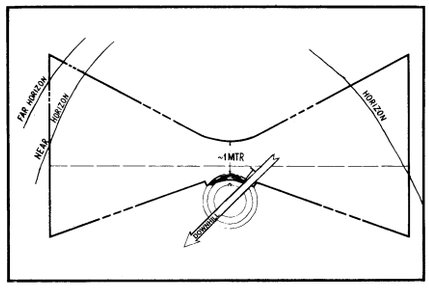
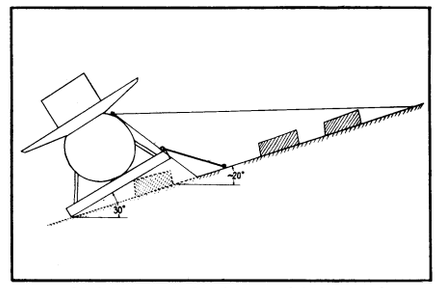
Photos and diagrams: L.B. Ronca et al

Venus Refined





Rectified Venera 9 photo of Venus shows numerous slab-like stones. Visible horizon is estimated at several dozen meters. Diagrams show photo coverage and direction of lander tilt (left) and approximate angle of tilt.

The only two photographs ever taken from the surface of Venus have now been improved to give a clearer look at that veiled world

BY JONATHAN EBERHART

The first spacecraft photos of Mars were a revelation. Old theories toppled, new ones arose, and the whole planet was transported a giant step closer to a reality that continues to evolve. Venus, however, clings more tightly to her mysteries. Despite the data from numerous flybys, orbiters and landers that have been there, there are only two photographs of that cloud-shrouded planet's surface. Taken by the Soviet Venera 9 and 10 landers on Oct. 22 and 25, 1975, they were highly distorted (the cameras' wide-angle lenses were not parallel to the local horizon), fuzzy (from electronic noise) and striped with regularly spaced vertical lines where the telemetry was periodically assigned to other kinds of data (SN: 11/1/75, p. 276).

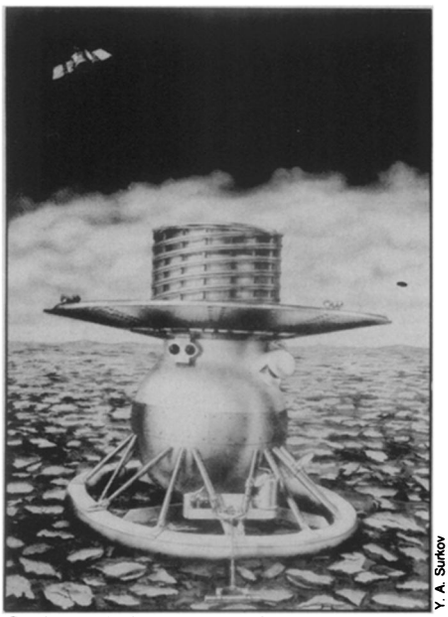
But they are the only ones. Not even the complex U.S. Pioneer-Venus mission scheduled to probe the atmosphere there next year will duplicate the feat. Thus these two photos are the sole visual input to human minds trying to fathom what, beneath that impenetrable veil of cloud, earth's so-called sister planet really *looks like*.

In the months since the photos were taken, Soviet researchers have been working to refine the images, along with the rest of the Venera 9 and 10 report. The distortion has been rectified, much of the noise has been filtered out, and some of the missing lines have been filled with imagery interpolated from repeated scans in which the telemetry gaps were in different places. The results are striking.

The real marvel, says Luciano B. Ronca of Wayne State University, who worked for several months with the Venera team under a National Academy of Sciences exchange program, is that the photos came out at all. There was some expectation (in the U.S. as well) that there would not be enough sunlight at the planet's surface even to see by, let alone take photographs. The landers carried their own lights, Ronca points out, "but it was a very great surprise that actually there was no need." The light level turned out to be "equivalent to a dark, rainy day on earth." Nearly as strange is the sharpness of some of the shadows, considering that the sunlight is diffused through what the Veneras have found to be a multilayered cloud deck some 20 kilometers thick.

The two landing sites, at least morphologically, are quite different. Venera 9 landed atilt, on either a rock or a slope, at an angle between 15° and 25°. Its single photo shows "a heap of stones," as Mstislav V. Keldysh of the Soviet Academy of Sciences describes the scene in the April Icarus. Many of the stones are rather slab-like, about 50 to 70 centimeters across and 15 to 20 centimeters high, with conspicuously sharp edges. There had been some expectation that exposed edges and surfaces would be well worn, although Cornell astronomer Carl Sagan has pointed out the lack of major terrestrial erosion processes on Venus: running water, seasonal and diurnal temperature changes, and cutting winds. The refined data, in fact, indicate that in its 53 minutes of life on the surface, the lander never detected winds faster than 0.7 meters per second (less than 1.6 miles per hour)—not necessarily a global condition, but a reasonable basis for reducing estimates of erosion from wind-blown dust. The surface material between the slabs seems to include a lot of grains smaller than the camera's rather coarse resolution (apparently at least a centimeter, estimates one U.S. planetologist) as well as some fragments several centimeters across.

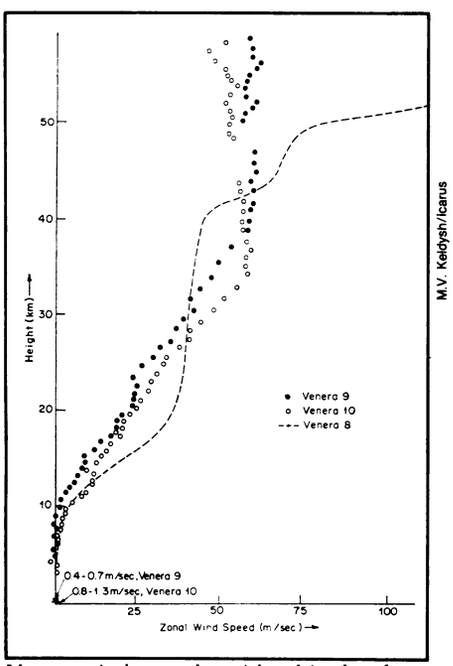
Venera 10, nearly 2,000 kilometers away, by comparison reveals "a rather smooth surface," Keldysh reports, "with but slight stony elevations." The elevations that do show, he says, "are covered with a relatively darker fine-grained soil," and the exposed edges seem to be more worn, suggesting that more active modification processes have been at work. Venera 10, which lasted 65 minutes, reported winds nearly twice as fast as those seen by Venera 9, but the speeds involved are still so low that "it is unlikely . . . that wind erosion is involved here."



Y. A. Surkov

Soviet artist's concept of Venera lander.

One possibility is chemistry. In fact, said a Venera team report given by Ronca at the recent Lunar Science Conference in Houston, the apparent "reworking" of the surface is "difficult to consider without the adoption of rather extensive surface chemical transformations." For example, basalts (suggested by uranium, thorium and potassium measurements from both landers) exposed to the carbon dioxide of the planet's atmosphere and about 0.1 percent atmospheric water (supported, at least in the upper atmosphere, by reflectance data) could result in the formation of calcite and of some partially hydrated silicates. Minor atmospheric constituents could also be involved, the team reported, which could mean a role for the sulfuric acid detected in the upper atmosphere from earth-based studies, as well as for reported traces of hydrochloric and hydrofluoric acids. The high surface temperatures may also play a part: Veneras 9 and 10 reported 455°C (851°F) and 464°C (867°F), according to team member Yuri A. Surkov.



M.V. Keldysh/Icarus

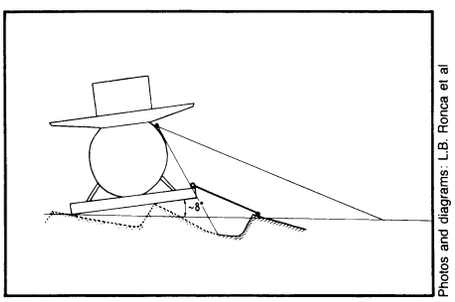
Venus wind speeds with altitude, from Doppler and anemometric measurements.

Uranium, Thorium, and Potassium Abundances[a]

	U (10^{-4}%)	Th (10^{-4}%)	K (%)
Venera 8	2.2 ± 0.7	6.5 ± 2.0	4.9 ± 1.3
Venera 9	0.5 ± 0.2	4.0 ± 0.25	0.9 ± 0.2
Venera 10	0.7 ± 0.2	1.1 ± 0.2	0.3 ± 0.1
Granite	9.04	21.9	3.24
Basalt	0.86	2.1	0.76

[a] Percentage by mass.

Still another factor affecting the surface could be the large effect of slight changes in surface elevation in the planet's severe environment. A 5-to-6-kilometer variation in altitude could be accompanied at a 50°C change in temperature and a pressure *change* of 40 terrestrial atmospheres. (The two landers reported surface pressures of 85 and 91 kilograms per square centimeter, says Surkov, and Keldysh believes that the landing sites were 1.5 to 2 kilometers above the mean surface level corresponding to a planetary radius of 6,051 kilometers.)



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Venera 10 landing site suggests more level terrain, with estimated visible horizon of several hundred meters. Diagram shows lander tilt angle.

It remains to be seen what processes if any are at work below the immediate surface. Venera 10 carried a "radiative densitometer" whose data, "corresponding to an effective depth below the surface of several dozen centimeters" according to Keldysh, suggest a density of 2.7 to 2.9 grams per cubic centimeter, typical of crystalline basalts. (Venera 8 earlier reported higher readings, suggesting more granitic material.) "Comparison of the evidence for the moon, the earth, Venus and Mars suggests that the same geochemical process occurs in all the terrestrial planets," Keldysh says, "subdividing them into shells, the outer one—the crust—being for the most part composed of basalts." But beyond such generalities, the depths of Venus will have to wait.

There is considerably more information, however, about the planet's atmosphere, with contributions from U.S. spacecraft, the Venera orbiters and notably the landers themselves on their way to the ground. The descent data indicate that the main region of clouds extends from 49 to 68 kilometers above the surface, with "provisional" layering in all but the uppermost 6 km. The droplets comprising the clouds seem to be confined to a narrow size range of between 0.5 and 2.5 microns, consistent, says Keldysh, with the possibility of substantial amounts of sulfuric acid. In the different cloud

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. . . Venus

layers, he says, the particle concentration ranges from 50-to-100 to 400-to-500 per cubic centimeter, which could bear on the mystery of the unexpected amount of sunlight at the surface. The derived volume scattering coefficient, Keldysh says, indicates that visibility, even within the clouds themselves, may be as high as 3 kilometers, implying that the "clouds" may really be just "a slight haze." A haze, that is, some 20 kilometers deep.

Still farther aloft, the Veneras have probed the planet's ionosphere, at least in a few points. "The Venus ionosphere is both closer to the planet and thinner than the earth's ionosphere," Keldysh reports, "with the higher electron concentration on the day side, although still 10 times less than in the terrestrial ionosphere." A recent study by Christopher T. Russell of the University of California at Los Angeles (SN: 3/19/77, p. 185) suggests that the ionosphere of Venus is indeed quite close to the planet, close enough that there may be considerable interaction between the solar wind and the atmosphere. If Russell is correct, then the solar contribution may be playing a major role in a "tree" of chemical and photochemical reactions that reaches all the way to the surface.

A real understanding of what lies beneath all those clouds, in other words, may be a long time coming. □

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