The PLANETARY REPORT

Volume XI Number 3 May/June 1991

Mars: Will We Ever Return?

A Publication of
THE PLANETARY SOCIETY

The Planetary Report (ISSN 0736-3680) is published six times yearly at the editorial offices of The Planetary Society, 65 North Catalina Avenue, Pasadena, CA 91106, (818) 793-5100. It is available to members of The Planetary Society. Annual dues in the US or Canada are $25 US dollars or $30 Canadian. Dues outside the US or Canada are $35 (US).

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COVER: The United States has scheduled the* Mars Observer *for a 1992 launch; the Soviet Union plans to send spacecraft to the Red Planet in 1994 and 1996. But these missions were well under way before the political upheavals of late 1989 effectively ended the Cold War and removed much of the competitive impulse that drove space exploration. Will telescopic views from Earth orbit, such as this image from the Hubble Space Telescope, become the future of planetary studies? Or will we find new reasons to explore the solar system?
Image: Space Telescope Science Institute

FROM THE EDITOR

Nations around the world are changing, shifting their political alliances and struggling to convert their economies. Few aspects of life will escape change. How will this all affect planetary exploration and the search for extraterrestrial life? In this issue of *The Planetary Report*, we continue to deal with this question, and we will keep on exploring possible answers.

 —*Charlene M. Anderson*

A Recycling Experiment

With this issue of *The Planetary Report*, we are trying an experiment: It is printed on recycled paper.

Many readers may not notice a difference, but others will see that the paper is a bit grayer, so the color images may not appear quite as bright as they would on virgin stock. Some may find, however, that the text is easier to read since the grayer stock is not as glaring as the brighter paper.

A large part of *The Planetary Report*'s mission is to bring you the spectacular images returned by interplanetary spacecraft. Will you be satisfied by their reproduction on recycled paper?

Some may feel it is environmentally responsible if the nearly three-quarters of a million magazines we produce each year are printed on recycled stock—but will we be better serving our members by doing it?

Since we are a membership organization, ultimately the decision is up to you. Please write to let me know how you feel about our recycling experiment. —*CMA*

Members' Dialogue

As administrators 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 our Society. We encourage members to write us and create a dialogue on topics such as a space station, a lunar outpost, the exploration of Mars and the search for extraterrestrial life.

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

Thank you very much for the most interesting and informative article, "Eureka! The Recovery of 1982DB" in the January/February 1991 issue of *The Planetary Report.* I am pleased with The Planetary Society's support for those dedicated to searching for new asteroids.

I must update readers of the *Report* about the misconception that 1982DB is the most accessible asteroid mission candidate. In January 1990, while researching newly discovered asteroids for accessible Near-Earth Asteroid Rendezvous candidates, I discovered 1989ML to be significantly more accessible than 1982DB. I promptly reported this to Robert Farquhar, widely known for his role in redirecting the International Cometary Explorer spacecraft to encounter comet Giacobini-Zinner, and to Brian Marsden, director of the Minor Planet Center of the Smithsonian Astrophysical Observatory.

Apparently this news has not become widely known. I plan to present a paper on the subject at an upcoming astrodynamics conference.

—JIM V. McADAMS, *Schaumburg, Illinois*

The following letters are in response to Carl Sagan's essay, "Humans to Mars: Can We Justify the Cost?" which appeared in the January/February 1991 issue of The Planetary Report.

If we could be sure that every dollar not spent on a Mars mission was spent on housing, education, health care or saving the environment, we'd have to consider it money well spent. But appropriations depend as much on political will as on economic realities. I could accept delaying a Mars mission to help feed the hungry or house the homeless. I can't accept spending the Mars money on the Strategic Defense Initiative or the Senate barbershop.

Space science has always been the poor stepchild of the manned program, and it's often been said that with no human program there would be no space science. As flawed as the shuttle program has been, we might not have had *Galileo* or *Magellan* without it. If we abandon plans to go to Mars because we can't justify a $100 billion price tag, we may find that Congress will no longer approve robotic missions with a $100 million price tag.

As long as Mars remains a goal with no fixed date, it helps fund the large number of precursor missions necessary in a rational program for its long-term exploration. Without human exploration, we may not get these missions funded. Tactically, it makes more sense to keep pushing for human exploration as a way of keeping the space science budget healthy, as long as we privately accept that human missions may not depart for another 50 years.

If organizations like The Planetary Society abandon the dream of Mars, no one else will carry the torch. We may find that we've lost a dream of evolutionary significance and are no closer to solving the other pressing problems of society than we were before.

—JON LOMBERG, *Honaunau, Hawaii*

There's a proverb that says, "If you wait until the wind and the weather are just right, you will never plant anything and never harvest anything." I think we're waiting for perfect weather to begin the manned exploration of Mars and the solar system, and there isn't any. I doubt that there ever will be. We must stop feeling guilty for asking our nation and world to do something they need to do and should do. NASA is not the reason there is poverty, illiteracy or illness. Eliminating everything we spend on space would not solve all these problems. Waiting to go to Mars won't either.

No age of history ever ended without an unfinished agenda. We are in the age of space and the answers to the problems that still beset us lie ahead of, not behind, us. I don't believe we'll help anyone by being deliberately stagnant in any area of scientific knowledge or endeavor.

The Planetary Society can spur the aerospace community and NASA to be more imaginative and daring. Little goals get little enthusiasm. If NASA can't seem to get excited and imaginative internally, then groups like The Society need to keep supplying enthusiasm, ingenuity and leadership from the outside.

Whatever and whenever our leaders decide, let's make our own commitment to go to Mars irrevocable and keep doing whatever is necessary until we get there. The wind and weather are good enough!

—DANIEL E. POWERS, *St. Francisville, Illinois*

NEWS BRIEFS

A panel advising NASA on how to compensate for the Hubble Space Telescope's flawed primary mirror and recurring "jitters" reported its conclusions to the space agency in January. But now NASA wants a different set of scientists and engineers to reevaluate the first group's recommendations.

A set of corrective mirrors figures prominently in the strategy panel's recommendations. This box of mirrors, called COSTAR, for Corrective Optics Space Telescope Axial Replacement, should correct the optical distortion afflicting three of the telescope's scientific instruments. But its potential cost and development time justify seeking another opinion, says Charles J. Pellerin, head of astrophysics at NASA's Office of Space Science and Applications.

Pellerin notes that, if the new panel backs COSTAR, NASA should have time to complete the device and include it in a Hubble servicing scheduled for 1993.

—from *Science News*

The ozone layer in Earth's upper atmosphere is being depleted much faster than scientists realized, and the United States could suffer 200,000 more skin cancer deaths than previously expected over the next 50 years, says William K. Reilly, administrator of the Environmental Protection Agency (EPA).

Reilly reports that rather than thinning by 1 to 3 percent during the last 12 years, as earlier studies indicated, the ozone layer over the US has been degraded by 4 to 5 percent. This new evidence was gathered by NASA.

In light of the new studies, Reilly is intensifying an EPA campaign to reduce the use of ozone-damaging chemicals and is "exploring the full range of options" to help other countries do the same.

According to the National Cancer Institute, US skin cancer mortality is now about 8,500 a year. [The planet Mars has no protective ozone layer; as a result, its surface is antiseptically clean.]

—from Rudy Abramson in the *Los Angeles Times*

Can Space Exploration Survive the End of the Cold War?

by Bruce C. Murray

In Dresden on October 9, 1990, a few days after the reunification of Germany, Dr. Murray delivered the plenary address at the annual meeting of the International Astronautical Federation. This paper is adapted from that talk.

Space exploration has been intimately tied to the Cold War that followed the bloody fever of World War II. As the Cold War ends, so does much of the energy and momentum that propelled us to wondrous achievements in space. I ask the question: Can space exploration survive the end of the Cold War?

It's been 46 years since the end of World War II, 34 years since *Sputnik 1*, 22 years since *Apollo 11* landed on the Moon, and less than 1 year since Germany was reunified. All these events are connected. The end of World War II launched the Cold War, in which competition between the two surviving superpowers triggered the great movement toward space. With *Sputnik 1*, the competition accelerated into a race, won when *Apollo 11* landed on the Moon. The Cold War continued for decades after the Space Race was over, but now that, too, is ending, as symbolized by Germany's reunification.

The American and Soviet space exploration programs are now running down. They no longer enjoy high national priority. The irony is that Mikhail Gorbachev, in his 1987-1988 pro-space period, was a lot like Nikita Khrushchev when he focused his country's efforts on space, resulting in *Sputnik 1*. But *perestroika* and its unintended side effects revised Gorbachev's priorities. In 1989, when President Bush called for the United States to return to the Moon and then go on to Mars, he was a lot like former President Kennedy trying to set the nationalistic *Apollo* goal to get the country moving. In the last few years of the 1980s, the highest leadership in both major spacefaring nations moved to do something really big in space. In both cases, these leaders found that their countries were not in the mood for a dramatic new leap in human exploration.

What about Europe, which even before the closing stages of the Cold War had a gross national product larger than that of either the US or the Soviet Union? Europe supports a much smaller civil space program, primarily because there is not yet any European human space program. Its priorities for space were already fairly low relative to all the other things it felt it had to do. Now, with the unification of Germany, the opening of Eastern Europe and new needs and opportunities vis-à-vis the USSR, there are tremendous new challenges that must be faced to shape Europe's future—and the world's. These will drain European resources and affect political priorities.

Japan is still developing its space identity. It must find a place in space consistent with its new status as a great economic power. However, it will not do for Japan simply to repeat the nationalistic endeavors of the US and the USSR. Japan must find a context that makes sense in the 21st century. It either has to compete or cooperate. But if it competes, with whom? Certainly not with the ghosts of American and Soviet accomplishments from decades past.

From Conflict to Cooperation—A Shared Adventure?

I am led to the conclusion that we are witnessing the end of the first great era of space exploration, which was born in the Cold War, declined as the Cold War ran down, and is ending when the Cold War ends—now.

So, a second phase begins. In the absence of Cold War international conflict, can international cooperation become the driver for new space exploration? Well, if it doesn't, if the spacefaring nations don't embrace international cooperation in space exploration, there isn't going to be much space exploration. Without the justification of shared endeavors to ensure—even celebrate—the peace, the public won't support the expense. That doesn't mean there won't be a few scientific missions now and then, but there is not going to be—for a very long, long time—a popularly shared and publicly supported adventure in which new worlds are opened. There will be only a minimal human space program, one confined to safe, low Earth orbit.

Are there any national factors that may push for that adventure in the next few years? I think there are at least three.

When Scott and Amundsen raced to the South Pole for the nationalistic glory of being first, no government leaders and very few scientists imagined that we would learn things in the remote, hostile Antarctic that would be highly relevant to the more clement, inhabited regions of Earth. Where do we now study the infamous ozone hole? In the Antarctic. That forbidding continent has become an extremely important information storehouse and observation post for global phenomena. What we learn in Antarctica can teach us about processes that affect all of us living on this planet.

Ulysses and Others—An Epic Attempt

With a sophisticated population in the spacefaring nations, the comparative planetology argument—that we learn about Earth by studying Earth and Mars, for example—carries some weight. This argument, especially when related to global environmental change, will drive robotic planetary science at some level, regardless of what happens to human exploratory endeavors.

The robotic spacecraft *Ulysses*, which is now on its way to study the Sun's polar regions, is a step in the continuing process of exploring the solar-terrestrial environment. There must be a connection between solar activity and climatic change on Earth; we just don't know what it is. *Ulysses* and its successors can help us find the link.

Mars and its polar caps, which hold records of the geologic times we Earthlings call Ice Ages, could spark similar "practical" interest. If something strange was happening at the same time on both Earth and Mars, that would suggest that the primary cause of glaciation was external to Earth. If there was no shared planetary history, then the origins of the Ice Ages would be due to some very rare internal activity on Earth.

Comparative planetology can be a long-term driver for a modest level of robotic scientific exploration of Earth's neighborhood of the inner solar system. Occasionally, perhaps, some planetary object farther out could be slipped into the program. But, overall, that's a fairly diminished range of possibilities.

Industrial Capacity—Worth Preserving?

What other drivers could make it worthwhile to fund and give priority to space exploration, especially human exploration?

There is the critical issue of industrial capacity. The US and the USSR have invested enormous sums in specialized aerospace capacities and, as the Cold War winds down, they have to make choices. Should they disband the aerospace infrastructure? In the US, that means the work force would be dispersed and would eventually show up in other places in the economy. In the USSR, it might mean large-scale unemployment and mothballed, obsolete factories. Or should the US and the USSR find ways to keep their space infrastructures intact?

Both countries have to make choices. The only way to maintain the world leadership in space that they now enjoy is to keep the programs that use it, and such efforts have to be nationally funded. The long-term need to retain and enhance aerospace capabilities was dramatically reinforced by the Iraqi invasion of Kuwait on August 2, 1990. If the leading industrial powers—the US, the USSR, Japan and Western Europe—don't

> ***We are witnessing the end of the first great era of space exploration, which was born in the Cold War and is ending when the Cold War ends — now.***

maintain their national aerospace capabilities, with future weaponry implications, then aerospace technology will truly become a marketplace enterprise. Then oil revenues can buy first-class weaponry, as Iraq tried to do.

There are going to be more wars. There are going to be more Iraqs because tension points throughout the world are unrelieved. From time to time, the self-interests of the US and other industrial countries will be

If the spacefaring nations don't embrace international cooperation in space exploration, there isn't going to be much space exploration.

threatened. Military force will have to be used again. Those countries that consider themselves world leaders will have to choose a few nationally funded, subsidized programs to keep some specialized technologies safely away from the marketplace, beyond what somebody else can buy. If they don't, they will eventually be confronted with military situations that will be very unpleasant.

So selective aerospace leadership is a driver. This is a sophisticated argument, and with regionalism and populism rising in the USSR, I'm not sure it will be easy to sell that point of view. It's not easy in the US either, although NASA's budget continues to be increased each year. In both countries there has been a diffusion of political power from the centers—Washington and Moscow—to many other constituencies. At the same time in Western Europe, there has been a reverse flow of power to transnational entities.

Another way of characterizing these changes is *privatization*, a popular word in England and the US, and one that is becoming popular in the USSR and in formerly communist countries. However, privatization politically means that the central government loses control of resources. And space exploration can only be carried out by central governments.

I assert that there is an inescapable national security need to keep special, high-technology industrial capabilities. Only targeted, very difficult programs will suffice. It doesn't do any good for governments to subsidize mundane programs. We cannot, for instance, settle for less than a space station that promises outstanding scientific and technological achievements—and is worth the cost. The results will be mundane industrial capability. Leading nations must subsidize state-of-the-art programs; they must attempt things that have not been done before if they wish to possess unequaled technological capabilities. Space exploration can provide the popular challenge for such technological nurturing, especially in a time of diminished perception of global war.

A Need for Heroes

The third argument I would offer for international cooperation in space among industrialized nations is that, as affluence develops, there is an acute need for heroes. The rise of industrialization often diminishes religious and traditional beliefs, resulting in a dearth of heroes, besides rock stars and athletes—and astronauts and cosmonauts. There is a genuine social need for individuals who go out and do something that the rest of us can't do. If industrialized societies don't produce moral heroes, nihilism and fragmentation loom. Providing heroes is part of ruling, part of governance.

Young people all over the world want to believe. They need faith in a future that holds more than just a new type of VCR. Even though they are materially better off than their parents, and much better situated than their grandparents, they want to believe there is something wonderful in the future, something they've not yet experienced, that no one has experienced. This basic human need is more profoundly sensed by political leaders than by scientists. Human spaceflight is a political manifestation in many ways, as it has always been in the US and the USSR, and may soon be in Japan and Europe.

Those are three reasons why I think spacefaring nations may decide to put energy and resources into international space exploration despite the strident demands of domestic issues. But will they? I can't prophesy. I do assert that the international exploration of space is a dream worth pursuing, and that the exploration of Mars can be the focus of that dream.

An Excellent Beginning

An encouraging start for this dream took place not on Mars, but in California's Mojave Desert. In September 1990, a team from the Centre National d'Études Spatiales, the French space agency, and representatives from the Babakin Center and the Institute for Space Research in Moscow worked with an American team organized by The Planetary Society and including volunteers from the Jet Propulsion Laboratory and students from Utah State University, Caltech, UCLA and the University of Arizona. This multinational team tested a prototype of a balloon intended to investigate Mars' atmosphere as part of the Soviet *Mars '94* mission. The American *Mars Observer* spacecraft is being modified to enhance the amount of high-resolution imaging and other data returned by the balloon.

In another example, 10 US scientists, including myself, worked on the Soviet *Phobos '88* mission. Soviet scientists are now working on *Magellan* and will work on *Mars Observer*. Americans have been selected to participate in the *Mars '94* mission. So cooperative robotic exploration of Mars is off to a good start.

Finding Answers Together

In order for humans to fly to Mars, we must gather more information about the martian surface, first with *Mars*

Observer, then with more ambitious robotic missions. This next phase must involve large rovers and, eventually, sample-return vehicles, which both the US and the USSR have studied. The best way to do this would be for the two leading spacefaring nations to work together, with European Space Agency, French or Japanese participation.

There are other technical challenges. For example, we do not now know how to enable humans to survive for the duration of the year or longer flight, then get out of the spaceship and successfully work on Mars. There may also be dangers from radiation during the flight that will be hard to overcome.

We could immediately accelerate our gathering of this critical physiological knowledge if the US and the USSR sat down together to design a program for a group of cosmonauts and astronauts (and individuals from other countries, if they wished to invest in this endeavor) conducting a series of long-duration tests on *Mir.* This effort could build on the pioneering Soviet flights and bring to bear American scientific and technological capabilities to provide the large and diverse human biomedical data base needed to make engineering choices for the interplanetary flight. The mission and system design for human flight to Mars cannot proceed far without these critical data.

Space exploration can provide the popular challenge for technological nurturing, especially in a time of diminished perception of global war.

Of Ships and Spaceports

Another thing we need if we are to get to Mars is a giant rocket. It will take a lot more propulsion than *Apollo* needed. Some kind of Earth-orbital facility for spacecraft assembly and fueling will probably be required, where the space shuttle or a yet-to-be-developed American heavy-lift vehicle can dock, as well as the Soviet *Energia,* ESA's *Ariane 5*, and maybe the Japanese *H-2.* You can call it a transportation node or a spaceport or whatever.

Sending humans to Mars is a big task. If it is to be an international endeavor, the key spacefaring nations must be able to operate from the same platform. Yet there is no such design or concept, so far as I know. This remains a critical step, one that must be addressed in the future.

Finally, the spaceship that carries humans to Mars must have unprecedented reliability. It's a long trip. You can't come home early. You have to be able to trust your ship. That ship will have to recycle the necessities of life, such as water and oxygen, to an unprecedented degree. It will be much more like going around the world continuously submerged in a submarine than like going to the Moon in the *Apollo* spacecraft. We must learn how to recycle and to live in an at least partly recycled environment.

Some of this work has already begun —on the ground—but it's very scattered. Ultimately the prototype for the Mars flight should be built in Earth orbit. We can test it, make it right, until we trust it in Earth orbit. Then crews can fly it to the Moon and back before setting out for Mars. This will be a natural way for international ground crews to learn to work together.

I have discussed these challenges in terms of time. We can wait longer for the spaceship than we can to begin the biomedical qualification or to investigate the martian surface environment. The path to Mars requires serious multinational discussion of robotic exploration, biomedical questions and the characteristics of the spaceport.

The international exploration of space is a dream worth pursuing, and the exploration of Mars can be the focus of that dream.

So this is my dream of a future among the planets, and it is one that is eminently realizable. An international Mars program would channel, enhance and catalyze interest in planetary exploration among all the spacefaring countries.

It is for this reason that The Planetary Society, with 120,000 members worldwide, is so focused on international exploration of Mars. We think that "Together to Mars" is the linchpin of future space exploration. A new era of international exploration must be our future, and it will both reflect the beginning of a new era on Earth and help bring it into being. We all have much work to do to make it happen.

Bruce C. Murray, Professor of Planetary Science at the California Institute of Technology and former Director of the Jet Propulsion Laboratory, is Vice President of The Planetary Society.

Magellan at Venus: The Continuing Mission

by Charlene M. Anderson

Earth and Venus were born almost at the same moment, in nearly the same region of space. These two planets are made of almost identical stuff that, having been subject to the same laws of physics, condensed into nearly spherical bodies of the same size with what we can assume are similar structures. But their faces—their surface features—are individual, and in some ways dissimilar. How did two siblings that began life so alike turn out to be so different? This is a prime question that the *Magellan* scientists are asking as they pore over the data the spacecraft is even now returning to Earth.

From models of planetary formation, scientists have deduced that gravitational energy was trapped within the planets during their formation and gradually leaks into space as heat. Adding to this, radioactive elements within the planet decay and release more heat. This combines with the primordial heat to melt a portion of these rocky worlds, creating the thick, near-surface layer of partly molten material called the mantle. On top of that, a thin crust cools off enough to become solid. But through that flimsy surface, heat from the interior continues to escape.

On our planet, heat flowing outward through the mantle causes it to roil like porridge over a flame. This heat drives plate tectonics, the process that shapes the face of Earth. On the surface, lightweight continents drift along, like scum in a soup pot, pushed or pulled around by the continuous formation of heavy basaltic crust as it wells up from the mantle through great rift valleys in the crust.

Sometimes the heat finds other avenues of escape, such as volcanic eruptions. Hot molten rock and superheated gases blow out of weak spots in the crust to release the pent-up heat of radioactive decay and planetary formation.

The processes that allow heat to escape from a planet's interior are among the most important ones in shaping its face. On a small planet without a substantial atmosphere, the scars left by this heat's escape have often been obliterated by craters, as we've seen on Mercury, the Moon and some satellites of the outer solar system. On Earth, the very process that releases the heat—plate tectonics—recycles the crust and, along with wind and water, eventually erases evidence of past cratering. On volcanically active bodies, such as Earth and Io, new crust erupts and buries the craters.

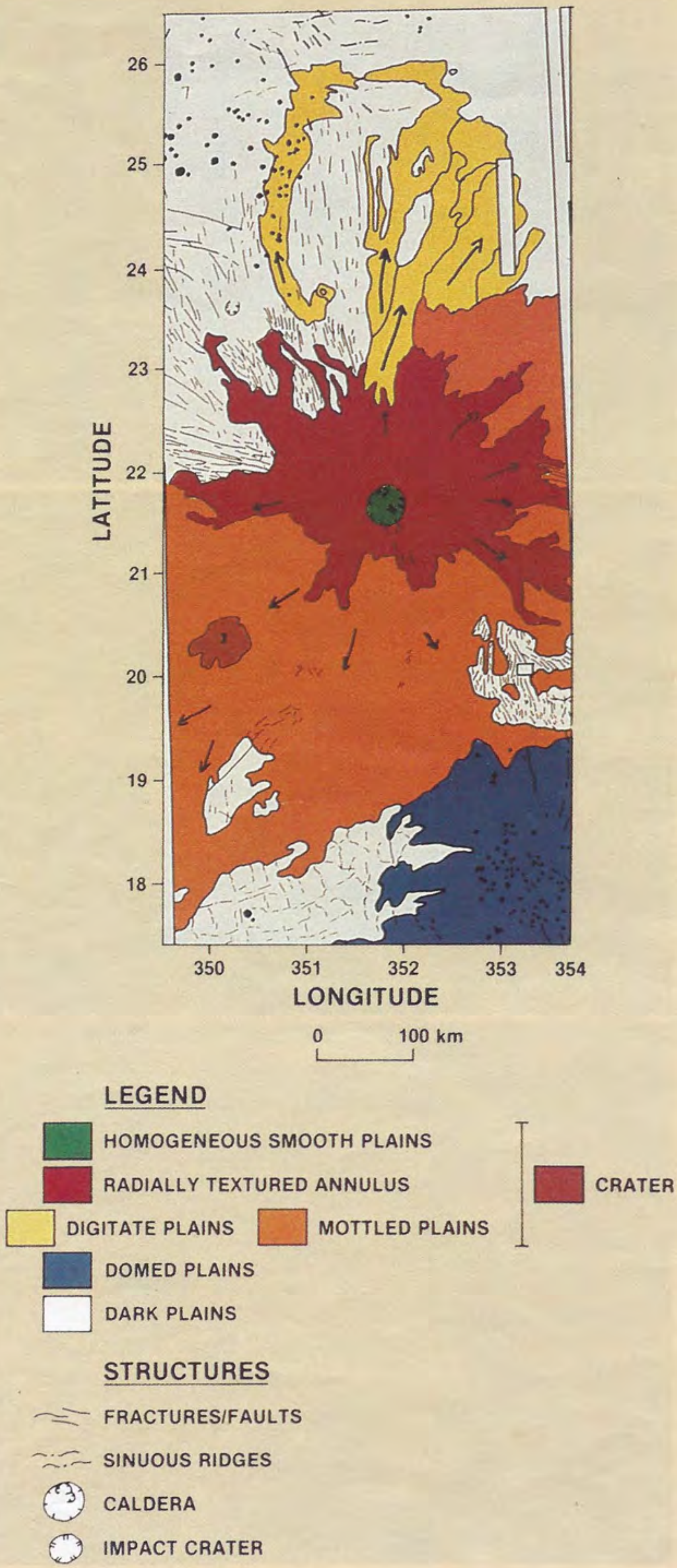
With *Magellan*, scientists are searching for evidence of these processes on Venus. They've already found impact craters and volcanoes. The impact craters are all fairly large, suggesting that small incoming bodies burn up in the dense atmosphere and do not make it to the surface. The craters look unexpectedly fresh, as if they have not been degraded by erosional processes. A few have been partly filled with lava, but on the whole they are remarkably well preserved. These craters all seem to be of about the same age, only a few hundred million years old. This is a puzzle. If erosion doesn't slowly wear them down, and if Venus' crust doesn't recycle as Earth's does, where have all the old craters gone?

Since there is, as yet, no unequivocal evidence of plate tectonics, some scientists have started using the term "blob tectonics" to describe what appears to have happened on Venus. A few brave souls have been willing to speculate that the region called Aphrodite is a spreading center, similar to regions on Earth where new crust pushes up from the mantle. They continue to scrutinize the images and may soon be better able to determine if Venus uses the same processes as Earth does to release heat from its interior, and whether the planet's heat engine is active today.

Here we examine some of the features that will help unravel the puzzle of Venus. We will take a close look at the region around Sif and Gula Montes, two large volcanoes in the Eistla Regio highlands. The highlands may have been formed by upwelling material from the hot interior of the planet. The volcanoes are more obvious expressions of the release of trapped heat. Each visual representation of the area tells a slightly different yet complementary story. By combining all the themes, scientists will come to a more complete understanding of the geologic history of this region and, eventually, of the planet as a whole.

From the *Magellan* mission we are learning much about the processes that shape rocky planets. We may find crucial clues to how our own planet functions—after all, it's hard to understand a family if you know only one of its members.

Charlene M. Anderson is Director of Publications for The Planetary Society.



Geologic Map of Sif Mons

The history of a planet's surface can be read by studying the different exposed geologic units. Using the *Magellan* data, a team of investigators has constructed this preliminary geologic map of Sif Mons and its surroundings. The volcano is an isolated, symmetrical peak, about 300 kilometers (190 miles) in diameter and 3.7 kilometers (about 2.3 miles) high. The crater-like feature at its summit is a caldera some 40 kilometers (25 miles) across, which is about 10 times larger than the summit caldera of Kilauea in Hawaii. In this map the caldera is identified as smooth, homogeneous plains.

Like the gently sloping shield volcanoes of Earth, Sif seems to have been formed by successive eruptions of fluid lava. A ring (annulus) of such textured lava flows surrounds the summit caldera. The mottled plains were formed by numerous overlapping flows. The finger-shaped digitate plains, between 250 and 350 kilometers (150 and 215 miles) long, probably represent the eruption of extremely fluid lava. Southeast of the volcano is a concentration of small shield volcanoes and lava flows, identified here as domed plains.

The part of Venus that includes Sif Mons, the western Eistla region, has been particularly well studied by *Magellan* scientists. Here and on pages 11, 12 and 13 we feature several different types of scientific products that they have created from the spacecraft data. Each one tells a slightly different story, and by combining them we can gain a deeper understanding of the processes that shape the planet.

Map: D.A. Senske, J.W. Head, Ellen Stofan and Jerry Schaber

Was She, or Wasn't She?

For years, ever since its image was revealed in early radar data, the crater Cleopatra has tantalized scientists, who wondered how it came into being. Sitting on the eastern flanks of Maxwell Montes, the highest mountains on Venus, the circular feature could have been a volcanic caldera, collapsed into the mountain following a tremendous eruption. Or it might have been an impact crater, blasted out by a meteorite that survived the trip through Venus' tremendously thick atmosphere (with a pressure 90 times that of Earth's).

Now, with *Magellan*'s radar resolution of about 120 meters (390 feet), the puzzle has been solved. Cleopatra is a classic, double-ringed impact crater, similar to many such features on the Moon, Mars and Mercury. It's about 100 kilometers (60 miles) across and 2.5 kilometers (1.6 miles) deep. From its eastern rim, a flow of molten rock breached the crater wall, streamed downhill and surrounded ridges on the slopes below. The rock may have been melted by the force of the meteorite striking the ground or by volcanism triggered by the impact.

Pancakes on the Griddle (Or, Pass the Syrup)

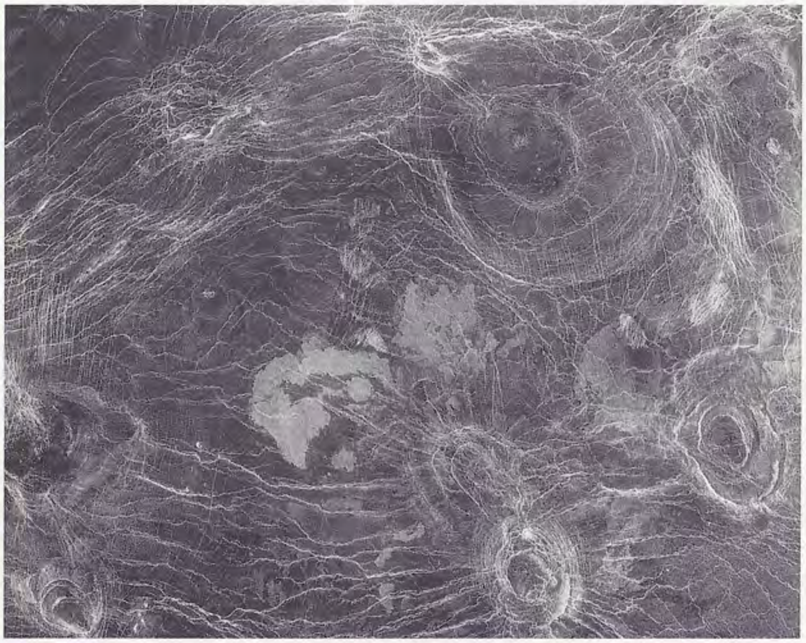
In the first rush of discovery, even serious and sober scientists are tempted to call strange and unusual landforms by the names of familiar objects. Such was the case with the pancakes on Venus, a series of dome-like hills averaging 25 kilometers (16 miles) across and 750 meters (2500 feet) in height that sit on the eastern edge of the Alpha Regio highlands. There are two competing explanations—so far—for their formation. They could be eruptions of viscous lava from vents in ground so level that the lava simply flowed evenly in all directions, like thick pancake batter poured on a griddle. Or they might be the surface expressions of shallow magma intrusions, welling up from the molten mantle, that pushed up the surface layer into domed forms.

Arachnoids on Venus

Strange, spider-like forms had appeared in the radar images from the Soviet *Veneras 15* and *16*, mapping spacecraft that began studying Venus in 1983. Scientists were puzzled by these "arachnoids," circular features surrounded by thin lines radiating out, and looked forward to *Magellan* data, which would reveal details 10 times finer than *Venera*'s.

In this *Magellan* image, the arachnoids don't seem quite so spider-like, but they are nonetheless intriguing features. They appear to be Venus' own distinctive way to release internal heat. When molten magma wells up from the mantle, it can form small hot spots under the crust. Above them the surface may bulge up, cracking as it deforms. When the magma subsides, the bulges collapse. Such a process may explain these arachnoids.

Images: JPL/NASA



Help Put Names on Venus

You can help name surface features on Venus. Scientists on the *Magellan* project, along with the US Geological Survey, have invited the public to propose names for the many impact craters and volcanic calderas that the spacecraft is discovering as it orbits the planet.

"We want everyone, especially students, to share in the adventure of discovery," commented R. Stephen Saunders, *Magellan* Project Scientist. The names suggested will be compiled for the Working Group for Planetary System Nomenclature, a committee of the International Astronomical Union (IAU) charged with naming solar system bodies and their surface features. (See the November/December 1990 *Planetary Report*.)

Features on Venus, by international agreement, are named after famous and notable women. Most of the names come from ancient religions and cultures, but craters and calderas are named for actual women.

There are a few rules to keep in mind when making your suggestions:

- The person must have been dead for at least three years.
- She must have been in some way notable and worthy of the honor.
- Names of military or political figures of the 19th and 20th centuries are specifically forbidden under the rules of the IAU.
- Names of persons prominent in any of the six main living religions are excluded from consideration.
- Names of specific national significance are also not allowed.

When you submit a person's name, include her birth and death years and a one- or two-sentence written rationale for the honor. Provide a reference book citation, if possible.

Send your suggestions to:

Venus Names
Magellan Project Office
Mail Stop 230-201
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109

Radar Image of Northern Gula

Radar images such as this form the bases for the various types of maps of Venus' surface. The brightest features here are fractures in the crust and long flows of lava spreading out from the eruptive zone in the center right of this image. At well over 300 kilometers (over 200 miles) long, they are longer than any comparable features on Earth. These flows appear to be relatively recent features and, because of their shape and extent, seem to have been formed by the eruption of thin, very fluid lava.

An intriguing surface marking is the long, dark streak in the northwest corner of the image. The streak does not conform to surface topography and appears to be younger than the nearby lava flows. At its eastern end are a couple of irregularly shaped impact craters that suggest a possible explanation. The streak may be evidence of an impact event similar to the one thought to have occurred over Tunguska, Siberia, in 1908. The incoming object may not have been big enough or cohesive enough to make it through the atmosphere intact. Nevertheless, its passage generated supersonic winds—much like a blast—that scoured the ground. The small craters may have been carved out by the surviving fragments.

Mosaic: JPL/NASA

Topographic Map of Sif and Gula Montes

Two types of information from *Magellan* are incorporated into this map: the relief of geologic features (topography) and the way they reflect the radar pulses from the spacecraft (the backscatter brightness). The hue of colors indicates their height, which, on Venus, is measured from the planetary radius of 6051.5 kilometers (3758 miles). The equivalent surface on Earth would be sea level. The intensity of the colors indicates features that are bright when seen at the microwave wavelengths of radar, such as the lava flows running down the volcanoes' sides.

Used in tandem with the geologic map, such an image can flesh out our picture of the Sif and Gula region. The peaks of the volcanoes clearly sit high above the surrounding plains, while the depth of the rift feature southeast of Gula, Guor Linea, is clearly indicated.

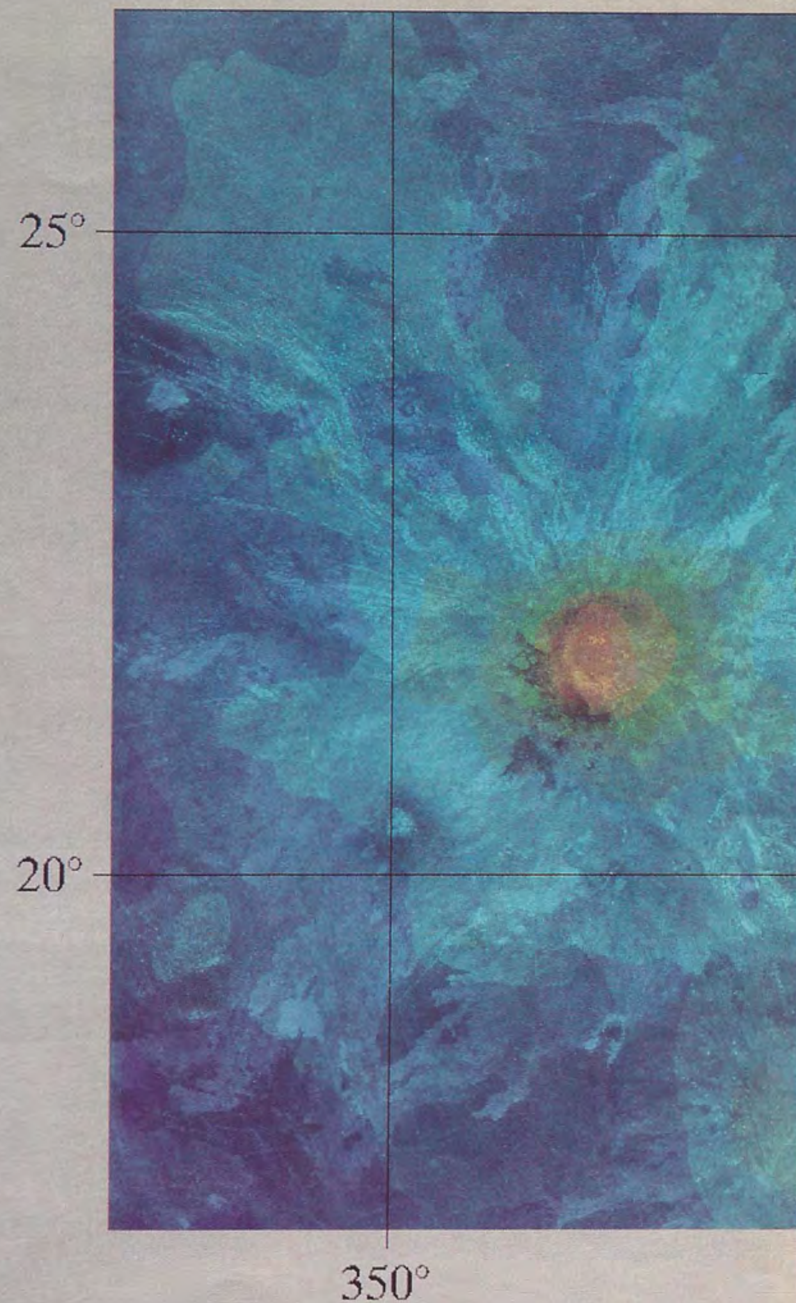
Map: JPL/NASA, MIT Center for Space Research and the Arecibo Observatory

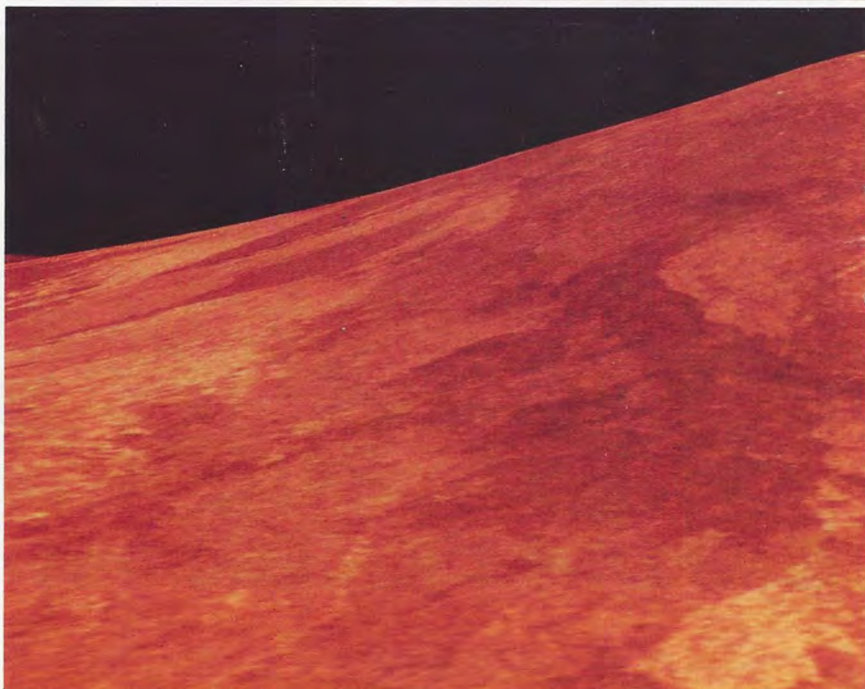
Over the Volcano

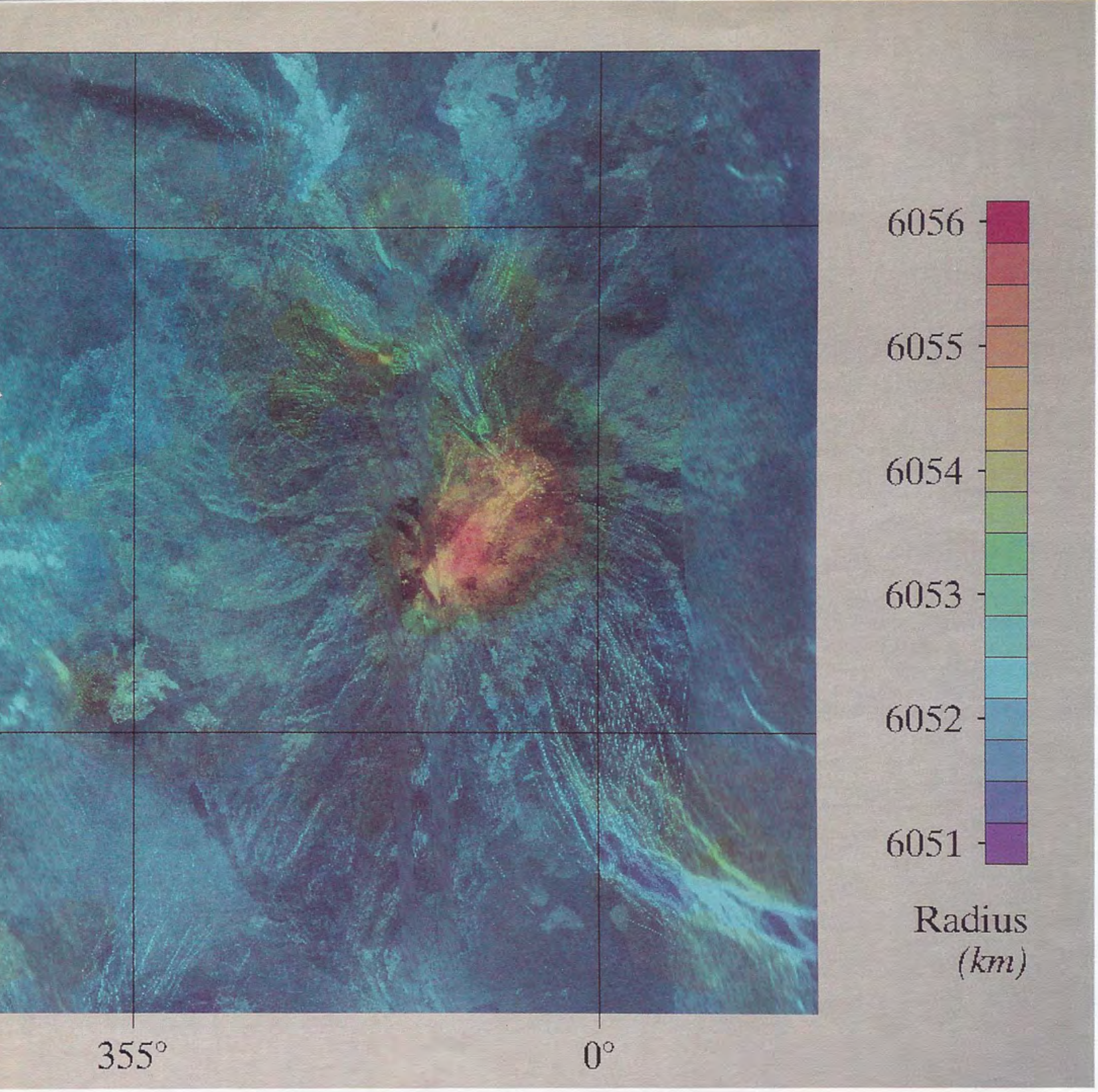
By superimposing radar imaging data on altimetry data, *Magellan* researchers created this oblique image of the volcano Sif. We are looking from the northeast to the southwest, toward the summit. The light-colored lava flows, with rough surfaces that appear bright to radar, extend 120 kilometers (75 miles) down the flanks of the mountain. They overlie darker, smoother flows, which indicates that they erupted relatively recently.

The technique of superimposing two types of data allows scientists to identify regions where lava flows are controlled by local topography; that is, where they follow the dips and avoid the bumps in the ground. This helps researchers understand Venus' volcanic processes and enables them to better compare these features with their earthly analogues.

Image: JPL/NASA



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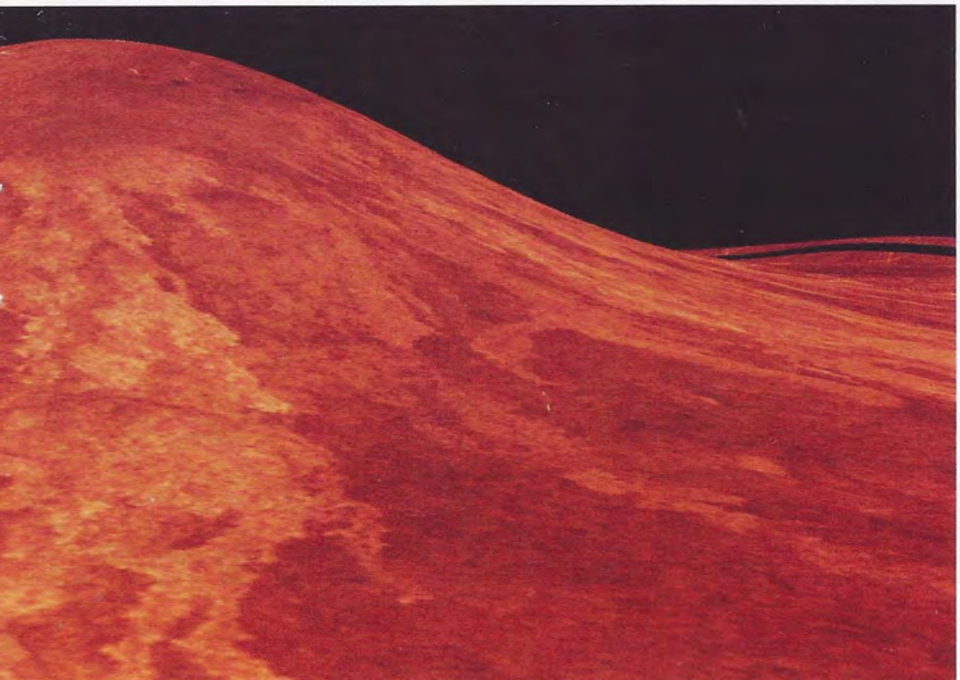

The Soviets and SETI:

The Search for Extraterrestrial Intelligence and *Perestroika*

Interviews by David W. Swift

The detection of a radio signal from an extraterrestrial civilization would be a transforming event in human history. After centuries of speculation, we would at last know that humans were not the only technologically advanced life-forms in the universe. This great potential has attracted researchers around the world to the search for extraterrestrial life. Every two years, the Commission on Bioastronomy of the International Astronomical Union holds a meeting to share their ideas and results of search programs.

The last meeting of this group took place in the town of Val Cenis in the French Alps. Several scientists from the Soviet Union attended the gathering, gave papers and listened to reports from researchers around the world. Sociologist David Swift from the University of Hawaii took advantage of their presence to ask them a few questions about their work, science in the Soviet Union, and the effects of *perestroika* and *glasnost*.

David W. Swift is a Professor of Sociology at the University of Hawaii. His latest book, *SETI Pioneers*, is a collection of interviews with leading figures in the search for extraterrestrial intelligence.

What are the effects of *perestroika* on Soviet science in general and on SETI in particular?

S. F. LIKHAVECHEV, *Moscow Power Engineering Institute:* The time of Brezhnev was a time of stagnation in science, and now those who are the true scientists are taking advantage of the new time. *Perestroika* has put forward several active, democratic people who have been trying to change the very stagnant situation in our science in general. The democratic process now occurring in our country has influenced the democratization of science, and the attitude people have toward scientists. The fact that we meet here and we discuss these problems shows the influence of *perestroika* on the questions discussed.

V. I. SLYSH, *Space Research Institute, Moscow:* The effect of *perestroika* on science in the Soviet Union is characterized by uncertainty due to funding policy. Is it to be changed or not? This is not known yet, and it brings some other problems to science.

One direction is to make science like a business, to put it in the same funding frame as a business, to make science look for sponsors and for money.

The other direction, the traditional approach, is that science is funded by the state, with a certain percentage of the national income—which is what I prefer, because science has to be developed whether or not it can earn some money, especially a science like astronomy.

VLADIMIR RUBTSOV, *Ukrainian Extramural Polytechnical Institute, Kharkov:* I hope the effect of *perestroika* on science will be quite positive. Now it is only positive because we have the ability to go abroad to meet foreign scientists and discuss with them the questions we are interested in. As for some further consequences, I think that in the spiritual context these consequences will be important. As for material consequences, I am not quite sure, because there will probably be some shortage of funds for purely theoretical investigations.

It is quite possible that if we have market relations in our country there may be some shortage of funds, at least in the beginning. But of course every Soviet scientist, I think, is for *perestroika* and for further development of the Soviet Union, because it is just impossible to be in such a state as we were in for the last 15 or 20 years.

VLADIMIR S. STRELNITSKIY, *Astronomical Council, Academy of Sciences, Moscow:* I can tell you that perestroika has had some influence on science. In particular, I would like to mention some attempts to reconstruct the system of funding. We have had a very bad system—maybe good for a man who is already involved in science and works somewhere, because he is guaranteed to be paid for life—but now there is some competition, and you must struggle a bit to get money. This is new for our system.

It is a good beginning because people now want to give their jobs more import, and the result is greater quality.

Will *perestroika* help SETI?

RUBTSOV: Yes, of course. Mainly because of the liberation of our mode of thinking, although there was no restriction on this field of investigation during the past—as distinct, incidentally, from the UFO subject. But of course the whole atmosphere plays a great role in scientific investigation, and the change of this atmosphere to one with more freedom will influence quite positively this search.

SLYSH: From one point of view, SETI is not considered a branch of science. It is more like a subject of public interest. Now, with more *glasnost*, there are many things such as ufology and extrasensory perception, and SETI is often classified as similar to these: not scientific.

But on the other hand, it was always difficult to explain to politicians, to statesmen, what profit one can gain from particular scientific projects, to get funds. SETI as a goal is more understandable to politicians. SETI and planetary research are easier things to explain, easier things to get money for, than black holes, extragalactic nuclei or astrophysical cosmology. If we are to struggle for money for fundamental science, we could use the SETI argument to get more.

Because laymen understand it better?

SLYSH: Yes. For example, my talk at this symposium will be connected with a particular astrophysical project called Radioastron, which stands for space-ground radio interferometer. It will be used for fundamental astrophysical problems, but it can also be used for SETI research. Perhaps this idea will get us additional support from the state.

Is this situation new?

SLYSH: This possibility arose only recently when, with *perestroika*, the funding policy was changed. Before *perestroika* we got a fixed budget from the state and did not have to worry about arguments for funding, but now we have to use all possible arguments to get projects funded. This connects *perestroika* and SETI with fundamental science. So, as I said, in my talk I will describe how my astrophysical project will be used for SETI research. And if this approach is accepted favorably by this community of scientists, maybe we will use it also with our government officials.

STRELNITSKIY: I don't see an influence of *perestroika* on the SETI problem yet. In the United States there is already a special SETI Institute. I don't know if people are paid or whether it is something people do out of enthusiasm in America, but there is something special. [Editor's note: The SETI Institute is a non-profit organization, funded by NASA, to support the NASA SETI program.] There already are specialists like Jill Tarter, for example. [Editor's note: Dr. Tarter is Project Scientist for the NASA SETI Microwave Observing Project.]

For us, SETI is extra work. We do it only out of enthusiasm, and there is even some psychological beating from colleagues who always treat the SETI people like crazy people. And each of the "crazy people" considers the others to be crazy. But no great influence of *perestroika.*

Maybe it coincided with some change at the top, of the administrators who are involved in the SETI work, and now there is some activation, some increase in activity in this field, but it is due rather to the appearance of new people in SETI.

At what level?

STRELNITSKIY: It changed at the level of the chiefs. It was natural because the ex-chiefs took other positions and so had to be replaced. Now there are several new people, and new people are often more active and interested in the problem (at least at the beginning!), so maybe we will accomplish some new things.

We also have new ideas about strategy in the search for extraterrestrials, and we will use the great telescopes—our biggest telescopes, the RATAN 600 radio telescope and the 6-meter optical telescope—to observe, in the framework of this new strategy. So I don't see something really very new in this field. But, in general, *perestroika* touched everybody in our country, so indirectly it appears everywhere, and in SETI and science in particular.

What do you see for the future of science in the Soviet Union?

STRELNITSKIY: The future of science in the Soviet Union will depend strongly on change in the organization of science. To begin with, we have to do something with our Academy [of Science], because it is a conservative structure now. Your system of labs as independent units, where projects are conceived and completed, and where people are very active in getting funding and in realizing their projects, is much better.

Another bad thing in Soviet science is the division between academy science [research, carried out in institutes] and university science [teaching]. In our universities, people have trouble doing research—trouble getting funds, trouble getting permission to go abroad and get experience there—whereas those in the Academy want to teach more than they can.

Your science is university research, as far as I know, so the university is a place where one does good research, whereas we teach in the university and do research in the Academy.

The typical situation in our universities is that people teach so much that they have no time to do good research, whereas in academies [institutes] people have no possibility of teaching, because to do this they must look for a place in the university. Very often one gives them a place, but without paying them, only to satisfy their desire to teach. So it is very bad now. I think we must change the situation and carry out actual science more in the university, as in the States.

There is now some movement to create informal organizations that will develop and protect science and scientists. For example, two months ago we created an astronomical society, but it depends on funding; the money is in the hands of the academicians now, and it is not always true that these academicians really know how this money may be efficiently used.

Do you think *perestroika* will help to improve this?

STRELNITSKIY: I think so, because now we have the ability to create associations and to struggle for these progressive forms of organization in science.

LIKHAVECHEV: The worst thing in our science is the dominance of the Academy. This system is very oppressive for free thinking, because you have an elite of scientists who, most of them, stopped working and are only organizers —but in most cases they are not the best organizers because only life can show who is an organizer. They are organizers only by name, but not by their capacities, so I think this time will be interesting for science, also.

Is this the first foreign meeting you've attended?

LIKHAVECHEV: No, but now we can discuss problems we wouldn't talk to you

Illustration: S. A. Smith

about earlier, and the fact that I have brought here the characteristics of the antenna devices that were not revealed before—this fact tells you a lot.

Can you tell us a bit about these antenna devices?

LIKHAVECHEV: I am from the special design bureau of the Moscow Power Engineering Institute. This bureau was founded in the 1950s, under the auspices of Sergei Korolev, who was the founder of Soviet rocket techniques. Now this bureau possesses some of the most powerful antenna complexes in the Soviet Union. In particular, our well-known system of space communications was developed in this design bureau. Also by means of antennas developed in this establishment, the famous images of the Moon, Venus and Phobos were obtained. [Editor's note: The images were transmitted from spacecraft to these antennas.]

What is your perception of this meeting?

STRELNITSKIY: It was a really interesting conference. I must say, however, that we have some trouble with the language, because we have very little and poor practice. We seldom go abroad, and so even if we can express ourselves in some broken English, we have trouble understanding fluent speaking. However, we have some printed material, and we compare it with what we understand from the oral discussion.

As Frank Drake said today, there are some new ideas, some new devices, and I think there is some progress in this field. Although we have had no contact with extraterrestrials, and nobody knows when we will have it, we understand better the problem itself, we understand better that the problem is a scientific problem.

Many talks were very interesting and indeed creative, but there were also some not so interesting and maybe crazy ideas—but it is always so. Freedom is freedom; we must make some future for ideas. If not, we wouldn't have people here who propose their "crazy" ideas on this vague question, and sometimes the crazy ideas turn out to be very creative.

What does the future hold for SETI research in the Soviet Union?

RUBTSOV: SETI has developed rather slowly because there are still no concrete results, so there is only half-interest in this investigation. But when SETI yields some concrete results, not only in finding some extraterrestrial civilization, but even in the technological results from the development of search systems, then I think progress in this field of investigation will not be so slow.

Do you see any danger of going back to the old days before *perestroika*?

STRELNITSKIY: Yes, this possibility exists. I don't want to believe that events will go in this way, but in fact the situation in the country is absolutely unstable and very unpredictable. Chance can change the way of the whole country. Because of the exterior situation, and because of the democracy that already guarantees some rights to speak, to express our opinions, I think we are protected against the extreme forms of Stalinism in our country now.

However, there are forces that are too conservative, so the possibility of going back always exists—as in your country, too. You are more stable, but there is always the danger of fascism to come. The situation may be so that some bad people can use the situation to pull the country into some totalitarian regime.

LIKHAVECHEV: *Perestroika* is a difficult process in our country for all types of intellectual activities. Unfortunately, at present fundamental science is not in the same framework as it is in the Western countries. Soviet scientists have problems both in their financial and in their intellectual activities. Despite all that, the intellectual potential of the Soviet Union is enormous, and we are able to deal with such problems as the search for extraterrestrial life. I do not doubt that within one or two years these problems will be solved, as far as the organization of science is concerned.

Is there anything else you'd like to say?

LIKHAVECHEV: The warming of relations between the United States of America and the Soviet Union is evidenced at this symposium. The Americans and Russians are very much alike, and if peoples are very much alike there can be no problems between them. □

World Watch

by Louis D. Friedman

WASHINGTON, DC—There's been a lot of action on the space station front. In last year's final budget appropriation, Congress directed NASA to scale down space station *Freedom*, both in complexity and in cost. The agency came up with a smaller, less ambitious design, but it kept the fundamental architecture. The cost estimate was reduced from $38 billion to $30 billion.

The station will still be assembled by a succession of shuttle flights, and astronauts will still have to undertake extravehicular activity (EVA) to build and maintain it. The number of flights to ferry segments into orbit was reduced from 30 to 23. EVA time has been cut in half, but astronauts will still have to work in space for longer than the combined EVA time to date in both the Soviet and the United States space programs.

The crew capacity was reduced from eight to four, and the target date for "permanent manned capability" was slipped to September 1999. The launch of the first element is still planned for 1995.

Europe and Japan are building modules to attach to the space station. The revised plan will require these international partners, as well as other American users, to change their own plans.

The station's reduced capability did not sit well with its potential users. In fact, the National Research Council's Space Studies Board, representing astronomy, planetary, solar, microgravity materials processing and life sciences, issued a report in March saying that *Freedom* was unsuitable and unjustified for any of these sciences. They noted that long-term biology experiments and life-support research would be impossible in the new plan, and that a stable microgravity environment for materials processing research was unlikely with humans aboard.

The White House's Office of Science and Technology Policy also reported that neither the station's cost nor the effort to build it was justified. They recommended (just as the officers of The Planetary Society did four years ago) that NASA refocus the project solely on supporting human space exploration.

Despite these criticisms, the administration, through a letter from Vice President Dan Quayle to NASA Administrator Richard Truly, supported the redesigned station. The Vice President stated that "science is but *one* reason for building a space station," while the "most compelling reason . . . is . . . to further American leadership in exploring space," and to reaffirm US "superpower status."

The officers of The Planetary Society strongly oppose the view that the space station is mainly a *symbol* of America's technological leadership, both on its merits and because it threatens the rest of the scientific space program. Especially jeopardized are the planned robotic missions in this year's budget, as well as the long-range prospects for President George Bush's Space Exploration Initiative (SEI). NASA has traditionally given these areas lower priority than the space station. Congress will almost certainly cut the proposed budget, and the programs to suffer will be in space science, robotic missions, new launch vehicles and SEI technologies. Bruce Murray testified to the Senate Subcommittee on Science, Technology and Space on this subject on April 16, 1991. Copies of his statement are available.

Long-duration flights, needed to test the limits of humans in space, are not planned until the next century. In addition, the US module does not have life-sciences capability, so the US must rely on the European module for such work. After the initial operating date in 1999, however, NASA does hope to extend the duration of flight capability and increase life-sciences support in the space station.

WASHINGTON, DC—Several options for human space transportation are being studied for the 1990s. These include a single-stage-to-orbit (SSTO) rocket being developed by the Department of Defense's Strategic Defense Initiative Organization (SDIO), the National Aerospace Plane (NASP), the Assured Crew Return Vehicle (ACRV) and the Personnel Launch System (PLS). In addition, two heavier-lift launch vehicles, Shuttle-C and the Advanced Launch Development Program (ALDP), are under study.

The Advisory Committee on the Future of the US Space Program (see the March/April 1991 *Planetary Report*) recommended that the US develop an unpiloted heavy-lift launch vehicle that would eventually be capable of carrying humans. They suggested that the design be based on a system being developed by the Air Force, but it should include components of the shuttle. NASA still favors the shuttle-based program, and the Air Force-NASA team for the new launch vehicle is stalled in resolving the differences.

The single-stage rocket would use technology elements from several programs, including the aerospace plane and the ALDP. It would be reusable and designed to fly to and from orbit. Configurations under study include horizontal takeoff and launch, vertical takeoff and launch, and mixed modes. (The Federation of American Scientists recently revealed a secret SDIO development of a nuclear rocket launcher—presumably separate from the SSTO concept.)

The ACRV is an emergency vehicle for the space station. In case of problems, the crew could jump into it and return to Earth. Some studies aimed at turning it into a reusable, two-way transportation vehicle are under way.

The Personnel Launch System is designed to carry up to 10 people on a heavy-lift launch vehicle. It is analogous to a ferry, whereas the ACRV is a lifeboat.

The aerospace plane is a technology program looking at a means of achieving hypersonic flight.

All of these projects are only in the paper stage, although the SDI organization hopes to have a prototype of the single-stage rocket ready to fly by 1995.

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

News & Reviews

by Clark R. Chapman

If ever there were a year to resolve NASA's institutional woes, 1991 would be it. A presidential committee—the Advisory Committee on the Future of the United States Space Program—led by Norman Augustine reported last December on ways NASA might recoup after such problems as the shuttle's disappointing reliability, flaws in the Hubble Space Telescope, and the deepening malaise of the nation's space scientists. (The Augustine report is available from the US Government Printing Office.) The committee's findings provide a benchmark for gauging this year's congressional debate on NASA's budget.

C-SPAN and NASA Select

The debate occasionally crops up on cable TV. If you have a satellite dish or subscribe to one of a few cable systems, you can tune in NASA Select. More widely available but less certain to carry NASA affairs is C-SPAN. I watched NASA Select the other day when Augustine and his vice chairman (Laurel Wilkening) testified before a congressional committee. The American space program clearly faces an uphill battle.

Politicians want to hear clear priorities so that in our debt-plagued budgetary process they can learn where to cut. They were pleased with Augustine's testimony. Though the report advocated 10 percent annual growth in NASA's budget to accomplish approved programs, Augustine nonetheless provided priorities for cutting. The very top, presumably uncuttable, priority is space science.

Many committee reports wind up in the trash can, but Vice President Quayle endorsed this report when it was issued, Congress is paying attention and even NASA is paying it lip service. Suddenly, many of NASA's traditional activities are now deemed to be "space science" by NASA management.

At the very bottom of Augustine's priorities (though still recommended) is Mission from Planet Earth. MFPE is the latest incarnation of SEI, or the Space Exploration Initiative, which is President Bush's program to send human beings to the Moon and on to Mars. MFPE would be funded on a "go as you pay" basis; that is, the pace would be set by the available funds. In today's fiscal climate, that can hardly inspire the dedicated commitment of the nation's best scientists and engineers, such as marked President Kennedy's "pay as you go" timetable for the *Apollo* program.

That MFPE has the lowest priority seems poor news for planetary exploration enthusiasts. By Augustine's logic, it shouldn't be good for space station *Freedom*, either. He told Congress that the sole justification for the station is for use in studying the capacity of human beings to travel to Mars. So if MFPE is delayed or axed, the space station should be cut, too. But Norman Augustine demurred from this logic in his congressional testimony. He thinks that a viable space program requires human activities beyond those afforded by the shuttle. So, despite its last place priority, the station is "essential" and apparently will continue to cut into the supposedly higher priority programs that have long crowded NASA's plate. Looks to me like business as usual.

Bad Genes or Bad Luck?

David Raup has written a delightful little book about life on this planet and about extinctions in particular (*Extinction: Bad Genes or Bad Luck*, W.W. Norton, 1991). It is as much about the philosophy and methodology of science as about the downside of evolution. The author, a statistical paleontologist at the University of Chicago, touches on such topics as the origin of life and the Search for Extraterrestrial Intelligence (SETI). His numerical arguments are in the familiar context of Las Vegas and the New York Stock Exchange. Several chapters resemble abbreviated versions of Stephen Jay Gould's anecdotal essays on evolution in *Natural History* magazine.

Raup contends that an emerging view of evolutionists is that species go extinct not because they are somehow inferior and lose out in the Darwinian struggle, but rather by sheer accident or "bad luck." Raup turns to a cosmic killing mechanism as the engine driving extinctions (hence also formation of new species to replace the old): the random bombardment by asteroids and comets.

Amazingly, the usually dispassionate Raup actually proposes that *all* extinctions might be due to impacts. He doesn't mean just all *mass* extinctions, like the one that wiped out two-thirds of then-existing species (including all dinosaurs) at the close of the Cretaceous period. Yet he can hardly mean that asteroids killed every one of the 5 billion to 50 billion species thought to have existed on Earth at some time (compared with the mere 40 million here today). Localized minor species, like many of those now being lost at a prodigious rate from burning and clearing of tropical rain forests, must have faced more serious hazards than meteorites falling from the skies, even before the advent of humankind. I think Raup means that nearly all of those now extinct species that were abundant and widespread enough to show up in the fossil record were done in by cosmic impacts. He sensibly acknowledges that his idea is "bizarre." But what if it's true?

Clark R. Chapman will be best man at the June 22 wedding of a couple who first met at a meeting of a local chapter of The Planetary Society.

SOCIETY *Notes*

MAY WE GIVE YOU A CALL?

Members have always been the driving force behind all that The Planetary Society does. We could not even consider such projects as the Mars Balloon and Rover, the asteroid discovery project and the search for extraterrestrial intelligence without your loyal support.

Now, because it is critical that we rally as much support as possible around today's issues, the Society is planning occasional "phone-a-thons" to members to raise extra funds for our projects.

Many members have told us that they regard these phone calls as a valuable means of contact with the Society, as well as a way to raise funds for their favorite projects. We have instructed our callers to refrain from any high-pressure tactics and instead to use the opportunity to inform you of the status of our projects. If you receive a call that is not up to that standard, please let us know.

If you do not want to be called, we will most certainly honor your request. Just let us know, and your name will not be included on the telephone list.—*Louis D. Friedman, Executive Director*

CALLING ALL VIKING VETERANS

All *Viking* team members are invited to attend a reunion at NASA's Langley Research Center to celebrate the 15th anniversary of the first *Viking* landing on Mars. Planned for July 20, the event is being held in conjunction with the July 17-19 Mars Symposium, "Mars Exploration: Past, Present and Future," in Williamsburg, VA.

Even after 15 years, *Viking* remains one of the most ambitious and productive planetary missions ever launched. While two orbiters imaged the surface from above, two landers investigated Mars close up, equipped with weather stations, soil sampling apparatus and several experiments that tested for evidence of martian life.

Family and friends are welcome at the party. For information, call (804) 864-3309. The deadline for reservations is July 1.

—Charlene M. Anderson, Director of Publications

AWARDS FOR RESEARCH IN ASTRONOMY

If you're a student doing research in astronomy, read on. The Planetary Society has been asked by the scientific research society Sigma Xi to let you know that it regularly awards small grants (800 to 1,000 each year) to support graduate and undergraduate research in all fields of science. A special fund is earmarked for research in astronomy. Awards are normally up to $600, with a maximum of $1,000. Application deadlines are February 1, May 1 and November 1 of each year. For information and applications, write to the Sigma Xi Committee on Grants-in-Aid of Research, P.O. Box 13975, Research Triangle Park, NC 27709, or call them at (919) 549-4691. *—CMA*

SHARED SUPPORT

What do Planetary Society members and the National Geographic Society have in common? Both are supporting the only team in Canada actively engaged in tracking near-Earth asteroids, Dr. Jeremy B. Tatum's group at the University of Victoria in British Columbia.

This is the second time Planetary Society members have come to Dr. Tatum's aid. Three years ago, we supplied a small grant for his astrometry program to measure with extreme accuracy the orbits of comets and asteroids. (See the May/June 1988 *Planetary Report*.)

The Planetary Society remains committed to supporting the important, but often underfunded, field of asteroid research. Eleanor Helin's Planet-Crossing Asteroid Survey, one of the world's leading discovery programs, and the International Conference on Near-Earth Asteroids, to be held at the end of June, are two other manifestations of our members' support. *—LDF*

MEMBERSHIP MAINTENANCE

You can help us deliver better service by remembering these tips:

- Renew early. We send out renewal notices four and a half months in advance to conserve Society resources and make delivery more efficient.
- Send us a change of address card when you move. The post office won't forward or return magazines, so we won't know you've moved until you tell us.
- Put your membership number on all correspondence and especially on your check when renewing membership. This number is printed on your membership card and above your name on your *Planetary Report* mailing label.
- When ordering gift memberships, be sure to include your name and address as well as the recipient's name and address. Gift memberships must be paid before we can put the names on file.
- Donations to special funds are restricted by law and may not be used toward your membership dues.

—Sue Pratt, Membership Coordinator

THE VOLUNTEER NETWORK PRESENTS . . .

On May 29, 1991, a series of space-related lectures will begin at the Free Library of Philadelphia, organized by our regional Volunteer Network Coordinator Bruce Ruggeri. Area members will soon receive flyers giving details.

Our Volunteer Network organizes similar programs around the world. If you would like a calendar of other Society events, please drop me a line.

—Carlos J. Populus, Volunteer Network Coordinator

KEEP IN TOUCH

Our mailing address:
The Planetary Society
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Pasadena, CA 91106

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Questions & Answers

Since Titan and Europa seem to be the two most likely sites for extraterrestrial life in our solar system (outside of Mars), are there any plans or proposals to send a* Viking*-type probe with biological detecting equipment to either one?
—James Boshnack, Katy, Texas

Titan, Saturn's largest moon, has an atmosphere rich with organic molecules, the carbon-based molecules out of which all life (as we know it) is composed. Its atmosphere is mainly nitrogen and methane. In the upper atmosphere, these molecules are broken up by bombarding electrons from Saturn's magnetosphere, the fragments recombine into more complex molecules and they settle down to the satellite's surface. Laboratory simulations suggest that, over geologic time, at least 100 meters (330 feet) of organic muck should have fallen onto Titan's surface as a result of these processes.

As a parachute slows Huygens' *descent to Titan's surface, the probe will analyze the chemistry of the satellite's clouds and atmosphere. It will also measure atmospheric temperature, pressure, density and energy balance. If* Huygens' *scientific instruments survive the landing, it will relay surface measurements back to the* Cassini *orbiter.*

Painting: Michael Carroll

All this means that Titan is fabulously interesting for our understanding of both organic chemistry and the kinds of prebiological processes that may have operated on Earth before the terrestrial origin of life. In order to evolve, life on Earth would presumably have required a supply of organic constituents readily available in the environment. Therefore, to understand the origins of life, we need to know what kind of non-biological organic chemistry preceded it. Understanding Titan's chemistry should help us do this. This is one of the motives behind the *Cassini* mission to Saturn, and the *Huygens* instrument probe that *Cassini* will release into Titan's atmosphere in the year 2002.

Nonetheless, Titan doesn't really seem to be a promising spot for life. Its surface temperature is around minus 179 degrees Celsius (minus 290 degrees Fahrenheit), far below the freezing point of water. Besides organic molecules, liquid water appears to be an absolutely essential ingredient for life as we know it. In the absence of liquid water, it seems likely that the organic molecules on Titan's surface have remained in a kind of aeons-long deep freeze of inactivity.

Europa is a very different world. One of Jupiter's four large Galilean satellites, it has a very bright surface of water ice cut by a network of brownish lines. The largest of these features are thousands of kilometers long and tens of kilometers wide; the smallest seem to go right down in size to the resolution limit of *Voyager*'s cameras. Europa has no atmosphere to speak of.

Although Europa is far from the Sun, it may still experience substantial heating. One source of such heating is simply the decay of radioactive elements in its interior. Another source is tidal heating by Jupiter. In the late 1970s and early 1980s, a number of planetary scientists tried to calculate how all this heating would affect Europa's icy surface. They discovered that one plausible model for Europa's interior was a rocky core overlain by an ocean of liquid water some tens of kilometers deep. This ocean in turn would be covered by an icy crust averaging less than 10 kilometers (6 miles) in thickness. The liquid ocean would be kept from freezing by the heat of radioactive decay and, especially, by tides. The dark, linear features would result from the fracturing of the ice crust.

Once the possibility of a Europan liquid ocean was recognized, it was natural to speculate on the possibility of life in that ocean. But nothing more than speculation is possible. We do not even know whether Europa really has a layer of liquid water in its interior, and spacecraft exploration has a way of making theorists' hopes of Earth-like oceans evaporate in the face of better data. *Voyager* simply didn't examine Europa closely enough to resolve the issue. The *Galileo* spacecraft, however, just might. For example, if liquid water is exposed to Europa's surface when new fractures form in the ice cover, the water should boil vigorously and create geyser-like clouds of vapor. These processes, if they are taking place, could be seen by *Galileo*.

Currently, then, there are no *Viking*-type missions planned for either Titan or Europa. One lesson from the *Viking* project may be that it is extremely difficult to search a world for microscopic life before the geology and surface chemistry of that world are reasonably well understood. If we are lucky, the *Galileo* mission will tell us whether there really is anything to be excited about as far as possible environments for life on Europa are concerned. After *Galileo*, we will be in a much better position to make decisions about further exploration.

—CHRISTOPHER CHYBA, *Laboratory for Planetary Studies, Cornell University*

Maybe if NASA seeded Venus' clouds with plant cells, they might release the oxygen from the carbon dioxide. This would make the planet cool down and become livable. Why don't they try this experiment?

—Scott Kobetis (age nine), Southfield, Michigan

The idea of altering another planet's atmosphere and climate to make them resemble those of Earth has been considered by planetary scientists, including some at NASA. The concept is usually called *terraforming*.

With Venus, you are quite right in pointing out that the first thing that one would want to do would be to reduce the amount of carbon dioxide (CO_2) in its atmosphere and to produce limited amounts of oxygen (O_2). It is, after all, the greenhouse effect of the CO_2 that makes the planet's surface temperature extremely hot—about 460 degrees Celsius (860 degrees Fahrenheit). But we should not forget that Venus is also much closer to the Sun than Earth is.

Unfortunately, converting carbon dioxide to oxygen requires more than just green plants—it also requires water (H_2O). One of the biggest problems in terraforming Venus would be to provide the water needed for photosynthesis. As you know, photosynthesis is the process by which green plants take CO_2 from the air and convert it to the energy they need to grow. The plants then exhale O_2 back into the air. Photosynthesis is the source of most of the O_2 in Earth's air.

The chemical reaction for photosynthesis can be written as $CO_2 + H_2O \rightarrow CH_2O + O_2$. The CH_2O is shorthand for organic carbon molecules, the living material of which plants consist.

Venus has no water on its surface and very little in its atmosphere. Because of the large amount of additional water required, it would be impractical to import it from Earth.

The most feasible idea that I have come across would be to divert the orbits of large numbers of comets to make them hit Venus. Because comets consist largely of water ice (we think!), this could, in theory, solve the water problem. But we'd still worry about other problems, like trying to make sure that the oxygen did not recombine with organic carbon to re-form carbon dioxide and water.

All in all, when we consider the many difficulties we'd encounter in terraforming Venus, most of us conclude that Mars would be a better target.

—JAMES F. KASTING, *Pennsylvania State University*

FACTINOS

Five years after comet Halley's pass by Earth, an immense dust cloud has erupted from its surface, making it hundreds of times brighter. In February, when the comet was some 2 billion kilometers (over 1 billion miles) from the Sun, astronomers saw that it had sprouted a shiny dust cloud that extended for about 290,000 kilometers (180,000 miles). The brightening was first detected from the European Southern Observatory in Chile by two Belgian astronomers, Olivier Hainaut and Alain Smette. They found that the cloud had increased the comet's brightness nearly 300 times over what it was supposed to be at that distance.

Since solar energy is thought to cause such outbursts, Halley's behavior at such a great distance from the Sun is "rather startling," said Dr. Brian Marsden of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. "This is much farther than anything we've observed before," he said.

—from the Associated Press

❖

Artie P. Hatzes of the University of Texas at Austin and his colleagues have coined a new term for the effect they think holds together frost-covered ice particles in the rings of Saturn. They call it "the Velcro effect."

In laboratory tests, Hatzes—together with Frank Bridges, D.N.C. Lin and S. Sachtjen of the University of California at Santa Cruz—studied the influence of tiny frost particles on the ability of solid ice chunks to stick together until they build up into larger bits. "Collisionally induced cohesion is one process by which small particles may coagulate and large particles may grow in size," the researchers suggest.

Lin thinks the sticking effect may also have played an important part in the origin of the solar system. The cores of the giant planets probably began when particles—either ice or dust—aggregated by sticking together, he says. This suggests that the sticking effect is significant in lumping together small chunks of other materials, like rock. Lin adds that gravity provides the only other likely way of grouping rocky bits into larger chunks, but he says the mass of the particles initially would be too low to start pulling them together to begin the planetary birthing process.

—from *Science News*

Have a Cosmic Summer!

Surf Titan!

Perfect summer gear for those cool nights on the beach — on either Earth or Titan. Surfers may someday actually be able to "shoot the curl" on Saturn's moon Titan. Believe it? The possibilities are detailed on a fact sheet that comes with the shirt — to help you explain to your friends just what "Surf Titan" means.

In this beautiful design, a golden wave breaks before a brilliant orange Saturn, symbolizing the seas that may roll across Titan, overcast by its ruddy hydrocarbon atmosphere.

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The Dutch caravelle from The Planetary Society's logo, the symbol of humanity's past exploratory endeavors, decorates this shirt and sails toward the symbol of new adventures, an *Ariane* rocket. A gray shirt with mustard and periwinkle.

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Is this actually the official T-shirt of the Mars Balloon Team? Here's the proof: Team members posed in their shirts on the front porch of Society headquarters. Of course, the shirts didn't look quite so good after several weeks of testing the balloon in the Mojave Desert! But they washed up well, and the team will wear them again for the next round of tests.

A balloon colored purple by the rays of the setting Sun drifts slowly across an orange martian sky in this design. Join the team!

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The Planetary Society staff and friends are a studious lot — they spend their summers at spots like the campus of a local institute of technology, where some of these shots were taken. That's our Director of Publications, Charlene Anderson, posing with T-shirt designer Steve Smith in the "Surf Titan" shirt. Our Computer and Membership Services Manager, Cindy Jalife, and her husband, Danny, model the "Earth" shirt. And although Mars Balloon Team members are too numerous to mention here, that's our Executive Director, Lou Friedman, just to the left of The Planetary Society sign.

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Michael W. Davidson is a biophysicist at the Center for Materials Research and Technology and the Institute of Molecular Biophysics at Florida State University, Tallahassee. The lunar samples were provided by John W. Dietrich of NASA's Johnson Space Center, Houston.

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