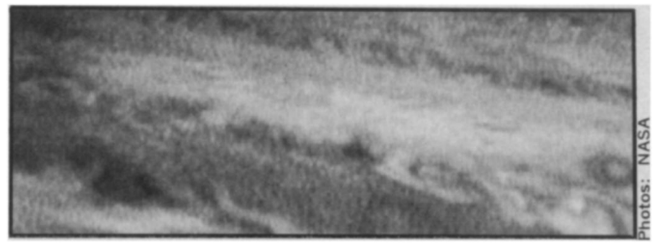
Jupiter revisited: The Rosetta Stone



Continent-sized swirls of cloud span northern Jupiter.

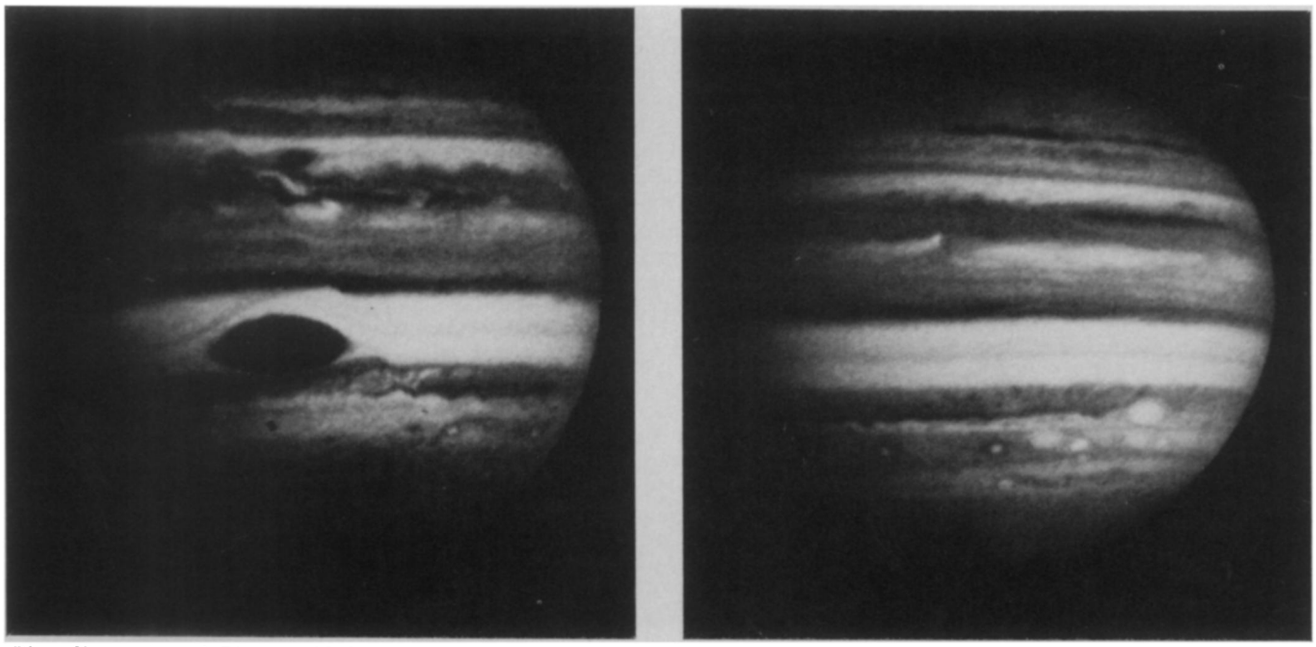
The teams of scientists studying Mariner 10's recent encounters with Venus and Mercury are not the only ones keeping insomniac hours. It's been scarcely four months since Pioneer 10 gave earthlings their first good look at Jupiter, and the Joviologists are still finding new causes for excitement every time they reexamine their data.

One of Jupiter's great unsolved mysteries, which may stay that way for years to come, is whether there is actually a solid planet there at all. Thousands of miles beneath the brightly colored clouds of the upper atmosphere, it is quite possible that future investigators will find nothing but more atmosphere, packed increasingly tightly until it gradually becomes a hard core of metallic hydrogen. Yet even without a planet, the vast ball may be the Rosetta Stone of the solar system, trapping its component gases with a mighty gravitational pull that has thus preserved a permanent record of what materials were available when the planets were being formed. "The hydrogen and helium in the solar system were created in the first few minutes of the 'big bang,' " says Robert Carlson of the University of Southern California, "so what we have measured in Jupiter's atmosphere was made at time zero."

What they have measured, by repeatedly refined studies of the planet's reflected ultraviolet light, is a mixture of 84 percent hydrogen and 15 percent helium, with one percent left over for methane, ammonia and other molecules. Acetylene and ethane are among the leftovers, says Stephen Ridgway of Kitt Peak National Observatory (SN: 2/9/74, p. 91), and last week Ridgway's earth-based infrared spectra added phosphene (PH_3) to the list.

The biggest atmospheric surprise has confronted Arvydas Kliore of the Jet Propulsion Laboratory, who has been analyzing the record of Pioneer's radio signal as it penetrated deeper and deeper into the atmosphere while the spacecraft passed behind the planet. Earth-based measurements of the temperature of Jupiter's upper atmosphere, says Kliore, have recorded no higher than about 220 degrees F. below zero. Yet Pioneer's data have now revealed that at a pressure of only half that of earth at sea level, apparently less than 125 miles down into the Jovian atmosphere, temperatures rise to a boiling 260 degrees.

Farther down, at about 2.8 earth atmospheres of pressure on the day side of the planet and 2.4 in the darkness, temperatures are indicated as high as 800 degrees. The surprise is that the heating should begin at such lofty altitudes, particularly with no indications either from earthly observations or from the infrared mapping device aboard the spacecraft. "It's a huge discrepancy," admits Kliore. "I can't explain it." The closest thing to a theory is that perhaps a haze or dust layer, while confusing watchers on earth, creates a greater greenhouse effect than anyone had expected, trapping and building the sun's incoming energy to unanticipated heights. (Jupiter was known even before Pioneer 10 to radiate at least two and a half times as much energy as it gets from the sun.



Blue filters aboard Pioneer 10 bring out the red spot, dark-rimmed white cloud tops and the newly seen giant plume.

This estimate will certainly rise, though Kliore says it will probably be somewhat less than double.)

Discrepancy or no, the Pioneer scientists are elated at the discovery, which bodes well for future explorations into the depths of the Jovian atmosphere. The higher temperatures mean a more diffuse atmosphere, which would present a smaller than predicted shock to a diving atmosphere probe. The large amount of hydrogen would provide good cooling during entry, and Pioneer's improvements in knowledge of the shape and gravity of Jupiter would allow flight controllers to better calculate the risky, shallow entry angle such a probe (launched from another spacecraft in orbit around the planet) would require. This could knock as much as five years off the time needed to produce a probe capable of withstanding a colder Jupiter.

The giant planet's wonders, however, extend beyond its atmosphere, and Pioneer is now revealing that they reach very far indeed. For a month before the spacecraft flew by the planet last Dec. 3, the University of Chicago's John Simpson had been recording huge, periodic bursts of highly energetic charged particles. Increasingly fine-toothed analyses of the data have now shown that the bursts were in evidence while the spacecraft was still six months away, writing Jupiter's signature across 100 million miles of sky. During the last third of that time, they even carried the 10-hour cyclic variation of the planet's rotation. "It looks," says Simpson, "as though we have gone from a region where the sun dominated . . . to a region where Jupiter dominates."

On the same titanic scale is the planet's strange magnetic field, which now looks considerably stranger. The real-time surprise of the mission occurred when the spacecraft, traveling inside the bow shock that is the junction between the magnetic field and the solar wind, passed back out of the bow shock and more than 10 hours later popped back in. The data tapes now show that when leaving the vicinity of the planet, Pioneer crossed the shock wave no fewer than 17 times.

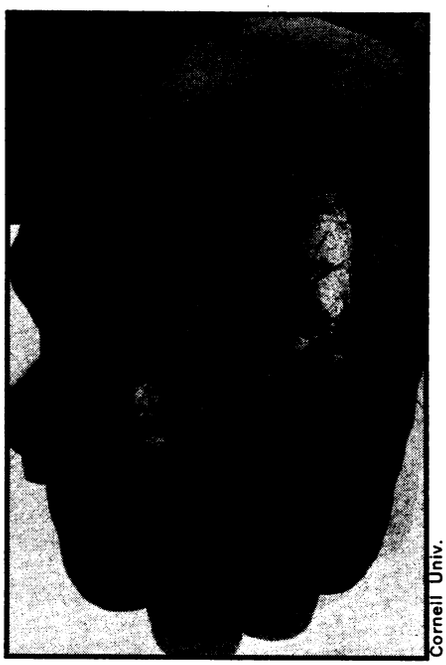
Where the sides of the shock cross Jupiter's orbit, the width of the field is some 80 percent of the mean distance between Venus and the earth. The radiation belts trapped within the field are similarly enormous, and intense. Unexpectedly vast numbers of high-energy electrons were as much as 1,000 times greater than the most extreme earth-based predictions, and make themselves felt millions of miles out in space. "We've been monitoring Jovian trapped radiation for years and years," says NASA's James Trainor, "and didn't know what it was."

Computer enhancement of Pioneer's photos of Jupiter show that it is fittingly spectacular. Several additional red spots range up to about a third the size of the famous one, which could easily swallow half a dozen earths. These, along with numerous surprisingly clear white spots, seem indeed to be rising convection cells, heated from below. Dark borders surrounding the white spots may simply be the overturning edges of the cells, where warmed vapor droplets or aerosols cool upon reaching the cloud tops and begin their cyclic descent. The most conspicuous feature, never before seen by man, is a 600-mile-wide cloud head emerging near the equator, trailing an 18,000-mile cloudy plume that may be driven by a violent Jovian jetstream roaring overhead at some 300 miles an hour. Chains of remarkably symmetrical whorls of cloud extend for several times the diameter of the earth along the sharp-edged belts of Jupiter, a planet to remember—and to visit again. □

A piece of the earth's core?

A group of Cornell University scientists believe that specimens of a mineral they have analyzed in their laboratory are pieces of the earth's outer core. If confirmed, the rocks would be the first samples of the core ever identified. The core's outer boundary lies at a depth of 2,900 kilometers, nearly half the distance to the center of the earth.

The evidence was reported this week at the annual meeting of the American Geophysical Union in Washington by Cornell geologists John M. Bird and Maura S. Weathers and chemists George H. Morrison and Robert I. Botto.



Cornell Univ.

Josephinite: Origin in earth's core?

The specimens are of the mineral josephinite, an iron-nickel alloy found along Josephine Creek in the Klamath Mountains of southwestern Oregon. Josephinite is apparently unique, having no resemblance in size, texture or total composition to other terrestrial iron-nickel minerals. The density of the rocks precisely matches that of the earth's outer core, determined through accumulation of seismic data.

The strongest evidence that the rocks are from the earth's core is the particular appearance of garnet in them. The garnet is aligned in strange, maze-like patterns that outline the crystal structure of the metal in the rock. The Cornell scientists regard the configuration as proof that the garnet became exsolved from the iron-nickel alloy in the solid state. They believe that this phenomenon could only have occurred as a result of the relaxation of pressure as the materials ascended from the inner earth.

"We propose that the josephinite is outer core material, having come from the core/mantle region of the earth's interior," say Bird and his colleagues.

How the material reached its present location is explainable by ramifications of the theory of plate tectonics. The material rose to the surface by some kind of convection mechanism as part of a slowly ascending plume of material from the deep mantle. It became incorporated in the Pacific crustal plate—a vast segment of the earth's crust and upper mantle underlying the Pacific Ocean. Westward movement of the Pacific plate eventually brought the portion containing the josephinite into contact with the Americas plate, where it was pushed up into its present location in the Klamath Mountains. □

Evidence for weakening gravity

Several theories of gravity propounded by modern cosmologists call for a gradual decrease in the strength of the force of gravity as the universe ages. But the most generally accepted theories, Newton's and Einstein's, hold the force of gravity constant throughout the ages. They explain most things so well that to cast doubt upon them requires discovery of some effect of weakening gravity that one or more of the other theories perdicts.

Now Thomas Van Flandern of the U.S. Naval Observatory reports that he has discovered such evidence for a