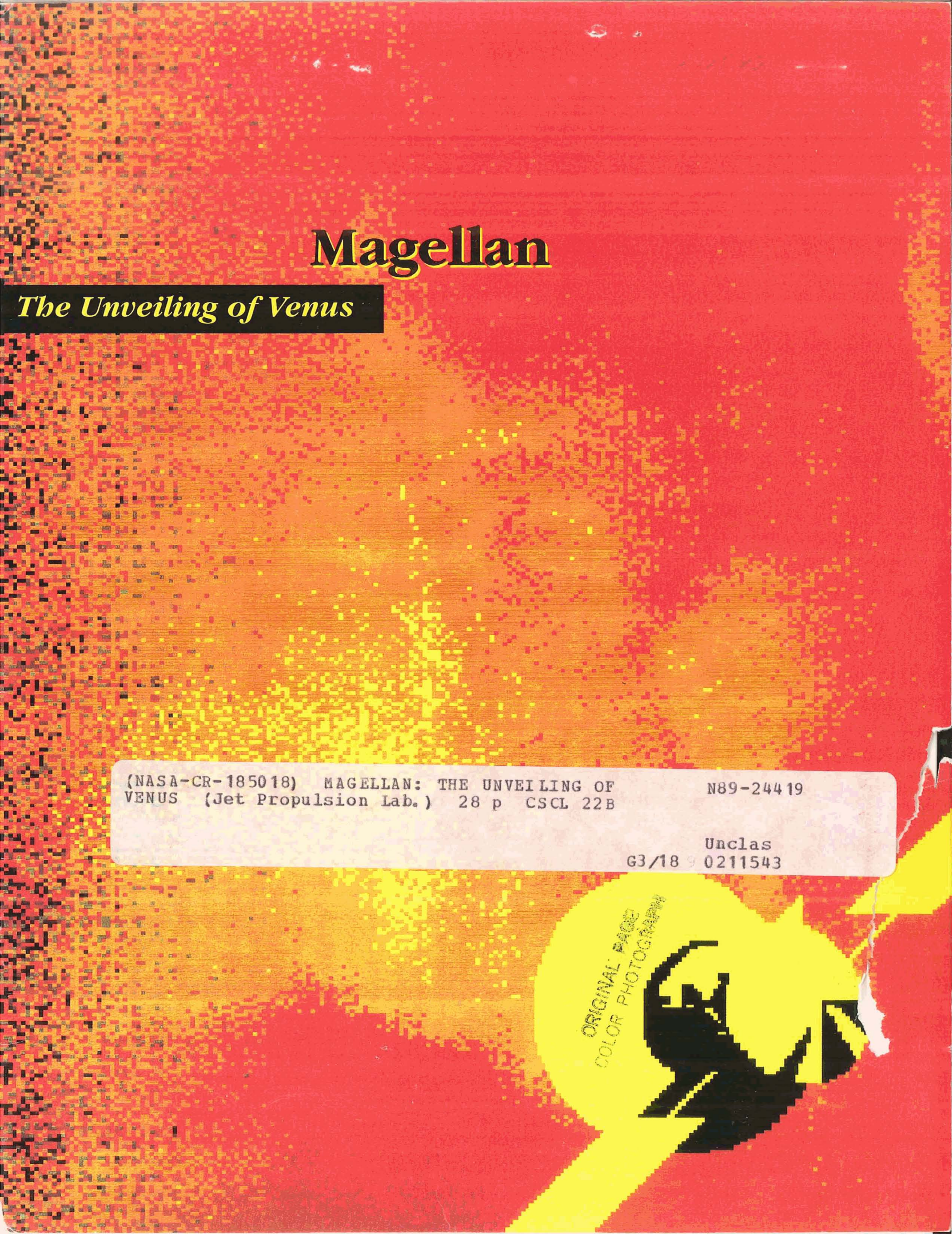
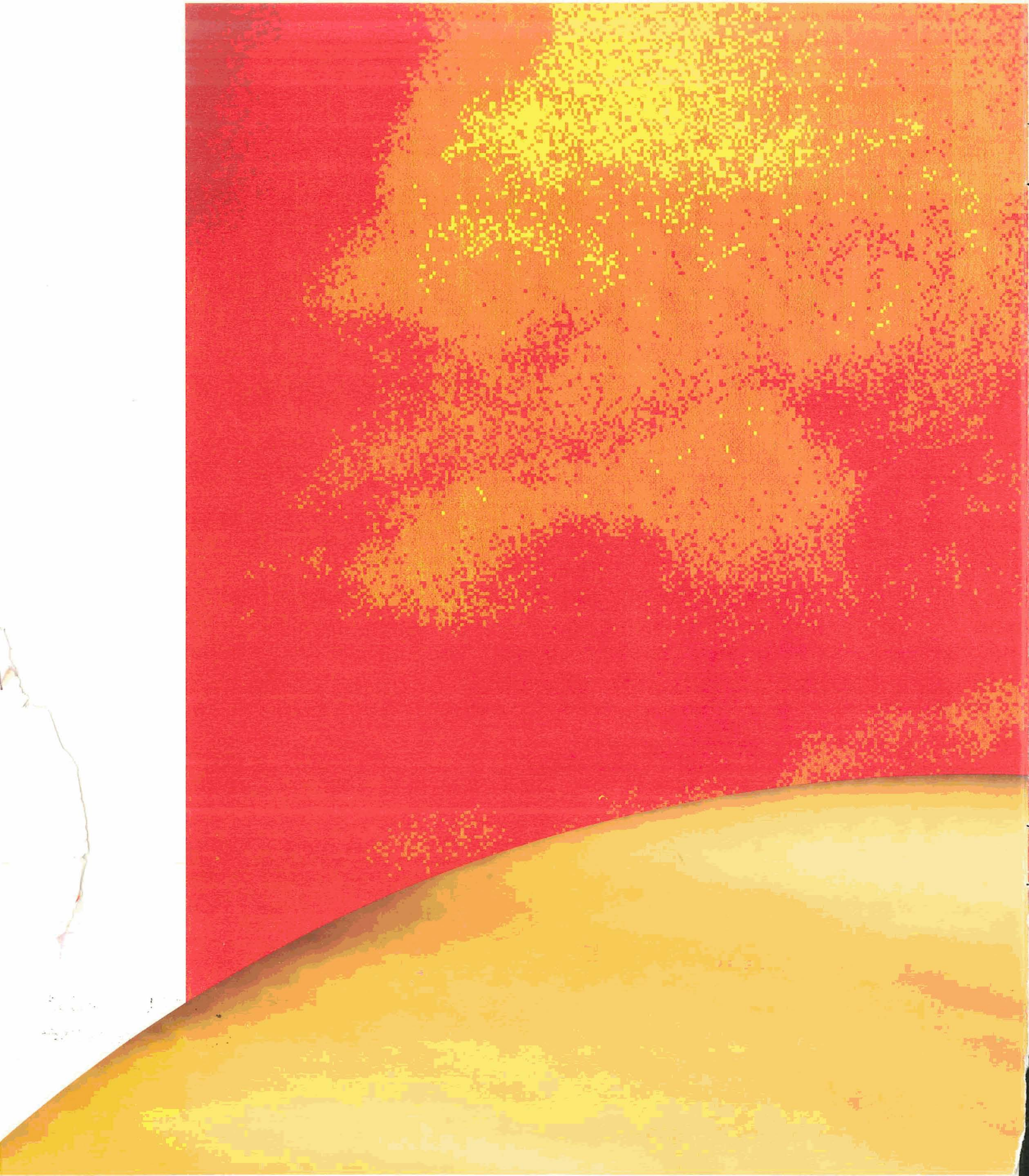
Magellan

The Unveiling of Venus





Of all the planets in the solar system, Venus is the most like our own Earth in size, mass, and distance from the Sun. The motions of our planetary "twin" were known to the ancients, and its apparent changes in shape, similar to the phases of the Moon, were first studied by Galileo more than four centuries ago. In the modern era, Venus has been one of the most visited planets in the solar system—20 spacecraft from the Soviet Union and the United States have been sent there since the early 1960s. Venus' sulfur-yellow clouds have been probed, its atmospheric structure and composition have been measured, and automatic landers have photographed portions of its landscape and chemically analyzed its rocks.

Yet, for all our fascination with Venus, we have only a sketchy, general knowledge of the planet's surface. While the faces of the other "terrestrial" planets—Earth, Mars, and the lighted sides of Mercury and the Moon—have long since been mapped, details of Venus' face are still largely unknown, due to the planet's dense, constant cloud cover. The clouds prevent us from photographing the solid surface from space with conventional cameras.

Since the early 1960s, scientists have used radar to counter this problem. Unlike visible light, radar waves penetrate the Venusian clouds and reflect off the solid planet back to Earth. With the help of computer processing, these radar reflections can be turned into pictures of the Venusian surface. Earth-based radar imaging is thus extremely valuable, but it also is limited—Venus always shows the same hemisphere to us when it is near enough in its orbit for high-resolution study, so only a fraction of the planet can be explored from Earth.

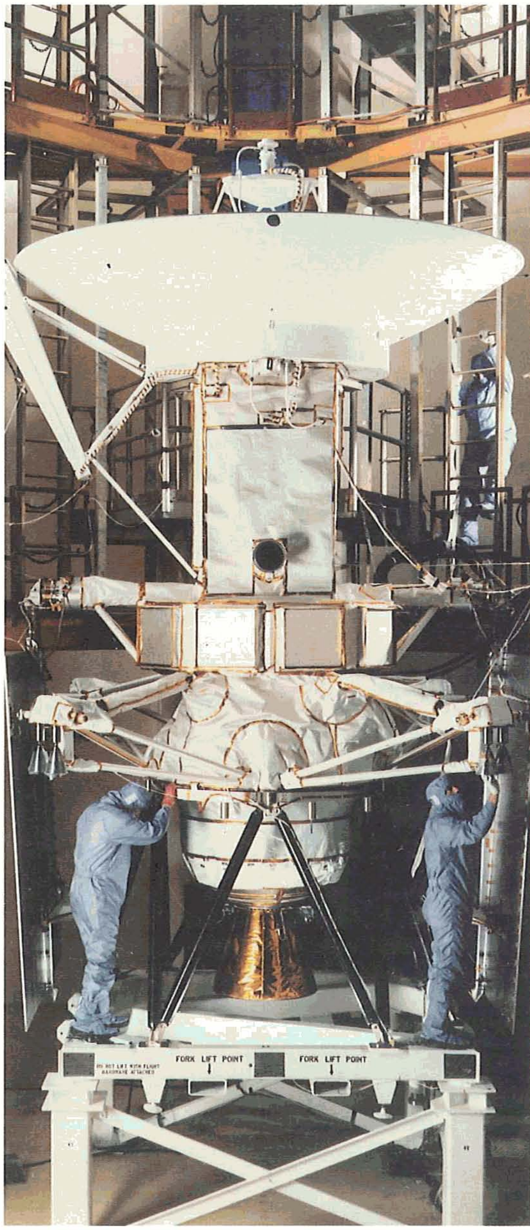
Therefore, in the late 1970s and early 1980s, the United States and the Soviet Union sent the Pioneer Venus and Venera spacecraft, respectively, to study Venus more closely and to image its surface with radar. These missions have answered many of our questions about Venus' atmosphere and large-scale surface features. However, many more questions remain unanswered about the extent to which Venus' surface has been shaped by volcanoes, plate tectonics, impact craters, and water and wind erosion.

To help answer these remaining questions, NASA plans to launch a new radar imaging spacecraft, Magellan (named for the 16th century explorer Ferdinand Magellan), from the space shuttle Atlantis in April 1989. Arriving at Venus in August 1990, Magellan will spend eight months mapping most of the planet at a resolution (a measure of the smallest objects that can be seen in its map) nearly ten times better than that of any previous spacecraft views of the surface. More than any other single mission, Magellan is expected to unveil the secrets of the Venusian past, just as Mariner 9 revealed the unsuspected richness of Martian geology in 1972. In 1990, for the first time, we will really come to know the face of our planetary "twin."

In 1978, NASA launched the Pioneer Venus Probe and Orbiter mission to conduct the most comprehensive investigation of Venus undertaken to date. Most of the experiments concerned the planet's atmosphere, but the orbiting spacecraft also carried a radar system that mapped 92 percent of the surface with a resolution of about 50 to 140 kilometers (30 to 84 miles). For the first time, planetary scientists had a global map of Venus. This map showed the existence of continent-like highlands (Aphrodite and Ishtar), hilly plains, large volcano-like mountains, and flat lowlands. However, as important as this radar map is, it shows only large-scale features. The hills and valleys, craters and lava flows—the telling details of Venusian geology—are as yet uncharted. ■ Five years after the Pioneer mission, in 1983, the Soviet Union sent two Venera spacecraft to map Venus at a resolution of approximately 2 to 4 kilometers (1.2 to 2.4 miles). Because of the nature of their orbits around the planet, the spacecraft were able to map only about 25 percent of the surface, near the north pole. In comparison, Magellan will map 70 to 90 percent of the planet at a resolution varying from 250 to 750 meters (820 to 2,461 feet).

THE MAGELLAN SPACECRAFT

A key feature of the Magellan spacecraft is the economy and relative simplicity of its design. To save costs, spare hardware has been used from other planetary projects, notably Voyager and Galileo. The 3,449-kilogram (7,604-pound) spacecraft has only one science instrument: a radar sensor. This one instrument, however, will perform three important functions: collecting imaging data of the surface of Venus, acquiring altimetric data of the planet's topography, and measuring the natural thermal emissions from the Venusian surface. Magellan's only visible moving parts are a pair of 3.5 by 3.5 meter (11 by 11 foot) square panels that collect solar energy for charging the spacecraft's nickel-cadmium

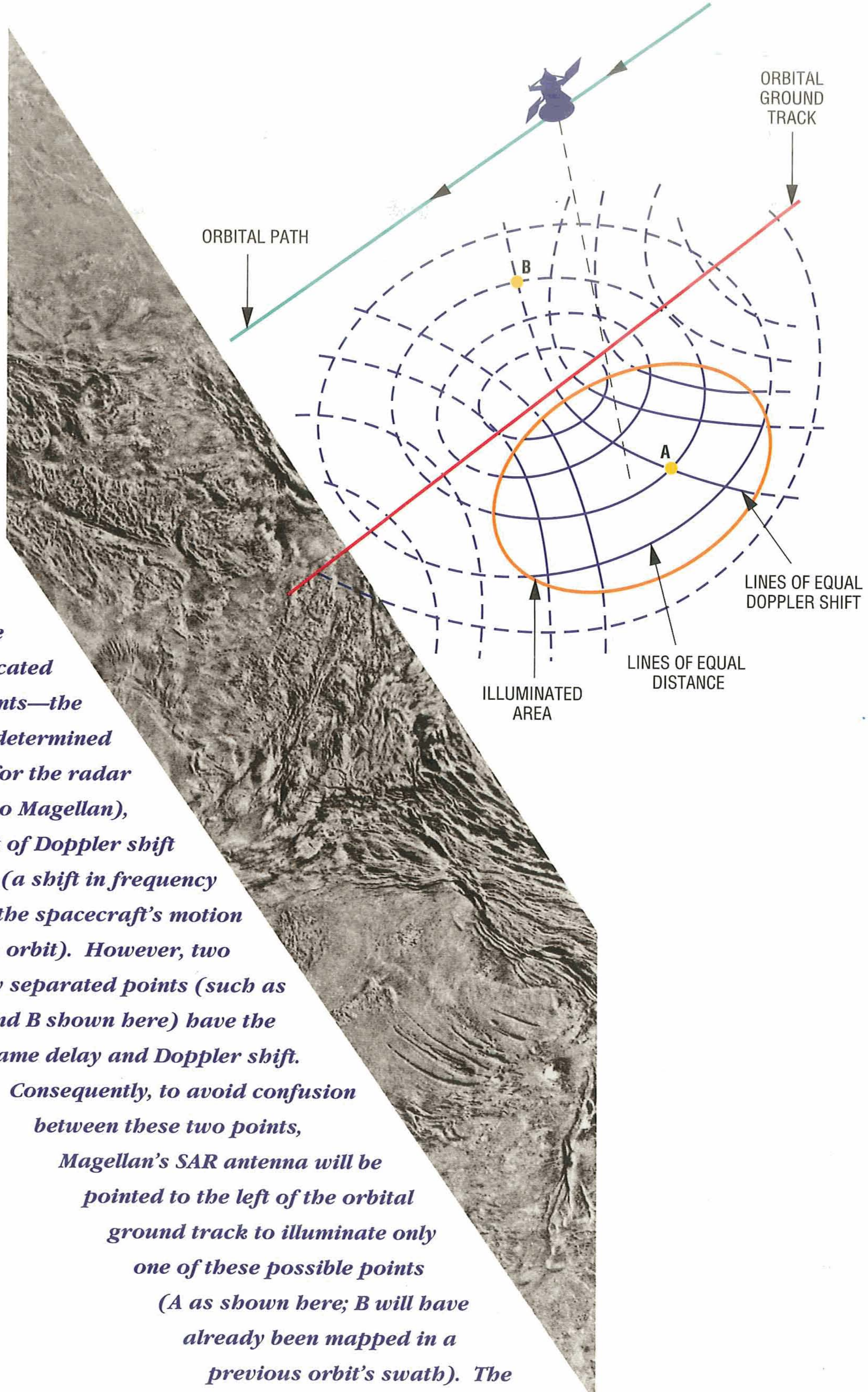


The Magellan spacecraft is prepared for testing in Denver, Colorado, at the Martin Marietta Astronautics Group, prime contractor for the spacecraft. Most of Magellan's major parts are wrapped in reflective white thermal blankets to maintain temperature control. The spacecraft's radar sensor was built by the Hughes Aircraft Company of El Segundo, California.

batteries. ■ Magellan's 3.7-meter-diameter (12-foot-diameter) high-gain antenna dish (used both for radar imaging and for communicating with Earth) and the ten-sided "bus," which contains some of the electronics subsystems, were both spares from the Voyager Project.

THE RADAR

With conventional radar, the resolution of an image depends on antenna size: the bigger the antenna, the better the resolution. A large antenna on a spacecraft, however, would be expensive and difficult to manipulate. To solve this problem, the signals from Magellan's synthetic aperture radar (SAR) will be computer-processed on Earth so that they will imitate, or synthesize, the behavior of a large antenna on the spacecraft. Through this synthesis, the onboard radar sensor will operate as if it has a huge antenna and will produce high-resolution images, even though the antenna is only 3.7 meters (12 feet) in diameter. This computerized process of "aperture synthesis" is what gives SAR its resolving power as well as its name. ■ As Magellan passes over the Venusian surface, its dish antenna will look downward and to the left side of the spacecraft's orbital path. For 37.2 minutes, the SAR antenna will emit several thousand radar pulses each second. Traveling at the speed of light, the pulses will strike and illuminate a 25-kilometer-wide (16-mile-wide) swath of the planet's surface, and then will immediately bounce back and be received at the instrument. ■ By recording the returned pulses, we can use two measurements on each pulse to locate each point on the planet's surface. The first measures the time it takes for the radar signal to return to Magellan; this will give the spacecraft's distance (or range) to that point. The second carefully measures the returned signals for their Doppler effect, a shift in frequency caused by the spacecraft's motion over the surface. This second measurement will give the location of the point with reference to the spacecraft's line of flight, since Magellan will be either approaching or receding from the point at any

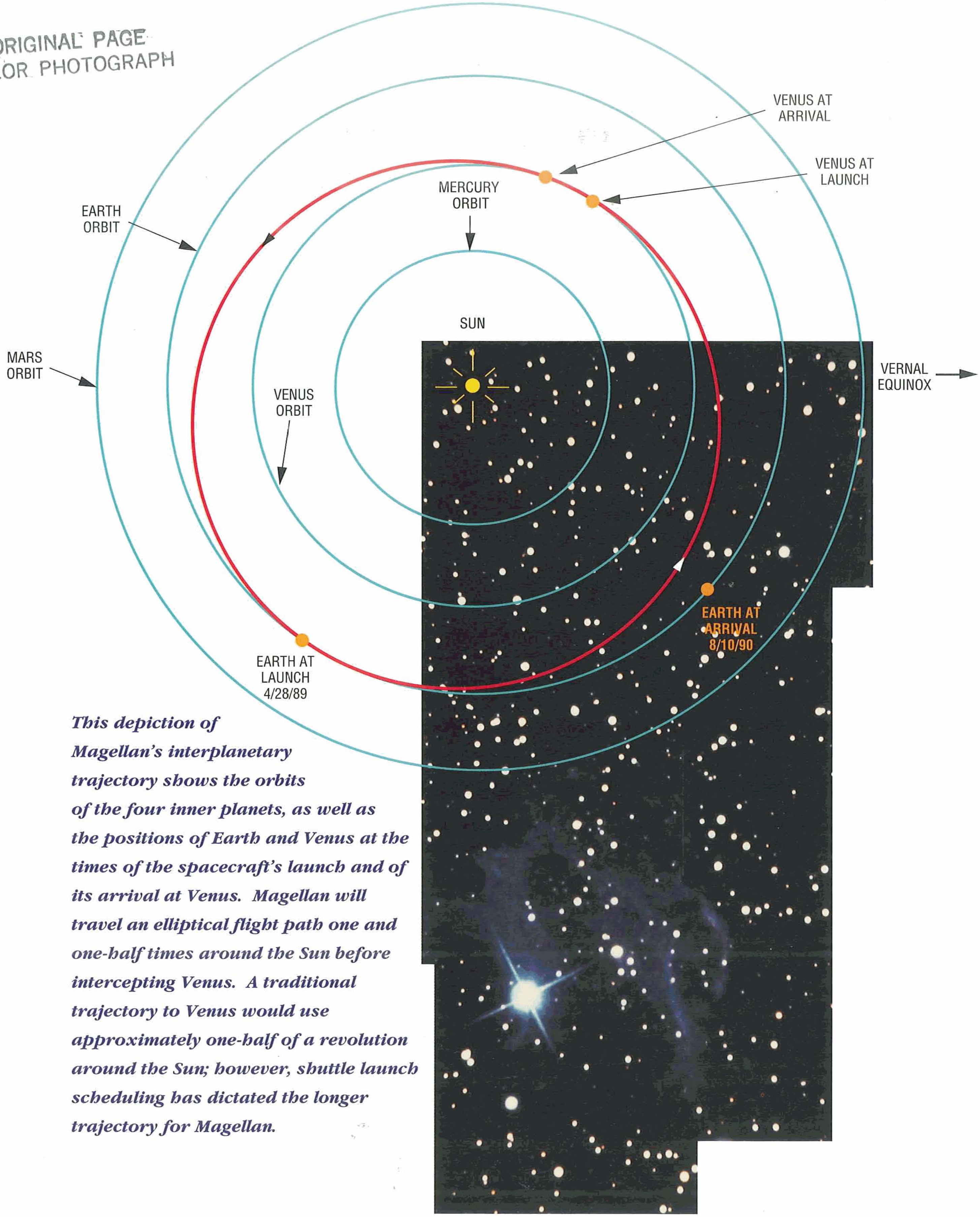


How synthetic aperture radar (SAR) works: Any point in the radar map image can be located by using two measurements—the distance to the point (determined by the time it takes for the radar signals to return to Magellan), and the amount of Doppler shift in the signal (a shift in frequency caused by the spacecraft's motion along its orbit). However, two widely separated points (such as A and B shown here) have the same delay and Doppler shift. Consequently, to avoid confusion between these two points, Magellan's SAR antenna will be pointed to the left of the orbital ground track to illuminate only one of these possible points (A as shown here; B will have already been mapped in a previous orbit's swath). The resulting radar map will therefore show only features to the left of the ground track. The portion of the Venusian surface shown here is a radar image from the Soviet Venera mission.

given time. ■ Since each point in the radar image will have a unique range and Doppler shift, these two coordinates, together with knowledge of the angle of the antenna's line of sight with respect to the surface, are all that is needed to determine the location of any returned signal. The brightness of the image at that point then becomes an element of the map image. ■ Through this technique, data will be collected by the radar instrument and radioed back to Earth, where images of the Venusian surface will be constructed by computers at the Jet Propulsion Laboratory. In these images, it will be possible to distinguish features as small as 250 meters (820 feet) for the equatorial regions of the planet (where Magellan will pass closest to the surface) and about 750 meters (2,461 feet) near the poles. By comparison, the best existing ground-based and spacecraft maps of Venus show no features smaller than 2,000 meters (6,562 feet).

APRIL 1989 TO AUGUST 1990: FROM EARTH TO VENUS

In late April 1989, Magellan will be carried into low Earth orbit by the space shuttle Atlantis. After several revolutions around Earth, the spacecraft, with an Inertial Upper Stage (IUS) booster attached to its base, will be deployed from Atlantis' cargo bay into its own orbit. After two-thirds of another revolution around Earth, the IUS will fire and propel the Magellan spacecraft toward Venus. The IUS will then be jettisoned. ■ The launch period will begin on April 28 and will last for 30 days. During this launch period, Venus will be approximately 255 million kilometers (158 million miles) from Earth. After launch, it will take just under 15 months for Magellan to reach its destination. Three adjustment maneuvers along the way will keep the spacecraft on time and on target for its rendezvous with Venus. ■ When Magellan arrives at Venus in early August 1990, a solid rocket motor attached to the spacecraft will fire to place Magellan in orbit around the planet. After a few adjustment maneuvers, the spacecraft will be in an elliptical orbit, with its lowest point at an altitude of 250 kilometers (155 miles) above the planet's surface and its highest point at 8,029 kilometers (4,989 miles). The time

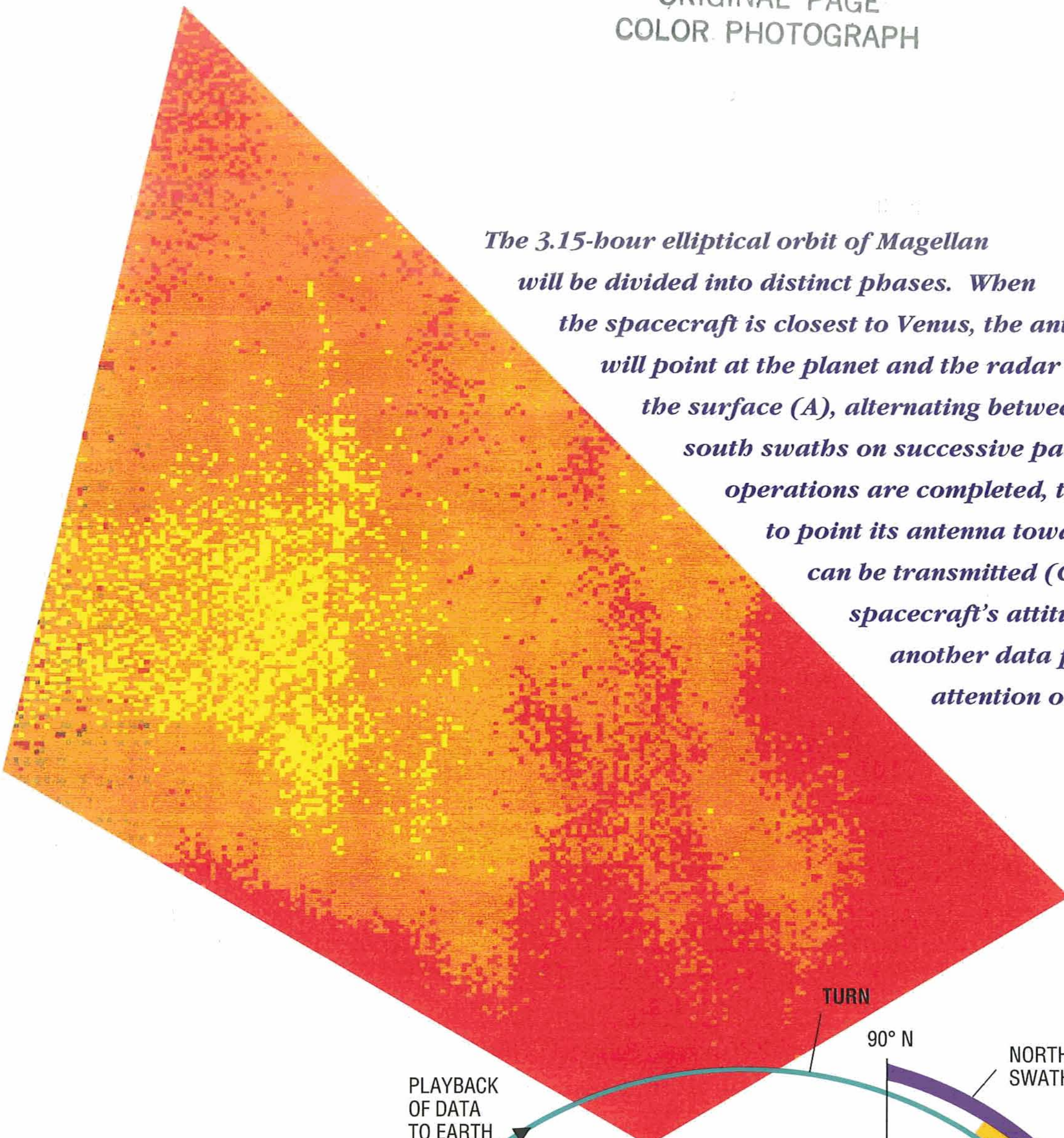


This depiction of Magellan's interplanetary trajectory shows the orbits of the four inner planets, as well as the positions of Earth and Venus at the times of the spacecraft's launch and of its arrival at Venus. Magellan will travel an elliptical flight path one and one-half times around the Sun before intercepting Venus. A traditional trajectory to Venus would use approximately one-half of a revolution around the Sun; however, shuttle launch scheduling has dictated the longer trajectory for Magellan.

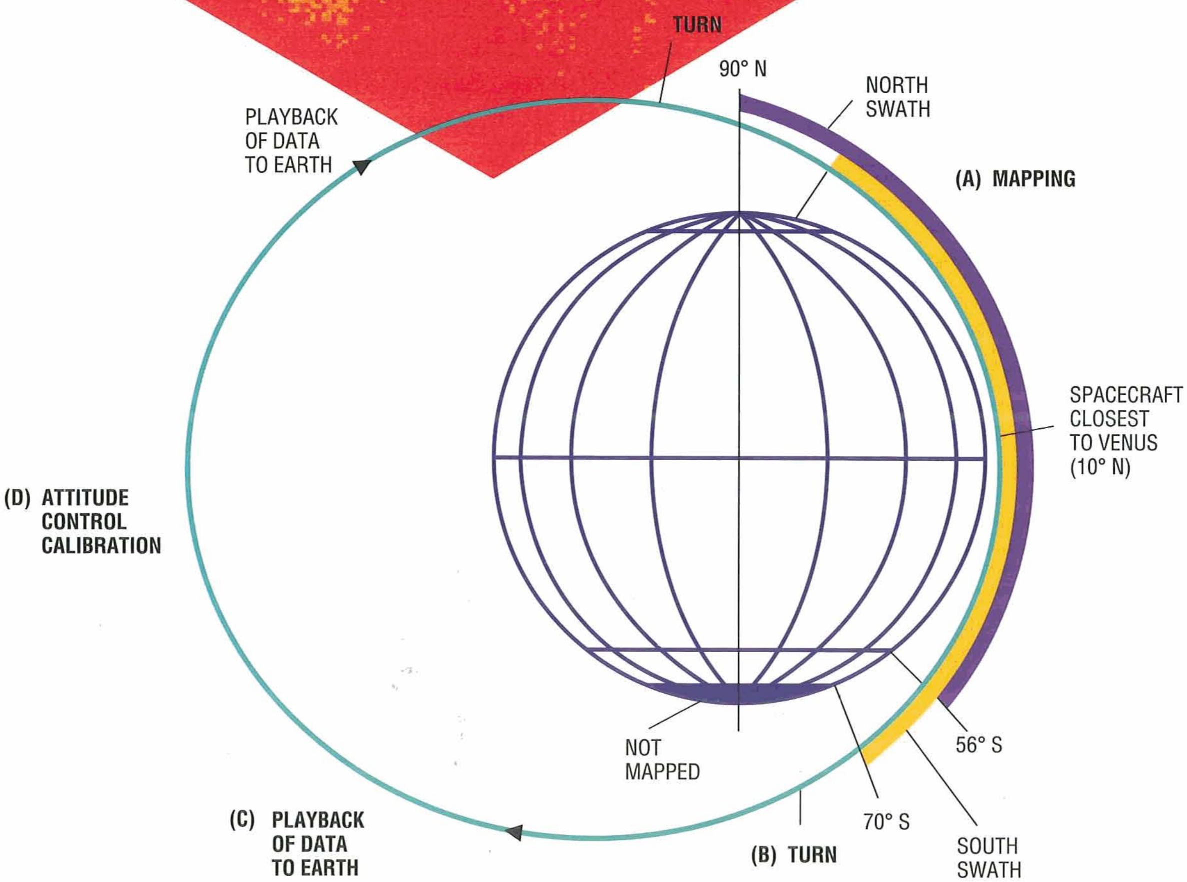
required for Magellan to make one complete orbit around Venus—the orbit period—will be three hours and nine minutes. Since the orbit will be tilted four degrees to the axis of Venus, the spacecraft will pass nearly, but not quite, over both the north and south poles.

AUGUST 1990 TO APRIL 1991: MAPPING THE VEILED PLANET

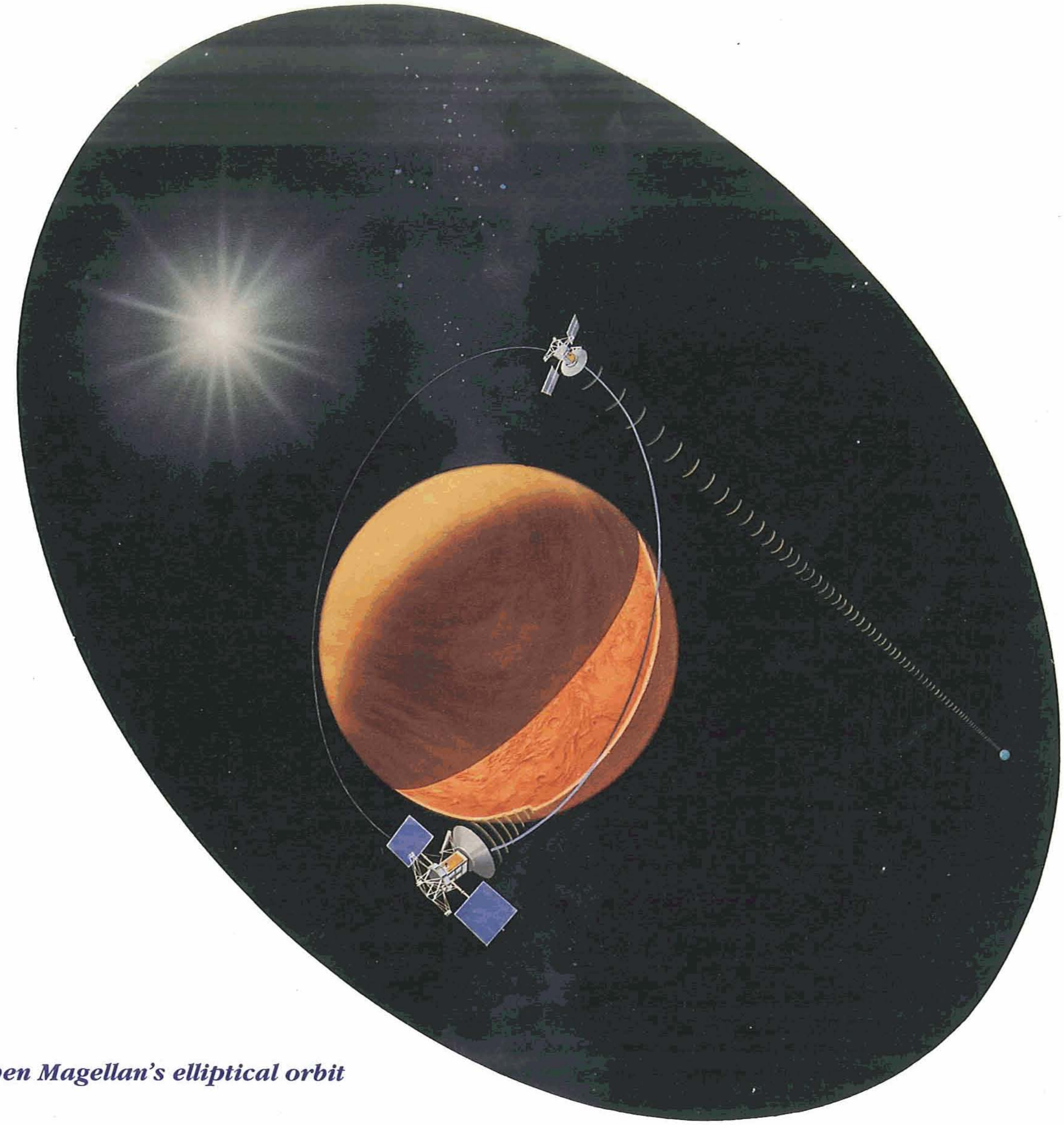
Although Venus is very much like Earth in size and mass, the veiled planet's rotation on its axis has several peculiar and unexplained differences. One is that Venus turns in the opposite direction from the way Earth does, spinning on its axis from east to west, so that the Sun rises in the west and sets in the east. Another is that the Venusian "day" is very long—it takes 243 of our Earth days for the planet to turn once on its axis. Since Magellan will be in a fixed, nearly polar orbit around a very slowly turning planet, it will take 243 days for most of the surface to pass under the spacecraft's gaze once. Thus the mapping will take 243 days. ■ The arrival date at Venus, August 10, 1990, will place Magellan in Venus orbit approximately three months before superior conjunction (the passage of the planet behind the Sun as seen from Earth). During superior conjunction, radio interference from the Sun's atmosphere will make it impossible to communicate with the spacecraft and to conduct the radar mapping. The resultant gap in mapping coverage can be filled in during subsequent 243-day mapping cycles. ■ Circling the planet every three hours and nine minutes, Magellan will pass closest to the surface just north of the equator, at 10 degrees Venus latitude, and will then move down around the south pole and around the planet in a wide loop. Because of this elliptical orbit, Magellan will be close enough to the surface to conduct mapping operations for only about 37 minutes out of each three-hour orbital period. The rest of the time will be spent transmitting the recorded raw data from the just-completed mapping pass, receiving telemetry instructions from Earth, and calibrating the spacecraft's attitude control system with reference stars. ■ During mapping operations,



The 3.15-hour elliptical orbit of Magellan will be divided into distinct phases. When the spacecraft is closest to Venus, the antenna will point at the planet and the radar will map the surface (A), alternating between north and south swaths on successive passes. After radar operations are completed, the spacecraft will turn to point its antenna toward Earth (B) so that data can be transmitted (C). After calibration of the spacecraft's attitude control subsystem (D) and another data playback, Magellan will turn its attention once again to the surface.



the high-gain antenna dish will point toward the surface of Venus. In addition to acquiring radar imaging data, the radar sensor will use a separate fan-beam horn antenna aimed at the surface directly beneath the spacecraft to conduct Magellan's altimetry experiment. Radar pulses from this antenna will bounce off the surface and return to the radar receiver. By measuring the time it takes for the signal to return, the altimeter will determine the distance to the point directly below the spacecraft, and so will construct a topographic profile of the planet in much the same way that sonar is used on board ships to profile the ocean floor. By mission's end, the Magellan altimeter experiment will have produced a topographic map showing height variations as small as 30 meters (98 feet) for the entire mapped part of the planet. ■ Several additional types of information will be collected by Magellan. When the dish antenna is pointing down at Venus, it will also be used to measure the amount of natural thermal emissions, from which temperature variations on the planet's surface can be determined. Analysis of the way in which the radar signals are reflected will yield data on the electrical conductivity and roughness of the Venusian surface. ■ *After each mapping pass, the spacecraft will recede from Venus and the tape recorders will be rewound in preparation for data transmission.* Because the same antenna used for mapping will also be used for radio communications, the spacecraft must reorient itself to point the antenna toward Earth. The transmissions will be received by the large antennas of NASA's Deep Space Network located at various sites around the world, then relayed to the Jet Propulsion Laboratory in Pasadena, California. While Magellan is in radio communication with Earth, precise measurements can be made of the slight changes in the spacecraft's orbital motions. These tiny motions, which are produced by variations in Venus' gravitational field, will provide important clues about the nature of the planet's interior. After its "call home" is completed, the spacecraft will maneuver into position to begin another mapping pass and will again point down toward the surface. ■ Since Venus will be rotating slowly

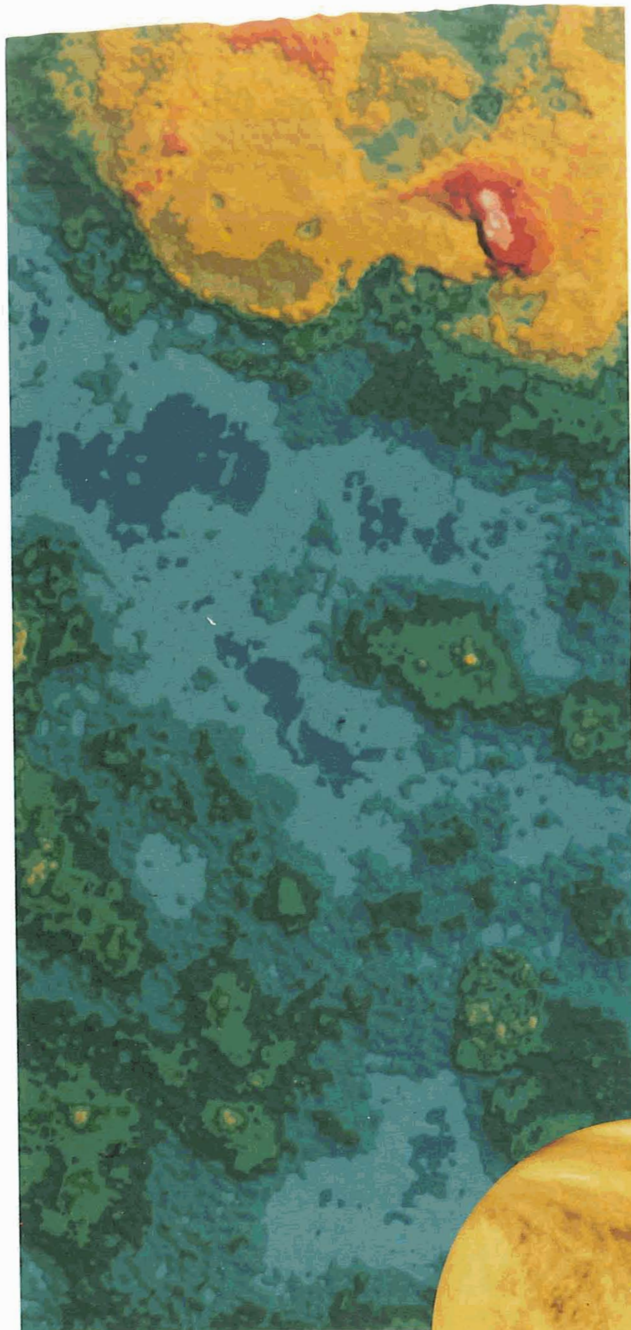


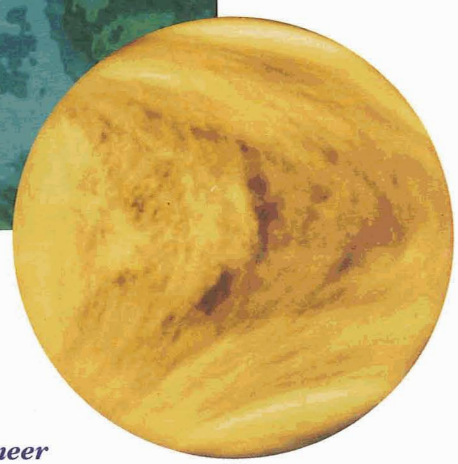
When Magellan's elliptical orbit brings the spacecraft close to the Venusian surface, the radar instrument will look through the clouds to map the solid planet. Magellan will spend most of the rest of its orbit transmitting data back to Earth.

beneath Magellan's orbit, the surface will be mapped in successive, slightly overlapping strips. Each strip, or swath, as it is called, will be about 25 kilometers (16 miles) wide and about 16,000 kilometers (9,942 miles) long. Close to the north pole, successive swaths will naturally converge, causing considerable overlapping. Since complete coverage of the north pole can be obtained by using every other swath, an alternating pattern of northern and southern mapping passes will be used. Thus, on one orbit, mapping will be performed from the north pole to a southern latitude for exactly 37.2 minutes. On the next orbit, mapping will start 4.7 minutes later than on the previous orbit and will stop 4.7 minutes farther south. ■ Magellan's inclined orbit and its limited time for transmitting data to Earth make it impossible to obtain full coverage of both poles during the course of one 243-day mapping cycle. Scientists and mission designers therefore faced a difficult choice: whether to fully map the northern or the southern hemisphere. Because the large "continent" of Ishtar, which extends into high northern latitudes, seems to have a number of significant geologic provinces, it was decided to provide full coverage of the northern hemisphere. Mapping of the low southern hemisphere, which does not have as high a scientific priority, will extend to about 70 degrees south latitude. ■ Thus, eight times each day, for 243 days, Magellan will take radar images of the Venusian surface. At the end of the primary mission, almost 90 percent of the planet will have been mapped. The image strips will be combined by computers on Earth into photomosaic images covering large regions of the Venusian surface.

THE PLANET VENUS

Earth and Venus have many similar characteristics, such as size, density, and the presence of atmospheres. However, they also show important differences. Although both planets are most likely made of the same type of silicate rock and probably have similar interiors, Venus does not appear to have a magnetic field as Earth does. Venus is closer to the



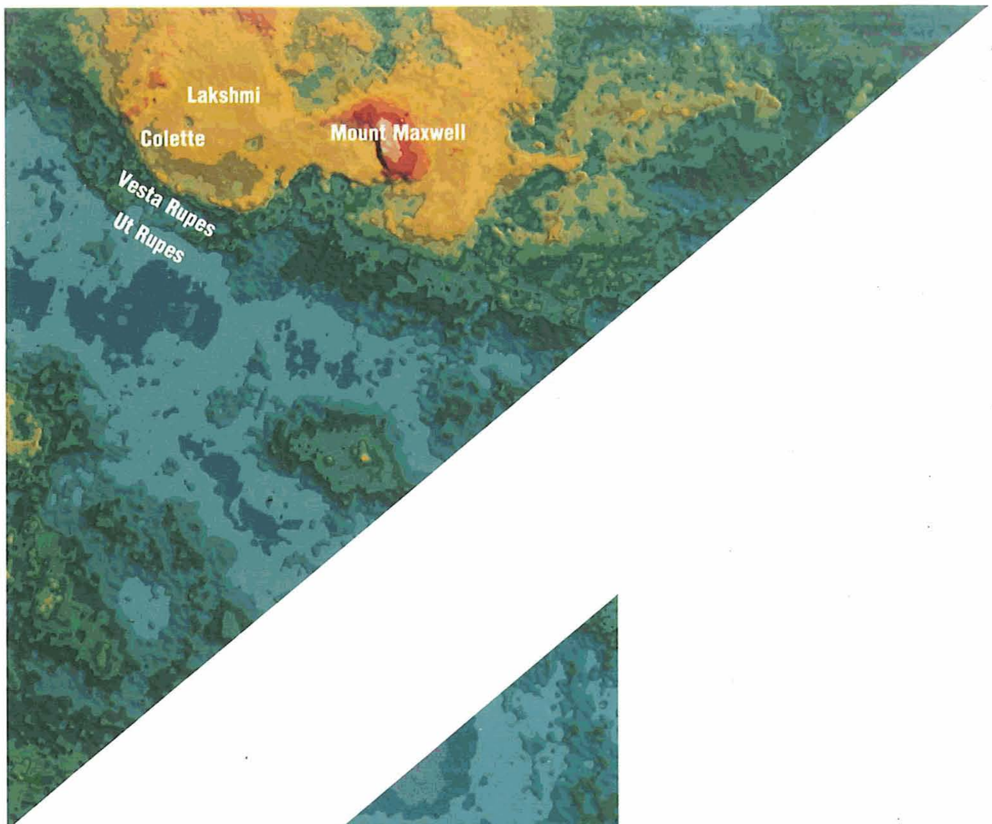


Sweltering under a perpetual cloud cover, Venus reveals no surface details even in ultraviolet light, but a radar instrument on the Pioneer Venus Orbiter revealed the large-scale geography of the planet for the first time. Blue areas represent the Venusian lowlands, while highlands are shown in green, yellow, and red.

Sun than Earth and receives almost twice as much solar radiation. Although both planets have atmospheres, the Venusian atmosphere is much denser than our own and is composed almost entirely of carbon dioxide, with a high-altitude covering of clouds laced with sulfuric acid droplets. This thick atmospheric blanket of carbon dioxide traps outgoing thermal radiation between the solid surface and the atmosphere. Far from being Earth's "twin" at the surface, Venus is a perpetual furnace, where surface temperatures reach 480 degrees Celsius (900 degrees Fahrenheit) and the atmospheric pressure is 90 times that of Earth. Any liquid water that might have once existed has long since disappeared: Venus today is bone-dry. ■ We know some things about Venusian geology from past space probes and from Earth-based radar studies. Soviet lander photos and chemical analysis experiments have shown that the rocks of the highland areas at the lander sites are basaltic, like the rocks on Earth's ocean floor or the rocks that are formed from oozing volcanic lava flows. ■ Venus' large-scale geography has been disclosed by radar studies from Earth, by the Pioneer Venus Orbiter in 1978, and by the Soviet Venera 15 and 16 missions in 1983. Most of the planet consists of either rolling upland plains (apparently composed of older crustal rock) or smooth lowland areas. There are two major "continents," or elevated plateaus—Aphrodite, named for the Greek equivalent of the goddess Venus, and Ishtar, named for the Babylonian equivalent—that appear to be younger geologically. Ishtar is about the size of Australia; Aphrodite is about twice as large, or approximately the same size as South America. Jutting up from the Ishtar highlands is one of the highest mountains in the solar system, 10,800-meter-high (35,400-foot-high) Mount Maxwell. Two other highland areas of possible volcanic and tectonic origin, Alpha Regio and Beta Regio, also stand out conspicuously.

A portion of the elevated "continent" of Ishtar Terra (about the size of Australia) is shown in this computer-processed Pioneer Venus image. At the center is Mount Maxwell (also called Maxwell Montes), which is 10,800 meters (35,400 feet) high, more than a mile taller than Mount Everest. There is some evidence that this huge mountain is an active volcano. The Lakshmi plateau, rising 4 to 5 kilometers (2.5 to 3.1 miles) above the mean level of Venus, is bordered by mountain ranges to the north and northwest. This plateau is thought to consist of thin lavas overlying an uplifted section of older crust. Soviet Venera radar data suggest that the depression called Colette is a collapsed volcanic crater. On Ishtar's southern flank are the Ut and Vesta Rupes (cliffs), which descend to vast lowlands.

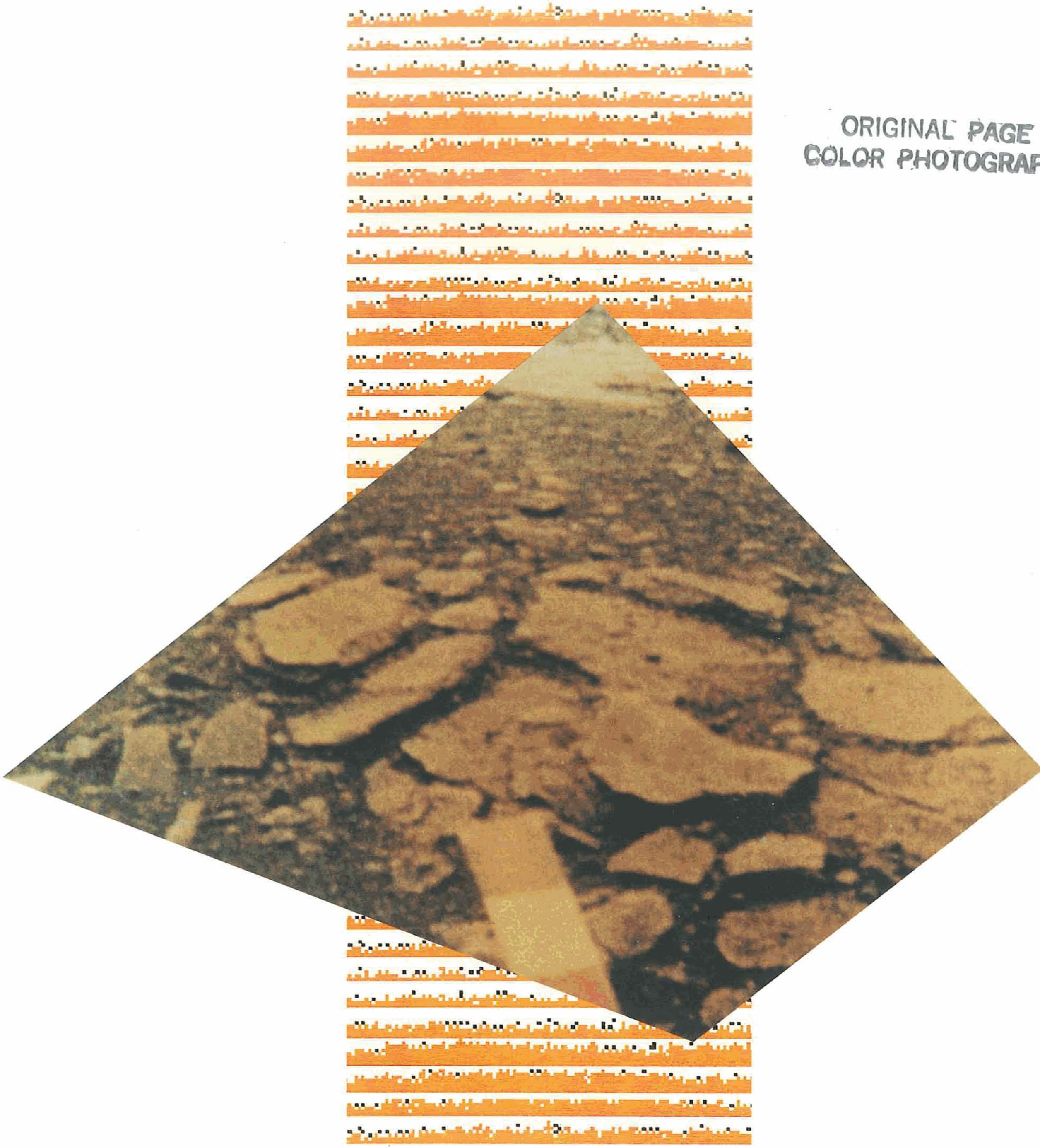
ISHTAR TERRA



APHRODITE TERRA

Aphrodite Terra, Venus' largest elevated landmass (about the size of South America), has two major mountain regions on opposite sides of the "continent." Aphrodite also has the lowest elevations on Venus—in the trenches of the Diana Chasma, which may be a rift valley caused by the movement of two blocks of crust away from each other.

Some 4.6 billion years ago, the planets of the solar system condensed as large, individual bodies in a whirlpool of solid material and gas revolving around the Sun. Heavier elements like iron and silicon remained in the inner solar system to form the rocky planets, Mercury, Venus, Earth, and Mars. The lighter gases—hydrogen and helium—went to form the giant planets beyond the asteroid belt. The largest rocky planet, Earth, was extremely hot in those millennia after it condensed into a solid sphere, and in its early history the planet released this heat through violent eruptions from great volcanoes that covered its surface. Earth still sheds its heat today, but now as a low simmer, with only isolated chains of volcanoes spewing hot material from its interior. ■ Earth's upper crust is divided into irregular, flat pieces—tectonic plates—that move around the planet's surface, driven by convection cells in the hot, fluid rock underneath the solid crust. Virtually all of Earth's large-scale geological features, including mountain chains and ocean basins, result from the movement of these plates. When continental plates collide, mountains such as the Himalayas and the Alps are thrust upward. Where the plates pull apart, rift valleys and ocean basins form. Earthquakes and volcanoes, the major geologic upheavals on our planet, occur primarily at plate boundaries where pieces of the crust are stretching apart or crunching together. One of the most important questions for the study of Venus is whether similar tectonic plate movements have shaped the surface of our planetary "twin." ■ Although we might reasonably expect Earth's "twin" to have similar processes shaping its surface, the limited data about Venus do not provide evidence of planetwide plate tectonics. On Earth, where plates are pushing away from each other in the middle of the Atlantic Ocean, there is a volcanic ridge thousands of miles in length where a great deal of the planet's internal heat is vented. No such conspicuous plate boundaries appear in the Pioneer Venus Orbiter map, suggesting that if a system of plate tectonics does exist on



This glimpse of the Venusian surface was taken by one of the Soviet Venera landers. The reddish appearance of the rocks is due to the reddish color of the thick atmosphere. The slabby rocks, which are probably volcanic in origin, would appear neutral gray in natural sunlight. The rectangular color bar at the bottom of the photo is a part of the lander.

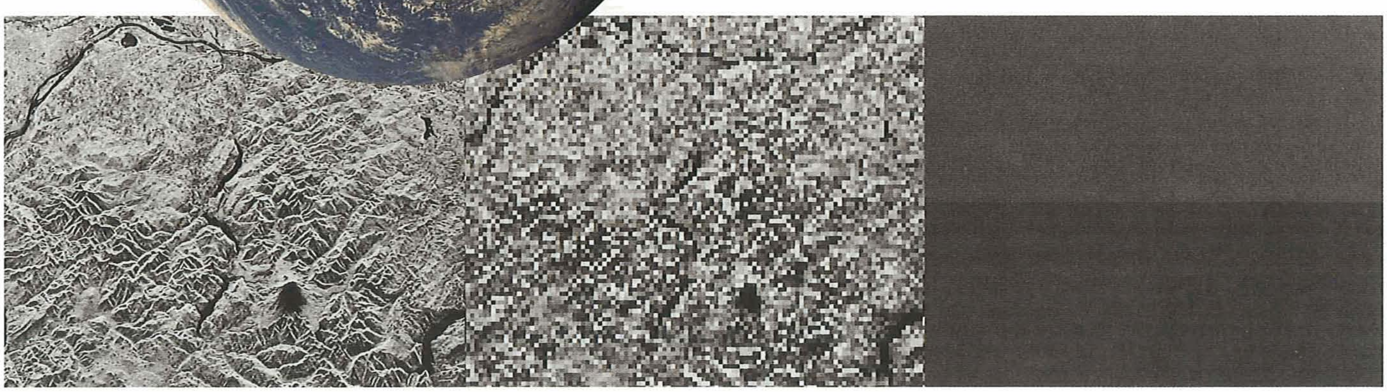
Venus, it must be of a different kind than Earth's. (However, evidence of plate tectonics, even on Earth, would only be marginally visible at the image resolution of the Pioneer Venus Orbiter. Also, the Venera 15 and 16 coverage [25 percent of the planet] may not be extensive enough to reveal a systematic, global pattern of plate tectonics.)

QUESTIONS FOR MAGELLAN'S EXPLORATION OF VENUS

Volcanoes

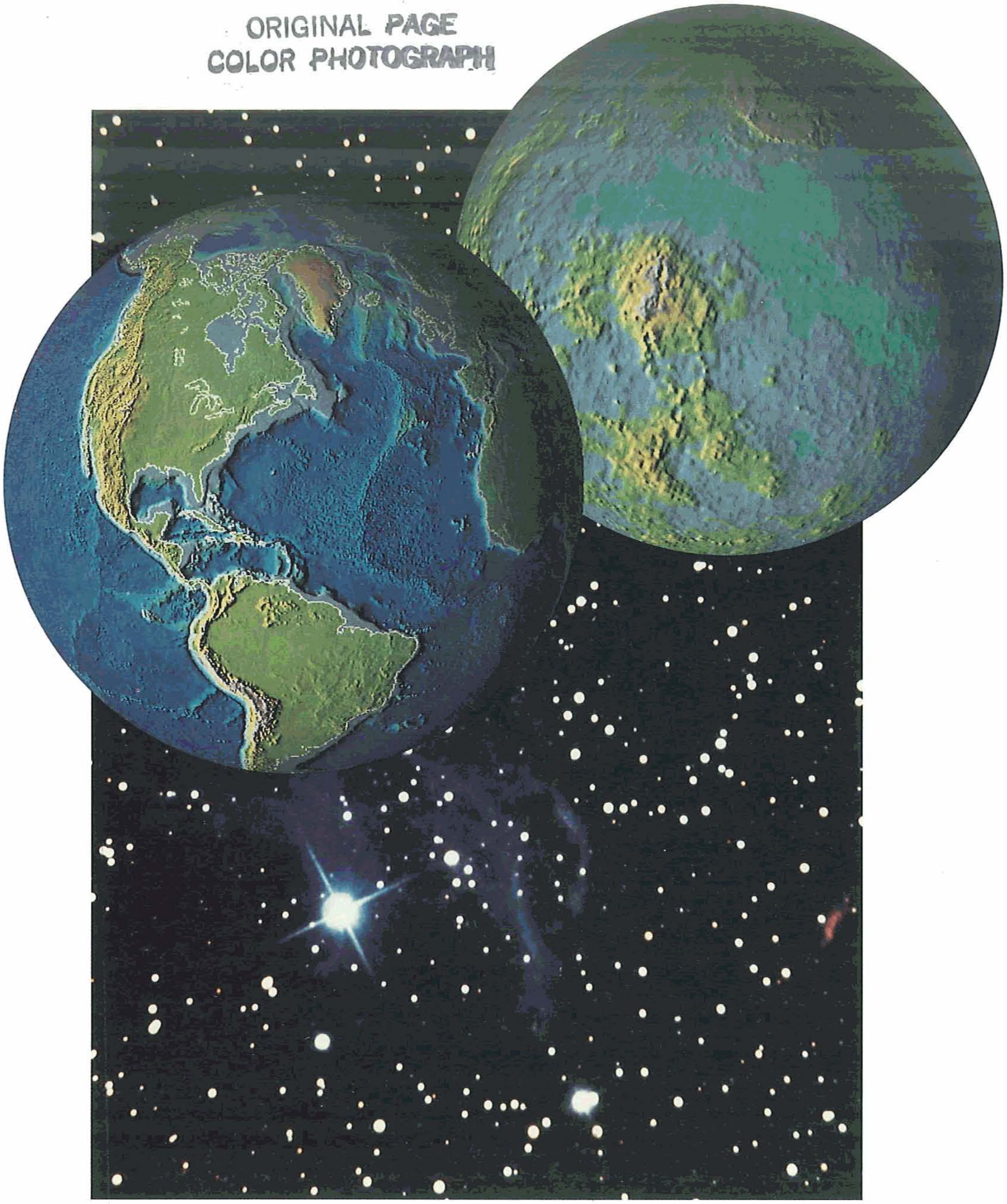
One of the most important tasks for Magellan during its mapping mission will be to take an inventory of volcanic craters and other volcanic features on Venus so that scientists can reconstruct the planet's geologic history. Ground-based and Venera radar images have shown the existence of volcanic craters on the Ishtar plateau. Variations in the concentration of sulfur dioxide in the atmosphere, detected by Pioneer Venus, suggest that Venus may be volcanically active. By counting how many volcanoes are on Venus' surface and identifying where and what kind they are, Magellan will provide data on the planet's internal processes. ■ The high-resolution radar images will allow us to discriminate between individual overlapping lava flows so as to determine the sequence of volcanic events that have helped shape the surface. By examining the slopes and shapes of these volcanic flows, scientists can make judgments about the composition of the lava and thus obtain further clues about the nature of the planet's interior and the thickness of the crust. ■ Earlier spacecraft data have shown that the gravitational field of Venus is stronger over the planet's elevated plateaus—evidence that these topographic features are related to the interior structure. Magellan's high-resolution gravity survey, constructed by precise measurements of the spacecraft's orbital motions, will provide details about this important correlation between gravity and topography.

The improvement in resolution expected from the Magellan data is illustrated in these images of the Mount Saint Helens region of Washington, which are simulations derived from the radar imaging data acquired by the Seasat oceanographic satellite. The still-active volcano does not show at the Pioneer Venus resolution. Although the feature is visible at the Venera resolution, it is not possible to tell whether it is a volcano or a meteorite impact crater.



MAGELLAN VENERA PIONEER

Meteorite impact craters also appear in abundance in radar images of Venus. Such craters are more plentiful than on Earth, but much less so than on Mercury, the Moon, and Mars. Another major task for Magellan will be to distinguish these impact scars from volcanic craters, to count how many are still preserved on the surface, and to note where they exist. It is important to establish Venus' impact cratering record, since the more cratered a surface is, the older it must be. Earth's surface is relatively young-looking and uncratered. Although meteorites have struck our planet in the past, most impact craters have been erased by wind and water erosion and by the constant motion of tectonic plates through time. The surface of Earth is a slate that has been drawn on, wiped clean, redrawn, and rewiped over millions of centuries. Venus, on the other hand, appears to retain evidence of a comparatively distant past. Magellan's global inventory of impact craters will have much to tell scientists about the history of the planet and the ages of different geologic provinces. The rate of surface cratering may also provide information on how dense the planet's atmosphere has been through time. ■ At the best resolutions obtained to date, it is unclear whether many of the circular features seen on Venus are the scars of old impacts, collapsed remnants of volcanic craters, or domes of rock somehow warped upward by tectonic forces. Magellan's high-resolution radar images will clear up the mystery. If these images show large stretches of old, cratered terrain, it would argue against tectonic motion in those regions, because crustal movements would destroy old craters. It would also indicate that the processes of erosion proceed much more slowly on Venus than on Earth.



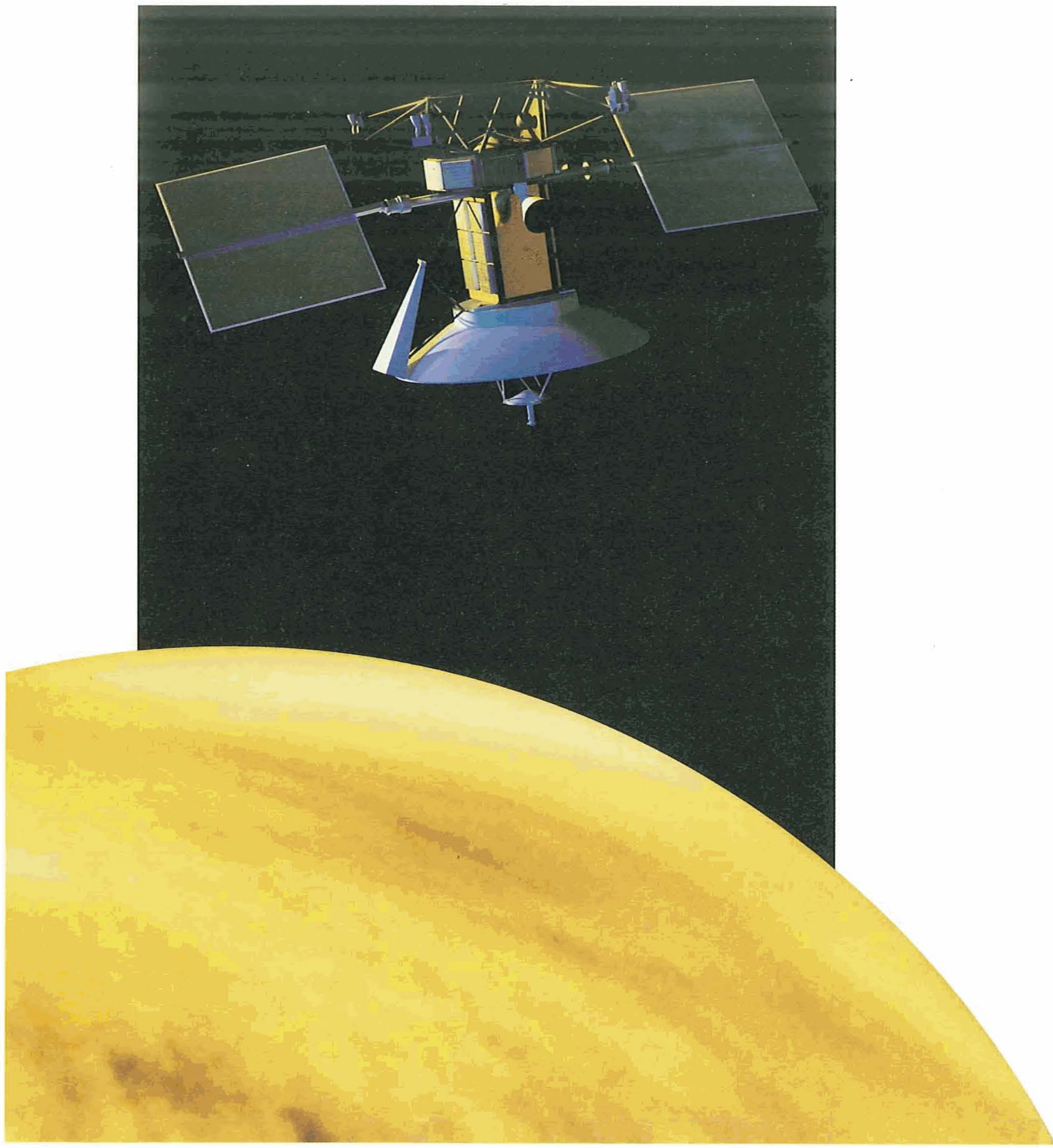
This computer-generated photo shows that only very general conclusions about the geology of a planet—Venus or Earth—can be drawn from radar images with the resolution obtained by Pioneer Venus. The images from the higher-resolution Magellan radar will give scientists a better understanding of processes that have shaped the Venusian surface and interior.

Faults, Ridges, and Mountains

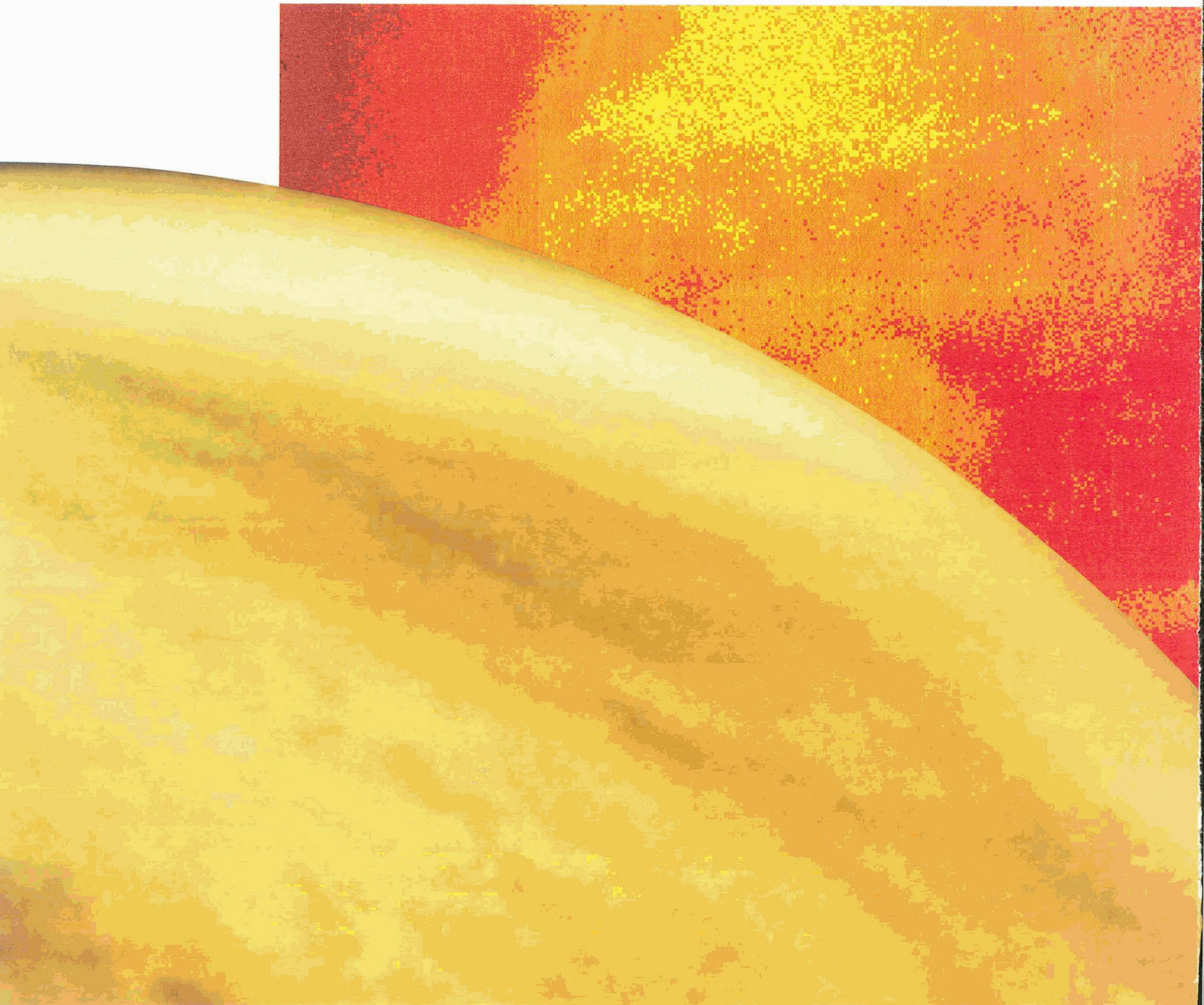
Some kind of crustal movement evidently is at work on Venus, because mountain-like folded ridges and rift-like valleys appear in Soviet radar images of Ishtar Terra. These features are most probably caused by the compression or extension of the crust. Magellan will reveal the details of these features, allowing scientists to characterize how Venusian tectonics work. It has been proposed that the high surface temperatures on Venus play a part in the distortion of the crust, and Magellan will provide new data to test that theory. Large rift valleys such as Devana Chasma in Beta Regio will be studied to see whether they were formed by volcanic processes or by tectonic motions.

Water and Wind

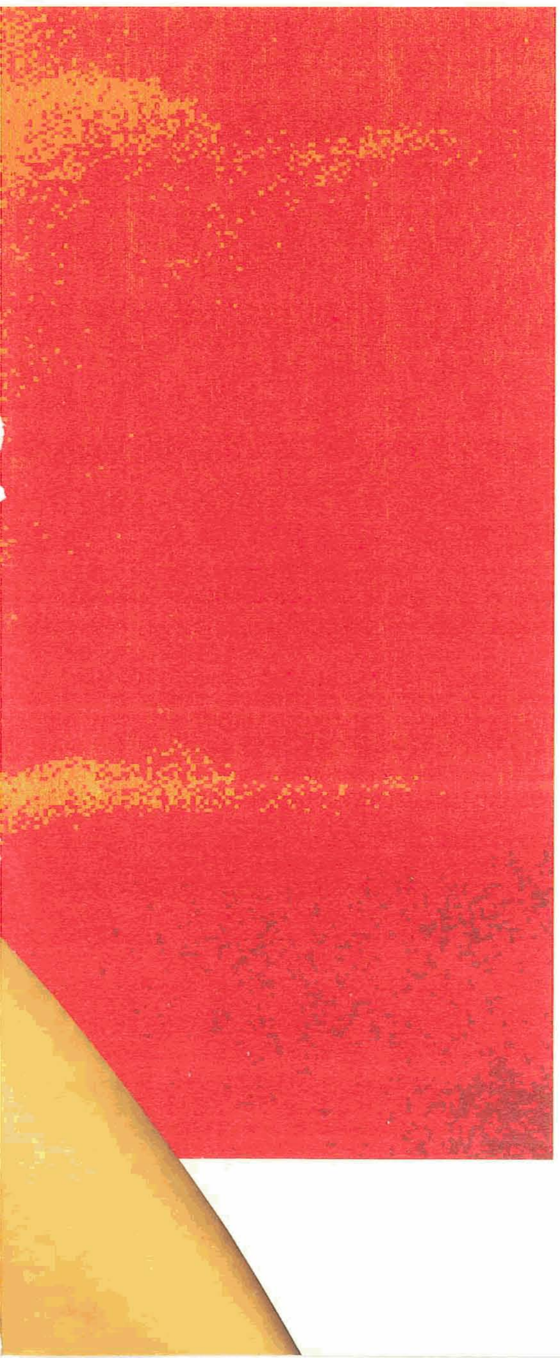
Another critical question about Venus is whether it once had water on its surface. Modern-day ratios of deuterium to hydrogen in Venus' atmosphere (measured by descending atmospheric probes) suggest that at some point in the past there was more water in the planet's atmosphere. Magellan will look for evidence of ancient marine terraces, river channels and deltas, or other geologic features that might point to the existence of ancient oceans. Such discoveries would have profound implications for the evolution of the planet's atmosphere as well as of its surface. ■ Although surface wind speeds on Venus are believed to be lower than on Earth, there may be large windblown dunes on the surface that would be evident in high-resolution Magellan images. The sizes and shapes of such dunes would allow scientists to reconstruct the wind behavior on Venus.



During its primary 243-day mission, Magellan will acquire more digital imaging data than all previous U.S. planetary missions combined. These data will be a legacy for future investigators of the veiled planet, just as the findings from the expedition of Ferdinand Magellan, the Project's namesake, were for the then-future explorers of Earth.



The Soviet Venera 15 and 16 spacecraft mapped less than one-third of the Venusian surface at high resolution. Over the course of one Venusian day (243 Earth days), the Magellan spacecraft will map most of the surface with detail that exceeds that of these best previous radar images. The resultant maps will reveal the traces (if they exist) of many fundamental planetary forces: volcanism, wind, water, and meteorite impacts—in short, all the processes that determine a planet's history and shape its face. By giving us this new information, the Magellan mission will help to tell us why Venus, our planetary "twin," is at the same time so much a stranger.



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