# What's Changing the Face of Venus?

## Magellan's early images say it's nothing like plate tectonics

By JONATHAN EBERHART and RICHARD MONASTERSKY

Planetary scientists often refer to cloud-covered Venus as Earth's mysterious twin, citing the two planets' similarity in size, density and distance from the sun. But the Magellan spacecraft's radar has now given scientists their sharpest look beneath Venus' thick atmospheric veil, and the emerging portrait suggests that while the twins resemble each other, they are certainly not identical.

Even more important is what these superficial differences reveal about the geologic processes molding the surface of each planet. Before the Magellan project, some researchers wondered if plate tectonics, the primary remodeling force on Earth, had also shaped the surface of Venus. But the images beamed back by Magellan so far show a wholly different — and previously unknown — type of tectonics at work.

"We see no evidence for Earth-like plate tectonics," says Magellan project scientist R. Stephen Saunders of the Jet Propulsion Laboratory in Pasadena, Calif.

The term "tectonics" describes the deformation of a planet's surface — in other words, the processes that create mountains, basins and other large geologic features. Here on our home planet, plate tectonics writes the rules. Earth's hard outer shell, the lithosphere, is broken into more than a dozen large and small pieces that slowly shuffle across the surface of the globe. Heat rising from the interior of the planet provides the power that moves these ever-restless plates.

When two plates separate from each other, they open up a rift through which molten rock from Earth's interior can rise to the surface. As the liquid rock cools, it attaches to the trailing edges of the receding plates. Called seafloor spreading, this continually active process creates all of the oceanic lithosphere — more than 60 percent of the planet's surface.

As if on a conveyor belt under the ocean, new lithosphere inches away from a midocean rift and across the planet's surface until, millions of years later, it reaches a place where two plates run into each other. Here, one plate dives beneath the other, sending the ocean lithosphere back into the planetary interior and building mountain ranges on the overriding plate.

Planetary geologists have long debated whether Venus has a similar surface-sculpting system. Indeed, images collected from previous missions led some researchers to suggest that one area in particular might contain Venusian versions of the kind of plate tectonic structures seen on Earth.

The area in question is a vast belt of equatorial highlands called Aphrodite Terra. Running 16,000 kilometers in length and about 2,000 kilometers in width, Aphrodite Terra wraps nearly one-third of the way around Venus' waistline. In the late 1980s, James W. Head and Larry S. Crumpler of Brown University in Providence, R.I., noted that the highland belt appears to share many similarities with the seafloor spreading ridges that cross Earth's ocean basins.

The researchers suggested that parts of Aphrodite Terra might represent a place where the Venusian outer shell cracks open, allowing molten rock to rise to the surface along linear rift zones. According to their theory, the hardened lithosphere would then move, conveyer-belt-style, away from the rift area and toward the lowland plains.

Still, Aphrodite Terra would not look exactly like a spreading center on Earth, Head and Crumpler reasoned, because Venus' high surface temperatures — averaging around 480°C, or almost 900°F — would render the veiled planet's lithosphere much more malleable than the plates here at home. For that reason, the researchers suspected Venus would not exhibit true plate tectonics. Nonetheless, they did anticipate eventually finding evidence for spreading and other elements of plate tectonics on Earth's sibling.

At the time, though, no one could test the spreading hypothesis because available images painted Aphrodite Terra with too broad a brush, lacking sufficient detail to answer the question.

Magellan has now provided the necessary high-resolution images of the highland belt. And the landscape exposed in those portraits doesn't show the characteristic features

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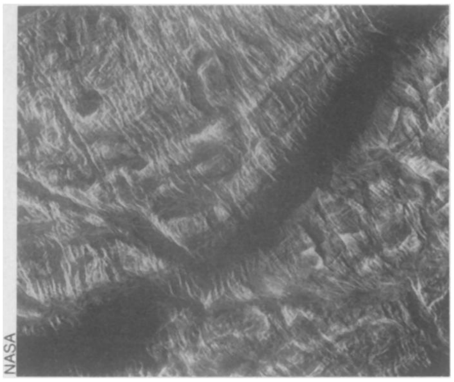
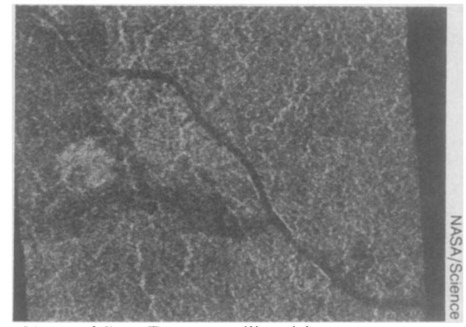
*No signs of plate tectonics here: This Magellan image shows the northern part of Ovda Regio, one of the highlands making up Aphrodite Terra. Some scientists had proposed that the area spread apart in a process reminiscent of plate tectonics. But the ridges running across the image tell a different story, suggesting that internal forces compressed the region horizontally, buckling the crust.*




*A tectonic epic: This part of Ovda Regio (directly south of the region depicted on the facing page) shows a long history of tectonic sculpting. Ridges and valleys — representing the earliest period — run northeast-southwest, indicating the region was squeezed perpendicular to that direction. Later, the crust was apparently stretched to produce northwest-trending fractures that cut through the older ridges. The largest valley, measuring 20 kilometers in width, contains dark material, probably lava.*




*River of fire: Features like this one suggest that hot lava eroded the Venusian surface, producing channels with remarkably constant width. The channels measure 0.5 to 1.5 kilometers across.*

of a spreading center, according to reports presented during the March Lunar and Planetary Sciences meeting in Houston.

"We see no evidence for spreading at Aphrodite Terra," says Saunders, one of the scientists who presented the new data.

Most important, images of these equatorial highlands fail to show a particular type of fault prevalent along spreading centers on Earth. Called transform faults, they connect adjacent segments of the spreading center and give Earth's mid-ocean ridges a characteristic staircase-like appearance.

As further evidence against spreading at Aphrodite Terra, the region lacks signs of the vast horizontal movement that would indicate new lithosphere journeying hundreds of kilometers from its birthplace, according to Sean C. Solomon of the Massachusetts Institute of Technology in Cambridge.

The new view of Venus would seem to dash the expectations of geoscientists who thought Aphrodite Terra might represent an analog of Earth's seafloor spreading centers. "From what we see now in those areas, I don't think anyone would propose seafloor spreading as an analogy," Saunders asserts.

That prediction may prove premature, though. With the data still warm, all parties have not reached exactly the same conclusions. Head believes scientists haven't had enough time to test whether Aphrodite Terra represents a crustal spreading site. He cautions that such features will look far different on Venus than they do on Earth, perhaps making it difficult to recognize them. "I don't think we can establish or rule out any of the major hypotheses [to explain that area]," Head says.

Even if Venus lacks the most basic elements of plate tectonics, that doesn't mean it's tectonically defunct. Far from it. Beneath the atmospheric veil lies a host of geologic structures sculpted by interior forces. Unlike all other planets save Earth, Venus has linear mountain belts indicating the crust has been squeezed horizontally. In some places, peaks rise even higher than Mount Everest. Scientists have also identified features called tesserae (regions of very complicated fractures) and coronae (large ringed structures) that do not appear on any other planet, including our own.

Many of the structures on Venus, including Aphrodite Terra, appear to have formed as a direct result of stirrings within the planet's mantle, say Roger J. Phillips of Southern Methodist University in Dallas and Raymond E. Arvidson of Washington University in St. Louis. Plumes of hot material rising toward the surface could cause the lithosphere to bulge in ways that produce mountain belts and smaller ridge belts. Alternatively, the same features might arise because of descending currents in the mantle. Such "downwellings" might drag lithosphere together like soapsuds collecting over an open bathtub drain, forcing the crust to bunch up into mountains and thick plateaus.

Volcanic activity has also played an extensive role in molding the physiognomy of the planet. Venus' volcanoes range from small hills to huge edifices hundreds of kilometers in diameter. From these volcanic centers, a wide variety of lava flows emanate. In a particularly striking discovery, scientists have observed narrow, river-like channels that were cut, they believe, by extremely hot lava flowing downhill. One such rill winds its way across the landscape for more than 1,000 kilometers — a distance comparable to the span between Washington, D.C., and Chicago.

The Magellan data indicate that volcanic eruptions in Venusian history must have resurfaced the entire planet, because Venus boasts a complexion relatively free of blemishes created by meteorite impacts. By contrast, Mars and the moon wear old, pockmarked faces.

Since all planetary bodies should have received their share of meteoritic hits throughout history, scientists use the number of still-visible craters as a rough measure of the age of the surface. The Magellan images indicate that Venus underwent a face-lift relatively recently, within the last few hundred million years. Previous Venus missions and Earth-based radar images had suggested that Venus presents a youthful visage, but these earlier instruments achieved only about one-tenth the visual resolution of Magellan's. Moreover, they left much of the planet unexplored.

With the new information pointing to a fairly young facade for Venus, researchers are debating how the planetary makeover occurred. One theory holds that about 400 million years ago, an intense period of eruptions — a planetary belch — paved the entire planet within a few dozen million years. But geologists are by nature averse to notions of catastrophic events, says Saunders. Many believe instead that large eruptions occurred in a staggered fashion, first in one area and then another, until they eventually resurfaced Venus.

Data coming in from Magellan should enable investigators to resolve within a year which model strikes closer to the truth, says Saunders. The Venus probe has already surveyed three-quarters of the planet's surface and will continue to fill in the remaining areas, some of which have never been mapped by spacecraft. NASA also plans to use Magellan to obtain precise gravity measurements that will offer clues about what lies beneath the planet's surface.

Like others involved in the Magellan project, Saunders believes the new information will enable scientists to figure out what kinds of tectonic processes — other than plate tectonics — have shaped the various structures now visible on the planet. But he cautions that it will take time to explain the enigmatic planet unfolding beneath Magellan's gaze.

To emphasize the magnitude of the task, Saunders compares Venus and Earth. Because Earth's ocean floor remains largely unsurveyed, scientists now have a better map of Venus than of their own home planet, he says — "so try to imagine a handful of geologists attempting to map the entire Earth in a few months and then making any sense out of it." □