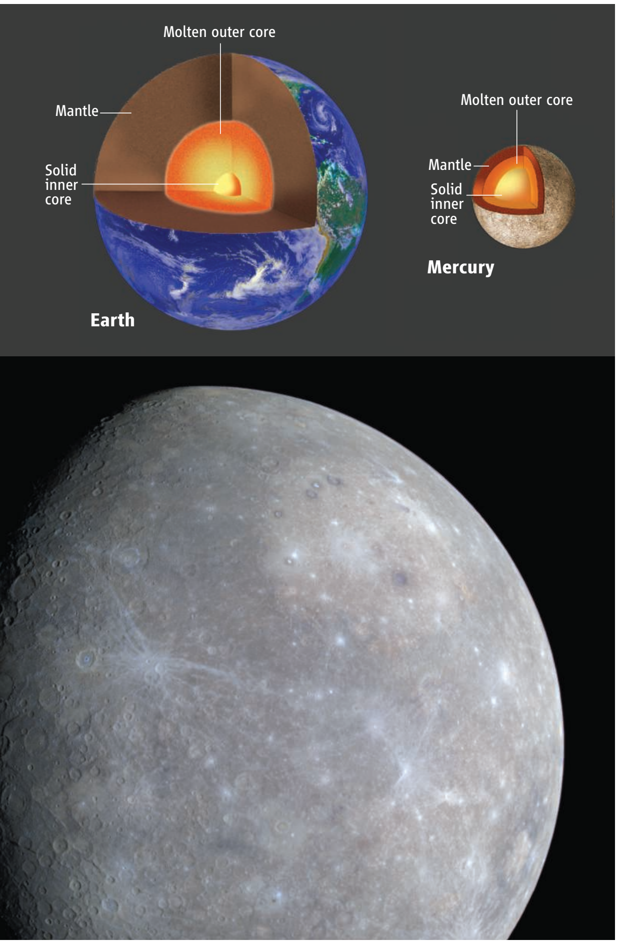
PLANETARY SCIENCE

Mercury Looking Less Exotic, More a Member of the Family

Mercury has always been the odd planet of the inner solar system. The smallest of the four rocky planets at little more than a third the diameter of Earth, it sports an iron core more than half the size of the entire planet Mars. How did such an extreme planet come to be in the same solar neighborhood as Earth, Venus, and Mars? The answer has usually involved extreme conditions: the sun nearly incinerating the stuff that made Mercury or an early cosmic collision that stripped away much of its rock.



Oddball. Extreme conditions at Mercury's formation may not be needed to explain its small size and relatively large core.

But observations from the first spacecraft to orbit Mercury are bringing the littlest planet back toward, if not into, the fold. "There are hints that Mercury is much more like Earth than we thought," says planetary geochemist G. Jeffrey Taylor of the University of Hawaii, Manoa, who is not on the MESSENGER team. "The key thing is that really high-temperature Mercury origins are out. And the materials that made Mercury were similar to those that made all the inner planets. That's pretty amazing."

The move toward family reconciliation comes courtesy of NASA's MESSENGER spacecraft, which went into orbit around Mercury on 18 March. It had already made three quick passes by the innermost planet, as Mariner 10 had made three flybys in the mid-1970s. But for deciphering the fundamental nature of a planetary body, there's nothing like going into orbit around it and probing it close in, repeatedly, and all over.

As MESSENGER team members report in seven papers in this issue of *Science*, some of the early returns only enhance Mercury's reputation for quirkiness. MESSENGER has found that the planet's weak magnetic field is oddly offset toward the north, reflecting something out of kilter in its molten iron core. Unlike all other magnetic fields in the solar system, Mercury's is unable to retain the charged particles that form Van Allen–type radiation belts. And they also found that great outpourings of lava spread across the planet even after it had cooled considerably.

But clues to Mercury's mysterious origins point instead in more conventional directions. The hints came primarily from two instruments that can measure the elemental composition of surface rock from hundreds of kilometers above. One records the spectrum of gamma rays either emitted in natural radioactive decay or excited by galactic cosmic rays hitting the surface. The other instrument picks up x-ray emissions triggered by solar x-rays. Together, analyses of the distinctive spectral peaks of 10 elements confirmed ground-based telescopic observations that Mercury's surface rock has very low iron relative to the other rocky planets. Surprisingly, it has 10 times the sulfur of Earth's rock. And Mercury's ratio of potassium, a relatively volatile element, to thorium, which is relatively nonvolatile, is similar to that of the other rocky planets.

The relatively high abundance of the volatile potassium "eliminated the exotic theories" of Mercury's origins, says Patrick Peplowski of Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, the lead author on the gamma-ray paper. One such theory pictured an exceptionally violent young sun baking the primordial dust that would become Mercury at 3000 K. But that would have prevented volatile elements from ever condensing into the solids that would become Mercury. Another theory had an outburst from the young sun blasting a larger Mercury, evaporating away enough rock to whittle it down to its present size. But again, not enough volatiles would remain.

And a collision of a nascent, larger Mercury with another planetary body of comparable size that stripped away much of Mercury's rock would not have worked either. A giant impact would have heated the planet enough to drive off much of its volatiles, at least in the current crop of giant impact models.

The new results also suggest Mercury was made out of much the same material as Venus, Earth, and Mars. "The potassium, thorium, and uranium match very well with chondritic meteorites," Peplowski says. Those are bits of rock of the sort thought to have been the building blocks of the other rocky planets.

But the x-ray results add a twist. The combination of high sulfur and low iron in Mercury's rock must have come from minerals that could have existed only if Mercury formed under chemically reducing conditions. That sounds bizarre, because all the other rocky planets formed under the opposite conditions: oxidizing ones. In fact, a reducing proto-Mercury could have been perfectly natural, say meteoriticists Denton Ebel of the American Museum of Natural History in New York and Conel Alexander of the Carnegie Institution for Science's Department of Terrestrial Magnetism (DTM) in Washington, D.C. In a paper published online 4 August in *Planetary and Space Science*, they showed that probably only water-free, organics-rich, comet-dust–like stuff would have survived near the sun to make Mercury. With no oxygen atoms from water around, reducing conditions would have prevailed.

While researchers may be paring away the more radical means of making Mercury, they still have a ways to go. Mercury's relatively huge metallic core remains a problem. Researchers have some ideas about that, but they still don't have a clue how the planet got so small. The still-growing trove of MESSENGER data may hold answers. After 30 years of groping in the dark, says MESSENGER team member Larry R. Nittler of DTM, "now we can start modeling the chemistry of Mercury for real." **–RICHARD A. KERR**

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