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COVER: In July* Phobos 1*, the first space probe to leave Earth for Mars since 1975, lifted off atop a* Proton *rocket from the Baikonur space complex in the Soviet republic of Kazakhstan. A few days later a second* Phobos *craft was launched on a similar mission. The probes' main purpose is to explore and analyze Phobos, one of Mars' two quirky moonlets. These are the first in a series of increasingly ambitious robotic probes that the Soviet Union plans to send to Mars, culminating in what could be a joint US/USSR trip with human crews to the planet early in the next century.

Photo: Chris Niedenthal/TIME Magazine

FROM THE EDITOR

In the world of planetary exploration, the big news of the summer was the launch of the Soviets' *Phobos* mission to that intriguing moon of Mars. This successful launch and the hiatus in the United States' space program direct our attention in this issue to the futures of the two major spacefaring nations.

Page 3 —Members' Dialogue—The drought this summer has forced the popular press to cover the greenhouse effect—a topic planetary scientists have been discussing for years (see the article by James F. Kasting in the January/February 1985 *Planetary Report*). The debate over the seriousness of the threat to Earth's climate leads off our mail column for this issue. But then we go right back to our members' favorite subject—Mars. Should The Planetary Society support a human mission to Mars? The debate goes on.

Page 4 —The United States' Future in Space: The Candidates Share Their Visions—The imminent general election in the United States is possibly the most crucial contest affecting the space program since 1960. The next President could set the American program back on course outward or continue the benign neglect of the past several years. The candidates of both major parties have issued statements on space, and we reprint them here for our members' information.

Page 7 —The Mars Balloon: A Novel Approach to a Treacherous Terrain—In 1994 the Soviet Union will launch another mission to the Red Planet. To take advantage of the Soviets' robust program, Planetary Society Advisor Jacques Blamont suggested that the best way to explore the martian surface would be by balloon. The Planetary Society has explored this idea, and we report the results of our efforts.

Page 12 —Visualize Venus: *Veneras 15* and *16* Radar Images—In late 1983 the Soviet Union's *Venera 15* and *16* spacecraft began circling Venus, and they have returned some of the most detailed information to date about this cloud-shrouded planet. We present here the latest results.

Page 14 —World Watch—With the Soviet space program booming and the United States' program poised to return to orbit, there's a lot of international news to report. We've expanded this column to give our readers all the latest developments.

Page 16 —Outbound to Mars: The *Phobos* Mission Is Launched—The *Phobos* mission is the first step in a Soviet campaign that will culminate in humans landing on Mars early in the next century. Here are the details of the mission.

Page 17 —Phobos: A Surface Mine or an International Park?—What will we do at Phobos after we've explored it? Three Hungarian astronomers have been thinking about this question and share their thoughts with Planetary Society members.

Page 18 —News & Reviews—The always articulate Clark Chapman introduces a magazine that may be new to our readers and reviews a major article on the Search for Extraterrestrial Intelligence, one of the Society's major interests.

Page 19 — Politics and The Planetary Society: A Personal View—As an organization that supports causes often buffeted by changing winds of opinion, people frequently ask us about The Planetary Society's positions on a range of political issues. Our Executive Director presents his view of the role of the Society in such affairs.

Page 20 —Q&A—If we read our mail correctly, this column is now the most popular in *The Planetary Report*. We particularly like the letter that called "Q&A" a "breath of fresh air." In this issue we tackle life on Mars, meteor showers and polar caps.

Page 22 —Society Notes—This regular feature again reports the news of the latest Society activities.

Since this is our September/October issue, we again present our once-a-year sales catalogue for our members' holiday shopping convenience. You'll find it bound into the center of this magazine. We hope you'll enjoy it.—*Charlene M. Anderson*

Members' Dialogue

As leaders of a membership organization, The Planetary Society's Directors and staff care about and are influenced by our members' opinions, suggestions and ideas about the future of the space program and of The Planetary Society. We encourage members to write us and create a dialogue with us on topics relating to the planetary program, such as the space station, the lunar base and the exploration of Mars.

Send your letters to: Members' Dialogue, The Planetary Society, 65 N. Catalina Avenue, Pasadena, CA 91106.

Clark Chapman's review of our recent *Scientific American* article (see News & Reviews in the May/June 1988 *Planetary Report)* on climate evolution was right on target until the final two paragraphs, where he states that we "pooh-pooh" the seriousness of climatic warming caused by fossil fuel carbon dioxide (CO_2). In reality, we think that the predicted increase in the greenhouse effect may cause real problems, the most significant being a gradual rise in sea level over the next few centuries. Increased CO_2 levels are not, however, likely to create the "runaway" warming that Chapman seems to fear. Our own calculations (J. F. Kasting and T. P. Ackerman, *Science*, December 12, 1986) indicate that the Earth's climate is stable against runaway even for CO_2 increases much larger than could result from the burning of fossil fuels. We are not aware of any other published calculations that might cast doubt on this conclusion. So, while one shouldn't pooh-pooh the greenhouse threat, neither should one lose too much sleep worrying about the end of the world.
JAMES F. KASTING, *NASA Ames Research Center*

The reason I joined The Planetary Society is that I believe the exploration and commercial exploitation of space are vitally important to mankind's future.

Having said that, I think you're jumping the gun with your advocacy of a piloted Mars mission. I took the Mars Petition in to work. The result? Not one signature. We all agreed it was reaching too far, too fast.

I would rather see the Society developing support and guidance for the space station among industry and Congress and supporting private launch efforts. I feel that in the long run this will develop a human presence in space more quickly and reliably than an expensive, *Apollo*-style, one-shot Mars mission.
JERRY ALLEN, *Westminster, California*

We believe the Mars goal that we advocate is not a "one-shot" effort but the beginning of a historic and open-ended process of human exploration of Mars. Naturally, we need a space station and launch vehicles—but in order to design them intelligently we need to know why and where they point. That is one purpose of our advocating this goal.
Louis D. Friedman, Executive Director

I'm becoming more convinced that, in dealing with government, an effective course of action is to advocate those programs that are in consonance with one's own objectives and toward which the government is inclined. By doing so, a path of lesser resistance is followed.

To paraphrase Mr. Sagan, today's plans may not (and probably won't) bear any resemblance to tomorrow's reality. Thus, it is far better to brag ten years hence that we have helped to establish a functioning Earth orbital platform that facilitates the steps to the Moon and Mars than to be forced to report that, although much progress has been made toward landing humans on Mars, the Society's efforts have not yet come to fruition.

I encourage The Planetary Society to exploit every opportunity that pushes forward our chosen objectives, even if it is only one step at a time. If we blindly insist that a particular goal be given priority in the face of prevailing monetary reality, the situation becomes very like the restoration of a classic automobile by an amateur. A great many resources may be expended on a carefully preened paint job. It may even win "Best of Show." But what useful purpose has been served when attendants must come to push it off center stage because the engine was not made operative?
LEON R. SAHLMAN, *Victorville, California*

At a recent meeting in Washington, the Space Science Board of the National Academy of Sciences presented a two-year study entitled "Space Science in the Twenty-First Century." It has much to say about the feasibility of extended human space missions. The following are quota-

(continued on page 23)

NEWS BRIEFS

In its January 1988 issue, *Astronomy* magazine published a readers' poll entitled "Deciding America's Future in Space." When asked what NASA's top priority should be, 32 percent of the 2,250 respondents said human space flight. After that was solar system exploration, 28 percent; orbiting observatories, 20 percent; advanced space flight vehicles, 13 percent; and "other" (including a space station and human Moon and Mars bases), 7 percent.

While readers overwhelmingly favored human missions, there was no "Moon versus Mars" debate. They were equally in favor of both. And surprisingly, even though the poll did not mention international cooperation in space, over 10 percent of the readers felt strongly enough about it to write in comments supporting exploration in space as a cooperative venture.
—from Kristine R. Majdacic in *Astronomy*

A congressional study reported in June that the US space program is clearly eclipsed by the Soviet Union's in only one area, the operational use of crews in Earth orbit. No nation has the lead in space. The study, prepared for the Senate Commerce Committee and its space subcommittee by the Congressional Research Service, noted that the Soviets' lead in that area existed long before the *Challenger* disaster and will remain long after the shuttle goes back into service.
—from the *Los Angeles Times*

The above-mentioned study (started in 1984 at the behest of NASA) also called for establishing a satellite network that would constantly observe the entire Earth.

At the same time it recommended intensive planetary exploration emphasizing Mars near the end of this century and the beginning of the next, including robotic landings on Mercury and Venus and probes into the atmospheres of Jupiter, Saturn, Uranus and Neptune.

The steering group for this study recommends that the present ordering of priorities in the national space program be changed in favor

(continued on page 23)

The United States' Future in Space:

The Candidates Share Their Visions

Even before the 1986 *Challenger* tragedy, the United States planetary program was in trouble. The last US mission to another planet, *Pioneer Venus*, was launched a decade ago, in 1978. The continuing triumphs of *Voyager 2*, which will reach Neptune in 1989, are the culmination of a project conceived in the 1960s and launched in 1977. *Galileo* to Jupiter, *Magellan* to Venus and the *Mars Observer*—all approved missions—are queued up on the ground, waiting for a resurrected shuttle to launch them. NASA's planetary program is living on past glory.

The golden age of space exploration began in 1961 when President John F. Kennedy set the United States on its way to the Moon. He galvanized a generation of scientists, engineers, politicians and citizens who sent a fleet of spacecraft to explore the Moon and planets, beginning with *Mariner 2* to Venus in 1962 and ending with *Pioneer Venus* in 1978. In between, 12 Americans walked on the Moon. Can the will, drive and ambition that sent emissaries to every planet but Pluto be rekindled?

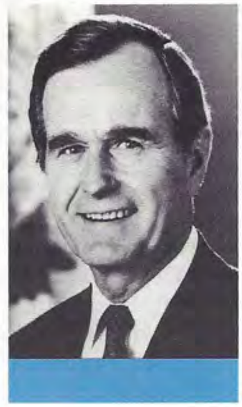
This November the United States will elect a new President. Will either major party candidate be the one who can restore the American space program and set a goal that can fire the public's enthusiasm for exploration?

As a non-profit, scientific and educational organization, The Planetary Society endorses no political candidates. But we do have the responsibility to inform our members about the major candidates' views on planetary exploration and the United States' space program.

We asked the campaign offices of Michael Dukakis and George Bush to provide us with the candidates' official positions on space. Governor Dukakis' office sent a full policy statement; Vice President Bush's office sent the text of a speech he gave at the Marshall Space Flight Center in Huntsville, Alabama. We reprint edited statements here for your information. *—Tim Lynch, Director of Programs and Development*

In 1978 Pioneer Venus *was launched to explore Earth's nearest neighbor. No US planetary missions have been launched since.*
Photograph: NASA Ames Research Center

George Bush



I would like to talk with you today about the future direction of our space program. Thirty years have passed since *Sputnik*—30 years that have not only changed the world, but literally have changed the way we see the world. Suddenly, we can see the world as it is—a tiny grain of sand in the vastness of space, a shining sphere in the infinite darkness.

I recall the old fisherman's prayer: "The sea is so large, Lord, and my boat so small." Well, we're all fellow passengers in this boat called Earth. We should be bold and venture seaward, but we must also make sure our boat is in good repair. The space program can play a major role in doing both.

It is becoming ever more obvious that man's activity on the planet is having a significant and possibly irreversible effect on our environment—not just locally, but globally.

To take but two examples, the hole in the ozone layer observed over the Antarctic, attributed to the use of chlorofluorocarbons, portends significant increases in skin cancer rates.

And our reliance on fossil fuels and the consequent warming of the Earth through the "greenhouse effect" could have radical implications for the future of agriculture in the United States and the world.

A hotter and dryer Midwest could go from breadbasket to basket case. The advancing deserts, particularly in Africa, could make large food-producing areas uninhabitable. Important variations in vegetation covers and in coastlines have already been observed with existing measurement capabilities.

We face the prospect of being trapped on a boat we have irreparably damaged—not only by the cataclysm of war but by the slow neglect of a vessel we believed to be impervious to our abuse.

Nature was once the great enemy of man—a ferocious and fearful force, to be conquered, tamed and harnessed to our needs. Now we find that we must protect her from ourselves. Walt Kelly was talking about pollution when he penned the immortal words, "We have met the enemy, and they is us."

Let us therefore use the great energy and excitement of our expeditions into space to look back, to discover what it is we are doing to our Earth, and to alter our self-destructive course. Let us use our dreams to help us find solutions.

Earlier this year Dr. Sally Ride delivered a report to NASA called *Leadership and America's Future in Space*, in which she outlined four reasonable options for the space program. The first she called "Mission to Planet Earth."

Such a global mission would create a global observational system in space, aimed at developing a fundamental understanding of the Earth system, in order to predict changes that might occur—either naturally or as a result of human activity.

Our space effort must incorporate elements of not only pure science and exploration, but also national security and economic growth. In order to develop a comprehensive strategy for space, as President I will create a National Space Council, chaired by the Vice President and composed of the heads of such departments as Commerce, Defense, State and Transportation in addition to NASA.

NASA should remain the lead agency in exploring the frontiers of space science and technology—from development of a trans-atmospheric vehicle to construction of a space station. What it should not be is a freight service for routine commercial payloads.

In the short term, I support construction of the replacement shuttle. But because Mission to Planet Earth would require the ability to launch large payloads, it would justify the building of a heavy-lift launch vehicle—designed for minimum cost instead of minimum weight.

Such a vehicle should deliver a pound of payload for a small fraction of the cost on the space shuttle.

The Soviets mass produce such vehicles and launch routinely. We need them, too. We particularly need them for SDI [Strategic Defense Initiative].

Any space-based defense will require a deep reduction in the price of placing cargo in orbit in order to be affordable. Indeed, costs need to be cut by a factor of 10.

I am committed to a vigorous SDI program. The Soviets have been working on strategic defenses much longer and harder than we have—indeed, well before my time at the CIA in the mid-1970s.

Mission to Planet Earth, a strong civilian launching program, and strategic defense—these are important immediate goals. But we must also dream great dreams. We must also look outward and reach toward the stars.

As a nation we owe our standing in the world as much to our brains as to our brawn. Yet we have no monopoly on intellectual initiative. To maintain our advantage, we must aggressively advance the frontiers of knowledge.

Our leadership in space provides direct payoffs in technological and economic progress. By forcing ourselves to reach demanding goals, we reap the rewards of the breakthroughs that result.

We should make a long-term commitment to manned and unmanned exploration of the solar system. There is much to be done—further exploration of the Moon, a mission to Mars, probes of the outer planets. These are worthwhile objectives, and they should not be neglected. They should be pursued in a spirit of both bipartisanship and international teamwork.

In the defense of our country or in the interest of economic growth, we must compete with the other spacefaring nations. But the expansion of our frontiers to the far reaches of the solar system should be a matter for cooperation among the peoples of the world—for ultimately we voyage outward not as Americans or Soviets, French or Japanese, but as humans.

The signing in April of a five-year agreement with the Soviet Union to cooperate "...in the exploration and use of outer space for peaceful purposes" is a first step in this direction.

International cooperation is also critical to the success of Mission to Planet Earth. Fortunately, the concept is supported by several international organizations and may emerge as a theme for the International Space Year, 1992.

For as we saw when *Apollo* went to the Moon, the view from space makes it inescapably clear that we are all citizens not just of our many nations but of a single human community.

As a nation, we must continue on the path that we have blazed, to discover and examine what lies beyond Earth. The exploration of space provides our children with a vision that ignites their energies and imaginations.

With faith in the future and a renewed sense of commitment, we can regain the spirit of *Mercury* and *Apollo*. The question for Americans, a people of pioneers, will never be "Should we explore the universe?" but "How can we not?"

Michael Dukakis

A generation ago, President John F. Kennedy raised our sights and the spirits of all Americans by challenging our scientists and citizens to go forward with a bold program of space exploration. *Mercury, Gemini* and *Apollo* fired our imaginations and our pride; *Voyager, Viking* and *Skylab* explored the depths of our solar system and the resources of our planet, gave us new insight into the origins of our universe and provided new knowledge and understanding with which we could improve the quality of life on Earth.

Sadly, in recent years, our space program has lost its sense of purpose. Despite annual expenditures approaching $10 billion per year, NASA is demoralized and our space effort is in disarray, our space science program no longer leads the world, and the tragedy of the space shuttle *Challenger* has created doubts about the ability of the United States to operate effectively in space. Our space program has been dominated by military considerations, while our competitiveness in the worldwide commercial market has steadily eroded.

Reinvigorating Space Science

Rather than spend billions of dollars for projects that serve narrow interests—such as the "Orient Express" space plane that will fly from New York to Tokyo in three hours, we should invest in a space program that will benefit our nation and humankind as a whole. We should emphasize research, the development of innovative technology and space science, to expand our knowledge of Earth's resources and the world's oceans, improve communications and reveal the mysteries of the universe. We must develop a comprehensive, long-term plan to assure stable funding for important space science projects such as the Venus Radar Mapper, the *Mars Observer*, the Advanced X-Ray Astrophysics Facility and the Hubble Space Telescope.

Assuring Our Access to Space

Second, we must restore our space transportation capability. I support the recommendation of the *Challenger* Commission to return the shuttle to service with a reduced flight schedule to help ensure higher safety standards, and to build a fourth orbiter, using proven technology. At the same time, the disruption caused by the shuttle disaster and the failure of the *Titan* and *Delta* rockets makes clear the need to diversify our nation's launch capability and develop affordable alternatives to the shuttle (such as new expendable launch vehicles) for delivering important payloads into space.

An Affordable, Practical Space Station

Third, we should review the options for the space station. I support the development, at a prudent pace, of a technologically sophisticated space science and engineering laboratory—but there are a number of less costly alternatives to the station now envisioned by NASA. These alternatives—including a station that need not be permanently manned—could be in operation much sooner and could meet most, if not all of the requirements of the larger, permanently manned space station.

Skilled Management for NASA

Fourth, I will appoint skilled managers at NASA who will restore professionalism and competence to our space program. Managers who will set high standards for NASA personnel and contractors—and who will make sure that those standards are met. The continuing failures in our shuttle program are symptomatic of management gone awry—our nation deserves better.

International Cooperation in Space

Finally, I will ask the Soviet Union, and other spacefaring nations, to join with the US in more cooperative efforts in space. While we must be careful to protect sensitive technologies in these cooperative programs, they offer an unparalleled opportunity for all nations to work together on projects which will benefit us all. We should renew the US-USSR Space Science Agreement, coordinate the 1989 Soviet mission to Phobos with the US Mars Observer flight, and invite the USSR to join with the US, Japan and the European Space Agency in the International Solar Terrestrial Physics Program. And we should explore with the Soviet Union and other nations the feasibility and practicality of joint space engineering activities that might pave the way to a joint manned mission to Mars.

Enhancing our Security in Space

I strongly oppose the administration's militarization of space. Star Wars and anti-satellite weapons not only make our nation less secure; they divert funds and attention from far more important space research efforts. As President, I will direct the Pentagon to focus its efforts on programs that will enhance our security, such as improved satellites for arms control verification and early warning of attack, communications, navigation and meteorology.

And I will challenge the Soviet Union to join with us in new agreements to protect our vital space activities and enhance our security. By negotiating a ban on testing anti-satellite weapons—including lasers and electronic interference. By developing guidelines for space operations—such as "keep out zones" that will reduce the danger of attacks on satellites. And by placing limits on military activities by humans in space.

Inspiring the Next Generation of Space Scientists

The future of the American space program depends on its ability to inspire and attract the bright young people of our nation. I support the establishment of educational programs that will motivate young people to explore careers in space science and technology. NASA, its scientists and engineers, and the private sector can be an important part of that effort.

During the 1960s, our space program became a symbol of what the American mind and spirit can accomplish. As President, I will work with all those involved in the adventure of space to restore our sense of pride and purpose; and to explore the final frontier. □

Policy Statements by Other Presidential Candidates

While every presidential candidate was asked his views on the space program, two statements by candidates who did not receive their party's nominations stand out.

Albert Gore, Jr., said, in part: "First, I will install a new generation of leaders at NASA.... Second, I will lead this nation to set clear goals in space.... Third, I will expand our vision of space exploration to include the exploration of our own planet.... Fourth, I will make the development of commercial applications of space technologies an integral part of the overall program.... Finally, I will reverse the imbalance between our military and civilian space programs...."

On the specific topic of Mars, Mr. Gore declared: "The next logical target for exploration is Mars. We should begin the planning process now, and ask others to share the costs. I will challenge the other spacefaring nations of the world, including the Soviet Union, to join with us in planning a long-range international expedition to Mars."

Jesse Jackson remarked, in part: "A new direction in space policy requires abandonment both of the Star Wars program and of the development of anti-satellite weapons. Star Wars is a cruel hoax. It offers an impossible technological solution to a political problem....

"Space technology is no longer the exclusive province of just the US and the Soviet Union. Western European countries, Japan, China and India all have active space programs.... Through the United Nations and other international bodies, the US should take the lead to see that technological developments in space truly do benefit all people everywhere....

"Planetary exploration by robot spacecraft has produced a golden age of astronomy. We have learned much about the mysteries of our very origins. But now, due to mismanagement and shortsightedness, the pace of that exploration has slowed. We must start up again.... Scientific exploration is not cheap, but it is an investment in our future. In the long run, it may cost us dearly if we choose to just stay at home.

"A joint US-Soviet mission to Mars is an idea with great potential to bring our peoples together in both practical and symbolic ways. Since Mars is the planet most like Earth, there is real scientific merit in learning more about it. Exploration of Mars is a logical outgrowth of growing capabilities in space. Both countries already plan unmanned missions to Mars. We ought to coordinate our efforts. We also should begin discussions with the Soviets on the feasibility of sending a human crew to Mars in a joint US-Soviet mission, perhaps with involvement by other nations as well."

For the full texts of all candidates' statements received by The Planetary Society, send $1.00 (to cover postage and handling) to: The Candidates, The Planetary Society, 65 N. Catalina Ave., Pasadena, CA 91106.

THE MARS BALLOON

A Novel Approach to a Treacherous Terrain

by Louis D. Friedman

The martian surface can be a treacherous place to explore. Although both *Viking* landers settled there safely, most of those involved in that operation now concede that luck played a part. Furthermore, the first landing sites on Mars were chosen precisely because they were the safest. Because they were safe, they were probably also the least interesting. In the future we will want to land in more interesting spots and travel in even more rugged terrain, extensively exploring the surface.

In 1977-78, I headed a study at the Jet Propulsion Laboratory (JPL) and NASA's Johnson Space Center that featured a competition between various vehicle designs for post-*Viking* Mars exploration. The goal was to go beyond the *Viking* sites and over the horizon to study this varied and interesting planet. We confidently considered rovers that we then thought could travel thousands of kilometers. Now we are less optimistic. Even if we use the most intelligent terrain guidance system available, we may have to settle for only tens or hundreds of kilometers for any given rover mission over the rugged deserts, canyons and mountains of Mars.

We were faced with a dichotomy between extensive exploration over large, varied areas and detailed observation at particular sites. So in addition to large rovers, we also studied multiple small rovers, hard landers (adaptations of Defense Department vehicles used for intelligence purposes), a Mars airplane that could fly close to the surface over extended distances, networks of penetrators that could be put into the ground at many spots, and highly capable orbiters for remote sensing. We did not consider a balloon, thinking that option had been ruled out earlier because the Red Planet's very thin atmosphere would require a very large

At sunrise on Mars a balloon system, driven by the night wind, drags a snake-like payload of scientific instruments. The upper balloon, filled with hydrogen, keeps the lower, slack balloon aloft through the night. As the Sun heats it,the lower one will fill with warm martian air, contributing added buoyancy to lift the payload off the surface. As a small suspended camera watches, the system will ascend, to be blown by the daytime winds to a new exploration site.
Painting by Michael Carroll

balloon to support any reasonably sized payload.

But Society Advisor Jacques Blamont of the Centre National d'Etudes Spatiales (CNES) in Paris proposed to us a very innovative balloon adaptation. He was already working on balloons for the Soviet *Venera* program, in which the French were playing an integral part. An inflatable "Mars ball" three to six meters in diameter would be hard landed on Mars and then pushed around by the wind. Instruments inside could make contact with the surface to take measurements.

The idea was judged feasible, although less useful than we had hoped. The wind would quickly blow the ball into a nearby depression or crater, and then stop: end of mission.

The Mars ball did strike many as combining two virtues necessary for Mars exploration—simple mobility and ability to surmount obstacles over large regions. But some means of powered locomotion had to be devised to avoid getting trapped in a low point. Students at the University of Arizona have been studying this idea for several years and have devised a large rover with inflatable wheels. Although it hardly looks like a ball now, it has retained the name. It uses inflating and deflating sections of the wheels to move forward. The large wheels allow it to overcome obstacles. A "dumb" rover, it would presumably not be very expensive to build, though it does require large amounts of power and runs at very slow speed.

Dr. Blamont, meanwhile, devoted his attention primarily to the Venus balloons used on the Soviet Venus-Halley's Comet Mission (VEGA) in 1984-86. The successful operation of the Venus balloons in 1985 stimulated new confidence and interest in using balloons for planetary exploration. Although he followed the evolution of the Mars ball as a rover, Dr. Blamont held fast to the simple idea of a wind-blown balloon to explore the martian surface.

In 1986, urged on by a Soviet initiative, he came up with the dual balloon concept that may aid in returning a surface sample to Earth by the end of this century. The Soviets were considering a three-phase program of: (1) orbiters, including some landed science (balloons and penetrators); (2) a rover; and (3) sample return. Dr. Blamont was not optimistic about the prospects for safely landing and operating martian rovers or for devising the artificial intelligence needed to give them any large degree of mobility.

The balloon's simplicity was appealing, but a single balloon would not permit repeated contact with the surface, a problem solved by the dual-balloon concept. A hydrogen or helium lighter-than-air balloon could keep a solar-thermal montgolfiere (named after the smoke-filled balloons launched by the Montgolfier brothers starting in 1783 that began the age of human flight) suspended at night, avoiding destructive contact with the ground. In the heat of the morning Sun the solar balloon would inflate, take off and lift the instrument package off the ground. The wind would blow the balloon over large distances.

At night, without the Sun's heat, the solar balloon would lose lift and, suspended only by the gas balloon, the system would descend so that its payload would make contact with the ground. The payload's instruments would take measurements during surface contact, and a camera could provide high-resolution images of the surface during the balloon's daytime flight.

Tom Heinsheimer of Titan Systems, Incorporated, a Los Angeles aerospace contractor, suggested that the Blamont design be enhanced by adding a valve on the solar balloon. Buoyancy could be controlled so that landings and traverses could be made at many sites. The payload could include a long guide rope, suspended beneath the balloon, to permit stable night landing and terrain following. The latter occurs because the rope acts as an automatic ballast, keeping the balloon at the right height for contact with the ground. The rope could also be used as a payload container for the ground instruments.

The Blamont-Heinsheimer design offered a neat and simple solution to the problem of Mars surface exploration, permitting large areas to be explored while simultaneously allowing detailed observations. No better means of acquiring site selection information and exploring the planet's surface had ever been offered, at least in such a simple package.

On one of his frequent trips to Pasadena to work as a Distinguished

Top right: During flight tests at Edwards, California, a small airborne computer is used to record balloon temperatures.

Right: A snake payload, drawn by a wind-blown balloon, emerges from a deep crack in a Mojave Desert lava flow. In addition to its function as an instrument container, the snake must serve as a guide-rope ballast for the balloon, and it must have the right combination of slipperiness, general flexibility and local stiffness to traverse difficult terrain without snagging.

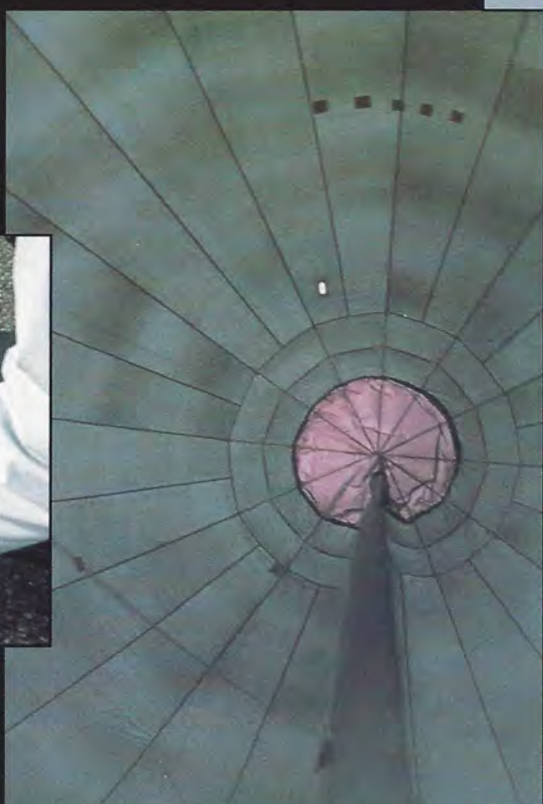
Photographs: James D. Burke, E. Hauptmann

Visiting Scientist at JPL, Dr. Blamont presented this idea to The Planetary Society. We were very intrigued by it and published an article by Dr. Blamont in the May/June 1987 *Planetary Report*. We had a great many questions about the Mars balloon and realized that some hard choices would have to be made because of the mass and power limitations of the payload that a balloon could carry.

Unfortunately, early in 1987 NASA was not studying the balloon concept at all and was examining only the classical Mars rover approach as part of a proposed sample-return mission. The French were quite interested, but CNES would not yet take formal responsibility for studying the Mars balloon and, in fact, had not yet been invited by the Soviets to take part in their mission. The Soviets were talking about a Mars balloon but had yet to complete the engineering studies. Soviet scientists and institutions were offering competing vehicle concepts for the early 1990s to provide most data for site selection and sample return at the end of the decade.

Following presentations by Soviet scientists indicating that the Mars orbiter balloon mission might be launched as early as 1992, we at The Planetary Society realized that a great deal of knowledge was needed in a hurry if the balloon's feasibility was to be evaluated and, more important, if the US was to have any chance of a role in the mission. NASA could not quickly implement such a study because the US-USSR space agreement then being negotiated made no mention of this Mars mission, so we realized that we would have to conduct the study ourselves.

We knew that our members supported our "seeding" of concepts like the Mars balloon that could help speed Mars exploration. We undertook the study with three purposes: to advance the concept, to understand its feasibility for all interested space agencies (the Soviets, the French and NASA), and to increase the chances



***Above:** Looking up into the montgolfiere balloon, inflated by the heat of the California desert sun. At the top is a circular rip panel that can be opened for descent.*

***Right:** A test balloon system, built by the French Centre National d'Etudes Spatiales (CNES) and sent to JPL for flights at the NASA Dryden Flight Research Center. The black montgolfiere balloon is shown partway through its solar inflation.*

for an American role in this new mission concept.

We formed a science working group and met several times to evaluate Mars balloon objectives. We quickly concluded that the balloon's unique contributions were high-resolution imaging near the surface over a wide area and surface contact at many sites, which would permit sampling and analysis. These became the principal balloon requirements. Other payload ideas have been suggested and considered throughout our study, but we have not given them priority.

During our study, another goal has become important: measuring soil conductivity to learn about possible liquid water content beneath the surface. Although this measurement is very important to understanding Mars' climatic history and to planning human missions, its feasibility is debatable, and it is still under study.

With these requirements from the science working group, we began to design an imaging system and a payload container for contact with the martian surface. For the imaging system we contracted with the Ball Aerospace Corporation and, in particular, with Alan Delamere, the designer of the *Giotto* camera that took such fine images of the nucleus of Halley's Comet. For the payload design we joined an ad hoc team of students and engineers brought together by their common interest in this innovative new concept.

By this point, JPL had started a minor NASA-sponsored Mars balloon technology project. Graduate students at the California Institute of Technology (Caltech), organized by Bruce Murray, had undertaken a Mars balloon project, and a similar group at Utah State University had been organized under Frank Redd. Titan Systems had received a small JPL contract for a Mars balloon system study. Titan's Dr. Heinsheimer, a balloonist himself, had extensive experience with designing, building and flying balloon systems on Earth. This ad hoc team conducted several studies and programs throughout 1987.

Candidate payload designs were of three generic classes: a gondola suspended below the balloon; a snake or rope configuration to be dragged beneath the balloon with a distributed series of instruments along the snake; and some sort of wheeled package, which we called a rollagon. There was no way to study these shapes and mass distributions theoretically. We had to build them and try them out over Mars-like surfaces. We traveled to the fresh lava flows of California's Mojave Desert, which we felt best simulated the rugged conditions of the martian surface. We conducted two sets of tests: one with payloads suspended be-

***Top:** As on the planet Arrakis in the novel* Dune, *the pitiless winds of Mars endlessly shift its fine sands, sculpting them into vast dune fields greater even than those of Africa and Arabia on Earth. Here we see a portion of the enormous dune field that rings Mars' north pole, always moving, driven by the circumpolar winds.*

***Above:** A variety of martian landforms: volcanic, tectonic, and impact-formed. Martian volcanos resemble those of Earth, though some are much larger. The volcano Ceraunius Tholus, with its 22-kilometer-wide summit caldera, dominates this image (bottom). As the martian crust bends and stretches or compresses due to tectonic forces, cracks and wrinkle ridges form (top right). And in the ancient past, when a meteorite smashed into an ice-laden surface, the result was a splosh crater surrounded by a muddy fringe with a characteristic rampart at its scalloped edge (left). Images: JPL/NASA* neath a piloted hot-air balloon, and one with payloads suspended beneath a helium balloon loosely tethered to people running along the ground.

From these tests we concluded that any gondola-like container would run into severe difficulties on the martian surface, most likely getting snagged in crevices or on boulders—and abruptly ending the mission. The snake-type payloads worked very well and proved extremely adaptable for going over many different terrains with relative ease. The rollagon, which sounded good in theory, never worked well, quickly snagging on rocks and falling into crevices.

But the snake payload did have one problem—thermal control. How could you put instruments in a distributed mass and keep them warm in the frigid martian environment? All battery concepts seemed to be too complicated and too massive. The batteries would be located at the end of the snake, but to use them to heat instruments located elsewhere would require extensive power lines throughout. JPL engineers found a possible solution: button heaters of radioisotopes that could be placed alongside each instrument. (These small units release heat but no radioactivity; they are hermetically encapsulated.) These permitted development of a feasible snake design. The ad hoc team then took all the different components—both balloons, suspended payload (primarily imaging) and ground payload—and put them together to develop a baseline design. The payload is very limited, but as a result of our desert tests, we've derived a design in which we have confidence.

Meanwhile, we were conducting other flight tests. We were measuring the montgolfiere's response time to solar heating and evaluating the flight characteristics of the dual balloon. We had—and have—some concerns because the balloon will be a new concept in an uncertain environment. We are using *Viking* wind data and atmospheric circulation models from NASA's Ames Research Center. We don't have great confidence in them, but they do enable us to make general predictions in accord with global data. Furthermore, our knowledge of different martian sites is limited. We worry about local environmental conditions changing on us suddenly. A great deal of work is still required in modeling and simulation tests of the balloons.

The balloon concept is made feasible by ultra-thin materials that are now the focus of some French experiments. Small balloons have been built and delivered to JPL, and larger models have been flown in France. Full-size balloons have not yet been made, and the materials are not yet fabricated. Thus, although we have confidence in the feasibility of the balloon design, we also recognize that we are pushing the limits of knowledge and technology in this innovative experiment.

We have recommended in our presentations to the Soviets and French that a simpler contingency plan be studied along with the dual balloon concept. Three alternatives have been offered thus far. The first, by the Soviets, is a single lighter-than-air balloon flying above the martian surface and thus failing to meet the ground-contact requirement. The second, suggested by Dr. Heinsheimer at Titan Systems, is a super-pressure balloon that would lift off at night due to the cooling and increased density of the martian atmosphere. The third, conceived by the JPL-Caltech team, is a "buoyant kite" that would sacrifice a great deal of the range of the flying balloon but would permit a more reliable buoyancy to avoid being forced into the ground by a payload snag. The dual balloon is the first choice and therefore serves as the baseline for the continuing French balloon studies and for Soviet system designs.

All three space agencies enthusiastically received the ad hoc team's work, presented in October 1987 at the International Astronautical Federation meeting in Brighton, England, and encouraged the team to continue its efforts. But we at the Society believed that we could not go much further with engineering tests and system designs without being given some agreed-upon responsibility in the program. No one was prepared to make that commitment.

The Soviets did, however, ask us to provide a mechanism so that Americans could continue to participate in the development of the balloon concept and, specifically, help define objectives and requirements. The Soviets were forming an International Mars Balloon Science Advisory Group and asked us to help Americans be part of it. We have agreed to do this.

In November 1987, the French formally agreed to be responsible for Mars balloon development in support of a Soviet 1994 mission. The Society together with the team has continued to serve as informal liaison to both the Soviet and French programs and to support, to a limited extent, some continuing studies so that our research reports can serve as the basis for formal team activity as it is organized. We expect this to happen now that the Soviet *Phobos* spacecraft have been launched. An additional report was presented to the Soviets and French at meetings in Moscow in July 1988.

We'll keep you informed as this project progresses. At any rate, we're very happy we were able not only to keep Mars ballooning research alive when no one else was funding it, but also to make some advances in this novel means of exploring the Red Planet.

Above left: At dawn in the Mojave Desert, a CNES balloon is inflated with helium in preparation for the day's simulations of a martian traverse.

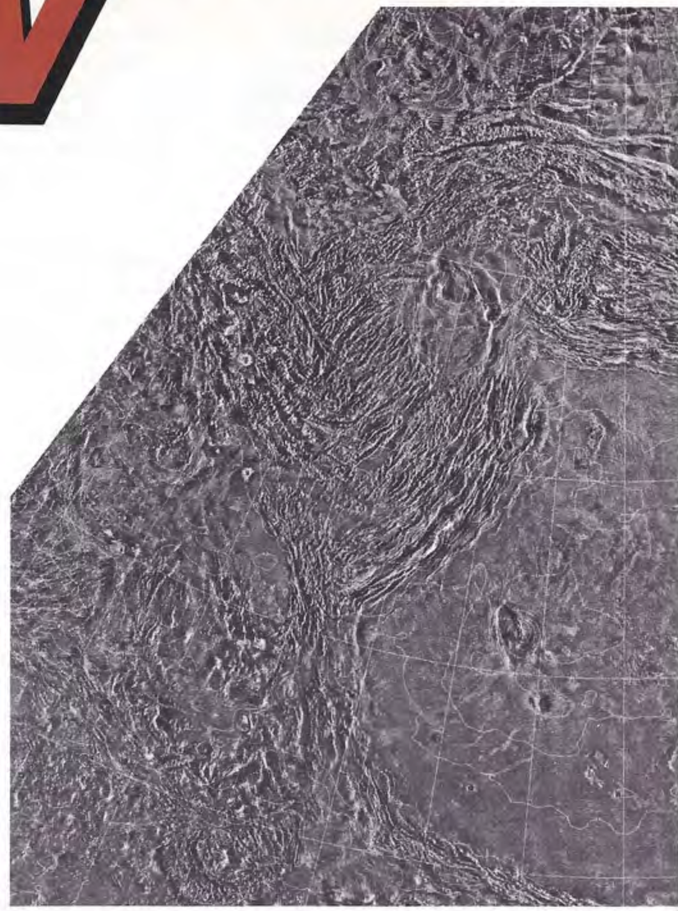
Left: Balloons carrying cameras drag various simulated martian payloads over the lava flows of the Pisgah volcano in California.

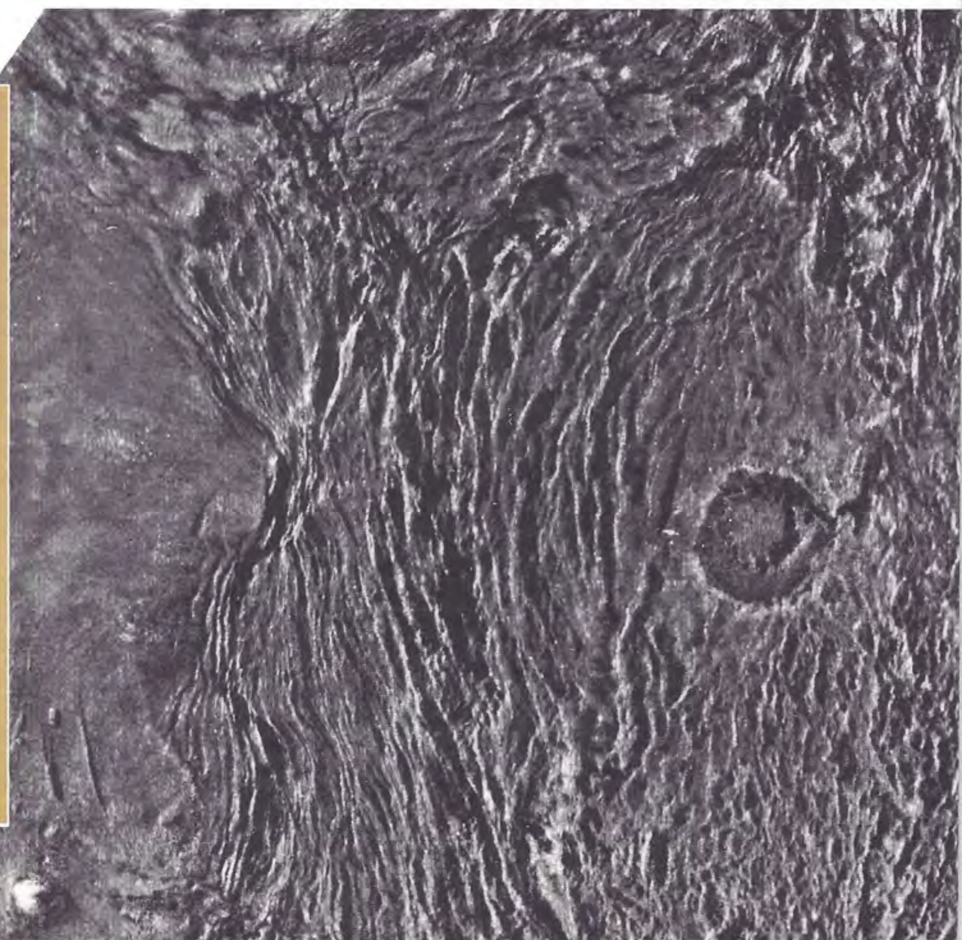
Louis D. Friedman is The Planetary Society's Executive Director.

Visualize Venus:

In November 1983, two Soviet spacecraft, *Veneras 15* and *16*, began a radar survey of the north polar region of Venus. (Radar must be used to pierce the planet's perpetual cloud cover, which hides the surface from visual imaging techniques.) Over the next several months, the two spacecraft, using powerful synthetic-aperture radars operating on principles similar to those used in the American *Seasat*, in military aircraft and in US shuttle flights, mapped Venus with resolutions as fine as one kilometer on the surface, revealing a startling panoply of landforms. In 1989, if all goes well, the American *Magellan* spacecraft will continue the radar mapping of Venus, extending the coverage over the rest of the planet's surface and increasing the resolution to hundreds of meters in selected areas. Based on the *Veneras 15* and *16* results, we already know enough to say that splendid discoveries await *Magellan*.

The images shown here are the result of careful computer processing of the data, done to show the finest detail of which the radars were capable and to achieve mapping fidelity in the location of objects in the scenes. They were provided to us by Dr. Duane Muhleman of the California Institute of Technology, who received them from Dr. O. N. Rzhiga of the USSR Academy of Sciences' Institute of Radioengineering and Electronics. The captions are by R. Stephen Saunders of the Jet Propulsion Laboratory.





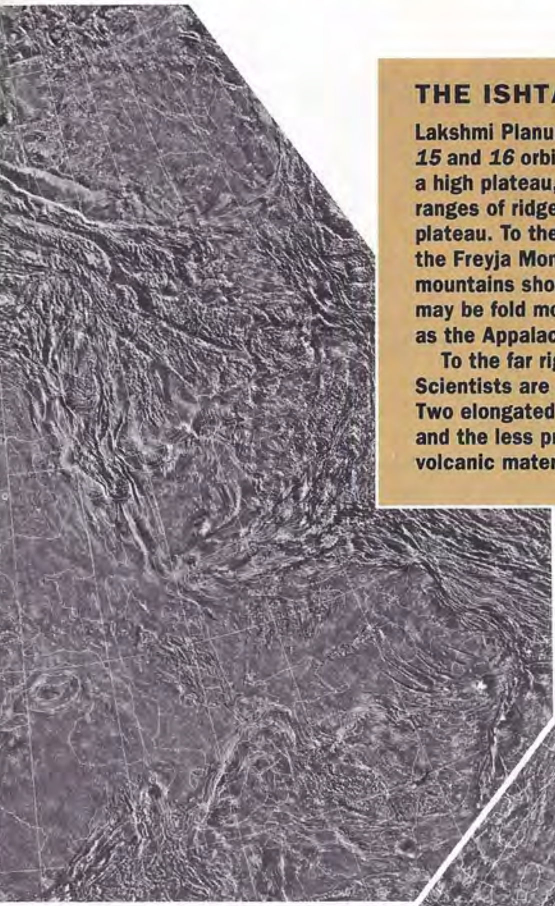
MAXWELL MONTES

Maxwell Montes (the mountains of Maxwell) lie on the Prime Meridian (0 degree longitude) at 65 degrees north latitude in the central part of Ishtar Terra. Maxwell Montes are a series of linear ridges and troughs; their crest runs north to south through the center of this image.

Cleopatra Patera (center right) lies on the east flank of Maxwell. The main crater is about 100 kilometers in diameter. There is also an inner crater about two kilometers deep. Cleopatra has some features of an impact basin—a circular outline and a multi-ringed, raised rim. Yet an impact explanation is not completely satisfactory since we can find no clear evidence of ejected material that should have been thrown out by the impact of a comet or asteroid.

The linear, gashlike features on the plains to the west run nearly parallel to the topography of Maxwell. These troughs may be tension faults, or graben, that form from the load Maxwell exerts on the crust of Venus.

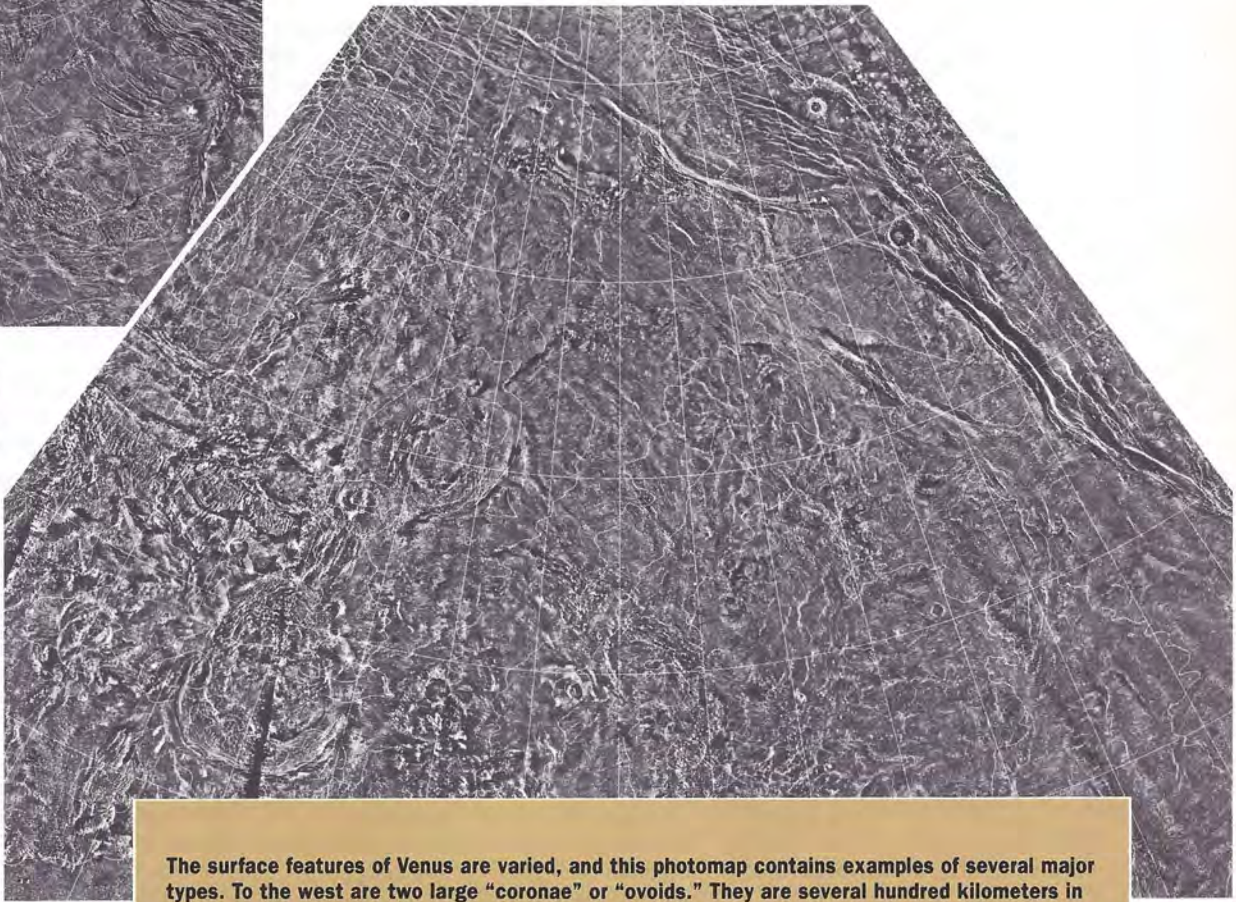
Veneras 15 and *16* Radar Images



THE ISHTAR REGION

Lakshmi Planum (plain) dominates this photomap, compiled from radar images taken by the *Veneras 15* and *16* orbiters. This relatively smooth region occupies most of the center of the map. Lakshmi is a high plateau, rising three to four kilometers above the low plains of Venus. The plains are ringed by ranges of ridge-and-valley mountains, which rise an additional three to seven kilometers above the plateau. To the south and southwest are the Vesta Rupes, a series of low ridges. To the northwest are the Freyja Montes, and on the east the Maxwell Montes, which rise to eleven kilometers. All these mountains show characteristic ridges and troughs that parallel the Lakshmi Planum margins. These may be fold mountain belts similar to those that occur along some continental margins on Earth, such as the Appalachian Mountains in the United States.

To the far right of this map is Cleopatra Patera, sitting on the east flank of the Maxwell Montes. Scientists are uncertain whether it is volcanic or was formed by an impact of an asteroid or comet. Two elongated volcanic calderas lie on Lakshmi Planum. The prominent caldera to the west is Colette, and the less prominent one to the east is Sacajawea. Both are associated with low shields, piles of volcanic material. The irregular outlines of volcanic flows from the calderas are visible in this image.



The surface features of Venus are varied, and this photomap contains examples of several major types. To the west are two large "coronae" or "ovoids." They are several hundred kilometers in diameter, roughly oval in shape, with relatively little relief. They contain low, interior ridges that are approximately concentric with their outer margins. Patterns resembling volcanic flows lie across these features and on their margins. Geologists generally interpret these coronae as the surface expression of rising low-density hot spots from within the mantle of Venus.

To the east is a series of ridges and valleys. Scientists interpret these features as tectonic (caused by deformations in the planet's crust), but both compression, which creates folds, and extension, which produces sets of faults, have been proposed for their origin.

Several impact craters, up to 60 kilometers in diameter, appear in this map. The crater to the northeast has a central peak and a rim that appears bright to the spacecraft's radar. The bright material reflects more of the radar because it is either extremely rough or is composed of highly reflective material.

World Watch

WASHINGTON—We hope that by the time you read this the space shuttle *Discovery* will have completed a successful mission and that the United States will have spectacularly returned to space. But no matter how successful this first flight after *Challenger*, we now know that the shuttle fleet alone cannot guarantee America's access to space or be the space workhorse of the 1990s. The dream of routine access to space in a cheap piloted vehicle should not soon be confused with reality.

NASA's official shuttle schedule, like all its predecessors, assumes that there will be no problems or delays. It has yet to take into account two new problems: the shortage of ammonium perchlorate (an oxidizer for solid rocket fuel) in the United States following the explosion of a manufacturing plant in Nevada, and the rumored shortage of parts needed to complete the missions scheduled for 1989.

Because of the two-and-one-half-year backlog, many scheduled launches are critical to both the civil and military space programs. Five space science missions are scheduled: the Hubble Space Telescope, *Magellan* to Venus, *Galileo* to Jupiter, *Ulysses* to the Sun's polar regions and the *Mars Observer*. The planetary missions are particularly vulnerable since they can only be launched when the planets' relative positions are favorable. For *Magellan* the launch window comes every 19 months, for *Galileo* every 13 months, and for *Mars Observer* every 26 months. Although NASA's planners have done a remarkable job in considering these missions' needs, the schedule is vulnerable to even minor problems.

This vulnerability has driven efforts to build a fleet of both expendable launch vehicles (ELVs) and space shuttles. Abandoning its earlier reluctance, NASA is now trying to procure ELVs for *Mars Observer*, the proposed Comet Rendezvous/Asteroid Flyby (CRAF) and the proposed *Cassini* mission to Saturn and Titan. Congress now seems to support ELVs for the planetary program, although the budget to pay for them was not yet approved as we went to press.

Congress is also studying the ammonium perchlorate problem, but concerns about the shuttle schedule and flight, which strike at the heart of the US space program, are graver.

KALININGRAD, USSR—At 9:38:04 pm on July 7, 1988, the Soviet Union launched a *Proton* rocket sending the *Phobos* spacecraft to Mars. I was privileged to join a small group of foreign visitors to watch the launch from the mission control center at Kaliningrad, outside Moscow. I was struck by the matter-of-fact, routine nature of the launch, with no announced countdown, fanfare, holds or delays. There were empty seats at some mission-control consoles, and except for the presence of visitors, nothing looked extraordinary—but it was.

The launch of the second *Phobos* spacecraft, on July 12, was equally precise. It blasted off on the exact second scheduled and reached its orbit to Mars as accurately as had *Phobos 1*. However, the missions were not without problems. On its first day of flight, *Phobos 1* experienced high internal temperatures that threatened some of its delicate sensors. The high temperatures apparently were due to the unlucky but arbitrary position of the spacecraft relative to the Sun. As soon as its orientation was changed, the temperatures cooled down. None of the instruments appears damaged by the temporary temperatures over 46 degrees Celsius (115 degrees Fahrenheit).

When the celebration began and the toasts were offered after the second launch, I was gratified that many cited The Planetary Society's role in furthering the international cooperation that contributed to the involvement of so many people from different nations.

Phobos is Earth's first mission to Mars since the US *Viking* mission was launched in 1975. It signals a new phase of martian exploration that will culminate in landing humans on the Red Planet, possibly within 25 years.—*Louis D. Friedman, Executive Director*

PASADENA—The *Mars Observer* project has had to drop two instruments —the VIMS (Visual-Infrared Mapping Spectrometer) and the radar altimeter—due to cost increases caused by NASA's delay of the launch from 1990 to 1992. Earlier this year NASA officials were even considering a further delay, from 1992 to 1994. However, because of strong support from NASA's own science advisors and from The Planetary Society for keeping *Mars Observer* on schedule, the agency kept the mission slated for 1992.

WASHINGTON—Congressional action on the fiscal year 1989 budget has thrown into doubt plans for the US space station. After resisting attempts to cancel or delay the project, Congress nevertheless withheld full support for NASA's proposed space station. It authorized funding for the station but held the funds in escrow pending consideration by the new President. If he fails to act before April 1989, the money will be released so the program can continue. However, as a result of this legislation, the new President is being asked to reconsider the entire program.

Support is growing for The Planetary Society Directors' position that the space station should be redesigned to be more suitable for studying long-duration human spaceflight and preparing for a mission to Mars. The NASA authorization bill passed by the House of Representatives mandates that "the space station be developed for human exploration of Mars." This would mean de-emphasizing microgravity processing, which lacks scientific and commercial backing.

HELSINKI, FINLAND—The Planetary Society sponsored a special session and a public lecture at the biennial meeting of space scientists who compose the Committee on Space Research (COSPAR) of the International Council of Scientific Unions. The topic was "The European Role in Mars Sample Return," and the sessions were cosponsored by the European Space Agency (ESA). Dr. Roger Bonnet, head of ESA's Space Science Program, presided over the sessions. Dr. Chris McKay of NASA Ames Research Center, coordinator of The Planetary Society's Mars Institute, acted as co-chairman for the Society. Dr. Michael Carr of the US Geological Survey gave the public lecture at a special session for Scandinavian Planetary Society members and COSPAR attendees.

Participants decided to seek a special COSPAR resolution stating that Mars rover and sample return should be conducted as an international mission, involving not only the US and the Soviet Union but also other spacefaring nations.

MOSCOW—After the *Phobos* launches, the Soviet Institute for Space Research organized several days of open meetings about Mars exploration. Representatives of the Soviet space centers described their plans for robotic and human missions to Mars. Their three-phase approach involves:

—Robotic exploration in the 1990s, culminating in a Mars rover and sample return mission;

—Tests of piloted systems in a robotic mode to try out spacecraft systems, orbital operations and even a Mars landing in the first few years of the next century;

—A piloted mission to Mars, perhaps by 2010.

Attention focused on the next Soviet mission, *Mars '94*, and two opposing approaches to the launch and design of the spacecraft. The first approach would use two *Proton* launches (the same vehicle that has been used for Soviet planetary missions for over 20 years) and spacecraft similar to those on the *Phobos* mission enroute to Mars. A landing system would include a small rover of about 150 kilograms that might range over 100 kilometers in a year; a balloon to fly over the martian surface, occasionally landing to make measurements (see article, pp. 7-11); and penetrators to measure soil composition.

The second proposal uses an *Energia* rocket—the new Soviet heavy-lift launch vehicle. It could launch a much larger orbiter of perhaps seven tons (carrying 600 kilograms of instruments instead of the *Proton*'s limit of 200 kilograms); a larger (600 kilograms) rover with a range of 1,000 kilometers; and several balloons, penetrators and atmospheric measuring stations. Many scientists and engineers doubted whether the sample return spacecraft or the large rovers could be ready for 1994 and wondered if such an approach would delay the mission until 1996 or 1998.

Thomas Heinsheimer of Titan Systems, Inc., attending as a representative of The Planetary Society's Mars balloon program, and *Mars Observer* chief scientist Arden Albee of the California Institute of Technology came up with an innovative suggestion for placing in Mars orbit a communications, navigation and data processing satellite network similar to those used around Earth. If *Energia* could launch such a network during the 1990s, the design of future vehicles to explore the martian surface would be much easier. Sophisticated communications and data processing systems in Mars orbit would enable many countries to contribute rovers, penetrators and balloons for smaller missions.

The increased payload made available by *Energia* would also permit the return of film from Mars orbit instead of transmitting television data from Mars orbit. A film return would increase the quantity and quality of data that could be returned—perhaps photographs of 30 percent of the martian surface with details as small as one meter!

Ironically, meetings like this are so new in the Soviet program that there are fewer rules and procedures than in corresponding meetings in the US. The town meeting atmosphere, coupled with Soviet capability to launch enormous payloads, means that many new ideas can be implemented without a lot of debate about "priorities." This will undoubtedly change as additional constraints and persons are involved in the process, but at this point, it is an extremely refreshing contrast to the excessive constraints of the recent American space program.

PASADENA—The Mars balloon relay experiment (MBR), a proposed joint effort by the US, USSR and France, may be conducted in 1995 using orbiting spacecraft and balloon stations on the planet's surface and in its atmosphere. This collaboration would be the most substantive step yet in American, Soviet and French space cooperation, establishing for the first time a Soviet role on an American spacecraft.

The *Mars Observer* would transmit information back to Earth from the balloon station, including on-site geophysical, geological and meteorological data and very high-resolution imaging data from a large surface area. The balloon instruments would sample the martian surface nightly.

The availability and capability of the receiving orbiter would determine the amount of data transmitted. If we assume a format like that of a US imaging system, from 100 to 750 high-resolution pictures should be available for the Soviet *Mars '94* mission.

If the necessary equipment is incorporated on the *Mars Observer* and if operations are sequenced correctly, then both the Soviet and the US spacecraft could receive balloon station data and retransmit them to Earth.

The Soviets have selected the Centre National d'Etudes Spatiales, the French space agency, to supply the *Mars Observer*'s balloon station relay equipment, which would probably include an antenna; a diplexer, which would allow simultaneous telecommunication of two independent signals by a single station or antenna; a transmitter; a receiver; and a decoder.

The orbiter transmitter would communicate with the balloon station, which would respond by transmitting data. The spacecraft would then decode the data, decompressing it if necessary and routing it to the *Mars Observer* camera (MOC). The MOC signal processing electronics would treat the data as though they were from the MOC sensors. The data would be buffered, compressed, formatted and transferred to the payload data subsystem for routing directly to the spacecraft transmitter or to the data storage subsystem for later transmission. This approach was selected for its technical capability, low cost and ease of implementation.—*William Purdy, Jr., Jet Propulsion Laboratory*

Outbound To Mars:

The *Phobos* Mission is Launched

by James D. Burke

One of the complex Phobos *spacecraft is prepared for launch. Photograph courtesy of A. Zakarov*

On July 7 and 12, two giant *Proton* vehicles lifted off from the Baikonur Cosmodrome in Kazakhstan, USSR. Each rocket placed into Earth orbit a large payload including a six-ton spacecraft destined for Mars. After traveling once around Earth, the launch vehicle's final stage and the spacecraft's own engine fired to boost each craft onto a transfer trajectory to Mars. So began the latest and most dramatic of the Soviet Union's explorations of the solar system. If all goes well, many long months from now, in the spring of 1989, these craft will rendezvous with one or both of Mars' small moons, Phobos and Deimos.

The innovative *Phobos* mission represents the next ambitious and confident steps in the USSR's deep-space program. Persistent Soviet efforts over many years finally yielded good scientific results at the Moon, Venus and Halley's Comet, but attempted ventures to Mars were less successful. When the American *Viking* missions went to Mars in 1975-76, the combination of their overwhelming technical superiority and their disappointing biological findings caused a lengthy pause in Soviet martian exploration. But after a decade, that exploration has now resumed; new missions are planned for coming years by both countries, and so a bright martian future is opening for us all.

Why Phobos? Good reasons, both scientific and practical, exist for making it the next target. Moons of all kinds are great subjects for scientific curiosity (even the origin of Earth's Moon is a subject of lively inquiry) because of what they can tell us about the evolution of the solar system. The two tiny moons of Mars are particularly interesting. Spectrometry shows their surfaces to differ strongly from that of Mars, and their orbits are evolving, with Phobos falling in toward Mars and Deimos going away. In only some tens of millions of years, a short time geologically, Phobos is expected to crash into Mars. Some scientists believe that both moons are captured asteroids; their dark, soft surfaces appear to reflect the chemistry of certain meteorites rich in organic matter.

When the *Viking* orbiters closely approached Phobos, they found its smoothly cratered surface to be crossed by hundreds of mysterious grooves unlike any other phenomenon observed in the solar system. The grooves appear to emanate from near the crater Stickney, the result of an impact that nearly disrupted the little moon. Is Phobos cracked through and through? Did the grooves result from venting of gases along the cracks? Was this a sort of sub-cometary phenomenon betraying an icy interior? Nobody knows, but the possibility that Phobos contains organic compounds, water and other volatiles makes it extremely interesting—not only scientifically but also as a resource for future human explorers of Mars. Also, Phobos and Deimos are relatively easy to reach; though the trip times are long, the speed changes required are modest, and therefore heavy payloads can be delivered.

The Soviets and their many international partners have taken good advantage of this opportunity. Each *Phobos* spacecraft carries an impressive complement of instruments, not only for the investigation of Phobos (the second spacecraft may possibly be retargeted to Deimos), but also for the remote observation of Mars. And though these objectives in themselves are ambitious, the spacecraft are also outfitted with a large array of solar and interplanetary instruments to be used during the long cruise to Mars.

As this mission proceeds, we shall keep our readers informed of its progress.

> As we go to press, we've just heard that Soviet ground controllers have lost contact with *Phobos 1* and are working to regain radio communication.

James D. Burke is a member of the Technical Staff at the Jet Propulsion Laboratory and serves as Technical Editor of The Planetary Report.

Phobos —

A Surface Mine or an International Park?

by Iván Almár, Andras Horváth and Erzsebet Illés

Recently Phobos and, to a lesser degree, the other martian satellite, Deimos, have been considered in several space colonization projects as principal sources of raw materials. The arguments appear in a number of US papers given at recent International Astronautical Federation congresses in Innsbruck (1986) and Brighton (1987), such as "Long Range Planning at NASA" by Ivan Bekey or "Asteroid Mining and the Moons of Mars" by Brian O'Leary. We quote the following excerpt from the abstract of the second paper:

"The presence of water on Phobos could be confirmed by a Soviet unmanned mission planned for 1988 launch. In later missions, water can be used for refuelling and life support....Water can be more economically delivered from Phobos to the lunar surface and to orbital space stations than from the surface of the Earth." Therefore, "Phobos and Deimos appear to represent key initial steps in industrializing space utilizing asteroidal and lunar resources."

Any surface mining on a large scale might severely change the surface appearance of these celestial bodies. The surface of Phobos is only about 1,500 square kilometers, smaller than the island of Mauritius. In just a few years of exploitation, the whole surface would be made unrecognizable even if efforts were made to protect selected areas such as crater Stickney.

We strongly feel that due to its special groove system Phobos is probably a unique body in the solar system. Based on a careful analysis of the best images then available, Illés and Horváth published the opinion a number of years ago concluding that Phobos might have a layered structure unexpected in such a tiny object.

The complex system of linear features found by the *Viking* orbiters in 1976 can be classified structurally based on their appearance as well as their distribution. Some of these features may follow very old layering cutting through the whole body of the satellite. Such layering would imply that Phobos is a near-surface piece of what was once a larger body, called a protoplanet. Since crater counting suggests that Phobos as an independent object is old, the parent body must have had a relatively short lifetime in which to produce such advanced inner differentiation. To determine whether or not Phobos really has a layered structure, we would have to perform surface measurements using special imagery, search for a possible permanent magnetic field and carry out seismic experiments on two separate parts of the surface.

If, however, space industrialization projects are implemented, Phobos will be in danger. Its unique groove system will be destroyed. We are convinced that humanity should look for an alternative solution and leave Phobos as a natural park for the sake of future generations of explorers. Maybe we are prejudiced; perhaps other astronomers or planetary scientists would be more interested in the preservation of other bodies in the solar system.

Nevertheless, we suggest that a group of experts should deal with the problem of selecting protected areas or protected bodies *before* the planning of industrial activities in space goes too far. The Planetary Society, as an internationally known non-governmental organization, could undertake the task and form an international consultative study group. Since long-range planning is required for any space industrialization project, establishment of such a group would not be premature. Our solar system, like our Earth, needs a well-considered strategy for preserving and using its natural resources.

Iván Almár is Deputy Director of the Konkoly Observatory in Budapest and President of the Hungarian Astronautical Society. Andras Horváth directs the planetarium and Urania Observatory in Budapest. Erzsebet Illés is an astronomer at the Konkoly Observatory.

At the "Steps to Mars" conference co-sponsored by The Planetary Society and NASA at the National Academy of Sciences in Washington, DC in July 1985, Society President Carl Sagan raised similar concerns about what he described as plans for the "strip-mining" of Phobos, although he noted that the grooved surface of Phobos looked as if it had *already* been strip-mined. Whatever the origin of the surface features of the martian moons, they represent a scientific treasure trove that we should make every attempt to preserve. This issue is part of a broad field of environmental ethics in the future exploration of the solar system, an arena in which The Planetary Society intends to be involved.

The crater Stickney dominates the face of Phobos, with the mysterious grooves appearing to radiate from the mouth of the crater.

Image: JPL/NASA

News & Reviews

by Clark R. Chapman

Every two months, the San Francisco-based Astronomical Society of the Pacific (ASP) publishes *Mercury*, a magazine for the general reader. Two chief aims of *Mercury* and the ASP are to inform and educate. Let's look at the May/June 1988 issue, bearing in mind that typical issues are more astronomical—and less planetary—in focus.

Although planetary science is treated in various earth science and astronomy texts, its true interdisciplinary nature is often lost. Earlier this year Addison-Wesley published a new textbook just on planets by David Morrison and Tobias Owen called *The Planetary System*, with a preface by Society President Carl Sagan. The cover article for the May/June *Mercury* adapts part of Morrison and Owen's treatment of the Moon.

Starting with the Moon's familiar aspects as seen by the naked eye, the authors methodically discuss lunar science and the history of lunar exploration by spacecraft. *Mercury*'s able editor, Andrew Fraknoi, has supplemented this first installment with occasional explanatory footnotes and specially selected illustrations. After an elementary, even treatment of lunar cratering and its implications for cratering on other planets, the article concludes with the promise, "to be continued."

Mercury includes a couple of "departments." One, called "Echoes of the Past," highlights some of the history of Lick Observatory (from both 100 and 60 years ago) before suddenly jumping to Fred Whipple's 1950 theory about the nature of comets.

A particularly intriguing department of *Mercury* is "The Astrophysical Zoo," in which we learn all about an interesting object in the heavens. For May/June, the object is the star RG0050-2722, the least massive star yet observed. According to author David Hughes, this faint star, about 82 light years away, has less than half the surface temperature of the Sun. Accordingly, it puts out only two-millionths of the Sun's radiation.

David Hughes says that it is "difficult to pin down" the difference between a real star, a brown dwarf and a planet. Unfortunately, it is especially difficult for Hughes himself. He seems to say that RG, at one-fortieth of the Sun's mass, is indeed a real star, but then he goes on to say that stars with less than eight percent of the Sun's mass are brown dwarfs. Further confused by an inconsistent comparison with Jupiter, the reader takes hope from Figure 2, which shows the dividing lines between stars, brown dwarfs and planets. Its caption promises to show the position of RG, which, alas, is missing from the diagram. This article was clear and helpful on some fundamental concepts in astronomy until the confusion. Fraknoi aids Hughes with footnotes about some other issues, but we remain unsure about whether or not RG is a brown dwarf.

Pioneering the Solar System

The second article in a series about the *Pioneer* spacecraft of the 1960s and 1970s leads with an obsolete artistic view of Saturn, showing none of the marvelous ring structure hinted at by *Pioneer 11* and revealed in full glory by the *Voyagers*. The rendition predates *Pioneer's* arrival at Saturn. Still, Saturn's globe is shown spherical, though its "squashed" shape (due to thick atmosphere and fast spin) has been known for centuries.

Pioneers 10 and *11* served as forerunners to *Voyager*. Though they returned comparatively unspectacular imaging data, they did achieve the first probing of the plasma environments of Jupiter and Saturn. NASA authors Earl Montoya and Richard Fimmel catalog the *Pioneer* discoveries and engineering triumphs. In telling the story of this inexpensive and highly successful series of American planetary missions, they can be forgiven for going too far in claiming, for example, that *Pioneer* obtained "a new understanding" of Jupiter's weather.

Editor Fraknoi has augmented the *Pioneer* article with the often-told, but still interesting, story of the famous interstellar message plaques, designed by Carl Sagan and Frank Drake, that were attached to *Pioneers 10* and *11*. The plaque design—complete with binary codes and naked human beings—is described in the words of Frank Drake.

Are We Alone?

When the *Pioneers* were launched, Frank Drake's optimism about contacting extraterrestrials was based on promising approaches to SETI (the search for extraterrestrial intelligence) rather than on any real expectation that aliens would soon find our *Pioneers*. But according to Gregg Easterbrook, writing in the August *Atlantic*, Drake is now less optimistic. And other contentious pessimists think we may really be alone, at least in the Milky Way galaxy. Easterbrook's readable, thought-provoking cover story ranges from the as-yet-unsuccessful astronomical searches for intelligent radio signals to some biologists' estimates of the chances of life developing from primordial soup.

I recognized many of the SETI issues (What do we dare say back if contacted?), learned about some new ones (the idea that since we were the first to evolve, we are alone for now due to the inherent time it takes stars and biological systems to produce intelligent life), and found some others more appropriate for religion (God's motivations) or science fiction (what happens to us if extraterrestrials have "beaten" the speed-of-light barrier). Planetary Society members should enjoy the discussions of Paul Horowitz's research, even though Easterbrook does not explicitly describe the Society's role in SETI.

Nearly three decades after Frank Drake's Project Ozma got underway, the fundamental question about our cosmic aloneness remains unresolved. The possibilities remain that we have company, we once had company, we are alone in the Milky Way, we are alone (period), and we are the first. It is fun to ponder the alternatives.

Clark R. Chapman is the co-editor of a new technical book about the planet Mercury, to be published by the University of Arizona Press before the end of the year.

Politics and The Planetary Society: *A Personal View*

by Louis D. Friedman

We're frequently asked, "What's The Planetary Society's position on the militarization of space?" Often this takes the form: "What is the Society's position on 'Star Wars'?" The answer is "None."

Since our formation the Society's Directors have affirmed our purpose as "encouraging the exploration of the solar system and the search for extraterrestrial life." Although occasionally some criticize this focus as too narrow, in fact it is as wide as the universe.

Within it we publish, lecture, meet, exhort, lobby, educate, entertain and inform. That focus involves us with the space programs of all nations; we deal with international cooperation, technology transfer (hence, national security), scientific research, the search for extraterrestrial intelligence (SETI), professional and amateur astronomy, education and launch vehicles (hence, perhaps even Intercontinental Ballistic Missiles).

Clearly all of these concerns are connected, and we could offer a reasonable defense of our involvement in the full range of issues—military, civilian, political, scientific, environmental, economic and social. For example, as part of our SETI program we're supporting a dolphin communications project as a means to investigate inter-species communication. Does this research with animals thrust us into the animal rights discussion and bring us into the protest over tuna fishing practices? Not yet.

By keeping our *raison d'être* focused on the exploration of new worlds, we can contribute uniquely and not diffuse our effectiveness. The Planetary Society has grown in size and significance, we believe, by not deviating from its course. We take on only those initiatives that fall within our specific focus: SETI, Mars, planetary missions and, soon, studying Earth as a planet.

Because military space developments clearly influence our activities, in 1985 we co-sponsored a symposium on "The Effect of Space Weapons on the Civil Space Program." We also are studying the possible use of decommissioned nuclear missiles as launch vehicles. But our involvement stops at the intellectual level, and we do not advocate any position outside our focus. Thus, we take no position on the Strategic Defense Initiative or on disarmament proposals.

But, you protest, everyone knows of Carl Sagan's stance against S.D.I. (e.g., "The Leaky Shield," *Parade*, December 8, 1985). Are we being disingenuous? Dr. Sagan's position is his own, as are the positions of all of our Board members, who as unpaid volunteers are free to express their opinions. The same is true of Advisors such as Hans Mark, former Secretary of the Air Force, or Harrison Schmitt, former Republican Senator from New Mexico, or Roald Sagdeev, the foremost Soviet space scientist and member of the Supreme Soviet. We believe we have succeeded in separating personal opinions from the positions of the Society. Several years ago we polled our membership and found The Planetary Society to have as many "conservative" as "liberal" members (at least among those who responded). The numbers were 25 to 23 percent, 52 percent being undeclared. We have no official ideology other than supporting our single focus.

Political, scientific and intellectual issues change with times and circumstances. After years of silence we finally took a position on the space station (*The Planetary Report*, July/August 1987) because of our support of human Mars exploration and the need to re-orient the station toward that goal. We have not hitherto advocated Earth science programs, but the need to care for our world and the growing scientific connection among Mars, Venus, the Moon, comets, asteroids and the understanding of Earth is too important to ignore. Thus, the Society will soon have a new thrust and a special issue of *The Planetary Report* highlighting Planet Earth.

The military has always been involved in space activities. Civilian space explorers (human and machine) did not mind riding on military rockets in the 1960s and 1970s. Few object to the reconnaissance and communications satellites of our military and intelligence agencies. Why not? In a world of superpowers, they are generally viewed as stabilizing forces, although they can sometimes be classified as part of a nation's weapon systems.

The introduction of true weapons into space would be a step beyond that taken by any country to date. With space weapons and S.D.I. The Planetary Society needs to sort out if we have opinions as exploration advocates or just as citizens concerned for our future. We have felt that the military use of space is a political issue, not an exploration issue. If S.D.I. is good for global security, then it might be a good thing even if it's not good for space exploration. If it endangers world security, it should be avoided even if it is good for space.

Others will debate the strategic and security questions raised by S.D.I. and by weapons in space. But as we did when we held our January 1985 symposium, we can consider their implications for civil space exploration. For example, US Senator Tom Harkin (D-IA) has introduced legislation to prohibit unilateral emplacement of active weapons in space and to begin negotiations towards a treaty to accomplish this goal, just as the Outer Space Treaty did for testing of nuclear weapons in space. Congressman George Brown (D-CA) has introduced a similar bill in the House of Representatives, urging elimination of anti-satellite weapons or protection measures for satellites. A weapons-free space (including the Moon, the planets and the asteroids) may offer a special chance to enhance cooperative planetary exploration by the spacefaring nations.

Should we consider these measures? How? Or are they strictly strategic weapons questions? I don't know. I am bringing the question before our Board of Directors and soliciting members' opinions. You may wish to request a copy of Senator Harkin's bill from his office—317 Hart Senate Office Building, US Senate, Washington, DC 20510. And you may wish to write to me at the Society's office in Pasadena. I look forward to hearing your views.

Louis D. Friedman is the Executive Director of The Planetary Society.

Questions & Answers

How does a comet cause meteor showers?
—Reina Escandon, Halifax, Nova Scotia

The nucleus of a comet is so small that it exerts very little gravitational pull. You could actually jump off a comet nucleus. As a result, the wind of escaping water vapor and other gases heated by the Sun blows tiny grains of the comet right off with them. These dust grains are typically less that one ten-thousandth of an inch in diameter. When there are enough of them, the pressure of sunlight on the grains blows them out from the nucleus and forms the beautiful dust tail.

Some particles, a hundredth of an inch in diameter or even many times larger, are also blown off the nucleus by escaping gases. These particles are blown off the nucleus at very low speeds and are also sufficiently heavy to be nearly unaffected by sunlight pressure. As a result, they continue to fly right along with the nucleus, very slowly spreading into a cloud of debris all along the comet's orbit around the Sun.

When Earth comes near any part of that orbit, cometary dust particles collide with our atmosphere and burn up from the friction, usually at an altitude of 100 miles or so. The trails of the burning particles appear to come from one part of the sky, called the radiant, in unusual numbers. Cometary material is very fragile, and there is no known case of larger cometary dust particles reaching the ground.

We know the shower meteors come from comets only because they share the same general path around the Sun. Very small particles do penetrate to lower atmospheric levels, and high-flying U2 aircraft may have captured some of them, known as the Brownlee particles, in special filters carried in a wing pod.
RAY L. NEWBURN, *Jet Propulsion Laboratory*

What constitutes proof positive that a life form existed on Mars even if the life form is not now living and was of the simplest form known to science?
—Wilfred S. Mitchell, Redmond, WA

That is a good question. Life is intrinsically difficult to define. This difficulty arises from both the incredible diversity of life on this planet and from the underlying unity of Earth life. From parasitic viruses to blue whales, life provides an amazing range of behavior, metabolisms, reproductive strategies and size. Yet all life on Earth is made from the same fundamental biochemical building blocks: 20 amino acids and the nucleic bases in DNA and RNA. (See the November/December 1987 *Planetary Report.*) The diversity of that life makes a simple characterization impossible, but the biochemical unity suggests that we have so far studied only one example of life. And it is always risky to generalize from one data point.

On November 17, 1966 the Leonid meteor shower was photographed from Kitt Peak, Arizona. In this time exposure, the stars left colored trails, while the Leonids made the pinkish streaks, some with multiple bursts. This particular shower was the greatest in history for which there are accurate counts—40 per second were seen by one member of the Kitt Peak observing team.

Photograph: Donald Pearson

Having admitted our difficult situation, let me explain our approach in designing a search for past life on Mars. (The search for living organisms, which we consider unlikely, is currently being planned only by the US for samples returned to Earth. The Soviet Union seems to have more ambitious plans.) If there ever was life on Mars, it was probably during the first billion years or so of martian history, when we think conditions may have been conducive to life—there may have been a thicker atmosphere and liquid water on the surface. During this period conditions on Mars may have been very similar to conditions on Earth. Here we have evidence (microfossils and stromatolites, structures built of blue-green algae and sediments) that life existed on Earth at that time. Based on the fossils from 3.5 billion years ago, we think Earth life then was limited to simple microbial ecosystems.

If there was life on Mars 3.5 billion years ago, it would have probably also been microbial and could have left similar fossil evidence. On Earth this evidence takes several forms: (1) stromatolites, (2) microscopic trace fossils in spiral, spherical and rod shapes, and (3) chemical changes such as carbon isotopic shifts (living chemical systems sort isotopes differently from the way they are partitioned in inorganic reactions). In other words, we are basing our search for past life on Mars on the methods used to study past life on Earth. Here we can compare living microorganisms with their fossilized counterparts. On Mars we probably will not have this luxury.

Proving that an interesting fossil is indeed of biological origin may require us to send biologists and paleontologists to Mars to study the fossils and their environment directly.

CHRIS McKAY, *NASA Ames Research Center*

What are the polar caps of Mars composed of?
—Rene Redfield, Costa Mesa, CA

The uppermost layers of the martian polar caps are composed primarily of frozen carbon dioxide, with lesser amounts of frozen water and dust. These layers are deposits of frosts, snows and ices laid down during the cold, dark fall and winter seasons. During this period, the polar caps advance to approximately 60 degrees latitude (Oslo, Norway sits at 60 degrees latitude on Earth), with over one meter of frost condensing at the poles. During the warm, sunlit spring and summer seasons, the solid deposits of the previous fall and winter sublimate (convert directly to gas), and the edges of the seasonal caps retreat towards the poles.

Beneath the advancing and retreating seasonal polar caps lie more massive permanent caps; under Mars' present climatic conditions they are not exposed to the atmosphere. These permanent deposits are generally confined to within 10 degrees of the martian poles and are thought to extend to depths of a few kilometers or more. In the north the permanent polar cap is composed of water ice and dust. In the south we have evidence that the permanent cap contains carbon dioxide frost as well. This asymmetry in the composition of Mars' permanent polar caps is a mystery that remains largely unsolved.

Our present understanding of Mars' polar caps is based entirely on information obtained by telescopic observations and spacecraft remote sensing data. In the future, landers, rovers and, eventually, humans will explore Mars' polar regions and bring back a wealth of new information. Of particular significance is the possibility that the permanent polar deposits may contain a record of past martian climatic history. Ice cores from Greenland and Antarctica have played a crucial role in unraveling the history of Earth's ice ages and oscillations in our planet's orbit and axis. Similar cores from Mars could reveal a great deal about its climate, both past and present.

—DAVID A. PAIGE, *University of California, Los Angeles*

ERRATUM: In the May/June 1988 "Questions & Answers" a piece of text was inadvertently omitted from the first answer. The sentences should read: *Voyager 1*'s planetary encounters ended with the Saturn encounter in November 1980 because the project's scientists felt that it was important to fly the spacecraft very close to Saturn's largest moon, Titan, to determine its size, measure its atmosphere, and attempt to photograph its surface. That choice forced *Voyager 1*'s path well below Saturn's equator at encounter, and the gravity of the ringed planet pulled the spacecraft into a trajectory well north of the plane of the outer planets' orbits.

FACTINOS

A new imaging technology called Seismic Tomography is enabling scientists to produce X-ray-like images of Earth's insides all the way down to its core.

One recent discovery is that Earth's core, a 4,000-mile-diameter ball of molten iron, is not the perfect sphere that most people believe it to be. The new images show vast mountains six to seven miles high, and deep valleys on the core. These features are upside down, though, in relation to Earth's surface because they're made of rock, while the core inside them is hot liquid iron. Some researchers think the upside-down mountains have oceans of lighter-density iron between them, making the upside-down array like anti-continents and anti-oceans 1,800 miles deep.

—from Philip J. Hilts in *The Washington Post*

○

A star about 90 light years from Earth has shown the best evidence yet for the presence of a planet orbiting a star other than our own Sun.

Scientists at the Smithsonian Astrophysical Observatory have detected a minute wobble in the motion of the star HD 114762 apparently caused by the gravitational pull of a massive planet with an orbital period of 84 days.

The companion's size has not yet been calculated with any certainty, but it is most likely a giant planet or a small brown dwarf star about 10 to 20 times as massive as Jupiter. Since its distance from the star is about the same as Mercury's from the Sun, it is probably extremely hot and totally inhospitable to any known life forms.

—from a Smithsonian Astrophysical Observatory news release

○

In June, astronomers flying over the southern Pacific Ocean saw Pluto's atmosphere directly for the first time when a star briefly disappeared behind the planet.

Flying at an altitude of 41,000 feet aboard NASA's Kuiper Airborne Observatory, Massachusetts Institute of Technology researchers used a video camera attached to a 36-inch telescope to record light from a faint, distant star as the tiny planet moved across their field of view in front of the star.

—from *Space Today*

SOCIETY *Notes*

MOMENTUM FOR MARS

May 1988 brought us a small step nearer the goal of a US-Soviet initiative for cooperative exploration of Mars as the two nations agreed at the Moscow summit to begin scientific exchanges for future missions. As a first step, the US has agreed to install a Soviet or French radio receiver on the *Mars Observer* to help collect data from the Mars balloon, planned for the Soviets' Mars 1994 mission.

On May 26 the Society ran a full-page ad in the *Washington Post* presenting the Mars Declaration. In July, *Time* and *Omni* magazines featured the Declaration, and *Omni* included a return postcard inviting more signatures.

Members are familiar with the Society's public actions, but the behind-the-scenes efforts may be less familiar. Kudos, then, and thanks to:

•Senator Spark Matsunaga (D-HI) and his former legislative assistant, Harvey Meyerson, for sparking congressional interest in the Mars goal;
•Representatives Robert Roe (D-NJ), Bill Nelson (D-FL), George Brown (D-CA) and Robert Toricelli (D-NJ), who were principally responsible for House initiatives on Mars;
•Senator Albert Gore, who made the Mars goal part of his presidential campaign platform, and Reverend Jesse Jackson, who endorsed it publicly;
•Samuel Keller, NASA's Deputy Associate Administrator of Science and Applications, who steered the federal bureaucracy's positive consideration of international cooperation in planetary exploration despite powerful opposition;
•NASA's International Affairs Office, which supported Mr. Keller;
•Michael Michaud of the State Department and John Negroponte, formerly of the State Department and now on the National Security Council staff, both of whom helped further US progress toward this goal;
•Colonel Roger Dekok of the National Security Council staff, who was responsible for the White House review of interagency space policy coordination; and
•Academician and Society Advisor Roald Sagdeev, who, as a peripatetic campaigner in both the USSR and US, has influenced both countries' consideration of a reasoned, step-by-step approach to cooperation.—*Louis D. Friedman, Executive Director*

SCHOLARSHIP WINNERS

The Planetary Society has recognized the academic achievements and science aptitude of five recent high school graduates and five continuing college students with scholarship awards. Katherine Lockwood has received the Society's National Merit Scholarship. Kerem Bilgé, Clifford "Scott" Merkle, Glen Gaidos and Orion Carlisle will start their college careers with scholarships from the New Millennium Committee. The Society has awarded college-level fellowships to Rebecca Koopmann, Mark Wilkins, John Blow, Janet Bowen and Robert Hoyt. Our congratulations!—*Susan Jundanian, Copy Editor*

SPECIAL APPEALS

Our occasional special appeals are requests for *voluntary* donations. Failure to contribute in no way affects a member's status.

Extra donations are used to initiate or develop special projects (such as SETI or the Mars Institute) that "seed" future exploration of the solar system and the search for extraterrestrial life. The funds raised are maintained as "restricted funds" in our accounting and are not mixed with operating expenses. Overhead is limited to the cost of preparing and mailing the appeals; the rest (nearly all) of the money goes to the project described.—*Tim Lynch, Director of Programs and Development*

INTERNATIONAL TRAVEL FUND

At the 1987 International Astronautical Federation Congress in Brighton, England the Alan Emil Award for International Cooperation was presented to the four leading space agencies, which together coordinated Halley's Comet activities. Receiving the awards were Academician Roald Sagdeev of Intercosmos (USSR), Dr. Roger Bonnet of the European Space Agency, Dr. Minoru Oda of the Institute for Space and Aeronautical Sciences (Japan) and Dr. Burt Edelson of the National Aeronautics and Space Administration (US).

The four recipients donated their $1,000 cash prizes to a fund for East-West travel promoting international cooperation in exploring the solar system. The Planetary Society will administer and promote the program and has allocated an equal sum from its international cooperation funds—established with members' donations—to initiate it. We are seeking additional grants from foundations and members. Write to the International Travel Fund, c/o The Planetary Society.
—*Lu Coffing, Financial Manager*

FROM GREAT BRITAIN

Spaceflight News and The Planetary Society have pledged mutual cooperation in communicating the goals of planetary exploration and the search for extraterrestrial intelligence throughout the globe. *Spaceflight News*, a general-interest space magazine published in Great Britain, addresses an international audience. The magazine has featured The Planetary Society in its pages and has included material adapted from *The Planetary Report*. The Society, in turn, is helping to introduce *Spaceflight News* in the US and Canada.
—*Charlene Anderson, Director of Publications*

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(continued from page 3

tions from the overview section of the report: "It is important to recognize that the limitations on human survival in space are not well known. At present, we are not certain that mission times can be extended greatly beyond those already experienced, even with considerable technological progress. Low gravity leads to loss of bone mass and other physical effects. High-energy, heavy ion radiation causes irreversible damage to cells, including brain cells. Human relationships in a small, isolated group can badly deteriorate and lead to the loss of functional capabilities. We have not demonstrated the feasibility of a closed ecological system yet, and resupply at a great distance for a long period could be formidable. We must address these issues before we can reach a final decision about the nature and extent of human involvement in expanding the frontier of space." And: *"It would be imprudent even to plan extended missions until these serious medical issues are resolved."*

Contrast these words with the following from The Mars Declaration being promoted by the Officers of The Planetary Society (*The Planetary Report*, November/December 1987): "Advances in technology now make feasible a systematic process of exploration and discovery on the planet Mars—beginning with robotic roving vehicles and sample return missions and culminating in the first footfall of human beings on another planet.... No major additional technological advances seem to be required, and the step from today to the first landing of humans on Mars appears to be technologically easier than the step from President John F. Kennedy's announcement of the *Apollo* program on May 25, 1961 to the first landing of humans on the Moon on July 20, 1969."

The differences seem irreconcilable.

NORMAN H. HOROWITZ, *California Institute of Technology*

Dr. Horowitz correctly notes the need for scientific knowledge about long-duration human flight. We need similar knowledge about Mars itself, which we hope is obtained from robotic flights in the 1990s. But note that humans have already survived in space as long as it takes to get to Mars. Our position is that it is imprudent to conduct these programs without a goal— and that, in fact, there will be little chance of conducting them if a coherent, publicly supported goal is not enunciated first.—Louis D. Friedman

Enclosed you will find my Mars Declaration form, signed with pleasure and great hope. As a young girl I once dreamed of teaching school children on Mars. The landing on the Moon was watched with awe, tingling and anticipation of a Moon base, yet that seemed to be the end.

Man—men and women—are all explorers. Our original searches for food and good homes led us to new territories and new friends and enemies, but we are not destroyers by nature. I'm appalled by this nation's defense expenditures. Excessive is a limited term at best. I don't understand why we have chosen leaders who do not look toward the future of our race. Yet we are all denying ourselves the opportunity for expanding our understanding of our lives, of our place in the great scheme of things, and of the universe and all the wonders that vast, limitless space holds for us. Only by answering your call can our voices be heard, and hopefully, someone will listen.

ANNE P. KORAL, *Fairbanks, Alaska*

UPCOMING EVENTS

October 7-8, 1988: Toronto, Canada—International SETI (Search for Extraterrestrial Intelligence) conference sponsored by The Planetary Society and the Ontario Science Center. Public session with Carl Sagan on October 8.

October 30, 1988: Austin, Texas—Public session with Carl Sagan prior to meeting of the Division for Planetary Sciences of the American Astronomical Society.

December 8-9, 1988: Washington, DC—International Cooperation Conference sponsored by The Planetary Society and the George Washington University Space Policy Institute.

CALL FOR LOCAL MARS WATCH INFORMATION:

San Diego, CA: Andrew Cutler, (619) 284-2779
Stockton, CA: Stewart Barber, (209) 952-5184
Ft. Collins, CO: Bob Marino, (303) 223-3784
Chicago, IL: Linda Low, (312) 339-1589
Shreveport, LA: Dr. Cran Lucas, (318) 797-5244
Boston, MA: Regina Mitchell, (617) 767-0698
St. Louis, MO: Amy White, (314) 741-9904
Elko, NV: Leonard Seymour, (702) 738-7916
Providence, RI: Harvette Matuszewski, (401) 245-4337
Charleston, SC: Danny Williams, (803) 552-6848
Dallas/Ft. Worth, TX: Ralph Willes, (817) 277-3584
Milwaukee, WI: Rodney Motto, (414) 462-7250

For additional listings, contact Marshalle Wells, c/o The Planetary Society.

NEWS BRIEFS

(continued from page 3)

of advancing space science. Many of the science objectives recommended for the years between 1995 and 2015 were similar to those proposed by The Report of the National Commission on Space and the report by Sally K. Ride, "Leadership and America's Future in Space."
—from Rudy Abramson in the *Los Angeles Times*

In June, NASA and Pentagon officials authorized the Pacific Engineering and Production Company near Henderson, Nevada to build a new rocket fuel plant to replace the one that blew up last May.

The biggest crunch in the space launch schedule due to shortages of ammoniun perchlorate (the solid fuel oxidizer produced by the plant) is expected to come in 1989. "It will be 1991 before we can breathe easy again," said Russell Bardos, NASA's director of shuttle propulsion and a member of the team studying the problem.

The officials also authorized the Kerr-McGee Chemical Corporation (located in Henderson as well), the only other producer of the oxidizer, to expand its manufacturing capacity. Even if both construction projects begin immediately, officals said, the nation's rocket fuel shortage will not be alleviated for at least two years.
—from John Noble Wilford in *The New York Times*

In 1972, when *Pioneer 10* was launched, its designers hoped the mission would last two or three years. Sixteen years later, the spacecraft is alive and well. Now almost 4.2 billion miles away, 45 times the distance from Earth to the Sun, it has traveled farther than any other human-made object.

The spacecraft's most important duty now is to search for the edge of the heliosphere, the vast area of space influenced by the Sun's magnetic field.

"*Pioneer 10* is one of the superb achievements of the human race," said James Van Allen of the University of Iowa. "It has yielded more scientific results than the entire US manned space program to date at a fraction of the cost."
—from Robert Irion in the *Chicago Tribune*

A PLANET WITH AN EARTH-LIKE ORBIT is about to be swallowed up by its sun—in this case an expanding red giant star. The star's intense heat has boiled the planet's oceans away and blown its atmosphere off like a comet's tail. Drag forces in the star's outer atmosphere will soon pull the scorched body down into its fiery interior.

Pamela Lee is an astronomical artist living in Modesto, California. She is a member of NASA's Fine Arts Program and is the first American artist whose work has flown in space on board the space shuttle. From Cycles of Fire *by William K. Hartmann and Ron Miller with Pamela Lee and Tom Miller, © 1987. Reprinted by permission of Workman Publishing, NY, NY.*

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