cal. The rice root nodules resemble those found on *Sesbania* and contain a small amount of nitrogenase, Jing says. Robert Burris, a veteran nitrogen fixation expert at the University of Wisconsin, Madison, is sufficiently intrigued by the result that he has accepted Jing's invitation to trek off to Beijing for a laboratory visit.

Barry Rolfe of the Australian National Laboratory in Canberra also has evidence that mutated rhizobia produce small nodules on rice. And at last September's meeting of the International Symposium on Nitrogen Fixation in Non-Legumes, held in Florence, Italy, Y. T. Chan of the University of Sydney reported that his group obtained nodule-like structures on wheat roots.

Yet, despite the promising results with nodulation in nonlegumes, no one has yet documented actual nitrogen fixation in these plants. Nitrogen fixation experts know that even with the presence of healthy nodules, there is plenty of opportunity for the system to go awry. The presence of air spaces in the new nodules may poison the oxygen-sensitive nitrogenase or the nodulated plant may not have the energy to fix nitrogen in a meaningful way.

For now, researchers working with nodulating nonlegumes have only demonstrated nitrogenase activity by measuring acetylene reduction, at best an indirect measure of nitrogen fixation. "The most sensitive way to assay for nitrogen fixation is to use the rare but stable isotope nitrogen-15, put it over the test material and then look for ^{15}N in proteins," Burris says. "This is the convincing test." He adds that, given the recent surge of interest in nodulation by rhizobia in nonlegumes, this key experiment should be attempted within the next 6 months.

Cocking, for one, agrees. His group now plans to try to improve the efficiency and frequency of nodule production. The nodules on the oilseed rape and rice plants are still pretty sparse by legume standards. But if all goes well, the researchers will, within the next year or two, do the more definitive assessment of nitrogen fixation, using the ^{15}N method. Then they will have a better idea about whether they are closer to the elusive goal of devising a general scheme for the design of self-fertilizing nonleguminous plants. ■ ANNE SIMON MOFFAT

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ADDITIONAL READING

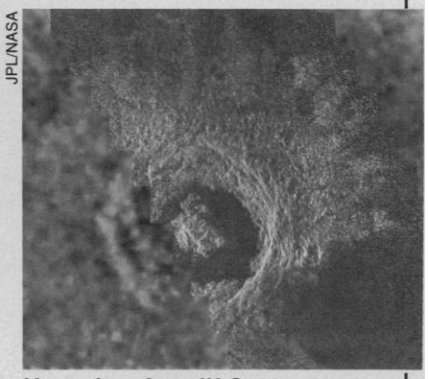
M. K. Al-Mallah, M. R. Davey, and E. C. Cocking, "Formation of nodular structures on rice seedlings by rhizobia," *J. Exptl. Botany* **40**, 473 (1989).

M. K. Al-Mallah, M. R. Davey, and E. C. Cocking, "Nodulation of oilseed rape (*Brassica napus*) by rhizobia," *ibid.*, in press in the December issue.

Venus Is Looking Too Pristine

The planetary geologists who are studying the radar images streaming back from Magellan find that they have an enigma on their hands. When they read the geologic clock that tells them how old the Venusian surface is, they find a planet on the brink of adolescence. But when they look at the surface itself, they see a newborn babe.

As the spacecraft's radar revealed one narrow strip of the Venusian surface after another during the first 2 months of its mission, Magellan scientists have been struck by the newly minted appearance of the craters formed by the impact of small asteroids and comets. Only one of the 75 craters identified on the first 5% of the planet mapped shows any of the typical signs of aging, such as filling up with the lava of volcanic eruptions or being torn by the faulting of tectonic disruption.



JPL/NASA

Venusian face-lift? *Magellan's sharper image (right) reveals the enigmatic freshness of this 34-kilometer impact crater.*

But by geologists' usual measure, these fresh-looking craters have had plenty of time to fall prey to the ravages of geologic change. Planetary scientists use the steady drizzle of asteroids and comets falling on a planet's surface to mark geologic time. Given some idea of the rate at which those impacts occur, a count of the number of craters on a given surface tells how long it has been exposed. According to this crater-count clock, the Venusian surface appears to be anywhere from several hundred million to a billion years old.

"We have been waiting for craters caught in the act of degradation by volcanism or such," says Magellan team member Sean Solomon of the Massachusetts Institute of Technology. "All of us are surprised we don't see a spectrum of states of preservation."

At the Division of Planetary Sciences meeting held last month in Charlottesville, Virginia, Magellan scientists strove to explain the paradox of young-looking craters on a relatively old surface. They raised the possibility that several hundred million years ago, a planet-wide volcanic outpouring wiped the slate clean, drowning any existing craters in a flood of lava. Then the flood would have had to turn off fairly abruptly so that the craters formed by subsequent impacts would remain pristine.

But such a global episode of volcanism generates another mystery. How could Venusian volcanic activity ebb so abruptly? Planetary physicists David Stevenson and Seth Bittker of the California Institute of Technology may have hinted at an answer when they recently speculated that just such a process may have taken place on Mars. Stevenson and Bittker said that the sources of Mars's lava might have become clogged with the residue of the melting that produced the lava in the first place—in essence, a self-sealing mechanism.

Other explanations for the uniformly youthful appearance of Venus's craters have been proposed, but researchers find them even less attractive than the perhaps far-fetched idea of volcanic episodicity. Could the planet have cooled so much that its volcanoes have turned off for good? Given its similarities to the still active Earth, this seems unlikely, Solomon says. Could Venus sport a version of plate tectonics? Then the planet would be continually turning out fresh crust whose craters would not be destroyed until the crust itself is consumed by sinking back into the mantle. Solomon, and most others, has yet to be convinced that such plate recycling is pervasive enough on Venus to explain the enigma (*Science*, 17 August, p. 742).

As Magellan continues to map Venus, team members await a resolution. Either many more degraded craters will begin to show up as Magellan works its way around the planet, and the enigma will evaporate, or it will be confirmed and, perhaps, enough clues accumulated to resolve it. That is, assuming the spacecraft is able to map the entire planet by next April, as scheduled. Magellan's early problems with its attitude control system (*Science*, 5 October, p. 27) appear to have disappeared as mysteriously as they began. And that's fine, Magellan team members say. They would much rather puzzle over the spacecraft's pictures than its machinery.

■ RICHARD A. KERR