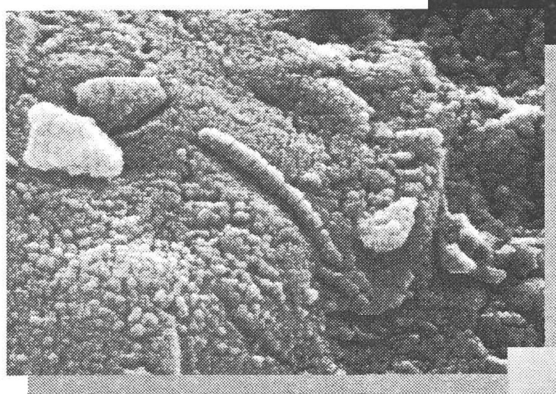
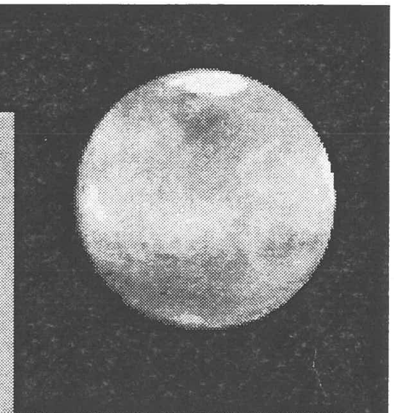
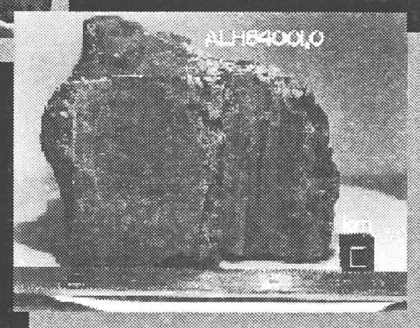
Lunar and Planetary Information
# BULLETIN

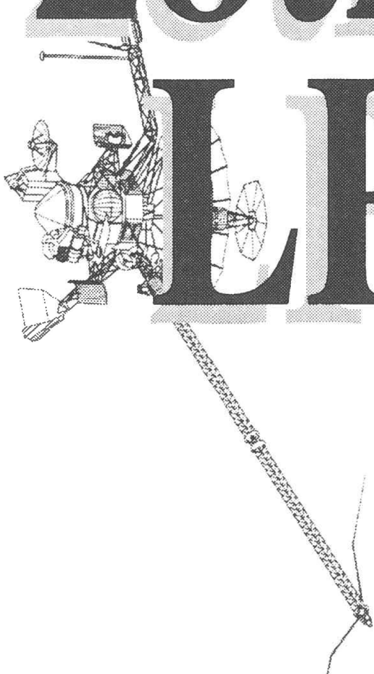
FALL 1996/NUMBER 81 • LUNAR AND PLANETARY INSTITUTE • UNIVERSITIES SPACE RESEARCH ASSOCIATION

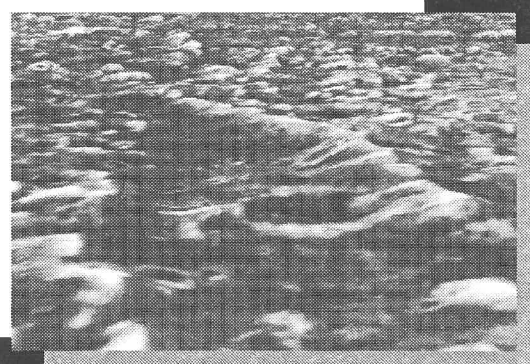
# 28th LPSC

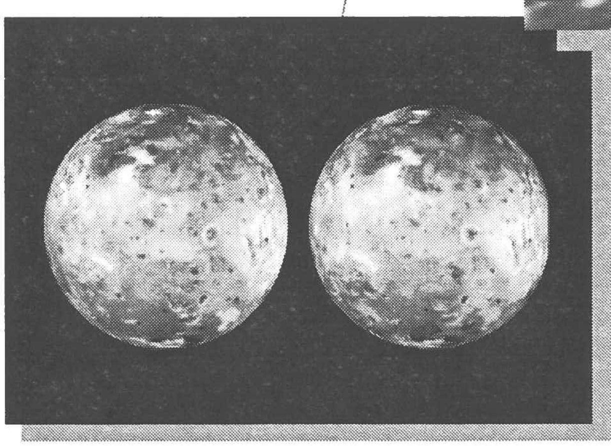










## *28th Lunar and Planetary Science Conference*

**For information on special sessions, see page 2**

# 28th Lunar and Planetary Science Conference

MARCH 17–21, 1997 HOUSTON, TEXAS

## World-Wide Web Site for all LPSC Information

The LPI Publications and Program Services Department has created a Web site with complete information on the 1997 LPSC at

**http://cass.jsc.nasa.gov/LPSC97**

From special session information to local area maps, this site is the "one-stop shopping" center for the conference.

Members of the community who do not have Web access will receive information in the final announcement, to be mailed in early February.

The 28th Lunar and Planetary Science Conference will be held in Houston, Texas, on March 17–21, 1997. Sessions will be held as usual at the NASA Johnson Space Center (JSC) and the Lunar and Planetary Institute (LPI).

The LPSC program committee created the conference program from abstracts submitted by researchers in appropriate scientific disciplines. Complete abstracts will be available on line this year in PDF format, viewable with the Adobe Acrobat reader, which can be downloaded free from the World-Wide Web site:

http://www.adobe.com/supportservice/custsupport/tsfilelib.html

*In addition to the traditional printed volumes, abstracts will be available on CD-ROMs for the first time; both versions will be available at conference registration.*

## Conference Format

The four-and-a-half day conference will be organized by topical symposia and problem-oriented sessions. Participants were asked to indicate a preference for oral, poster, or title-only presentation when submitting an abstract to the confererence.

## Presentations

Oral presentations will be scheduled during the conference to allow eight minutes for speaking and seven minutes for discussion and speaker transition. Poster presentations will be scheduled for Tuesday and Thursday evenings from 6:30 to 9:30 p.m. at the LPI. Authors of papers scheduled for poster presentations will be asked to be available to display and discuss their results in the poster area during the assigned time period. Additionally, posters may be viewed at LPI each day of the conference. Shuttle transportation between the Gilruth Center and LPI will be available. Each poster will have a space 44" × 44" for display. Requests for tables, computers, video equipment, etc., cannot be honored due to the limited space available for poster displays.

## Special Sessions

### Galileo: Summary of Mission

There will be a special plenary session on Galileo featuring an invited talk by Torrence Johnson entitled "Galileo: Year One at Jupiter," from 1:30 to 2:30 p.m. on Monday. Immediately following the plenary there will be a special parallel session on Galileo and a second special parallel session on Tuesday morning.

### Masursky Lecture

The Harold Masursky Lecture Series will continue again this year with a plenary session, to be held from 1:30 to 2:30 p.m. on Wednesday, entitled "Meteorites on Ice," noting the twentieth anniversary of the first U.S. expedition to recover Antarctic meteorites, and the two decades of research that followed. A special session entitled "New Results on the Possibility of Life in a Martian Meteorite," will be held in plenary immediately following the Masursky Lectures. This session will consist of invited talks and a panel discussion.

### Poster and Display Sessions on Education

Two special poster/display sessions on education will be held at LPI on Tuesday and Thursday evenings during the regular technical poster sessions. The format provides much more interaction, which is lacking in an oral session; it allows participants to demonstrate some of the projects hands-on rather than simply describing them orally. The education special sessions will be located in and around the LPI library. Participants will be expected to provide their own computer equipment.

## Chili Cookoff

The chili cookoff and barbecue dinner will be held on Wednesday, March 19, from 6:00 to 9:30 p.m. at the Landolt Pavilion. A chili cookoff team entry form can be found at the LPSC Web site.

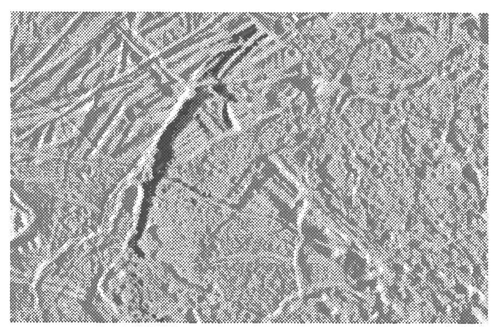
Out-of-town teams are encouraged to enter. Because the conference staff can no longer provide cooking equipment, the preparation-on-site rule common to most cookoffs will be waived to encourage more team participation. The goal of this event is fun, not serious cooking competition. We need more teams to take part in the cookoff, and will cancel the cookoff portion of the event if we do not receive sufficient entries by the February 24 deadline. Join the fun by entering your favorite concoction and compete against other secret recipes. There will be awards for best presentation as well as first-, second-, and third-place awards for the best chili.

## Registration

The fee of $50 ($30 for students) covers conference services. You must preregister and prepay by February 24, 1997, to avoid a $20 late fee. Foreign participants who state on the registration form that they have a currency exchange problem may pay in cash at the meeting and avoid the $20 late fee if they return the form by February 24, 1997. You can register by completing and submitting either the electronic registration form or the downloadable registration form found at the LPSC Web site.

Requests for cancellation and refunded fee will be accepted through March 7, 1997. Those who fail to attend and do not notify the LPI Publications and Program Services Department prior to March 7 will not receive a refund.

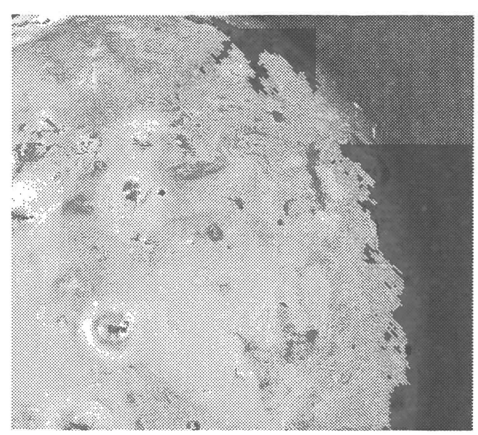
### Sunday Night Registration and Reception



The Sunday night registration and reception will take place as usual at LPI from 6:00 to 9:00 p.m. The location is shown on the local area map found on the Web. Shuttle buses will operate from selected hotels to LPI on Sunday night.

### Hotel Reservations

A list of local hotels can be found at the Web site. Although making reservations is the responsibility of each participant, we have negotiated reduced rates at some locations. When you call a hotel, you must tell them you are attending the Lunar and Planetary Science Conference and ask for the conference rate. Refer to the area map on the Web for the locations of JSC, LPI, and local hotels.



### Conference Shuttle Service

Conference shuttle buses will provide service between most hotels, the JSC Gilruth Center, and LPI in the morning, during lunch, at the close of sessions, and during special events. Computer displays, exhibits, poster sessions, and other conference-related events will be located at LPI; shuttle buses will make hourly stops there throughout conference week. Your conference badge will serve as your bus ticket. A detailed shuttle schedule will be provided to all registered participants.

### Additional Information

For further information on the conference program or logistics, please call the LPI Publications and Program Services Department at 281-486-2158.

# GUIDE TO TECHNICAL SESSIONS AND ACTIVITIES

**Monday morning, 8:30 a.m.**
Room A — Mars Flows and Processes
Room B — ALH 84001: Carbonates and Life (?)
Room C — Origins of Planetary Systems: Observations and Theory

**Monday afternoon, 1:30 p.m.**
Room C — SPECIAL SESSION (plenary)— Galileo: Year One at Jupiter

**Monday afternoon, 2:30 p.m.**
Room A — Achondrites
Room B — Mars Tectonics and Geophysics
Room C — SPECIAL SESSION—Galileo Mission Results: Overview and Io
Room D — Dust to Spherules—Captive and At Large

**Monday afternoon, 5:30 p.m.**
Room A — Reception to honor the GSA 1996 Stephen E. Dwornik Student Paper Award Winners

**Tuesday morning, 8:30 a.m.**
Room A — Ordinary and Enstatite Chondrites
Room B — Mars Remote Sensing
Room C — SPECIAL SESSION—Galileo Mission Results: Europa and Ganymede
Room D — Lunar Basins to Regolith: Processes and Effects

**Tuesday afternoon, 1:30 p.m.**
Room A — Presolar Grains
Room B — Lifeless (?) Martian Meteorites
Room C — Outer Planetary Satellites
Room D — Future Missions? Innovation and Ambition

**Tuesday evening, 6:30–9:30 p.m.**
LPI — SPECIAL SESSION— Education and Outreach: Activities and Resources
LPI — Poster Session I

**Wednesday morning, 8:30 a.m.**
Room A — Chondrules
Room B — Mars Water, Climate, and Life
Room C — Lunar Highlands Crust
Room D — Iron Meteorites

**Wednesday afternoon, 1:30 p.m.**
Building 2 — SPECIAL SESSION (plenary) Harold Masursky Lectures: Meteorites on Ice and the Mars Connection

Symposium: New Results on the Possibility of Life in a Martian Meteorite

Panel Discussion — Life on Mars: Science Issues and Directions

**Wednesday evening, 6:00–9:30 p.m.**
Conference Social Event, Landolt Pavilion

**Thursday morning, 8:30 a.m.**
Room A — Carbonaceous Chondrites
Room B — Venus Regional and Global Analysis
Room C — Lunar Origins and Igneous Evolution
Room D — The Impact Story— Mechanics, Experiments, Models

**Thursday afternoon, 1:30 p.m.**
Room A — Early Solar System Chronology
Room B — Venus: The Lithosphere and the Atmosphere
Room C — Lunar Mare Basalt Diversity and Distribution
Room D — Terrestrial Impact Structures Ejecta, and Tektites

**Thursday afternoon, 3:00 p.m.**
Room B — Mercury

**Thursday evening, 6:30–9:30 p.m.**
LPI — SPECIAL SESSION— Education and Outreach: Activities and Resources
LPI — Poster Session II

**Friday morning, 8:30 a.m.**
Room A — CAIs and Hot Topics
Room B — Small Bodies, Near and Far
Room C — Planetary Interior Processes

## PHONING LPI
## Note New Area Code 281

The area code for dialing LPI was changed from "713" to "281" in November 1996. The change includes most of the region outside the outer loop road (Beltway 8) that circles Houston. Johnson Space Center is now in the 281 area code, as are the local hotels convenient to LPI and JSC. Downtown Houston numbers will retain the 713 prefix.

**LPI Director's Office**
281-486-2180; fax: 281-486-2173

**LPI Center for Information and Research Services**
281-486-2182; fax: 281-486-2186

**LPI Scientific Secretary**
281-486-2192; fax: 281-486-2162

**LPI Computer Center**
281-486-2165; fax: 281-486-2155

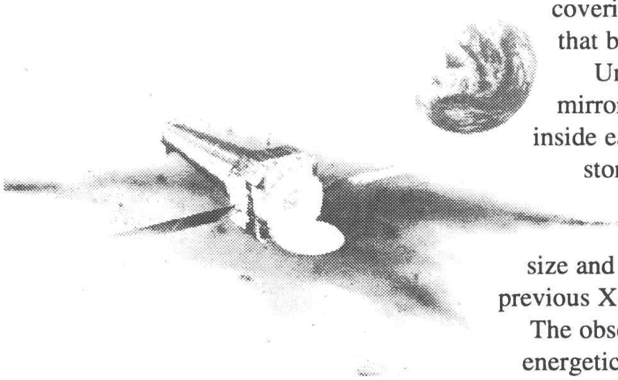
**LPI Publications and Program Services**
281-486-2166; fax: 281-486-2160

# NEWS FROM SPACE

## AXAF MIRROR ASSEMBLY COMPLETED

The third of NASA's "Great Observatories," a powerful X-ray telescope, took a big step closer to completion recently with the assembly of its high-resolution mirrors. The last of four pairs of unique mirrors that form the heart of the Advanced X-ray Astrophysics Facility (AXAF) were aligned and cemented into place at Eastman Kodak's Federal Systems Division in Rochester, New York, in September.

"The extreme sensitivity of the mirrors made the installation a very delicate and painstaking process," said John Humphreys, Project Development Manager at Marshall Space Flight Center. "Successful completion of the process represents a real achievement in the development of the telescope."



The high-resolution mirror assembly was outfitted with additional hardware and a covering in preparation for testing and calibration in a special facility at Marshall that began in mid November.

Unlike the concave, nearly flat mirrors used in optical telescopes, the AXAF mirrors are shallow, almost cylindrical cones. The four pairs of mirrors are nested inside each other. X-rays enter the telescope, graze off the mirrors — much like a stone skipping across the surface of a pond — and are focused onto a plane 30 feet behind the front of the mirrors.

The largest of the mirrors is 47.2 inches, the largest ever made. The size and accuracy of the mirrors will make AXAF 100 times more sensitive than previous X-ray telescopes, producing images 10 times sharper.

The observatory is scheduled for a shuttle launch in 1998. In orbit, it will observe energetic X-ray sources such as neutron stars, black holes, debris from exploding stars, quasars, cores of galaxies, and galaxy clusters. Joining the Hubble Telescope and the Compton Gamma Ray Observatory, it will extend the "Great Observatories" exploration into the X-ray spectrum.

## SIGNS OF LIFE ON EARTH 3.85 BILLION YEARS AGO IN GREENLAND ROCKS

Scientists reporting in the November 7 issue of *Nature* believe they have evidence for life in ancient sediments on Akilia Island in southern West Greenland that are at least 3.85 billion years old.

The scientists, from UC San Diego's Scripps Institution of Oceanography, UCLA's Department of Earth and Space Sciences, the Australian National University, and England's Oxford Brookes University, present evidence that suggests life may have emerged 300 million to 400 million years earlier than previously thought.

"We look in rocks like this for chemical suggestions and isotopic evidence, and we found both," said T. Mark Harrison, professor of geochemistry at UCLA and director of the W. M. Keck Foundation Center for Isotope Geochemistry. "It would be wonderful to see a head and toes, and, while we don't have those, we have found very strong isotopic evidence for ancient life."

". . . in the cases of Earth's most ancient rocks and minerals, we are actually better off relying on this type of isotopic evidence — chemofossils — rather than on the shape of life-like objects with which nature has often been deceiving the unwary," said Gustaf Arrhenius, professor of oceanography at UC San Diego and principal investigator for the research project.

The researchers analyzed carbon inclusions in apatite grains to measure the ratio of $^{12}C$ to $^{13}C$ using a high-resolution ion-microprobe mass spectrometer. They found that

# HST CENSUS SUGGESTS MASSIVE BLACK HOLES INHABIT MOST GALAXIES

With the discovery of three black holes in three normal galaxies, an international team of astronomers suggests that nearly all galaxies may harbor supermassive black holes that once powered quasars — extremely luminous nuclei of galaxies — that are now quiescent.

This conclusion is based on a census of 27 nearby galaxies carried out by the Hubble Space Telescope and groundbased telescopes in Hawai'i, which are being used to conduct a spectroscopic and photometric survey of galaxies to find black holes that have consumed the mass of millions of Sun-like stars.

The findings, presented at the 189th Meeting of the American Astronomical Society in Toronto, Canada, should provide insights into the origin and evolution of galaxies as well as the role of quasars in galaxy evolution.

As a result of the survey, the researchers now believe that supermassive black holes are so common that nearly every large galaxy harbors one. They also suggest that a black hole's mass is proportional to the mass of the host galaxy, so that, for example, a galaxy twice as massive as another would have a black hole that is also twice as massive. This discovery suggests that the growth of the black hole is linked to the formation of the galaxy in which it is located. The number and masses of the black holes found are consistent with what would have been required to power the quasars.

"We believe we are looking at 'fossil quasars' and that most galaxies at one time burned brightly as a quasar," says team leader Doug Richstone of the University of Michigan, Ann Arbor. These conclusions are consistent with previous HST observations showing quasars within a variety of galaxies, from isolated normal-looking galaxies to colliding pairs.

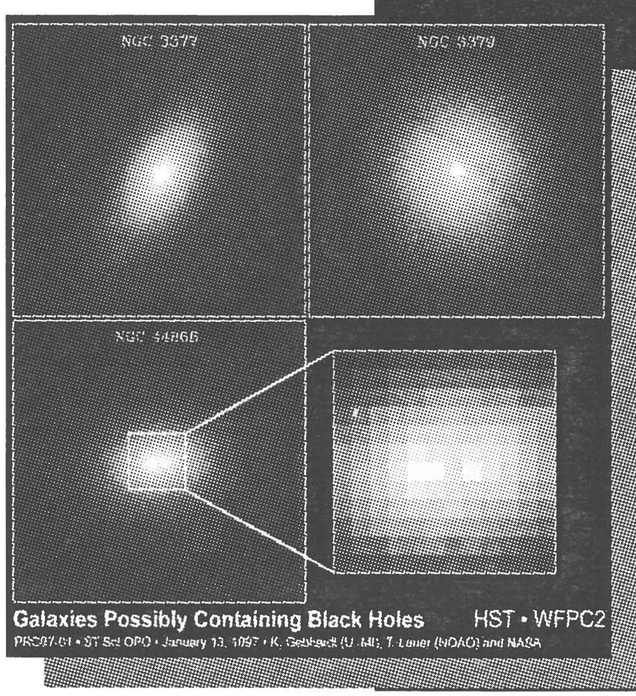
Two of the black holes in the cores of galaxies NGC 3379 (also known as M105) and NGC 3377 have masses of 50 million and 100 million Suns, respectively. These galaxies are in the "Leo Spur," a nearby group of galaxies about 32 million light years away, roughly in the direction of the Virgo cluster.

Located 50 million light years away in the Virgo cluster, NGC 4486B has a 500-million-solar-mass black hole. It is a small satellite of the very bright galaxy M87 in the Virgo cluster. M87 has an active nucleus and is known to have a black hole of about two billion solar masses.

Though several groups have previously found massive black holes in galaxies the size of our Milky Way or larger, these new results suggest that smaller galaxies have lower-mass black holes, below Hubble's detection limit, where the black hole's mass is proportional to the host galaxy's mass.

It remains a challenging puzzle why black holes are so abundant, or why they should be proportional to a galaxy's mass. One idea, supported by previous Hubble observations, is that galaxies formed out of smaller building blocks of star clusters. A massive "seed" black hole may have been present in each of these protogalaxies. The larger number of building blocks needed to merge

*Continued on page 19*




*The three galaxies (right) are believed to contain central, supermassive black holes. The galaxy NGC 4486B (lower left) shows a double nucleus (lower right).The images of NGC 3377 and NGC 4486B are 2.7 arcseconds on a side, and for NGC 3379 the size is 5.4 arcseconds; the lower right is a blow-up of the central 0.5 arcseconds of NGC 4486B.* **Credit: Karl Gebhardt (University of Michigan) and Tod Lauer (NOAO)** the carbon aggregates in the rock have a ratio of about 100 to 1 of the lighter isotope compared to the heavier. "The light carbon, $^{12}C$, is more than 3% more abundant than scientists would expect to find if life were not present, and 3% is, in this case, a very large amount," Arrhenius said.

The ratio is within the range of measurements made on younger rocks that are more certainly associated with biological activity, such as the 3.25 million-year-old Australian chert that contains bacteria-like organisms. Metamorphic alteration of the Akilia formation has left no trace of such organisms in the older rocks.

The inclusion of the carbon in apatite, which is often formed by biotic processes, but can also be formed inorganically, is "suggestive, and not surprising, but does not in itself establish life," according to Arrhenius.

If they are indeed the result of living organisms, these residues suggest that life arose almost simultaneously with the end of the late heavy bombardment of the inner solar system by meteoric debris. They could even represent a biota that began and was subsequently erased by catastrophic impact 3.8 billion years ago, to be followed by life's reemergence several hundred million years later.

"Life is tenacious, and it completely permeates the surface layer of the planet," said Steve Mojzsis of Scripps. "We find life beneath the deepest ocean, on the highest mountain, in the driest desert and the coldest glacier, and deep down in the crustal rocks and sediments. Not knowing what conditions are needed for the emergence of life, it is only possible to speculate about its existence elsewhere in the universe. An important contribution to the solution of this problem could come from exploration of the surface of Mars for traces there of extinct life."

## REPEAT BURSTS POSE NEW GAMMA-RAY PUZZLE

The mystery of where and how high-energy bursts of gamma rays originate has been given a puzzling new twist with the detection of the first sequence of repeated bursts in one region of the sky.

Four separate gamma-ray bursts were detected in two groups of two in rapid succession on October 27 and October 29. Astronomers based at Marshall Space Flight Center measured the unique sequence using the Burst and Transient Source Experiment (BATSE) instrument onboard the Compton Gamma Ray Observatory. The repeated bursts are unlike any of the other 1700 gamma-ray bursts observed by BATSE, which have been observed in all regions of the sky.

The BATSE finding is expected to add to the already vigorous debate on the distance to the sources of gamma-ray bursts and their causes — subjects still unresolved despite nearly 25 years of study.

BATSE usually detects only about one gamma-ray burst a day that lasts from 10 to 30 seconds, and the locations of these events on the sky appear to be randomly distributed. "That's what makes these recent events so unusual," said Charles Meegan, BATSE experiment co-investigator. "They came right after one another, about two days apart, and all from the same part of the sky. Moreover, the last one was much longer than usual, lasting 23 minutes."

The BATSE astronomers cannot yet say for sure whether these events were produced by just one object in space or several, but "it would be unlikely that this actually happened by chance" in four unrelated places, said Marshall Space Sciences Laboratory astrophysicist Valerie Connaughton.

"Some astronomers argue for an explanation that the origin of these bursts is fairly local, just outside our own galaxy," says Gerald Fishman, BATSE principal investiga tor, who agrees that the recent events are likely related. "But most believe that bursts come from remote parts of the universe, at cosmological distances of a billion light years or more."

Another unsolved mystery is how bursts are created. One theory suggests that bursts do not repeat from the same source because they involve a tremendous explosion that destroys the source in the process. Another possibility is that bursts occur when neutron stars merge, which would not be consistent with repeating bursts. "This discovery of multiple bursts adds fuel to the debate as to the source of the bursts," said Fishman.

The discovery was confirmed by three other gamma-ray burst detectors. Scientists from Goddard Space Flight Center, the University of California at Berkeley, and the Ioffe Institute in Russia participated in the discovery.

## RESEARCH SUGGESTS MOST OF EARTH'S OXYGEN SUPPLY WAS PRODUCED BY GEOLOGIC EVENTS

Refined calculations and new evidence support a revolutionary suggestion that global-scale geologic events produced the bulk of Earth's oxygen supply, a NASA scientist reported at the Geological Society of America meeting in late October.

Scientists have long believed that oxygen collected in Earth's early atmosphere as a by-product of photosynthesis, in which plants take in carbon dioxide and water to produce organic matter and oxygen. David Des Marais, of Ames Research Center, first suggested in 1992 a relationship between oxygen and plate tectonics, in which plate collisions that built enormous mountain ranges and increased erosion buried huge amounts of organic matter in ocean beds.

"Although photosynthesis did provide an oxygen source strong enough to sustain the amount of existing oxygen, the creation and assembly of large modern-sized continents was responsible for early dramatic increases in oxygen," Des Marais said.

His research correlates oxygen surges in the atmosphere 2.2 to 2.0 billion years ago with changes in the amount of carbon stored in Earth's crust at that time. During that time, several of Earth's "micro" continents crashed together, forming new, stable modern-sized continents. As the continental fragments collided, mountain ranges formed. Their steep slopes produced rapid erosion and sedimentation, key to Des Marais' theory.

Organic matter is normally consumed by bacteria and animals, a process that utilizes oxygen (respiration), producing energy and carbon dioxide and water as by-products. According to Des Marais, when huge amounts of organic matter were buried during tectonic collisions, oxygen was freed to accumulate in Earth's early atmosphere.

"The cycle of photosynthesis (which produces oxygen) and respiration (where oxygen is consumed) is an almost break-even process," Des Marais said. Only when large amounts of organic material are buried in ocean sediments during tectonic upheavals can the amount of oxygen in the atmosphere increase substantially, he added.

A recent independent study concludes that approximately three large continental masses were assembled between 2.5 and 1.9 billion years ago by the collision of smaller land masses. Two of these were assembled between 2.2 and 1.9 billion years ago.

*Continued on page 19*

# PUBLICATIONS FROM LPI

## BOOKS

| QUANTITY | CODE | TITLE | PRICE | TOTAL |
|---|---|---|---|---|
| | PRO-20 | PROCEEDINGS OF THE TWENTIETH LUNAR AND PLANETARY SCIENCE CONFERENCE | $10.00 | |
| | PRO-22 | PROCEEDINGS OF THE LUNAR AND PLANETARY SCIENCE CONFERENCE, VOLUME 22 | $10.00 | |
| | B-ACM | ASTEROIDS, COMETS, METEORS 1991 | $10.00 | |

## SLIDE SETS

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| NEW | S-LIFE | LIFE ON MARS? **(AVAILABLE MARCH 1)** | $22.00 | |
| | S-RED | THE RED PLANET: A SURVEY OF MARS (40 SLIDES) | $22.00 | |
| | S-IMPACT | TERRESTRIAL IMPACT CRATERS (26 SLIDES) | $20.00 | |
| | S-WINDS | THE WINDS OF MARS: AEOLIAN ACTIVITY AND LANDFORMS (30 SLIDES) | $20.00 | |
| | S-STONES | STONES, WIND, AND ICE: A GUIDE TO MARTIAN IMPACT CRATERS (30 SLIDES) | $20.00 | |
| | S-VOLC | VOLCANOES ON MARS (20 SLIDES) | $18.00 | |
| | S-APOLLO | APOLLO LANDING SITES (40 SLIDES) | $22.00 | |
| | S-OCEANS | SHUTTLE VIEWS THE EARTH: THE OCEANS FROM SPACE (40 SLIDES) | $22.00 | |
| | S-CLOUDS | SHUTTLE VIEWS THE EARTH: CLOUDS FROM SPACE (40 SLIDES) | $22.00 | |
| | S-GEOL | SHUTTLE VIEWS THE EARTH: GEOLOGY FROM SPACE (40 SLIDES) | $22.00 | |
| | S-CLEM | CLEMENTINE EXPLORES THE MOON (20 SLIDES) | $18.00 | |
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| | S-HAWAII | VOLCANIC FEATURES OF HAWAII AND OTHER WORLDS (40 SLIDES) | $22.00 | |

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| | 93-07 | ANTARCTIC METEORITE LOCATION AND MAPPING PROJECT, 2ND EDITION | $0.00 | |
| | 94-01 | VENUS DATA ANALYSIS PROGRAM: DIRECTORY OF RESEARCH PROJECTS (1993–1994) | $0.00 | |
| | 94-05 | WORKSHOP ON PARTICLE CAPTURE, RECOVERY, AND VELOCITY/TRAJECTORY MEASUREMENT TECHNOLOGIES | $0.00 | |
| | 95-01 | MARS PATHFINDER LANDING SITE WORKSHOP II: CHARACTERISTICS OF THE ARES VALLIS REGION AND FIELD TRIPS IN THE CHANNELED SCABLAND, WASHINGTON | $0.00 | |
| | 95-02 | WORKSHOP ON METEORITES FROM COLD AND HOT DESERTS | $0.00 | |
| | 95-03 | WORKSHOP ON DISCOVERY LESSONS-LEARNED | $0.00 | |
| | 95-04 | WORKSHOP ON MARS TELESCOPIC OBSERVATIONS | $0.00 | |
| | 95-05 | PLANETARY SURFACE INSTRUMENTS WORKSHOP | $0.00 | |
| | 96-01 | WORKSHOP ON EVOLUTION OF MARS VOLATILES | $0.00 | |

## LPSC ABSTRACT VOLUMES

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| | ABS-27 | LPSC XXVII | $0.00 | |
| | ABS-28 | LPSC XXVIII | $0.00 | |

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# MARS ROUNDUP

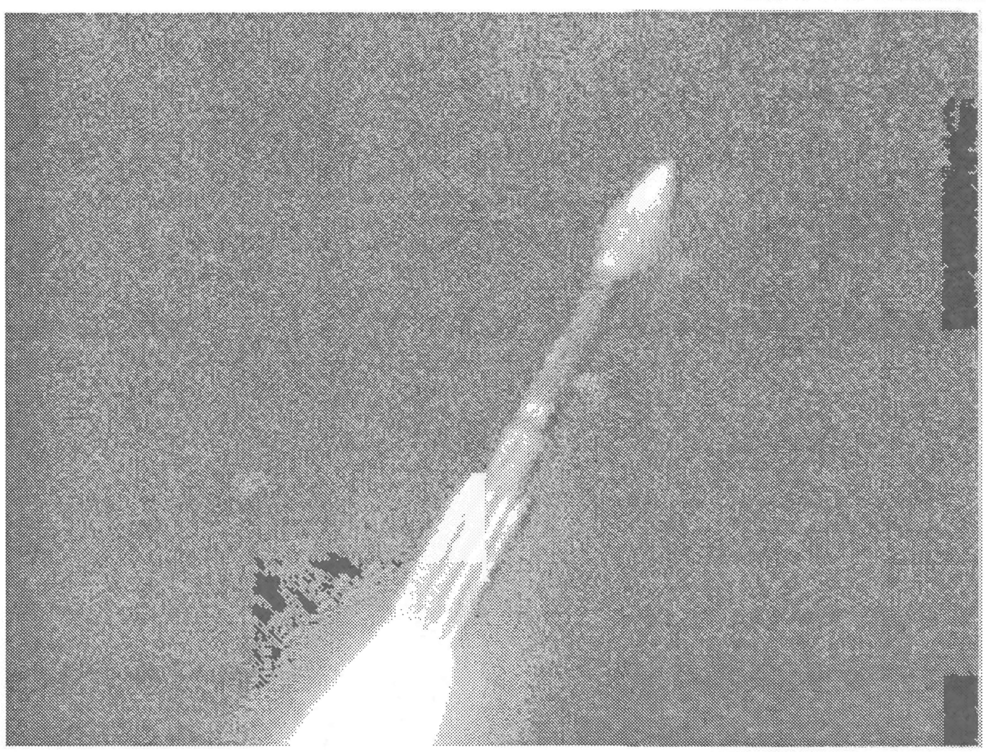
## TWO OUT OF THREE ON THEIR WAY

Two of three missions to Mars were on their way to the Red Planet as 1996 drew to a close.

Mars Global Surveyor, a mission to map the planet from orbit using some of the same instruments flown on the lost Mars Observer craft, was launched successfully from Cape Canaveral by a Delta II booster on November 7 and should arrive at Mars September 12, 1997.

Mars-96, launched on November 16 from Baikonur Cosmodrome, Kazakhstan, unfortunately never left Earth orbit. After some initial confusion, most observers now believe the fourth stage of its Proton booster failed to reignite to push the spacecraft out of Earth orbit. Instead, following separation from the booster, the craft reentered in a matter of hours to crash in remote regions of Bolivia or Chile. The booster stage reentered the following day into the Pacific Ocean some 900 miles east of Easter Island. Several eyewitness reports from northern Chile of fireballs that appeared to be an object breaking up apparently confirm the demise of the Mars craft in South America. All its scientific instruments, including an orbiter, two penetrators, and two small landers, were lost, a sad result for the Russian-led international consortium of scientists who developed them.

Mars Pathfinder, carrying the tiny Sojourner rover vehicle, was also successfully launched on a Delta II from Cape Canaveral in the very early morning hours of December 4. Because it takes a more direct path to Mars, the craft will arrive nearly two months before Mars Global Surveyor. If all goes well with the unique landing sequence, Pathfinder will arrive at Ares Vallis on Mars on July 4, 1997, where it will image its surroundings and sample the chemical composition of rocks with the Sojourner rover.



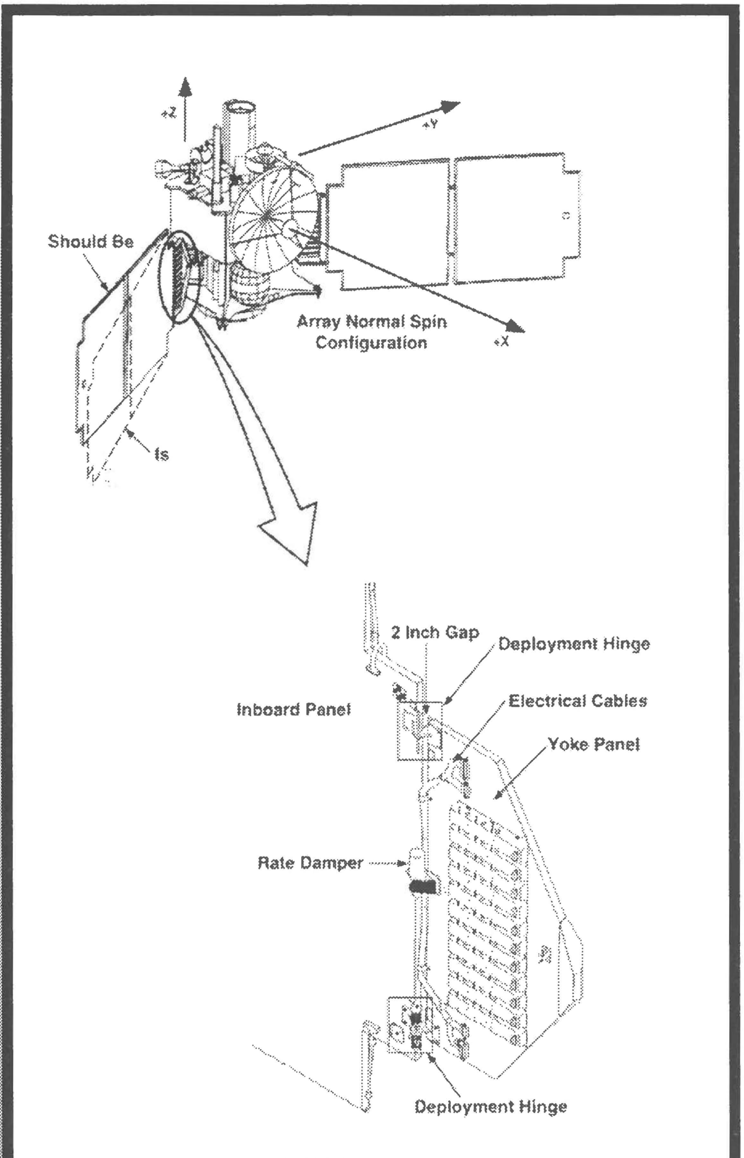
*Delta II booster lofts Mars Global Surveyor.*

# MGS SOLAR PANEL GLITCH SHOULD NOT HINDER MISSION GOALS

Mission engineers studying a solar array on Mars Global Surveyor that did not fully deploy during the spacecraft's first day in space have concluded it should not significantly impair Surveyor's ability to aerobrake into its mapping orbit, or affect its performance during the cruise and science portions of the mission.

The panel is one of two 11-foot (3.5-meter) wings that were unfolded shortly after launch November 7 and are used to power the spacecraft. Currently, the so-called –Y direction array is tilted 20.5° away from its fully deployed and latched position.

"After extensive investigation with our industry partner, Lockheed Martin Astronautics, using a variety of computer-simulated models and engineering tests, we believe the tilted array poses no extreme threat to the mission," said Glenn Cunningham, MGS project manager at JPL. "We plan to carry out some activities in the next couple of months using the spacecraft's electrically driven solar array positioning actuators to try to gently manipulate the array so that it drops into place. Even if we are not able to fully deploy the array, we can orient it during aerobraking so that the panel will not be a significant problem."




Diagnosis of the solar array position emerged from two weeks of spacecraft telemetry and Global Surveyor's perfect performance during the first trajectory maneuver on November 21 in which a 43-second burn changed the spacecraft's velocity by about 60 miles per hour (27 meters per second), just as expected. The burn was performed to move the spacecraft on a track more directly aimed toward Mars, since it was launched at a slight angle to prevent its Delta third-stage booster from following a trajectory that would collide with the planet.

Both the telemetry data and groundbased computer models indicate that a piece of metal called the "damper arm," which is part of the solar array deployment mechanism at the joint where the entire panel is attached to the spacecraft, probably broke during the panel's initial rotation and was trapped in the two-inch space between the shoulder joint and the edge of the solar panel, Cunningham said.

Engineers are working to develop a process to clear the obstruction by gently moving the solar panel. The damper arm connects the panel to a device called the "rate damper," which functions in much the same way as the hydraulic closer on a screen door acts to limit

*Line drawing of Mars Global Surveyor showing the current position of the solar panel in its fully deployed position, including a blow-up that shows the area in which the broken deployment mechanism is located.*

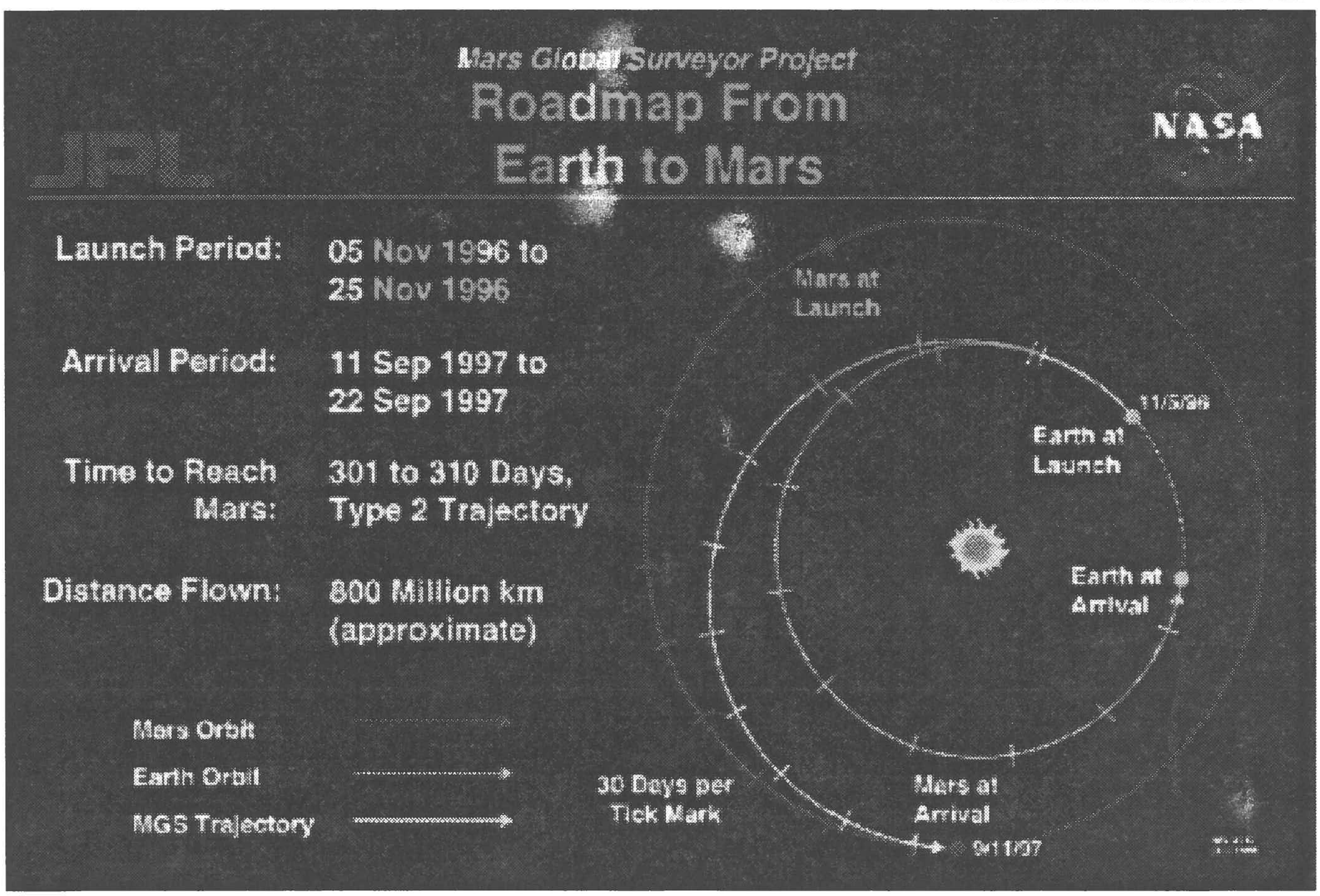
the speed at which the door closes. In this case, the rate damper was used to slow the motion of the solar panel as it unfolded from its stowed position.

Engineers have been reevaluating the aerobraking phase of the Global Surveyor mission, which begins in September 1997 after the spacecraft slows into an elongated orbit around the planet using its onboard rocket engine. The solar arrays are essential to the aerobraking technique and will be used to drag the spacecraft into its final, circular mapping orbit. First tested on the Magellan spacecraft at Venus, aerobraking allows the spacecraft to carry less fuel, instead using its atmospheric drag to gradually lower itself into the correct orbit around the planet.

"Since we launched early in our window of opportunity, we will not have to aerobrake as fast to reach the mapping orbit, and this reduces the amount of heating that the solar panels are exposed to," Cunningham said. "In the event that our efforts to latch the solar array properly in place are not successful, this reduced heating should allow us to tilt the array in such a way to prevent it from folding up and yet still provide enough useful aerobraking force." Additional analysis and testing will be performed over the next several months to verify this hypothesis.

Meanwhile, Mars Global Surveyor continues to perform very well with science instrument calibrations beginning by the last week of November. At the same time, the Mars Relay radio transmitter has been turned on for a post-launch checkout. Radio amateurs around the world are gearing up to participate in a radio tracking experiment in which they will become receiving stations for the low-power beacon signal transmitted by the Mars Relay radio system.

Mars Global Surveyor is traveling at a speed of about 74,000 miles per hour (119,000 kilometers per hour) with respect to the Sun.



# HUBBLE CAPTURES SPRING DUST STORM AT NORTH POLE OF MARS

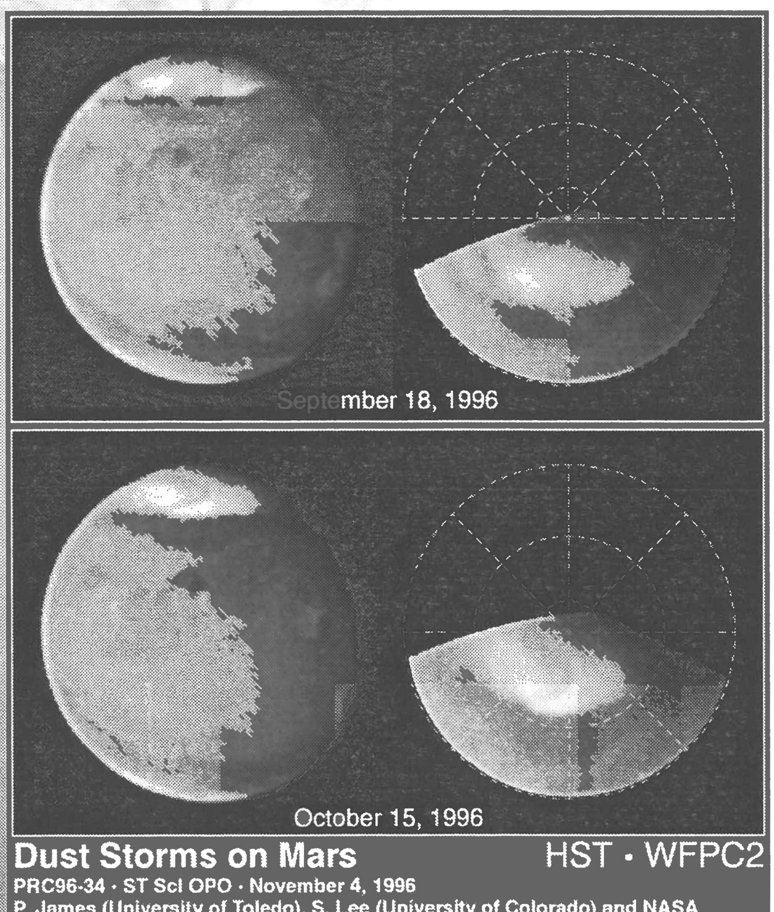
Two Hubble Space Telescope images of Mars, taken about a month apart on September 18 and October 15, 1996, revealed a Texas-sized dust storm churning near the edge of the martian north polar cap. The polar storm is probably caused by large temperature differences between the polar ice and the dark regions to the south that are heated by the springtime Sun. Increased sunlight also causes the dry ice in the polar cap to sublime and shrink.

Mars is famous for large, planetwide dust storms. Smaller storms resembling the one seen here were observed in other regions by Viking orbiters in the late 1970s. However, this is the first time that such an event has been seen near the receding north polar cap. The images provide new insights into the behavior of localized dust storms on Mars, which are typically below the resolution of groundbased telescopes. This kind of planetary weather report will be useful in preparing for the landing of Mars Pathfinder in July 1997 and the arrival of Mars Global Surveyor orbiter in September 1997.

To help compare locations and sizes of features, map projections (right of each disk) are centered on the geographic north pole. Maps are oriented with 0 degrees longitude at the top and show meridians every 45 degrees of longitude (longitude increases clockwise); latitude circles are also shown for 40, 60, and 80 degrees north latitude. Color images (http://www.stsci.edu/pubinfo/Pictures.html) were assembled from separate exposures taken with the Wide Field Planetary Camera 2.

***Top** (September 18):* The notch in the white north polar cap is a 600-mile (1000 kilometer) long storm — nearly the width of Texas. The bright dust can also be seen over the dark surface surrounding the cap, where it is caught up in the martian jet stream and blown easterly. The white clouds at lower latitudes are mostly associated with major martian volcanos such as Olympus Mons. This image was taken when Mars was more than 186 million miles (300 million kilometers) from Earth, and the planet was smaller in angular size than Jupiter's Great Red Spot!

***Bottom** (October 15):* Though the storm had dissipated by October, a distinctive comma-shaped feature can be seen curving across the ice cap. The shape is similar to cold fronts on Earth, which are associated with low-pressure systems. Nothing quite like this feature has been seen previously either in groundbased or spacecraft observation. The snow line marking the edge of the cap receded northward by approximately 120 miles (200 kilometers), while the distance to the Red Planet narrowed to 170 million miles (275 million kilometers).

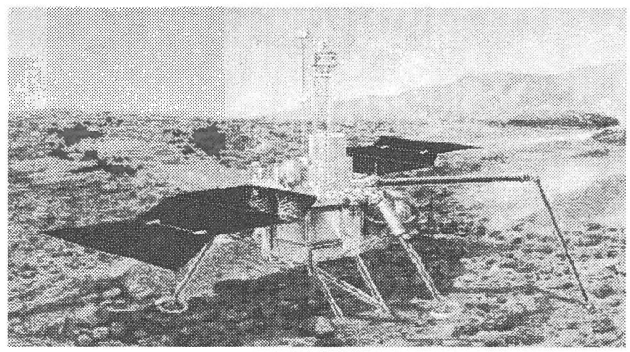



Phil James, University of Toledo; Steve Lee, University of Colorado and NASA

# NEW MILLENNIUM MICROPROBES WILL ACCOMPANY 1998 MARS SURVEYOR LANDER

Two small science probes will hitch a ride on NASA's 1998 Mars Surveyor Lander to touch down on Mars in 1999. The microprobes will demonstrate innovative new technologies as part of the New Millennium program. "A successful demonstration of the microprobe technologies will enable a wide range of scientific activities that would not be affordable with conventional technologies," said Dr. John McNamee, manager of the 1998 Mars Surveyor Lander and Orbiter project at the Jet Propulsion Laboratory.

"In particular, scientific investigations which require a relatively large number of surface stations distributed over the surface of Mars, such as seismic or meteorology networks, will be made possible by the microprobe concept," McNamee said. "In addition, microprobe penetrators may be the most efficient and effective way of obtaining soil samples and measurements from below the sterilized martian surface."



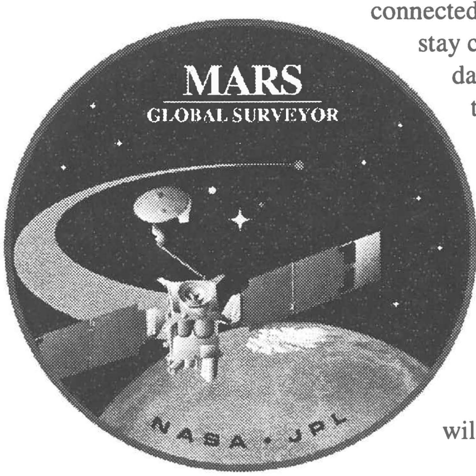
As they test technology that could lead to a meteorological network to study the martian climate, the Mars microprobes will complement the Mars Volatile and Climate Surveyor science package carried by the 1998 Mars Surveyor Lander by demonstrating an advanced, rugged microlaser system for detecting subsurface water. Such data on polar subsurface water ice should help scientists better estimate the global abundance of water on Mars.

Future missions to the planet could use similar penetrators to search for subsurface ice and minerals that might have been hospitable to the development of some form of life on Mars.

The 1998 Mars Surveyor Lander will be launched in January 1999 and spend 11 months en route to the Red Planet. Just before it enters the martian atmosphere the microprobes, mounted on the spacecraft's cruise ring, will separate and plummet to the surface using a single-stage entry aeroshell system. Chosen for its simplicity, this aeroshell does not separate from the microprobes, as have traditional aeroshells on previous spacecraft, such as the Mars Pathfinder and the Viking landers.

The probes will plunge into the surface at an extremely high velocity of about 446 miles per hour (200 meters per second) to ensure maximum penetration of the martian terrain. They should impact the surface within 120 miles (200 kilometers) of the main Mars '98 lander, which is targeted for the icy south polar region.

On impact, the aeroshells will shatter and the microprobes will split into a forebody and aftbody. The forebody, which will be lodged one to six feet underground, will contain the primary electronics and instruments. The aftbody, connected to the forebody by an electrical cable, will stay close to the surface to collect meteorological data and deploy an antenna for relaying data to Earth.




The microprobes will weigh less than 4.5 pounds (2 kilograms) each and be designed to withstand both very low temperatures and high deceleration. Each integrated package will include a command and data system, a telecommunications system, a power system, and primary and secondary instruments. Nearly all electrical and mechanical designs will be new to space flight.

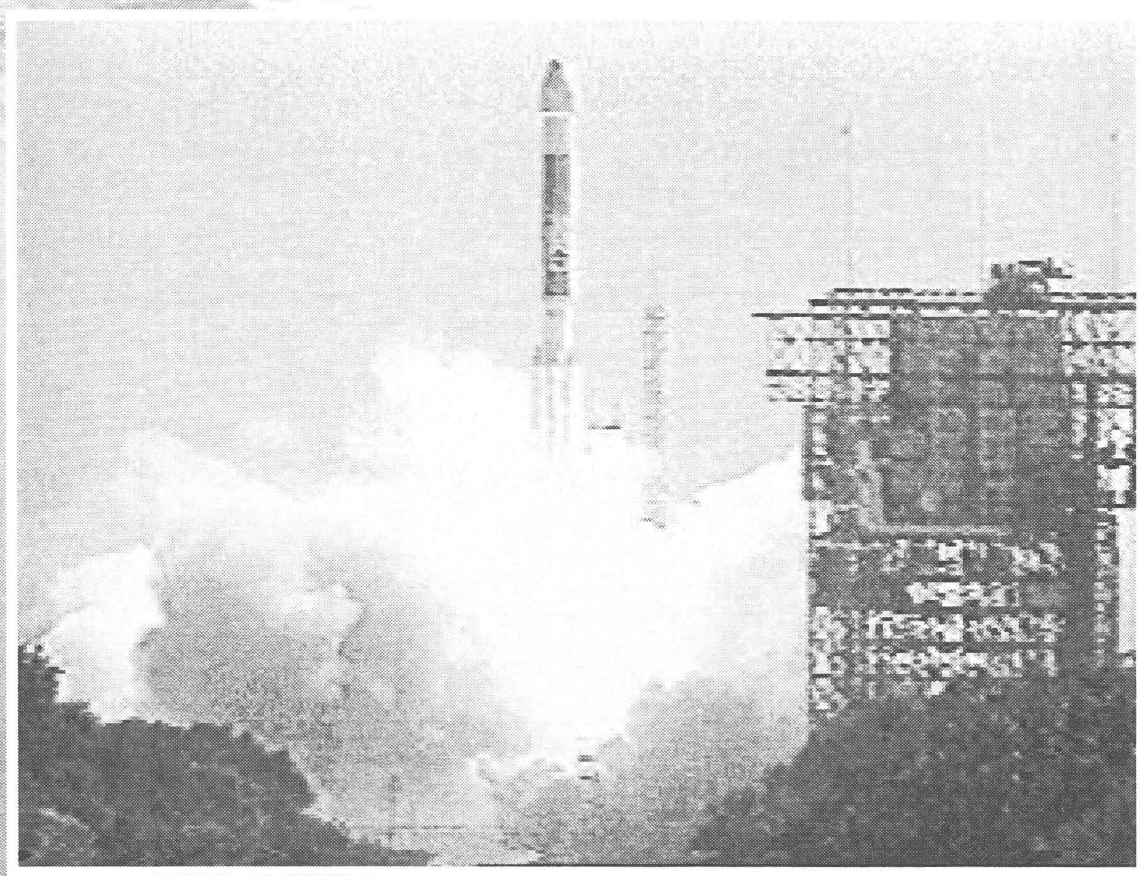
"In addition to a team of industrial partners that will help develop advanced technologies to be demonstrated during the mission, we have just selected Lockheed Martin Electro-Optical Systems as a primary industry partner to participate in the integration and test program for the microprobes," said Sarah Gavit, Mars microprobe flight leader at JPL.

Technologies proposed for demonstration on this second New Millennium flight include a lightweight, single-stage entry aeroshell; a miniature, programmable telecommunication subsystem; power microelectronics with mixed digital/analog integrated circuits; an ultra-low-temperature lithium battery; a microcontroller; and flexible interconnects for system cabling.

*In situ* instrument technologies for making direct measurements of the martian surface will include a water and soil sample experiment, a meteorological pressure sensor and temperature sensors for measuring the thermal properties of the martian soil.

"The Mars microprobe mission will help chart the course for NASA's vision of space science in the 21st century, a vision that incorporates the concept of 'network science' through the use of multiple planetary landers," said Kane Casani, manager of the New Millennium program. The probes will become the first technology to be validated in this new network approach to planetary science.

"Networks of spacecraft will address dynamic, complex systems," Casani said. "For example, a single lander can report on the weather at one spot on a planet, but a network of landers is needed to characterize the planet's dynamic climate. Similarly, a single seismometer will indicate if a quake has occurred on a planet, but a network of seismometers can measure the size of a planetary core. We need multiple spacecraft to go beyond our initial reconnaissance to completely characterize dynamic planetary systems the way we are able to do on Earth."



# CALENDAR 1997

## JANUARY

### 26–30

**Space Technology and Applications International Forum (STAIF-97),** Albuquerque, New Mexico. Includes: **14th Symposium on Space Nuclear Power and Propulsion; 2nd Conference on Commercial Development of Space; 2nd Conference on Next Generation Launch Systems; 1st Conference on Future Space and Earth Science Missions; 1st Conference on Synergistic Power and Propulsion Systems Technology; 1st Conference on Applications of Thermophysics in Microgravity.** Contact: Mohamed S. El-Genk, Technical and Publications Chair, or Mary Bragg, Institute for Space & Nuclear Power Studies, University of New Mexico, School of Engineering, Albuquerque NM 87131-1341. Phone: 505-277-4950; fax: 505-277-2814.
E-mail: mjbragg@unm.edu

### 29–Feb 1

**The 1997 International Conference on Mobile Planetary Robots & Rover Roundup,** Santa Monica, California. Contact: The Planetary Society, 65 North Catalina Avenue, Pasadena CA 91106-2301. Phone: 818-793-5100; fax: 818-793-5528.
WWW: http://planetary.org/tps/

## FEBRUARY

### 4–5

**In Situ Resource Utilization (ISRU) Technical Interchange Meeting,** Houston, Texas. Contact: Stephen J. Hoffman, Science Applications International Corporation. Phone: 281-244-3827.
E-mail: hoffman@snmail.jsc.nasa.gov
WWW: http://cass.jsc.nasa.gov/isru97.html

### 13–18

**AAAS Annual Meeting and Science Innovation Exposition,** Seattle, Washington.
E-mail: iau164@nrao.edu.
WWW: http://www.cv.nroa.edu/library/meetings.html

### 24–26

**Mars Polar Ice and Instrumentation Workshop,** Houston, Texas. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 281-486-2123; fax: 281-486-2160.

## MARCH

### 10–20

**Formation and Evolution of Solids in Space: A NATO Advanced Study Institute—4th Course of the International School of Space Chemistry,** Erice, Sicily. Contact: J. Mayo Greenberg, Huygens

## MARCH (CONTINUED)

Laboratorium, P.O. Box 9504, 2300 RA Leiden, The Netherlands. Fax: 31-71-5275804.
E-mail: mayo@rulhl1.leidenuniv.nl

### 17–21

**28th Annual Lunar and Planetary Science Conference,** Houston, Texas. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2166; fax: 713-486-2160.
E-mail: simmons@lpi.jsc.nasa.gov
WWW: http://cass.jsc.nasa.gov/LPSC97

## APRIL

### 18–20

**Extinctions in the Fossil Record,** Macomb, Illinois. Contact: Tom Witherspoon, 6611 Miller Road, Dearborn MI 48126-1915. Phone: 313-582-3139.

### 20–26

**National Science and Technology Week 1997**. Contact: NSTW, c/o National Science Foundation, Room 1245, 4201 Wilson Boulevard, Arlington VA 22230. Phone: 703-306-1070.
E-mail: nstw@nsf.gov
WWW: http://www.nsf.gov/od/lpa/nstw/geninfo/start.htm

### 21–25

**European Geophysical Society XXII General Assembly,** Vienna, Austria. Contact: EGS Office, Max-Planck-Strasse 1, 37191 Katlenburg-Lindau, Germany. Phone: 49-5556-1440; fax: 49-5556-4709.
E-mail: egs@linax1.mpae.gwdg.de

### 25–27

**Workshop on Early Mars: Geologic and Hydrologic Evolution, Physical and Chemical Environments, and the Implications for Life,** Houston, Texas. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 281-486-2123; fax: 281-486-2160.
E-mail: gary@lpi.jsc.nasa.gov
WWW: http://cass.jsc.nasa.gov/earlymars.html

### 27–30

**4th Compton Symposium on Gamma Ray Astronomy and Astrophysics,** Williamsburg, Virginia. Contact: Tina Obrebski, Code 7650, Naval Research Laboratory, 4555 Overlook Avenue SW, Washington DC 20375.
E-mail: compton4@osse.nrl.navy.mil
WWW: http://osse-www.nrl.navy.mil/cgrosymp.htm

# CALENDAR 1997

## MAY

### 26–JUN 6

**Aspen Workshop on Formation of Extrasolar Planets and Brown Dwarfs,** Aspen, Colorado. Contact: Aspen Center for Physics, 700 W. Gillespie, Aspen CO 81611.
E-mail: jane@acp1.zgsw.com

## JUNE

### 2–6

**Seventh Annual V. M. Goldschmidt Conference,** Tucson Arizona. Contact: Michael J. Drake, Department of Planetary Sciences, Lunar and Planetary Laboratory, The University of Arizona, Tucson AZ 85721. Phone: 520-621-6962; fax: 520-621-4933.
E-mail: goldconf@lpl.arizona.edu
WWW: http://cass.jsc.nasa.gov/goldschmidt.html

### 8–13

**12th IAA Man in Space Symposium: The Future of Humans in Space,** Washington, DC. Contact: Terri Jones, USRA, Division of Space Life Sciences, 3600 Bay Area Boulevard, Houston TX 77058-1113. Fax: 713-244-2006.
WWW: http://cass.jsc.nasa.gov/12misf.html

### 13–18

**13th Annual North American Workshop on Cataclysmic Variables,** Jackson Hole, Wyoming. Contact: Local Organizing Committee.
E-mail: cv@kaya.uwyo.edu

### 15–20

**Gordon Research Conference on Origins of Solar Systems,** Henniker, New Hampshire. Contact: John Kerridge, Department of Chemistry 0317, UCSD, La Jolla CA 92093 *or* Alan Boss, Department of Terrestrial Magnetism, 5241 Broad Branch Road, Washington DC 20015. [Contributed papers in the form of poster talks welcomed.]
E-mail: jkerridg@ucsd.edu
E-mail: boss@axp1.ciw.edu

### 19–25

**9th Rencontres de Blois: Planetary Systems—The Long View,** Blois, France. Contact: L. M. Celnikier, Observatoire de Paris-Meudon, 92 Meudon, France. Fax: 1-45-07-74-69.
E-mail: blois97@mesiob.obspm.fr

### 23–Jul 4

**International Workshop on Synthesis of Light Elements in the Early Universe,** Trento, Italy. Contact: Hannu Kurki-Suonio, Department of Physics, Theory Division, P.O. Box 9, FIN-00014, University of Helsinki, Finland.
E-mail: hkurkisu@pcu.helsinki.fi

### 30–Jul 2

**109th Annual Meeting of the Astronomical Society of the Pacific,** Chicago, Illinois. Includes: **Scientific Symposium on Astrophysics from Antarctica (6/30-7/2); Symposium on Teaching Astronomy in Community & Small Colleges (6/30-7/1).** Contact: Annual Meeting, ASP, 390 Ashton Avenue, San Francisco CA 94112. Phone: 415-337-1100; fax: 415-337-5205.
E-mail: lkeechler@aspsky.org
bally@nebula.Colorado.edu (scientific symposium only)
WWW: http://www.aspsky.org

## JULY

### 17–19

**Workshop on Parent Body and Nebular Modification of Chondritic Materials,** Maui, Hawai'i. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2166; fax: 713-486-2160.
E-mail: cloud@lpi.jsc.nasa.gov
WWW: http://www.pgd.hawaii.edu/metsoc/

### 21–25

**60th Meteoritical Society Meeting,** Maui, Hawai'i. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2144; fax: 713-486-2160.
E-mail: cloud@lpi.jsc.nasa.gov
WWW: http://www.pgd.hawaii.edu/metsoc/

### 21–25

**CHERBS '97—Conference on the High-Energy Radiation Background in Space,** Snowmass, Colorado. Contact: Pam Solomon, Code 691, NASA Goddard Flight Center, Greenbelt MD 20771. Phone: 301-286-8797; fax: 301-286-1629.
E-mail: xrphs@lepvax.gsfc.nasa.gov

### 28–Aug 1

**29th Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society,** Cambridge, Massachusetts. Contact: Richard P. Binzel, Massachusetts Institute of Technology, Room 54-426, 77 Massachusetts Avenues, Cambridge MA 02139. Phone: 617-862-3698; fax: 617-283-2886.
E-mail: rpb@astron.mit.edu

# CALENDAR 1997

## AUGUST

### 30–Sep 5

**Sudbury 1997: Large Meteorite Impacts and Planetary Evolution,** Sudbury, Ontario. Contact: Burkhard Dressler, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2112; fax: 713-486-2162.
E-mail: dressler@lpi.jsc.nasa.gov
WWW: http://cass.jsc.nasa.gov/sudbury97.html

## NOVEMBER

### 11–14

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

**BLACK HOLES** *continued*

and form very luminous galaxies naturally would have provided more seed black holes to coalesce into a single, massive black hole residing in a galaxy's nucleus.

An alternative model is that galaxies start at some early epoch with a modest black hole (not necessarily approaching the masses observed in the Hubble census), and that the black hole consumes some fixed fraction of the total gas shed by the stars in the galaxy during their normal evolution. If that fraction is around one percent, the black holes easily could be as massive as these observations indicate, and naturally would be proportional to the current luminosity of the galaxy.

Critical groundbased observations to identify galaxies that might contain black holes were obtained for all three of these objects by John Kormendy with the Canada-France-Hawai'i Telescope (CFHT) on Mauna Kea. The NGC 4486B black hole detection also was based on CFHT spectra.

Hubble then allowed the team to peer deep into the cores of the galaxies with resolution unavailable from groundbased telescopes and measure velocities of stars orbiting the black hole. A sharp rise in velocity means that a great deal of matter is locked away in the galaxy's core, creating a powerful gravitational field that accelerates nearby stars.

The team is confident their statistical search technique has allowed them to pinpoint all the black holes they expect to see, above a certain mass limit. "However, our result is complicated by the fact that the observational data for the galaxies are not of equal quality, and that the galaxies are at different distances," says Richstone.

One of the features of the February 1997 servicing mission to Hubble will be the installation of the Space Telescope Imaging Spectrograph. This spectrograph will greatly increase the efficiency of projects, such as this black hole census, that require spectra of several positions near one another in a single object. The group of researchers will continue the census with the refurbished telescope.

**NEWS FROM SPACE** *continued*

These collisions formed Himalayan-class mountains with high rates of sedimentation in the ocean, burying organic matter.

According to Des Marais, the formation of stable, large continents also protects and stores larger amounts of organic carbon for hundreds of millions of years, further allowing the atmosphere to accumulate large amounts of free oxygen.

Furthermore, new calculations by Des Marais reveal that the increases in atmospheric oxygen and sulfate (oxidized sulfur) in seawater between 2.2 and 2.0 billion years ago were too large to be explained only by the slow decline in volcanic activity over Earth's history. The decline in volcanism had been previously offered as an alternative to Des Marais' continental evolution hypothesis.

Des Marais' research is supported by the space science division at the Ames Research Center and the Exobiology Program in NASA's Office of Space Science, Headquarters, Washington, DC.

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Pam Thompson, Editor

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# INSIDE



28th
Lunar and
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MARCH 17–21, 1997 HOUSTON, TEXAS


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