Magellan: No Venusian Plate Tectonics Seen

The first good look at a suspected Venusian analog to Earth's mid-ocean ridges reveals nothing that is familiar

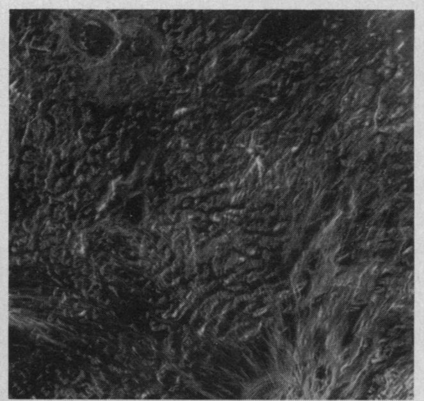
Houston—In its first months of mapping the cloud-shrouded surface of Venus, the Magellan spacecraft has revealed details of spectacular mountain ranges, high plateaus, great volcanoes, and pervasively deformed crust. But it has yet to answer a crucial question: What's behind all this planetary sculpting? Is it some version of the plate tectonics that shape Earth's surface—after all, Venus has often been considered Earth's sister planet—or a process unique to Venus?

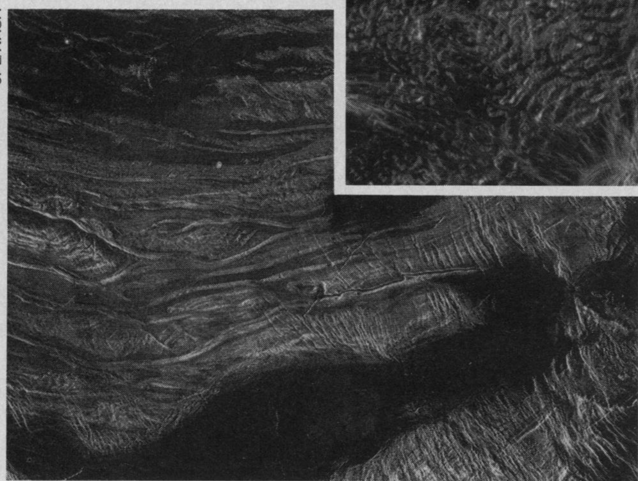
Planetary scientists had been waiting eagerly for images of a feature called Ovda Regio that they hoped would provide some answers. What some of them expected was a view of part of the tectonic machine that produces the plates. But when the first of those images came, they showed little evidence of plate tectonics. Indeed, they reveal a planet that looks to be no sister to Earth.

As part of the highland called Aphrodite Terra that wends its way 16,000 kilometers along the equator, Ovda Regio was the centerpiece of a model of Venusian plate tectonics proposed by James Head and Larry S. Crumpler of Brown University shortly before Magellan settled into orbit around the planet (*Science*, 17 August 1990, p. 742). To Head and Crumpler, images of Aphrodite sent back by Pioneer Venus 10 years ago looked like the Mid-Atlantic Ridge, a long, thin volcano or spreading center where new crust forms along the crest and subsides away in either direction. And the 3500-kilometer ellipsoid of Ovda Regio resembled Iceland, a high-standing plateau built on the Mid-Atlantic Ridge by an underlying plume of rising mantle material that feeds volcanic outpourings to the surface. Uniquely Venusian conditions—such as the 450°C surface temperature—might blur the comparison with Earth's mid-ocean ridges a bit, Head and Crumpler said, but they thought that once Magellan's high-resolution radar images superseded Pioneer Venus' myopic views, a half-dozen different sorts of features characteristic of an Earth-like spreading center would snap into focus.

The Ovda images show none of the features predicted by Head and Crumpler, however. These images were not received and processed in time to be included among the papers in this special issue of *Science* (see pages 247-312), but Magellan researchers had a quick look at them before gathering here for the Lunar and Planetary Science Conference in late March. In a hastily assembled poster, Ellen Stofan of the Jet Propulsion Laboratory and Robert Grimm of Southern Methodist University (SMU) compared the faults, folds, and lava flows of the new Magellan images with predictions of several pre-Magellan models for Ovda. Their conclusion: "The crustal spreading model [proposed by Head and Crumpler] is the only one that can be rejected with reasonable confidence (at least for this region), but only by virtue that its predictions are quite specific."

"Venus clearly has a unique style; it's just a whole new world," says Magellan team member Sean Solomon of the Massachusetts Institute of Technology. "It's much more interesting than the moon or Mars, but it's not plate tectonics." Stephen Saunders, Magellan project scientist, agrees, but adds: "I don't want to downplay the enormous value of [Head and Crumpler's] thinking. It's focused attention on important data." Head is not yet ready to throw in the towel, however. "If crustal spreading is operating there, it doesn't jump out at you," he concedes. "But right now, I don't feel comfortable ruling out any of the models. We're still overwhelmed by the detail."





JPL/NASA

A strange land. *Ovda Regio's ridges (8- to 20-kilometer-wide lighter banding) formed by compression, not by the extension of crustal spreading that is typical of plate tectonics.*

If Earth-like plate tectonics cannot account for Ovda Regio, what can? The two leading alternatives to crustal spreading involve the churning of mantle rock beneath the outer shell or lithosphere of the planet. Solomon sees evidence in the Magellan images that, unlike on Earth, flowing mantle can grab the overlying Venusian lithosphere and drag it about, either piling crust into ridges, plateaus, and mountain belts or splitting it with great rifts. Such deformation is widespread in the relatively thin, hot Venusian crust.

If mantle traction is the prime mover of Venusian crust, the question for Ovda Regio becomes whether the mantle beneath it is rising or sinking. In the "blob tectonics" model of geophysicists Robert Herrick and Roger Phillips of SMU, a blob of hot mantle rock rises toward the surface, driving the lithosphere and crust upward as mantle is squeezed upward and outward ahead of the blob. Then the blob flattens against the bottom of the domed lithosphere and spews magma onto the surface to form a volcanic hot spot. Herrick and Phillips see four such hot spots, including Ovda, making up western Aphrodite, each at a different stage of a blob's life cycle. In contrast, Duane Bindschadler of the University of California, Los Angeles, and Mark Parmentier of Brown University have proposed that mantle dragging crust with it converges on Ovda and sinks, leaving behind a swollen mound of crust like water bunching scum over an open drain.

Whether blob, scum, or some other model eventually wins out, most planetary scientists would agree with Head about Magellan's superb imaging: "It's going to make us think through the basic physics of how things work." Planetary scientists have a lot more thinking to do before they figure out how Venus works.

■ Richard A. Kerr