MIDNIGHT ON THE RED PLANET

From orbital height in the dead of night—taking the temperature of Mars

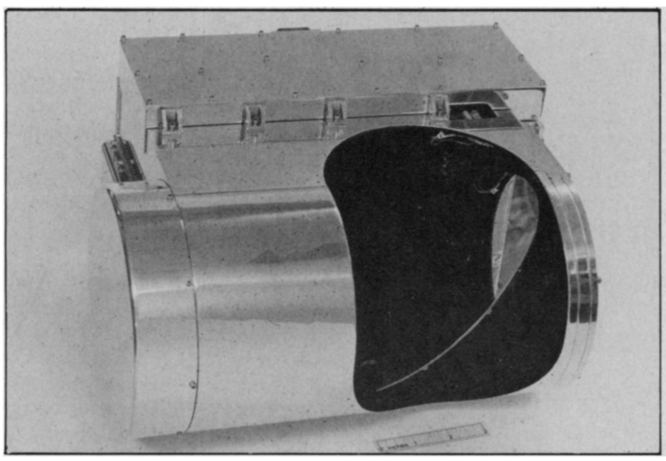
BY JONATHAN EBERHART

Recording the deep chill of the witching hour on Mars is an evocative enough idea—surely there's a short story there somewhere—but it is also important for an understanding of the planet. It is not so much a matter of simply knowing the Martian temperature in the dead of night as of finding out how the different parts of that diverse world cool down from the lesser chill that passes for the warmth of day.

By taking temperature readings at selected times around the clock, it is possible to find out how rapidly the surface materials absorb and give off heat—a property called thermal inertia. This can help determine whether given parts of the surface are dominated by sand, rocks or boulders, while relating also to such factors as the role of the winds in distributing heat around the planet.

The Viking orbiters each carry a heat sensor—an Infrared Thermal Mapper (IRTM)—for this purpose, and have been scanning the planet since the day they arrived, weeks before the landers descended to the surface. In August of 1976, for example, it was the IRTM temperature measurements that led to the conclusion that the Martian residual north-polar cap consists almost entirely of water, since the readings were too high for frozen carbon dioxide but low enough for water ice.

The polar caps, however, respond more to seasonal than to diurnal effects. It is the rest of the surface that requires careful day-and-night study. Readings just before dawn show how cold the ground has gotten during the night; sunrise measurements reveal the beginnings of the day's warming, while readings during the afternoon show just how much heat the surface material has actually taken in. Sundown and the coming of night show the curve reversing, as the stored heat is given off. To complete the cycle, a midnight reading should show the surface approaching its coldest point, which will be monitored in the pre-dawn hours.



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Viking's thermal mapper takes Martian temperatures from orbit.

But the midnight watch is a risky one. The orbiter is normally oriented with its solar panels facing the sun, while the IRTM and other instruments are on a "scan platform" facing the other way to look at sunlight reflected from the planet. Looking at the planet's midnight meridian thus requires waiting until the spacecraft is on the dark side of Mars—the side away from the sun—then turning the craft so that the sensors are pointing in a sunward direction. A direct look at the sun would burn out the sensors, so the maneuver, the data collection and an additional maneuver to return the spacecraft to its original orientation all had to be performed while the orbiter was in the shadow of Mars. (This only happens twice per Martian year, for a few days each time, since the orbit is inclined to pass "above" and "below" the shadow.) Any malfunction delaying the return maneuver would have risked blinding the instruments.

As a result, says IRTM team leader Hugh H. Kieffer of the University of California at Los Angeles, only a single midnight temperature scan has ever been taken. It appears on the cover of this issue of SCIENCE NEWS. Weeks were spent in setting up and rechecking the computer sequence for the maneuver, Kieffer says, and some flight-team members were a bit apprehensive. Even though everything went perfectly, it is probable that the image will remain the only one of its kind, since the reduced size of the present and future Viking flight team makes such tricky maneuvers difficult.

The image is not a photograph, but a compilation of between 5,000 and 7,000 individual data points, taken by orbiter 1 from about 18,500 kilometers away during a period of about 20 minutes. They were processed by a computer to show the lowest temperatures as dark blue, running up through a 256-step spectrum in which the highest temperatures are red. The emissions recorded are in the 18-to-26-micron band—the longest-wavelength channel in the IRTM and the one most sensitive to low temperatures. The best spatial resolution, which is at the center of the disk, is about 100 kilometers. The season is roughly equivalent to mid-August on earth.

As the picture appears on the cover, north is at the top with the near-dawn edge to the east (right). The spacecraft is slightly south of the Martian equator, so that 0° latitude is about 35 percent of the way down from the top. (The equator is curved, since the disk represents the readings as a true spherical projection.) The consistently dark blue region at the bottom is the south polar cap; the huge volcano Olympus Mons is the blue spot near the edge at about the 10:00 position on an imaginary clockface, while the canyon Valles Marineris runs along just below the equator in the red region at right center. A careful look will reveal three dark blue spots in the locations of the other three major Martian volcanoes: Ascraeus Mons (north of the equator on the midnight meridian), Pavonis Mons and Arsia Mons (slanting away from Ascraeus Mons toward the lower left).

The lowest temperature on the disk, says Kieffer, is 139°K (-209.2°F), which occurs at 82°S, just 8° from the south pole. The warm spots, however, are surprising. In an idealized example, one would expect the western edge to be warmest, since it has most recently been in sunlight. The readings would then get colder and colder across the disk from left to right, not to warm up again until the beginnings of dawn, which is just out of sight around the right-hand edge. Instead, the highest temperatures are almost all the way over to the right, at about 15°S, where the IRTM indicates a reading of 180°K (-135.4°F).

Thus the Martian "canyonlands"—the red horizontal swath—seem to have held their heat all night long, giving them what Kieffer says is the highest thermal inertia on the planet. The region of rapid red-to-blue color changes in the upper left, on the other hand, is cooling more rapidly.

The midnight heat map, Kieffer says, fills in a longitudinal arc 135° long in the effort to compile round-the-clock temperature data. Notwithstanding the global picture, however, individual disks still catch the eye. Near the center of the disk, for example, a mottled orange rectangle juts toward the northwest into a blue field. It shows a temperature of 170°K, with sharply contrasting readings of 160°K immediately to the northeast and southwest. It is east of Arsia Mons, in the great southern plains of Mars. "There," Kieffer says, "is where the giant dust storms begin." □