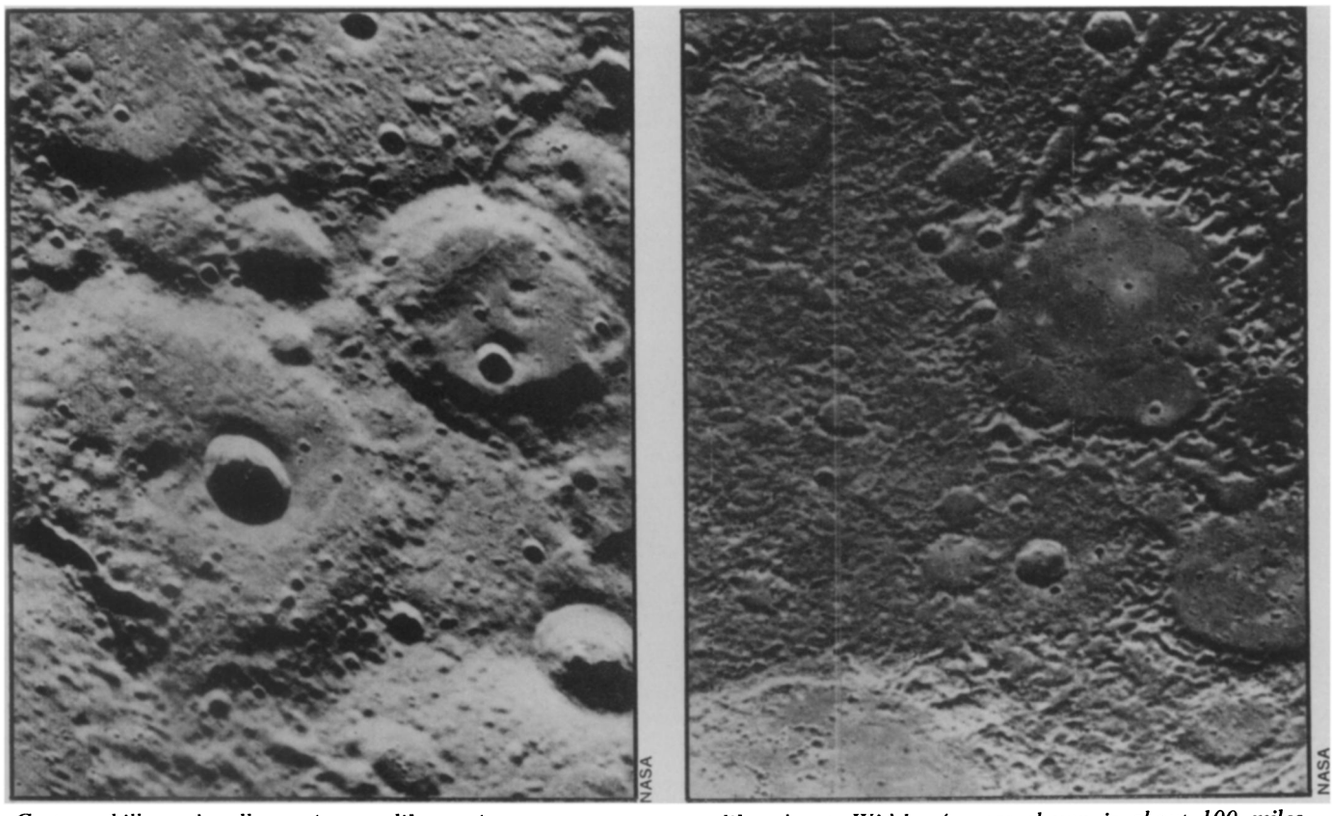
The Strange and Cratered World of Mercury



Craters, hills and valleys: A moonlike surface on a not-so-moonlike planet. Width of areas shown is about 100 miles.

Until last week, the majority of planetologists felt, with good reason, that Mercury was a pretty nothing planet. No atmosphere (the solar wind would blow it away), no magnetic field (the planet's slow rotation would not create the dynamo effect necessary to sustain one), no ionosphere (no magnetic field to trap the ionized particles), no moons. All in all a dull world.

Now it is "strange," "startling," "spooky," and "fascinating," all thanks to a few days of observations by Mariner 10.

The first spacecraft ever to fly by Mercury has taken close-up photos that reveal a heavily cratered surface and transmitted reams of surprising data that invalidates many of the theories about the sun's nearest and smallest planet.

"The thing that surprised me most," says Bruce Murray of the California Institute of Technology, leader of the huge team analyzing Mariner's photos of Mercury, "is that it looks just like the moon." Yet the planet is too dense to be like the moon through and through, one of the few earth-based estimates that Mariner confirmed. The spacecraft precisely pinned down the ratio of the sun's mass to that of Mercury as 6,023,600 to 1 (recent earth-based calculations have contained uncertainties as great as 50,000 to 1).

Mercury's "bright spot" turned out to be this crater within a crater. Astronomers propose naming it for the late planetologist Gerard P. Kuiper.

"If it were really like the moon in terms of the mare flows and the whole business that goes with that," says Murray, "that's a chemical statement . . . that is very inconsistent with the bulk density of Mercury." But in fact Mercury seems to embody just such an inconsistency: a lightweight, moon-like surface enclosing a heavy, earth-style center. Says Murray, "It could easily have a large iron core."

Finding out just how much of the planet is core will take weeks or months of computer analysis of the subtlest changes in the spacecraft's path. The resemblances to earth's moon, on the other hand, are readily apparent. The entire surface is pocked with crater upon crater, like the bleak highlands of the moon. Some are young enough —perhaps tens of millions of years— that dust or the darkening effects of the solar wind have not had a chance to hide the light-colored rays left by material blasted outward during the craters' formation. But the exciting ones are the old craters. Murray believes they may be relics of the planet's

origin, well over 4 billion years ago, since there are traces of no planetwide events since then that could have covered them up. There are a few piled up cliffs, or scarps, but none of the vast fissures or mountain ranges that characterize the past of the moon.

Yet there is more to the lunar resemblance, including vast smooth areas like the maria and level-floored craters filled in by some still-not-identified process. This fine material, in fact, may be Mercury's most moonlike part, blanketing the planet in a remarkably even layer perhaps a few centimeters deep with "almost no exposed rocks." So says David Morrison of the University of Hawaii, whose readings of infrared emissions suggest a surface layer with moonishly low thermal conductivity, the same high porosity and other similar features. An astronaut walking on Mercury, he says, would leave footprints very much like those on the moon.

One of the jobs of Morrison's experiment was to measure the planet's widely ranging surface temperatures. Daytime readings, measurable from earth, get as high as 800 degrees F., depending on Mercury's distance from the sun. A Mercurian night, however, is 88 days long, giving the surface plenty of time to cool off. As Mariner 10 crossed the planet's terminator, or twilight zone, the temperature fell from about 370 degrees above zero to 200 degrees below zero in only a few hundred kilometers on the surface, then kept on dropping to about 280 below. This gives Mercury a temperature range of more than 1,000 degrees F., by far, says Morrison, the widest in the solar system.

A major surprise was the discovery that the supposedly airless world has an atmosphere. Harvard astronomer Edward Reeves has privately reported signs of one in data from Skylab, recorded when Mercury passed in front of the sun, but the idea seemed so unlikely that he is said to have been discouraged from publishing his findings. The atmosphere is extremely thin, less than one hundred-billionth as dense as earth's, says Michael B. McElroy, also of Harvard, but is indisputably there. The major element is helium, measured out to as far as about 300 miles from the planet, possibly delivered by the solar wind. Another source may be the decay of radioactive materials within the planet. This, according to McElroy, could mean that Mercury has as much uranium and thorium in its crust as does earth.

Other gases include argon, another decay product, neon from the solar wind, and possibly xenon. Conspicuously absent, except for a possible trace near the surface, was hydrogen, which was earlier reported as "extensive" by Soviet astronomer Nikolai Kozyrev.

The most significant discovery about the atmosphere, says A. Lyle Broadfoot of Kitt Peak National Observatory, was the existence of a helium "tail," streaming out from Mercury in a direction away from the sun. It was significant because shaping the tail was another unexpected Mercury feature, a magnetic field.

Norman Ness of NASA's Goddard Space Flight Center was another who expected the planet to have, at least to his magnetometers, a lunar look. It didn't. "It has turned out that Mercury is not at all like the moon." About 20 minutes before the spacecraft reached its closest distance to Mercury (about 466 miles), there were very clear signs of a bow shock, a shock front formed by the solar wind ricocheting off the planet's enveloping magnetic field, of which the moon has little or none.

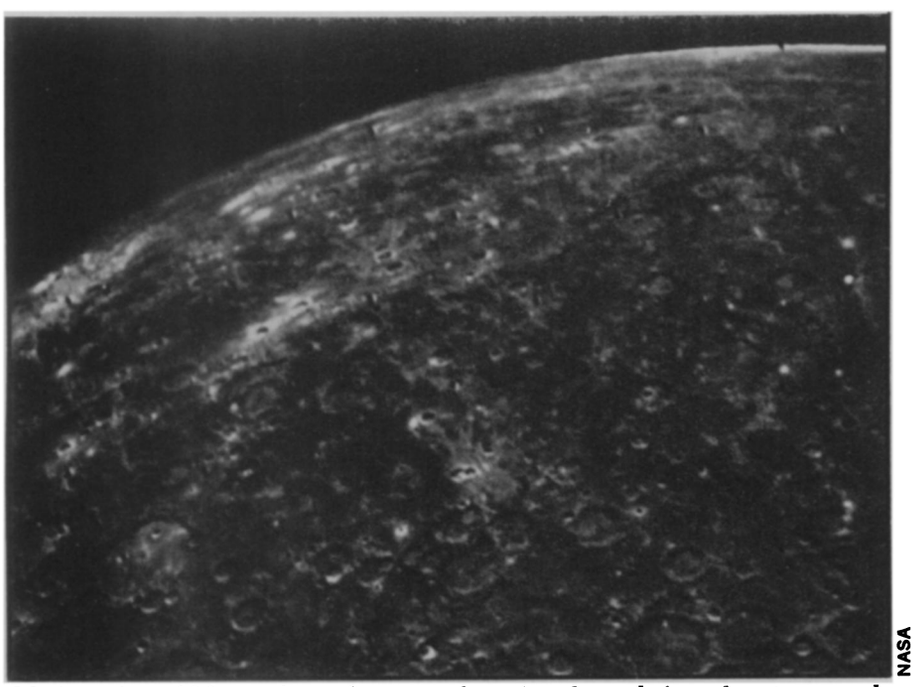
Mercury's magnetic field, it seems, is not completely enveloping. It is so weak—as little as a thousandth as strong as earth's—that the minute push of the solar wind perhaps does not even let the field lines close on the side away from the sun. This would mean that trapped charged particles stream continuously off into space, and that the surprisingly abundant high-energy electrons reported by University of Chicago's John Simpson must be continuously replenished by some mysteriously potent source.

Another mystery is the source of the magnetic field, since the slow rotation of Mercury virtually eliminates the dynamo theory. "The sweeping of interplanetary field lines past the planet," suggests Ness, "may generate an electrical current flow in the planet, and/or a possible weak ionosphere, then generates the magnetic field observed."

The ionosphere, sought directly by H. Taylor Howard of Stanford, did not appear in the earliest analysis of Mariner's data. But the same analysis failed to detect the atmosphere, which is a million times too thin for it, so an extremely weak ionosphere has not been ruled out.

A burst of excitement was generated at the possibility of what would have been one of Mariner's major accomplishments: the discovery of a moon of Mercury. The signs, sudden brightening of the ultraviolet emissions recorded by Broadfoot's spectrometer, appeared repeatedly to the accompaniment of growing excitement. The culprit, however, after checks and counterchecks, seemed at last to have been a star, lined up against phenomenal odds to look in repeated observations as though it were a captured orbiting object.

With flawless—if occasionally misleading—data pouring in from the spacecraft, it came as a shock when engineers at the Jet Propulsion Laboratory in Pasadena discovered that the spacecraft was having some problems. About 30 hours after Mariner 10 passed its point of closest approach to Mercury, one of its two solar panels suddenly began drawing excess power, and the temperature in one equipment compartment shot up about 30 degrees. No data were lost, no experiment suffered, but the heat continued to rush upward, possibly from a short circuit. As the heat rose, optimism fell about the spacecraft's chances of surviving until September when it is scheduled to come around again for its second meeting with Mercury. □



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Mariner view of Mercury's southwest quadrant four hours before closest approach.