov. Background information and educational context for the images can be found at http://galileo.jpl.nasa.gov/images/io/ioimages.html.

The Jet Propulsion Laboratory, Pasadena, California, manages the mission for NASA's Office of Space Science, Washington, DC. JPL is a division of the California Institute of Technology, Pasadena, California.

EROS UNMASKED

DATA RETURNED FROM NEAR REVEALS NEW VIEWS OF THE MAJOR ASTEROID

NASA/JHUAPL

Early returns from the Near Earth Asteroid Rendezvous (NEAR) mission indicate that 433 Eros is no ordinary space rock.

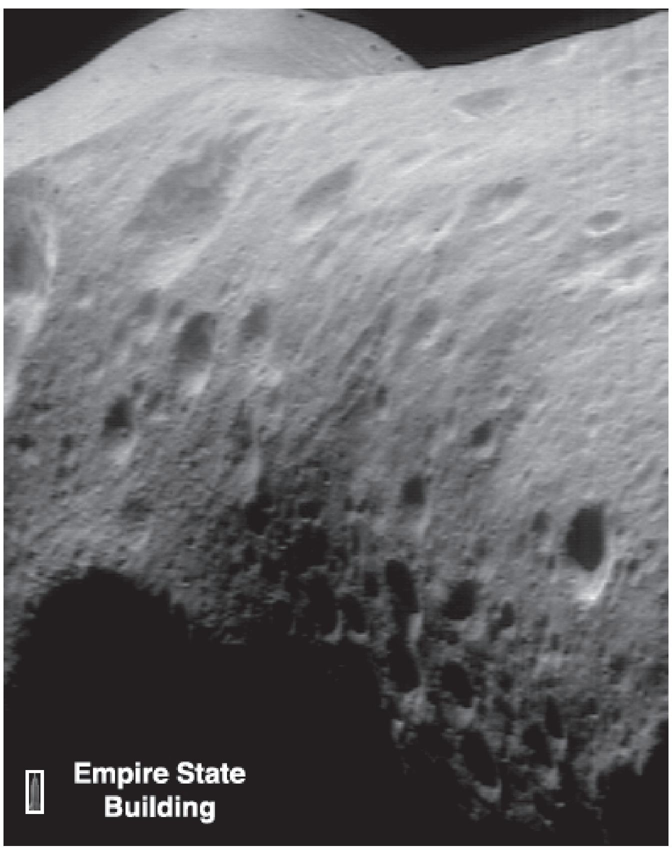
"Eros in our first month of observations has proven to be a marvelous and fascinating object," says Dr. Andrew F. Cheng, NEAR Project Scientist from the Johns Hopkins University Applied Physics Laboratory, which manages the mission for NASA.

Among other discoveries, NEAR team members have found evidence of geologic phenomena that could have originated on a much larger parent body from which Eros was derived. In their search to decipher the mysteries of Eros, they have obtained the first-ever laser range returns from an asteroid and the first-ever X-ray detection of an asteroid. High-resolution images have revealed an abundance of ridges, chains of craters, and boulders.

Since the NEAR spacecraft met up with and began its historic orbit of Eros on February 14, 2000, NEAR team members at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, which manages

the mission for NASA, have pored over images and other early scientific returns. It will take months to unravel the deeper mysteries of Eros, but data from NEAR's final approach and first days of orbit offer tantalizing glimpses of an ancient surface covered with craters, grooves, layers, house-sized boulders, and other complex features.

Scientists now know that Eros' mass is 2.4 grams per cubic centimeter — about the bulk density of Earth's crust and a near match of the estimates derived from NEAR's flyby of Eros in December 1998.



NASA/JHUAPL

Images of the north polar region of Eros reveal large boulders on the eastern rim of the depression known as the "saddle." A thumbnail of the Empire State building is shown for scale.

"With this new data, it now looks like we have a fairly solid object," said radio science team leader Dr. Donald Yeomans of NASA's Jet Propulsion Laboratory.

Even without in-depth analysis, pictures snapped with NEAR's Multispectral Imager offer several clues about Eros' age and geography. The large number and concentration of craters point to an older asteroid, while uniform grooves across its craters and ridges hint at a global fabric and, perhaps, underground layers. In addition to numerous boulders, the digital camera has also captured brighter spots on the surface that NEAR scientists are eager to study.

"We want to correlate the changes in color with the geologic features," says Dr. Scott Murchie, a science team member from the Applied Physics Laboratory. "If we see a crater, for example, is it different on the outside than on the inside? Is the face of a cliff different than the ridge? This data will eventually tell us about the asteroid's history."

As of mid-March, the NEAR multispectral imager has returned more than 2400 images. The unprecedented images show chains of craters, numerous boulders as small as 50 meters across, and long ridges that extend for several kilometers across the surface.

Conspicuous on many of the crater walls are bright markings that Dr. Peter C. Thomas of Cornell University says are part of the loose, fragmental material on the surface, called regolith. This material appears to vary in properties across the asteroid, perhaps in response to impact cratering events.

"We have found that Eros is literally covered with craters smaller than about 1.6 kilometers in diameter," says Dr. Clark R. Chapman of the Southwest Research Institute.

The spacecraft has been in a nearly circular orbit around Eros, traveling approximately 200 kilometers from the asteroid's center, and taking images closer to an asteroid than has ever been done before.

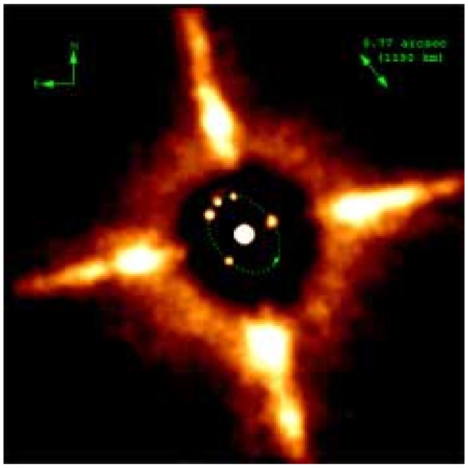
On Saturday, April 1, the spacecraft fired its thrusters for 36 seconds and began gradually descending into position to start a 100-kilometer orbit on April 11.

NEAR team members say the new orbit will yield sharper images of the asteroid's abundant geological features and more information about its many ridges, grooves, and craters.

"As we get down lower and lower, the resolution of all the instruments will improve, and there will be a lot more to come," said Cheng.

Portions of this story were adapted and condensed from official NASA press releases.

NEWS FROM SPACE



Laird Close (ESO), Bill Merline (SWRI)

The above infrared image (1.6 micrometers) is a superposition of six detections of the new moon. The dashed line shows the orbit of the moon around the primary asteroid (45) Eugenia. The period of the orbit is 4.7 days. The moon travels in a clockwise direction (with north up and east to the left). The radius of the nearly circular orbit is 1190 kilometers. The main asteroid's diameter is close to 215 kilometers (depicted here as a central white circle) and we estimate the moon's size is 13 kilometers in diameter.

ASTRONOMERS DISCOVER MOON ORBITING ASTEROID

An international team of astronomers has discovered a moon orbiting the asteroid (45)Eugenia. The pictures, taken with the Canada-France-Hawaii Telescope (CFHT) on Mauna Kea, Hawai'i, are the first images of an asteroidal satellite taken from Earth. The team's findings were reported in the October 7, 1999, issue of *Nature*.

Previous attempts to photograph such satellites, using both groundbased telescopes and the Hubble Space Telescope, revealed no satellites. The only other such picture came from an interplanetary spacecraft, *Galileo,* when it discovered a small moon, now known as Dactyl, around asteroid (243)Ida in 1993. The observations could only be accomplished because of a new technique, called adaptive optics, that reduces the blurring caused by Earth's atmosphere.

A surprising result of this discovery is the very low density of the primary asteroid, which is only about 20% denser than water. Most asteroids appear dark and have been thought to be composed primarily of rock, which is about three times denser than water.

"A picture is emerging that some asteroids are real lightweights," said Dr. William Merline, leader of the team and a senior research scientist at the Boulder office of the San Antonio-based Southwest Research Institute (SWRI).

A recent flyby of the NEAR spacecraft confirmed that another asteroid, (253)Mathilde, also has a low density.

"Either these objects are highly porous rubble piles of rock, or they are mostly water ice," said Dr. Clark Chapman, another team member, also from SWRI.

The presence of a moon allows scientists to determine the mass of an asteroid because of the effect of the primary asteroid's gravity on its small moon. The size of most asteroids is known from standard astronomical studies. If both the mass and the size are known, researchers can learn the asteroid's density. The density then gives a clue to the asteroid's makeup — either in terms of composition or structure.

"If these asteroids are rubble piles, it tells us about the severity of collisions in the asteroid belt and its subsequent evolution. If the objects are largely ice, covered with a dark coating, then these objects may be remnants of burned-out comets and will further our understanding of the connection between comets and asteroids," said Dr. Christophe Dumas of the Jet Propulsion Lab in Pasadena, California.

"It is almost certain that the satellite was formed by a collision," said Merline. "As we know from the formation of our own moon and the craters on planetary surfaces, collisions played a large role in the formation of our solar system. Satellites of asteroids give us a window into these collisions, and help us understand how and why our solar system looks like it does."

The light from stars and other celestial objects is distorted by the atmosphere, much as water distorts our view of an underwater object. The new technique, pioneered at the University of Hawai'i by team member Dr. Francois Roddier, analyzes the distortions and corrects the light beam by means of what is essentially a "fun-house mirror" back into its previous, undistorted form.

"CFHT's exceptional site, telescope, and adaptive optics now allow us to see far sharper detail through the Earth's atmosphere. In many cases we can now compete with the clarity of space-based telescopes," said Roddier.

Previously, faint and close satellites would have been lost in the glare of the primary asteroid.

"It is similar to taking a photo of a candle located 400 kilometers away and then discovering a firefly (that is 300 times fainter) flying within 2 meters of the flame," said Dr. Laird Close, a participant from the European Southern Observatory in Germany.

Eugenia orbits the Sun in the main asteroid belt, a collection of thousands of asteroids between the orbits of Mars and Jupiter. Researchers estimate that the diameter of the satellite is about 13 kilometers. Eugenia's diameter is about 215 kilometers. The researchers have determined that the satellite has a circular orbit about 1190 kilometers away from Eugenia and orbits about once every five days.

While awaiting assignment of a permanent name, the satellite has been given provisional designation, by the International Astronomical Union, of S/1998(45)1, the first satellite of asteroid (45) that was discovered during 1998.

IMAGES REVEAL DRAMATIC DIFFERENCES BETWEEN MARS POLAR CAPS

New high-resolution images from NASA's *Mars Global Surveyor* spacecraft comparing the ice caps at the north and south poles show that the difference between the two regions is in the "cheese." The north polar cap has a relatively flat, pitted surface that resembles cottage cheese, while the south polar cap has larger pits, troughs, and flat mesas that give it a holey, Swiss-cheese appearance.

"Looking like pieces of sliced and broken Swiss cheese, the upper layer of the martian south polar residual cap has been eroded, leaving flat-topped mesas into which are set circular depressions," said Dr. Peter Thomas of Cornell University, Ithaca, New York. Nothing like this has ever been seen anywhere on Mars except within the south polar cap, leading to some speculation that these landforms may have something to do with the carbon dioxide thought to be frozen in the south polar region."

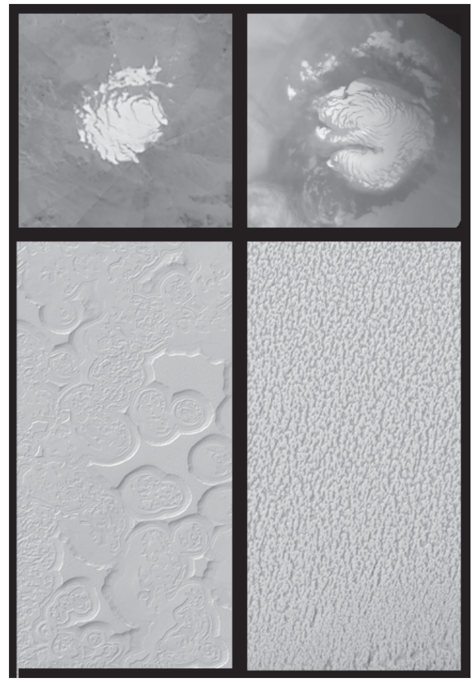
In a paper published March 9, 2000, in *Nature*, members of the *Mars Global Surveyor* imaging team describe some of the newly discovered differences in polar terrain.

"The unusual shapes of the landforms on the north and south polar caps suggest that these regions have had different climates and histories for thousands or perhaps even millions of years," said Thomas, one of the authors of the paper. "We are discovering them for the first time because Mars Global Surveyor is working to provide high-resolution views of the tremendously diverse terrain on Mars over all martian seasons."

"These landforms may be telling us what the south polar cap is made of," says Dr. Andrew Ingersoll of the California Institute of Technology, Pasadena, California. "The north residual cap — the part that survives the summer — is made of water ice. The south residual cap seems to be made of frozen carbon dioxide, otherwise known as dry ice, but we don't know if this is a veneer a few meters thick or a solid block that extends down 2 or 3 kilometers. These images may help us decide."

The north polar cap is covered mainly by pits, cracks, small bumps, and knobs that give it a cottage-cheese look. The pits that have developed on the surface are spaced close together relative to the very different depressions in the south polar cap. These pits probably developed slowly over successive spring and summer seasons.

"If we discovered that both polar caps are mostly water, it would leave a mystery about why there is so little carbon dioxide on Mars. Earth has a lot of carbon dioxide, but creatures living in the ocean have turned it into limestone rocks. Without oceans or life, Mars should have a lot more carbon dioxide on its surface than we seem to be finding," explained Ingersoll.



NASA/JPL/Malin Space Science Systems

Martian dairy products: High-resolution images of the planet's south polar region (left) show circular depressions that resemble Swiss cheese, while the north pole surface (right) appears to have bumps and knobs that resemble cottage cheese.

NASA RESPONDS TO MARS POLAR LANDER QUESTIONS

NASA has officially responded to charges brought forth by James Oberg of United Press International (UPI), who claimed in a story entitled "NASA Knew Mars Polar Lander Doomed" that NASA knew there was a problem with the *Mars Polar Lander* propulsion system prior to the December 3 landing attempt and "withheld this conclusion from the public."

NASA has categorically denied the charge. Here is a summary of the actions taken by NASA and the review team following the failure of the mission and related to UPI's allegations:

- The Stephenson Report, Phase 1, was released to the public on November 10, 1999, during a press conference at NASA Headquarters. The report made 11 different references to technical issues or concerns involving the propulsion system and the entry, descent, and landing sequence.
- The thruster issue was specifically addressed in the press conference and in "MPL Observation No. 5" and other public recommendations of the Stephenson Phase 1 report. It was entitled "Cold Firing of Thrusters," and dealt in detail with the catalyst bed issue cited by Oberg of UPI in his March 21 story.

NASA/JPL/Caltech

Artist's rendering of the Mars Polar Lander on the planet's surface.

- According to NASA, public documents released on November 10, and available on line at the NASA Web site, confirm that NASA did indeed publicly address propulsion issues, and specifically, the propulsion system's "catalyst bed" temperature concern.
- NASA officials say they knew about the concerns with the propulsion system, took corrective action, and hid nothing from the public. NASA says it made its concerns known in early November.
- Several failure scenarios have been reported in the press since the loss of the lander, including the scenarios involving a lander-legs microswitch failure. News media such as the *Denver Post, Space Daily,* and National Public Radio's "All Things Considered" have covered this angle. NASA officials note that there is no new information in the UPI report relating to this specific issue. The lander-legs issue is among the failure modes NASA continues to study.
- Both the Stephenson and Casani (John Casani, retired JPL flight programs head and also director of mission assurance) teams have conducted intensive reviews relating to *Mars Polar Lander,* and their teams have surfaced no evidence relating to thruster acceptance testing irregularities as alleged by the UPI story. In fact, members of the review teams have called the claims "complete nonsense."

Contact with the Mars Polar Lander was never established after its scheduled landing on December 3, 1999. The mission failure was especially troubling to NASA in a year that had already seen the loss of the *Mars Climate Orbiter.* The *Orbiter* was lost as it was entering orbit around Mars on September 23. The loss was blamed on a failure between teams to convert between metric and standard units.

In a less-significant but still disappointing loss, the Japanese/U.S. Astro-E mission was abandoned after being launched in early February. Because of rocket failures, the Astro-E failed to reach the altitude necessary for a proper orbit. The main mission of the ASTRO-E was to observe astronomical objects in X-ray wavelengths, and to perform very fine and wide-band X-ray spectroscopy of cosmic high-temperature plasmas.

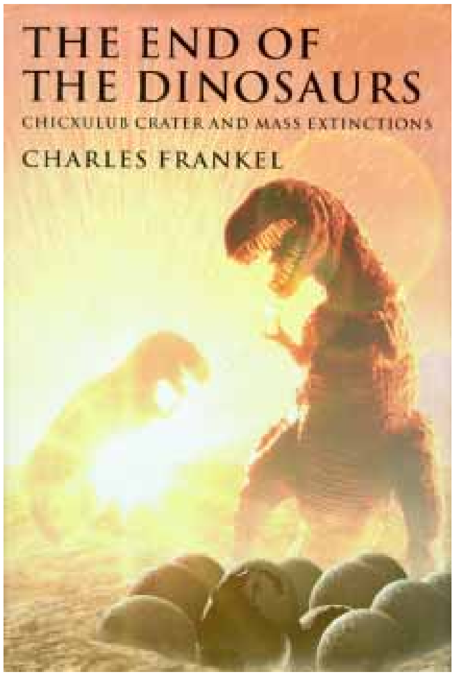
PLANETARY SOCIETY OF JAPAN LAUNCHED

The Planetary Society of Japan, a new nonprofit space organization, was officially launched in November 1999 in Tokyo. The Planetary Society of Japan (TPS/J) will be an independent affiliate of The Planetary Society, an international organization headquartered in Pasadena, California.

Dr. Tamiya Nomura, the former high commissioner of the Space Activities Commission in Japan, will head the newly formed organization as its president. Yotaro Kobayashi, chairman of Fuji-Xerox Co., will serve as vice president, and Jihei Akita, senior fellow and Japan representative of the MIT Media Laboratory and a member of The Planetary Society's Advisory Council, will serve as executive director.

NEW IN PRINT

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



REVIEW

THE END OF THE DINOSAURS: Chicxulub Crater and Mass Extinctions
by Charles Frankel
212 pages. Hardcover, $24.95.
Cambridge University Press, 1999

This very readable book is for the general reader, as is advertised by the publisher. This is immediately evident from the title: Dinosaurs are the attention-grabber, well known to the general public, but provide no evidence for whatever happened at the end of the Cretaceous. The story of the events at the end-Cretaceous 65 million years ago is instead spun from the evidence provided by much smaller creatures and plants, and from geochemistry and mineralogy. Frankel tells this story as it has been worked out by others, and indeed does not really devote an awful lot of attention to dinosaurs. He starts with quite a detailed table of contents, which by itself will give a reader the basic story!

The book is laid out clearly, in a chronological manner going back 200 years to the development of stratigraphic history and concepts of extinction, and to the concept of *mass* extinction, and then to the question of the faunal and floral change long known at the end of the Cretaceous. Lyell, who took a long time to accept Darwin's vision of evolution, recognized that the change at the Cretaceous-Tertiary boundary — for instance in mollusks — was equivalent in scale to that developed over the entire succeeding Tertiary (although Frankel doesn't say this). Lyell — and Darwin — believed there must have been a substantial time gap represented by that boundary. We now know that the Tertiary changes took place over 65 million years, and the Cretaceous-Tertiary changes over a much tighter time frame. Some might have been virtually instantaneous, others might have taken a few years or hundreds of years.

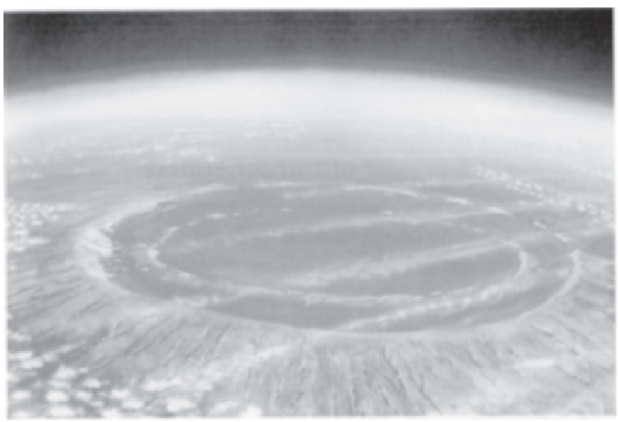
Frankel jumps quickly to describe the scientific advances in the 1970s and 1980s, starting with the inference by Alvarez, Alvarez, Asaro, and Michel (1980) that there had been a large asteroidal or cometary impact at the end of the Cretaceous. He describes how that event might have caused the demise of the dinosaurs and that of other land species and ocean dwellers. He describes other evidence (e.g., shocked quartz) recognized globally that substantiated the reality of an impact, geochemical signatures that better defined what actually happened physically and biologically, and paleontological evidence that showed what lived and what died and when. Frankel also describes the opposition to the concept, which was (and in some quarters still is) extremely strong. The culmination is the recognition of the crater, buried in the Yucatán, which was the result of the impact, and is the subject of continuing study and proposals for drilling. This end-Cretaceous event and the Chicxulub crater have much to tell us about impacts and Earth history. So goes the first two-thirds of this book.

The last one-third has nothing directly to do with the title of the book. It is about other mass extinctions in Earth history, how they might have been caused by impacts, and about how those impacts might be periodic. The last chapter is about the impact hazard in the present and near future.

Frankel's book is nicely laid out, and richly illustrated. It may be too richly illustrated in that many of the portraits of key players don't offer much additional information. A few of the photographs are out of focus or poorly reproduced, but most are good quality. While covering most of the lines of evidence for an impact, its consequences, and the extinctions, it does not get so deep as to be incomprehensible; the reader is not going to be drowned by discussions of carbon, sulfur, or oxygen isotopes. At the same time, the reader will not learn much about exactly how important these arcane characteristics actually are and how they are used as evidence. The book has several pages of references, including other general works as well as some specific research papers, that adequately lead the turned-on reader to more information.

Frankel is not a research scientist in this field, and in many respects the book does not compare with those by others who are (such as Walter Alvarez's *T Rex and the Crater of Doom,* which has an even more public-eye-catching title). On the other hand, he does have the background and experience to write this book more than just competently; he has been to many of the sites discussed and spoken at length with the site researchers. For instance, he attended the Catastrophes in Earth History conference in Houston organized by the LPI in 1993, and the associated field trip to the boundary sections in northeast Mexico organized by the LPI with Wolfgang Stinnesbeck.

While this is a readable and thorough (for the level addressed) book, it does have a few shortcomings. It was originally written and published in French, and although French scientists have made significant contributions, the text leans a little too much toward French influences than is warranted (presumably in view of the interests of the original audience). The last third of the book is not very balanced. The unwary reader is led to the idea that it is most likely that nearly all major extinctions are caused by impact. There is continued reference to impacts near or at major extinction boundaries, but given that there are about 150 known impacts during the last 500 million years or so, the chances are that almost any boundary will have *some* impact within a few million years or so. This of course is a valid field for study, and considerable thought is currently being given to the nature of major extinctions and their causes. Except for the Cretaceous-Tertiary boundary, no such boundary can be yet said to be impact generated, and many are almost certainly not (such as the end-Ordovician glaciation event, although Frankel even tries to suggest that the glaciation might have been impact produced; well, maybe, but pushing every little possibility isn't very instructive). The impact hazard is really a separate subject, and in this chapter the danger all seems rather overblown. Of course there is a risk, and of course there *will* be impacts in the future. That's a certainty. But few of us need to lose sleep over it right now, given the asteroid-comet population distributions and the timescales involved. We have far greater risks for humanity to worry about.



William K. Hartmann

Artist's rendering of the Chicxulub impact crater.

— *Graham Ryder, Rene Martinez, and Ann Martinez*

(The three reviewers are all geologists. Graham Ryder is a staff scientist at the Lunar and Planetary Institute. Rene Martinez is with the Science Payloads Department at Lockheed Martin Space Operations. Ann Martinez teaches science at Clear Lake Intermediate School.)

RECENTLY PUBLISHED

Voyage to the MilkyWay: The Future of Space Exploration, By Donald Goldsmith, TV Books, 1999, Hardcover, $27.50. Companion to the two-part PBS documentary of the same name, this book surveys the technological and theoretical advances that may one day make interstellar space travel possible, as well as the history behind such efforts.

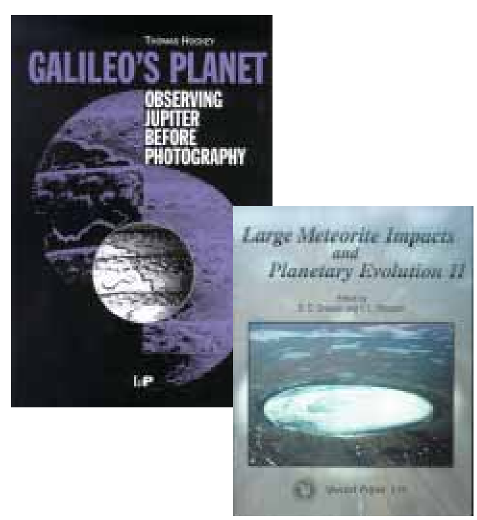
Internet Resources for Professional Astronomy: Proceedings of the IX Canary Islands Winter School of Astrophysics, Edited by Mark R. Kidger, Cambridge University Press, 1999, Hardcover, $74.95. A guide to impact of the Internet on professional astronomy, with each chapter dealing with a separate range of the electromagnetic spectrum (e.g., radio, infrared, and optical astronomy). Includes information on how to find and use data with examples of data analysis from telescopes such as the Hubble.

Starlight Nights: The Adventures of a Star-Gazer, By Leslie C. Peltier, Sky Publishing, 1999, Softcover, $19.95. First published in 1965, this memoir of famed comet hunter Leslie Peltier offers a passionate and engaging account of one man's love affair with the sky. The new version includes a foreword by David H. Levy and photographs culled from the Peltier family album.

Deep-Sky Wonders, By Walter Scott Houston, Sky Publishing, 1999, Hardcover, $29.95. Collection of columns by longtime *Sky & Telescope* columnist "Scott" Houston, selected and arranged by S&T editor Stephen James O'Meara. Building on the columns, O'Meara has strived to create a year-round guide to the star clusters, nebulae, and galaxies and has supplemented the columns with his own commentary.

NASA Mission Reports. Compiled and edited by Robert Godwin, this series from Apogee Books (http://www.cgpublishing.com/) repackages original NASA mission reports. Each book includes such material as the original press kit, the premission report and objects, technical reports, and postflight reports and summaries. In addition, each book includes a CD-ROM with documentary footage to supplement the text. New books in the series include:

- *Apollo 11: Volume Two,* 168 pp., $13.95.
- *Apollo 12,* 248 pp., $16.95.

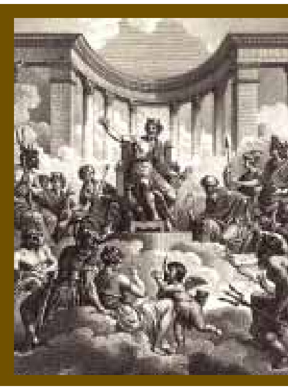


Galileo's Planet: Observing Jupiter Before Photography, By Thomas Hockey, Institute of Physics Publishing, 1999, Hardcover, $49.50. Traces the history of humankind's quest to understand the giant planet in the era before photography. Hockey, an associate professor of astronomy at the University of Northern Iowa, begins his narrative with the invention of the telescope and moves onward to cover such astronomers as Cassini, William Herschel, Mayer, Lassell, Webb, Parsons, and Hirst. Illustrations include several black-and-white photographs of the astronomers as well as their own drawings and diagrams of Jupiter.

Large Meteorite Impacts and Planetary Evolution II, Edited by B. O. Dressler and V. L. Sharpton, Geological Society of America, 1999, Softcover, $72.75. This imposing volume presents the full papers for abstracts originally presented to the Sudbury 1997 conference on Large Meteorite Impacts and Planetary Evolution. The expanded volume is thus more comprehensive for the specialist and more accessible to the non-specialist. The book includes an array of color photographs, detailed tables and graphs, and microscopic imagery.

The Mythology of Planets

A History of Naming the Heavenly Bodies



Ever since the Greeks first named the mysterious objects they saw moving in retrograde fashion in the sky above, the planets and their satellites have been associated with the gods and heroes of mythology. For like gods, these objects appear to move in enigmatic ways and exude the strange colors and characteristics that embody the unpredictable tempers of the deities of Greek and Roman mythology.

While different cultures and societies have named the planets throughout history, the names that are most familiar now are those approved by the International Astronomical Union. The IAU has been the official arbiter of planetary and satellite nomenclature since its organizational meeting in 1919 in Brussels. (See "IAU Planetary Naming Conventions," p. 17.)

What follows is an accounting and history, beginning with Mercury and moving outward toward Pluto, of how the planets were discovered and named. The IAU has adopted certain naming conventions to keep the names consistent within categories, although a few anomalies have worked their way into the system. The process is a dynamic one, as the IAU continues to field requests to name new objects and satellites as they are discovered.

MERCURY The closest planet to the Sun was named Mercurius by the Romans because it appears to move so swiftly. In Roman mythology, Mercury was a god that served as messenger to the other gods.

VENUS The bluish planet Venus was named for the Roman goddess of love (she was called Aphrodite in Greek mythology). This planet was considered to be the brightest and most beautiful object in the heavens. Other civilizations have often named it for their god of love or war.

The MOON Every civilization has had a name for the satellite of Earth that is known in English as the Moon. The name is of Anglo-Saxon derivation.

MARS Named by the Romans for their god of war because of its bloodlike red color. (The Greek god of war was Ares, hence the adjective "areocentric" and the names of such formations as Ares Vallis.) Other civilizations were also inspired to name this planet for its striking red appearance. For example, the Egyptians named it "Her Desher," meaning "the red one."

Phobos. Inner satellite of Mars; named in 1877 by the discoverer, Asaph Hall, for one of the horses that drew Mars' chariot; also called an "attendant" or "son" of Mars, in chapter 15, line 119 of Homer's *Iliad.* This Greek word means "fear."

Deimos. Outer martian satellite, also named by Asaph Hall for one of Mars' horses/sons/companions; the word means "dread" or "terror" in Greek.

JUPITER The largest and most massive of the planets was named Zeus by the Greeks and Jupiter by the Romans. Zeus (or Jupiter) was the most important and powerful of the Greek gods, and was considered the ruler of the heavens.

Satellites of Jupiter:

Metis. Metis was the first wife of Zeus. He swallowed her when she became pregnant; Athena was subsequently born from the forehead of Zeus. Discovered by Stephen Synnott in 1979–1980.

Adrastea. A nymph of Crete to whose care Rhea entrusted the infant Zeus. Discovered by D. Jewitt and E. Danielson in 1979.

Amalthea. Discovered by E. E. Barnard in 1892, who eventually chose a name suggested by Flammarian for the satellite. Amalthea (a goat in some accounts, a princess of Crete in others) suckled Zeus as a young child.

Thebe. A nymph abducted by Zeus; she is the namesake of the Greek city of Thebes. Discovered by Synnott in 1979–1980.

Io. Galileo discovered Io, Europa, Ganymede, and Callisto in 1610. Simon Marius' claim to discovery of the jovian satellites shortly before Galileo was not accepted. Galileo suggested that the four be known as "Medicea Sidera" to honor his patron, but the name was not accepted by other astronomers. Instead, they chose names given the four satellites by Marius in 1613; the names were of four of Jupiter's illicit loves.

Galileo refused to accept Marius' names; instead, he identified the moons by Roman numerals, a secondary designation system that has been adopted for all satellite systems to the present.

Io, the daughter of Inachus, was changed by Jupiter into a cow to protect her from Hera's jealous wrath, but Hera recognized Io and sent a gadfly to torment her. Io, maddened by the fly, wandered throughout the Mediterranean region.

Europa. Beautiful daughter of Agenor, king

Neptune and Triton, Bernini, Gian Lorenzo, ca. 1620–1621.

of Tyre, she was seduced by Jupiter, who had assumed the shape of a white bull. When Europa climbed on his back he swam with her to Crete, where she bore several children, including Minos.

Ganymede. Beautiful young boy who was carried to Olympus by Jupiter disguised as an eagle. Ganymede then became the cupbearer of the Olympian gods.

Callisto. Beautiful daughter of Lycaon, she was seduced by Jupiter, who changed her into a bear to protect her from Hera's jealousy.

Leda. Seduced by Zeus in the form of a swan, she was the mother of Pollux and Helen. Discovered by Kowal in 1974.

Himalia. Himalia was a Cyprian nymph who bore three sons of Zeus. Discovered by C. Perrine in 1904.

Lysithia. Discovered by S. Nicholson in 1938.

Elara. A paramour of Zeus; mother of the giant Tityus. Discovered by C. Perrine in 1904–1905.

Ananke. Ananke was the personification of necessity or fate. Discovered by S. Nicholson in 1951.

Carme. A nymph and attendant of Artemis; mother, by Zeus, of Britomartis. Discovered by Nicholson in 1938.

Pasiphaë. Wife of Minos; mother of the Minotaur. Discovered by P. Melotte in 1908.

Sinope. Daughter of the river god Asopus and Merope; she was abducted by Apollo. Discovered by Nicholson in 1914.

SATURN Roman name for the Greek Cronos, father of Zeus/Jupiter. Other civilizations have given other names to Saturn, which is the farthest planet from Earth that can be observed by the naked human eye. Most of its satellites were named for Titans, a race of godlike giants who, according to Greek mythology, were brothers and sisters of Saturn.

Satellites of Saturn:

Pan. Son of Hermes and Dryope; half-human, half-goat god of shepherds and flocks. Discovered in 1990 orbiting in the Encke Gap in Saturn's A ring.

Atlas. A Titan, he held the heavens on his shoulders. Discovered by R. Terrile in 1980.

Prometheus. Brother of Atlas and Epimetheus; he gave many gifts to humanity, including fire. Discovered by Collins and others in 1980.

Pandora. In Greek mythology, she was the first woman on Earth; she married Epimetheus and opened the box that loosed a host of plagues upon humanity. Discovered by S. Collins and others in 1980.

Janus. Discovered by Audouin Dollfus in 1966, this small satellite was later proved to have a twin, Epimetheus, that shares the same orbit but never actually meets Janus. It is named for the two-faced Roman god who could look forward and backward at the same time.

Epimetheus. Discovered by the Voyager team in 1981 and named by them for the Greek backward-looking god.

Mimas. Discovered by William Herschel in 1798 and named by his son, John, in the early nineteenth century for a Titan felled by Hephaestus (or Ares) in the war between the Titans and Olympian gods.

Enceladus. Also discovered by Herschel in 1798 and named by his son for the Titan Enceladus. Enceladus was crushed by Athene in the battle between the Olympian gods and the Titans; earth piled on top of him became the island of Sicily.

Tethys. Discovered in 1684 by Giovanni Cassini, who wished to name it and the other three satellites that he discovered (Dione, Rhea, and Iapetus) for Louis XIV. However, the names used today for these satellites were applied in the early nineteenth century by John Herschel, who named them for Titans and Titanesses, brothers and sisters of Saturn. Tethys was the wife of Oceanus and mother of all rivers and Oceanids.

Telesto. One of 3000 Oceanides, water nymphs born to Oceanus and Tethys. Discovered by B. Smith and others, 1980.

Calypso. A daughter of Atlas and paramour of Odysseus. Discovered by Smith and others in 1980.

Dione. Discovered by Cassini in 1684. Dione was the sister of Cronos and mother (by Zeus) of Aphrodite.

Helene. Discovered by P. Laques and J. Lecacheux in 1980 and named after an Amazon who battled with Achilles.

Rhea. Discovered by Cassini in 1672 and named for another of Cronos' sisters who was also his wife. Her youngest son was Zeus.

Titan. Discovered and named in 1665 by Huygens, who first called it "Luna Saturni." The Titans were a race of godlike giants who personified the forces of nature.

Hyperion. Discovered by C. and G. P. Bond and by William Lassell on the same night in 1848; named by Lassell for one of the Titans.

Iapetus. Discovered by Cassini in 1671 and named by John Herschel for one of the Titans.

Phoebe. Discovered and named by William H. Pickering of Harvard University in 1898. Phoebe was a Titaness, the daughter of Leda and sister of Helene.

URANUS Uranus was discovered by William Herschel in 1781. Several astronomers, including John Flamsteed and Le Monnier, had observed it earlier but had recorded it as a fixed star. Herschel tried unsuccessfully to name his discovery "Georgian Sidus" after George III. The planet was ultimately named by Johann Bode in 1781 for the ancient god of the heavens who was the father of Saturn.

Satellites of Uranus:

Cordelia. Daughter of Lear in Shakespeare's *King Lear.* Discovered by the Voyager 2 Team in 1986.

Ophelia. Daughter of Polonius, fiancée of Hamlet in Shakespeare's *Hamlet, Prince of Denmark.* Discovered by the Voyager 2 Team in 1986.

Bianca. Daughter of Baptista, sister of Kate in Shakespeare's *Taming of the Shrew.* Discovered by the Voyager 2 Team in 1986.

Cressida. Title character in Shakespeare's *Troilus and Cressida.* Discovered by the Voyager 2 Team in 1986.

Desdemona. Wife of Othello in Shakespeare's *Othello, the Moor of Venice.* Discovered by the Voyager 2 Team in 1986.

Juliet. Heroine of Shakespeare's *Romeo and Juliet.* Discovered by the Voyager 2 Team in 1986.

Portia. Wife of Brutus in Shakespeare's *Julius Caesar.* Discovered by the Voyager 2 Team in 1986.

Rosalind. Daughter of the banished duke in Shakespeare's *As You Like It.* Discovered by the Voyager 2 Team in 1986.

Belinda. Character in Pope's *Rape of the Lock.* Discovered by the Voyager 2 Team in 1986. (With Umbriel, one of only two uranian satellites not named after Shakespearean characters.)

Puck. Mischievous spirit in Shakespeare's *A Midsummer Night's Dream.* Discovered by the Voyager 2 Team in 1986.

Miranda. Discovered and named by G. P. Kuiper in 1948 for the heroine of Shakespeare's *The Tempest.*

Ariel. Discovered by William Lassell in 1851; named by John Herschel for the benevolent spirit in Shakespeare's *The Tempest.*

Umbriel. Discovered by William Lassell in 1851; named by John Herschel for a malevolent spirit in Pope's *Rape of the Lock.*

Titania. Discovered by William Herschel

Head of Demeter-Europa, A.D. 140–160, Carlos Collection of Ancient Greek Art.

in 1787; named by his son John in the early nineteenth century for the queen of the fairies in Shakespeare's *A Midsummer Night's Dream.*

Oberon. Discovered by William Herschel in 1787; named by his son John in the early nineteenth century for the king of the fairies in Shakespeare's *A Midsummer Night's Dream.*

Caliban. Discovered by Gladman, Nicholson, Burns, and Kavelaars in 1997; named for the grotesque, brutish slave in Shakespeare's *The Tempest.* This name has provisional approval.

Sycorax. Discovered by Gladman, Nicholson, Burns and Kavelaars in 1997; named for Caliban's mother in Shakespeare's *The Tempest.* This name has provisional approval.

Atlas, Farnese, second century A.D.

NEPTUNE Neptune was actually "observed" as early as 1690 by John Flamsteed, who thought it was a fixed star. Its existence was predicted by John Couch Adams and Urbain Le Verrier, who were independently able to account for the irregularities in the motion of Uranus by predicting the orbital elements of a trans-uranian body. Using the predicted parameters of these two men, Johann Galle observed the planet in 1846. Galle wanted to name the planet for Le Verrier, but the planet was eventually named for the Roman god of the sea.

Satellites of Neptune:

Naiad. The name of a group of Greek water nymphs who were guardians of lakes, fountains, springs, and rivers. Discovered in 1989 on Voyager 2 imagery.

Thalassa. Greek sea goddess; mother of Aphrodite in some legends; others say she bore the Telchines, a mythical genus of priests. Discovered in 1989 on Voyager 2 imagery.

Despina. Daughter of Poseidon (Neptune) and Demeter. Discovered in 1989 on Voyager 2 imagery.

Galatea. One of the Nereids, attendants of Poseidon. Discovered in 1989 on Voyager 2 imagery.

Larissa. A lover of Poseidon. Discovered in 1989 on Voyager 2 imagery.

Proteus. Greek sea god, son of Oceanus and Tethys. Discovered in 1989 on Voyager 2 imagery.

Triton. Discovered in 1847 by William Lassell, Triton is named for the sea-god son of Poseidon (Neptune) and Amphitrite. The suggestion of the name Triton has been attributed to the French astronomer Camille Flammarion.

Nereid. Discovered by G. P. Kuiper at the McDonald Observatory in 1949. The Nereids were the fifty daughters of Nereus and Doris and were attendants of Neptune.

PLUTO Discovered in 1930 by American astronomer Clyde W. Tombaugh during a systematic search for a trans-neptunian planet predicted by Percival Lowell and William H. Pickering. The last planet discovered was named after the Greek god of the underworld who was able to render himself invisible.

Charon. Pluto's lone satellite, whose size has led some scientists to dub Pluto-Charon a binary planetary system, was discovered in 1978 by two American astronomers, James W. Christy and Robert S. Harrington. It was named after the mythological ferryman who carried souls across the river Styx into the underworld.

Much of the preceding information was drawn and adapted from the U.S. Geological Survey's Web site on planetary nomenclature (http://wwwflag.wr.usgs.gov/USGSFlag/Space/nomen/nomen.html). The information was used with permission from the USGS.

Ganymede and Zeus, decoration in Hamburger Kunsthalle.

IAU Naming RULES AND CONVENTIONS

Names adopted by the IAU must follow various rules and conventions established and amended through the years by the Union.The rules were formally adopted in 1977 and have been modified through the years as needed. The official conventions are as follows:

1. Nomenclature is a tool and the first consideration should be to make it simple, clear, and unambiguous.
2. The number of names chosen for each body should be kept to a minimum, and their placement governed by the requirements of the scientific community.
3. Duplication of the same name on two or more bodies is to be avoided.
4. Individual names chosen for each body should be expressed in the language of origin. Transliteration for various alphabets should be given, but there will be no translation from one language to another.
5. Where possible, the themes established in early solar system nomenclature should be used and expanded on.
6. Solar system nomenclature should be international in its choice of names. Recommendations submitted to the IAU national committees will be considered, but final selection of the names is the responsibility of the International Astronomical Union. The Working Group for Planetary System Nomenclature strongly supports equitable selection of names from ethnic groups/countries on each map; however, a higher percentage of names from the country planning a landing is allowed on landing site maps.
7. No names having political, military, or religious significance may be used, except for names of political figures prior to the nineteenth century.

Marble statue of Aphrodite (Venus), the goat-footed Pan, and Eros, ca. 100 B.C.

8. Commemoration of persons on planetary bodies should not be a goal in itself but should be reserved for persons of high and enduring international standing. Persons being so honored must have been deceased for at least three years.
9. When more than one spelling of a name is extant, the spelling preferred by the person, or used in an authoritative reference, should be used. Diacritical marks are a necessary part of a name and will be used.
10. Ring and ring-gap nomenclature and names for newly discovered satellites are developed in joint deliberation between WGPSN and IAU Commission 20. Names will not be assigned to satellites until their orbital elements are reasonably well known or definite features have been identified on them.

In addition to these general rules, each task group develops additional conventions as it formulates an interesting and meaningful nomenclature for individual planetary bodies. Most of these conventions are self-evident from study of the appendixes that follow.

Io-Isis, early second century A.D. Roman

NAMING CONVENTIONS

Names for all planetary features include a descriptor term (Appendix 5), with the exception of two feature types. For craters, the descriptor term is implicit. Some features named on Io and Triton do not carry a descriptor term because they are ephemeral.

In general, the naming convention for a feature type remains the same regardless of its size. Exceptions to this rule are channels (valles) on Mars and craters on the Moon, Mars, and Venus; naming conventions for these features differ according to size. The categories for naming features on each planet or satellite (and the exceptions) are listed in Appendix 6. One feature classification, regio, was originally used on early maps of the Moon and Mercury (drawn from telescopic observations) to describe vague albedo features. It is now used to delineate a broad geographic region.

Named features on bodies so small that coordinates have not yet been determined are identified on drawings of the body that are included in the IAU Transactions volume of the year when the names were adopted. Satellite rings and gaps in the rings are named for scientists who have studied these features; drawings that show these names are also included in the pertinent Transactions volume. Names for atmospheric features are informal at present; a formal system will be chosen in the future.

The boundaries of many large features (such as terrae, regiones, planitiae, and plana) are not topographically or geomorphically distinct; the coordinates of these features are identified from an arbitrarily chosen center point. Boundaries (and thus coordinates) may be determined more accurately from geochemical and geophysical data obtained by future missions.

Ancient Mythology and Art on the Web

The Encyclopedia Mythica
http://www.pantheon.org/mythica/

Nancy Mautz's Creative Impulse: The Artist's View of World History and Western Civilization
http://history.evansville.net/

31ST LUNAR AND PLANETARY SCIENCE CONFERENCE SETS ATTENDANCE RECORDS

The 31st Lunar and Planetary Science Conference marked another record-breaking year, with 1116 scientists from 24 countries attending the conference held at the Gilruth Center, NASA Johnson Space Center, in Houston on March 13–17, 2000.

There were 1096 abstracts submitted to the conference for review and scheduling by the program committee, co-chaired by Dr. Carl Agee, NASA/JSC, and Dr. David Black, LPI. The final program for the conference, cosponsored by the Lunar and Planetary Institute and the NASA Johnson Space Center, included 447 oral presentations, 454 poster presentations, 10 invited talks, and 172 print-only presentations.

Highlights of this year's conference included a special session on the NEAR Mission first results, with presentations focused on the geology, collisional history, magnetic field data, and spectrometer/X-ray results of the asteroid. Dr. John Wood delivered the Masursky Lecture, "Chondrites: Tight-Lipped Witnesses to the Beginning," at a plenary session on Monday afternoon. Other oral sessions at the conference included Galileo at Io, Mars Geophysics, New Views of the Moon, and Martian Meteorites. The poster sessions were again held at the University of Houston–Clear Lake near the Center for Advanced Space Studies (which houses the LPI and also served as the gathering point for conference open-house activities and a special NEAR press conference).

DEBRA RUEB PHOTOS

Dr. Carl Pilcher, NASA Headquarters, discusses the future of the Mars program during a question-and-answer session at the University of Houston–Clear Lake.

Conference participants circulate among the displays at Thursday night's poster session at the University of Houston–Clear Lake.

Katherine D. Ocker Stone (left) and Prinya Promprated, Ph.D. candidates at the University of Tennessee, enjoy the barbecue dinner at Wednesday night's chili cook-off.

HOW TO BUY A STAR

One of NASA's frequently asked questions from the public is, "Can I buy a star and name it for someone, or have it named for me?" While some commercial firms may claim to officially register a name of your choice for a star, these names have no official validity. A few bright stars (such as Rigel) have ancient, traditional Arabic names, but otherwise stars are known by catalog numbers and positions in the sky. Like the names of bodies in the solar system, the names of stars are formally certified by the International Astronomical Union.

For answers to other space-science-related frequently asked questions, visit NASA's Web site at http://www.nasa.gov/qanda/index.htm.

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Brian Anderson, Editor

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The Bulletin welcomes the submission of articles and essays dealing with issues related to planetary science and exploration. Please send articles or announcements to: B. Anderson, 3600 Bay Area Boulevard, Houston TX 77058-1113.

Phone: 281-486-2164, fax: 281-486-2125
E-mail: lpibed@lpi.usra.edu

NEAR RENAMED FOR SHOEMAKER

In March, NASA renamed the NEAR spacecraft in honor of Dr. Eugene M. Shoemaker, the late geologist who influenced decades of research on the role of asteroids and comets in shaping the planets. The Near Earth Asteroid Rendezvous spacecraft will now be known as NEAR Shoemaker.

Shoemaker died in a 1997 car accident in the Australian outback while on an annual study of asteroid impact craters. With his wife and research partner, Carolyn Shoemaker, he was part of the leading comet discovery team of the past century, perhaps most famous for finding the comet (Shoemaker-Levy 9) that broke up and collided with Jupiter in 1994.

CALENDAR 2000

MAY

2–5
Fourth IAA International Conference on Low-Cost Planetary Missions, Laurel, Maryland. Contact: Diana Whitman, Mail Stop 4-278, Johns Hopkins University, Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel MD 20723-6099.
Phone: 240-228-7150; fax: 240-228-5969
E-mail: diana.whitman@jhuapl.edu
http://sd-www.jhuapl.edu/IAA

16–20
AMICO 2000: Asteroids, Meteorites, Impacts, and Their Consequences, Nördlingen, Germany. Contact: Michael Schieber, AMICO 2000, Rieskrater-Museum Nördlingen, Eugene-Shoemaker-Platz 1, D-86720, Nördlingen, Germany.
Phone: 49-9081-273-8220; fax: 49-9081-273 82220.
E-mail: rieskratermuseum.noerdlingen@donau-ries.de
http://www.stecf.org/~ralbrech/amico

30–June 3
2000 Spring Meeting of the American Geophysical Union, Washington, DC. Contact: AGU Meetings Department, 2000 Spring Meeting, 2000 Florida Avenue NW, Washington DC 20009.
Phone: 202-462-6900 or 800-966-2481; fax: 202-328-0566
E-mail: meetinginfo@agu.org
http://www.agu.org

JUNE

12–16
Galaxy Disks and Disk Galaxies, Rome, Italy. Sponsored by the Vatican Observatory.
http://debora.pd.astro.it.disks/

JULY

17–19
Cosmos in the Classroom: National Symposium on Teaching Astronomy to College Non-Science Majors, Pasadena, California. Contact: 2000 Cosmos in the Classroom, Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco CA 94112.
Fax: 415-337-5205
E-mail: meeting@aspsky.org
http://www.aspsky.org/meetings/2000hedsymposium.html

AUGUST

6–17
31st International Geological Congress, Rio de Janeiro, Brazil. Contact: Av. Pasteur, 404, Casa Brazil 2000, Urca, Rio de Janeiro, RJ, Brazil.
Phone: 55-21-295-5847; fax: 55-21-295-8094
E-mail: 31igc@31igc.org
http://www.31igc.org

7–18
International Astronomical Union XXIVth General Assembly, Machester, UK. Contact: General Assembly Registration World Event Management.

AUGUST *(continued)*

IAU (continued)
Phone: 44-1274-854-116; fax: 44-1274-854-110
E-mail: enquiries@iau-ga2000.org
http://www.iau-ga2000.org

21–25
The Second International Conference on Mars Polar Science and Exploration, Reykjavik, Iceland. Contact: Stephen Clifford, Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston TX 77058-1113.
Phone: 281-486-2146
E-mail: clifford@lpi.usra.edu
http://www.lpi.usra.edu/meetings/polar2000/

27–Sept. 1
25th European Congress on Molecular Spectroscopy, Coimbra, Portugal. Contact: Rui Fausto, Department of Chemistry, University of Coimbra, P-3049 Coimbra, Portugal.
Phone: 351-39-852080 /351-39-857037; fax: 351-39-827703
E-mail: rfausto@gemini.ci.uc.pt
http://qui.uc.pt/~rfausto/eucmos_xxv/principal.html

28–Sept. 1
63rd Annual Meeting of the Meteoritical Society, Chicago, Illinois. Contact: Andrew M. Davis, Department of the Geophysical Sciences, The University of Chicago, 5734 South Ellis Avenue, Chicago IL 60637.
Phone: 773-702-8164; fax: 773-702-9505
E-mail: a-davis@uchicago.edu
http://www.lpi.usra.edu/meetings/metsoc2000/

NOVEMBER

8–10
Conference on the Earth-Moon Relationship, Padova, Italy.
Contact: Cesare Barbieri, Department of Astronomy, University of Padova, Vicolo Osservatorio 5, 35122 Padova, Italy.
Phone: 39-049-829343; fax: 39-049-8293507
E-mail: cbarbier@ux1.unipd.it; barbieri@pd.astro.it

13–16
Summit 2000: Annual Meeting of the Geological Society of America, Reno, Nevada. Contact: GSA Meetings Department, P.O. Box 9140, Boulder CO 80301-9140.
Phone: 303-447-2020 or 800-472-1988; fax: 303-447-0648
E-mail: meetings@geosociety.org
http://www.geosociety.org

DECEMBER

5–7
ICSO 2000, International Conference on Space Optics, Toulouse Labège, France. Contact: Agence DAG-25, rue Saint Guilhem, 31400 Toulouse, France.
Phone: 33-05-61-25-15-00
E-mail: icso@dag.fr
http://www.cnes.fr/colloque