Feeling the Face of Venus

By JONATHAN EBERHART

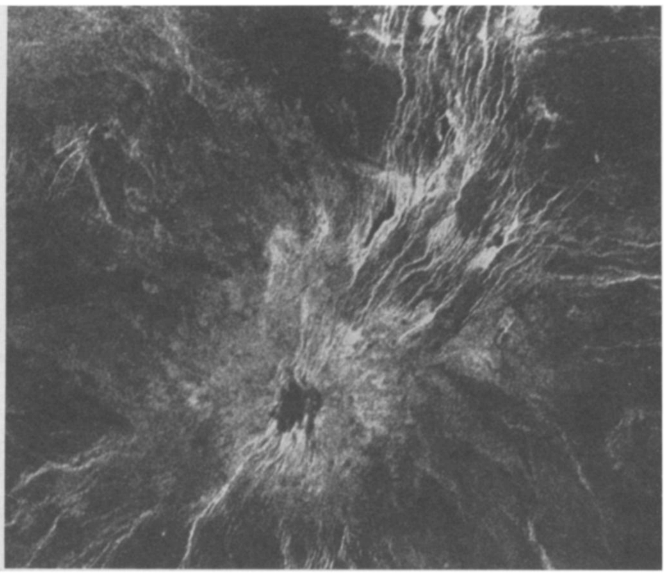
Venus resembles Earth in some fundamental ways — its size, mass, gravity — and its surface is slashed by what seem to be rift zones similar to Earth's, where the crust was apparently wrenched apart by the planet's internal thrashings. Vast highlands rise above the surrounding terrain like continents, and Venus' thick atmosphere comes complete with clouds. But how close is the resemblance? Did Venus once have oceans? Might the rifts mean it has undergone something akin to plate tectonics? And in perhaps the most intriguing possibility of all, is Venus still volcanically active, not just in the geologically recent past of a million or more years ago, but erupting and evolving even today?

The first U.S. spacecraft to another planet in 11 years will radar-map its clouded surface

The first successful mission from Earth to another world carried the U.S. Mariner 2 to Venus in 1962. The most recent U.S. interplanetary mission, called Pioneer Venus, took off in 1978, bound for the same destination. No interplanetary spacecraft from the United States has ventured forth since then, though several, launched previously, have continued on to Jupiter, Saturn and Uranus. But now, after an 11-year hiatus, Venus is once more the goal.

The craft, called Magellan, will blast on its way as early as April 28, after riding into Earth orbit aboard the space shuttle. It should reach Venus 15 months later. Magellan carries only a single scientific instrument — a synthetic-aperture radar system expected to send back more data than have all of the instruments aboard all of Magellan's U.S. planetary predecessors — Voyagers, Vikings, Mariners, Pioneers — put together.

Its objective at Venus is straightforward: Take the best look yet at Earth's sister planet by peering through the blanket of clouds obscuring Venus' surface. Mariner 2, a mere "fast flyby," revealed that the temperature deep in the planet's atmosphere exceeded 800°F, hot enough to melt lead. Neither it nor Mariner 5 in 1967 carried a camera. The only actual "pictures" of the surface came from four short-lived Soviet landing craft, called Veneras. Each of them survived around an hour, though even some otherwise cynical U.S. scientists considered this quite a technological accomplishment, given the heat, the sulfuric-acid clouds on the way down and an atmospheric surface pressure like that more than half a mile deep in a terrestrial ocean.



D.B. Campbell/National Astronomy Ionosphere Center

One of the sharpest views yet of Venus, made from the Arecibo radio telescope, shows a large volcanic construct called Theia Mons, across a possible rift system known as Devana Chasma. Linear features extending north, south and west may be faults associated with the rift.

For a global view, planetary scientists have relied on radar, whether from spacecraft orbiting Venus or from an antenna on Earth. Radar beams simply ignore the clouds, bouncing off the rocky surface to create their own maps of Venus' terrain. The Pioneer Venus Orbiter, still at work after more than a decade, carries a radar (as well as an ultraviolet camera that never sees below the cloudtops) that has mapped elevations over about 92 percent of the planet. The smallest spot it can distinguish is about 30 miles across — a single picture element or "pixel" — which means a surface might have to be many times that size to be recognizable by its shape. Nonetheless, the Pioneer Venus Orbiter's data have provided the first "visible" large-scale details of Earth's closest planet, revealing mountains, plateaus and rolling plains.

Some round features captured by the orbiter's radar frustrate scientists, who cannot tell whether they indicate volcanic calderas or craters caused by meteorite impacts. Smaller hills and valleys go unnoticed by the radar, as do lava flows, minor fracture zones and lesser craters possibly produced by rocks tossed out onto the terrain by volcanic eruptions or deposited by meteorite impacts. Masked like the details of a blurred photograph, such missing details are limitations to the record – to the evidence – of much of a planet's evolution.

About 10 times as sharp are the radar measurements from the Soviet Venera 15 and 16 orbiters, which reached the planet in 1983. Besides measuring the heights of surface elevations by using the radar as an altimeter, the Veneras provided images of variations in surface radar-reflectivity. According to Saterios S. Dallas and Neil L. Nickle of the Magellan project team at NASA's Jet Propulsion Laboratory in Pasadena, Calif., the Soviet images enable scientists to recognize large impact craters and perhaps some channels. In order to identify certain other features, however – such as lava cones atop their surrounding flows, or perhaps characteristics that would help define major volcanic provinces – Dallas and Nickle suggest researchers might need radar images of a major portion of the planet's surface. The two Veneras, in comparison, mapped only about one-fourth of Venus, virtually all of it around the north pole.

Some three times sharper still – more than 30 times better than the Pioneer Venus Orbiter's maps, though covering far less of the planet – are images produced a few months ago with the Arecibo radio telescope in Puerto Rico by Donald B. Campbell of Cornell University and his colleagues. These images reveal complex patterns of intersecting ridges and valleys, for example, that might be invisible at a lower resolution.

Magellan, however, should provide images about 10 times as sharp as the latest from Arecibo, 40 times the resolution of the Venera images and more than 400 times that of the altimetry maps from the Pioneer Venus Orbiter – and do this for 70 to 90 percent of the planet. In fact, Magellan's single instrument will provide altimetry data as well, along with microwave measurements of thermal emissions from the surface. Scientists can relate these emissions to the "thermal inertia" of the terrain to help understand whether the surface material is solid bedrock or overlying finer grains, perhaps indicating processes of erosion in the past.

In addition, the heat measurements could reveal "hotspots" or other patterns that might support the exciting possibility that Venus is still internally active. The only confirmed example of volcanism presently at work anywhere in the solar system besides Earth itself is on Jupiter's moon Io. Although that finding by the Voyager 1 spacecraft marks one of the major discoveries of planetary science from space, Io's volcanism does not seem to exist for the same reason as Earth's. Instead, it apparently results from tidal stresses due to a gravitational tug-of-war on Io between Jupiter and Europa, another Jovian satellite.

Venus has no satellites to produce such tidal forcing. So if it turns out volcanically active, it is likely to represent a second example of Earth-style volcanism, driven by the heat of the planet's own gravitational self-compression or radionuclide abundance, which geophysicists would then expect to prove a significant factor in molding the topography and complexion of Venus.

One possible indication that such activity is happening even now, says Larry W. Esposito of the University of Colorado in Boulder, is that the amount of sulfur dioxide in Venus' atmosphere may have increased just before the Pioneer Venus Orbiter got there in 1978 and has been slowly decreasing ever since (SN: 10/1/83, p.213). This implies an erupting volcano may have released the sulfur dioxide, Esposito says.

If such eruptions do take place, Magellan's sharp radar images may provide a clue. It is a long shot, scientists admit, but it could happen if Magellan lasts long enough to circle Venus a second time. Such an extended mission would begin 243 days after the primary one, the time required for the craft's radar swath to cover the planet completely. Graphic evidence of a change in topography since the previous look – due, for instance, to a fresh, new lava flow – might well provide the high point of Magellan's career.

Apart from such a dramatic find, scientists expect the high-resolution radar images to help them determine the sequence of past volcanic events by studying which volcanic flows overlie which others. In addition, the slopes and contours of such flows could indicate the "runniness" of a specific outpouring, giving geologists clues to its composition.

Magellan's planners expect it to make one scientific contribution that does not involve radar. Using the radio signals it sends to Earth, scientists intend to track the craft precisely. Past spacecraft studies suggest a stronger gravitational field over the planet's elevated plateaus than over its lowlands. Changes in Magellan's orbital motion should indicate whether the major topographic features are related to the interior structure.

Magellan is not scheduled to enter its Venus-circling orbit until August 10, 1990, after which the present plan calls for 17 days of checking out the craft itself and the all-important radar system. But even now, scientists and other officials with the project at Jet Propulsion Laboratory, which will serve as Magellan's mission control, express excitement about NASA's long-awaited return to planetary exploration. "All right!" says Stephen D. Wall of Jet Propulsion Lab, who also worked on the Viking missions to Mars. "It's gonna happen!" □

M. Kobrick/JPL

It's all in how you look at it: Radar images of Mt. St. Helen's, prepared from one taken in 1978 by the Seasat satellite, show the scene first with the sharpness of Magellan's Venus resolution, where the minimum picture elements or "pixels" are only 120 meters across and reveal sharp hillcrests, a river with branching channels and more. The center example's 5,020-meter pixels indicate the limitations of the Venera 15/16 view, showing only general contours plus what may be fluvial, or fluid-formed, features. In the Pioneer Venus Orbiter version at right, details are unreadable from its two pixels, each 50,000 meters wide.