Forecast:
High Winds and Methane Rain

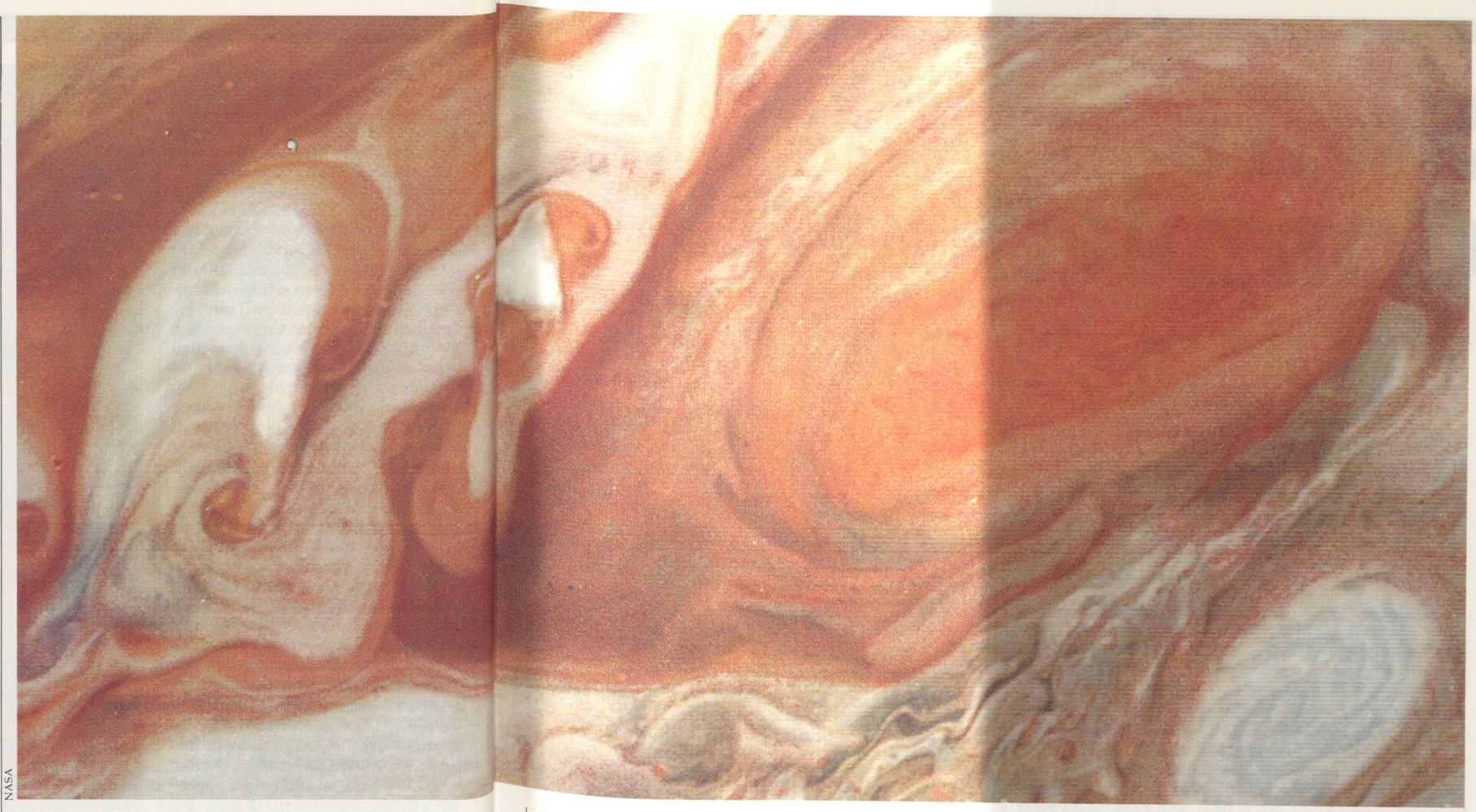
by Stephen Haines

The several thousand images of Jupiter and Saturn gathered by the Pioneer and Voyager spacecraft have produced "an explosion of knowledge," according to Dr. Garry Hunt of Imperial College of Science and Technology in London. Hunt, an atmospheric physicist, spoke recently at NRC about the weather patterns observed on the two giant planets. Although the pictures indicate conditions alien to the earth's weather patterns, Hunt stressed the many surprising similarities between Jupiter and Saturn that researchers have found.

Both planets exhibit a banded appearance, an observation detected by earth-bound telescopes and confirmed in detail by the spacecraft cameras. The bands are formed by the action of high-speed, eastward and westward winds that move cloud tops across the atmospheres. Eastward winds, which blow in broad bands at very high speeds near the equators of both worlds, also appear in narrow jets of lower speed away from the equator and are much stronger than their equally narrow westward blowing neighbors. Each planet's streaked appearance seems reasonable in light of their size and angular speed of rotation — ten times bigger than earth and spinning between two and three times as fast.

Meteorologists are concerned with the "energy budgets" of the atmospheres they study — that is, where the energy is introduced into the atmospheres, and how it moves about. Jupiter and Saturn both manage to provide something extra for their budgets which Earth does not — they produce more heat internally than they receive from the sun. Unlike the earth, where activity is driven by solar heat at the equator and energy moves to the poles, heat from the interiors of Jupiter and Saturn keeps the average temperature from each pole to the equator nearly constant.

Among Jupiter's surprises is the Great Red Spot (GRS). Its angry, carmine colour was first observed in 1664, and it was identified as an atmospheric storm of astonishing size and duration. Hunt, who is a member of the Voyager imaging team, noted that the GRS is but one of many large oval spots scattered between the equator and about 45° North and South. They are cooler than their surroundings with the circling winds similar to high pressure zones on earth. They also appear and disappear in a matter of years — the GRS is unique in its longevity. Why all of the storms except the GRS are white remains a mystery. Hunt



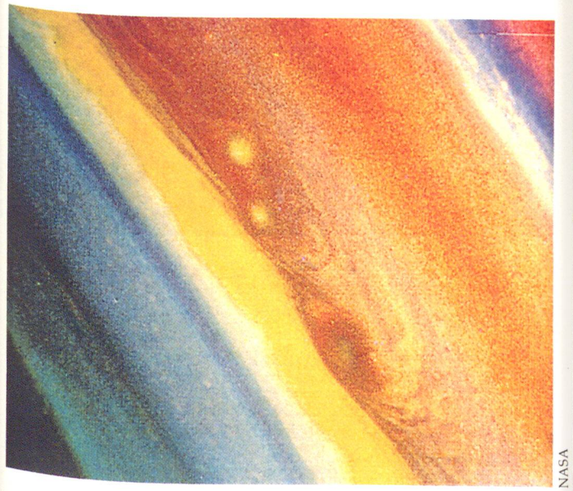
NASA

The smallest detail that can be seen of this view of the Great Red Spot is less than 100 km across. Both red and white spots exhibit similar patterns, differing only in colour. The eddies are from wind blowing from the east (right).

suggests the Red Spot may be much deeper than the others and that its colour comes from phosphorus produced by sunlight at the cloud tops from phosphine (PH_3) brought up from deeper layers, trapped by it and not by the white spots.

Saturn's more monochromatic appearance belies an atmosphere even more active than Jupiter's. Also banded, Saturn has much faster winds — 1500 km/h at the equator compared with Jupiter's 500 km/h — but lacks the large eddies and massive storms of the larger world. Like Jupiter, Saturn produces more heat than it receives (about two to three times as much), which is responsible for its greater convective activity. According to Hunt, this internal power is the cause of Saturn's haziness in the upper atmosphere. The haze appears to be methane droplets and the layer acts in many ways like the ozone layer high in our own atmosphere where many strong chemical reactions take place.

Hunt cautioned that, although he favoured the idea that internal heat drives the weather on the two planets,



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Close-up views of Saturn revealed numerous features not previously observed. In this picture, a high pressure storm more than 3000 km in diameter and two smaller convection cells are visible. A narrow wind stream, moving at 150 m/s, flows along the top of the yellow band above.

another theory based on solar radiation as the driver has been recently proposed for Jupiter. This computer-generated model applies the mathematics of earth's weather mechanisms and assumes that the Jovian wind patterns are not all that deep. According to the model, solar heat at the equator initiates north-south air movement in a shallow layer at the top of an atmosphere that is thousands of kilometres deep. The moving air is then swept to one side by planetary rotation. The process continues until the atmosphere exhibits a series of alternating eastward and westward wind belts — the chief characteristic observed on Jupiter. Large eddies in the system are the white (and one red) ovals which are part of the energy transfer mechanism. Heat coming up from the planet dissipates through this zone too slowly to have significant effect.

Resolution of these theories will have to wait for Project Galileo, set for launch to Jupiter in 1986. This "third generation" of remote explorers will orbit the planet and send probes into the atmosphere. The information they transmit before sinking into the sea of liquid hydrogen hidden far beneath the clouds will indicate what activities are taking place in the regions we cannot now see.