Mercury: More Surprises in the Second Assessment

The Mariner 10 mission to Mercury produced dazzlingly clear pictures of what seemed from the earth only a fuzzy sphere. The early assessments—that Mercury is moon-like in appearance but has a trace atmosphere and evidence of an intrinsic magnetic field—have been substantiated. Now, after more study, the Mariner 10 investigators are able to quantify their characterizations of the innermost planet. They are finding that the magnetic field does not seem centered on the planet, that high energy electrons and protons are accelerated in some cyclic fashion that is still mysterious, and that Mercury underwent a period of global compression very early in its history.

Because Mercury rotates slowly (once in 58.6 days) and emits no radio emissions that can be detected from the earth, the early evidence for a magnetic field was surprising. The data still do not force one to conclude that there is an intrinsic magnetic field, but the case is strong. Mariner 10 found that the solar wind passing Mercury formed a detached bow shock. If it is not the result of a complicated process that induces a magnetic field around the planet, then Mercury has a significant intrinsic field. That field is apparently not tilted more than 10° away from the pole, but it seems to be offset by 47 percent of the radius of the planet (see page 151). Perhaps it is the remnant of an extinct dynamo.

Since no magnetic field was expected at Mercury, particles were not expected to be accelerated to high energies by the interaction of the solar wind with the planet. But electrons and protons with energies above 100 kev were found. Furthermore, the large fluxes of electrons showed 6-second fluctuations that were at times accompanied by similar fluctuations of protons (page 160). Such well-defined structure was certainly not expected in the streams of high energy particles, and it will probably be quite difficult to find a physical mechanism that will accelerate particles with opposite charges simultaneously.

The morphology of the surface of Mercury is extremely similar to that of the moon, but one set of features seems to be unique to Mercury. Long cliffs or scarps, at least 3 km high and frequently over 500 km long, are widely distributed over the old and heavily cratered regions of the planet. They may be the result of compressional forces in the crust and have no lunar counterpart (see page 169). On the other hand, the tensional features of the moon, such as the graben which are valleys formed where the crust pulls apart, are not found on Mercury.

The scarps can be explained in a direct fashion if Mercury is chemically differentiated into a light silicate crust and a dense iron-rich core, as in the earth. Earth-based measurements of the albedo (the fraction of reflected light) of Mercury indicated a surface similar to the silicate crust of the moon, which has a density of about 3 g/cm^3. Mariner 10 showed that this analogy holds true for specific regions of Mercury as well as the whole disk. Along with other evidence, this indicates that Mercury is not a homogeneous aggregate of solid debris left over from the condensation of the solar nebula, but was chemically differentiated at some point early in its history. The high density of the planet, 5.4 g/cm^3, indicates that an iron-rich core with terrestrial composition would extend outward 75 to 80 percent of the radius of the planet. A very plausible explanation of the scarps is that they were formed by compressive stresses set up in the crust as the core cooled and shrank. Such a large core would also allow an intrinsic magnetic field frozen into Mercury to be offset as greatly as measured by Mariner 10.

Alongside the surprising details of the close assessment of Mercury, the impact of the early assessments should not be forgotten. Lava-flooding of large basins by some sort of volcanism appears to be a stage in the evolution of planets, for Caloris (left half of the cover photo) is similar to Hellas on Mars and Mare Imbrium on the moon. Even more striking, Mercury, like the moon and Mars, appears to have evolved asymmetrically. Rough and heavily cratered crust, thought to be the primordial surface, seems to cover half the planet, while smoother plains seem to cover the rest. Why three of the five bodies studied among the inner planets have such modal asymmetry is perhaps the greatest puzzle of all.

The first pass by Mercury gave pictures of about 25 percent of the planet under good viewing conditions. After orbiting the sun, Mariner 10 will return on 21 September. The second pass, by the south pole, should increase the picture coverage to about half the planet. If the spacecraft continues to function well, a third pass could give still more information next March.

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Nitrogen Fixation: Research Efforts Intensify

Under the pressures of increasing populations and shortages of energy and fertilizer, food reserves have dwindled, and abundance is being supplanted by scarcity. Because of the tightening global situation with regard to both food and energy, techniques that can increase food production without expending large quantities of energy are assuming new importance. Many scientists think that biological nitrogen fixation—the reduction of atmospheric nitrogen to ammonia by bacteria and blue-green algae—is one key to attaining this goal.

Ammonia availability is critical to agriculture because the supply of such fixed nitrogen frequently limits field crop productivity. If not produced naturally by soil microorganisms or by release from soil minerals, it must be applied in the form of commercial fertilizers; but the Haber-Bosch process, the current industrial process for ammonia synthesis, consumes large quantities of fossil fuel energy (see box).

Participants in a recent symposium* considered all aspects of the nitrogen fixation problem—everything from its economic and agricultural ramifications, to the genetics of the organisms that fix nitrogen, to the biochemistry and

* International Symposium on Nitrogen Fixation, sponsored by the Charles F. Kettering Research Laboratory and the National Science Foundation, 3 to 7 June 1974, Pullman, Washington.