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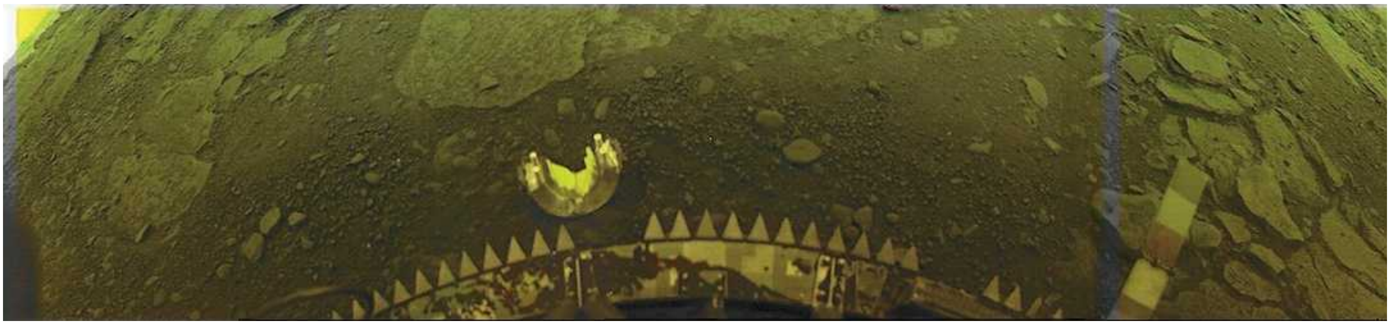
THE GIRL NEXT DOOR

D. P. MITCHELL



Hanging bright in the morning sky, Venus's allure is obvious; but its blasted surface looks too hot to handle. **Eric Hand** investigates the difficulties of returning to the closest planet — and new plans to reap the rewards of doing so.

The panorama is distorted and claustrophobic, overcast by a thunder-in-the-air gloom. Flat rocks fill the view, framed by the menacing, serrated teeth of the spacecraft and a patch of yellow sky. The lens cap lies discarded in the dust as if the cameraman had been mugged. Or melted.

It was 1982 when Venera 13, one of many Soviet missions to Venus, landed in this hellish place. The four cell-phone-quality panoramas it and its sister probe sent back (see opposite page, bottom) are still the only colour pictures of the surface that researchers have. As the morning or evening star, Venus is the brightest and loveliest of the planets, but as a subject for science it is barely an also-ran. The European Space Agency's Venus Express, launched in 2005, is the first mission to Venus since NASA's Magellan mission, launched in 1990, was brought to a fiery end in the planet's atmosphere in 1994. Between the two, Mars got all the love, with a mission almost every year. NASA's planetary database now contains about 25 terabytes of martian data; America's space-age Venus data total only 400 gigabytes — a tenth of the return from the two Mars rovers launched in 2003.

"Venus has been like the forgotten planet," says Håkan Svedhem, project scientist on the Venus Express team. "Mars has completely taken over."

There are various explanations for the neglect, but as Venus Express is showing (see articles starting on page 629) a dearth of beguiling questions is not one of them. The runaway greenhouse effect that boiled away the oceans the planet seems to have started off with draws a lot of attention and speculation. But scientists are also interested in the rocks below. Venus, unlike Mars but like Earth, retains enough internal heat to drive large-scale planetary processes — flows in the mantle and the crust. But the ways these processes have played out on Earth and Venus are vastly different — in part, perhaps, because of that vicious greenhouse effect and the absent oceans.

To address these questions, planetary scientists want a surface mission that picks up where the Venera probes left off. "You reach a point where you want to do more than fly-bys and orbiters," says David Grinspoon, astrobiology curator at the Denver Museum of Nature and Science in Colorado. "We need to push for these more comprehensive missions that explore the deep atmosphere and surface *in situ*." Now Grinspoon and other venusian diehards may be getting a few crucial rungs higher on NASA's to-do list. "From my perspective, we can't ignore Venus any longer," says NASA's director of planetary exploration James Green. "We're not going to ignore it. It's gathering momentum." Earlier this month, Green announced that NASA would consider a 'flagship' mission, its highest, multi-billion-dollar mission class. He has set up a team to study the science questions to be asked and the technology that would be needed.

One explanation for the neglect of Venus is simple. Human exploration is a stated priority for NASA; human exploration of the surface of Venus is next to inconceivable. Mars is by far the most plausible outpost beyond the Moon — and it has the added bonus of being considerably more likely than Venus to offer a discernible record of past life.

Extraterrestrial life and human exploration excite the public. And if that drives science policy, then so be it, says Steve Squyres, a planetary scientist at Cornell University in Ithaca, New York, and lead scientist for NASA's Mars rovers. "We are doing science with public money and lots of it. We have to keep in mind not just our own academic interests," he says. Although he says he is equally interested in both planets — as a young professor he worked on the Magellan mission to Venus — his academic career is now centred squarely on Mars. "To a certain extent, you have to go where the data are," he says.

> "We can't ignore Venus any longer."
> — James Green

Which leads to the other advantage of Mars. Scientists study Mars because they can. Mars orbiters can map its surface across the whole electromagnetic spectrum using radar, a wide range of infrared and visible wavelengths, ultraviolet and even γ-rays. So far, the only thorough mapping of Venus's shrouded surface has been by radar, first by some of the Venera probes, then by Magellan.

And Mars science isn't limited to orbiters. The thin atmosphere makes slowing down landers hard, but once you're down, life's not too difficult: Squyres's rovers have trundled along for years now. It's far easier for engineers to design instruments to survive the cold of Mars than it is to immerse a probe in Venus's crushing atmosphere and scalding temperatures.

That hasn't stopped Kevin Baines. "I've been trying since 1992 to get this country back to Venus," says Baines, a planetary scientist at the Jet Propulsion Lab in Pasadena, California, who believes that he holds the record for the greatest number of NASA-rejected Venus mission applications. His proposals in the 1990s included an infrared imager that would map the surface, at night, using spectral gaps in the atmospheric greenhouse to glimpse the hot surface below — a technique Venus Express is now using in the hopes of finding evidence of contemporary volcanism. Spotting active eruptions might kindle interest — Mars's volcanoes, though monumental, are thought to be almost entirely dormant — and might also help explain the chemical structure of the atmosphere. But so far, Venus Express has not found any lava hot spots. And an instrument that was supposed to locate tell-tale plumes of sulphur rising from volcanoes has failed to send back any useful data.

With Venus Express pursuing much of the science of his rejected orbiters, Baines has moved on to balloons — something the Soviet Union deployed on Venus more than 20 years ago with the Vega probes. In terms of ballooning, the charms of Venus and Mars are reversed. The hardly-there atmosphere on Mars is deeply inimical to the idea of floating lazily from place to place (which has not stopped such missions being suggested). The thick atmosphere on Venus, on the other hand, is ideal. A balloon 55 kilometres up in the venusian atmosphere would operate at comfortable temperatures and pressures, ferried around the world by ample winds.

Baines says his silvery-green balloon would be 7 metres across and five layers thick. With a coating of Mylar to reflect the Sun and a layer of Teflon to protect against sulphuric acid, a balloon could last months, perhaps a year, he says. A high priority for such a mission would be to measure the abundance of various isotopes of noble gases, which would allow scientists to deduce new details of the planet's history. Baines is also considering dropping 5-kilogram probes, like ballast, which would take pictures of the surface as they fell to a crash landing.

The probes might target specific spots on the surface. Most of the surface of Venus is basalt, and apparently rather young basalt at that — eruptive evidence of the heat within. The age is known because Magellan found very few large impact craters on the surface compared with the surfaces of Mars and the Moon. Fewer craters, other things being equal, mean younger crust. On Earth, large parts of the crust are kept young by plate tectonics. On Venus, though, there is no evidence of the faults that a surface made of shifting plates should have.

One proposed explanation for the oddity is that instead of producing plate tectonics as on Earth, convection currents in Venus's mantle knead the crust continuously, thickening and thinning it in a way that leaves it crater-free. Another, more dramatic, hypothesis is that every so often the crust gets so thin and cool and dense that it cannot support itself on the mantle. This 'catastrophic resurfacing' theory holds that, 750 million years ago, all the crust sank at

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once, turning the entire planet into a sea of magma. "That's a good way to get rid of a lot of heat," says Steve Mackwell, director of the Lunar Planetary Institute in Houston, Texas, and a master of deadpan delivery.

Without new data, it is hard to decide between theories. Dropping probes into the right places might help — and might reveal clues to what the surface was like before. If, for example, they were to find some ancient granite, a rock that on Earth is produced by water-assisted recycling of the crust, they would be opening a window into a time when Venus was more like Earth, a time when it might have had continents, oceans and plate tectonics. "That would be a revelation," says Baines.

The nuclear fridge option

A lander or rover might also search out minerals or structures associated with now-closed chapters in the planet's history. Although tricky, a surface mission is not impossible, says Larry Esposito of the University of Colorado at Boulder. There are three choices: insulate your probe and do the science quickly (as the Venera probes did, and Baines's drop-probes would); use temperature-resistant electronics; or refrigerate the craft. The technologies of deep-sea submersibles that investigate black-smoker chimneys on Earth could translate well to venusian probes of the first sort, Esposito says, whereas heat-resistant electronics, which might be required for, say, a network of passive seismometers listening for quakes and eruptions, would be expensive to develop. A rover mission, or anything else intended to lead an active life of longer than a day, would need refrigeration, which requires a continuous power source. That means nuclear power of some sort. And that means a very expensive mission.

A nuclear rover might stretch the budget of even a flagship mission (the Mars Science Laboratory, a non-nuclear, non-refrigerated proposition, is currently budgeted at US$1.7 billion). A simple lander, though, or a balloon, might be cheap enough to fall within NASA's $700-million New Horizons mission category. And a bargain basement $425-million Discovery-class orbiter is still a possibility. Vesper, a Venus orbiter that would explore the carbon chemistry of the atmosphere, was proposed for the next round of Discovery missions by Gordon Chin, a planetary scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland. It has survived to the last stage of the selection process, but as Baines and Chin know from experience, a long history as bridesmaids has yet to see a Venus mission win its own special day.

With a flagship mission on the cards, might NASA be less likely than ever to approve a smaller Venus mission? Baines thinks otherwise.

Balloons would be oddly apt for studying Venus.

NASA/JPL-CALTECH

Venus orbiters and balloons could act as scouts for a major mission, he says. "If we can get those to work, people will be more comfortable spending the big money of a flagship mission."

Other nations may also quicken the pace of discovery. Although Europe has no firm plans to follow on from Venus Express — itself something of an afterthought in the wake of Mars Express — Japan has an orbiter slated for 2010. And Russia, which has not launched a successful planetary mission since the fall of the Soviet Union, has proposed a Venera-D mission that might include a lander with a launch window of 2016–18.

> **"We put Venus up on this pedestal, and it disappointed us."**
> — David Grinspoon

A farewell to fantasy

Engineering a viable Venus probe, and paying for it, is only part of the challenge. To justify a flagship mission, NASA's Green says it is up to scientists to ask compelling questions that demand new research. Beyond that, they need to engineer a new narrative, one that rallies other scientists and excites the public.

In pre-space-age science fiction, that wasn't a problem: Venus was a young, oceanic planet shrouded in cloud that acted as a counterpoint to the ancient clear-skied deserts of Mars. Sometimes it was a swampy home to dinosaurs, sometimes to frog people.

Mars, though, largely through chance, has managed to hold on to the narrative that has held sway since the days of Percival Lowell and his canals — the story of a once-watery planet transformed into desert, with vestiges of the life of its early wetter days possibly still preserved. Venus, on the other hand, lost its allure, its swamps and oceans evaporated by the evidence of prohibitive surface temperatures that emerged in the 1960s. (The dream lingered on — the Venera landers were designed to float if they landed in the sea.) "Venus suffers from not fulfilling our pre-space-age expectations," says Grinspoon. "We put Venus up on this pedestal. And it disappointed us."

In the past decade, an alternative narrative for Venus with obvious appeal has sprung up: Venus as a cautionary tale of greenhouse warming run amok. "Now, I think, the environment is a bigger concern," says Esposito. "It's causing people here on Earth to pay more attention to Venus." Chin goes so far as to say that the case for Venus exploration has been helped by Al Gore's Nobel prize for campaigning on global warming.

Gore himself might be wary of exaggerating the links too much. Earth's atmosphere is 0.04% carbon dioxide; that of Venus is 95%. If humans burned all of Earth's fossil fuel in one go, the atmosphere would still be only about 0.2% carbon dioxide, says James Kasting, a planetary scientist at Pennsylvania State University in University Park. Besides, Kasting says, models show that distance from the Sun is the critical factor in pushing a carbon-dioxide greenhouse over the edge into an ocean-evaporating runaway state. Only in a billion years, when the Sun is 10% hotter, will such a thing be likely on Earth, he says.

But perhaps Venus doesn't have to be of direct relevance to Earth's future to be exciting. Perhaps its very difference will be the key to its importance. For a long time the study of Earth-like planets has been limited to just Earth and its two nearest neighbours, siblings with life histories to compare and contrast. But those days are coming to an end. Current missions such as France's Corot, and future missions such as NASA's Kepler, due to launch in 2009, may discover a far greater range of Earth-sized planets outside the Solar System.

To understand the thin streams of data from those far-off worlds, an understanding of the full range of possibilities for an Earth-like planet's evolution will be important. "What if we find a couple dozen planets — and they're all dead planets?" asks Sara Seager, an astrophysicist at the Massachusetts Institute of Technology. "We're going to want to understand them." Studying Venus, she says, "might help us understand what leads to a habitable planet and what leads to a dead planet." In the context of the farthest planets ever studied, the story of the planet closest to hand may take on a new importance. ■

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See also News & Views, page 617.