The Diminutive Domes of Venus

They look volcanic and may number in the millions

By JONATHAN EBERHART

Beneath Venus' dense, acrid clouds, which perpetually shield its surface from the eyes of Earth-bound observers, lie tens of thousands of low, dome-shaped features. For several years, planetary scientists have pondered the origin and significance of these gentle mounds, which have appeared in radar images made of the planet since 1983. Apparently the result of volcanism, the domes constitute "the most abundant geological feature on the planet," says Jayne C. Aubele of Brown University in Providence, R.I.

"I'm excited about the domes, and other scientists are beginning to be also," Aubele says. "The presence of a volcano on the surface of a planet always tells us something about the planet. The presence of tens of thousands of volcanoes overwhelms me."

Soviet researchers first noted the existence of the domes in radar images made by the Venera 15 and 16 spacecraft, which orbited Venus and scanned its north polar region from October 1983 to July 1984. The scans covered only about 25 percent of the planet, but Zhenia Slyuta of the Vernadsky Institute of Geochemistry in Moscow reported in 1988 that they revealed about 22,000 domes, with diameters ranging from 20 to 2 kilometers—the smallest size the radar could detect with its resolution.

If the Veneras' limited sampling proves representative, Venus could have at least 88,000 domes pimpling its face. More likely, Aubele says, "there are probably millions of smaller ones." And this, she notes, "means they are more abundant than impact craters on Mars."

Small domes near the radar's resolution limit can be harder to identify with certainty than the bigger ones. However, even eliminating every dome smaller than 5 km from the Venera maps still leaves about 7,000 of the geologically intriguing features, Aubele reported late last month at the American Geophysical Union meeting in Baltimore.

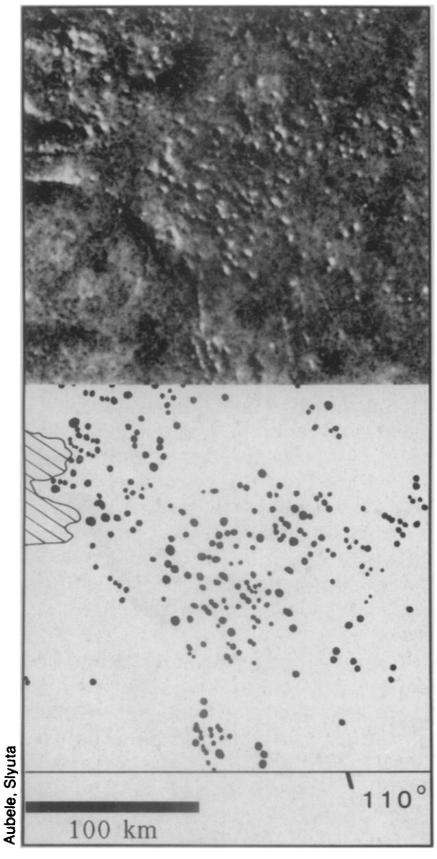
Venus' domes also pop up in radar mappings made with the Arecibo radiotelescope in Puerto Rico, James W. Head of Brown University told SCIENCE NEWS. Much of the data obtained at Arecibo comes from a radar beam reflected from the planet's surface at too wide an angle to show topographic features such as domes. (Scans with narrower angles provide better images of the small-scale roughness of the surface than of its large-scale peaks and valleys.) However, most of the larger domes detected by the Soviet spacecraft do appear in the Arecibo data, Head says. He adds that an early analysis indicates domes exist nearer the equator as well, although this finding requires further confirmation.

"Probably several dozen small hills or domes" also show up in radar scans made with the Goldstone radiotelescope near Barstow, Calif., says Raymond E. Arvidson of Washington University in St. Louis. Some of the domes lie in locations different from those detected by either Arecibo or the Veneras, he adds.

Pioneer Venus, a U.S. spacecraft that reached the planet in 1978, also has mapped its large features. But even the 20-km domes are too small for that craft's radar to detect.

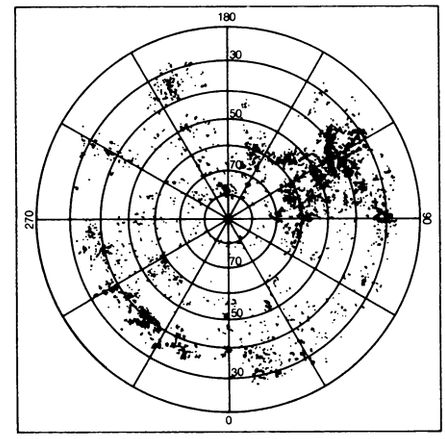
The next spacecraft capable of seeing the domes will be Magellan, a U.S. radar mapper due to reach Venus on Aug. 10. Magellan will make about 60 percent of its measurements with its radar antenna aimed at angles too wide for detailed topographic studies, says Ellen Stofan of NASA's Jet Propulsion Laboratory in Pasadena, Calif. However, she adds, good "dome data" should be available within about 30° of the planet's north and south poles. Furthermore, Magellan should detect domes and other details about 10 times smaller than those visible to the Veneras—thus revealing features as small as 0.2 km.

"At Magellan resolution, we may be able to detect differences in eruption type



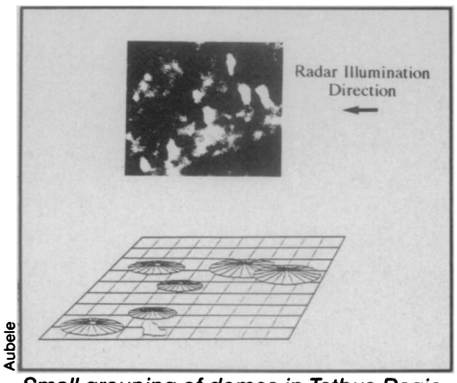
Aubele, Slyuta

About 400 small, dome-like features in an area called Tethus Regio in Venus' northern hemisphere show up in this portion of an image created from Venera 15 and 16 radar data, and in the accompanying map.



Aubele

Map of Venus' northern hemisphere shows about 7,000 domes 5 to 20 km in diameter.



Aubele

Small grouping of domes in Tethus Regio includes one with an adjacent lava flow, probably a sign of the dome's volcanic origin.

or evolution, or, most important, differences in relative age," Aubele says.

Magellan will orbit Venus, not make a quick "flyby" *à la* Voyager's trips past Jupiter, Saturn, Uranus and Neptune. Its basic, or "nominal," mission will last 243 days—just time enough to scan the entire surface once. Scientists and mission officials hope the craft will complete as many as four more mappings of the entire surface, imaging it with the radar beam aimed at different angles.

With Magellan on station, the number of known domes, at least in Venus' polar regions, appears likely to grow considerably. But what are these gentle rises punctuating the planet's surface, and how did they form?

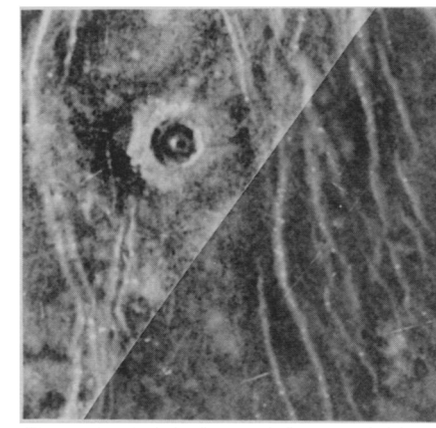
"The main problem with them, and the reason other people did not begin to work with them immediately, is their size as planetary features and the limiting resolution of Venera," Aubele says. "When we began this research, we weren't even certain if they were volcanic features."

Now she and Slyuta have prepared an article about the domes' nature and origin for the journal EARTH, MOON AND PLANETS, scheduled to appear at about the time Magellan goes into orbit around Venus.

The researchers propose that the small domes are "shield volcanoes," which result from lava oozing out onto the surface rather than exploding upward and hardening into a mountainous peak. Aubele and Slyuta believe the domes are the sites of multiple, nonexplosive eruptions, with Venus' inner heat driving small but repeated outpourings of magma, which remains relatively plastic, or fluid, under the planet's atmospheric surface temperature of about 900°F.

The individual domes appear to consist of relatively small amounts of material, usually less than 1 cubic km and typically forming gradual slopes as low as 1 to 5°. "In fact," says Aubele, "if you were walking up one of these things, you might not even be able to tell that it was any different from the surrounding plains."

Arvidson adds that the accurate measurements of the surface's roughness, though they would be a far less direct sign of domes than an actual contour map, may provide another kind of clue about how the domes formed. The roughness measurements, he says, show signs of stratigraphy — not necessarily layers of different rock types, but areas where some apparent flows have sharp edges as though they were recently laid down. Others have smoother surfaces, suggesting a longer existence in the hot, corrosive Venus environment. As Arvidson describes scientists' quest to identify and understand the numerous little domes, step one is to work out the topography, then focus on the overlying roughness measurements to spot variations that may distinguish older from newer lava layers.



Aubele, Slyuta

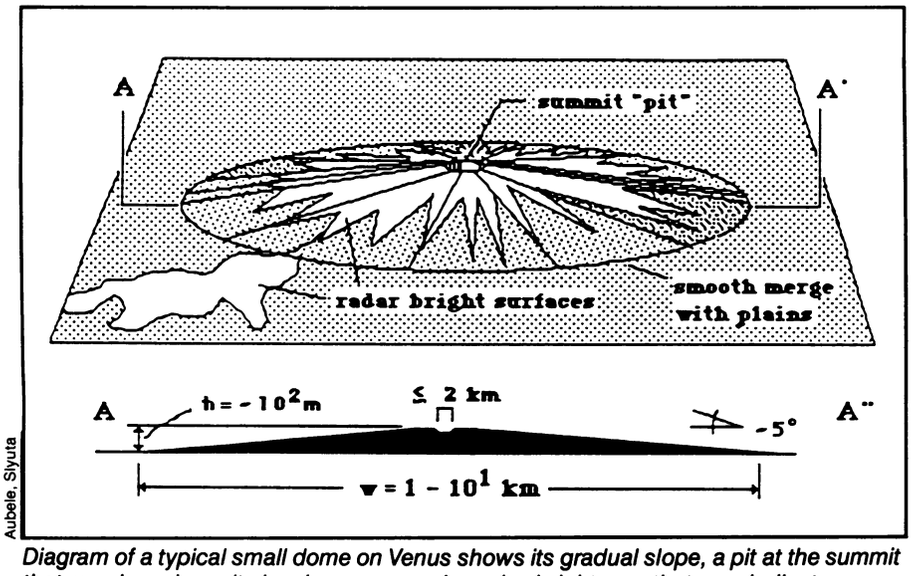
The radar-bright "aureole" around this dome may have resulted from an old lava flow that appeared during the dome's formation but was subsequently buried by the younger, smoother material typical of the surrounding plains.

The Venera north-polar map shows domes in every direction, although they appear particularly common in two regions. A major question about these two clusters, Aubele and Slyuta say, is whether they are due to hotspots, like the one believed to have produced the Hawaiian islands as Earth's Pacific Plate moved slowly over it, or simply resulted from thin spots in an unmoving crust where volcanic heat can break through.

The dome-like features may not prove unique to Venus, but researchers know of few examples on other rocky, terrestrial-type worlds. Arvidson says Mars has "a few conical hills," but even if they emerged through similar geophysical processes, they are probably 10 to 100 times rarer than those on Venus and even less abundant than those on Earth's moon. The Mariner 10 spacecraft's photos of Mercury show only one side of the planet and are not sharp enough to show domes like those on Venus.

"The only other similarly numerous volcanic landforms on any planet in the solar system that we have been exposed to are the seamounts on Earth's ocean bottoms," says Aubele. Scientists have estimated that a million submerged seamounts exist in the Pacific Ocean alone, she adds, and many of them appear to have a volcanic origin. In fact, according to the forthcoming paper by Aubele and Slyuta, "the dominant geologic association of Venus' small domes is with features that have been interpreted to be volcanic."

The domes are more than mere curiosities. If in fact they are still active and releasing magma, they will confirm a belief of many planetary scientists, including what Arvidson calls a majority of the Magellan team: that volcanic Venus did not cool down in a "geologically recent" past millions of years ago, but continues to erupt to this day. □



Aubele, Slyuta

Diagram of a typical small dome on Venus shows its gradual slope, a pit at the summit that may have been its lava's source, and a radar-bright area that may indicate an additional lava outpouring.