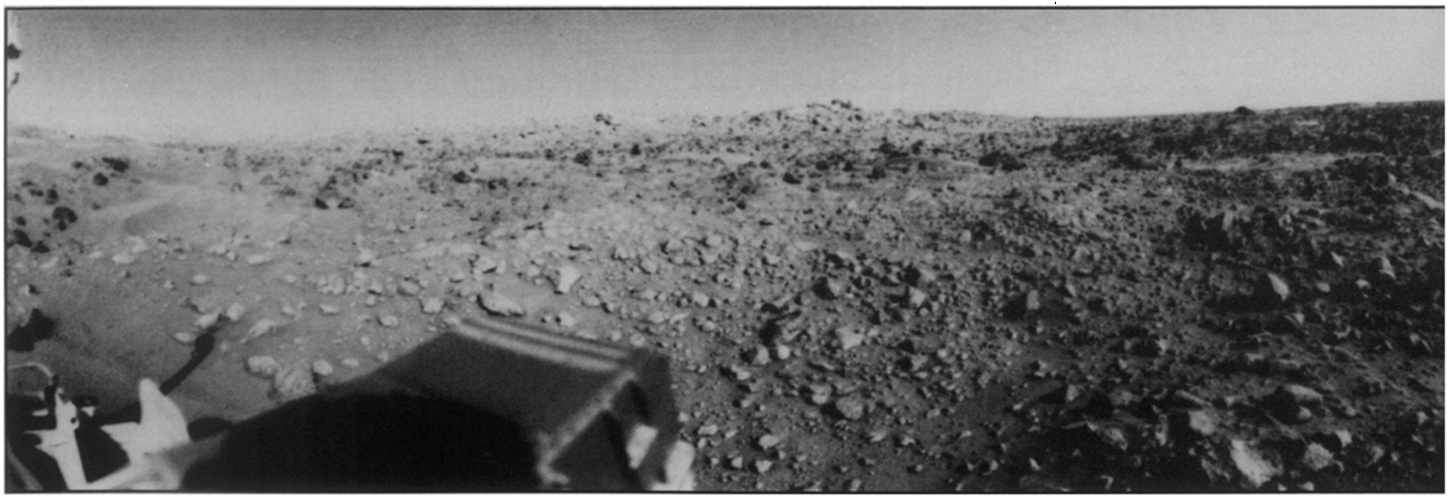


The Dry, Cold, Rocky Ground of Mars

"Touchdown! We have touchdown!" The voice of Richard A. Bender, head of the Viking Lander Performance Analysis Group, rang clearly over the control-room communications system. A decade of planning, a billion dollars and the titanic efforts of thousands of people had at last borne fruit: the first successful landing on planet Mars.

Previous interplanetary missions have all been tense at their critical moments, but for the Viking landing, the stakes seemed particularly high. The unexplained failure of Soviet attempts in the past had already given the mission's prospects an ominous cast, and frustrating weeks of searching from orbit for a safe landing site had added an extra burden of suspense. Bender's announcement, besides triggering rousing cheers, left many members of the Viking team and other NASA officials nearly limp. "I can't think about the science right now," said Noel Hinners, NASA associate administrator for space science, shaking his head in wonderment. "I had tears in my eyes," said beaming Project Manager James Martin, veteran of an aerospace career spanning more than a third of a century. "This has got to be the happiest day of my life." Thomas A. Mutch of Brown University confessed that despite his optimism, he hadn't been able to sleep the night before.

Mutch had particular reason for elation. As head of the lander's photographic analysis team, the landing alone for him would not be enough. But less than an hour after the craft settled gently down on the western slope of Mars's Chryse basin, Mutch and his colleagues began to see what they had worked so long to achieve: the first images taken from the Martian surface.

Other instruments besides the cameras were already at work—Viking's meteorological instruments were sampling the weather, and the surface atmospheric pressure had been measured at about 7.6 millibars, a hopeful sign for past existence of water concentrations. But the spectacular pictures were the center of attention. The initial photo showed merely the ground within a meter or two of the lander, together with one of the spacecraft's feet, but it brought gasps from the hundreds of observers gathered at monitor screens at the Jet Propulsion Laboratory in Pasadena. So sharp was the detail (and even sharper images were to follow in a few days), that pea-sized rivets on the footpad were well within the picture's limits. Next came a sweeping 300° panorama showing some 20 kilometers of Martian horizon. The word "awesome" would require no journalistic license.

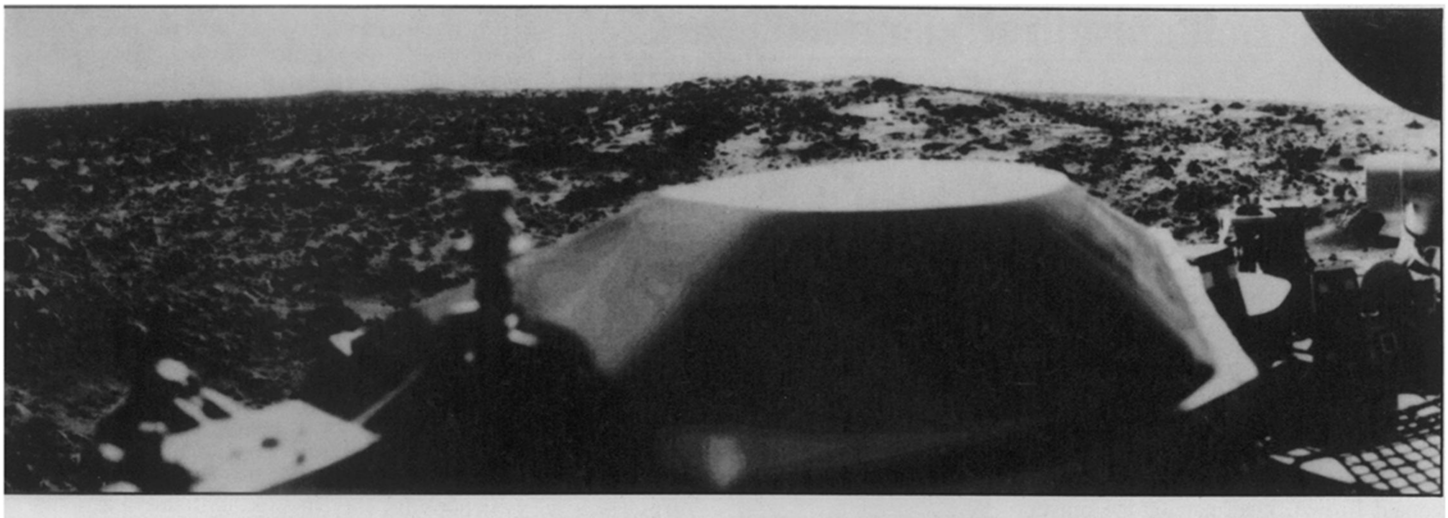
On the left-hand end of the panorama, a faint, ghostly mesa seems to shimmer in the distance, as apparent sand dunes roll in the foreground. Bumps on the horizon were tentatively described as the ramparts of craters, and careful peering reveals a cloud layer over the left center of the image. The sky darkens toward the top of the picture, not surprising for a planet with less than a hundredth of earth's atmosphere, but the brightness it did show came as a surprise to Viking scientists. The initial picture, according to James Pollack of NASA's Ames Research Center in California, indicates a sky as much as 100 times as bright as would be expected for clear air (even Martian air) alone. The implication is that, at least when the picture was taken, the atmosphere contained suspended particles in concentration similar to those over earthly oceans, with particle sizes of "a few tenths of a micron."

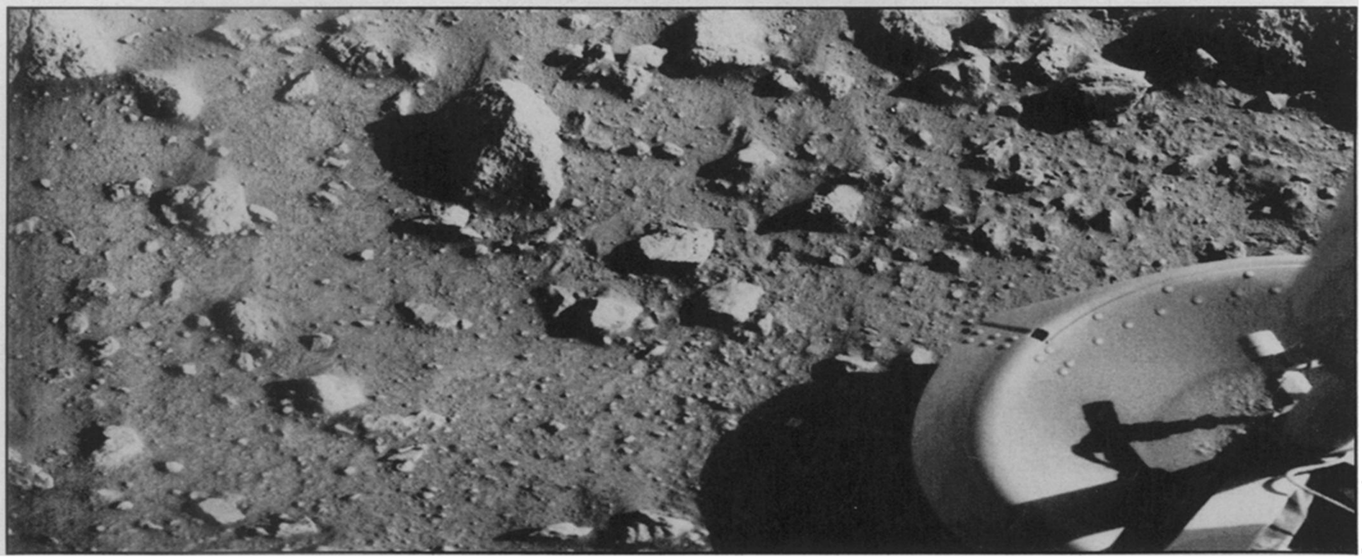
In a broad sense, the site seems to resemble a rock-strewn terrestrial desert or, suggests team member Alan Binder of Science Applications, Inc. in Tucson, a heavily eroded lava field such as those found in northern Mexico and Arizona. On earth, Binder says, the apparent sand dunes and such features are often found to be accumulations of fine volcanic ash. But whether lava or sand, the site looks more like a desert than like the moon.

Few earthly deserts consist entirely of the trackless wastes of unbroken sand that are often their stereotype, and the terrain where the Viking lander rests is similarly diverse. "My impression from this region is that Mars is marvelously heterogeneous," says Cornell astronomer Carl Sagan. "And this is a spot chosen for its blandness." The panorama shows large rocks and small, ranging from boulders a few meters across in the distance to small pebbles that range down to below the camera's resolution. The close-up view reveals rocks with sharp-edged facets and pitted surfaces, some of them partly covered with fine-grained particles of sand or other soil. One approximately shoe-sized rock in the close-up's upper left corner shows horizontal and vertical fractures, together with pitting, that strongly reminded geologist Elliot C. Morris of the layered basalts found on the moon by Surveyor 7.

One of Viking's most hoped for goals is to determine whether, in fact, large quantities of now-vanished water have left their mark on the planet. The landing site shows some possible wind-caused features—dark "flowtails" of dust, deposits apparently blown up onto the sides of rocks—but the issue will not be so easily resolved. "I have a feeling," says Binder, "that wind is not the primary modifier of this surface." Some observers felt that the panorama showed contours suggestive of long dry-flow patterns. Unlike the moon, Binder observed, the rocks strewn about the site do not seem to be related directly to nearby craters. Instead, he said, they might have been transported along with finer sediments by flowing water (perhaps from the numerous channels that lead toward Chryse basin), then uncovered later by wind action.

Even before it reached the ground, however, the lander was making history with the first direct analysis of the Martian atmosphere. The final result, according to





Photos: NASA

First photographs ever taken on the surface of Mars: A 300° panorama taken in the late Martian afternoon (above). Horizon features are approximately 3 kilometers (1.8 miles) away. Rocks and finely granulated material (sand or dust) are clearly seen in photo of ground near Viking lander (below). Center of the image is about 1.4 meters (four feet) from camera. Large rock in the center is about 10 centimeters (4 inches) across. At right is a portion of the Viking footpad.

Alvin Seiff of NASA's Ames Research Center, should be a profile extending from as high as 300 kilometers above the surface down through the peak ion concentration at 135 kilometers (where Viking also recorded a temperature of −216° F, compared with 27° F at 200 to 250 kilometers) all the way to the surface. The surface pressure at the site, says Seiff, was 7.3 millibars, comfortably above the triple point of water, indicating that the site is about 2.9 kilometers below the estimated mean Martian surface pressure. The atmospheric temperature at the site was measured at 241°K (−25.6° F), almost balmy by Martian standards, but, it was recorded in the height of summer in the afternoon near the subpolar point—virtually the warmest conditions available.

The most exciting result, however, emerged from the mass spectrometer that was measuring the composition of the upper atmosphere during the descent. The key data, reported by entry science team leader Alfred Nier of the University of Minnesota, were the findings of 2 to 3 percent nitrogen, an element vital to all life on earth, and 1 to 2 percent of the by now nearly notorious argon, completely undetectable from earth. Implications could be profound for Viking's search for life on another world.

If, says Michael McElroy of Harvard University, the earth and Mars formed with similar proportions of potassium-40 (of which argon-40 is a decay product), Mars ought to have about 25 times the amount of argon-40 detected by Viking. This suggests that gases have been passing from the lithosphere to the atmosphere much more slowly than they have on earth. This could also apply to water vapor, McElroy suggests, but even if the amount of water vapor released was small, relative to what it might have been, there could still have been a substantial amount. Perhaps anough to account for the seemingly water-related features on the surface. In fact, he adds, all but about one-fortieth of the released water vapor is still in the surface regolith, and the tiny remainder that escaped into space would have been the equivalent of an ice layer three meters thick over the whole planet. So there's plenty left.

If the nitrogen detected by the descending lander emerged at the same slow rate, says McElroy, the early atmosphere of Mars would have been somewhat thicker—but not much—than it is today, perhaps 16 or 17 millibars, including about 7 millibars of nitrogen. About two-thirds of the released nitrogen disappears into space, he says, but the remainder is borne into the upper atmosphere until it dissociates and recombines with carbon dioxide to form nitric oxide, which is heavy enough to fall back to the ground. "So if you like," McElroy says, "the ionosphere is producing a shower of fertilizer for the Martians." Recent unexpectedly low temperatures measured over the Martain south pole which were tentatively attributed to a large inert-gas component in the atmosphere, could, says McElroy, have been due to readings from a layer of ice crystals rather than the surface (SN: 7/10/76, p. 20). □