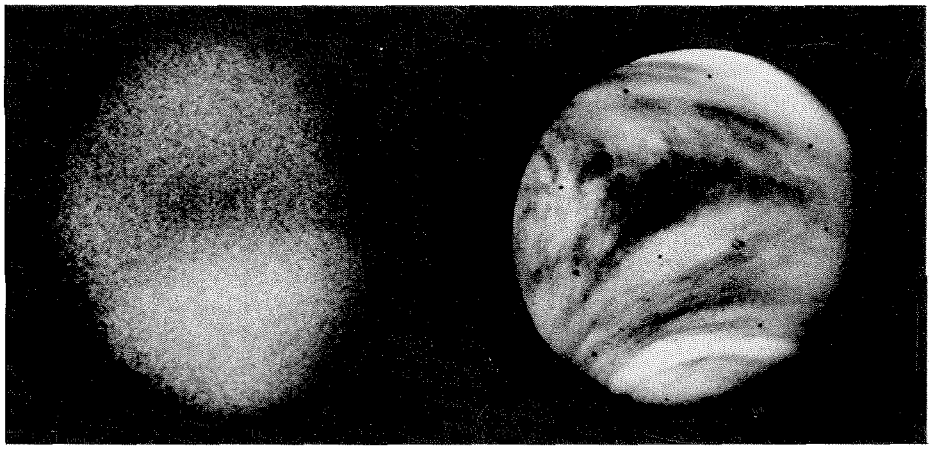
Payoff from Venus

For Bruce Murray, professor of planetary science, and for his co-workers in the Space Photography Laboratory and at Caltech's Jet Propulsion Laboratory, the more than 3,000 close-up photographs of Venus taken by Mariner 10 in February represent the payoff on a long-shot gamble. The emphasis early in the U.S. space program was on radio probing of Venus rather than photographic reconnaissance, so it was a gamble he almost didn't have a chance to take.

The reluctance of the National Aeronautics and Space Administration to commit a spacecraft to a photographic mission to Venus is understandable, for Venus is obscured by an atmosphere almost 100 times as dense as Earth's. In the early 1960's even the best Earth-based pictures of the planet revealed practically no detail in visible light; however, faint markings were discernible when Venus was photographed in ultraviolet light. There was considerable controversy over the nature of these markings—whether they were signs of large-scale atmospheric activity, atmospheric waves, or just chance groupings of stratospheric clouds with no significance at all.

Murray became convinced about that same time that the markings were significant, and he tried twice to get photographic experiments aboard Venus probes before finally succeeding with the 1973 Mercury-Venus flyby. The first time was in 1964 on Mariner 5, which was originally designed as a photo-



The ultraviolet markings in the atmosphere of Venus present a dramatically different appearance as seen from an Earth-based telescope (left) and from Mariner 10.

As Mariner 10 flew by Venus at a distance of 453,000 miles, it snapped this picture of the entire planet, computer-enhanced here to bring out the details.

graphic spacecraft. But NASA decided to remove the television cameras and related equipment to make room for another experiment.

Murray's second attempt came in late 1967, when NASA was considering redesigning a Mariner-Mars spacecraft for a flight to Mercury via Venus in 1970. But this mission had to compete for funding with the 1971 Mars orbiter and was eventually passed over.

Finally, the current Mercury-Venus flyby was approved, and Murray, as head of the television experiment team, talked NASA into altering the cameras to photograph in the invisible ultraviolet region of the spectrum on the chance that the faint Venusian cloud markings were a significant and relatively stable phenomenon. Furthermore, he persuaded them to make changes in the spacecraft radio system so that thousands, not hundreds, of pictures could be returned, resulting in recording the time variation of the atmosphere.

Murray's expectations as to the scientific importance of the markings seem to be verified. The markings are stable and recurring and may be caused by clouds moving high in Venus's atmosphere, where the pressure is 10 to 20 percent that of Earth. The patterns are unlike those of Earth. It is exactly these differences (plus a few similarities) that excite Murray and his fellow Venus-watchers. What will interest them even more will be finding out why the features show up only in ultraviolet light; nothing but a haze appears under normal light.

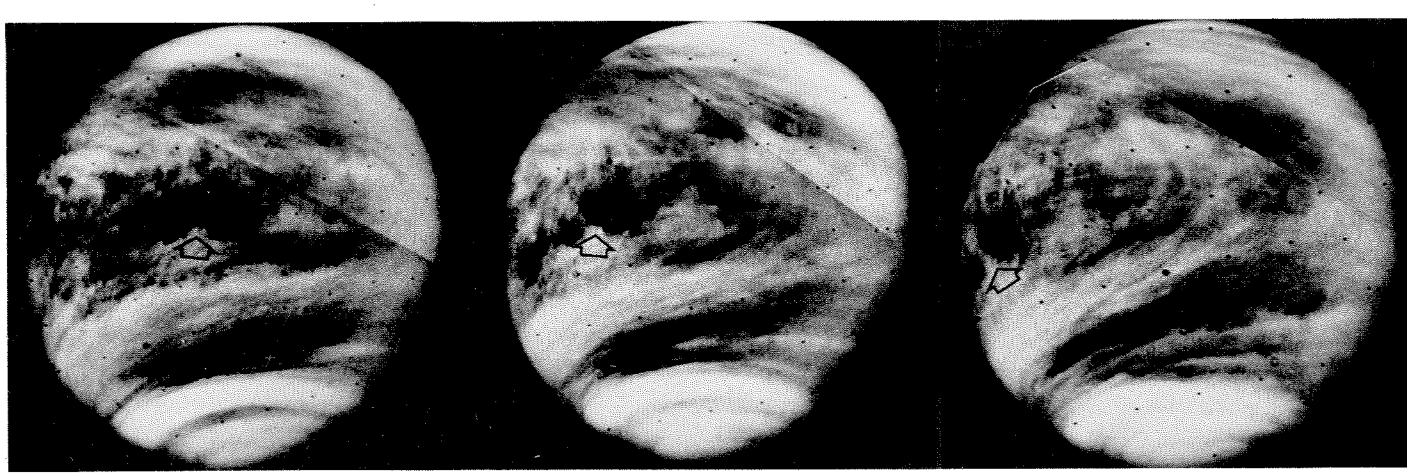
One member of the television team, Verner E. Suomi, a meteorologist from the University of Wisconsin and a visiting professor of atmospheric sciences at Caltech, has speculated that the clouds are formed from streams of hot air that spiral out from the equator, move in flat layers toward the planet's north and south poles, and then sink to the surface. Suomi feels that, oddly enough, these cloud patterns resemble those of a theory of atmospheric circulation first suggested in 1735 by the British meteorologist George Hadley to explain phenomena observed on Earth. However, Earth rotates too fast to produce the simple cloud patterns he predicted, but Venus, which rotates just about once every 243 days, demonstrates Hadley's ideas to perfection.

"Hadley's theory was correct," says Suomi. "He just had the wrong planet."

The detail seen in the ultraviolet photographs probably occurs only in the upper 3 to 4 miles of Venus's 40-mile-thick atmosphere, and there is no direct way of telling from photographs what is going on underneath. However, it seems unlikely that there are any Earth-like storms in the Venusian atmosphere.

Instead of towering clouds that hover over the surface, Venus seems to be blanketed with smooth cloud layers covered with haze. Features seen from Earth as bands, or streaks, are revealed by Mariner 10's ultraviolet television cameras to have the wispy, elongated quality of terrestrial cirrus clouds. They probably circulate above the planet at about 200 miles an hour and in the same direction as the planet but much faster.

The results of an infrared radiometer experiment designed and built by Guido Münch, professor of astronomy, confirm that the massive Venusian atmosphere stores so much heat that in spite of its long night (124 days) its dark side is essentially as hot as the side facing the Sun. The experiment also reveals that the difference in cloud-top temperature



This series of mosaics shows the rotation of the ultraviolet markings that appear in the Venusian atmosphere (arrows). These markings circle the planet every four days, even though the planet itself rotates only once every 243 days.

between the equator and the poles is small compared to that on Earth.

Other experiments aboard Mariner 10 indicate that planetary Venus is more nearly round than the Earth, the Moon, or Mars; has an electrically charged upper atmosphere but practically no magnetic field; and is possessed of a comet-like tail of protons and electrons that extends away from the Sun.

Mariner 10 has also radioed back measurements that confirm the presence of hydrogen in the Venusian atmosphere. Some of that element is locked into sulfuric acid and water molecules in the clouds, but its presence as a gas in greater-than-predicted amounts may challenge one theory that the hydrogen was released by comets colliding with the surface of the planet. Another theory suggests that the hydrogen was swept into the atmosphere by the solar wind—particles "blowing" out from the sun. It also seems clear that this hydrogen prevents solar radiation from breaking down the carbon dioxide atmosphere of Venus into a more Earth-like one.

Important as it is, the information transmitted from Mariner 10 in its brief encounter with Venus is only a minor by-product of the mission's prime target—Mercury. The innermost planet of the solar system, Mercury is not much larger than the Moon, yet it is denser than Earth. Because of its position in relation to the Sun, it cannot be observed in detail by Earth-based telescopes; in fact, the 750-km-resolution (about 500 miles) observed from Earth is worse than that of the Moon seen by the naked eye. Mariner 10 is scheduled to execute a week-long picture-taking mission in which the spacecraft and its cameras will zoom in closer and closer to Mercury, until the final pictures are at a resolution of 0.1 km (about 350 feet). That is just as good as the best Mariner 9 photos of Mars.

Research Notes

Earthquake Side Effects

The days are slightly longer during periods of intense earthquake activity around the world. Also, during these periods, the earth's poles wander faster.

Don Anderson, professor of geophysics and director of Caltech's Seismological Laboratory, made this surprising correlation after studying three periods in history when giant earthquakes were prevalent—1835 to 1847, 1896 to 1911, and 1933 to 1942. (A giant earthquake is one of magnitude 8.5 or greater—or one that causes a large tsunami or seismic sea wave.) In addition to the giant earthquakes, the general level of seismic activity was also greater during those periods.


Don Anderson

During these seismically active periods the earth's rotation rate was abnormally slow, meaning that the days were slightly longer. During the 1896-1911 period the length of the day increased by about eight milliseconds. The rate is known back for many centuries from astronomical studies of the motions of the stars, sun, moon, and planets.

It is not yet clear whether the earthquakes slow the earth's rotation rate, or whether the slowdown activates great earthquakes. But earthquakes are only part of the story. The much larger movements involving the shifting of mass near the earth's surface are probably responsible for both the earthquakes and changes in the rotation rate. This motion is provided by the activities of the huge tectonic plates that make up the lithosphere, the outer 45 miles of the earth.

Most geologists believe that the earth's entire surface down to a depth of 45 miles is made up of a mosaic of massive plates that move in relation to each other, riding and sliding on a layer of plastic rock about 80 miles thick. The largest of these is the Pacific Plate, which extends from Japan to the west coast of the United States and from Alaska southward many thousands of miles.

The Pacific Plate is moving faster than the others and seems to dominate the earth-rotation effect among the plates. It is diving under the Aleutian Islands and Japan and is scraping past California along the San Andreas Fault. A piece of the Pacific crust is diving