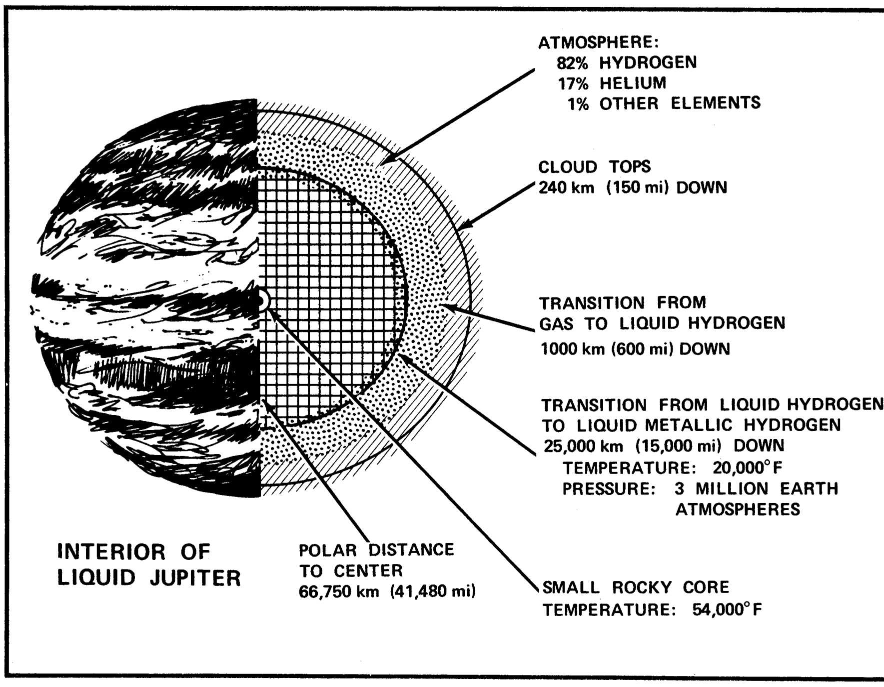
Jupiter: The Planetless Planet?



Illustrations: NASA

Pioneer 10 scientists probe further into the solar system's second biggest ball of hydrogen

by Jonathan Eberhart

What is Jupiter? Its vast size and near-primordial mix of elements almost seem to suggest that it is a former candidate for starhood that failed to ignite, but William Hubbard of the University of Arizona estimates that it never stood a chance—it would have had to be some 80 times larger to be capable of generating a star's self-sustaining reactions. Yet Hubbard and the other scientists analyzing Pioneer 10's flight past Jupiter last December (and awaiting Pioneer 11's repeat later this year) have found that, for all its size, the giant planet may scarcely be a planet either.

If there is a real, rocky world beneath those multicolored clouds, it is a tiny one, squeezed into the bottom few percent of Jupiter's 44,000-mile depth and tortured by 54,000-degree F. temperatures more than six times hotter than the surface of the sun. Everything else is atmosphere, or more precisely, a sort of atmosphere-ocean continuum in which the gas of the uppermost levels is compressed to near liquidity as little as 600 miles down. Barely 35 percent of the way down, at about 15,000 miles, the liquid hydrogen that is most of Jupiter (even the upper atmosphere includes only 17 percent helium, with an additional one percent for "other") starts becoming liquid metallic hydrogen. Not a solid, exactly—solid hydrogen at temperatures of tens of thousands of degrees is difficult to conceive, Hubbard points out—but at pressures millions of times greater than earth's sea-level atmosphere the definition of a liquid may be largely academic.

And the whole planet seethes. Vast convection currents roam up and down throughout the hydrogen ball, although Hubbard estimates that because of Jupiter's great size and gravitational pull they could take from 10 years to a century to travel from the center to the cloud tops. The long, ponderous scale of changes on Jupiter, says Andrew Ingersoll of the California Institute of Technology, could mean that the famous Great Red Spot, known to earthly observers for centuries, is about as significant on the giant planet as a rather lengthy hurricane of a few weeks duration on earth.

In the upper reaches inhabited for the present by the Red Spot, however, the pace of events is anything but leisurely. The features of Jovian "weather" are driven by a strong Coriolis force opposing a planet rotating at about 22,000 miles an hour, which, says Ingersoll, is probably the major reason for Jupiter's strikingly banded appearance. Features that would be large cloudy regions on earth are pulled out into continuous stripes. Yet even among the stripes, all rotating in the same direction, the differences in speed between slower and faster stripes can produce shear winds as fast as 300 to 400 miles an hour. It is even possible that it is such a difference that holds the Red Spot in place, like a ball bearing turning between two surfaces moving in opposite directions. Computer simulations of Jovian weather using Pioneer 10's data suggest, in fact, that apparent vortex-type features such as the Red Spot (Pioneer 10 photographed several others) may be able to exist only along such shear lines, where the adjacent faster and slower winds can sustain their spin.

The light and dark bands that girdle the planet are believed to be alternately cooler and warmer, and higher and lower, regions. The wide, white zones, according to Pioneer 10's information, seem to be about 15 degrees cooler and about 12 miles higher in the atmosphere than the darker belts. The light color is probably that of ammonia crystals, while the darker stripes may mark the presence of sulfur in the form of ammonia hydrosulfide crystals. Farther down may be frozen water crystals and possibly even liquid water, the Pioneer researchers suggest, although water has never been observed there.

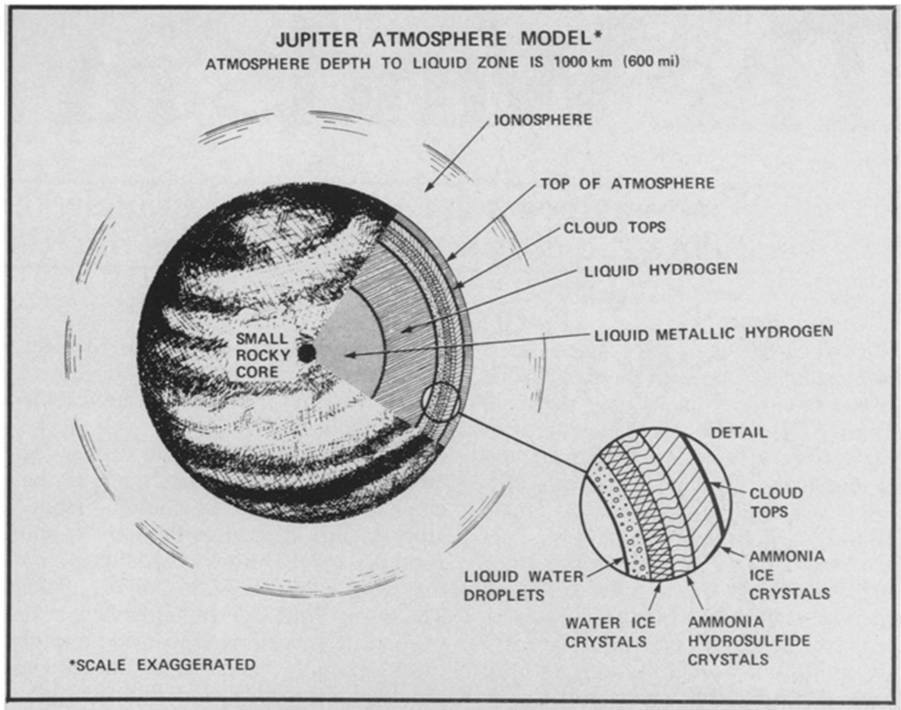
Above the visible clouds lies Jupiter's invisible outer atmosphere, extending possibly as much as another 150 miles. Guido Munch of the California Institute of Technology believes that this outer layer may contain not only some ammonia, but enough mixed-in methane to absorb the sun's heat and create a temperature inversion, perhaps 21 miles above the cloud tops. Above that, there may be a layer of aerosol droplets and hydrocarbons such as ethane and acetylene (detected from earth-based infrared measurements) which also add to the heat absorption. These high, invisible, heat-absorbing layers may be the reason that one of Pioneer's experiments, a radio-occultation measurement, showed significant heating in the atmosphere to begin at much higher altitudes than was indicated by Munch's infrared heat-mapping device (SN: 4/13/74, p. 236).

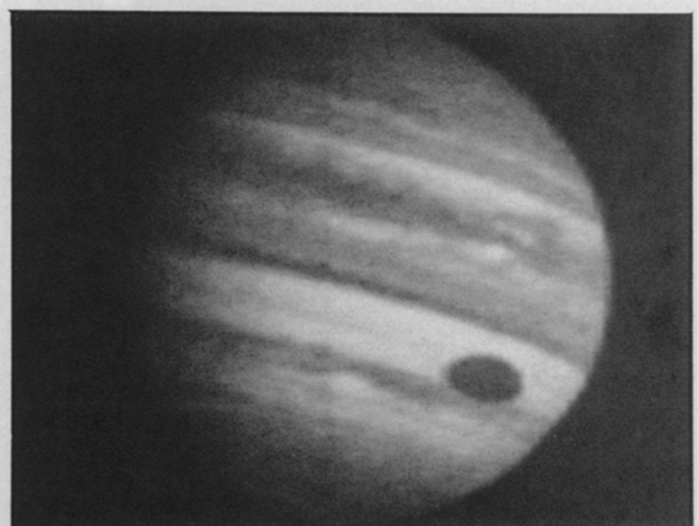
Resolving this discrepancy may be possible with further study of Pioneer 10's data, abetted by that from the identical instruments aboard Pioneer 11, due at Jupiter in early December. But more likely, says Pioneer project scientist John Wolfe of NASA's Ames Research Center in California, is that neither the Pioneers nor the scheduled Mariner Jupiter-Saturn mission to be launched in 1977 will solve the riddle. The answer, he feels, may require sending a probe into the Jovian atmosphere itself. Ironically, says Wolfe, the dust particles that have also been hypothesized in such a heat-trapping layer might well cause a thermal plasma around the probe, which would block radio signals to earth confirming the very phenomenon that censored the message.

Although probeless like its predecessor, Pioneer 11 will have its own contributions to make. Unlike Pioneer 10, it will fly clockwise around the planet, as well as completing a greater arc on its way back across the solar system to a September 1979 rendezvous with Saturn. As a result, it will sweep through 360 degrees of Jupiter's huge magnetic field, at the same time approaching to within little more than half Pioneer 10's closest distance to the planet. Besides refining magnetic, atmospheric, solar wind and other measurements, Pioneer 11 will provide another look at Jupiter's vast—and lethal—radiation belts.

In the few minutes Pioneer 10 spent in the most intense part of the belts, it absorbed 1,000 times the radiation dose required to kill a man. Carefully "hardened," or radiation-proofed, probes may some day be able to spend short periods in the intense zones, but human researchers may be limited in the foreseeable future to looking on from the outermost of Jupiter's major satellites, Callisto.

Io, the innermost large moon, has become of particular interest since Pioneer and other data have indicated it to have an atmosphere (possibly including methane snow), an ionosphere (apparently including a sodium cloud extending more than 200,000 miles into space, suggesting to some researchers a surface layer of sodium chloride—table salt) and a mysterious hydrogen cloud reaching a third of the way around its orbit. An international, 10-day "Io week" beginning Nov. 6 will focus observations on that intriguing world. □





From invisible top to inaccessible bottom, the Jovian atmosphere (above) is still largely an educated guess. Photos of banded clouds (right) are combined with meteorology from earth in efforts to understand Jupiter's windy weather.