Lunar and Planetary Information
BULLETIN

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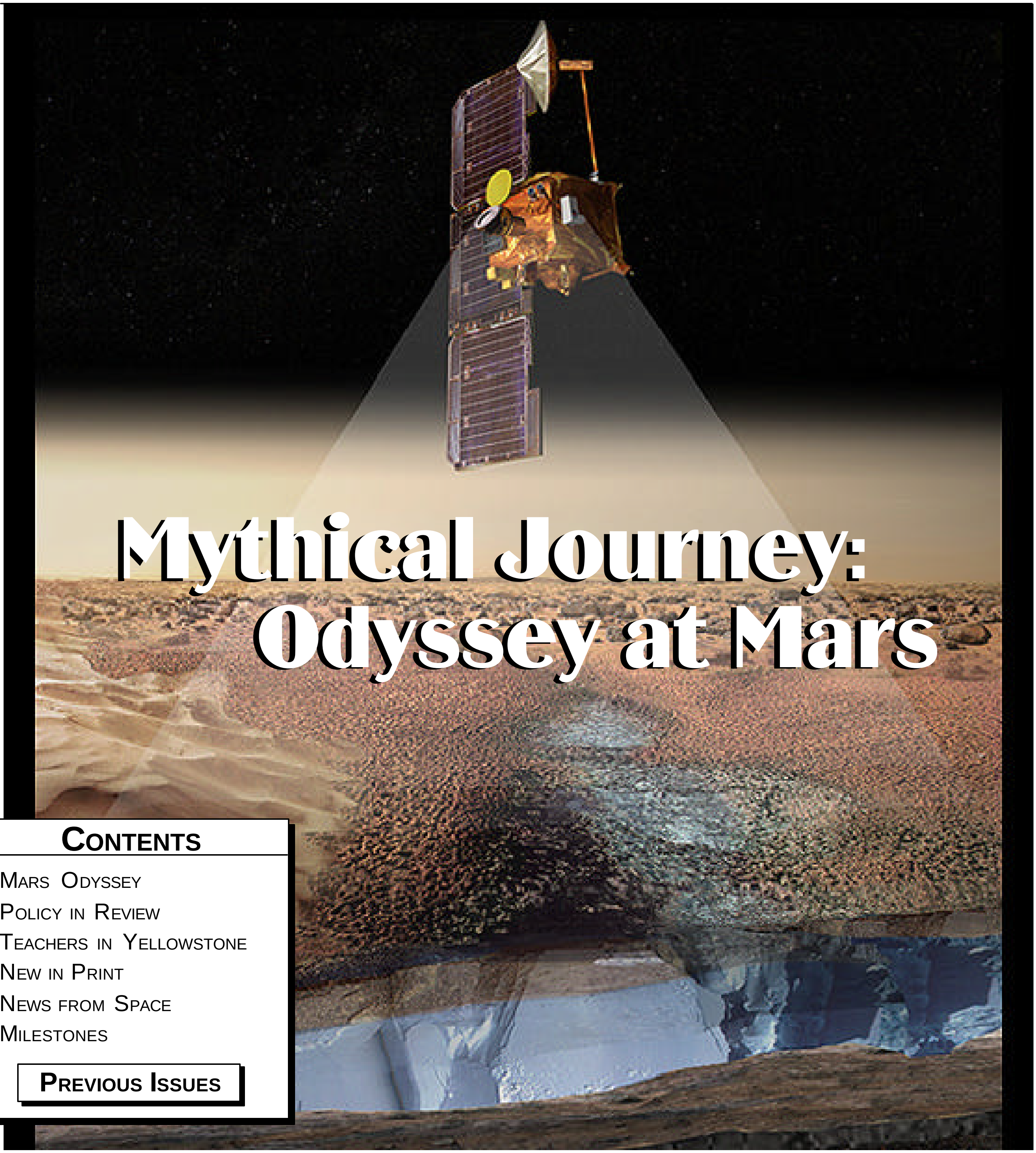


Contents

Previous Issues

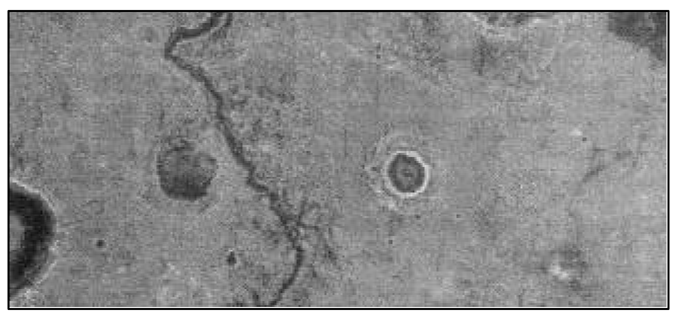
The Mythical Journey of Mars Odyssey

Launched on April 7 of last year, *2001 Mars Odyssey* is an orbiter carrying science experiments designed to make global observations of Mars to improve our understanding of the planet's climate and geologic history, including the search for water and evidence of life-sustaining environments. The mission will extend for more than a full martian year (two-and-a-half Earth years).

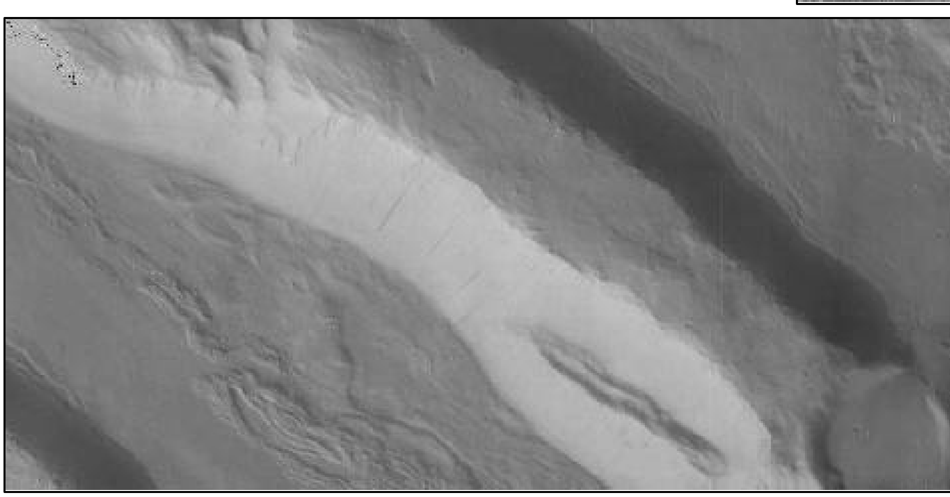
The following two pages represent a small sampling of the current state of *Odyssey*'s science and imaging. All images in this feature, as well as the cover image, are used courtesy of NASA's Jet Propulsion Laboratory, which manages the Mars Odyssey mission. More information about the mission can be found at the http://mars.jpl.nasa.gov/.

The cover image depicts an artist's rendering of ice-rich layers in the soils of Mars being detected by instruments aboard NASA's *2001 Mars Odyssey* spacecraft. Measurements by the gamma ray spectrometer suite of instruments indicate that the upper meter (three feet) of soil contains an ice-rich zone with an ice abundance of 20–50% by mass. The ice-rich areas surround the polar regions of Mars, down to latitudes of about 60°, in both the north and the south. The instruments detect the signature of hydrogen, indicating water ice, to a depth of about 1 meter (3 feet).

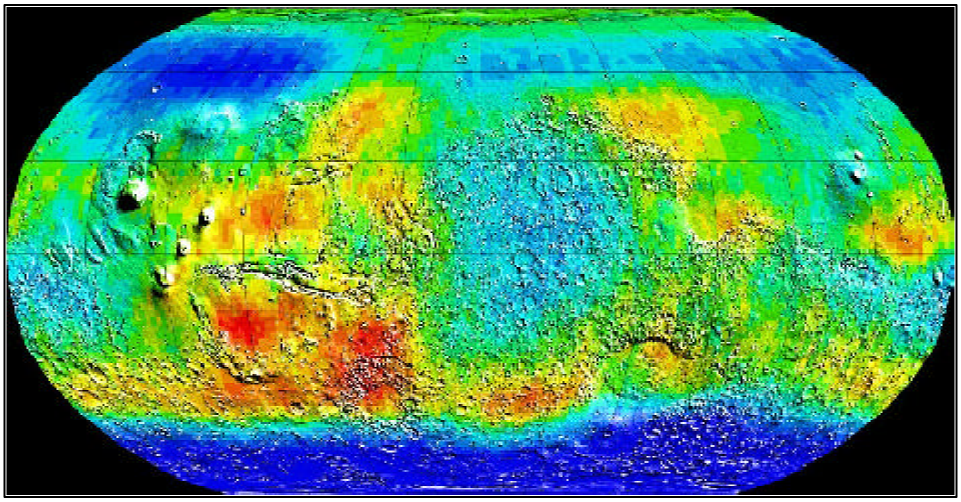
(Above) Infrared imaging from NASA's Mars Odyssey spacecraft shows signs of layering exposed at the surface in a region of Mars called Terra Meridiani.



(Above) This nighttime thermal infrared image shows differences in temperature that are due to differences in the abundance of rocks, sand, and dust on the surface. Rocks remain warm at night, as seen in the warm (bright) rim of the 5-kilometer-diameter crater on the right of this image.

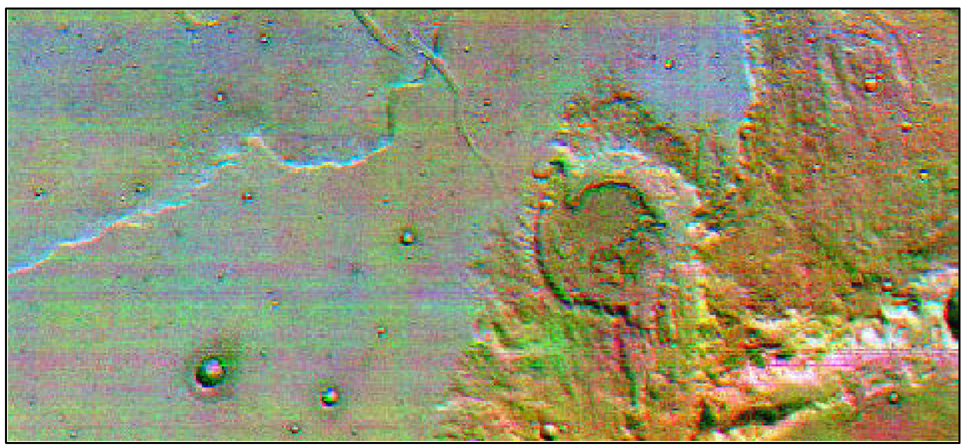


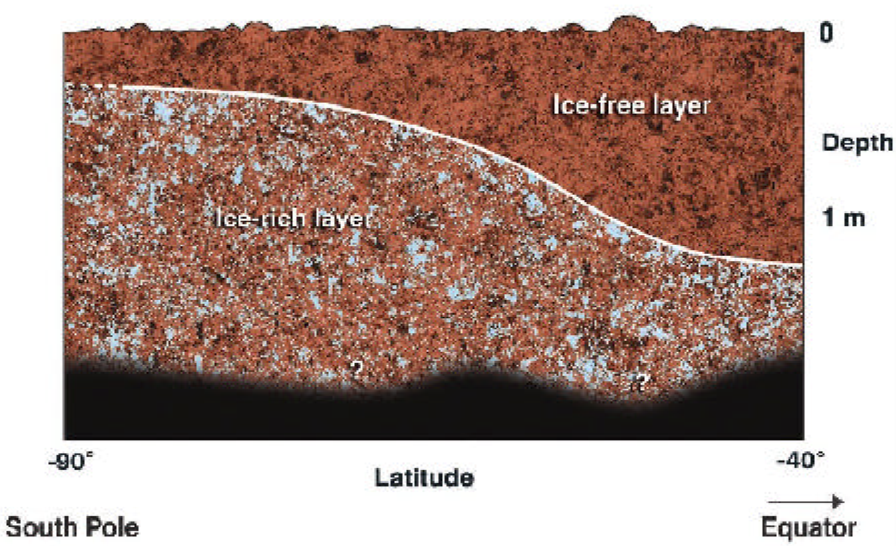
(Left) This visible-light image, taken by the thermal emission imaging system's camera, shows the highly fractured, faulted, and deformed Acheron Fossae region of Mars.



(Left) Observations by Mars Odyssey show a global view of Mars in intermediate-energy, or epithermal, neutrons. Soil enriched by hydrogen is indicated by the deep blue colors on the map, which show a low intensity of epithermal neutrons. Progressively smaller amounts of hydrogen are shown in the colors light blue, green, yellow and red. The deep blue areas in the polar regions are believed to contain up to 50% water ice in the upper 1 meter (3 feet) of the soil. (The image appears in black and white in the print version of the Bulletin.)

(Right) This is the first high-resolution color infrared image taken of Mars (shown in black and white in the print version of the Bulletin). The image was constructed using 3 of the 10 infrared filters on the thermal emission imaging system of Mars Odyssey. Color infrared images reveal differences in the surface materials' composition, and three different compositional units can be detected in this region, known as Terra Sirenum.





(Left) This diagram shows a possible configuration of ice-rich and dry soil in the upper meter (3 feet) of Mars. The ice-rich soil was detected by the gamma-ray spectrometer suite of instruments aboard Mars Odyssey.

POLICY IN REVIEW

The following letter, directed to Dr. Colleen Hartman, Director, Solar System Exploration Division, and Mr. Orlando Figueroa, Director, Mars Exploration Program, presents the most recent findings of the Solar System Exploration Committee. Dr. Michael Drake, chair of that committee, has submitted this letter to this forum for public review. The layout has been changed for publication purposes.

August 8, 2002

Dear Colleen and Orlando:

The Solar System Exploration Subcommittee (SSES) of the Space Science Advisory Committee (SScAC) met from July 17 to 19, 2002, in Washington, DC. The purpose of this letter is to summarize the findings and recommendations of that meeting.

Solar System Exploration Program —

Dr. Colleen Hartman briefed the SSES on the current state of the Solar System Exploration Program. The major topic was the draft NRC Report "New Frontiers in Planetary Science," about which more is described below.

Mars Program —

Orlando Figueroa briefed the SSES on the current state of the Mars Program. *Mars Global Surveyor* continues to produce important scientific observations. *Mars Odyssey* has confirmed the presence of soil saturated in water ice polewards of 60°S latitude. Mars Exploration Rovers development continues, although schedule is of concern. *Mars Reconnaissance Orbiter* is progressing on schedule, as is the *Mars Scout* selection and *Mars Smart Lander.*

The results of the MEPAG Pathways subgroup were reported. The SSES notes that the MEPAG process has resulted in a remarkable unity of vision of the future of Mars exploration, in marked contrast to the differing visions of only six months earlier. For the first time there is a coherent strategy for Mars exploration that will likely be broadly accepted by the diverse elements of the planetary science community. The SSES endorses the MEPAG strategy.

The results of the MEPAG Mars Sample Return subgroup also were reported, in terms of the concepts, requirements, and costs of a minimum mission that would be scientifically acceptable. Estimates of the cost of such a mission indicate that it could be done for less than $1.5 billion (in 2002 dollars). The group indicated that the mission could not successfully be done at this price unless there is a strong technological linkage between the *2009 Mars Smart Lander,* the initial sample return mission, and subsequent sample return missions, and unless an aggressive technology development program is put into place within the next two to three years. The SSES concurs with the high scientific value of an early sample return and recommends that means to implement these approaches be investigated.

Human Capital —

The SSES considered two ways in which NASA can more effectively utilize the human capital at its disposal. Of specific concern is the training of the next generation of Solar System Exploration researchers such that the maximum scientific return from the nation's investment in Solar System Exploration missions can be achieved. Additionally, given NASA's recent reemphasis on education, it is critical that the agency continuously strive to present a highly qualified but diverse (in age, race, and gender) face to the nation in its very public activities. First, the SSES endorsed the recommendation of the "Decadal Survey" committee to establish a "Planetary

Fellows" program. Second, the SSES specifically considered that NASA has an extraordinary opportunity for workforce development and education through the addition of recent Ph.D.s (~<10 years out) to flight teams through Participating Scientist programs. The SSES recommends that consideration be given to how a program to ensure inclusion of recent Ph.D.s on Participating Scientist teams might be implemented.

Research and Analysis Grant Processing —

The planetary science community has consistently noted that processing of grants after selection is very slow. Specific problems have been identified, the most important being the perennially understaffed NASA HQ Solar System Office and grant processing delays at Goddard. NASA HQ is very concerned. Solutions being implemented involve hiring new personnel at NASA HQ to process grants, and working with Goddard to improve grant processing. The methods used by NSF to process grants are being investigated for insight into improving NASA grant processing.

Cassini —

During the SSES meeting, Dr. Colleen Hartman was separately briefed on the science rationale for an overguideline request that amounts to $10M in FY03 and $35M over the next four fiscal years. The overguideline request would allow the project to substantially increase the amount of effort devoted to science planning relative to what is possible under the baseline funding profile established in 1994, as well as to complete deferred data analysis software development before tour begins. This would result in a significant increase in the scientific productivity of the *Cassini* orbiter. The overguideline request comes very late in the budget cycle for FY2003, because the 2003 operating plan has long been approved; it remains to be determined to what degree this request can be granted. Discussions with the project are continuing.

The SSES views returning the maximum possible amount of data from *Cassini* as of high scientific priority. We are confident that Dr. Hartman understands the problem and will attempt to provide as much relief as is possible within the context of a fixed Solar System Exploration budget.

Roadmap —

The SSES discussed the Solar System Exploration Division Roadmap in the context of the recently released draft NRC Report "New Frontiers in Planetary Science." This report represents a consensus of the planetary science community developed between the summers of 2001 and 2002. The SSES broadly concurs with this report and notes that its priorities within mission categories are consistent with those already developed by the SSES for approximately the next five years. The NRC Report will form the basis of the Solar System Exploration Division Roadmap. The roadmap will also discuss areas that were not adequately addressed or need elaboration, and will be responsive to the probability that priorities will change in response to new discoveries, technical readiness issues, and programmatic considerations.

Sincerely,

Michael J. Drake, Chair
Solar System Exploration Subcommittee

Teachers Go to Extremes on Summer Field Trip

Extremely ancient rocks, extremely recent geysers, hot springs that harbor extremely strange forms of life — Yellowstone National Park has them all in abundance. What do they tell us about the history of Earth? What clues can they provide about the history of other solar system bodies and the possibility of life on these other worlds?

Teachers from across the country joined experienced geologists, planetary scientists, and astrobiologists in Yellowstone National Park to examine these features. After a four-day field study, they returned to Montana State University in Bozeman to relate the extremely old rocks and life in extreme environments in the park to conditions on other solar system bodies, combining field observations with results from space exploration through laboratory experiments, presentations, and activities suitable for the classroom.

Although there was plenty of macrobiology to be seen (bison, elk, a grizzlie, and more), the teachers concentrated on the opposite extreme: the microscopic organisms that create microbial mats where they live in some of the weirdest conditions imaginable. They helped scientists with the Ames Astrobiology Team collect small samples from mats — green, yellow, pink, purple — and took measurements of the temperature and pH in the hot springs that these creatures inhabit. They found temperatures from boiling, to hot enough to dip a finger in for only an instant, to tepid. Some springs were acidic enough to eat holes in clothing, not to mention skin, and some were poisonously alkaline. Sulfur-laden habitats were easily detectable by the reek of "rotten eggs."

Back at the laboratory at Montana State, the group used microscopes to examine the samples collected in the field. The variety of creatures ("extremophiles") revealed by high-powered microscope represented the earliest life on Earth and the only life for about two billion years of its history. Scientists and teachers considered other planets and moons and where we might look for microbial life or its fossils, even though conditions for life seem unlikely to present-day humans.

They also used reflectance spectrometers to analyze the light reflected from the various colors of microbial mats and to consider the possibilities and the difficulties of detecting such things by remote sensing. Hands-on classroom activities related to these themes were interspersed with discussions comparing ancient and modern Earth with other worlds.

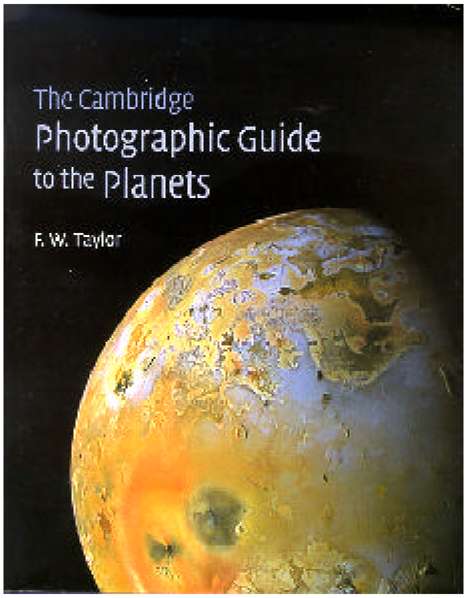
The LPI, in its Broker/Facilitator role with NASA's Office of Space Science, developed and sponsored the workshop "Extremities: Geology and Life in Yellowstone and Implications for Other Worlds." Held July 26–August 2, 2002, it was also sponsored by the NASA Ames Astrobiology Team and Montana State University, with teacher support from the University of Washington Broker; the Space Grant Consortia of Mississippi, Tennessee, Texas, Wyoming, and Washington; and some individual school districts.

" . . . a great experience that totally excited me about space science -- something I typically haven't been too interested in."
— Secondary School Teacher, Wyoming

Participating scientists represented the University of Washington (A. Irving), Lunar and Planetary Institute (W. Kiefer and A. Treiman), Ames Astrobiology Team (T. Hoehler), Montana State University (D. Ward, J. Priscu, and C. Foreman), and the University of New Mexico (H. Newsom). The program was developed by P. Thompson (Lunar and Planetary Institute) in consultation with the science team. Teachers and EPO specialists represented Arizona, California, Massachusetts, Mississippi, New Mexico, Tennessee, Texas, Washington, and Wyoming.

NEW IN PRINT

These publications are available from booksellers or the publisher listed. Please note that the LPI does not offer these books through its order department.



REVIEW

The Cambridge Photographic Guide to the Planets
by F. W. Taylor
306 pages
Cambridge Univ. Press, 2002
Hardcover, $50. 306 pp.

This volume could not have been produced 20 years ago. It has been made possible in particular by the advent of NASA's "faster, better, cheaper" program, which has spurred numerous unmanned orbiter and probe missions to previously unvisited solar-system bodies. Among other benefits, these missions have provided a family album of revealing photographs of our many previously unseen and mysterious neighbors.

The *Cambridge Photographic Guide* provides a solid photographic introduction to the solar system for general readers. Beginning with Mercury and moving out toward Pluto and the Kuiper Belt, each planetary system is given a 30–40-page treatment, with the exceptions of Uranus, Neptune, and Pluto, which understandably receive shorter shrift. Asteroids and comets are considered in their own chapter between Mars and Jupiter. The Jupiter chapter itself includes equal treatments of the Galilean moons and does not deal extensively with the planet itself, besides providing an explanation of the body's banded colors. Images throughout the book include color plates, black-and-white photos and mosaics, computer-generated images, computer-enhanced images, and exaggerated constructions.

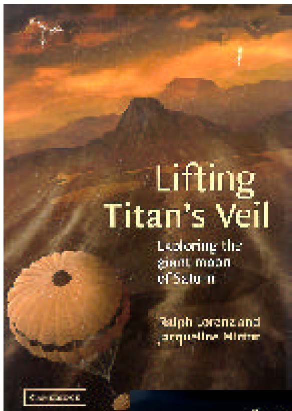
Taylor's captions are vivid, clear, and concise, so that the reader with no geological training will find himself in the first chapter quickly learning the effects of impact melting, shock waves, and impact energy on the character of a planet's surface. All basic terms, from "basin" to "terminator," are explained in nontechnical and accessible fashion. Other topics Taylor touches on include the system of naming features and the need for future missions to fill gaps in image collections. In addition, an introductory chapter deals with the formation and evolution of the solar system.

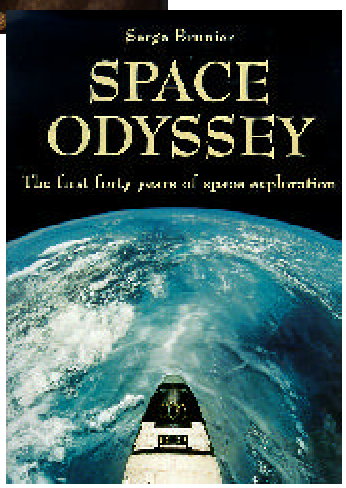
The specialized planetary scientist will likely find this book's text too basic, although astronomers and general space scientists may find much value in the book as an illustrative guide to planetary science. Planetary scientists may consider the book as a useful teaching tool, appealing display item, or simply a fetching photographic diversion. In most respects, however, the book appeals most instantly to the scientifically curious general reader and photography buff. In some ways, the book provides an interesting contrast to Carl Sagan's sweeping *Cosmos* (1980), which relied in no small part on speculative illustrations and comparative Earth photographs. In short, the book is an arresting reminder of the stunning collection of photos and photo mosaics that have been amassed from 30 years of solar-system exploration and a compelling record of the journeys of *Pathfinder, Galileo, Magellan, Clementine,* and the rest of man's team of continuing explorers.

— Brian Anderson

(Brian Anderson is the editor of the Lunar and Planetary Information Bulletin.)

NEW IN PRINT





RECENTLY PUBLISHED

Lifting Titan's Veil: Exploring the Giant Moon of Saturn. By Ralph Lorenz and Jacqueline Mitton. Cambridge Univ. Press, 2002. 260 pp. Hardcover, $29. Descriptive overview of man's knowledge and exploration of the second largest moon in the solar system, beginning with the satellite's discovery in 1655 up to the *Cassini* mission.

Space Odyssey: The First Forty Years of Space Exploration. By Serge Brunier. Cambridge Univ. Press, 2002. 192 pp. Hardcover, $40. From the catalog: "From the first flight by Yuri Gagarin in 1961, via Neil Armstrong's first steps on the Moon in 1969, to the latest Mars missions, it has taken only forty years for the exploration of space to become one of humanity's greatest ever achievements. Space Odyssey follows through the great moments of this saga, telling the tale of four hundred men and women who have been into space, some of whom have walked on the Moon." Oversized.

Also Received

Hands-On Astronomy: A Cambridge Guide to Equipment and Accessories. By H. Burillier and L. Christophe. Cambridge Univ. Press, 2002. Paperback, $14.

Flash! The Hunt for the Biggest Explosions in the Universe. By G. Schilling. Cambridge Univ. Press, 2002. Hardcover, $28.

Radiative Transfer in the Atmosphere and Ocean. By Gary E. Thomas and Knut Stamnes. Cambridge Univ. Press, 2002. Hardcover, $90; paperback, $45.

An Introduction to Radiative Transfer: Methods and Applications in Astrophysics. By Annamaneni Peraiah. Cambridge Univ. Press, 2002. Hardcover, $110; paperback, $40.

Supernovae and Gamma-Ray Bursts: The Greatest Explosions since the Big Bang. Edited by M. Livio et al. Cambridge Univ. Press, 2002. Hardcover, $80.

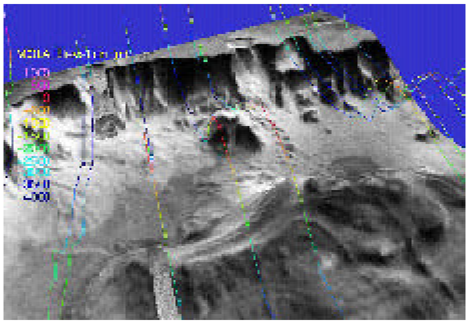
Air-Sea Interaction: Laws and Mechanisms. By G. T. Csanady. Cambridge Univ. Press, 2001. Hardcover, $95; paperback, $34.95.

Visions of the Future: Astronomy and Earth Science. By J. M. T. Thompson. Cambridge Univ. Press, 2001. Paperback, $24.95.

The Physics of Atmospheres, Third Edition. By John Houghton. Cambridge Univ. Press, 2002. Hardcover, $95; paperback, $35.

Children of the Stars: Our Origin, Evolution, and Destiny. By D. R. Altschuler. Cambridge Univ. Press, 2002. Hardcover, $28.

NEWS FROM SPACE



NASA Ames Research Center

3D VRML depicting Viking terrain data and surface images, with embedded high-resolution images and laser altimeter tracks from the Mars Global Surveyor.

NASA Unveils Marsoweb Web Site

Marsoweb, an interactive Web site developed by NASA, is helping scientists select suitable landing sites for future missions to Mars.

Scientists preparing for NASA's next Mars mission, the twin Mars Exploration Rovers scheduled for launch in June and July 2003, are able to view more than 44,000 high-resolution images of Mars collected by the *Mars Global Surveyor*. Some show detail at less than 3 meters per pixel. These images are registered with context images and maps of thermal properties, rock abundance, slope roughness, and geology acquired by the *Viking* and *Global Surveyor* orbiters and with altimeter and mineralogical data returned by *Global Surveyor,* which is still operating at Mars. The Web site provides scientists with special software tools to facilitate their interpretation of the data.

Ames' CMEX planetary geologist and project leader Dr. Virginia Gulick of the SETI Institute and Glenn Deardorff, a visualization technologist in the NAS Division at NASA Ames who has an undergraduate degree in geophysics, developed Marsoweb over the past three years to make a significant contribution to the ongoing Mars exploration program.

"It is easy to be overwhelmed by the great variety of available data relating to a candidate landing site," said Gulick, who serves on a NASA committee guiding the landing site selection process. "By pulling everything together and adding advanced visualization and analysis tools, we've enabled people to focus on studying the candidate sites and not lose time worrying about how to display, manipulate, and compare all the relevant, but disparate, datasets," she said.

"More than 100 sites on Mars have been considered by dozens of planetary scientists who are involved in analyzing candidate landing sites," said Deardorff. "Marsoweb provides a resource for them to increase their productivity as they wade through the available data."

Marsoweb includes an interactive feature developed by Deardorff that allows scientists to view Mars' surface in perspective and from any angle to help assess prospective landing sites from a collection of more than 400 images. This Marsoweb software feature contains a Virtual Reality Modeling Language (VRML) component that provides a three-dimensional image of the surface of Mars. Using the VRML, users can enjoy zooming through the canyons and valleys of Mars or over its volcanos and desert dunes. Another time-saving feature of the Web site allows scientists to rapidly superimpose high-precision elevation data from the Mars Orbiter Laser Altimeter (MOLA) on images of the surface.

For more information, visit the Marsoweb Web site at http://marsoweb.nas.nasa.gov.

LPI Scientist: Europa Has Thick Ice Shell

Detailed mapping and measurements of impact craters on Jupiter's large icy satellites reveal that Europa's floating ice shell may be at least 19 kilometers thick. These measurements, by staff scientist and geologist Dr. Paul Schenk at the Lunar and Planetary Institute, are reported in the May 23 issue of *Nature*. The results are based on stereo and topographic analysis of images of impact craters on these satellites acquired from NASA's *Galileo* spacecraft, currently orbiting Jupiter and heading toward its final plunge into Jupiter in late 2003.

Geologic and geophysical evidence from *Galileo* supports the idea that a liquid water ocean exists beneath the icy surface of Europa. Debate now centers on how thick this icy

(continued on page 13)

MILESTONES

Herrick takes helm of Broker/Facilitator contract

Herrick

Dr. Robert Herrick has been appointed principal investigator for the Lunar and Planetary Institute's Broker/Facilitator contract. The Broker/Facilitator program, administered by NASA's Office of Space Science Education and Public Outreach, is facilitated by the LPI for the mid- and southwestern region of the United States. The program aims to connect scientists with educators and educational programs. Dr. Herrick, whose primary research interests are impact cratering and large-scale tectonic and volcanic history of the terrestrial planets, has been with the Institute since 1993.

"I personally find educational and public outreach to be a challenging and rewarding task," Herrick said. "I strongly feel that every scientist should spend some effort communicating their work to the general public and working to improve general science literacy. After all, the citizenry does pay our salaries. Over the years I have been very involved in the planning and development of LPI's outreach program, and I now look forward to managing our Broker/Facilitator effort to broaden the participation of space scientists in educational outreach."

More information on the Broker/Facilitator program can be found on the LPI Web site at http://www.lpi.usra.edu/education/EPO/broker.html.

LeBlanc Appointed Director of DSLS

LeBlanc

Dr. David Black, President of Universities Space Research Association, announced in February that Dr. Adrian LeBlanc has been named Director of USRA's Division of Space Life Sciences in Houston. "Dr. LeBlanc brings to USRA a rich and varied research background, including numerous studies of bone loss and osteoporosis and vast experience in nuclear medicine, medical radiation, and imaging," Black said. "These experiences will be vitally important to his leadership of the division and its scientists and staff to facilitate participation of the university community in NASA's biomedical research programs."

More information on the Division of Space Life Sciences can be found on their Web site at http://www.dsls.usra.edu.

Space Science Manager Dies at 59

Huckins

Dr. Earle K. Huckins III, 59, a top manager for the Office of Space Science at NASA Headquarters in Washington, DC, died July 22 at his home in Centreville, Virginia, of complications from amyotrophic lateral sclerosis, often called Lou Gehrig's disease.

From February 1996 until November 2001, he served as Deputy Associate Administrator for Space Science at Headquarters, responsible for the executive direction of NASA's space science flight program including missions such as the Hubble Space Telescope; the Chandra X-Ray Telescope; and planetary missions including Mars Pathfinder, Mars Global Surveyor, Mars Odyssey, the Galileo mission to Jupiter and the Cassini mission to Saturn.

During his tenure as deputy, he oversaw the successful launch of 25 space missions. He was also responsible for the overall contract management of the Jet Propulsion Laboratory (JPL), Pasadena, California. He resigned as deputy in November 2001 because of his declining health, but continued working as a special assistant.

PUBLICATIONS FROM LPI

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	C-RSPECTG	ALTA REFLECTANCE SPECTROMETER CLASSROOM LESSONS **(CD-ROM)**		$10.00	

		OTHER PUBLICATIONS **AVAILABLE FOR THE COST OF SHIPPING AND HANDLING**		
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	CB-971	NINTH ANNUAL V. M. GOLDSCHMIDT CONFERENCE **(BOOK)**	$0.00	
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	CB-1095	CONFERENCE ON THE GEOPHYSICAL DETECTION OF SUBSURFACE WATER ON MARS **(BOOK)**	$0.00	
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	CB-1128	THE MOON BEYOND 2002: NEXT STEPS IN LUNAR SCIENCE AND EXPLORATION (BOOK)	$0.00	
	CB-1129	SOLAR SYSTEM REMOTE SENSING (BOOK)	$0.00	

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Each Teacher's Guide (hard copy)	$8.00	$40.00

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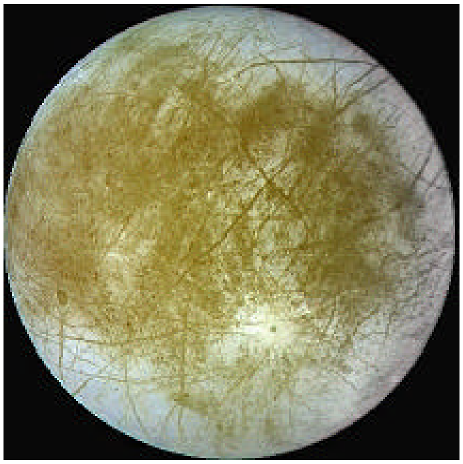

Europa

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shell is and the implications for life forms that could exist in the ocean. An ocean could melt through a thin ice shell only a few kilometers thick exposing water and anything swimming in it to sunlight (and radiation). A thin ice shell could melt quickly and then refreeze, giving photosynthetic organisms easy access to sunlight. A thick ice shell — tens of kilometers — would be more difficult to melt through and, since sunlight cannot penetrate more than a few meters into the ice, would preclude photosynthetic organisms. It would also require other processes to expose any ocean material on the surface, where we can search for it.

Dr. Schenk's estimate of the ice thickness is based on a comparison of the topography and morphology of more than 200 impact craters on Europa and on its sister satellites, Ganymede and Callisto. Although both Ganymede and Callisto may have liquid water oceans inside, they also have extremely thick ice shells (roughly 100–200 kilometers). Thus the final surface expression of most craters will be unaffected by the warmer ocean and can be used for comparison with Europa, where the depth to the ocean is uncertain but likely to be much shallower.

Dr. Schenk found that the shapes of Europa's larger craters differ significantly from similar-sized craters on Ganymede and Callisto. His measurements show that this begins with craters larger than 8 kilometers in diameter. The difference is caused by the arming of the lower part of Europa's less-thick ice shell by the ocean. Warm ice is soft and flows relatively quickly (as in glaciers on Earth).

Craters larger than ~30 kilometers show even more dramatic differences. Craters smaller than this are several hundred meters deep and have recognizable rims and central uplifts (standard features of impact craters). Craters on Europa larger than 30 kilometers have no rims or uplifts and have little topographic expression. Instead, they are surrounded by sets of concentric troughs and ridges. This observation implies a fundamental change in the properties of Europa's icy crust at increasing depths. The most logical is a transition from solid to liquid. The concentric rings may be caused by wholesale collapse of the crater floor. As the originally deep crater hole collapses, the material underlying the icy crust rushes in to fill in the void. This inrushing material drags on the overlying crust, fracturing it and forming the observed concentric rings.

Larger impacts penetrate more deeply into the crust and are sensitive to the crustal properties at those depths, providing clues to the thickness of the ice shell. Dr. Schenk estimated how big the original crater was and how shallow a liquid layer must be to affect the final shape of the impact crater. Numerical calculations and impact experiments by other researchers were used to produce a "crater collapse model" that is used to convert the observed transition diameter to a thickness for the layer. Hence, a crater 30 kilometers wide is sensing or detecting layers 19–25 kilometers deep. Although there are some uncertainties in this model (10–20% because of the difficulty of duplicating impacts mechanics on Earth), Schenk concludes that the icy shell cannot be only a few kilometers thick, as some have proposed.

Does a thick ice shell mean there is no life on Europa?

"No," Schenk said. "Given how little we know about the origins of life and conditions inside Europa, life is still plausible. If organisms inside Europa can survive without sunlight, then the thickness of the shell is of only secondary importance. After all, organisms do quite well on the bottom of Earth's oceans without sunlight, surviving on chemical energy. This could be true on Europa if it is possible for living organisms to originate in this environment in the first place."

He points out that Europa's ice shell could have been much thinner — or even nonexistent — in the distant past, allowing a variety of organisms to evolve. If the ocean

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began to freeze over, the organisms could adapt to new environmental niches over time, allowing life of some sort to survive.

A 19–25-kilometer-thick crust will, however, make drilling or melting through the ice with tethered robots impractical.

"The challenge will be for us to devise a clever strategy for exploring Europa that won't contaminate what is there yet find it nonetheless. The prospect of a thick ice shell limits the number of likely sites where we might find exposed oceanic material. Most likely, ocean material will be embedded as small bubbles or pockets or as layers within ice that has been brought to the surface by other geologic means," Schenk said.

Images and more information about Schenk's research can be found at http://www.lpi.usra.edu/research/europa/thickice/.

Four Arrested in Scheme to Sell Moon Rocks

On July 20, 2002, the Federal Bureau of Investigation (FBI) Tampa and the NASA Office of Inspector General (OIG) recovered priceless lunar samples brought back to Earth by each of the Apollo missions that landed on the Moon. A 600-pound safe containing lunar samples from every Apollo mission was stolen from the NASA Johnson Space Center (JSC) on July 13.

James F. Jarboe, Special Agent in Charge, FBI Tampa Division, and Lance Carrington, NASA OIG Assistant Inspector General for Investigations, announced the arrest, without incident, of three individuals, Thad Ryan Roberts, age 25; Tiffany Brooke Fowler, age 22; and Gordon Sean McWorter, age 26. The three were taken into custody in Orlando, Florida, by Special Agents of the FBI and the NASA OIG and charged with Conspiracy to Commit Theft of Government Property and Transportation in Interstate Commerce of Stolen Property. A fourth individual, Shae Lynn Saur, age 19, was arrested in Houston and also charged with conspiracy. Roberts, Fowler, and Saur were student employees at JSC.

Jarboe stated that since May 2002, an FBI undercover operation had utilized e-mail to communicate with an individual offering priceless moon rocks, which the individual described as the world's largest private and verifiable Apollo rock collection. The e-mail messages were sent from several locations: the University of Utah, JSC, and a public library in Houston. The continued exchanges included curatorial and historical records on the samples provided by the seller, and culminated in a meeting at a restaurant in Orlando over the weekend of July 20–21 to finalize the purchase of the Apollo moon rocks.

The defendants arrested in Orlando made their initial appearance before U.S. Magistrate Judge Thomas B. McCoun on July 22, 2002.

The FBI began this investigation after receiving a tip through an e-mail address established by the Tampa Division for Internet Fraud Matters. The e-mail address is ifcc.tp@fbi.gov. The NASA OIG also operates a cyber-hotline, which can be found at http://www.hq.nasa.gov/office/oig/hq/hotline.html.

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CALENDAR 2002

OCTOBER

6–11

34th Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society, Ann Arbor, Michigan.
Contact: DPS Chair Mark Sykes
E-mail: Sykes@as.arizona.edu

10–19

World Space Congress 2002, Houston, Texas.
Contact: American Institute of Aeronautics and Astronautics, 1801 Alexander Bell Drive, Suite 500, Reston VA, 20191-4344.
E-mail: wsc2002@aiaa.org
http://www.aiaa.org/wsc2002/

12–16

Impacts Through the Eyes of Geoscientists and Astronomers, Prague, Czech Republic.
Contact: jakes@natur.cuni.cz or petr.jakes@vednik.cz
http://www.natur.cuni.cz/impact

27–30

Geological Society of America Fall Meeting, Denver, Colorado.
Contact: Geological Society of America
Phone: 303-447-2020 or 1-800-472-1988
E-mail: meetings@geosociety.org

DECEMBER

6–10

American Geophysical Union Fall Meeting, San Francisco, California.
Contact: AGU, 2000 Florida Avenue N.W., Washington DC 20009.
Phone: 202-462-6900

FEBRUARY 2003

2–6

Space Technology and Applications Forum (STAIF-2003), Albuquerque, New Mexico.
Contact: Institute for Space and Nuclear Power Studies, The University of New Mexico, Farris Engineering Center, Room 239, Albuquerque NM 87131-1341.
Phone: 505-277-2813
Fax: 505-277-2814
http://www.unm.edu/~isnps/

7–9

Impact Cratering: Bridging the Gap Between Modeling and Observations, Houston, Texas.
Contact: Publications and Program Services Department, Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston TX 77058-1113.
Phone: 281-486-2151
Fax: 281-486-2160
E-mail: taylor@lpi.usra.edu

MARCH 2003

17–21

34th Lunar and Planetary Science Conference, Houston, Texas.
Contact: Publications and Program Services Department, Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston TX 77058-1113.
Phone: 281-486-2144
Fax: 281-486-2160
E-mail: walley@lpi.usra.edu

JULY 2003

6–11

Gordon Research Conference on the Origins of Solar Systems, Roger Williams College, Bristol, Rhode Island.
http://www.grc.uri.edu.