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# NATIONAL GEOGRAPHIC

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SEE "DIVE TO THE EDGE OF CREATION" MONDAY, JANUARY 7, ON PBS TV

**U**NTIL RECENTLY, the very idea of seeing an atom in motion seemed the wildest of fantasies. But this spring you will see one, that tiniest bit of an element, filmed by scientists at the University of Chicago. It is a part of an hour of wonders called "The Invisible World"—third in the new season of National Geographic Specials to be shown over television stations of the Public Broadcasting Service.

We are pleased to offer once again four American-made programs of quality, taste, and family interest, coproduced with Pittsburgh's PBS station WQED. And, for the fifth year, Gulf Oil Corporation support has made this series possible.

Our season opens on January 7 with "Dive to the Edge of Creation," an experience you will long remember. Geologist Robert D. Ballard and biologist J. Frederick Grassle of Woods Hole Oceanographic Institution take us to the floor of the Pacific Ocean where, a mile and a half down, two of earth's crustal plates are separating. In this rift zone, molten lava wells up and hot springs nourish strange life forms.

On February 4, "Mysteries of the Mind" examines the awesome capabilities of the human brain. It features a special Plexiglas model of a section of the brain in action. A yogi in India consciously lowers his blood pressure, a paralyzed woman in New York raises hers, posing unanswered questions about the mind's control of matter.

In addition to the electron-microscope pictures of the atom, "The Invisible World" on March 3 features extraordinary slow-motion, infrared, ultraviolet, and X-ray photography used to fathom such mysteries as honeybee navigation, the basic structure of matter, even the health problems that afflicted ancient Egyptians.

The season concludes on April 7 with "The Superliners: Twilight of an Era," a fond memoir of the life and times of great Atlantic ocean liners such as *Mauretania* and *Lusitania*, *Queen Mary*, *Normandie*, *United States*, and *Queen Elizabeth 2*. Only the last is still in service; with the passing of the rest, an era of elegance also vanished.

We hope your family will enjoy and learn from these programs. Other specials like them have proved that television can be both informative and popular.

*Silvestro Brown*

# NATIONAL GEOGRAPHIC

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January 1980

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*Succeeding beyond scientists' dreams, two spacecraft discover a ring around the largest planet and active volcanoes on its moon Io. By Rick Gore, with photographs by NASA.*

## Long-eared Owls— Masters of the Night 31

*Photographer Art Wolfe takes a look into the homelife of a winged, deadly predator.*

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*Lush grasslands once mantled much of the central United States; now controversy snarls efforts to preserve a few remnants. By Dennis Farney and photographer Jim Brandenburg.*

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*On this northernmost and least populated Japanese island, Douglas Lee and photographer Michael S. Yamashita find wildlife and wild country—and a hardy people with pioneer spirit.*

## Utah's Art Galleries in Stone 97

*Former park ranger Gary Smith records canyon figures and scenes left by a people lost in time.*

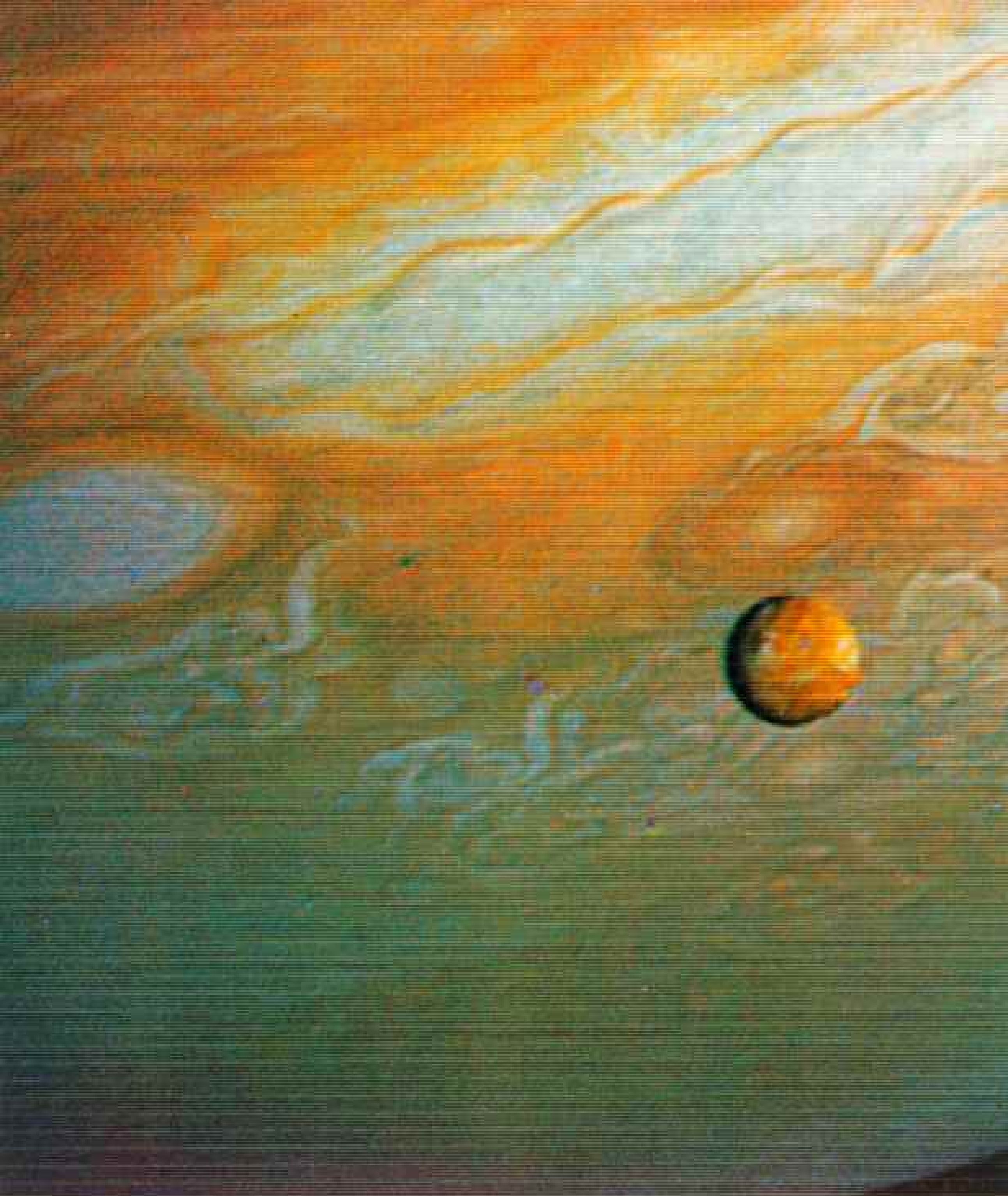
## Fair of the Berber Brides 119

*In Morocco's Atlas Mountains, Carla Hunt and Nik Wheeler visit a festival that brings couples together for instant marriage.*

## Life Around a Lily Pad 131

*From diatoms to snapping turtles, thousands of creatures share a mini-world that subsists on and about a single floating leaf. Photographs by Bianca Lavies, with text by Charles R. Miller.*

**COVER:** *The solar system's only known active volcanoes beyond earth fling material high above the sulfurous crust of Jupiter's moon Io. High-contrast image by Voyager 1, NASA.*



# What Voyager Saw: Jupiter's

By RICK GORE NATIONAL GEOGRAPHIC SENIOR STAFF

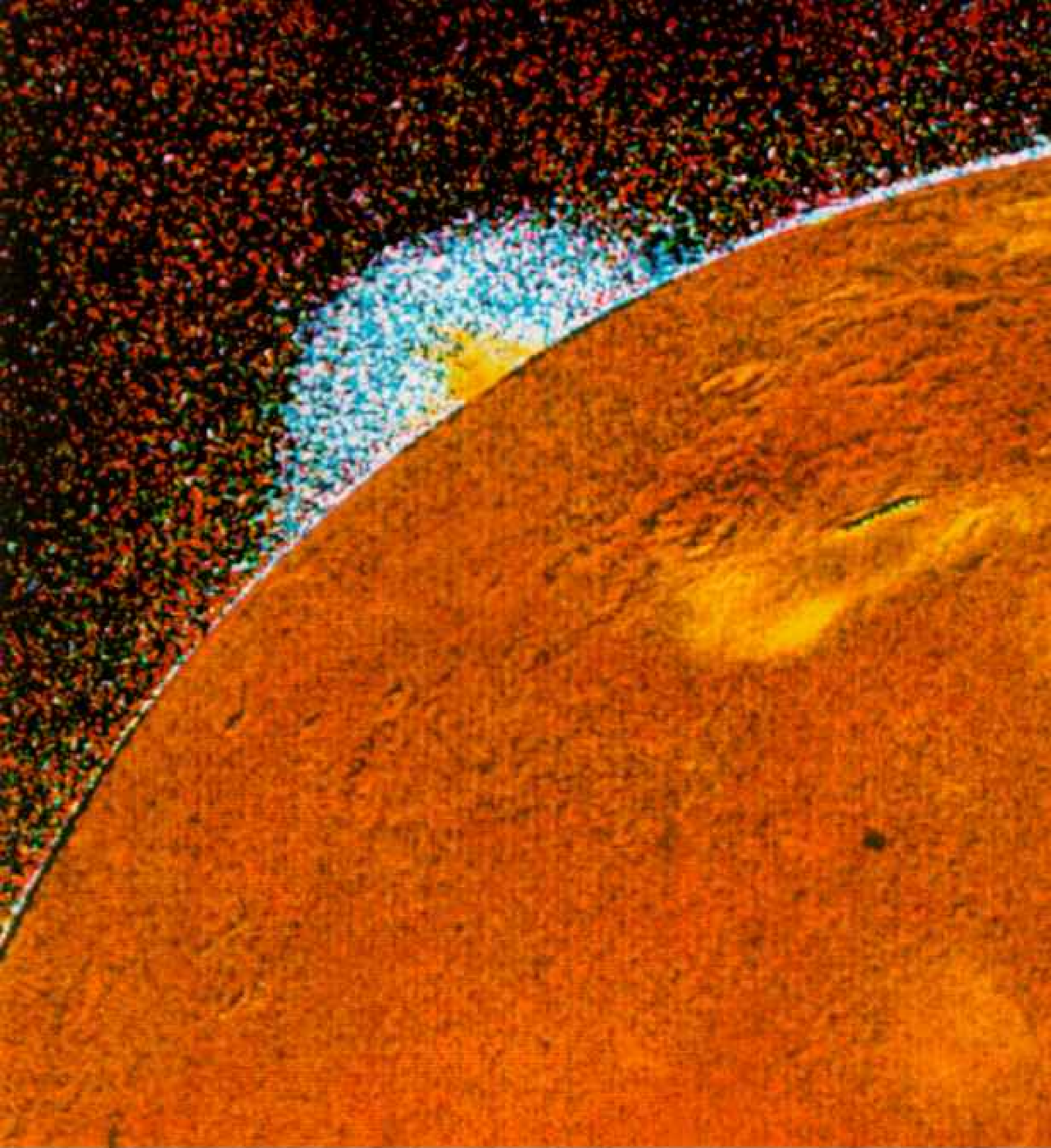


Volcanic in orbit: giant Jupiter

# Dazzling Realm

Photographs by NASA

Two small spacecraft find worlds so bizarre and unexpected that at first scientists could only shout like seamen making landfall at an undreamed of archipelago



**T**HE EXCITEMENT was subsiding at the Jet Propulsion Laboratory on Friday, March 9, when Linda Morabito made her discovery. Most members of the Voyager imaging team, exhausted by days and nights of nonstop encounter with Jupiter and its moons, were taking a long weekend off. But Morabito, one of the unsung navigation engineers who had steered Voyager 1 on its picture-taking flight past Jupiter, was at work.

Jupiter's gravity field had already flung Voyager 1 off toward Saturn for a late 1980 rendezvous. Now Morabito was doing a low-priority, post-flyby check on the orbits of Jupiter's moons.

Her team steers by the stars. She sat at a computerized imaging module and called up onto its screen a picture that Voyager 1 had taken looking back at Jupiter's odd moon Io. Near Io she expected to find a star named AGK3-10021. Its exact location relative to Io



**S**ULFUROUS FOUNTAIN leaps up against the black of space from the limb of Io, Jupiter's innermost large moon (left, shown in false color).

Scientists had deduced that surface pocks (bottom) were volcanic calderas, some larger than any on earth. Engineer Linda Morabito (below), while doing routine navigation checks, spotted a plume rising 280 kilometers (174 miles)—first evidence of active volcanism beyond earth.



ALBERT WOLDVAY



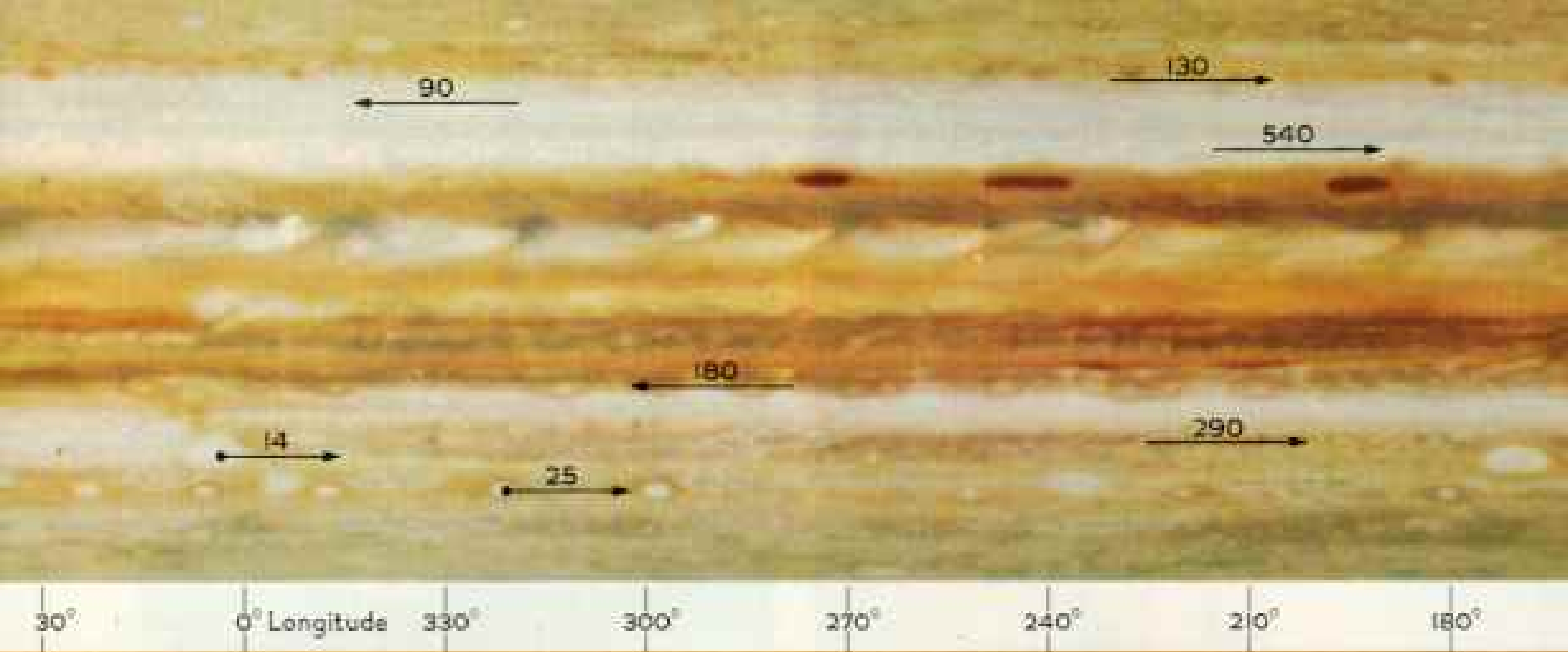
would help them calculate the moon's orbit more precisely. AGK3-10021 is a faint star, so Morabito used her computer to exaggerate its brightness on her screen. As she did, a great umbrella-shaped plume also emerged on the edge of Io.

"I'd never seen anything like this before—and I suspected no one else had either," she recalled.

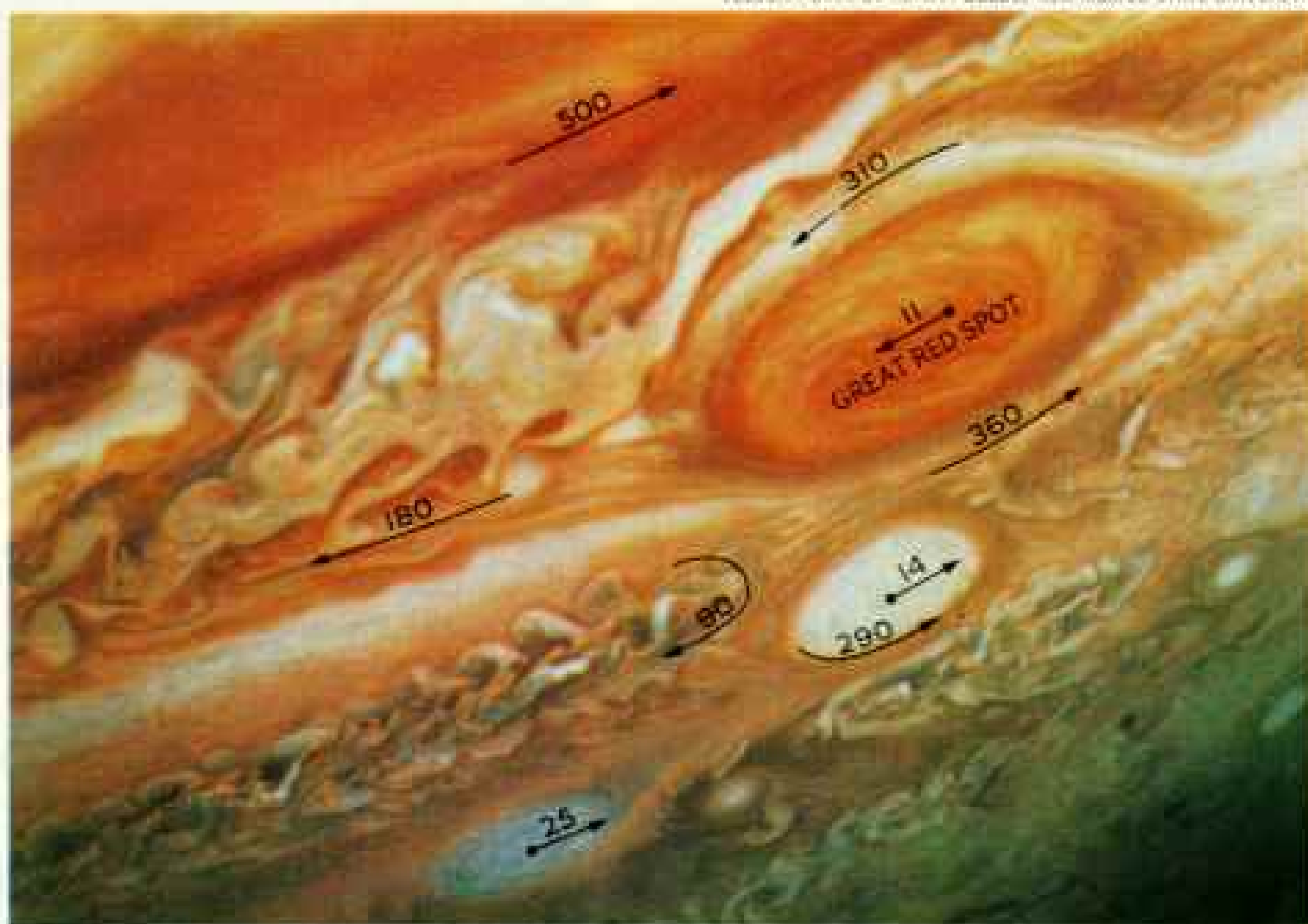
Indeed, not since Galileo saw four moons circling Jupiter in 1610 had anyone seen

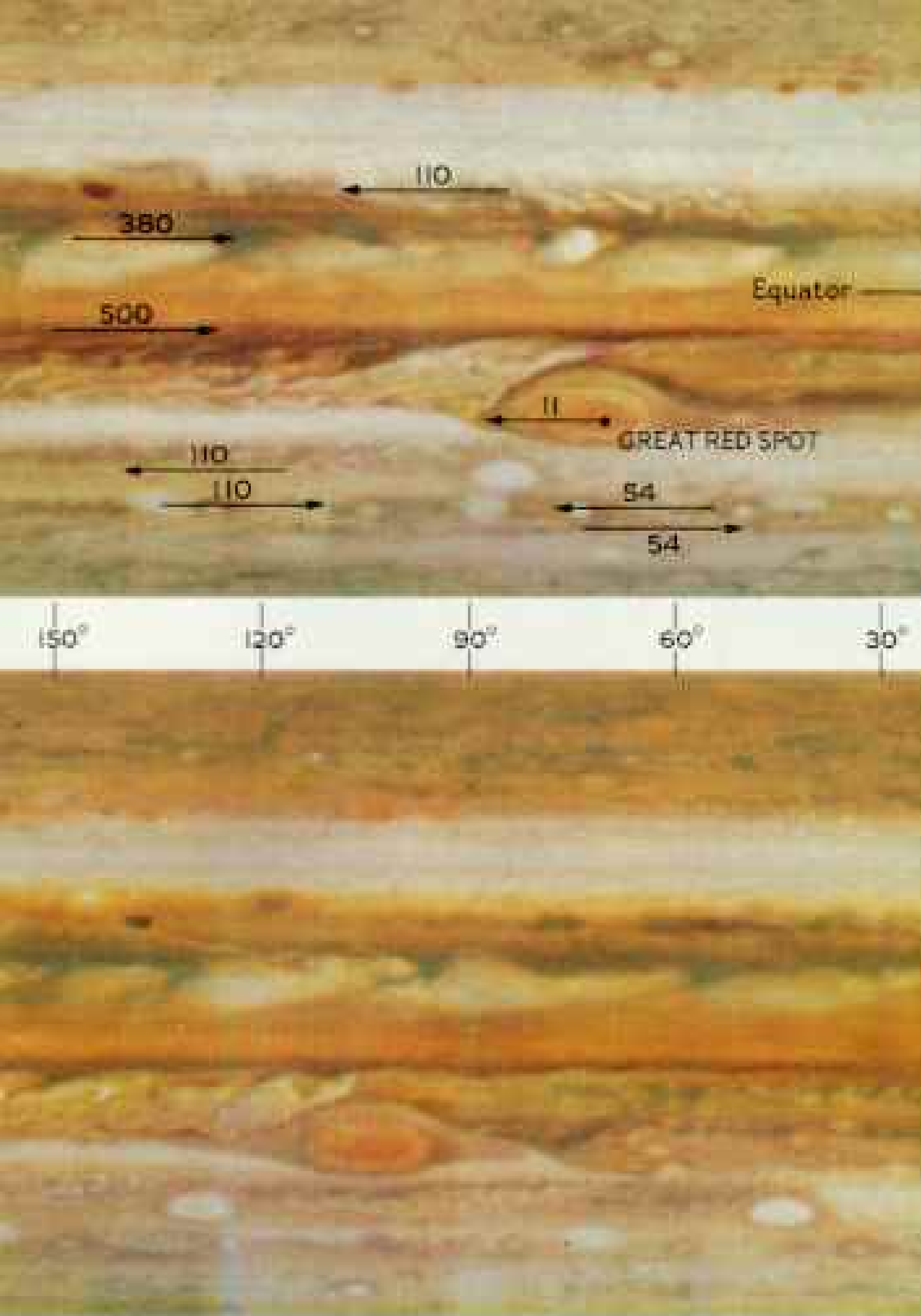
such a remarkable sight in Jupiter's realm. Voyager had found a volcano erupting, its plume rising 280 kilometers (174 miles).

Morabito knew that an active volcano on Io could be the greatest find of the planetary exploration program. It would mean that some other world in our solar system is still geologically alive. So she and her colleagues checked and rechecked the picture before taking her discovery to the imaging team. By Monday *(Continued on page 11)*



ARROWS AND NUMBERS INDICATE CLOUD DIRECTION AND VELOCITY IN KILOMETERS PER HOUR (1 KM = 0.6214 MILES)  
 VELOCITY DATA BY BETTIE F. BEEBE, NEW MEXICO STATE UNIVERSITY





**JUPITER, UNROLLED** in two views taken four months apart by *Voyagers 1 and 2* and aligned by longitude (*left*), shows changes in the bright zones and dark belts of the planet's atmosphere. Most evident are the 30-degree westward migration of the Great Red Spot in the southern hemisphere and the changed positions of the white ovals beneath it. Numbered arrows show velocities and directions of clouds, including those in the turbulent Great Red Spot region (*lower left*).

Near the equator, a row of white horsetail clouds, somewhat dissipated after four months, releases heat from below by convection. Their regular spacing, as with the small white ovals, may be caused by waves in the rapidly rotating planet's atmosphere.

Jupiter's atmosphere may have flow patterns more predictable than those of earth's, but its chemistry is more complex. Depending on temperature and pressure, cloud decks of different chemical composition, inter-layered with transparent hydrogen and helium gas (*diagram*) form a sandwich a hundred kilometers thick. Whereas earth has only one zone of weather, the troposphere, based on the evaporation, condensation, and precipitation of water, Jupiter has three: one of water, one of ammonium hydrosulfide, and one of ammonia. Below the atmosphere, the planet is mainly liquid hydrogen and helium. It has no solid surface.

NATIONAL GEOGRAPHIC ART DIVISION

## Jupiter's cloud cover



## A Jupiter movie

Scientists studying movements in the atmosphere of Jupiter employ time-lapse still photography converted to a movie. To approximate that effect, hold the magazine closed and flip the lower right-hand corner back to front with your left thumb so that the small images of the planet appear to show motion.

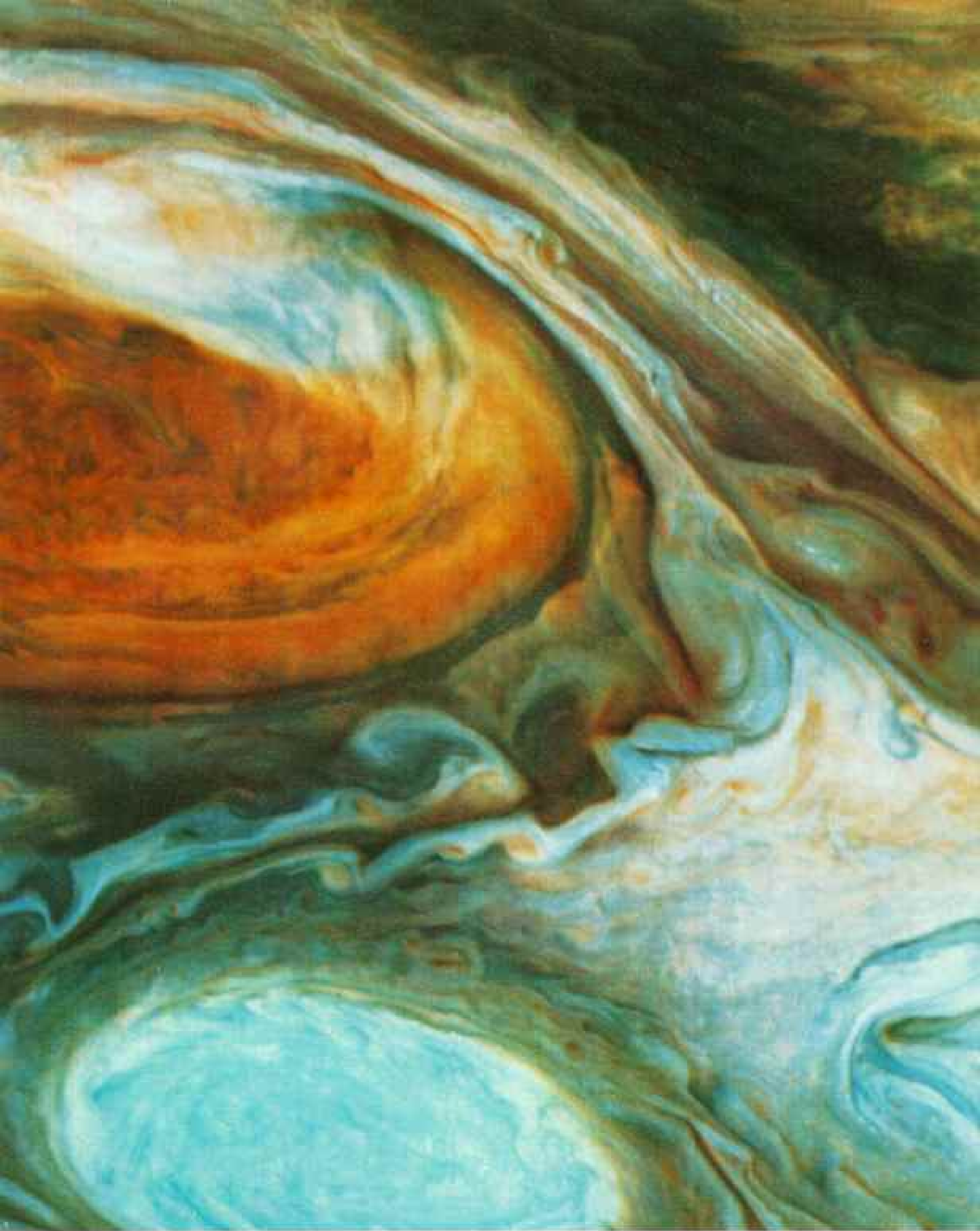






**W**EATHER of the violent Jovian sort, the immense high-pressure area called the Great Red Spot swirls in a view enhanced in red and blue to emphasize detail. Its true color (**right**) may be

due to traces of phosphorus or organic molecules being transported from below. The spot has been seen by telescope for at least a century and possibly three. And although it has been shrinking, the spot



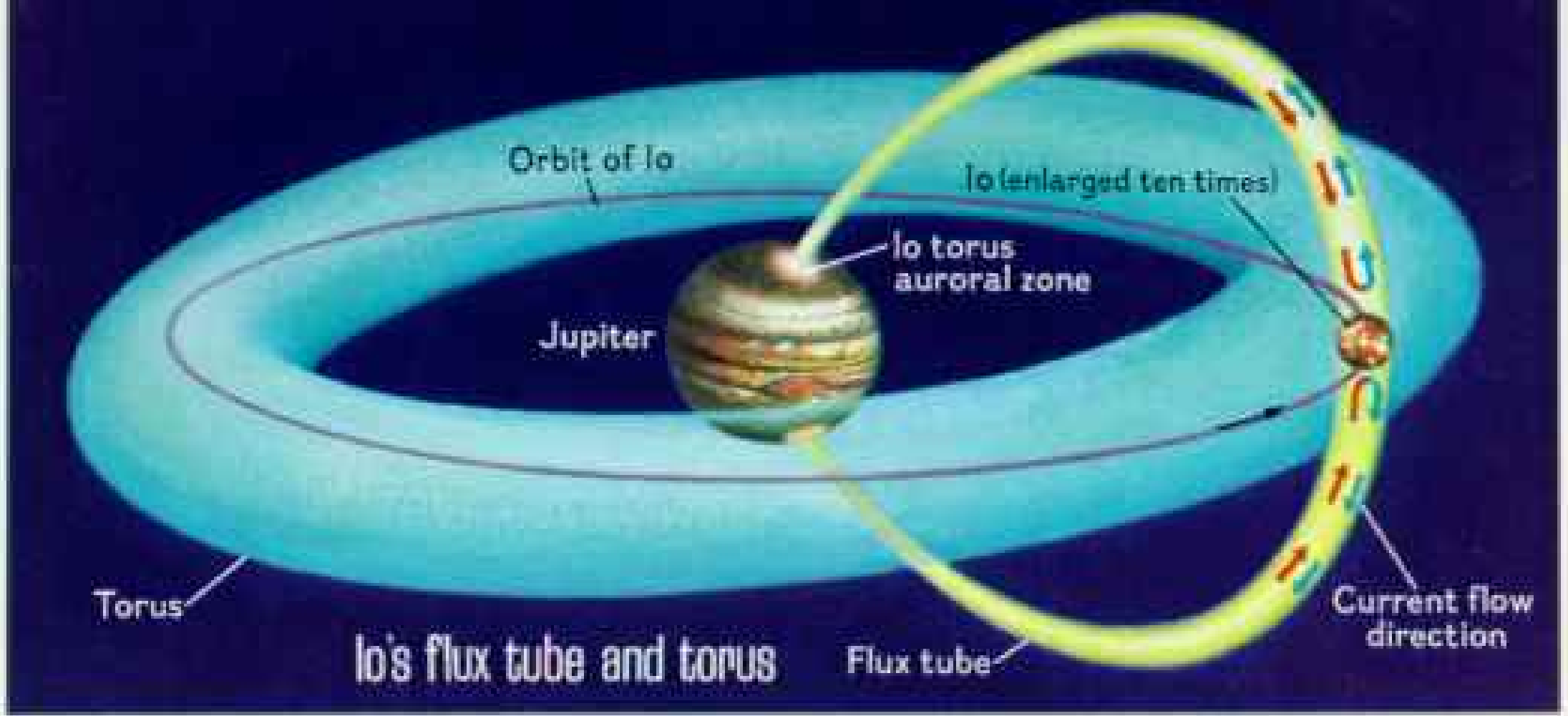
could hold two earths like peas in a pod.

The large oval to the south is also a high-pressure cell, but with different trace chemicals and only forty years old. Jupiter's visible features remain intact

for so long partly because, unlike earth's storms, they do not pass over varied terrain. Also, because the atmosphere is very cold and the storms large, energy tends to be lost slowly.

*What Voyager Saw: Jupiter's Dazzling Realm*

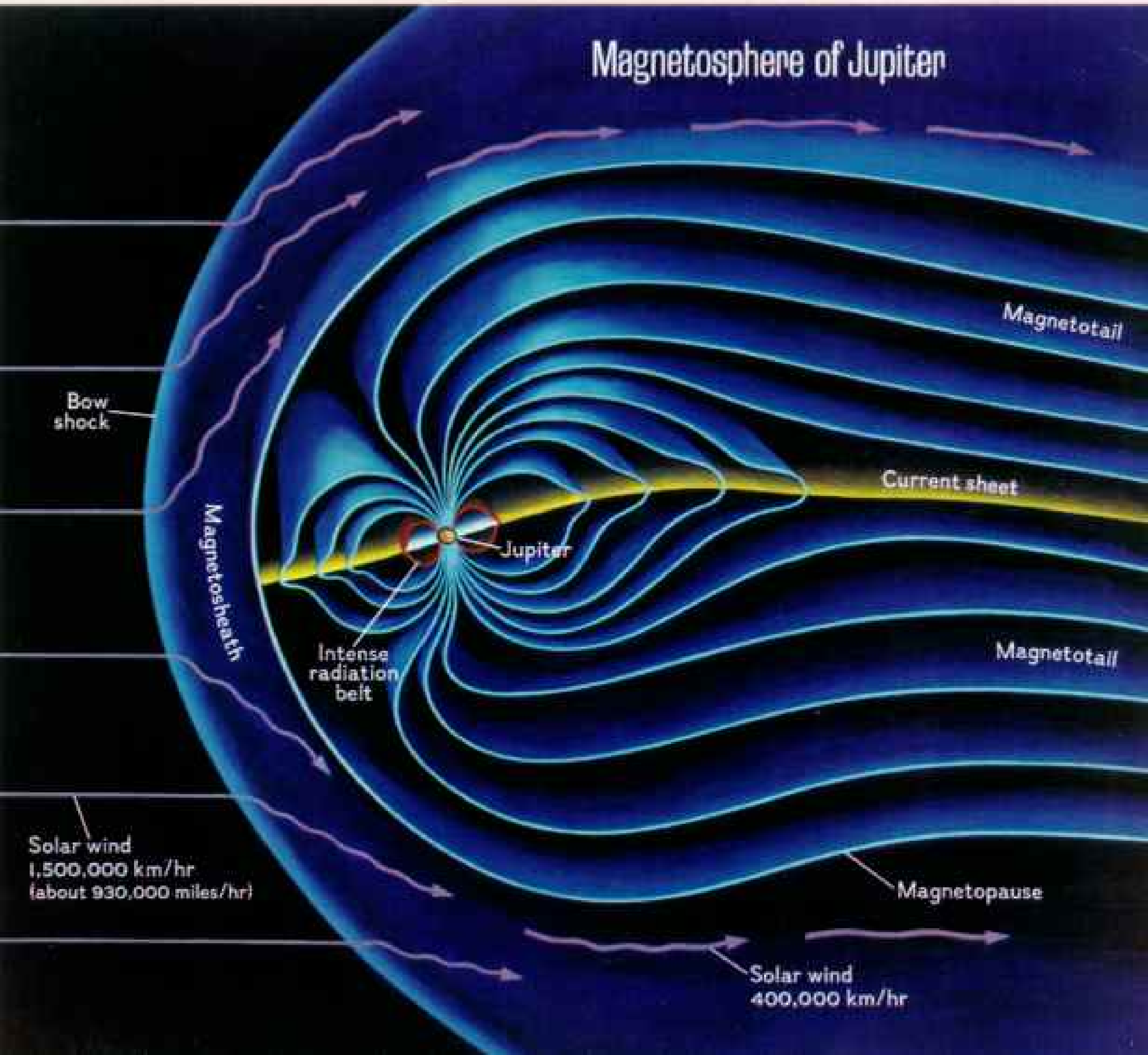




PAINTING BY NATIONAL GEOGRAPHIC ART DIVISION

**B**ETWEEN SUPERCHARGED Jupiter and agitated Io courses a current of five million amperes (above, indicated by arrows) passing in and out of a region called the flux tube. Material that escapes from Io's turbulent surface, such as volcanic

gases, forms an invisible doughnut-shaped cloud, or torus, of charged particles. Voyager observed another energetic interaction—the ionized atoms of the solar wind hitting and being deflected by Jupiter's great magnetic field (below, cutaway view).



(Continued from page 5) morning the stunned scientists had found not one, but at least half a dozen erupting volcanoes. Frigid on the outside, Io apparently throbs with volcanism.

Io is caught in a tug of war between Jupiter and its sister satellites, Europa and Ganymede. These tugs create enormous, pulsating tidal bulges in Io's shape. In some places Io's surface literally goes up and down a hundred meters every day and a half. It probably is these endless tugs that heat Io's crust, much as a paper clip grows hot if it is repeatedly flexed.

**T**HE DISCOVERY of Io's volcanoes on March 9 topped off a heady week. Voyager 1 had been launched on September 5, 1977. It began taking its first pictures of Jupiter in December 1978. In mid-January at a planetary conference, imaging-team leader Brad Smith had told me calmly that a few surprises were beginning to show up in Voyager 1's first, distant images of Jupiter. The planet's cloud cover had changed considerably, he said, since two Pioneer spacecraft had flown by in 1973 and 1974 with less sophisticated cameras. Those Pioneer images had fortified the conventional idea that Jupiter's atmosphere was well ordered, with smooth, planet-encircling bands of clouds that are easily seen through telescopes on earth.



Amalthea, a small inner satellite

The closer Voyager 1 got, however, the less order it saw. Countless swirls and eddies wove through tumultuous jet streams that roar around the huge planet (pages 6-7). Near the equator one stream raced as fast as 500 kilometers an hour. Only a few degrees of latitude away another jet stream tore around the planet going in the opposite direction at 180 kilometers an hour, creating spectacular shear features. The whole atmosphere seethed like a kettle of bubbling bright paints that would not mix.

When I saw Smith again, during the encounter at JPL, he had lost his earlier aplomb. "All our theories on the Jovian atmosphere have been shot to hell," he said at

a press conference. "We are like students going into an exam thinking we know all the answers and then going blank. We just don't know what to make of it."

Next came the encounters with Jupiter's moons—Io, Europa, Ganymede, Callisto.

These four moons that Galileo found in 1610 were, in fact, the first bodies in the solar system to be discovered by telescope. They range in size from slightly smaller than our moon to a little larger than the planet Mercury. Astronomers knew their sizes, densities, and overall colors. They could look at the spectra of the light the moons reflected and speculate about the materials on their surfaces. But they could say almost nothing about the geologic forces that shaped them. They were unknown worlds.

Voyager also photographed the tiny, close-in moon Amalthea, rarely seen from earth. People had imagined that Amalthea could be anything from an asteroid captured by Jupiter's great gravity to an abandoned spaceship. Voyager 1 proved Amalthea to be a dark red, rocky, cigar-shaped body.

Meanwhile, Voyager's other data continued to pour in. By week's end the 815-kilogram (1,797-pound) spacecraft had also:

- Found the Jovian atmosphere to be crackling continually with lightning. Many scientists are now convinced that this lightning must be triggering the formation of organic molecules, the chemical foundations of life, in the caldron of Jupiter's clouds.

- Discovered grand-scale auroras around Jupiter's poles.
- Seen charged particles that are much hotter than the interior of the sun.
- Found a thin ring around Jupiter. Four months later Voyager 2 took pictures of this ring, backlit by the sun and glowing brilliantly. Analyzing the pictures, scientists were excited to discover a small, potato-shaped satellite, Jupiter's 14th known moon, on the ring's outer edge. These discoveries make rings a major new realm of planetary inquiry. Where do ring particles come from? In Jupiter's case they could flow in from Io's volcanoes. Perhaps they are debris from comets or the ejecta from meteorite impacts on the inner moons. Jupiter's new moon actually may be



what defines the edge of the ring, sweeping up the particles at the ring's outer limits.

Astronomers used to ask why only Saturn has rings. Recently Uranus was also found to be ringed. Now suddenly the question is: How many rings are there? And do they all, including Saturn's, have little moons?

**J**UPITER, the Roman mythological king of the heavens, is a fitting name for the planet visited by Voyager. When the solar system was born some 4.6 billion years ago, Jupiter swept up more than 70 percent of the material available to the planets. It probably formed swiftly from a swirling disk of dust and gas millions of kilometers wide. At its most dramatic stage, this disk collapsed—possibly in just three months—into a glowing red ball some 200,000 kilometers wide. It has now shrunk to 143,000 kilometers. It orbits 778 million kilometers from the sun.

Some 1,300 earths could fit within Jupiter's volume. Jupiter has 318 times the mass of earth, yet only one-fourth its density. You might think of Jupiter as a great gasbag. If you could put it in water, it would almost float. This balloon rotates so rapidly that its day takes only ten earth hours, but its year, because of Jupiter's longer path around the sun, lasts 12 earth years.

All anyone can see of Jupiter are its clouds, which go down only a hundred kilometers. Deep within, the planet probably has a molten core of silicates and metals the size of the earth. Otherwise its composition is much like the sun's—massive quantities of hydrogen and helium. These gases mix and probably form shells tens of thousands of kilometers thick around the core.

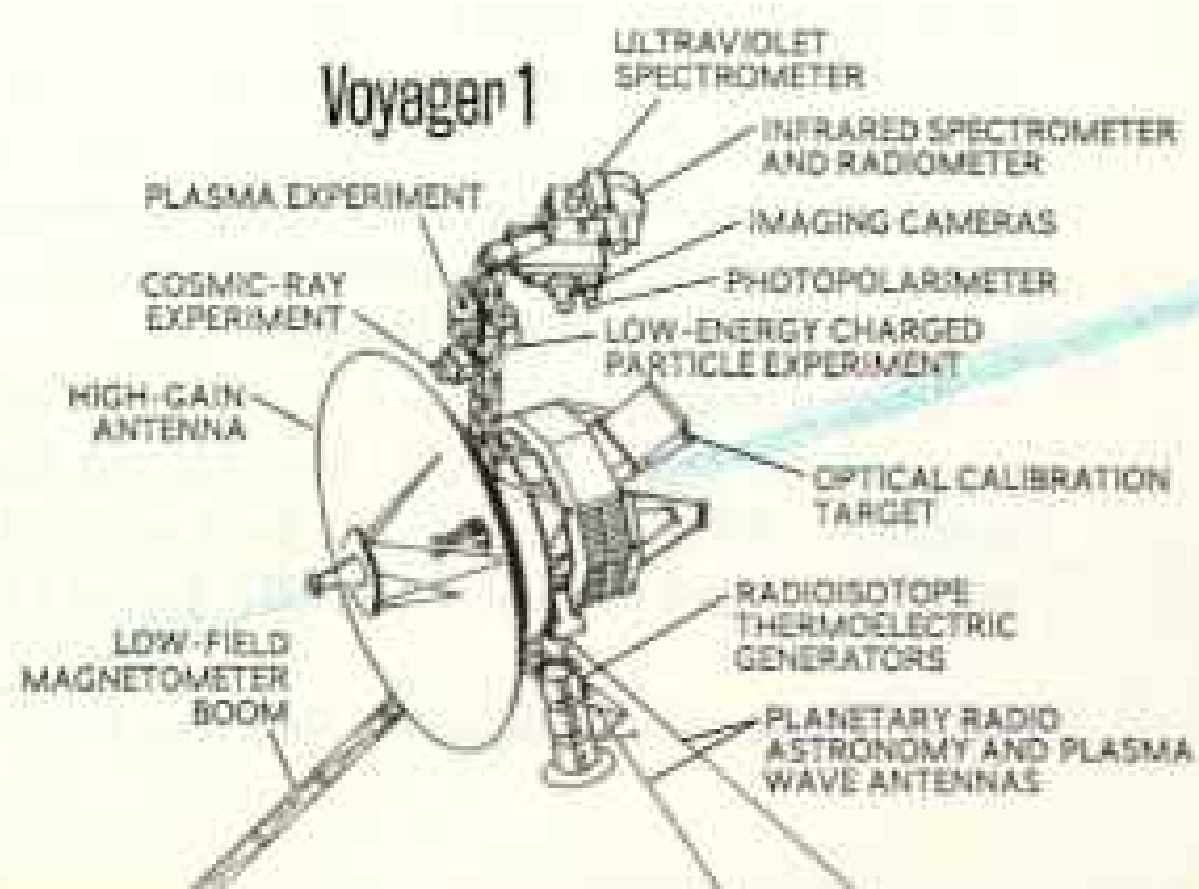
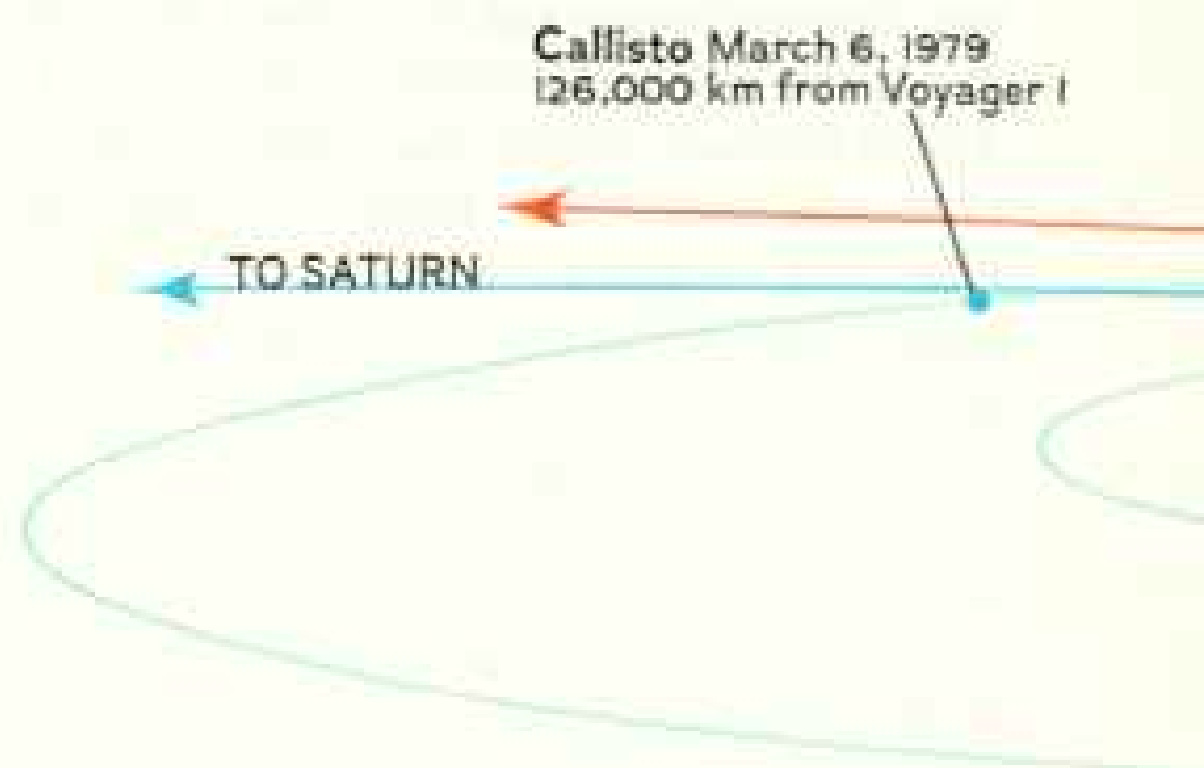
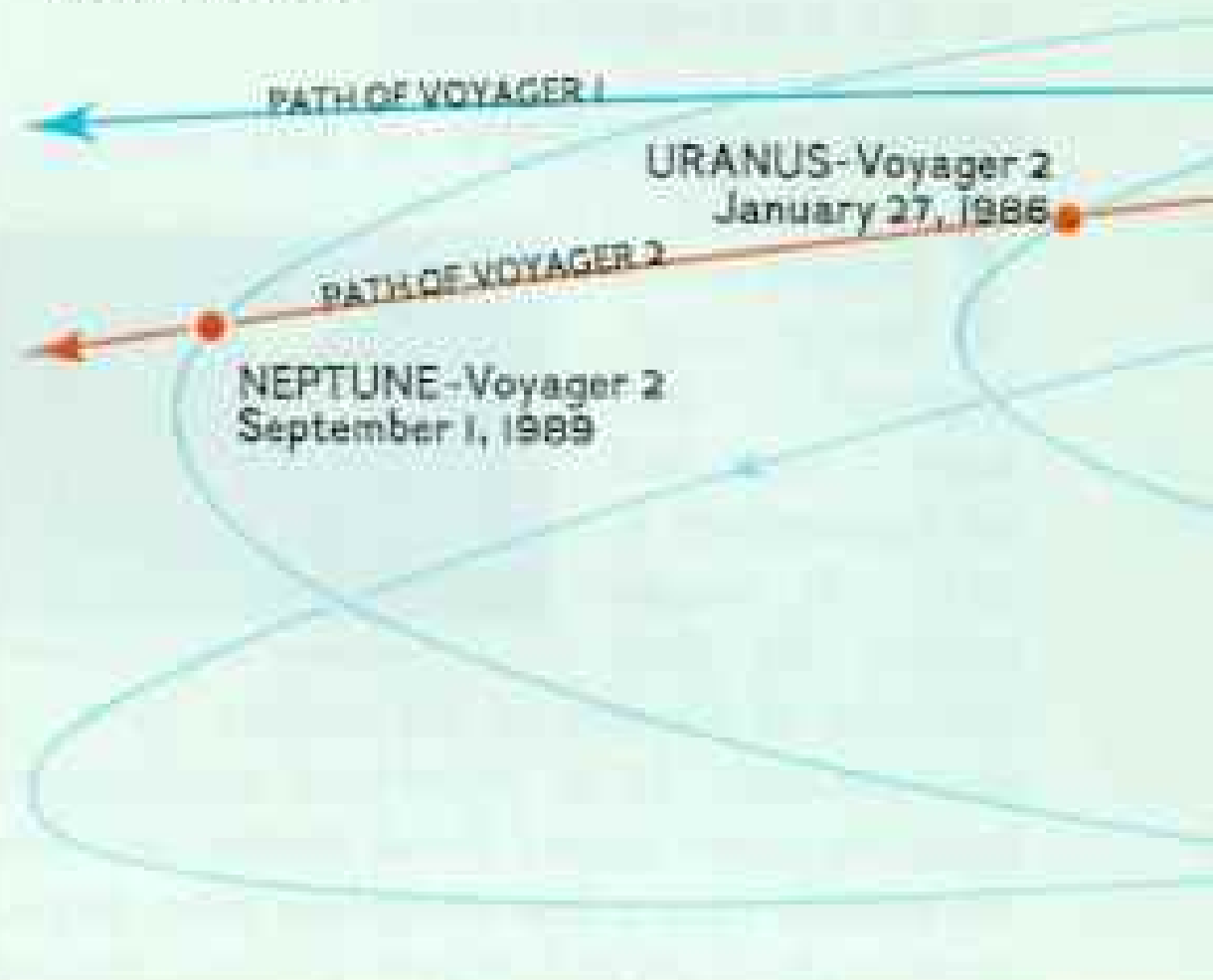
When Jupiter originally collapsed, tremendous heat was unleashed. Some of that intense heat of formation was trapped within the planet and is still slowly leaking out. Although temperatures at Jupiter's cloud tops are colder than minus 120°C (minus 184°F), its center may reach 30,000°C (54,000°F), or five times that at the sun's surface. The pressure near the center equals a hundred million earth atmospheres.

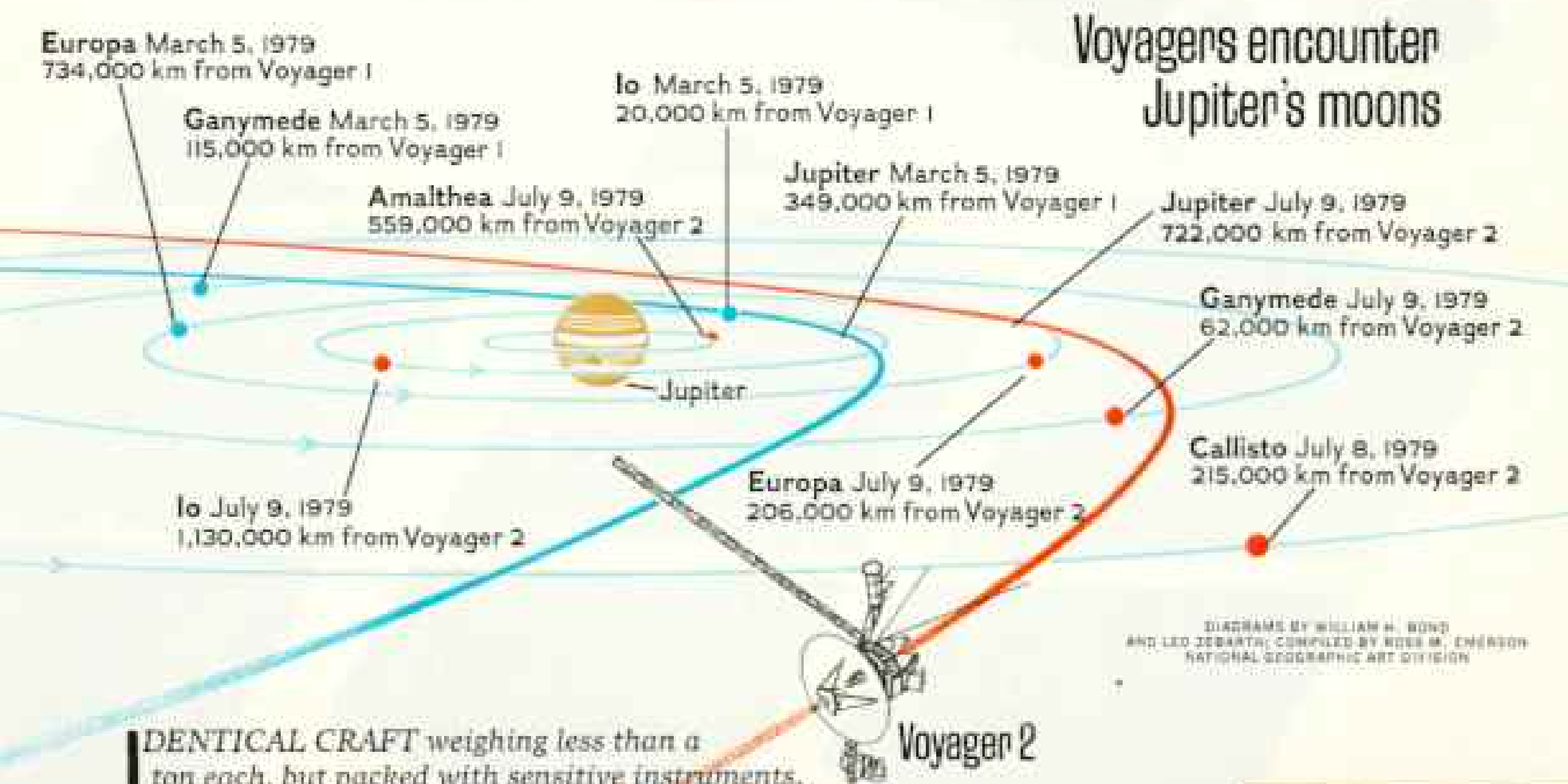
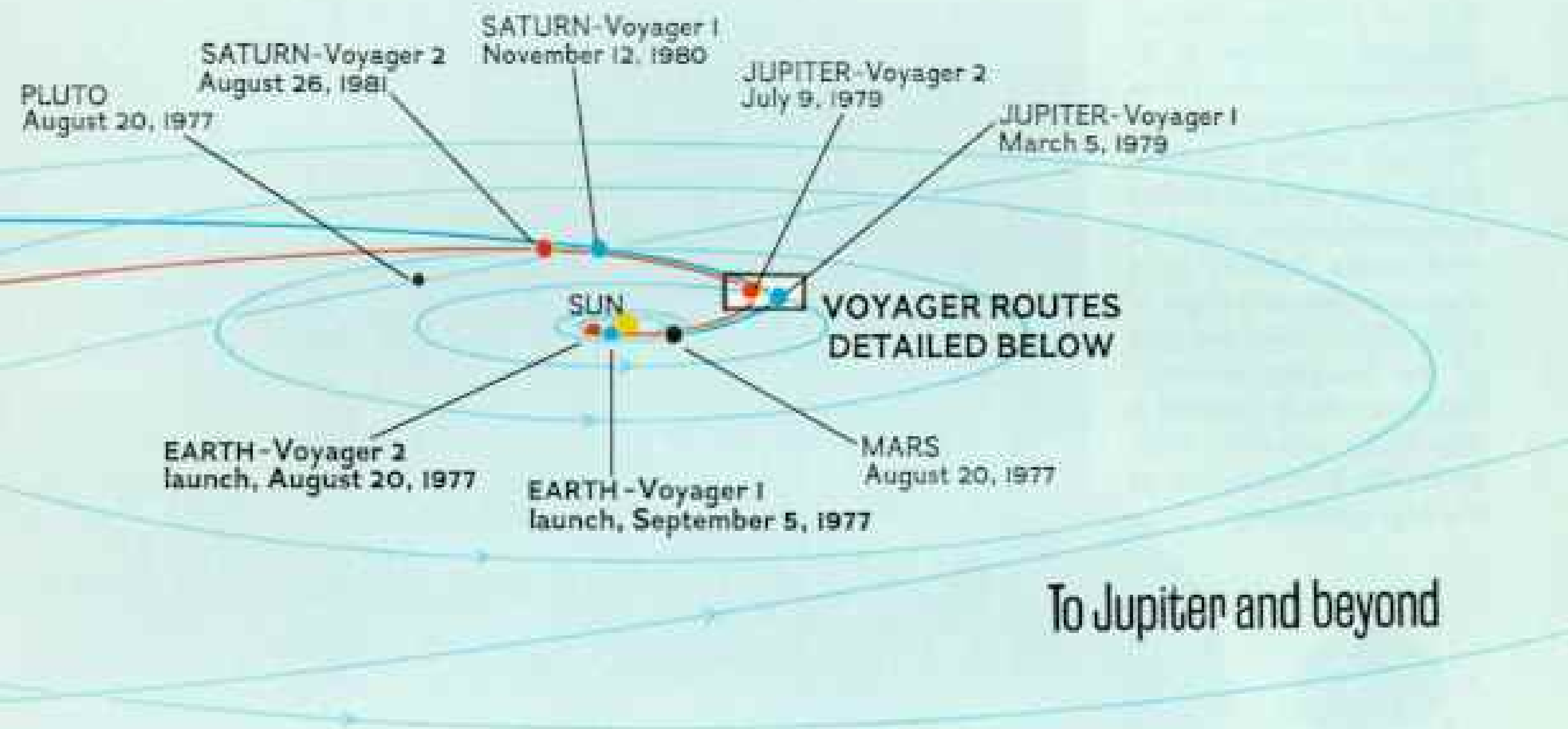
Under these conditions hydrogen liquefies and also becomes metallic. This metallic form is an electrical conductor, and as the great internal

*(Continued on page 16)*



*With different trajectories the courses of the spacecraft increasingly diverge. They will exit the solar system, never to return.*

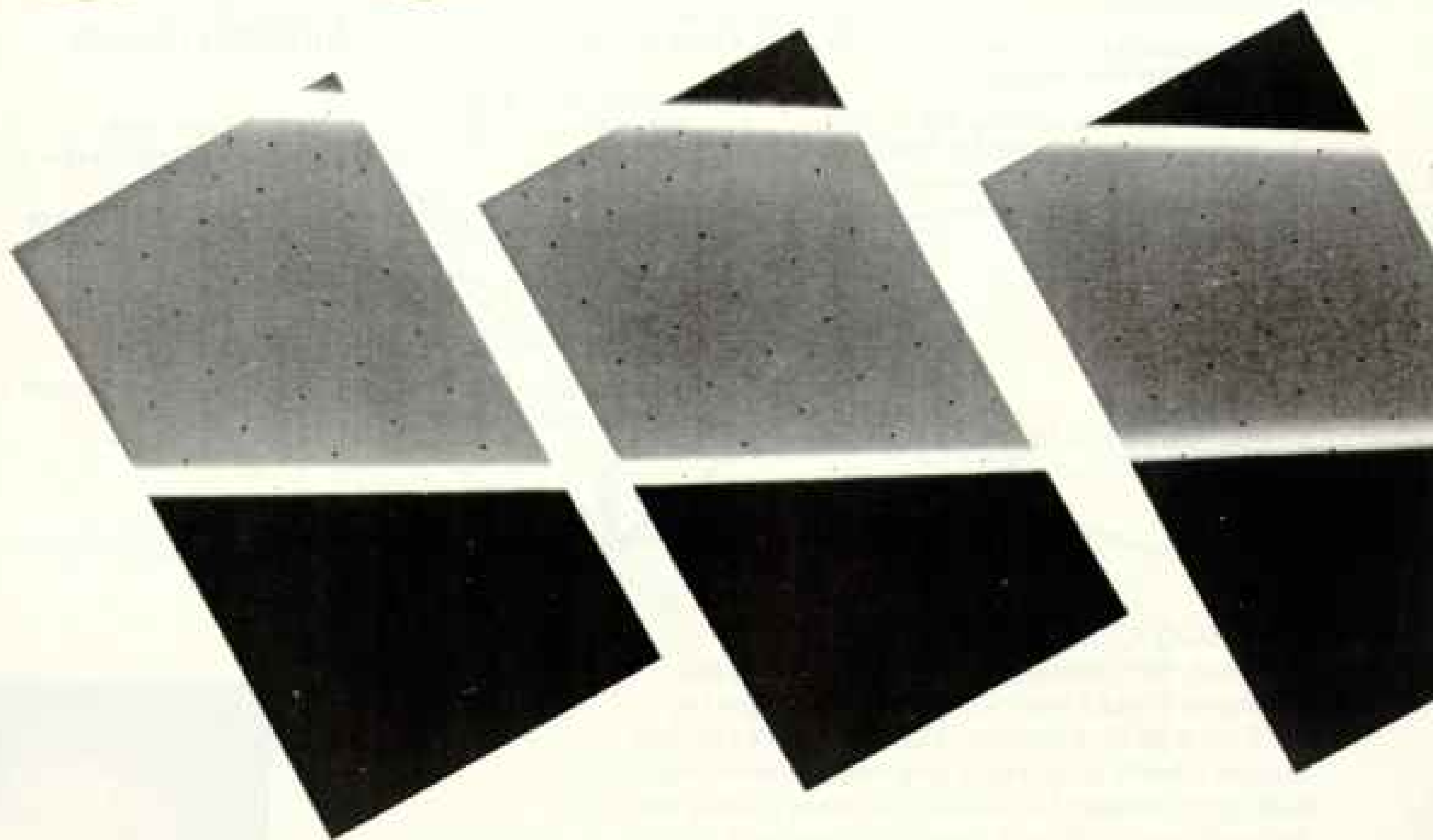


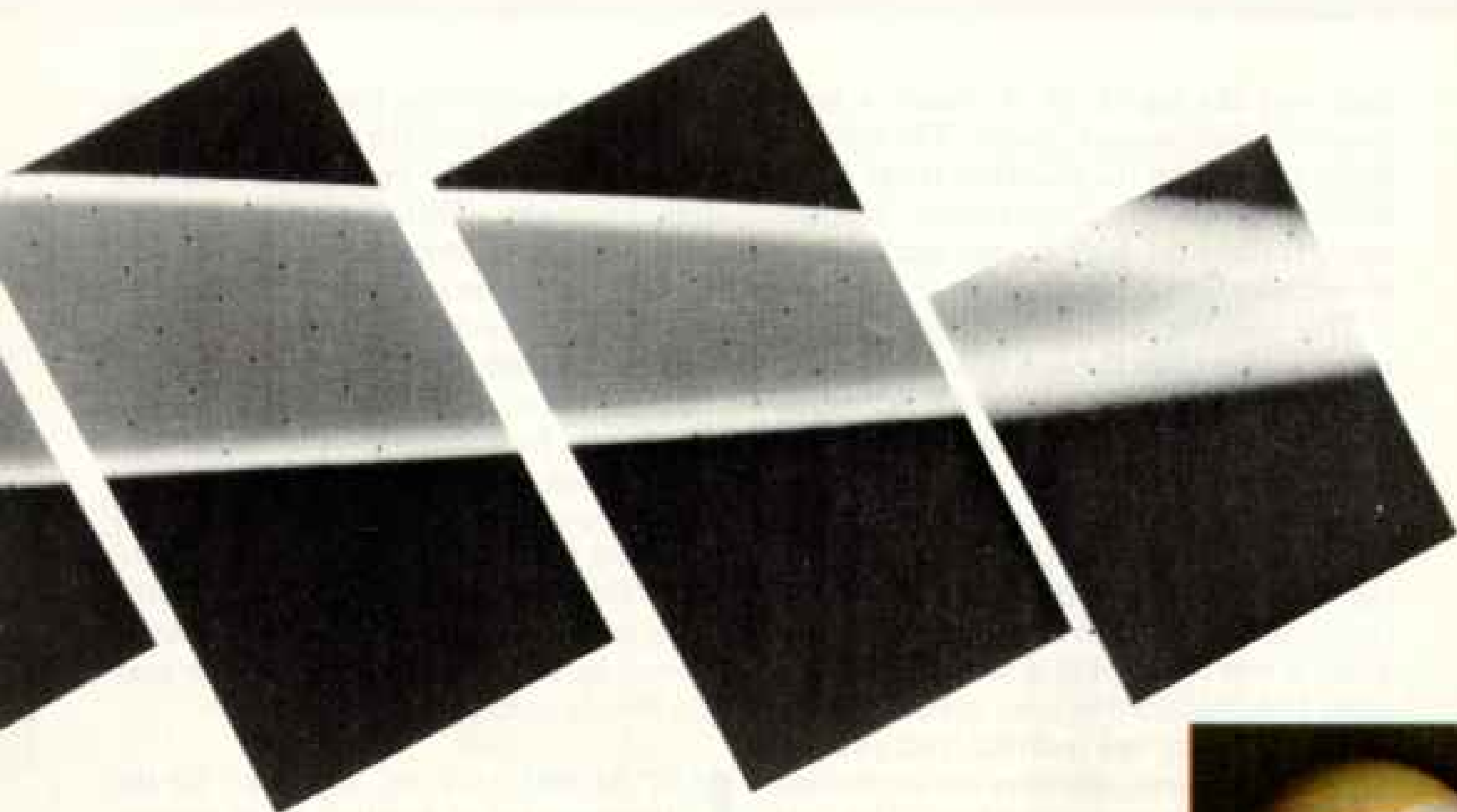
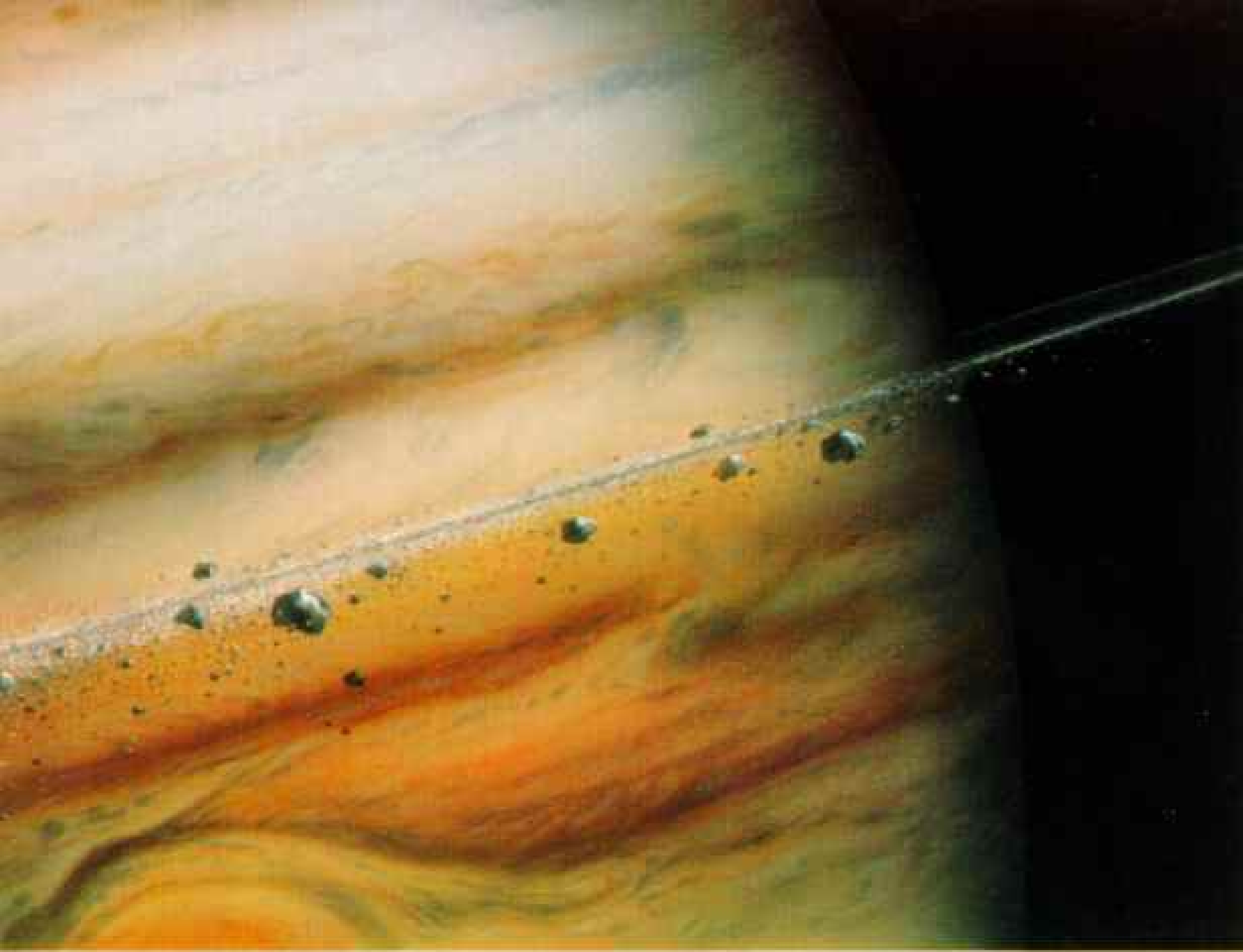


**IDENTICAL CRAFT** weighing less than a ton each, but packed with sensitive instruments, Voyagers 1 and 2 were launched 16 days apart in 1977. On a faster trajectory, Voyager 1 leads the way. Voyager 2 backs it up and is targeted to further explore findings of Voyager 1 or investigate areas it could not. Both will go on to Saturn, and, if all goes well, Voyager 2 will fly by Uranus and Neptune before sailing out among the stars.



**A** GREAT SURPRISE sent by Voyager 1 was the faint image of a ring extending 58,000 kilometers (36,000 miles) from Jupiter's cloud tops, perhaps debris from Io's volcanoes. Artist Ludek Pesek paints it as composed of rocky material (right). Voyager 2 images (below) suggested that most of its particles are too small to be seen with the naked eye. They are visible only as a mass when sunlight strikes them from behind, much as dust motes floating in a room are seen in a shaft of light. (Black dots are part of the imaging process.) But later study showed a tiny rocky satellite, Jupiter's 14th known moon, at the edge of the ring.





*What Voyager Saw: Jupiter's Dazzling Realm*





heat stirs the liquid up, it creates a huge magnetic field around Jupiter. The field extends out around the planet as far as seven million kilometers, entrapping trillions upon trillions of high-energy particles in invisible radiation belts.

This vast region, the magnetosphere, is much bigger than the sun (lower diagram, page 10). It is four times as far away from us as the sun, but were it visible, it would appear larger than our moon.

Sometimes the magnetic field releases bursts of its trapped particles. These cosmic rays have been detected as far away as Mercury, some 700 million kilometers. Until the 1940s it was believed that most cosmic rays came from outside the solar system. Today we believe many are spun off from Jupiter.

All the Galilean satellites are embedded within Jupiter's magnetosphere. They are bombarded by high-energy electrons, protons, and other ions so lethal that man could

not hope to land on any Galilean moon, except perhaps Callisto, the farthest out. This radiation is actually eroding Io's surface atom by atom. These surface particles, along with those from Io's volcanoes, are captured by Jupiter's magnetic field and create a charged gas cloud, called a torus, that Io moves through as it orbits.

Furthermore, as Jupiter's magnetic field sweeps past Io, it generates an electric current flowing between the planet and its moon (upper diagram, page 10). Voyager 1 measured the current at five million amperes. This translates into two trillion watts, or the capacity of all earth's power plants. Some scientists speculate this power may help heat Io to its hyperactive state.

**L**AST FEBRUARY 28, Voyager 1 hit the leading edge of Jupiter's great magnetosphere. The encounter was under way. Scientists call this leading edge the



bow shock. It is indeed an area of great shock, for it is there that the forces of the sun clash with those of Jupiter.

The sun's outer surface is continuously blowing away, sending out streams of hot ionized gases called the solar wind, which is traveling at a million and a half kilometers an hour when it collides with the bow shock. Then its speed suddenly slows to only 400,000 kilometers per hour—and most of its particles are deflected.

Prior to Voyager, it was thought that some particles would leak through the tail end of this shield and be carried right into Jupiter's polar regions. There they would strike atoms in the atmosphere, which in turn would glow, creating auroral displays like those on earth. Voyager did indeed find great auroras, but their cause was a surprise. Those auroras, at least, are apparently triggered not by solar-wind particles, but by electrons streaming in from Io's torus.

*What Voyager Saw: Jupiter's Dazzling Realm*

**P**ULLED AND TUGGED by the gravity of Jupiter, Europa, and Ganymede, the crust of Io seethes with tidal forces that heat its upper layer, inducing volcanism. Eruptions spew a hundred kilometers or more above the surface (left), unchecked by atmosphere or strong gravity.

Voyager 1 also recorded splotted terrain (top), marked by black spots and crescents. Six hours later, bluish clouds, probably of sulfur dioxide (above), had appeared over the crescent at right.

Were Io an earth satellite, it would shine six times brighter than our moon.



## Three views of eruptive Io



HAROLD MASURSKY

What causes Io's volcanism? Based on Voyager observations, scientists have constructed various models to explain it. Harold Masursky of the U. S. Geological Survey postulates a mechanism in which sulfur-enriched silicate magma erupts through a silicate crust rich in sulfur—a process similar to earthly volcanism but richer in sulfur. Variations in the chemistry of the magma chambers and in their physics account for different types of eruptions and, therefore, different features on Io. In this

model, surface sulfur is shown as a light coating.

Masursky does not feel that the Voyagers' "eye-blink" view of Io can be projected across its entire history. "The bodies that we know best—earth, the moon, and Mars—have had highly variable periods of activity." Why, he argues, should Io be the lone exception? But: "No geologist trained to approach complex geologic phenomena would propose one model as solving the problem."



BRADFORD A. SMITH

"Whatever sulfur can come out of Io's interior has come out," asserts imaging-team leader Bradford A. Smith of the University of Arizona. He cites the billions of years of tidal heating, a much more energetic and constant process than the breakdown of radioactive isotopes that heated earth's core. In his model sulfur four kilometers deep has been forced above the silicate subcrust, and when silicate volcanism occurs, it is under a sulfurous crust and a liquid sulfur ocean. This, Smith

thinks, has been going on for four billion years and is a self-limiting system: "If you were to dump more sulfur on the surface of Io, an equal amount would seep back into the molten silicate interior." Violent volcanism occurs in the crust when liquid sulfur dioxide ( $\text{SO}_2$ ) meets molten sulfur, producing explosive decomposition of the  $\text{SO}_2$ .

A choice between the two models—or others—may have to wait upon Galileo, a spacecraft scheduled for the mid-1980s.



LAURENCE A. SODERBLOM

A different kind of eruption was seen mainly in the south polar region where terrain resembles parts of the American West, with eroded cliffs and isolated mesas.

According to the U. S. Geological Survey's Laurence A. Soderblom, gas-ice mixtures of  $\text{SO}_2$  blast away from the base of the cliffs like ten thousand Old Faithfuls.

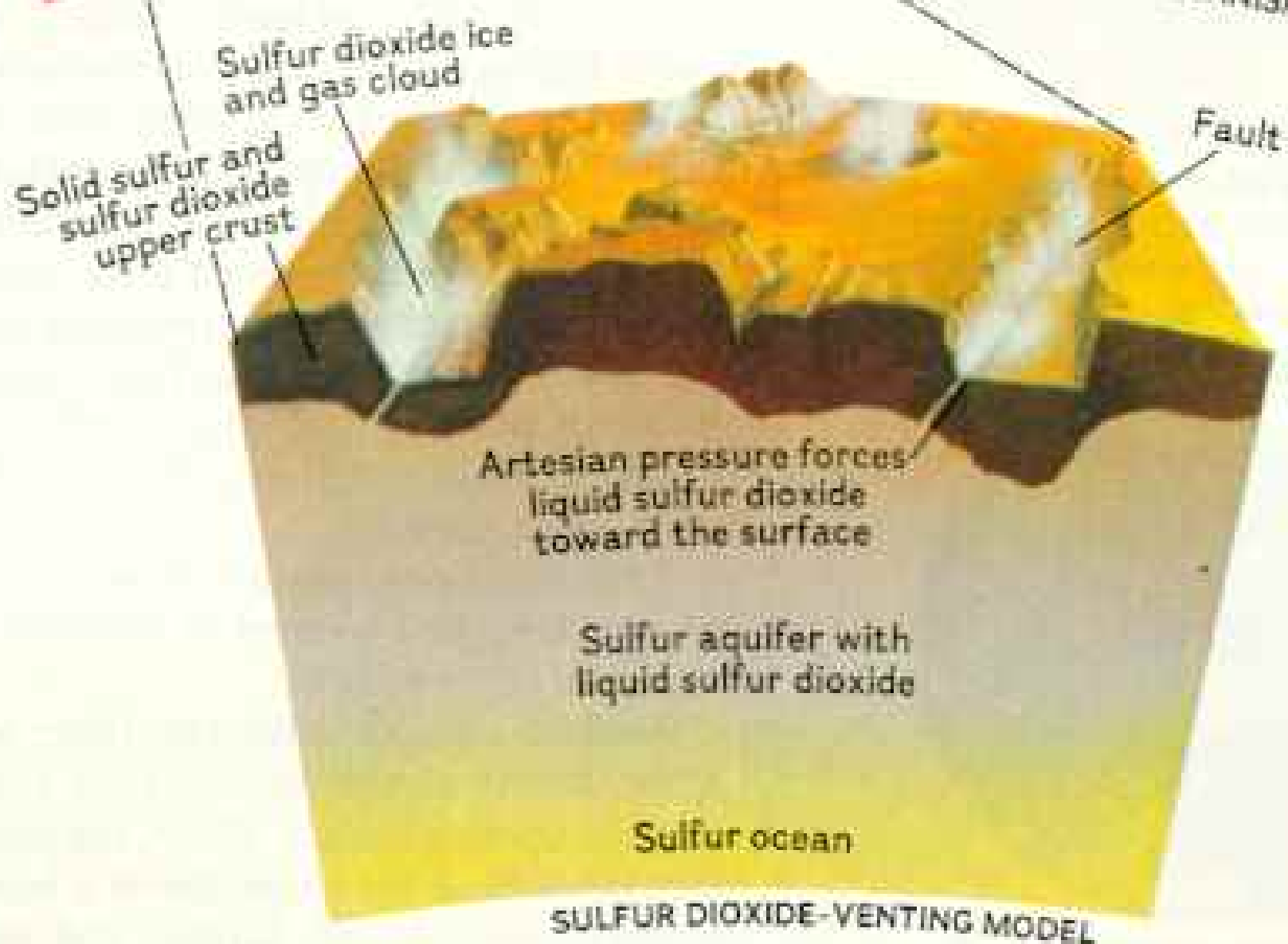
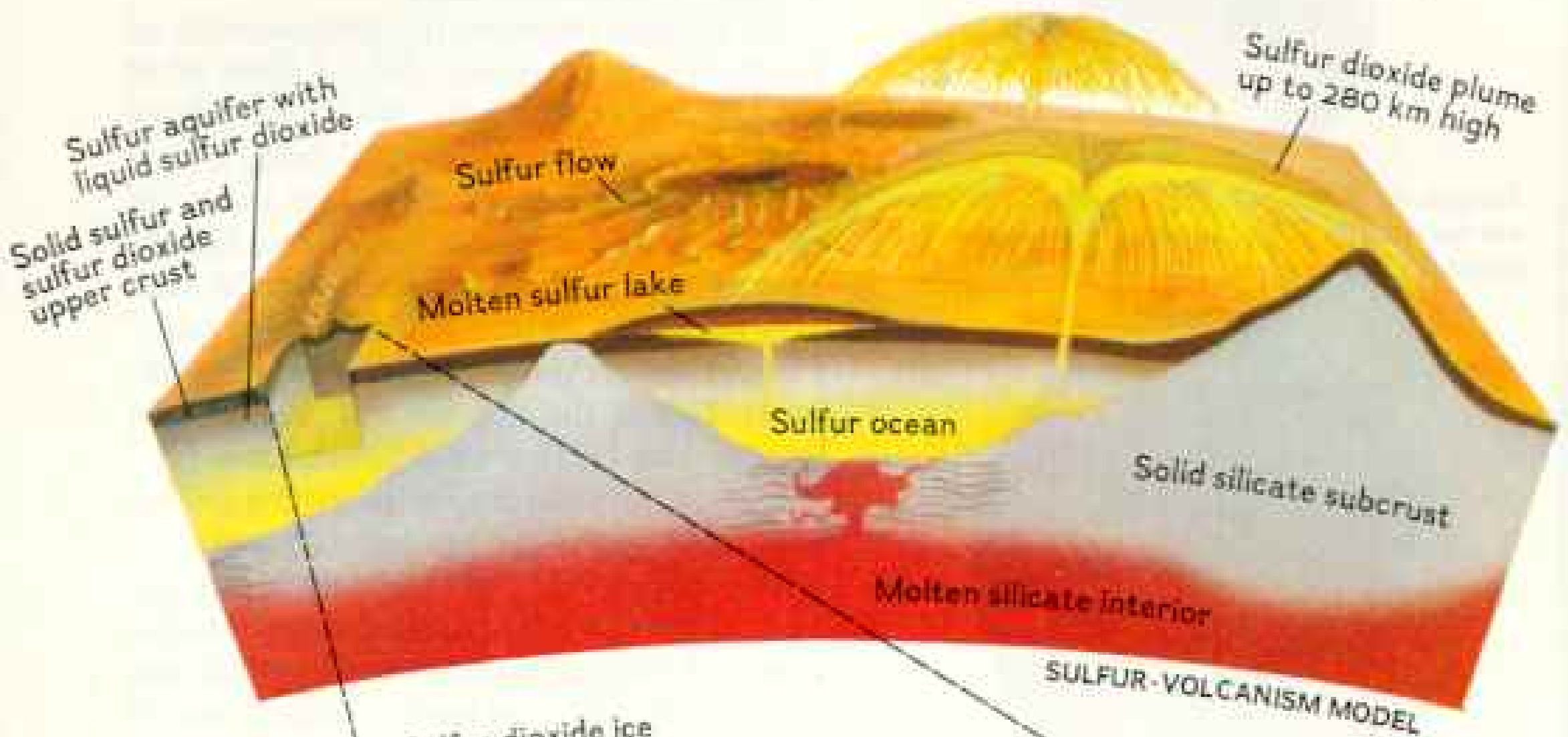
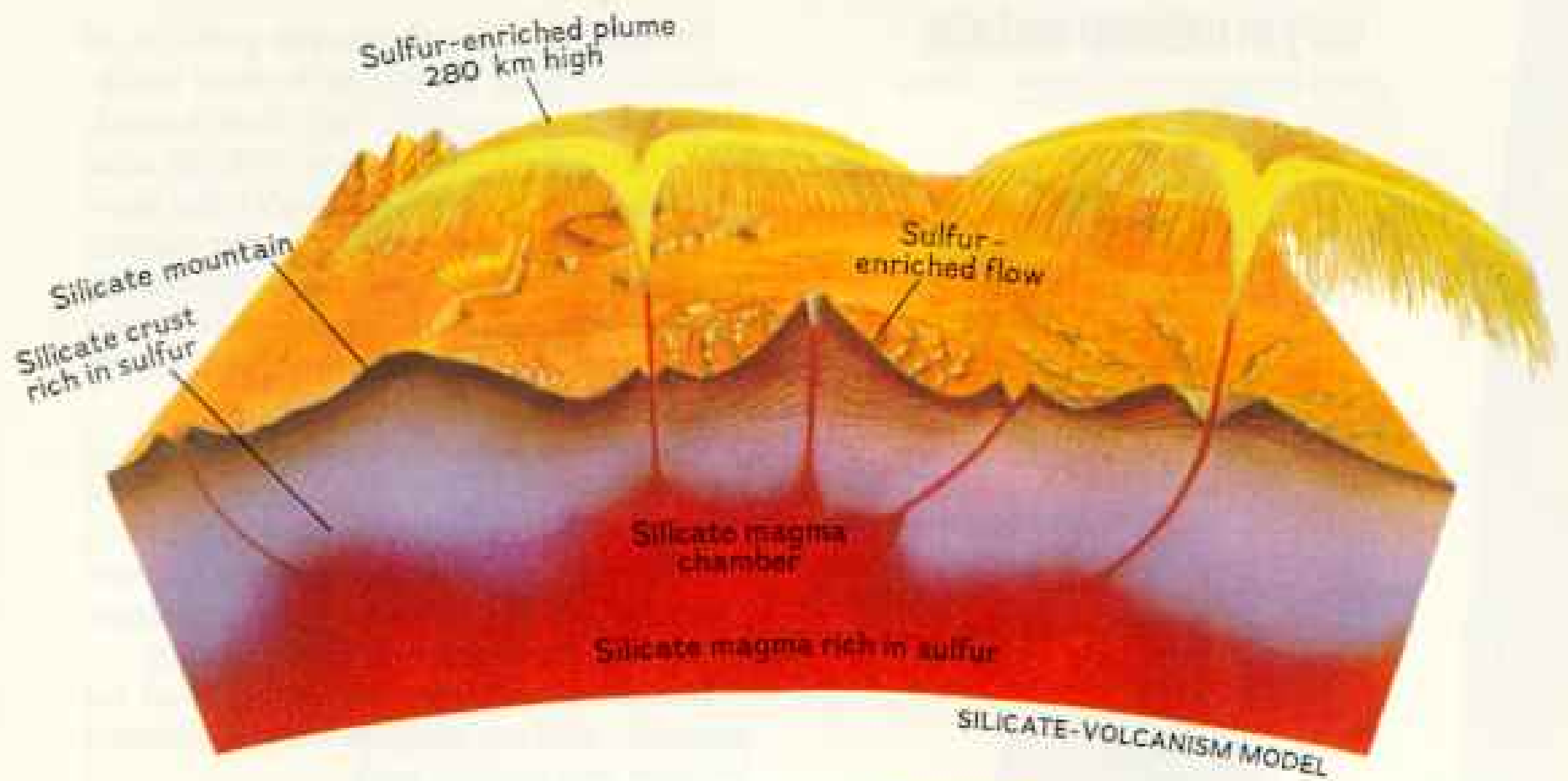
Liquid  $\text{SO}_2$  percolates up or is forced up from the aquifer by artesian pressure. When it has risen near the surface, the  $\text{SO}_2$  can no longer remain stable as

a liquid. It explodes into a gas and ice cloud like a carbon dioxide fire extinguisher going into action.

Pressures are great enough to erode the cliffs and to send the  $\text{SO}_2$  spewing out as far as fifty kilometers, where it falls as snow, collecting in the fashion of the Antarctic ice cap.

"I suspect," Soderblom says, "that those cliffs are actually slabs of solid  $\text{SO}_2$ ."

DEBORAH SHERMAN (TOP); PHILIP D'HEAN



PAINTED BY JAIME QUINTERO  
NATIONAL GEOGRAPHIC ART DIVISION



## Galilean moons vary in makeup and size

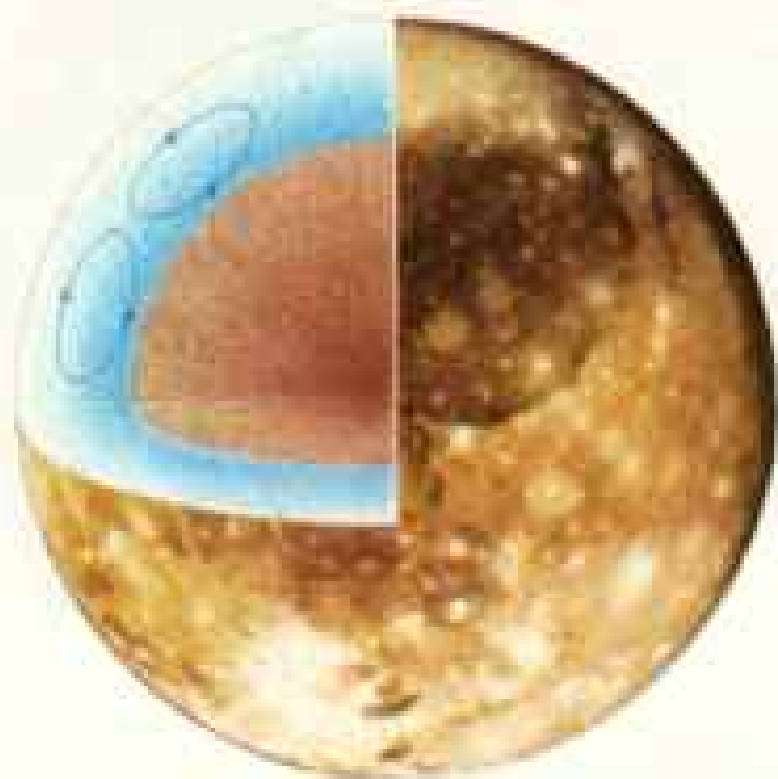
INTERIOR MODELS PROVIDED BY TORRENCE V. JOHNSON,  
JET PROPULSION LABORATORY



**Io**, 3,640 km in diameter, circles Jupiter at an average distance of 421,600 km. Probable structure: sulfur and sulfur dioxide crust, molten silicate interior, and possible solid core.



**Europa**, 3,130 km in diameter, circles Jupiter at an average distance of 670,900 km. Probable structure: ice crust, silicate interior, and possible solid core.



**Ganymede**, 5,270 km in diameter, circles Jupiter at an average distance of 1,070,000 km. Probable structure: ice crust, convecting water or soft ice mantle surrounding silicate core.



**Callisto**, 4,850 km in diameter, circles Jupiter at an average distance of 1,880,000 km. Probable structure: thick ice crust, convecting water or soft ice mantle surrounding silicate core.

Voyager also found charged particles of sulfur from Io as far out as the bow shock. Some of these particles had been heated, perhaps by their interactions with the solar wind, to more than 300 million°C, the highest temperature known in the solar system. However, so few of these particles exist in the magnetosphere's near vacuum that their intense heat had no effect on the spacecraft. Nor would they on a human being.

The bow shock is in constant motion. If the solar wind is blowing hard, the bow shock may be pushed in as close to Jupiter's surface as four million kilometers. Voyager 1 met the bow shock five times as the magnetosphere pulsed back and forth in space.

But the bow shock is invisible, and for drama it could not compete with the pictures Voyager was sending back.

As Voyager closed in, its cameras could no longer take in the whole globe. I think all of us at JPL began to tingle. We almost felt we were on board the spacecraft, doing a slow and relentless zoom into a secret corner of the universe that was intricate and bizarre beyond our fantasies. A picture would flash onto the screen. "Oh, no! This can't be real," I would say to myself. "This is over the rainbow. This is the approach to heaven—at least as Van Gogh would have painted it."

Soon a more stunning image would appear, making the last one seem obsolete.

The Great Red Spot swirled before us. For a time we seemed headed down into the center of this mysterious vortex, which has been observed for at least a century and is easily big enough to swallow two earths.

We saw three whirling white ovals below the red spot. Astronomers had puzzled over these ovals in particular, because their birth had actually been observed forty years ago out of a thin white cloud streaming around the planet. In time-lapse films scientists watched what looked like thunderstorms raging in plumes that rose from the clouds near the equator.

The moons, too, rapidly grew larger. Until now they had seemed to be more myth than real other worlds.

All the Galilean satellites had been named after objects of the mythological Jupiter's wide-ranging fancies. Callisto, the most distant satellite, is the namesake of a beautiful maiden who enticed Jupiter and thereby

provoked the jealousy of his wife, Juno. Juno destroyed Callisto's allure by turning her into a bear. A similar fate befell Io, the inspiration for the closest Galilean moon. After her romance with Jupiter, she ended up as a heifer, pursued by Juno's gadfly.

The two middle moons inherited their names from more fortunate friends of Jove. To elude the watchful Juno, he approached beautiful Europa as a bull. His noble gentleness seduced Europa. She climbed upon his back, and the two flew off to Crete, where she became an object of worship. Ganymede, a handsome youth, also caught Jupiter's eye, and he whisked the boy away to become the cupbearer to the gods.

**T**HE FIRST ENCOUNTER was a distant, glancing look at Europa, as Voyager 1's trajectory sped it in for its swing around Jupiter. Unfortunately, from more than a million kilometers out the craft saw only enough of Europa to tantalize.

"It looks like the earth in a deep ice age with all its oceans frozen," said imaging team member Larry Soderblom.

Enormous and mysterious stripes crisscrossed Europa, raising questions only Voyager 2's much closer flyby four months later could clarify.

For the time being, everyone's attention was easily distracted by Io. White patches on its surface radiated brilliantly amid mottled shades of red and orange. When he saw one of the first close-ups, team leader Brad Smith said that Io looked like a pizza.

A heart-shaped region a thousand kilometers across, which in a few days proved to be the deposits laid down by an active volcano, dominated early Io images. Then, as the spacecraft drew close, it found strange black hot spots—later speculated to be crusted-over lakes of lavalike sulfur. Here and there rose mountains as high as ten kilometers—perhaps remnants of an earlier crust.

Disturbingly, Voyager 1 did not see a single meteorite crater on Io. On earth such processes as weathering and volcanism have erased most craters. But the surfaces of every solid body we have studied in the solar system—the moon, Mercury, Mars and its moons—are peppered with them. Crater counting has become a cornerstone of planetary sciences, the way that scientists date

features on other planets. Basically, the more craters a surface has, the older it is.

"We were terribly upset to see no impact craters on Io," recalled Smith. "If our theories were right, the absence of craters meant that some processes had to have reworked Io's surface within the past million years. That's just a blink of an eye geologically."

The team anxiously awaited close-ups of the next moon, Ganymede. If Ganymede also lacked craters, then the idea that meteorites bombarded the entire solar system would be suspect. Or perhaps Jupiter had somehow protected its moons from the meteorites that struck the inner planets. In either case a vital method of dating bodies in the solar system would be lost.

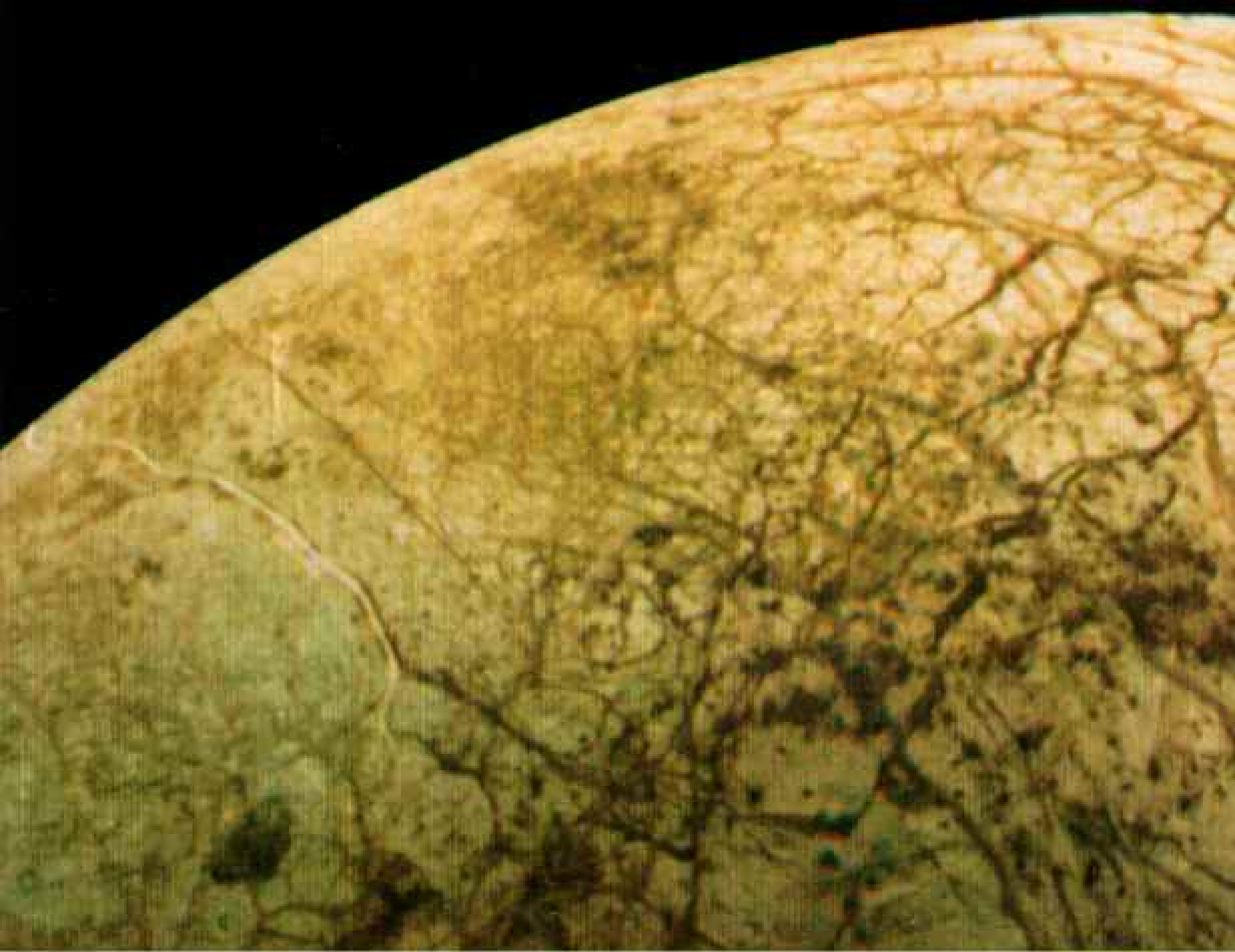
The weary team sequestered themselves in their conference room to greet the first Ganymede close-ups. It took only a few seconds for Larry Soderblom to cry "Crater!" His colleagues cheered with relief. They quickly found several more, and champagne corks blew.

Ganymede had more than craters to display. Its crust appeared broken into fragments, like the pieces of a mosaic. These pieces seemed to be made of two distinct types of terrain. One had shoulder-to-shoulder craters; the other looked heavily grooved, as if someone had raked it.

There was scarcely time to puzzle over these features, however, before Callisto close-ups began coming in. Mercury-size Callisto was darker, but its surface was pricked by innumerable bright craters.

Callisto apparently had been severely battered during its youth. One giant impact region has concentric ridges that look like frozen ripples and extend for 3,000 kilometers. This was surely one of the most cataclysmic meteorite strikes to ever occur in the solar system. The crater counters quickly realized that all of Callisto and much of Ganymede are completely saturated with craters. That means their surfaces are extremely old. These moons, we can safely say, have been dead a long time. However, Io's surface, as the discovery of volcanoes would reveal, is being reworked continuously.





## Europa

*Cue ball of the satellites, Europa may prove to be the smoothest body in the solar system. Streaks that paint its surface were probably fissures in the surface ice*

**B**Y THE TIME Voyager 2 flew by in July, the scientists had digested their data better, but the excitement over Io had scarcely diminished. Linda Morabito had discovered her volcano, and the surface of Io was confirmed to be the youngest known in the solar system.

One of the first things the scientists noticed in the new Io pictures was that the huge heart-shaped volcanic region they saw earlier had changed into an oval. The volcano's debris pattern had inexplicably shifted, and the volcano itself had shut off. However, six other volcanoes were still erupting and presumably had been doing so continuously since March.

Callisto looked as dead as it had on the first flyby, but Ganymede's terrain, seen closer up, appeared much more complicated. There were a smooth and relatively

young basin, an adjacent mountainous region, and remnants of a great ancient meteorite crater like the one on Callisto. Apparently early in its youth Ganymede had a convulsive period that lasted long enough—perhaps several hundred million years—to rework part of its surface.

Europa, however, was Voyager 2's star. The scientists were predicting that water-rich Europa could be heated by the same kind of tidal tugging as Io—albeit much less so. "We were hoping to see Old Faithful going off," said geologist Hal Masursky.

Voyager 2 saw no geysers—but its resolution was only good enough to detect mammoth ones. The great global stripes that Voyager 1 had spotted proved spectacular close up. They made Europa resemble a cracked white billiard ball. Yet the "cracks" had no relief. They looked almost painted



*that were filled by upwelling water or soft ice. Their patterns suggest that at one time Europa's ice crust was expanding and cracking on a grand scale. Only a few impact craters mar the moon's surface, indicating it is relatively young.*

on. All of Europa, in fact, turned out to be remarkably flat with few craters. So the scientists concluded that Europa has a relatively young surface.

An Io-like tidal heating may indeed be keeping the crust of Europa plastic and the ocean beneath its icy surface either liquid or soft ice. But no one can do more than guess at what mechanisms Europa uses to erase its craters.

**D**ESPITE many unanswered questions, we now know enough about these four new worlds to imagine visits to them. If we landed on Io first, 421,600 kilometers from Jupiter, this is what we would probably see.

Most of Io would look like a painted desert with an intermingling of sulfurous colors (page 16). Sulfur dominates the landscape

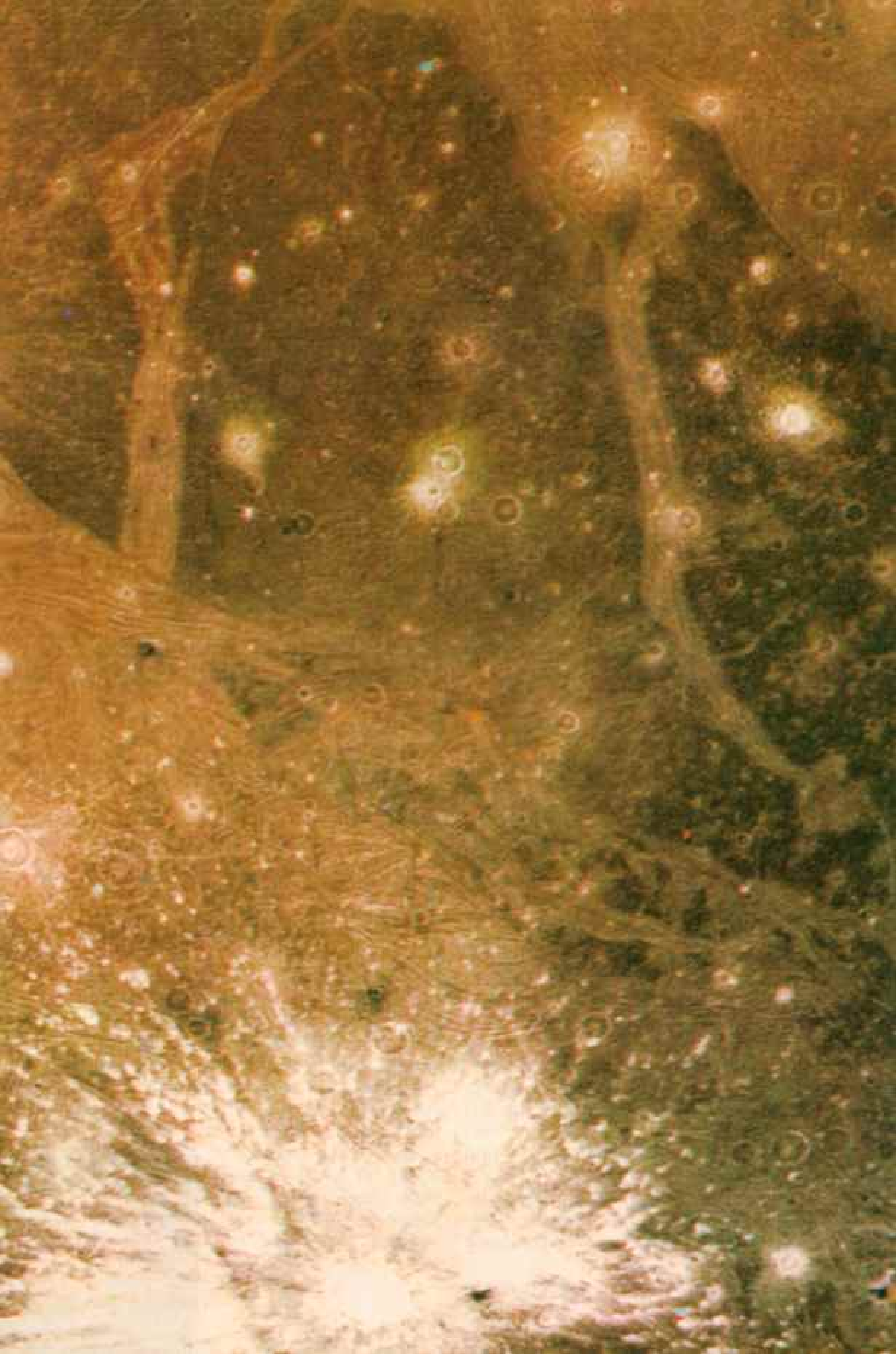
because all lighter materials, such as water, have been lost to space. In fact, Brad Smith holds that sulfur is Io's water, and that the surface of the moon has a four-kilometer-deep sulfur ocean (page 19). Only the upper kilometer or so of this sulfur sea is frozen. Below, the sea would be molten.

Hal Masursky, on the other hand, says that the sulfur on Io is basically a dusting that covers up a silicate landscape similar to volcanic regions found on earth. In either case, Io's volcanoes are blowing off a lot of sulfurous material. Most falls back on the surface, but about a hundred kilograms a second escape the moon.

The sulfur dioxide blown off creates a tenuous, foul-smelling atmosphere. If we were walking across Io, a







# Ganymede

*Darkest is oldest: This rule applies to the icy surface of Ganymede, dirtied by debris accumulated early in its history and most visible in a large circular area (below). Brightest is youngest: Fresh white ice was ejected by the most recent meteorite impacts (left).*

To geologists, the most intriguing features are sinuous strips of alternating parallel grooves and ridges (bottom) that indicate crustal movement billions of years ago.



pastel yellow, orange, and bluish white snow might fall on us. If we visited the satellite's poles, we would find deep banks of this sulfur dioxide snow.

These polar snowbanks have big, puzzling scarps, which on earth we would say had been carved by wind or water.

But Io has no wind and is utterly arid. Most likely this erosion comes from within, when high-pressure liquid sulfur dioxide, trapped beneath the surface like water in an artesian well, manages to break through. As it does the liquid explodes into the atmosphere in a gas and ice cloud, and the ground above its former reservoir collapses.

Moving toward Io's equator, we would walk across large white patches of sulfur dioxide frost, or come to the shore of one of the crusted-over black lakes. These lakes could be floods of black molten sulfur flowing out from fissures and freezing over. Or they could be created when a surge of heat from the interior melts pieces of the surface.

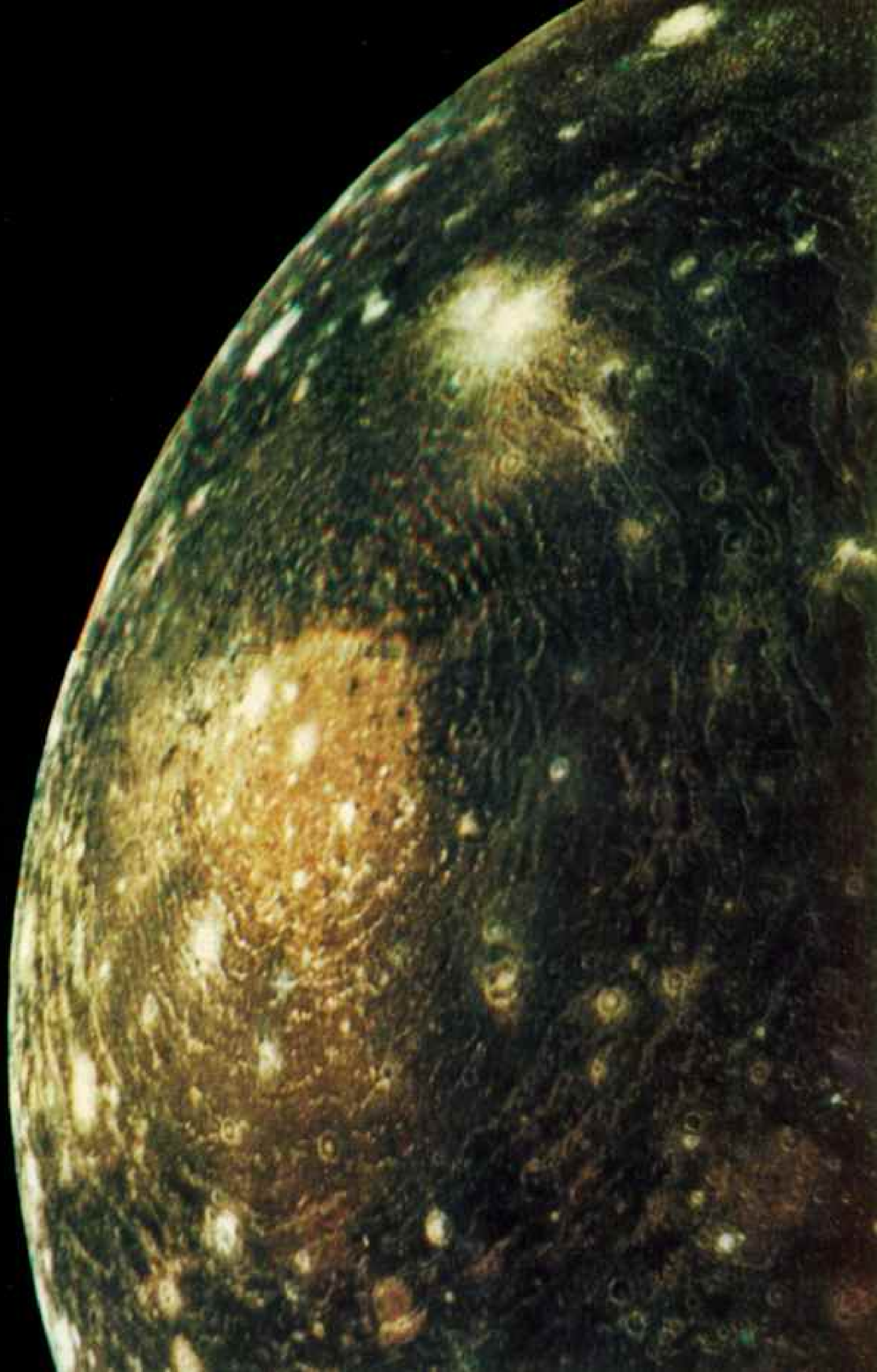
If we approached one of Io's large volcanoes, the moon's flatness would break suddenly. From the center of the caldera, which might be tens of kilometers wide and a kilometer deep, we would see an erupting storm throwing debris skyward at nearly one kilometer a second, comparable to the most violent eruption of Mount Etna. Like a rain of bullets, blobs of sulfur would pour down on us at the same speed.

**I**F WE COULD MOON HOP, we would be eager to go 250,000 kilometers farther out from Jupiter and descend on Europa, a totally different world.

We would probably land on the ice ocean that dominates the surface of Europa. It would be like landing in the Arctic Ocean and trudging across pack ice. We would find the horizon relentlessly flat. If we walked across one of the great stripes, we might know it only by the darkened color. It would be like crossing translucent garden mud in winter. We would surely pause to try to determine what had caused these stripes.

The surface would feel like crusty snow, and our feet would occasionally punch through. We might pass vast regions of smooth ice ponding,





# Callisto

The ghost of a huge meteorite appears as a light-colored circle surrounded by concentric ridges heaved up by its collision with Callisto (left). The impact basin has been filled in by ice, and, though later battered by smaller meteorites, is nearly level.

Unlike Ganymede, where crustal faulting and movement reworked the surface, Callisto shows a more nearly complete record of impacts. Seen in a different view (right), they stand shoulder to shoulder across the face of the satellite.

From turbulent, craterless Io to moribund, heavily pocked Callisto, Jupiter's satellites vary because of differences in composition and internal heating, factors largely determined by distance from Jupiter. In other words, what a Jovian moon is like depends on where it is.

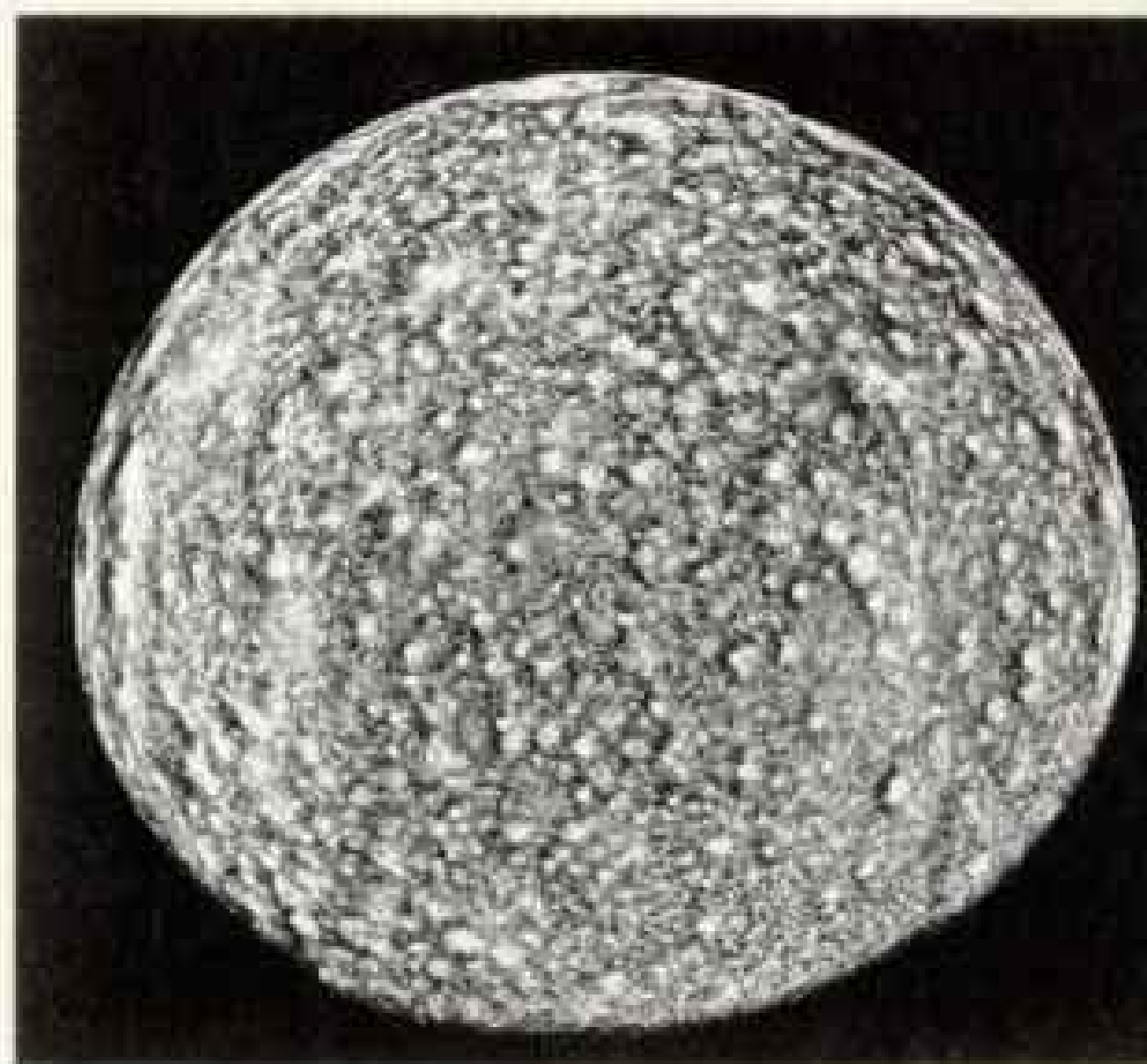
where water has welled up from the ocean beneath. Very possibly we would see numerous big ice crystals rising from the ground.

Eventually we would approach the shore of one of Europa's frozen-over continents. Here the silicate base of the moon nears the surface, the crust is more rigid, and the landscape turns a mottled, muddy brown. This more solid ground can still support the ridges and rims of meteorite craters. In other places such craters have sagged into the softer frozen sea. We might also have to climb over smooth mounds of very clear ice a hundred meters high, which run like ribbons through this muddier-looking terrain. These ribbons could be fault lines through which clean ice from below the surface has extruded.

If there are geysers on Europa, they would be almost as unpleasant to walk past as Io's volcanoes. Their ice-pellet fallout would make a stinging sleet storm on earth seem like a gentle rain.

**L**ET'S CONTINUE our moon hop out to big Ganymede, which has considerably more water than Europa. Ganymede's water apparently has frozen to a much greater depth. Trekking across Ganymede would be like crossing a glacier. The surface would crunch beneath our steps. Aeons of micrometeorites have pulverized it into crushed ice.

If we landed on one of the grooved, or



raked, blocks on Ganymede's surface, our walk would often be a climb. The grooves may be the valleys in between ice extrusions, or they could be the result of buckling. In any event the effect is chains of ridges a hundred meters high and about ten kilometers apart. After a while, however, this washboard pattern would end abruptly, and we would find ourselves gazing across a vast, ancient muddy brown ice pond covered with the remnants of bygone craters. Even though Ganymede's crust is frozen harder than Europa's, it still cannot support much weight. Therefore the ridges and rims created by meteorites on this older terrain have largely sunk back into the surface.

Why does Ganymede have both old and new terrain? Scientists do not know. But clearly Ganymede was once active enough to create tectonic blocks—icy versions of the drifting continental plates on earth.

At some point its interior must have been stirred enough to cause sections of the original surface to break away and become plates that were later reworked and grooved.

What could have stirred up Ganymede so? The moon might have begun with too much inner heat to shed. However, there's another idea. Since all the Galilean moons always keep the same face toward Jupiter, the master planet's gravity must have "despun" these once fast-



rotating bodies long ago. As Ganymede was despun, the energy in the spin could have warmed the interior, stirring it up enough to move the crust around.

To planetary scientists Ganymede is therefore a grand find. "We may learn more in the long run from Ganymede than from earth about the way plates move," says Larry Soderblom. "Ganymede is a frozen record of tectonism in its naked form."

**T**ECTONISM, however, never surfaced on Callisto, our last stop. Callisto's dark slurry crust probably froze as it formed, and, except for the barrages of meteorites, not much has happened there in the past four and a half billion years.

Crossing Callisto's endless rim-to-rim craters would tax our legs and lungs, were there air to breathe. Callisto's ice mantle froze faster and grew rigid earlier than Ganymede's. It has thus supported meteorite craters and ridges for more years. Consequently its entire surface is rough.

We would head for Callisto's great cataclysmic impact basin. The vista there would reward us for our labor. What an awesome object it must have been that hurtled out of the murk of the infant solar system and made Callisto shudder so. That huge meteorite blasted a hole 200 kilometers across and scores of kilometers deep. Steam must have gushed out from the moon, and briefly Callisto had an ocean. Like a massive, instantly melted glacier, Callisto's ice crust poured into the impact zone and refroze. Today we would find the basin flat but would wander amid a wondrous jumble of icy spikes and jagged protrusions—chunks of the old crust afloat in a frozen morass.

"There's no such thing as a boring Galilean satellite," says Larry Soderblom.

**A**S THEIR ASTONISHMENT over Voyager's encounters abated, the project's scientists began making more sense of Jupiter's perplexing atmosphere. They concluded, for instance, that the Great Red Spot, the white ovals, and many still smaller spots are all the same type of feature. They are similar to strong high-pressure systems on earth, but larger and much longer lived. They may be one way Jupiter gets heat out of its interior.

Why do Jupiter's cloud features last so long—hundreds of years in some cases? On earth a big hurricane dissipates its energy in a few weeks.

"Jupiter's storms have deep roots, with much more mass. That makes them more stable," suggests Andrew Ingersoll of the California Institute of Technology. "Also, unlike earth, Jupiter has no topography to break up its storms."

"Jupiter is colder than earth, and cold bodies don't lose energy as readily as warm ones," adds Reta Beebe of New Mexico State University. "Moreover, the materials in Jupiter's cloud cover do not radiate heat as well as water clouds on earth."

Many questions remain about the mechanics of Jupiter's atmosphere. Some of these may be answered in the mid-1980s by a still more sophisticated mission named Galileo. Galileo will shoot a probe deep into Jupiter's atmosphere. The main spacecraft will go into orbit around the planet, taking extreme close-ups of the moons and watching the atmosphere change on a daily basis.

Even Galileo will probably not answer the long-standing question of whether there is life on Jupiter. Voyager's discovery of lightning makes it almost certain that chemical precursors to the molecules of life are being manufactured continually in Jupiter's clouds. The warmer regions of Jupiter's atmosphere are quite similar to that of early earth. One could fantasize about great jellyfishlike creatures lurking in the Jovian clouds. But most scientists believe the atmosphere is too unstable for life. Simple organic chemicals could never have settled in one place long enough to develop into complex biological molecules.

As for the Voyager spacecraft, they will fly past Saturn in November 1980 and August 1981 respectively. If all goes well, Voyager 2 will head on to Uranus for a 1986 encounter, reaching Neptune in 1989. Voyager 1 will sail on out of the solar system without further planetary encounters. Both bear a present from earth, should someone someday in some other solar system find them. They carry dozens of scenes from earth, pictures of human beings, and recordings of terrestrial sounds. Someone somewhere might consider these even more interesting than what Voyager saw. □




**T**OO SMALL to become a star, too massive to solidify, Jupiter is at the center of a scale-model solar system. Io, on the left, and Europa pass by (above), their proximity exaggerated by the telephoto lens.

Jupiter is still shedding primordial energy; its hottest areas appear whitish in an infrared image (left) taken from earth. And to Voyager it has shed more knowledge than in all the time since Galileo turned his telescope on the night sky in 1610 and discovered four moons of the giant planet.



*What Voyager Saw: Jupiter's Dazzling Realm*





## LONG-EARED OWLS

# Masters of the Night

ARTICLE AND PHOTOGRAPHS BY  
ART WOLFE

**F**ROM dusk to dawn it haunts the fields, a silent-winged wraith with claws that kill. Eyes that mock darkness and ears that can hear a mouse squeak from afar search the night. At the slightest rustle from its earthbound prey, the hunter swerves in flight . . . and the long-eared owl strikes with uncanny accuracy.

Long-eared? Well, not really. In fact, the hornlike tufts that give the bird its name have nothing to do with hearing. Instead they act as little semaphores, mirroring alertness or well-being and helping in a favorite disguise. Up they go as the bird squints its saucer eyes and compresses its feathers, stretching its body until, at first glance, it looks like nothing more than a stubby branch.

In reality, this raptor has few known enemies besides man: only its own largest relatives, such as great horned owls. Encounters with man are uncommon—camouflage and nocturnal habits make long-eared owls elusive. They can be found in woods near open fields over most of North America and Eurasia and in parts of Africa. A pale subspecies, the western long-eared owl (*left*), ranges from northwestern Canada to Mexico.

You'll most likely see them at

twilight, when they begin the night's hunt. Listen and you may hear a repertoire of calls that could make a mockingbird jealous, from hisses to hoots to catlike mews of alarm.

I heard the whole gamut on the mid-April day when, 35 feet up in a pine tree, I stood eye to eye with a newly hatched owlet. As a wildlife photographer with a longtime interest in owls, I was not alarmed by the frantic parents stooping and flapping around me. Suddenly one dropped like a feather duster to the ground, fluttering with what looked like a broken wing.

I went along with the ruse. When I stepped down, the bird lured me farther away, then took to the air, satisfied it had saved its young.

After camping for several days at the foot of their pine, I could photograph the family without causing a stir. Several owl families lived in the grove I had chosen in the heart of Washington, my native state.

Do long-eared owls display territorial possessiveness? Those I observed didn't seem to. This year, at least, they had no need for it. Miles of open fields, the birds' preferred hunting habitat, furnished an ample supply of rodents, their staple diet.





**E**ARLIEST BIRD of a brood waits for siblings that will hatch within two or three days of each other (*above*). Remains of a previous meal, left, will be fed to the owlet later. Breeding pairs lay from three to eight eggs annually, each slightly smaller than a hen's egg, usually in nests built and abandoned by other species of birds.

Well supplied by both parents' hunting, the owlets sprout to half size by their third week (*left*). Soon they begin "branching," climbing up and down nearby limbs and sometimes lining up on a branch outside their nest (*right*). Such gymnastics probably help them learn to grip and balance.





**G**HOSTING toward its first kill, a 5-week-old owlet homes in on its prey (*top*), then swoops for the strike (*above*). Moments later it perches with a small rat it will swallow whole (*right*). By eight weeks the young sport mature plumage (*left*). The adult-size birds stand a foot high, with a wingspan three times that, but weigh little more than half a pound. The weight-to-wing-area ratio, combined with extremely soft feathers, produces the soundless flight that makes the long-eared owl's strike a sudden—and fatal—surprise. □





# The Tallgrass Prairie: Can It Be Saved?

By DENNIS FARNEY

Photographs by JIM BRANDENBURG

**T**HERE IS HARDLY any prairie left in Illinois, the Prairie State. And when I finally found the prairie there, it was caged in like a prisoner.

A prairie is not, as you may think, any old piece of flatland in the Midwest. No, a prairie is wine-colored grass, dancing in the wind. A prairie is a sun-splashed hillside, bright with wild flowers. A prairie is a fleeting cloud shadow, the song of a meadowlark. It is wild land that has never felt the slash of the plow.

I drove out one October afternoon, through the spreading suburbs west of Chicago, searching for these things. I found toll-booths. Bulldozers, gouging out basements. Billboards. And everywhere, the subdivisions the billboards advertised.

Then I saw it, a remnant of the landscape that once covered much of Illinois.

The prairie was there, in a pioneer cemetery surrounded by a chain link fence.

And outside the fence was the most encouraging sight I'd seen all day. A young man was walking, head down, collecting wild-flower seeds in an old bakery sack.

"You look like a prairie restorationist," I hailed him. Ken Klick looked up, then grinned his confirmation. "My 'prairie's"

only fifteen feet by five—my backyard," he said. "But these wild flowers are so rare I want to do whatever I can to save them. I'm taking these few seeds home to plant."

We wriggled under the ugly fence. Inside, like a scene from Edgar Lee Masters' *Spoon River Anthology*, tombstones stood amid the swaying grass. Beneath them were sod-busters of the 1840s and 1850s. Kinley Charles, 1821-1861. Mary His Wife, 1831-1879. Joseph Thompson. Jacob Brook. With others, they had tamed this landscape—tamed it all but the wild remnant that now engulfed their headstones.

The autumn wind moaned in the chain link fence and rustled dryly in a clump of coarse leaves at our feet. "That's the compass plant," Ken said, pointing out that the vertical leaves face east and west to best catch the sun.

"There's the rattlesnake master," he continued. It was reputedly used as folk medicine to cure snakebite. "Over there is the shooting star." Come May, its pale pink, swept-back petals suggesting falling stars would blanket the slope.

Ken stooped to pick up a beer can and paused among the headstones. A milkweed seed drifted by on its puffy parachute. A

*Native of a vanishing land, Indian grass sways beneath the sun on a remnant of tallgrass prairie. The white man's plow all but destroyed the original Midwest grassland. Now a modern-day feud smolders over a proposed national park in the Flint Hills of Kansas, a plan fiercely resisted by ranchers as a land grab.*



wedge of geese honked across the sky, heading south.

"This prairie makes me sad," Ken said softly. I felt it too. That tiny caged-in prairie symbolized a loss so vast as to be almost incomprehensible to modern Americans. It symbolized a lost landscape—the landscape of the tallgrass prairie.

Once that landscape stretched from Ohio to eastern Kansas and the Dakotas, and

from Texas into Canada, a great triangle beneath an empty sky (map, page 43). Once it was wild land; try to imagine it as it must have been.

There were wild flowers, hundreds of kinds of wild flowers, blooming in their place and season. There were elk and shaggy bison, and prairie chickens booming out their mating call on brisk April mornings. Great trees hugged the stream channels and



floated like islands on distant horizons. And there was grass in abundance, dozens of kinds of grass. Eight feet tall on favored sites, belt high in most places, it was green and bronze and wine and gold, rippling and shining in the sunlight.

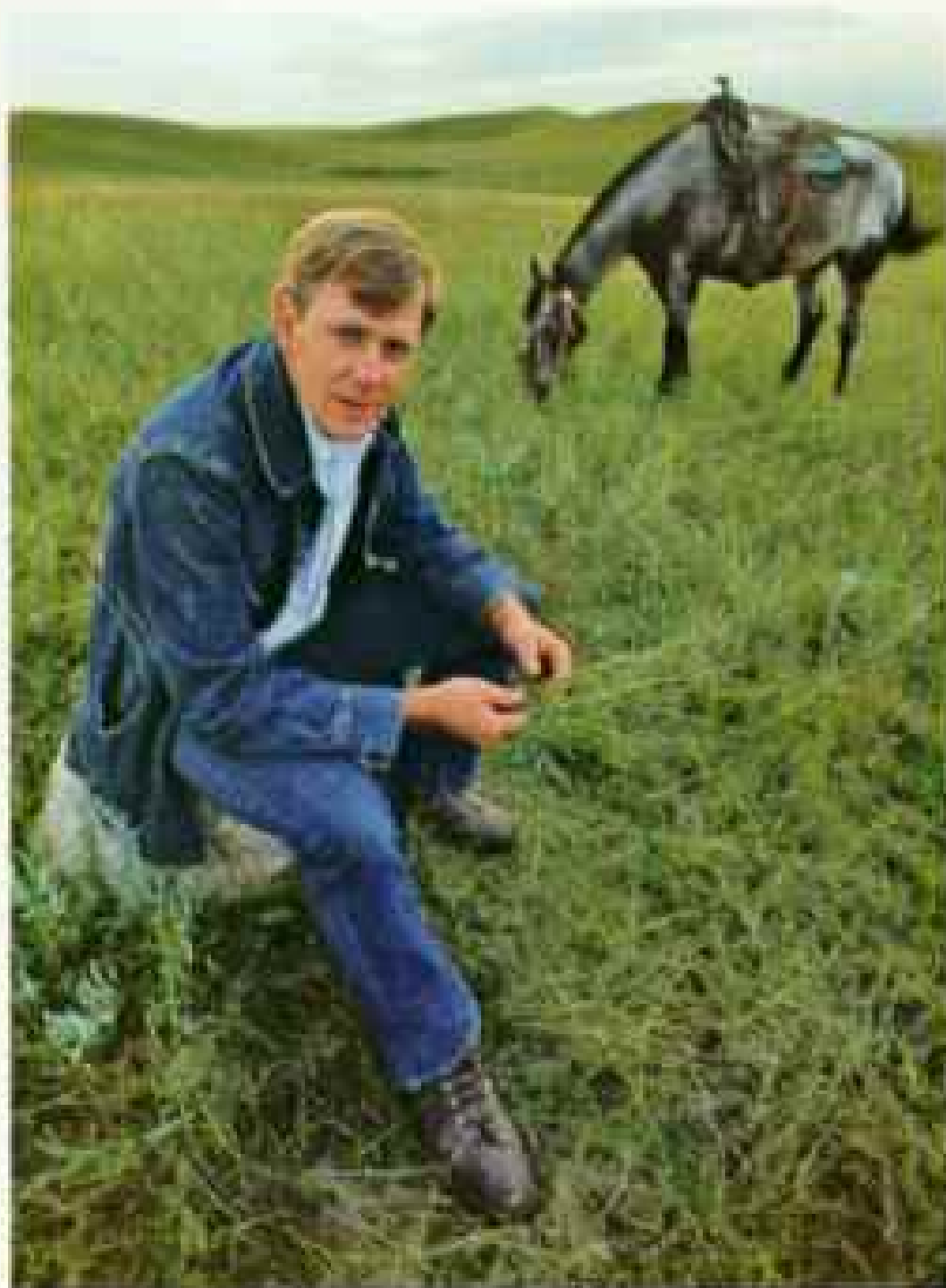
It's almost gone now, that shining, swirling landscape. Other prairie survives, characterized by shorter grasses, on the dry, thinly populated Great Plains to the west.

*Among the galaxy of wild flowers that spangle the prairie, blazing stars shoot up from Cayler Prairie in Iowa. Such preserves dot the Midwest, but most are small. Park proponents seek 320,000 acres in the Flint Hills of Kansas and Oklahoma, a size needed to revive the native ecosystem and evoke the vastness of the virgin prairie.*



*Her firm stand is made clear by bumper stickers (right) on the farmhouse of Mrs. Lowell Thierer near Alma, Kansas. The Thierers are antipark but not antipublic. They hold molasses-making festivals and run two old-time museums on their land, part of the proposed park site.*

*Real horsepower, less harmful than wheels, serves Paul Bultsma (below), who manages South Dakota's Samuel H. Ordway, Jr., Memorial Prairie.*



But the tallgrass prairie, the king of prairies, became the corn belt. Became Chicago, became Des Moines, became home for 25 million people. As the homesteaders' steel plows sliced through its matted roots, it all but vanished in a ringing, tearing sound.

That didn't happen in the Flint Hills of eastern Kansas, a fifty-mile-wide swath that runs north-south across the state. There the plow ran into a thin and stony soil, and so today the Flint Hills remain cloaked in prairie and in a kind of turn-of-the-century peacefulness as well. The hills are dotted with quiet little towns like Cottonwood Falls, with its splendid French Renaissance courthouse and a main street straight out of Thornton Wilder's *Our Town*. The low

stone walls hint of far-off New England. It remains a country of cattle, boots, and branding irons, and of stone barns and houses that seem as rooted to the land as the grass itself.

Almost all these flat-topped hills are wrapped around limestone, deposited by an ancient sea more than 200 million years ago. Embedded in the limestone are nodules of flint, which give the region its name. Here environmentalists are pressing for a Tallgrass Prairie National Park. A proposal to be presented to the U. S. House of Representatives seeks a park of 320,000 acres, split into three parcels. It would fill a gap in the National Park System, which contains no significant reserve of tallgrass prairie.



Vehemently opposed to the park are the Flint Hills ranchers. KEEP THE GRASSLANDS FREE bumper stickers on their cattle trucks. The ranchers fear government condemnation of their land and the changes an influx of tourists might bring to their thinly populated region. They argue that they're already preserving the prairie—in the form of ranches.

The prairie arouses strong emotions. When I survey the world from a prairie hilltop, as shadows edge out into wooded valleys and the meadowlark sings its lilting song, what I feel is pure exhilaration. I believe my grandfather Dennis Farney must have felt it too, although mingled with fear and loneliness; a Kansas sodbuster in the

1880s, he traded a job in New York City for a sod dugout on a windswept Kansas divide.

I grew up three miles from that central Kansas dugout, on a wheat farm that retained two small prairies, slightly degraded. I own them now. And although I live half a continent away, in suburban Washington, D. C., I work on them each spring. There's something innately satisfying about planting seeds in the awakening earth.

A growing number of people share my enthusiasm. The 1970s have brought a great surge of prairie preservation and prairie restoration activity, a phenomenon seemingly bound up with some larger national search for continuity and permanence. I examined that phenomenon recently, returning to

the wide and open country of my youth.

My journey took me to Ordway Memorial Prairie in South Dakota, a jumble of hills and wetlands deposited by glaciers. As I lay belly down in the grass at dusk, dark shapes suddenly loomed against the sky, rocking and pounding. Bison! Heads lowered, powerful shoulders working, they thundered by me into the darkening landscape.

I talked with John Humke, midwestern vice president of the Nature Conservancy, which preserved that prairie as a refuge for both plants and wildlife. Saving ecologically valuable land is the conservancy's sole function; it preserves plants, animals, and samples of ecosystems that might otherwise be obliterated—1.5 million acres nationally to date. In that total are 39,000 acres of prairie—74 projects in 11 states.

"I used to dream of a million dollars for buying prairie," Humke told me. "In the past decade we've spent ten million."

And I met the prairie restorationists—hundreds of them now, rescuing wild flowers and attempting the almost impossible: reconstructing the prairie on ground that was once plowed.

You can grow a prairie facsimile in five or ten years. But some scientists think it could take 200 years to reconstruct the intricate prairie ecosystem. Others think 500. Still others, never. No matter. The prairie-restoration movement continues to grow, part of the impulse that moves some people to restore old homes and trace genealogies.

"It's roots," restorationist Robert Betz told me. "That's why you've got this whole movement of trying to recapture the past. The prairie represents the past. It represents something you can grab onto, something that endures."

### Seeking an Elusive Milkweed

Bob Betz, a 55-year-old biology professor at Northeastern Illinois University, radiates enthusiasm. In the field he wears a red baseball cap and seems to talk in italics. In the mid-1960s he spent two years searching for Mead's milkweed, a flower so rare that few living botanists had ever seen it. He tracked it down in a virgin prairie along a Missouri railroad track.

"Study a wild flower long enough and you form a kind of rapport with it," he told me

with a grin. "People ask me what I want to be reincarnated as. A Mead's milkweed on a Nature Conservancy prairie!"

An improbable thought, but no more so than the Nature Conservancy prairie where I met Bob Betz. Picture a virgin prairie—two blocks from the golden arches of a McDonald's restaurant. Twenty miles south of Chicago's Loop, the Gensburg-Markham Prairie is awash in suburbia. Kids explore it while eating McDonald's French fries. Cars whoosh by it on the Tri-State Tollway. And yet its 93 acres are like an impressionist painting, splashed with color by scores of wild flowers.

"This is the most complicated project we've ever done," Neil Gaston said. Gaston, executive director of the conservancy's Illinois chapter, explained that the site had been subdivided but not developed. The conservancy was given sixty acres and has bought the rest—one lot at a time.

That preserved prairie did my heart good. Yet I couldn't help feeling that something essential was missing there. What was missing was space—unlimited space. Rancher Jack Ferrell has that. He picked me up in the Flint Hills town of Beaumont, in southeastern Kansas, and we were on our way out to visit his spread.

Ferrell at 72 is windburned and tough. Beneath his turned-up Stetson his face is ruddy; white stubble is poking through. He talks of riding herd in a chill factor of minus 50 degrees; frost formed beneath his sweatband in two minutes flat. He talks of a day in 1936 when the temperature hit 118°F and his saddle was "as hot as an iron stove." Squared off and stocky, he walks with a limp. "Picked on the wrong horse once."

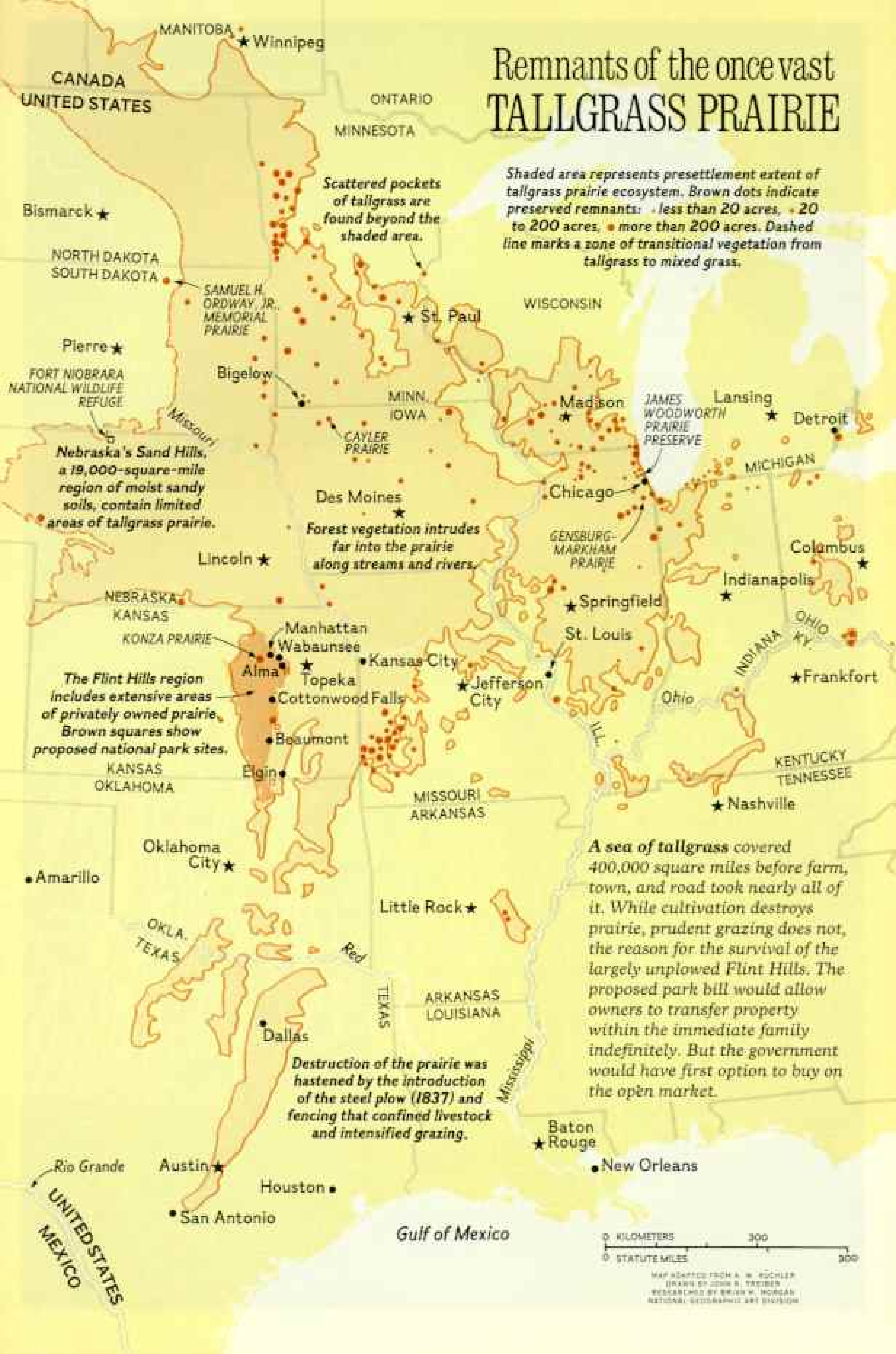
We thumped across a cattle guard and onto the Ferrell ranch: 7,000 acres surrounding a native-stone ranch house. Gearbox whining, our jeep labored up a hillside and finally stopped on a high ridge.

"Now *there*," Ferrell announced, "are the hills." There seemed to be only hills, grass, and sky. I could pick out a windmill and Herefords standing belly deep in big blue-stem, the hallmark grass of tallgrass prairie.

"You're looking at Elk County, Greenwood County, and Chautauqua County," Ferrell said as I took in the landscape that billowed away to the blue-gray horizon.

# Remnants of the once vast TALLGRASS PRAIRIE

Shaded area represents presettlement extent of tallgrass prairie ecosystem. Brown dots indicate preserved remnants: • less than 20 acres, • 20 to 200 acres, • more than 200 acres. Dashed line marks a zone of transitional vegetation from tallgrass to mixed grass.



Scattered pockets of tallgrass are found beyond the shaded area.

Forest vegetation intrudes far into the prairie along streams and rivers.

Destruction of the prairie was hastened by the introduction of the steel plow (1837) and fencing that confined livestock and intensified grazing.

A sea of tallgrass covered 400,000 square miles before farm, town, and road took nearly all of it. While cultivation destroys prairie, prudent grazing does not, the reason for the survival of the largely unplowed Flint Hills. The proposed park bill would allow owners to transfer property within the immediate family indefinitely. But the government would have first option to buy on the open market.



MAP ADAPTED FROM A. W. RECHLER (DRAFT BY JOHN R. TATLER) RESEARCHED BY BRUCE W. MORGAN NATIONAL GEOGRAPHIC ART DIVISION





**Prairies show up** in unlikely places—some saved, some restored. A familiar sign of suburban America shines through the grass on the James Woodworth Prairie Preserve (left), whose rusty fall colors lie surrounded by suburban Chicago (above). The preserve lets cityfolk see what once covered the bulk of the state. Most of the 5.3-acre plot had never been plowed or even grazed when bought by the University of Illinois in 1968. Biologists study the ecosystem and explore ways to improve prairie maintenance. Visitors may view exhibits in the interpretation center, then take a look at the prairie's more than 200 plant species.

The measure of a man falls short on a prairie being restored at the Fermi National Accelerator Laboratory west of

Chicago (below). Standing 5 feet 11, biologist Robert Betz uses two meter sticks end to end to gauge Indian grass, a dominant plant in the tallgrass prairie. The lab's atom-smashing ring, 1.25 miles in diameter, encircles 700 acres of former farmland. So far, 125 acres have been reclaimed. For authenticity the prairie is planted with indigenous seeds from other northern Illinois prairies, painstakingly gleaned by volunteers.



*Plainly made for a simpler day, the Bigelow Town Hall in Minnesota was built as a one-room school (right). The Swedish forebears of Melissa Mahlberg (below) broke sod in the area in the 1870s, a time when Scandinavian immigrants settled in large numbers on the prairie's northern reaches.*



"We're in Butler County. And, oh yes, there's Cowley County over there. How far can we see? I'd say forty miles."

The plow had blackened the narrow stream valleys below us more than a century earlier. But the hills still rippled in grass, guarded by limestone that cropped out everywhere. Small wonder that the homesteaders had turned from crops to cattle.

"Ain't nothing prettier than a red cow on a green hill," Ferrell told me.

The first sizable herds to graze on Flint Hills bluestem were Texas longhorns, driven north each spring across the open range. By the 1890s the longhorns were shipped out by rail, and the Kansas border town of Elgin was billing itself the "Greatest Cattle Shipping Point in the World."

"There were nine saloons in those days, and they just stayed open until everybody got too drunk to care anymore," 90-year-old Fred Dunn, a onetime stockyard worker, told me in the living room of his Elgin home.

Today Elgin's brick-paved main street is lined with gutted buildings; at high noon you can hear a dry leaf scuffle half a block away. Just this side of a ghost town now, it's a victim of a long-term population outflow that plagues much of the region.

To prosper, ranchers must wring more dollars out of their bluestem sod. Discovering basic information about the prairie that will help ranchers without disrupting the intricate prairie ecosystem is one goal of Kansas State University plant ecologist Lloyd Hulbert.

Hulbert's laboratory, outside Manhattan, Kansas, in the heart of the Flint Hills, is the 8,116-acre Konza Prairie, biggest in the Nature Conservancy system of prairie preserves. I visited him and the Konza on a sparkling October day.

Our pickup labored past sturdy streamside oaks and started up a grassy slope. Sumac flamed scarlet against the grass, and the rough-leaved dogwood was turning rusty



NO HUNTING

WALTON FARM



brown. I looked at the shrubbery and saw some splendid autumn scenery. Hulbert saw fuel for a long-overdue prairie fire.

"What flames we'd have here!" he said cheerfully.

"Leave a prairie unburned, and eventually you get a forest on it," he explained. Indians set fires to stampede game, and destroyed invading trees and shrubs in the process. Lightning also ignited range fires. But the number of prairie fires declined sharply with the white man's arrival. As a result, Hulbert continued, "Woody plants now cover many areas that were never forested in presettlement times."

### Fire Is a Valuable Tool

To redress the balance, Hulbert has returned to the ancient tool of fire. The controlled fires he sets in spring devastate shrubs, trees, and early greening invaders like Kentucky bluegrass. The prairie grasses and wild flowers, generally deep rooted and still dormant, never feel them.

Hulbert and I topped the ridge and stopped in a stand of big bluestem. Its seed heads, wine colored and heavy, swayed in the wind as Hulbert stepped out, steel tape in hand.

"Seventy-two and one-half inches, that one," he reported.

Later, in a wet lowland, we found cordgrass ninety-seven inches high.

Always experimenting, Hulbert burns some plots every spring, some as seldom as once in ten years. He hopes to reintroduce elk, bison, and pronghorn, as well as cattle, then compare the various grazing effects.

"We won't fertilize though," he said. "The objective is to get the Konza back as close to its presettlement condition as we can." The idea is to use the preserve as a benchmark against those changes in grazing and cropland that can be measured.

Ranchers concede there may be value in Hulbert's search for better management techniques. But their tolerance vanishes at the first thought of the federal government commandeering their land for tourists.

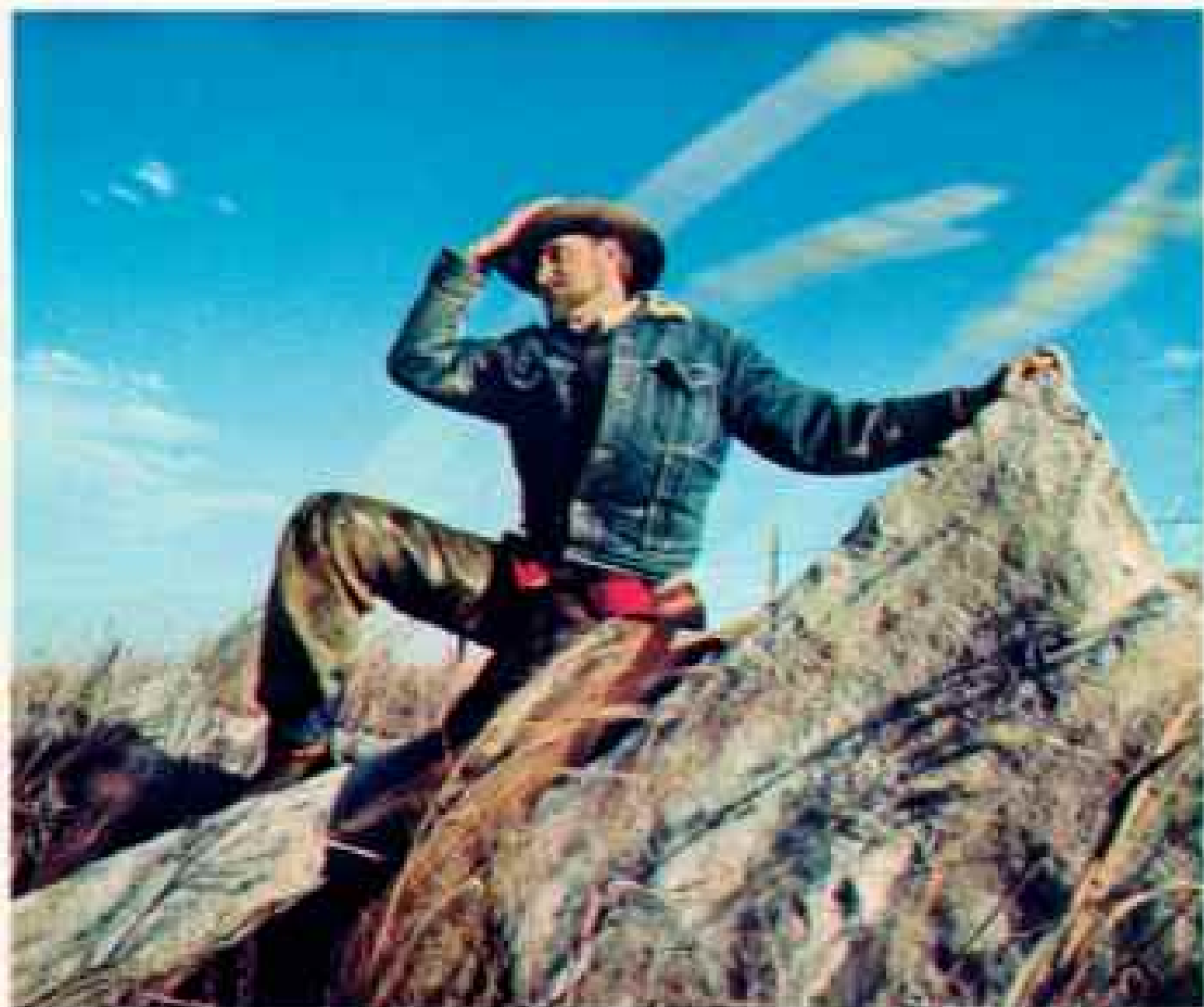
"You know, by golly, what would happen then?" demanded Orville Burtis, an 87-year-old rancher. "Then they'll have to run blacktop roads through it. Have to have rest stations. Have to have a place to buy pop



*Blazing the path for better growth, fire—whether set by man or nature—is an old prairie ally. Deliberate spring*



burning on the Konza Prairie in Kansas, a research preserve (top), removes dead plants. Afterward (above), the growth will be thicker. Were it not for fire, woody species would get the upper hand and eventually turn the land into forest.



*"What vanishing prairie?" asks Jim Hess (left), a fifth-generation Flint Hills rancher. Chairman of the antipark Kansas Grassroots Association, Hess says ample prairie preserves already exist. Ranchers have well protected the rest, he claims, and will continue to. Not necessarily, counters park proponent Larry Wagner, who, crippled with polio, tours the Flint Hills with his father (right). Wagner, a founder of Save the Tallgrass Prairie, says a park ensures that the land will never be plowed or developed.*

and beer. And pretty soon the realistic part of it—the back-to-nature-just-exactly-like-God-Almighty-made-it part—is gone. Why can't they let it *alone*?"

"To be right honest with you," Jim Hess told me, "ranchers aren't much interested in having the government interfere with them. Ranchers are an independent bunch. What bothers us most is the use of eminent domain. We feel it's wrong for one group of people to take land from another."

O. James Hess, 34, is the chairman of the Kansas Grassroots Association, Inc., formed to fight the proposed Tallgrass Prairie National Park. I found him on the open range, working as cold rain pattered in the grass. With whistles, shouts of "hi-yah!" and a cattle prod, he helped his dad and brother crowd the wild-eyed animals into a truck.

We returned to ranch headquarters, framed by flat-topped hills and a wooded valley, and came to a modern frame house—Jim's house, built in 1975. A hundred yards more brought a second house. Brother Alan's house, built in 1915 by grandfather O. W. Hess. Another twenty yards: a third house, made of creamy limestone. Jim's parents live there; great-grandfather Otto John Hess built it in 1892.

We walked another hundred yards, to a stone wall surrounding a graveyard. Great-great-grandparents John and Gertrude Hess lie there. They settled the land in 1856.

Five generations, each adding to the ranch. To lose 8,000 acres of it—the amount

included in one site currently considered for the park—would be to lose part of oneself.

"We feel that preserving the history, heritage, and culture of the Flint Hills is just as important as preserving the grass," Jim told me. "The Flint Hills are a classic case of people living in harmony with their environment. We feel a park would destroy more than it would create.

"Oh, there are other arguments too," Jim continued. Loss of beef production, for example. But the tone of his voice told me that such arguments are secondary to him. The wind raced past us as Jim Hess looked out over his country.

"It's just kind of nice," he said softly, "not having anybody else out here."

When Jim Hess argues against the park, he argues in terms of freedom. When Lawrence Wagner, a co-founder of Save the Tallgrass Prairie, Inc., argues for the park, it also is in terms of freedom. "Consider vastness," Larry Wagner has written. "The sea, the desert, the prairie, the polar ice caps. Where else the clear, uncluttered view? Where else the windswept freshness?"

Wagner is 56 now, a lawyer in Shawnee Mission, Kansas. Some of his earliest memories are of camping in the Flint Hills with his parents. He grew up an outdoorsman, a lover of open country. He fly-fished for bass in Flint Hills streams that slid, clear and cool, over gravel banks. He was a World War II pilot.

Then polio struck him down. At 30 his



arms were useless; he could barely move his legs. He spent six months in an iron lung. He travels with a respirator now. It's not essential, just handy, but still he says, "I have to think every time I take a breath."

His chauffeur is his 81-year-old father, Ray, who looks 65 and drives like 18. We raced off down country roads in a cloud of dust and gravel to inspect the "park."

Larry Wagner calls it the park, as though park status were already an accomplished fact. As our van pulled up on a high ridge overlooking a great sweep of country, he pulled air from the respirator's hissing tube and gazed down.

"A feeling of vastness—I get it more here than anywhere else," he said.

Cloud shadows drifted before us, gliding across rounded hills. Over a landscape encompassing perhaps 200 square miles, the grass was waving, waving in the wind.

#### Here Buffalo Could Roam Again

On this ridge, Ray Wagner thinks, the American explorer Zebulon M. Pike reined in one September day in 1806. Pike wrote in his journal, "In one view below me [I] saw buffalo, elk, deer, cabrie [pronghorn] and panthers [cougars]."

Of these, deer remain in the proposed park area and pronghorn have been reintroduced. All day long, as we drove through the high empty country, Larry Wagner was mentally repopulating it with bison and elk, Franklin's ground squirrels, even river otter

and big-eyed chub. All these, and more, could flourish there.

We bounced across a stream in a shower of water. "These wooded valleys would really be useful to elk in winter," Wagner said. Elk roamed the prairie once, foraging primarily on grass but using trees and shrubs as well for cover and for food in winter.

They'd find what they need in the proposed park: three units totaling 320,000 acres. Environmentalists recently upped the ante; a decade ago they sought only 60,000 acres. But they've offered ranchers a major concession: no land acquired by condemnation unless development or plowing threatens its value as parkland.

Instead, the government would simply designate where it intends to establish a park. Within these boundaries existing ranchers could continue ranching indefinitely, passing their land on to descendants. But whenever a ranch inside the boundaries was placed on the open market, the government would have first option to buy it. Acquiring the parkland this way would take a century or more.

Land within the three parcels that already produces oil and natural gas would be classified as national preserves, so that exploitation could continue.

Keeping intact a sense of openness, "a feeling that the prairie goes on forever," would be one prime objective of the park, as Wagner sees it. Another, equally important, would be maintaining an ecosystem. "Our

opponents talk about preserving pastures; we talk about preserving an ecosystem."

The distinction is central to Wagner's argument. A range pasture is preserved prairie in the sense that it has never been plowed. But it's threadbare prairie, Wagner and others argue. Many kinds of wild flowers and some kinds of wildlife simply aren't there; they haven't been able to coexist with ranching. A park might bring them back.

Wagner concedes that a park inevitably would intrude somewhat on the region's way of life, but thinks the changes wrought by a park would be minor compared to the changes that economic forces and random development are bringing right now.

### Stemming the Change of Time

A slow but pervasive shift in the ranching economy—away from summer fattening of out-of-state steers bound for autumn market, toward year-round breeding and fattening operations—is intensifying pressure on the land. Wagner and I saw threadbare prairies that day, severely overgrazed.

Some ranchers control brush with herbicides—devastating to broadleaf plants, including the wild flowers that are as integral to a prairie as grass itself. One oilman-rancher has seeded his land with fescue, a nonnative grass that greens up earlier in the spring. Wagner fears others may follow his example, replacing the original vegetation with alien species.

Three more reservoirs may join the six major ones already in the Flint Hills, obliterating more prairie. Heavy industry is moving in. A new coal-fired energy complex on the edge of the region is visible thirty miles away. Its chimneys are 600 feet tall. The sprawling complex will eventually consume 12,000 acres. It radiates transmission lines. A planned nuclear plant east of the Flint Hills will send out more of them.

There will always be some prairie in the Flint Hills, no doubt. But how much longer will there be that vast all-of-a-piece landscape we saw that day?

The afternoon was ebbing now. The distant hills were shaded in purple and gray. The sunlight was liquid gold, pouring across a landscape of bronze and green. A chill wind sighed in the grass as our van stopped on a south-facing ridge.

Ray Wagner gently lifted his son into his wheelchair. I asked Larry what he felt in such a setting. "Freedom," he replied, "a freedom from known bounds. When I see the horizon fading off in the distance, I'm liberated, unfettered. Serenity? Yes, I experience serenity here too. But I can find that in other places. Only here can I get this feeling of liberation."

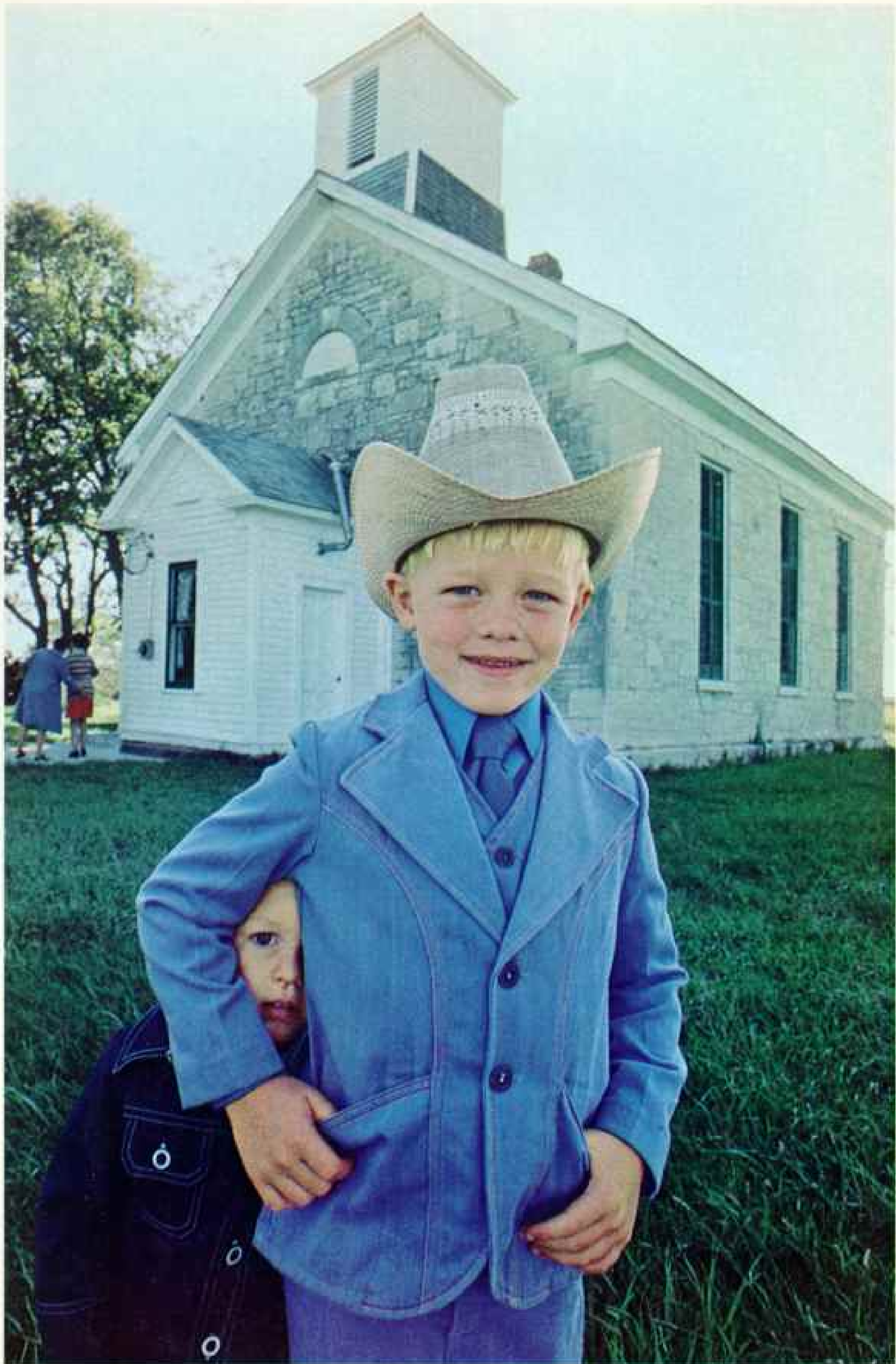
Prairie restorationist Bob Betz, who lives outside Chicago, also knows of such a prairie. But he visits it only in his imagination. For Betz's prairie, the Illinois prairie, virtually disappeared a century ago.

And so Betz has a dream. Someday, somehow, he'd like to re-create the Illinois prairie on a site large enough—say 5,000 acres—to

*(Continued on page 59)*



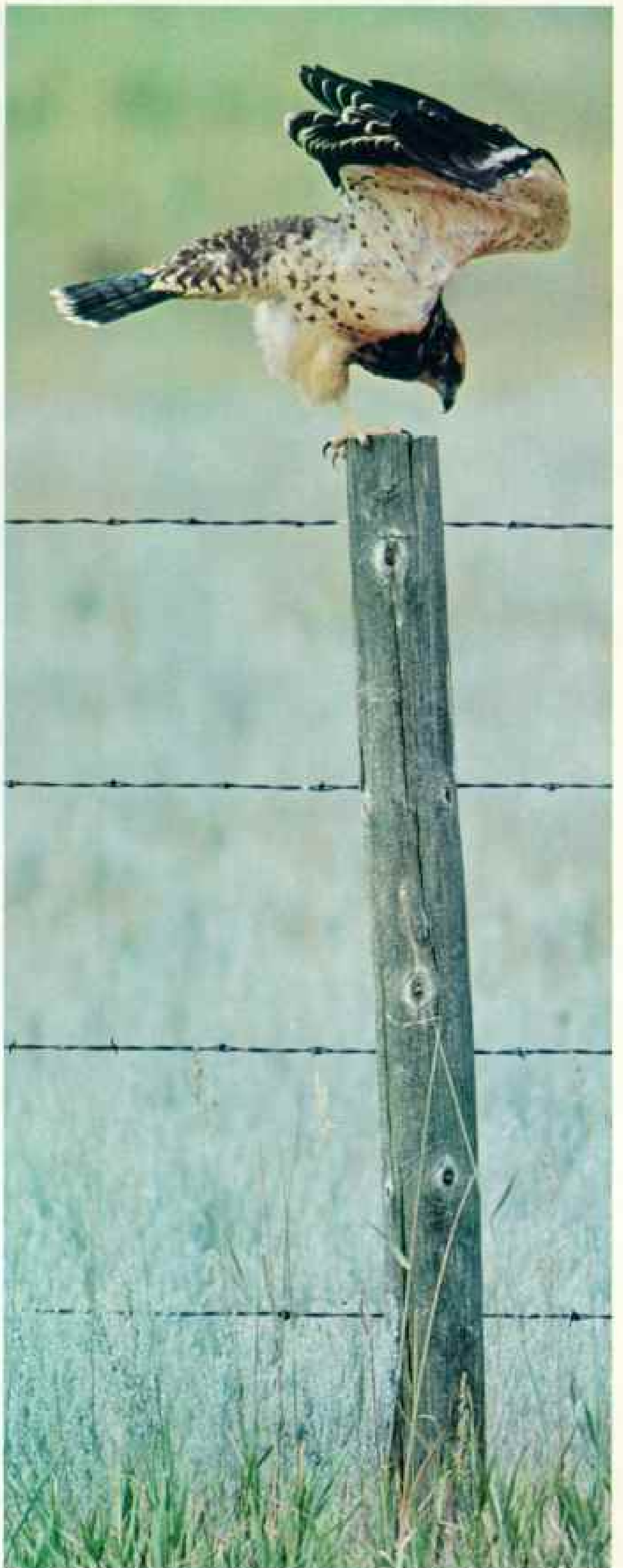
**Beecher Bible and Rifle Church** (right) was built on the prairie at Wabaunsee, Kansas, in 1860 by antislavery settlers. Abolitionist Henry Ward Beecher supplied Bibles and guns to ward off Missouri raiders who wanted Kansas a slave state. The small, integrated congregation includes Curtis Gardenhire, 77 (above), whose father was born a slave. Visitors Dwayne and Bryan Wohler play outside.





*Down-to-earth prairie residents, many birds build homes on the ground. Beside pasqueflowers, harbingers of spring, a newborn horned lark, one of the first feathered species to hatch, waits agape for food (above). With such a vulnerable nest, the horned lark mother cleverly protects her young by drawing attention to herself. "She flutters away," as Audubon noted, "feigning lameness so cunningly" that few "can refrain from pursuing her."*

*Another kind of show is put on by the greater prairie chicken*



*(facing page). The cock takes on his rivals in combat—part real, part ritual—for a piece of turf, where he dances and displays to attract a mate. His characteristic booming call is amplified by inflatable neck sacs. From the sidelines the watching hens approach, favoring dominant males.*

*Other birds are drop-in visitors. The Swainson's hawk (right), pausing during his migration, stretches on a fence post while hunting for small rodents and grasshoppers.*

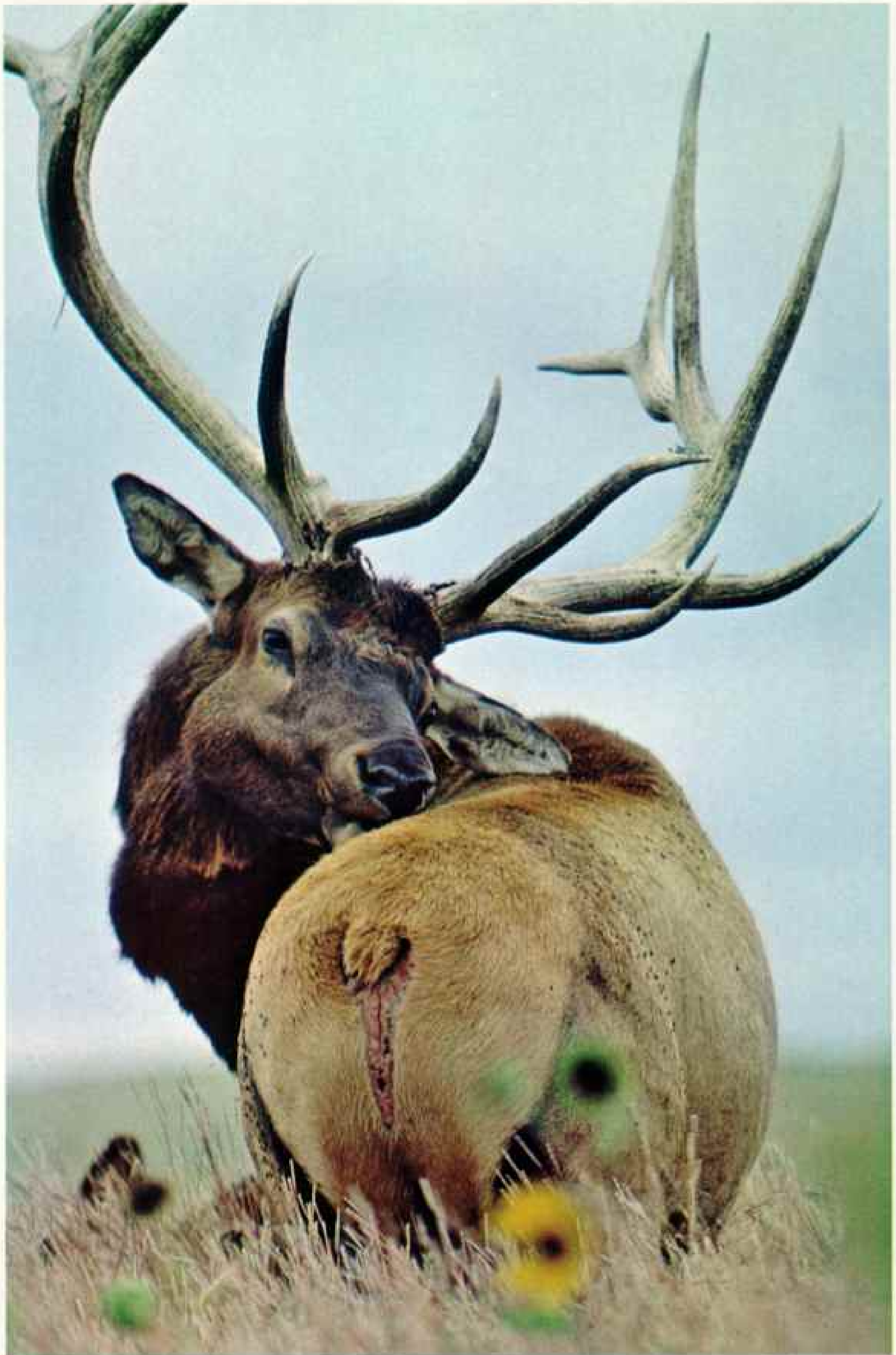




*Escapes from plow and pavement, prairie plants survive in ditches across*



*the Midwest. A strip of cordgrass grows between road and field.*



(Continued from page 52) capture the original's sweep and spaciousness. I joined him one November morning as he prepared to take another step toward that goal.

"Looks good, eh?" he asked exuberantly. "That's an incipient prairie in there!"

We stood beside a grass drill, a tractor-drawn implement used for planting, looking into a seed box crammed with prairie seeds. There were seeds of little bluestem (big bluestem's shorter cousin), fluffy as a mouse's nest. Indian grass, dart shaped and sharp. Prairie cinquefoil, mere specks of dust. Culver's root, looking strangely like coffee grounds. Two dozen species mingled together—360 pounds of seed.

Had it been purchased in small quantities from commercial dealers, that seed would have cost thousands of dollars. For seed of some prairie flowers can cost as much as twenty dollars an ounce. But the seed was free, handpicked by volunteers on remnants of prairie within fifty miles of Chicago. This method guaranteed seed precisely adapted to the area. Now it was ready for planting in a most curious setting.

Imagine a giant doughnut. The doughnut is four miles in circumference, made of concrete and buried in the earth 35 miles west of Chicago. This is the housing for one of the world's most powerful atom smashers, at the Fermi National Accelerator Laboratory. There, scientists accelerate protons to nearly the speed of light, then smash them to study the basic structure of matter.

Now imagine the hole in that doughnut. It is a mile and a quarter across, 700 acres in area. In that hole, surrounded by 20th-century technology, Bob Betz, colleague Tony Donaldson—a Fermi electrical engineer—and a lot of other enthusiastic volunteer helpers are re-creating the 19th-century Illinois prairie, piece by piece.

"I like wildness," Betz told volunteer Polley Cosgrove that day. "I like the idea of wildness. I'd like to see us restore areas as reserves for our grandchildren. The reserves would be kind of like Noah's ark. Then, if

our grandchildren ever wanted to expand the areas of wildness, they'd have these nuclei. That's what we really are trying to do now—save the nuclei."

It isn't easy. Some of the rarest, most beautiful flowers—the white-fringed prairie orchid and prairie gentian—are exasperatingly finicky. The orchid needs particular soil microbes, and those microbes vanished when the virgin prairie was plowed. These species are perhaps best planted years, even decades, after earlier waves of pioneer species have reclaimed the soil.

But pioneers like big bluestem and blazing star present their own problems. Little in their evolutionary history has equipped them for taking hold rapidly on cultivated soil. In contrast, their nonnative competitors are superbly equipped. For many of our common weeds evolved on the ancient cultivated fields of Eurasia, then hitchhiked to America with the settlers. They're genetically programmed to hit the ground running.

#### Stamina Wins the Race

Finally, prairie plant seedlings spend more energy growing down than up. A year-old big bluestem may have a bundle of strong roots but only a wispy top. The seedling is shaded by fast-growing weeds, which need an occasional mowing to keep them in check. If the prairie natives can hang on, the odds tilt in their favor.

"Weeds are sprinters. Prairie plants are long-distance runners," Betz told me. "They're tough babies. Compared to them a dandelion"—he shrugged in utter contempt—"is nothing!"

I saw this for myself when Betz and I inspected two earlier plantings at the Fermi lab. The initial planting of 1975 was flourishing, head high, glinting bronze in the November sun. But its boundary with the 1976 planting hit us like a stop sign. On the 1975 side, grass; on the 1976 side, thistles.

There appeared to be nothing else. Even Betz, that most ebullient of men, looked downcast. We waded on, picking thistle

*Home on the range again, a bull elk turns against backbiting flies on Nebraska's Fort Niobrara National Wildlife Refuge. Except for such preserves, the mountains have offered the elk their main havens following their extermination on the tallgrass prairie.*



*Buffalo roam in a low black mass against a South Dakota sunset on Ordway Memorial Prairie, restocked in 1977 nearly a century after the last of the area's*

barbs out of our thighs. Then something caught his eye, and he gave a little shout.

"Grass!" Betz was crashing through the thistles now. Another tiny clump appeared, then another; suddenly we could pick them out all around us. "See it? See it?" Betz demanded. "See the reddish tint? My God, we've got grass in here!"

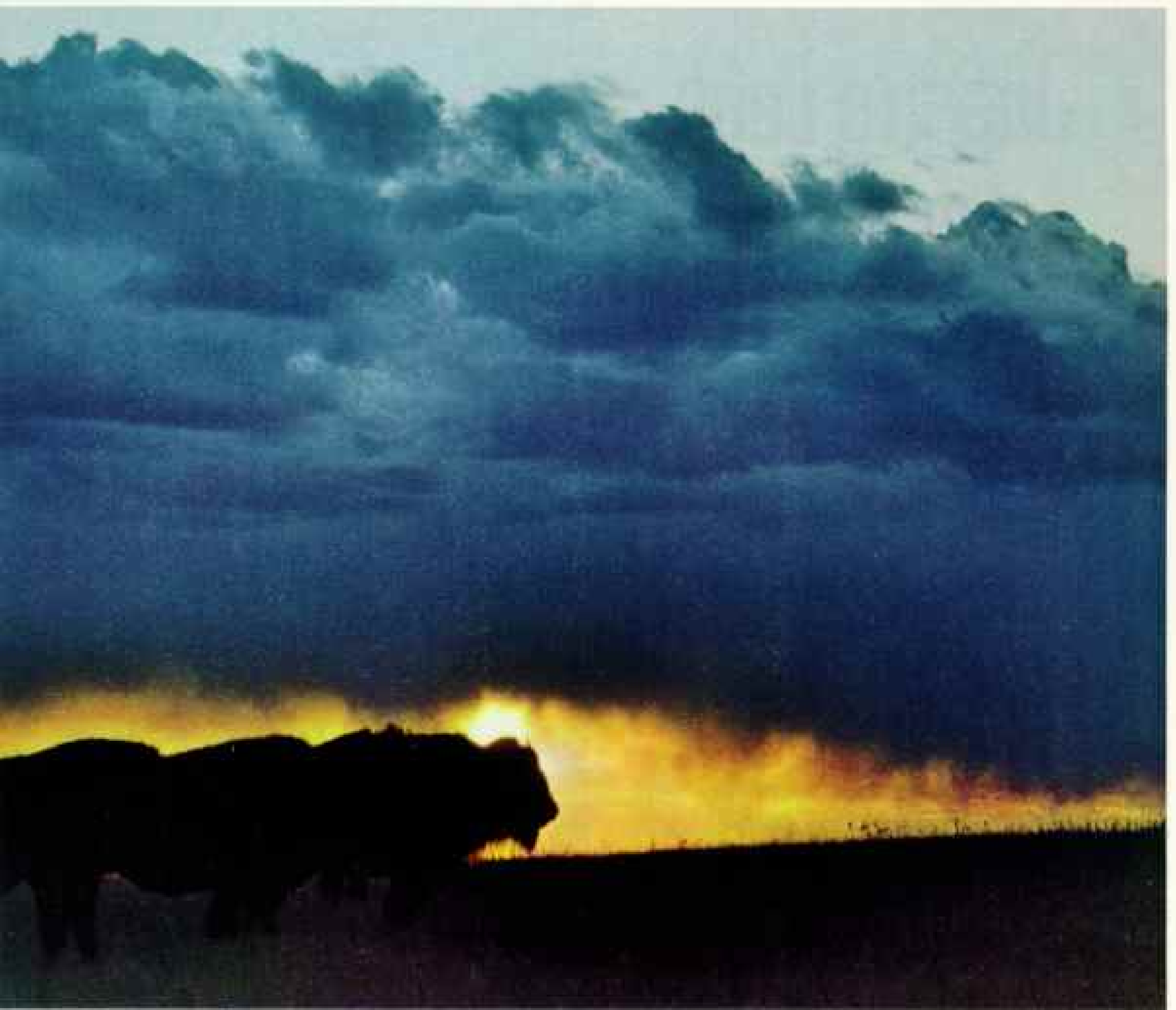
Although the grass was almost invisible, Betz knew that its fragile appearance was deceptive. The strength of the seedlings was underground, in the deep roots they'd sent down during their first critical year of life. Soon they would turn to shooting up and bushing out—choking out the competing thistles just as surely as the once tiny 1975 seedlings had done. The wild flowers, in

hiding now, would eventually follow, if the past was any guide.

"Oh, wait until I tell Tony!" Betz continued jubilantly. "We've got—I can tell you right now—nine more acres of prairie!"

Nearby a tractor pulling a seeder was roaring down a row. Another planting was in high gear, an experiment with autumn planting that could greatly accelerate the pace of restoration.

The previous plantings had been in spring, just after a final cultivation to suppress weeds. But most prairie seeds won't germinate until their dormancy has been broken by the cold and dampness of winter. So Betz and his volunteers had to mimic those conditions by moistening their seeds



*native herd died out. Just as the bison were regenerated after nearly disappearing, preservationists seek a similar revival for the beasts' original home—the prairie.*

and refrigerating them in plastic containers.

Autumn planting does away with this cumbersome procedure. Of course, it also makes cultivation the following spring impossible—the prairie seedlings would be destroyed—and so the weeds sprint off to an even faster start. But, to Betz, the risk is worth taking. “If we’re ever going to build prairies on a large scale, this is the way to do it,” he said that day.

We flagged down the tractor and clambered aboard the drill. Amid a great squeaking of gears, rotating metal fingers of the drill reached up, snatched, then thrust the fluffy seeds down into tubes that led to the ground. The falling seeds glinted one last time in the chill November sun. Then they

fell into the moist black earth and were gone.

The sun was an orange ball now, almost gone itself. Betz and I retreated to the edge of the field and watched the tractor weave its pattern like a shuttle on a loom. Above us big jets descended slowly toward O’Hare International Airport. A flock of blackbirds wheeled, settled in upon the newly planted prairie—and started eating prairie seeds.

“Hey!” Betz shouted. “Get out of there! Go bother somebody else’s prairie!” He walked out into the field, waving his arms and making fierce noises.

“You know,” a watching Polley Cosgrove told me, “that man is worth his weight in prairie seeds.”

And that’s worth a lot. □

# Japan's Last Frontier HOKKAIDO

By DOUGLAS LEE

NATIONAL GEOGRAPHIC STAFF

Photographs by  
MICHAEL S. YAMASHITA

**H**IDEO SAITO first touched a cow in his 19th year. He had traveled more than seven hundred miles from his home near Japan's third largest city to do so. It was his introduction to a way of life he had barely dreamed of, one that was only possible in his country on its northernmost island—Hokkaido.

He told me his story one cold March afternoon in a barn that rang with the cries of geese, turkeys, and a noisy assortment of other residents. The animals belonged to Saito-san, but clearly the barn belonged to his animals. Steam rose from a bull calf on the floor of the barn as the dairyman tended his farm's latest recruit, a Holstein all of ten minutes in this world.

"You see, I was born near Osaka on Honshu, the main island. I remember a few children from farms attending my elementary school, but by junior high there were no farms left—only city."

As the urban-bred son of a white-collar worker, Saito-san had stood in good position in the march that carries most of Japan's youth toward guaranteed lifetime employment in government or industry.

*Winter holds fast to the corrugated slopes of Hokkaido's Mount Yotei even as spring unfurls below. Here in Japan's far north, an island frontier still challenges questing spirits after a century of pioneering.*









Although bowed by the weight of her 87 years, Tomeyo Oba of little Tokoro still braves February's snows and winds out of Siberia.

Hokkaido's bitter winters and its distance from the ancient centers of Japanese civilization long conspired to keep most of the island in the hands of the Ainu, the island's aboriginal people. Modernization began in the late 19th century, and now few traces of the Ainu's culture endure. But stretches of the wilderness that once sheltered it survive in snowbound mountain strongholds and an extensive system of national parks (map).



Instead, after graduating from high school in 1964, Saito-san left the parade.

"We have a saying," he continued, "'Ten birds go together.' All my friends were going off to school with no idea of what they wanted to do. I didn't know what I would do either, but I wanted independence. Then I saw a pamphlet for the College of Dairying in Hokkaido, and I thought to myself, 'I have a chance there.'"

Saito-san's 190 acres would cover 75 average-size Japanese farms. He owns a dairy herd of 105 cattle, five times the usual number. He cannot see his nearest neighbor's house, for his fields lie on the very edge of the Tokachi Plain's arable land, sloping up Tsurugi Yama, Sword Mountain, toward a forest of spruce and fir and a peak with a crown like broken glass. Wind-driven snow spumed over its crest as we walked across crusted drifts to his house.

"The local farmers thought I was crazy when I started here in 1971," he said. We sipped tea by a hot stove in his living room, together with my interpreter, Kunio Kadowaki. A lamb nibbled at the sleeves of

1-year-old Aya-chan while our host's wife, Emiko, washed vegetables.

"They told me I should buy land near the city. But my dream was to farm in the American style—raise my own grain, be self-sufficient. Here on the mountain I've had room to expand. I let my cows roam in the fields instead of shutting them in stalls all day as most farmers do."

He laughed—a spare, open-faced man who smiles more often than he doesn't—"I came to Hokkaido for freedom. Maybe my animals like freedom too."

### Wilderness Only a Century Ago

Again and again, in weeks of travel, I would meet the likes of Saito-san: men and women who have turned from the mainstream of old Japan, from its ancient beauties and modern computerized order, to seek in Hokkaido what seems impossible elsewhere in their island nation.

They find a refreshing absence of industrial sprawl . . . only 5 percent of Japan's dense population spread over more than a fifth of the nation's land . . . a national park





larger than Grand Teton . . . people who like to call themselves the Americans of Japan.

All these they find because Hokkaido is the last open country Japan still holds—an island that only a hundred years ago, when Tokyo was one of the largest cities on earth, remained a virtual wilderness.

Trace an outline of Japan on a map of the world and traverse it along the lines of latitude until it rests on eastern North America. Hokkaido's 30,313 square miles, a territory just smaller than Maine, lie in the heart of New England, and the two regions share much in climate, even in appearance. Cool-weather forests of pine, birch, beech, oak, larch, and a dozen other species blanket 70 percent of the island, often draping along its contours in the orderly rows of scientific management. Fast waters in streams and swift rivers drain out of sharp-ribbed mountains that top out at Mount Asahi, 7,513 feet high, where snow lingers into summer.

The Pacific coast is Thoroughbred country, a white-fenced Kentucky of Japan. (Horse racing is the nation's most popular betting sport.) Elsewhere cattle and broad-shouldered draft horses graze in high-walled valleys. Percherons, Bretons, Clydesdales first cleared the land and then pulled the plows that tamed it, but today they are bred for *bamba*, a race in which they drag sledges carrying driver and ballast weighing as much as a ton (page 72).

A tendril of the Kuroshio, the Pacific Ocean's counterpart of the Gulf Stream, curls into the Sea of Japan to thaw Hokkaido's west coast. In the east the Oyashio washes south past the long, Soviet-annexed Kuril Islands chain from the Bering Sea—

*A wealth of land enables Hokkaido to rival the nation's most fertile regions in rice production and surpass them in dairying, potatoes, and sugar beets. Large paddies invite mechanized planting (left), three times faster than traditional hand-planting techniques (top).*

*Home and haven for a tiny fishing village (overleaf), Kojima, or Little Island, rides the sea like a factory ship. Kelp, a prime summer take, dries on its gravel beach above molded concrete wave breakers.*









*Where beef is a treat, fish is a staple that keeps much of Hokkaido's huge fleet busy year round. Hauls by small family-owned boats from the Sea of Japan include rockfish and Atha mackerel (above). Elsewhere salmon ranks among the most prized catches, fetching \$4 a pound at Hakodate's wholesale market (left). A widespread artificial-hatchery system helps ensure future stocks. The fishery's longest arm reaches out to rich continental shelves in the northern Sea of Okhotsk and off North America—where strict quotas by the United States and the Soviet Union limit catches within 200-mile boundaries.*

cold, rich with nutrients, a river of food for one of the world's best fishing grounds.

Pack ice nudges south in the Sea of Okhotsk, bringing harbor seals to winter along the shore. Sea lions, too, inhabit the coastal waters, although not in the numbers found in earlier days when this island fastness was the last domain of a people very different from those we know as the Japanese.

They called themselves the Ainu, and occupied Japan's northern regions for at least a millennium.\* To the Japanese they were the Ezo, "alien people who live in the north." The same name was given to this island.

For many centuries Ezo remained terra incognita, a wild haven for smugglers and outcasts from the turbulent history played out on the islands to the south. Except for Japanese settlement on the Oshima Peninsula, nearest Honshu, the bulk of the rugged island was left to the Ainu to hunt and fish as they had always done. Then, in the latter half of the 19th century, Japan changed forever.

A liberal revolution under the new Meiji emperor turned the country away from centuries of feudal rule toward the model of the industrial West. The decision was made to tap the northern treasure-house of timber, coal, fish, and that one resource more precious than any other: land. Ezo, the barbarian isle, became Hokkaido—North Sea Route—and the demise of the Ainu as a people was sealed.

"As immigration to Hokkaido began, the Ainu were forced to assimilate," said Mineo Kaiho of the Historical Museum of Hokkaido. "Even in earlier periods the Ainu were economically under Japanese control through trade, but the Meiji government stressed adoption of Japanese dress, customs, and language."

From the museum steps we could see Sapporo, the capital and queen city of Hokkaido, home to one in four of its 5½ million people. A city with its back to the mountains and its face to the island's most fertile plain, Sapporo stepped into international prominence when the Winter Olympic Games were held here in 1972.

\*Aided by a research grant from the National Geographic Society, ethnologist Sister Mary Inez Hilger studied the Ainu and wrote of them in the February 1967 issue of the GEOGRAPHIC.





Beside the museum stands a tower erected in 1970 to celebrate the centennial of Hokkaido's pioneers. It has been a focal point for minor tremors of protest in the last few years. To Japanese, the tower's hundred meters symbolize a century of progress. To many Ainu, they represent a hundred years of domination.

Perhaps 20,000 people can claim some Ainu heritage. Estimates of full-blooded individuals range from a few hundred to none. Some scholars have theorized a Caucasoid strain in these hirsute, light-skinned people, while others argue that they are of Mongoloid stock.

Discrimination is a real problem for many. In marriage, Japanese families sometimes go so far as to hire a detective to check on the background of a potential spouse; minority ancestry usually ends the match. In jobs, lack of opportunities in other fields sometimes leaves few alternatives to wood-cutting or carving wooden souvenirs in tourist-trap *kotan*, small Ainu villages of dubious authenticity.

#### An Ainu Clings to His Roots

A different sort of *kotan* stands beside Shigeru Kayano's house at Biratori. It is the creation of a man struggling almost single-handedly to shield the flickering flame of his Ainu heritage.

On a few occasions his *kotan*'s straw huts have been the scene for Ainu rituals, even marriage ceremonies, pieced together as authentically as possible from Kayano-san's research among the elders who still remember. Hope mingles with bitterness as he speaks of the lack of official support for his efforts to preserve a language that only he and a handful of others still understand.

"Little ones learn quickly. I want to start a kindergarten where both Japanese and Ainu children would learn our tongue. An hour a day would be enough. We Ainu have no written language, so once the spoken word is gone, there's nothing left.

"Once in Alaska I saw Eskimos studying

Eskimo. In China I saw street signs in Korean and other minority languages. So it is possible to have separate identities within one country. Japanese don't like to admit the existence of others here. Some support, some money from the government for my school, for job training, for housing, that would be a kind of *nengu*, a compensation for the land they got from us. That's not much to ask in payment for a whole country."

#### Still a Pioneer at 85

Railroads had snaked out to open much of the interior of Hokkaido by the time Jinkichi Meguro arrived in 1916, but the land where he settled, near present-day Obihiro, still lay under virgin forest. That was fine with him; he was 21, and handy with an ax.

"There were tall trees then. We cut them in winter, level with the snow. In spring the stumps stood three feet high." His gold teeth gleamed in the winter sunlight that streamed into the parlor of the family's modern wooden home. His son Hiroichi and grandson Yutaka sat near him on the floor while Yutaka's bride served tea and *mochi-gashi*, glutinous cakes of pounded rice stuffed with sweet bean paste.

"We didn't eat mochi when we were first here," said the grandfather as we chewed. "We ate what we raised—millet, barley, wheat. Ah, we were very happy when we could eat mochi!"

In 1940 Meguro-san was able to buy the land he had been renting, and today the family raises beans, wheat, and sugar beets, a crop introduced by American advisers in Hokkaido's infancy, on 55 prime acres.

"This is a very good world we live in now. The houses were made of straw when I first came here. Nobody imagined the kind of progress we have today."

Twenty-six-year-old Yutaka Meguro sat beside his wife, Naoko. She had moved to Hokkaido less than a year before. After working part-time jobs on neighboring farms, she was introduced to Yutaka by a go-between, a friend of the grandfather.

*Plodding race pits massive draft horses pulling sledges, each ballasted to the horse's own body weight, in the island passion called bamba. Over 200-meter courses, like this one at Obihiro, the animals cross two humps. The limits of endurance dictate a tense pause before the final surge over the second hump.*



Like many elders, he makes a hobby of arranging the formal matches that still account for more than half the marriages in Japan. The Meguros are his 11th success.

"A lot of my friends can't find wives," said Yutaka. "Not many girls today want to live on a farm." The problem is common in a country recently escaped from its rural roots, with many memories of hardscrabble times still fresh.

So critical is the shortage of farmwives on Hokkaido that local and prefectural organizations send troops of fifty young farmers at a time to meet like numbers of marriage-minded girls in Tokyo and Osaka. Hokkaido wants to keep its farmers happy—and keep its farmers.

The fields outside the window were white; the windbreaks of larch and birch stood ice rimed and bare.

"What do you do now, when the land is still frozen?" I asked the family.

"Nothing!" Hiroichi-san replied happily. "Eat, sleep, watch television. . . ." He arched an eyebrow. "Drink sake."

"This moment we live in is very good," his father said. "I could never wish for a better time than now."

#### Farmers Accept Hokkaido's Challenge

The settlement of the island is still under way in the hills of eastern Hokkaido. Shiny new silos stand like chessmen on a board of raw fields drawn by windrows of freshly



*Three-year vigil drags on for Mrs. Mitsuko Iizawa, far left, whose husband is imprisoned in the Soviet Union for illegal fishing—his sixth such incarceration. Tetsuzo Nagasaki, right, has twice been imprisoned, as have thousands of other Japanese since Soviet occupation of former Japanese territories at the end of World War II pushed nautical boundaries to within two kilometers of Hokkaido's shore. Japan holds that it rightfully owns four of the occupied islands, shown on a billboard (above) proclaiming Return the Northern Territories.*

bulldozed trees: Japan's largest current land project is transforming 37,500 acres of marginal land into a thriving dairy center. For "colonists" who take over the large new farms, debts are enormous and the commitments of labor daunting, but project planners have found no shortage of takers.

In the nearby Abashiri area Dr. Minoru Takedatsu, a fast-talking veterinarian with little time for formalities, understands the reasons.

"Veterinarians and mailmen are about the only people moving around here from November to April, and I hear all the farmers' stories. They're gamblers—they care more about how much they can borrow than about how soon they can pay it back. In

Kyushu, where I grew up, it's the opposite."

A fascination with Hokkaido's wild country first drew the veterinarian to Abashiri, and he is a leading expert on the Ezo red fox. Like much of Hokkaido's wildlife, this fox is not found on Honshu. A natural demarcation zone, named the Blakiston Line after the scientist who first defined it, runs through the Tsugaru Strait separating the two islands. The line relates many of Hokkaido's animals to subarctic Sakhalin, the Kuril Islands, and Siberia.

Five red foxes, an arctic fox, and a Japanese raccoon dog yammered excitedly in pens behind his house as Takedatsu-san's daughters fed them pieces of chicken. Kids and kits had grown up together, and the

children play with the foxes like friends. "Not pets," Takedatsu-san cautioned. "With foxes you must be equals."

"Unfortunately, the more I've written about foxes, the less mystery they have. Farmers once considered them magic animals. If they killed one, they would be punished by the gods. Now they hunt them on snowmobiles. It's my great regret."

#### Human Pressure Menaces Animals

Hunting of foxes stems in part from government bounties prompted by local outbreaks of echinococcosis, a disease sometimes transmitted to humans, and in part from the value of their pelts. Bounties and a thick pelt also make the Ezo brown bear a target, as does its gallbladder, prized as a folk remedy. One bear may fetch \$2,000.

This close cousin of the Alaska brown bear raids livestock and sometimes kills a mushroom picker or fisherman in the mountains. Conflict is inescapable where civilization and the last wild refuges exist so close together: Hokkaido University zoologists tell of sightings just outside Sapporo, and estimate a population of three thousand. Animal writer and filmmaker Masanori Hata disagrees (page 84).

"Twenty years ago you could go into the Hidaka Mountains and choose which set of prints to follow. Now it takes days to find a single bear. The bounty is unfair. We are entering their territory, not the opposite."

Hata-san has raised two cubs in his Animal Kingdom near Hamanaka. We talked for a long afternoon about remarkable creatures: the *ito*, a freshwater relative of the salmon that grows large enough to eat rats; the Steller's sea eagle; Blakiston's fish owl; the black marten.

Some are success stories. A popular symbol of the island came back from presumed extinction here in the 1920s. In 1924 about twenty tancho cranes were discovered in the Kushiro-Nemuro marshes. The area was promptly designated a national monument, and the birds increased steadily. Now there are 257 of these red-crowned beauties.

Citizens' response to conservation programs is enthusiastic, as I witnessed one day in an extraordinary celebration in the heart of Sapporo.

Children sang the "Baby Salmon Song,"



*Snow worshipers search Mount Asahi, the island's highest peak (above), for strips of unmelted snow in June—earning the title ski-kichigai (ski crazy). Most of the island's young people are just that, and many have moved here from Japan's southern islands for the freedom of wide-open spaces found nowhere else in the nation. Hikers on another part of the mountain treat themselves to a warmer reward. Damming thermal streams with a makeshift rock wall, they enjoy what amounts to a birthright for every Japanese: a hot bath, whenever and wherever possible (right).*





composed especially for this occasion, the release of fry into the Toyohira River, from which pollution had driven the fish years before. Politicians gave speeches and a band played. A tank truck rolled down to the riverside amid a swarm of photographers and television cameras, and children and parents carried 200,000 fry in buckets from truck to river (page 90).

The greatest hazard to the young salmon may have been the crowd itself, surging right into the icy water. As the fry formed into silvery banners and waved off down the current, I read a translation of a letter written to the fish by one of the youngsters, a boy in the second grade.

"Salmon baby, you will meet many friends. But when you go down the river, don't hit the rocks. Don't be eaten by seals. Salmon baby: Fight! Fight!"

Parks cover nearly 10 percent of Hokkaido, and there's a whiff of sulfur at the heart of almost every one. Two volcanic chains dominate the island, and thermally heated water bubbling out of the mountains' grumbling guts rivals skiing as the parks' greatest attraction; bathing is as much a rite as a simple act of cleanliness for Japanese, who plunge into scalding water as regularly as Americans brush their teeth.

"Our parents' generation never heard of camping," said park ranger Tetsuro Kaji. "They vacation at the bath resorts. Climbing is popular, and more and more students are going into the outdoors. But outdoor recreation is fairly new in Japan."

I glimpsed what those outdoors have to offer one snowy afternoon near the tree line in Daisetsuzan, Japan's largest national park and the roof of Hokkaido. I stood on



cross-country skis and fished for rainbow trout, an imported species, in thermal streams unfrozen in the alpine-cold.

That night I saw the park's more traditional attractions after I blew into the resort town of Sounkyo with a blizzard on my tail. I'd had my fill of storms. One that caught photographer Mike Yamashita and me traveling through mountain passes at night gave us an hours-long nightmare of near-zero visibility on a road all but erased by drifting snow—the most frightening drive of our lives. During another on the island of Rishiri, I stood in a room suddenly plunged into darkness and watched tin roofs peel away like cardboard against the skyline.

But this night I forgot about the storm and followed the time-honored prescription for guests at a Japanese inn: a mind-numbing hot bath, then a meal of many courses,

*Push-button affluence came last to Hokkaido of Japan's four main islands. But it has arrived, as these dispensers indicate. More important, a high-powered government development agency has thrust Japan's most up-to-date road system to the far corners of the island.*

served in the room by the inn's floor matron. Finally, gratefully, I crawled into my *futon*—the comfortable Japanese sleeping pallet—and savored its warmth while snow gusted past the streetlamps below.

As I slept, five students from Hokkaido University were fighting the blizzard for their lives, and losing.

About a hundred miles to the east on a peninsula named Shiretoko, derived from the Ainu for "land's end," they struggled all that night and all the next day to keep their tent free of wet, driving snow. It collapsed in the afternoon with all their food inside it. The group's leader died of exposure; one student set off down the mountain for help. When rescuers swarmed up the next morning, only one other still lived.

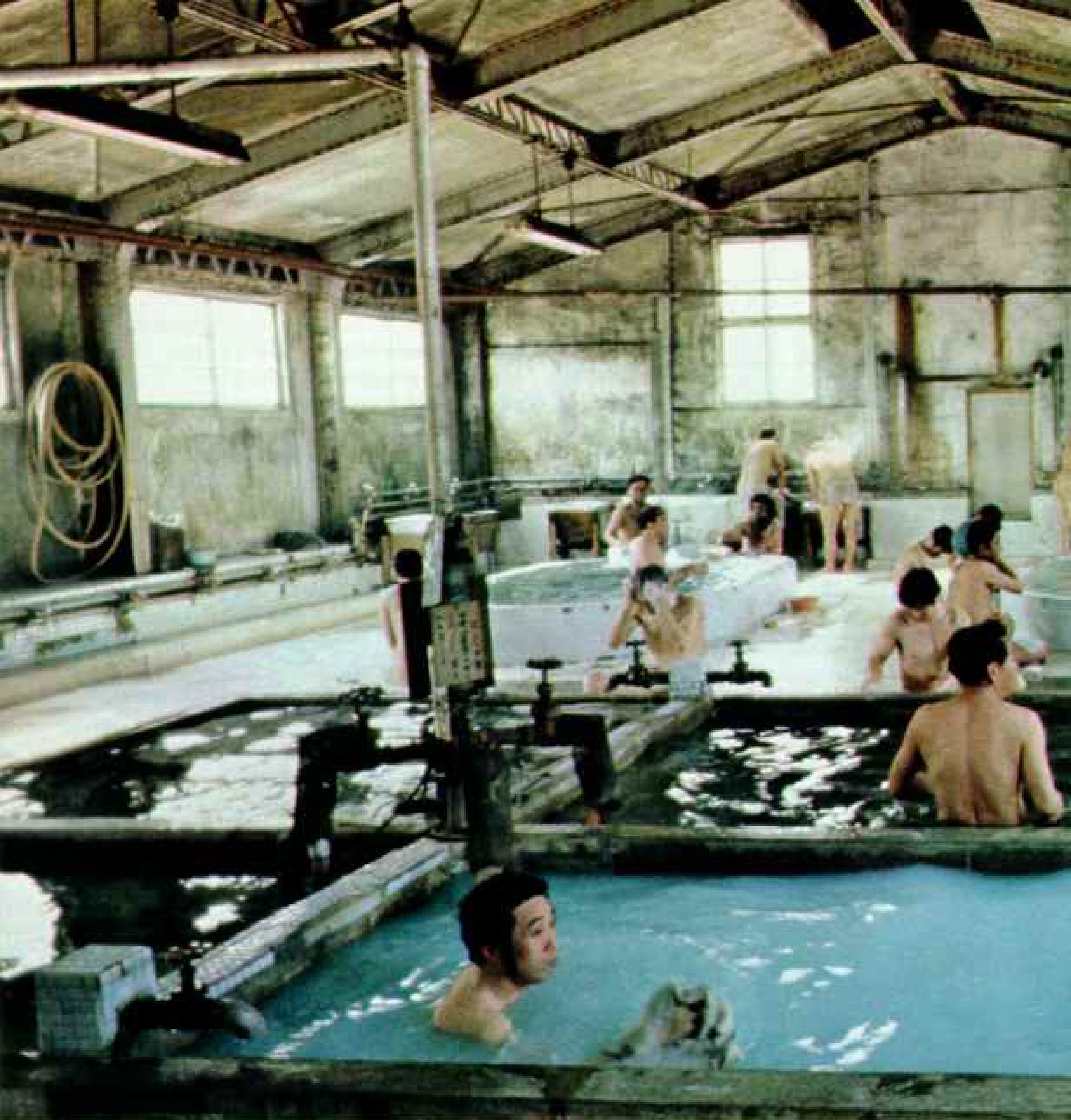
"They made the decision to get out too late," said Kenji Shiga, who, as assistant mayor of Rausu, the nearest town, had directed rescue operations. "They had experience, but they were from the southern islands. Local people know how severe it is here in the mountains by the sea. Sometimes you can't even walk on the streets in town."

#### Siren Song Draws Love-struck

The bitter ends of Hokkaido hold a romantic fascination for many Japanese. While deep, clear caldera lakes and famous spas draw the lion's share of Japanese visitors to Shikotsu-Toya and Akan National Parks, more and more find their way to even more remote hinterlands.

A national park encompassing Rishiri and Rebun Islands and a stretch of marshy coastline is famous for its spring flowers, but much of its lure lies in its proximity to Soya, the northern cape of Japan. Shiretoko National Park became a favorite of single women after a love song set there swept Japan in 1970. Feelingly it told of the long northern summer twilight—"the white nights of Kunashiri" *(Continued on page 86)*







*Day in darkness ends for mine workers emerging from a shift (left) in the Ishikari coalfield, Hokkaido's largest. In company baths miners soap and rinse, as Japanese etiquette demands, before soaking in hot-water pools (above).*

Coal was a prize that helped spur Hokkaido's development. Exploration has since indicated reserves equal to half the nation's total. Yet high domestic mining costs led industry in the 1950s to decrease

its reliance on Hokkaido's coal. Many a former boomtown now consists mainly of rotting rows of empty company housing.

Future energy needs in a country that imports almost all its fuel may revive the mines. And development-agency projects are planned to create new jobs near the Ishikari field. Present heavy industry—pulp mills and iron- and steelworks—is centered to the south of Sapporo, the island's capital and largest city.



*Thoroughbreds paw a frozen paddock in Hidaka, Japan's biggest breeding region.*



*Horses race on the southern islands, to the gain (or loss) of ten million fans.*





*Body language* expresses affection between Jack, a stag, and animal writer Masanori Hata (left), who raised the Ezo deer at his Animal Kingdom menagerie (Ezo is the archaic name for Hokkaido). Other residents—all native to the island and dwindling in population—include Ezo red foxes, an Ezo brown bear, and hardy little ponies (top).

Hata-san says of the many admirers who seek his guidance, "Young

people come to me, asking how to get jobs protecting wildlife, but there are few opportunities in that field in Japan. Often they have to go abroad. . . . It's very sad."

While his work with indigenous island species continues at the isolated Animal Kingdom, Hata-san lives in a newly built log house (above) in less remote Naka Shibetsu: "My political center," he says. "I can do nothing alone."



*Best part of the school week is three hours of instruction — by classroom teachers —*

*(Continued from page 79)* that seem to drift over from across the strait—and of a day of parting, and of tears beneath wheeling white sea gulls. Most visitors to this “land’s end” ride sightseeing boats around the peninsula or visit the Five Lakes near the park’s boundary, then leave. But the untrammelled wilderness is there. It is a miracle of sorts, in this crowded country.

#### The Great Provider, the Sea

Some nations have their plains and steppes, flat immensities of fertile cropland. Japan has the sea. Even in Hokkaido’s interior it is a presence never farther removed than beyond the next mountain range. Racks of drying fish hang under the eaves of farmhouses and fishing huts, and the smell

of seaweed drifts far inland on the breeze.

Hokkaido’s indomitable fishermen go out on their harsh northern seas in every sort of vessel, and what can be taken from the ocean, they take—in all, 20 percent of Japan’s total catch.

Canoe-size boats creep among fields of floats just offshore, tending cultivated scallops and seaweed, including a kelp prized throughout Japan. Sea urchins, oysters, and other shellfish are gathered, and farther out cod, pollack, mackerel, octopus, squid, hairy crabs, and king crabs are taken by ships as large as a hundred tons.

Once, along the Sea of Japan, fleets set out in spring for herring, but no longer. As happened in the North Sea about the same time, the seasonally swarming hosts that drew



*on one of the many dozen ski slopes that make Hokkaido a carnival of winter sports.*

fishermen as long ago as the seventh century A.D. all but disappeared in the 1950s.

Today in areas like Shiretoko it is said, "If it's not a salmon, it's not a fish." There lucrative catches have made some salmon fishermen *navikin*—turned to gold. (The term also describes a pawn in Japanese chess that crosses the board to become a queen.)

Four out of five of Hokkaido's long-range boats operate within the Soviet Union's 200-nautical-mile boundary, adopted in 1977, and restrictions have cut the high-seas catch to half of the 1.5 million tons taken in 1976. Ironically, a reduction of offshore nettings has benefited some inshore fishermen by increasing prices for salmon—red, chum, king, humpback, and silver.

The roots of Russo-Japanese disputes

over northern borders go deep. Since the Soviet Union occupied Japanese territories to the north of Hokkaido and expelled all Japanese at the end of World War II, almost 13,000 Japanese fishermen have been arrested for fishing in waters they consider their own. A recent Soviet military buildup in these territories has exacerbated the dispute.

For the Japanese Government, Soviet occupation of the "four islands"—Kunashir, Iturup, Shikotan, and the Habomais—remains one of the principal stumbling blocks to the signing of a Russo-Japanese peace treaty. For the fishermen of Nemuro and Rausu, all but hemmed in by Soviet-claimed waters just offshore, it is a daily problem and sometimes a tragedy.

From the flying bridge of the Maritime



Safety Agency's patrol boat *Kitagumo* (Northern Cloud). Kunashir was a white monument on the horizon of a sparkling blue sea. Growlers, little icebergs, slid past our bow. The Soviet Union began somewhere a few hundred yards to starboard, and beyond the boundary stretched the long tan bluffs of the Habomai Islands.

The men of Rausu and Nemuro pursue a precarious business. Many stay within Japanese waters despite the wealth of fish just across the boundary. Others bribe guards on Soviet patrol boats with luxury items, or even with information. "A picture of you entering our offices could be used by such a person," a safety-agency official told me, not quite in jest.

There are many, though, who simply brazen it out, nipping over when no Soviet vessels are in sight and getting out while the getting's good—sometimes.

"They used to imprison many of those they caught, but now the Soviets usually just fine them," I was told. "Only two men are in prison right now, a captain and a fishing master."

Despite official coolness, emergencies at sea transcend all politics. The same patrol boats that Japanese fishermen usually dodge have plucked them off foundering vessels or towed them to safety on occasion.

#### Fisherman Fights for Islands' Return

Hiroshi Sawagami wants more than people rescued; he wants to save the islands themselves—for Japan. To that end, he heads the local Committee for the Reversion of the Northern Territories. Perhaps more than for most, his stake is bitterly personal. He was born on Kunashir, but has seen it only three times in the last three decades, each time en route to Soviet prison camps, once on Sakhalin, twice in Khabarovsk on the mainland. All told, he has lived five years of his life in Soviet detention.

A heater beneath the table was warming Sawagami-san's knees when we met at his home that night. He sat drooping from fatigue after a fishing trip that had begun at 3 a.m. Fortified with tea, he spoke slowly about his captures and imprisonment.

"They were foggy days . . . I couldn't tell how far from shore I was. The Soviet inspectors used a handbook; they didn't speak



**Anchor link** between Hokkaido and the rest of Japan, the port of Hakodate (above) handles a constant stream of ferries to and from Honshu. Storms often close the ferry route, but a tunnel now under construction will provide more reliable train service. To many Japanese, Hokkaido is not quite Japan, and in fact island styles like nontraditional chimneyed houses (right) reflect adaptation to its harsher climate—and a flexibility that gives those who choose Hokkaido a reputation for being mavericks.



Japanese. They couldn't understand my explanations.

"There was an interpreter when they examined me on Shikotan, but I couldn't tell what they wrote down. They just told me to sign, and said my sentence would be longer if I refused.

"Each time I got the same sentence: two years for violating territorial waters, two years for illegal fishing, but each time I was released early. On Sakhalin I worked in a quarry. Near Khabarovsk we sewed Soviet military uniforms. That was a little easier."

Insurance taken out specifically against capture provided his wife and four children with half his usual income during those times, and helped, along with back pay from his fishing cooperative, to replace his boats, which were confiscated.

Sawagami-san's committee plans to continue lobbying its case in the United Nations. "International opinion may be the only way to get the islands back. The younger generation here is enthusiastic, but elsewhere they're tired of hearing about it. The Japanese Government is concerned, but nothing they've done has worked.

"They are traditional Japanese lands. We pioneered them and cleared them with our own hands, and we will only accept the return of all four islands."

And what about his personal feelings toward the Soviets? He watched his cigarette die in the ashtray, sipped his tea, then turned to my interpreter. "Tell him, I want to see the four islands returned."

#### Sapporo, the Tokyo of Hokkaido

Uneasy awareness of the Russian bear was a major impetus to the settlement of Hokkaido. To deal with the new land, government planners sought American agricultural expertise. One adviser, the prominent educator Dr. William S. Clark of Amherst, Massachusetts, who established the Sapporo Agricultural College in 1876, left his students with this advice: "Boys, be ambitious in the service of the Lord." The first three words stuck, and have guided Hokkaido's leaders ever since.

From a raw frontier outpost, the island's capital city, Sapporo, has grown into a thriving communications and transportation center. Company men on two- or



*"Come back when I'm bigger!" A youngster starts salmon fry on their way to the sea (top) in Sapporo's Salmon Baby Festival, an event that reintroduced the fish to a once polluted river in the city's center.*

three-year stints there often leave their families in Tokyo or Osaka, where more prestigious schooling is available for their children—a vital consideration in a nation whose leaders spring almost wholly from a handful of highly competitive universities.

The businessmen join the ranks of "Sapporo bachelors," and the city's pleasure quarter feeds off them. The Susukino, it is called, and no frost can chill the action of its nightly business day.

But the gemstone of the planners' visions lies at the southernmost tip of the island: a hole in the rock beneath the ocean from Hokkaido to Honshu. Scheduled for completion in 1983, it will be, quite simply, the longest tunnel in the world—32.3 miles.

Train tracks ran gleaming off around a curve in the silent gallery. An engineer pointed at the concrete vault above us. "The ocean begins here."

A whistle shrieked as a yellow service train barreled out of a side tunnel. We hopped aboard and headed in, 120 meters beneath the surface of the Tsugaru Strait, and going deeper.

The strait is a boisterous stretch of water, too hazardous for ferries an average of eighty times a year, when Hokkaido is cut off from all but air traffic. A typhoon in 1954 took down a ferry, drowning 1,218 passengers; surveying for the tunnel began in earnest soon after. Perhaps its greatest benefit will be a symbolic end to the isolation that characterizes Hokkaido in the minds of Japanese on other islands.

We made our way toward a noise like dinosaurs in a cave. Two front-end loaders backed away from their attack on the tunnel face. The black rock was cool, veined with little faults that sometimes spouted seawater from above. Water dripped onto my hand from the ceiling's huge supporting beams; it tasted of salt.

Somewhere ahead of us, on the far side of several miles of solid rock, men and machines were working in the same strange half-light in another tunnel, slowly chewing their way out from Honshu toward a midsea rendezvous with us. The engines revved behind me, impatient to continue gnawing at the foundations of the ocean floor. I pocketed a little lump of the underworld and turned back toward daylight.

Down the mountain road southwest of Sapporo is a lake as blue as the sea, stopped at its far end by a peak with a plume of steam whirling off its top. Rounding the lake, you notice the trees: dead and splintered, their branches stripped by some unbearable weight. A town tucks into the folds at the mountain's foot. Entering, you see fresh scars of raw mud, and an occasional building wrenched and cracked by movement of the earth. This is Toyako Onsen, a hot-spring spa whose volcanic patron, Mount Usu, turned on it on August 7, 1977, and covered it with ash and falling rock.

Many times over the next 15 months ash rained from an inky sky. Heavy rains in October 1978 brought mud flows down the mountain, taking three lives in Toyako Onsen, the eruption's only human fatalities. But the town is still a casualty: Although the last ashfall occurred that same month, tourism is down 40 percent. What the smoldering mountain gave, it took away.

#### Volcanic Usu Grows in Its Sleep

Viewed from its lip, the crater looked like hell after the fire department had left. Professor Yoshio Katsui pointed across its bowl at a cliff of naked red earth and rock. "That is Naka-Usu, a new peak. It's still growing three centimeters a day. At the height of the eruptions it was rising two meters a day, but it's slowing down. Some volcanoes have cycles, and according to this one's history, it will probably be quiet for another thirty or forty years."

Probably?

We wandered through the ravaged basin. Steam rose from countless holes and cracks. Hot mud burbled down from a side valley. Professor Katsui picked up a piece of twisted wire that fenced the woods when trees still lived there.

Suddenly a hissing and clattering came from the heights around us. Crows called and took to the air as boulders slid and bounded down. The mountain bucked beneath us as though a giant hand had ever so gently lifted its edge and dropped it without warning. A rumble, unutterably deep, sounded from below and about us. Professor Katsui laughed.

"That was only Mount Usu saying, 'Hello, Mr. Lee!'"

Aftershocks rippled for a time, then came another blow. "That's quite characteristic," he commented, "several shocks occurring in a series. These local volcanic tremors are usually not strong."

I could not be sure if the earth still fluttered, or if I felt only the pounding of my heart. "When we feel the stronger shocks, is the mountain . . . ?" I pointed at the cliff. He nodded. "At the moment you feel it, the mountain is growing."

### The Challenge Remains

Weeks later, when I had returned from this island to my home where the earth does not move, my heart would still race at the roar of a jet or the rumble of a passing truck. But it is the quiet moments that rest in the mind and triumph in the memory . . . the silence of frozen Lake Akan at dusk, or a dawn at the Zenkoji Temple when, amid greening pathways, a drumbeat sounds as the priest lights candles and chants before gilded altars.

And I recall an afternoon when the first buds of spring showed amid the headstones of the foreigners' cemetery in Hakodate. The oldest port in Hokkaido, it was one of the first three in all Japan opened for trade in the middle of the last century. A hard wind kicked whitecaps across the harbor as I read stories etched on the gravestones. Captains and captains' wives, diplomats and engineers from Britain, Denmark, Germany, America, these voyagers watched the harbor where their journeys had ended. In those times Japan was a book opened to the first page, and this port was the key.

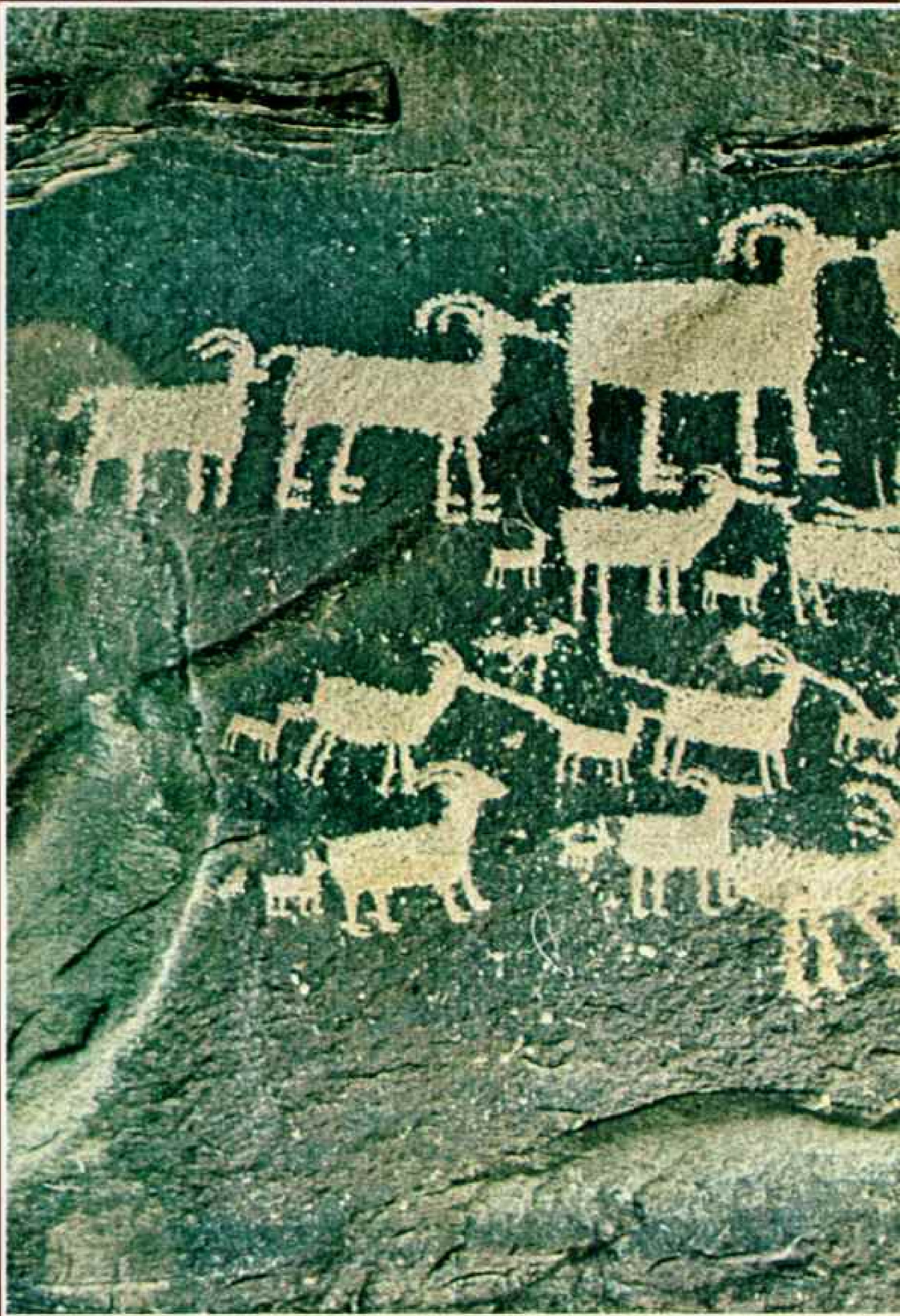
For the Japanese, too, Hakodate was an entrance then, a toehold of civilization on the edge of an unknown opportunity and challenge. When the pioneers stepped ashore in Hokkaido, it was a land not yet sorted and labeled, a fresh start, a New World in miniature.

For Japan, it still is. □

*Steam and silence wreath fishermen in Daisetsuzan, Japan's largest national park, where thermal streams flow out of the mountains' fiery heart and through the pristine high country that is the essence of Hokkaido's lure.*











# Utah's Rock Art Wilderness Louvre

A PICTURE ESSAY BY GARY SMITH

WITH MICHAEL E. LONG

NATIONAL GEOGRAPHIC SENIOR STAFF



**T**UCKED IN CANYONS, carved on boulders, the rock art of Utah has led me on an odyssey through time—from a 19th-century Ute Indian's rendition of the passing of the pipe near Ouray (*above*) to sandstone masterpieces that may be thousands of years old.

As a former backcountry ranger in Canyonlands National Park, I had not forgotten those gems in a wilderness Louvre. Two years ago I returned to photograph them and to try to fathom their meaning.

In Cottonwood Canyon, I viewed a hunting scene (*foldout, left*) carved about

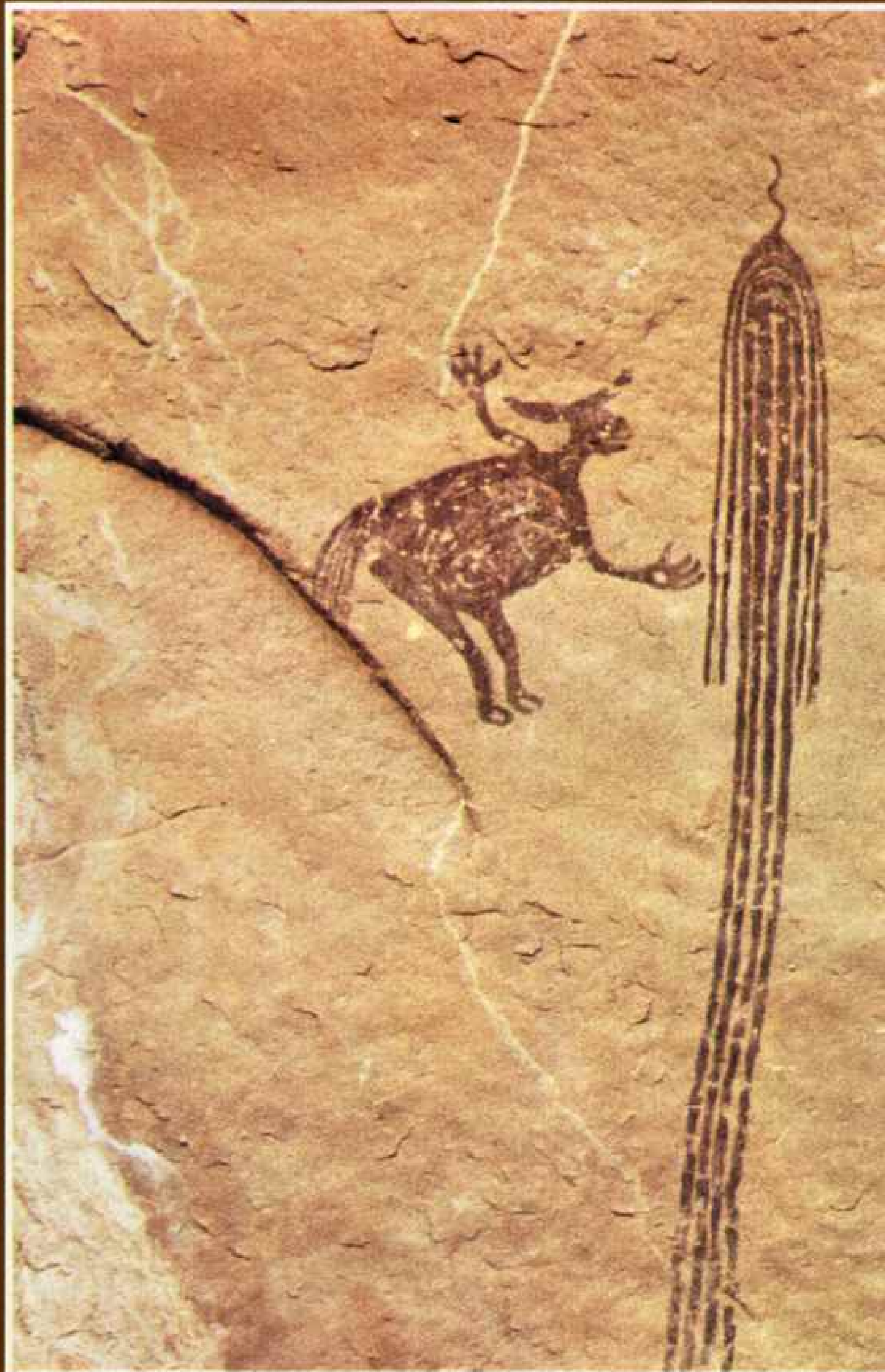
A.D. 1000 and credited to an artist of the Fremont culture—named for artifacts found along the Fremont River. His bowmen still confront their quarry of bighorns, but why are the sheep linked to a mysterious horned figure?

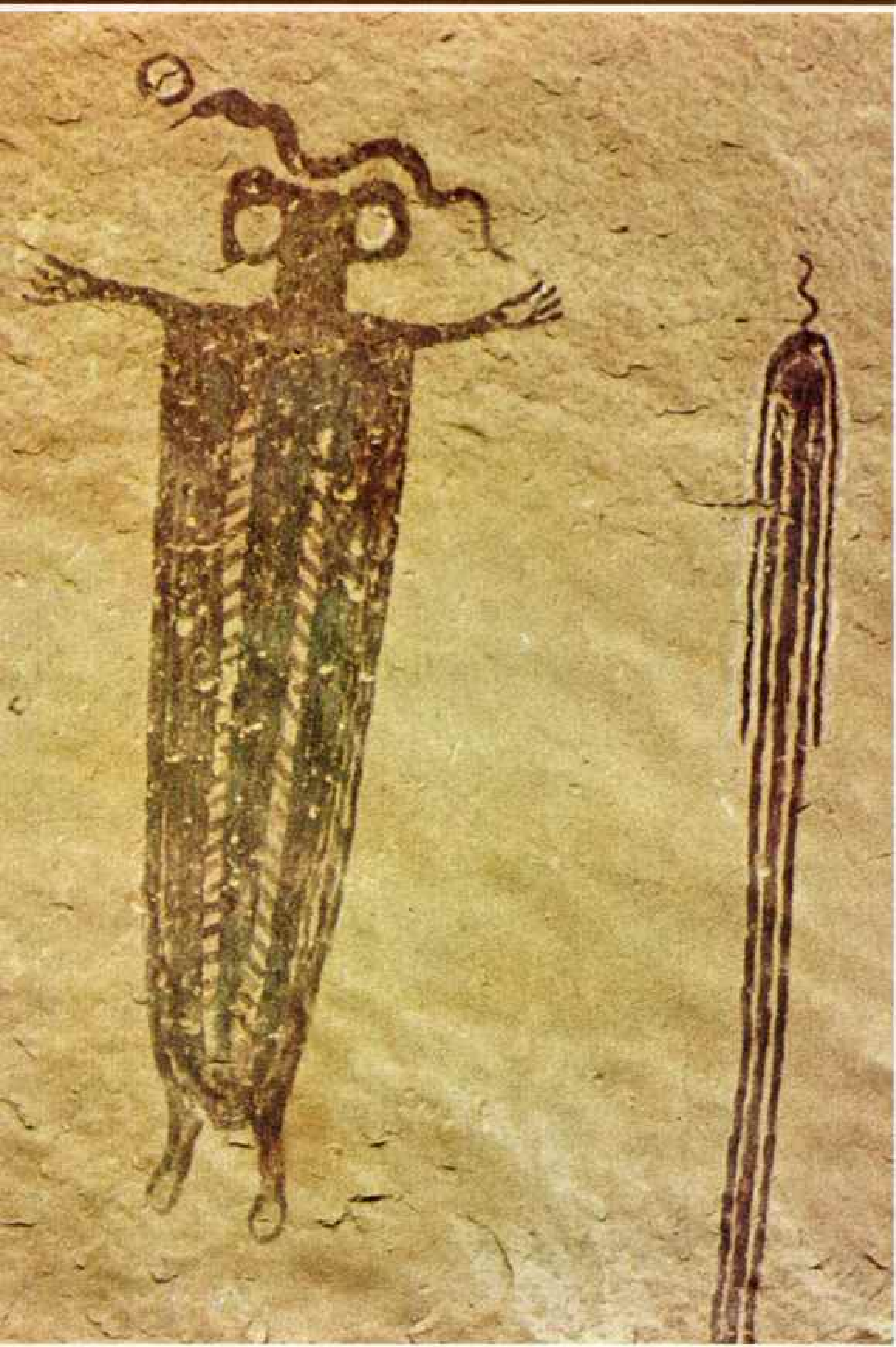
Consulting rock art experts, I found myself entering a world of hypothesis and speculation, an unfamiliar universe of primitive peoples guided by shamans who possessed remarkable magico-mystical powers.

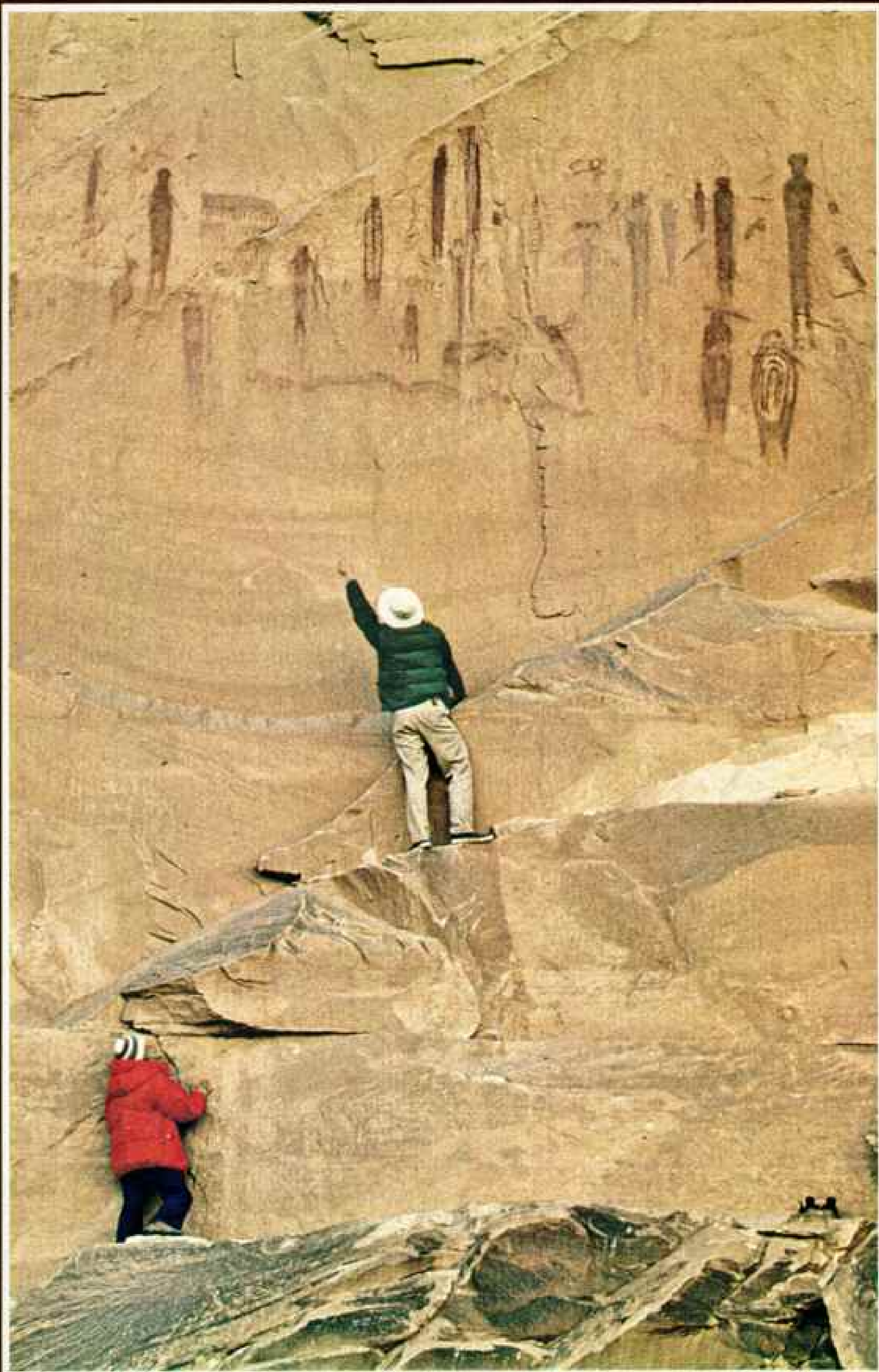
The mysterious figure in the hunting scene, I learned, could represent a shaman with the ability to ensure the hunt's success.

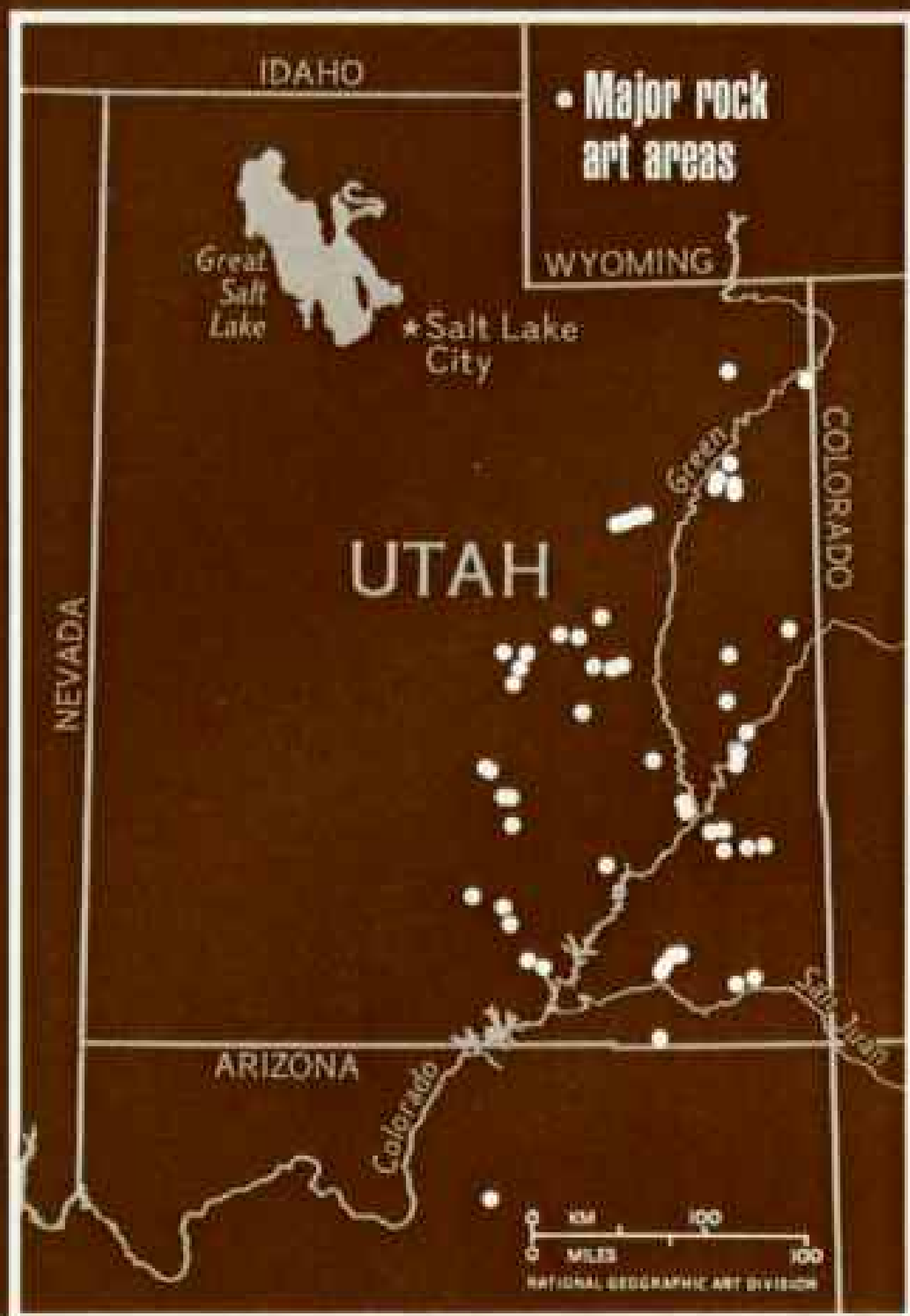
West of Green River I photographed a snake and a fantastic beast in the company of an anthropomorph (*following pages*). The figure's haunting, bulbous eyes are characteristic of a rock art style defined by art historian Polly Schaafsma as Barrier Canyon, where a treasure trove of such figures is found.

Recent archaeological discoveries suggest that Barrier Canyon artists may have put brush to rock more than 6,000 years ago.









**S**LOWLY FADING from a sandstone wall, a group of Barrier Canyon paintings (*opposite*) still yields intriguing detail. A visitor points to what appears to be a rain cloud near a man holding a snake. Today the Hopi Indians of Arizona grasp live snakes while dancing to bring rain.

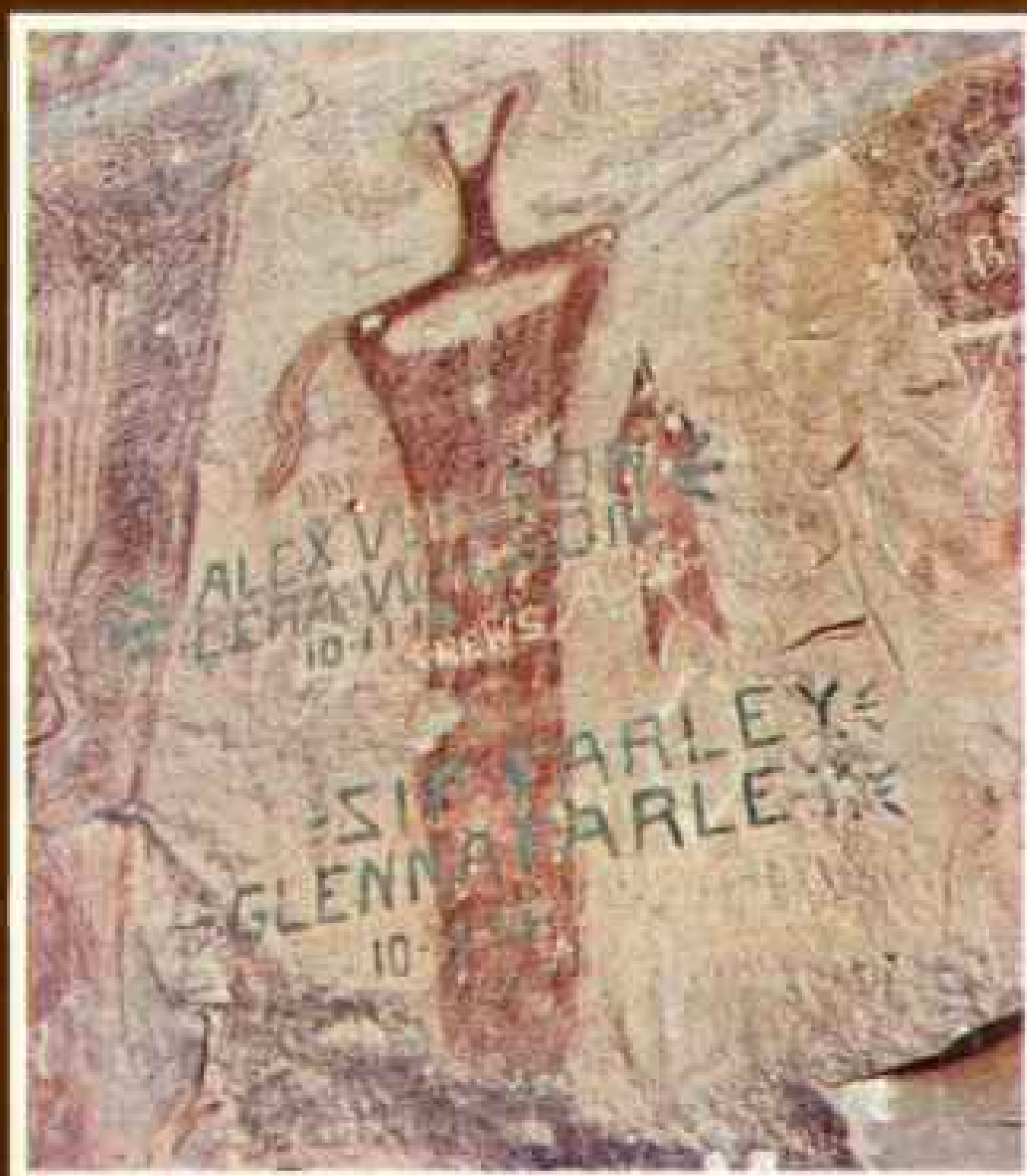
These paintings are in Barrier Canyon itself, now officially known as Horseshoe Canyon.

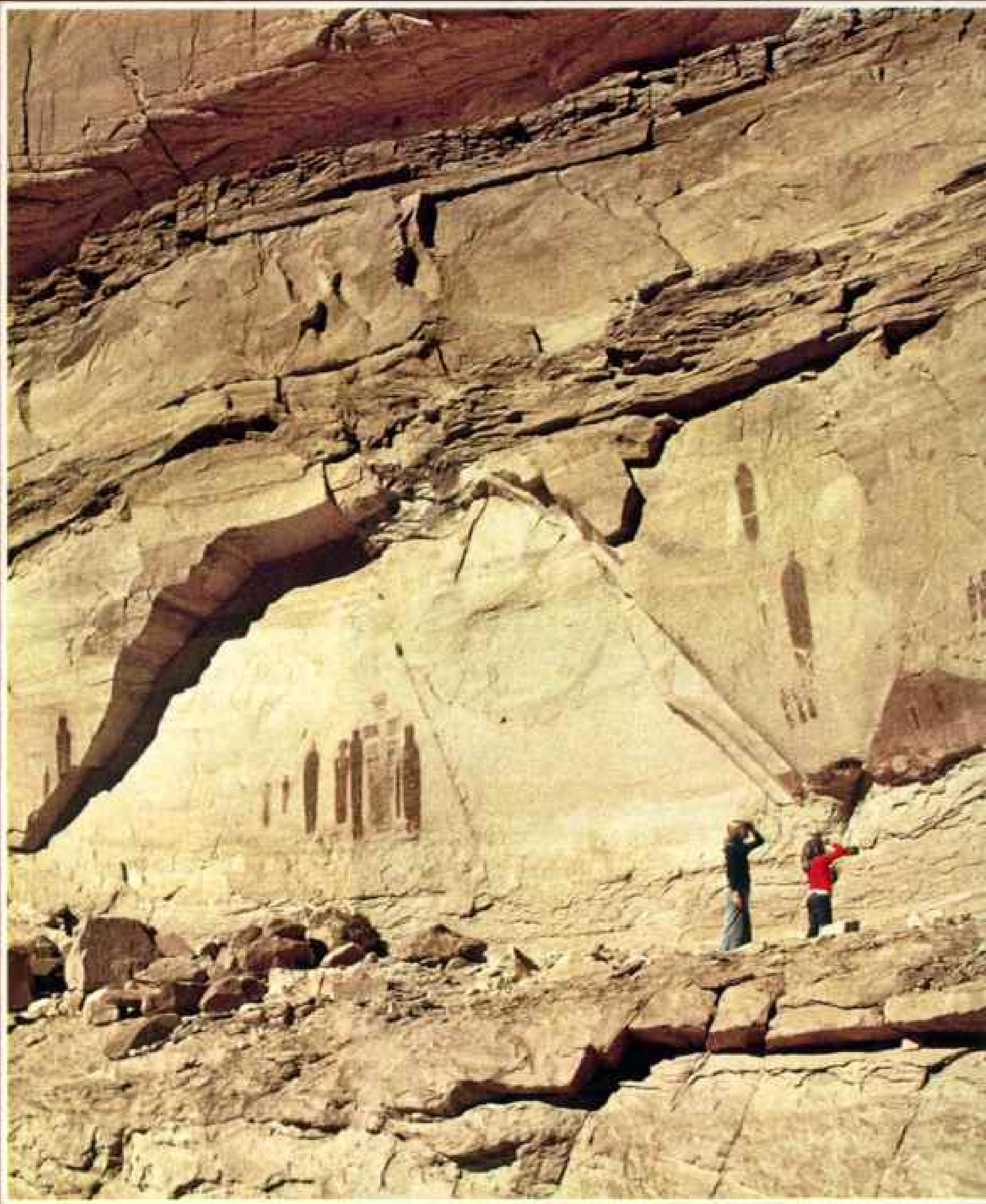
Many sites are near rivers (*map*). Others are close to springs, paths, and harvest areas used by the ancient artists.

I got to know these people by my feet. I found their camps, granaries, and potsherds. One time their footholds in a sheer canyon wall saved me from being stranded through a cold and sleepless night.

I also discovered that their art is threatened. The acidic effluent from power plants is beginning to pollute the pure dry desert air that preserved the treasures. Vandals flout an antiquities preservation law, desecrating them with chalk, paint, even rifle bullets.

You can see what happened to a Barrier Canyon-style painting (*left*) near the San Rafael River. I wonder if those folks would write their names across the "Mona Lisa."

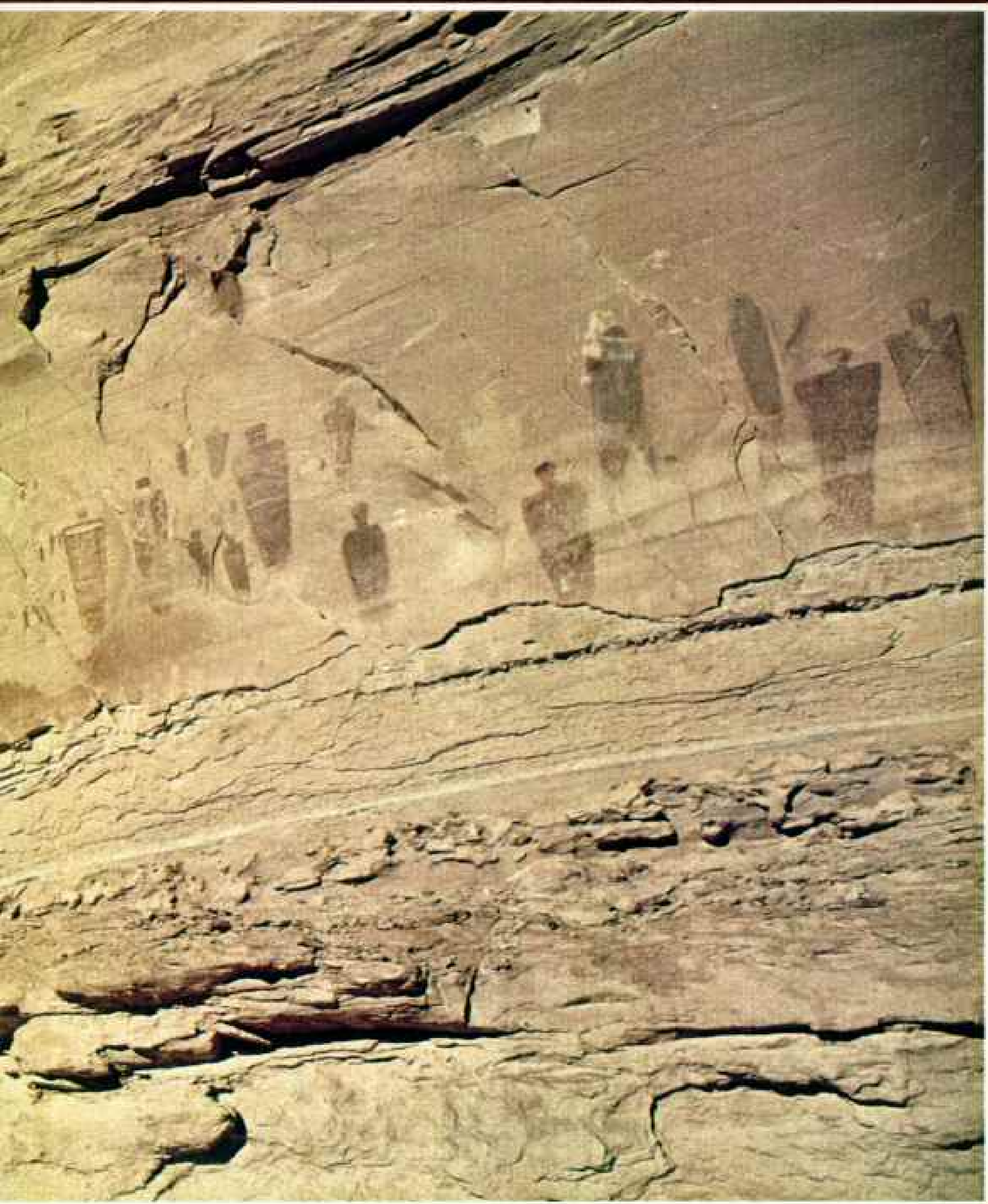




**G**HOSTLY FIGURES lend an ethereal air to the spectacular Great Gallery in Horseshoe Canyon.

The group at far left, popularly known as the "Holy

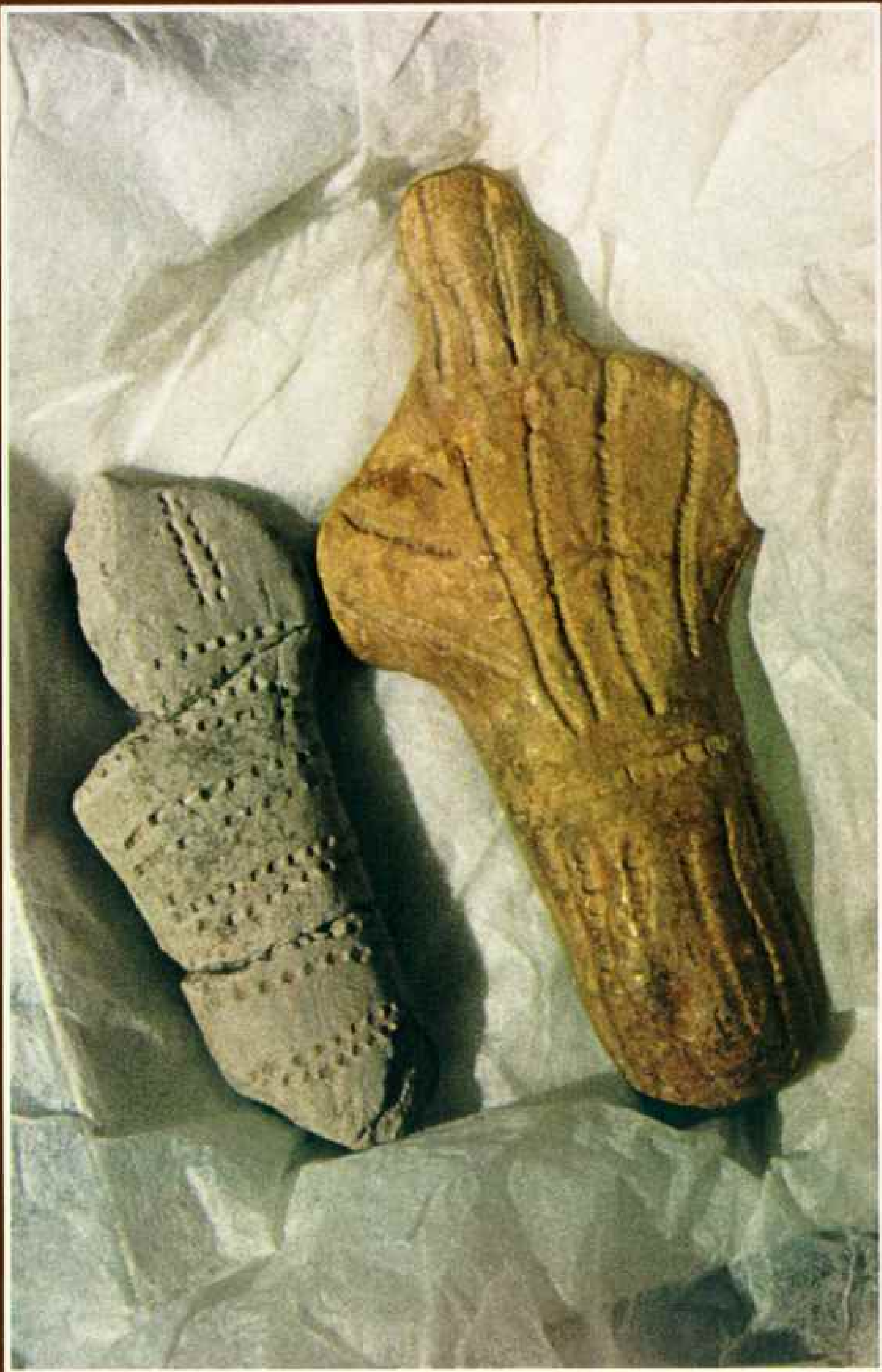
Ghost and His Family," appears in three dimensions, unusual in rock art. A spatter technique emphasizes the otherworldly appearance of the life-size main figure.



“These are not paintings of men,” Polly Schaafsma concludes. “Exaggerated, staring eyes, unusual headdresses and torso decorations suggest the

supernatural. I’m sure this was a sacred place.”

I agree. I’ve spent many a moonlit night here. The wraithlike figures seem to dance right off the walls.





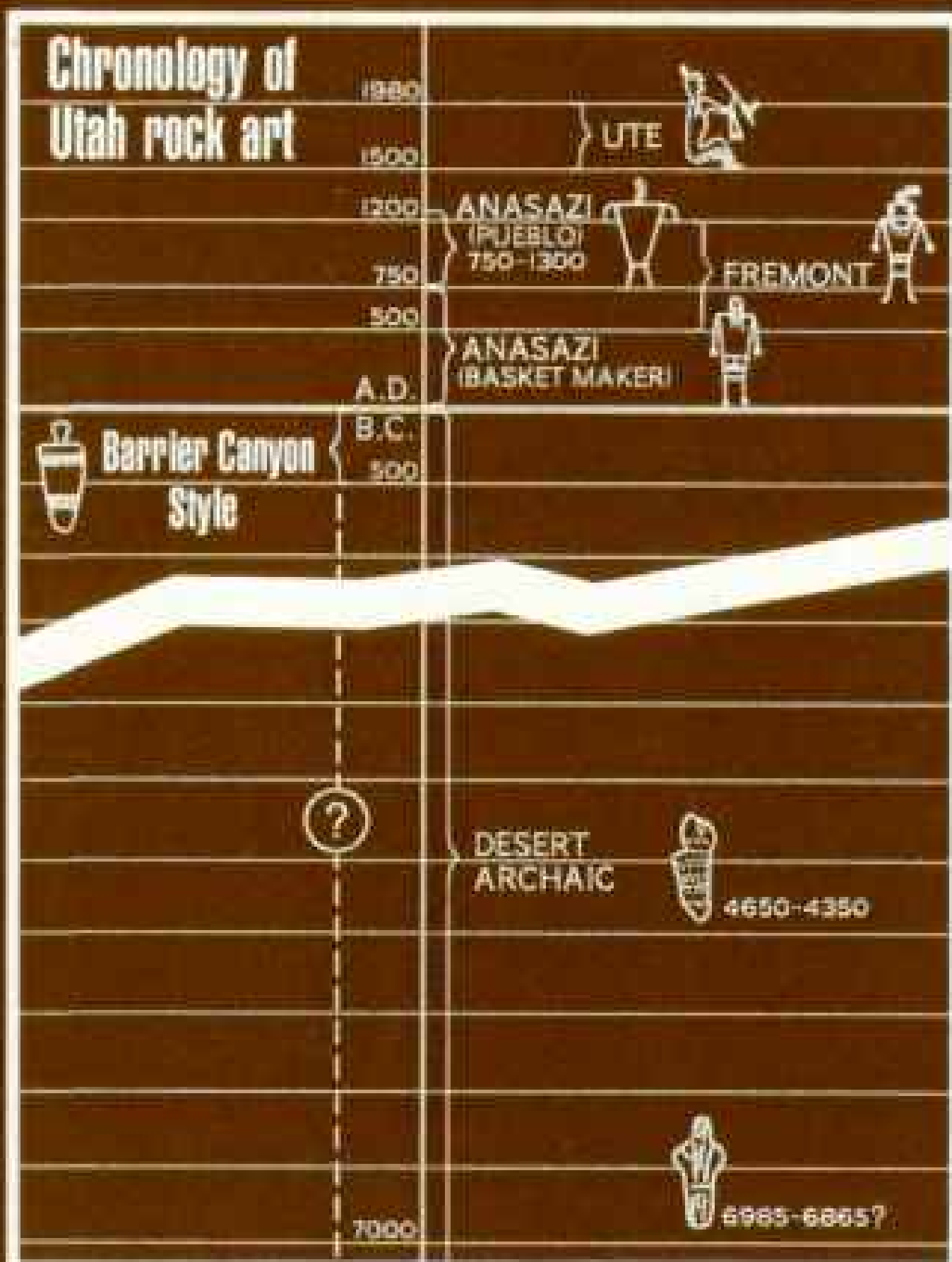
**A**NCIENT figurines from a dig in southern Utah bear Barrier Canyon dot patterns and torso decorations (*far left*).

The dot patterns on the fragmented figurine are akin to those on Great Gallery paintings (*left*), thus raising a tantalizing question: Can the paintings, previously believed to be no older than 500 B.C. (*diagram, below*), be as old as the figurines?

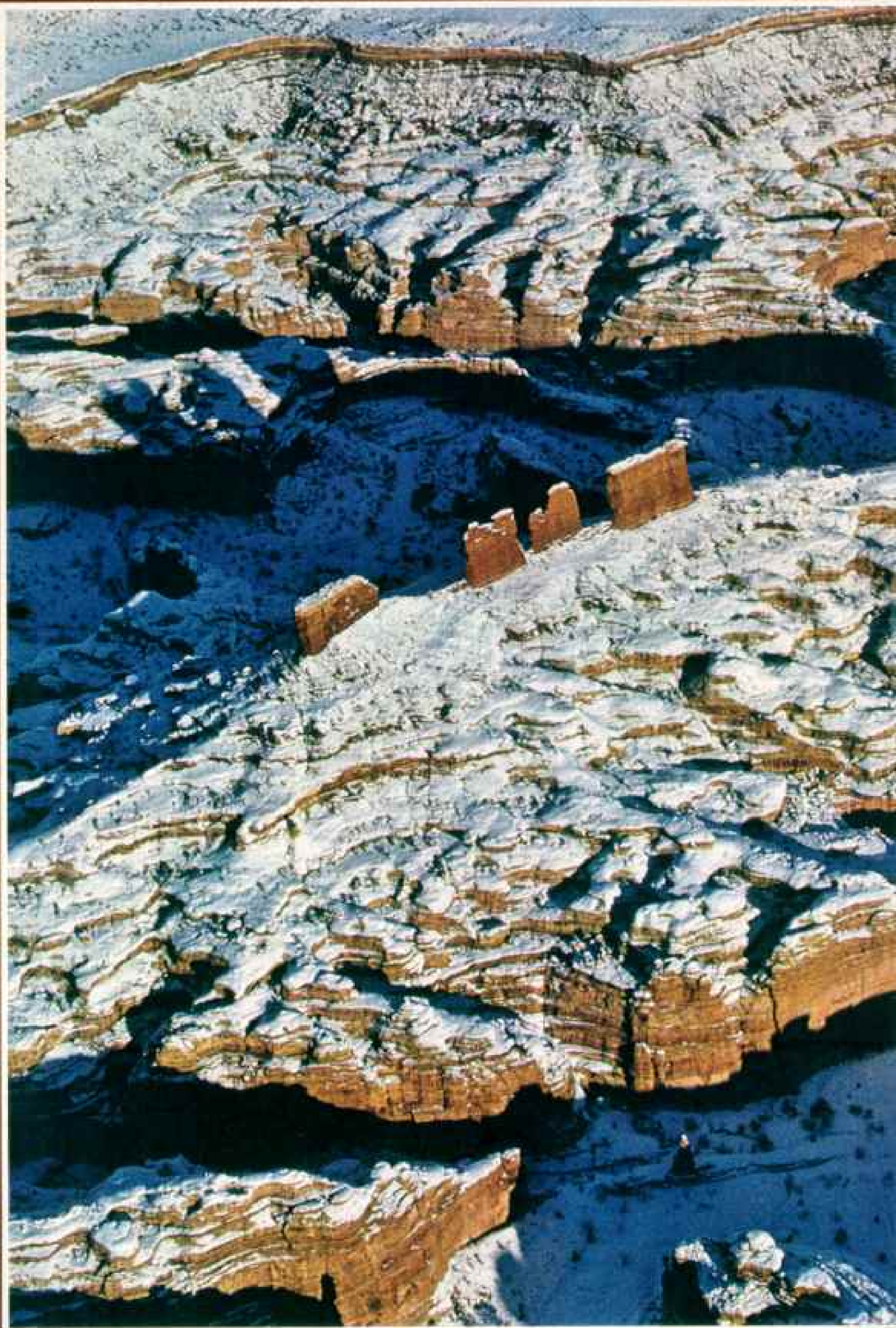
University of Utah archaeologists date the fragment between 4650 and 4350 B.C. The intact figurine was found near a sandal dated at 6925 B.C., but Jesse Jennings, professor of anthropology and the dean of Utah archaeologists, regards the association as possibly misleading. "The figurine may have been introduced from a more recent layer of the site," he explained.

Comparing the figurines with the paintings, Polly Schaafsma said, "The similarities are exciting indeed. If the paintings prove to be as old as the figurines, they would be the oldest dated rock paintings anywhere in North America."

Canyonlands' formidable Maze (*following pages*) proved no puzzle for the forgotten artists. Scores of paintings and petroglyphs reveal their passages through its labyrinths.











**S**PARRING for elbowroom, incredible beasts share a boulder with anthropomorphic figures at Rochester Creek near the

small town of Ferron.

At top center a figure seems to ascend a rope, a familiar symbol in primitive cultures used to portray the journey of

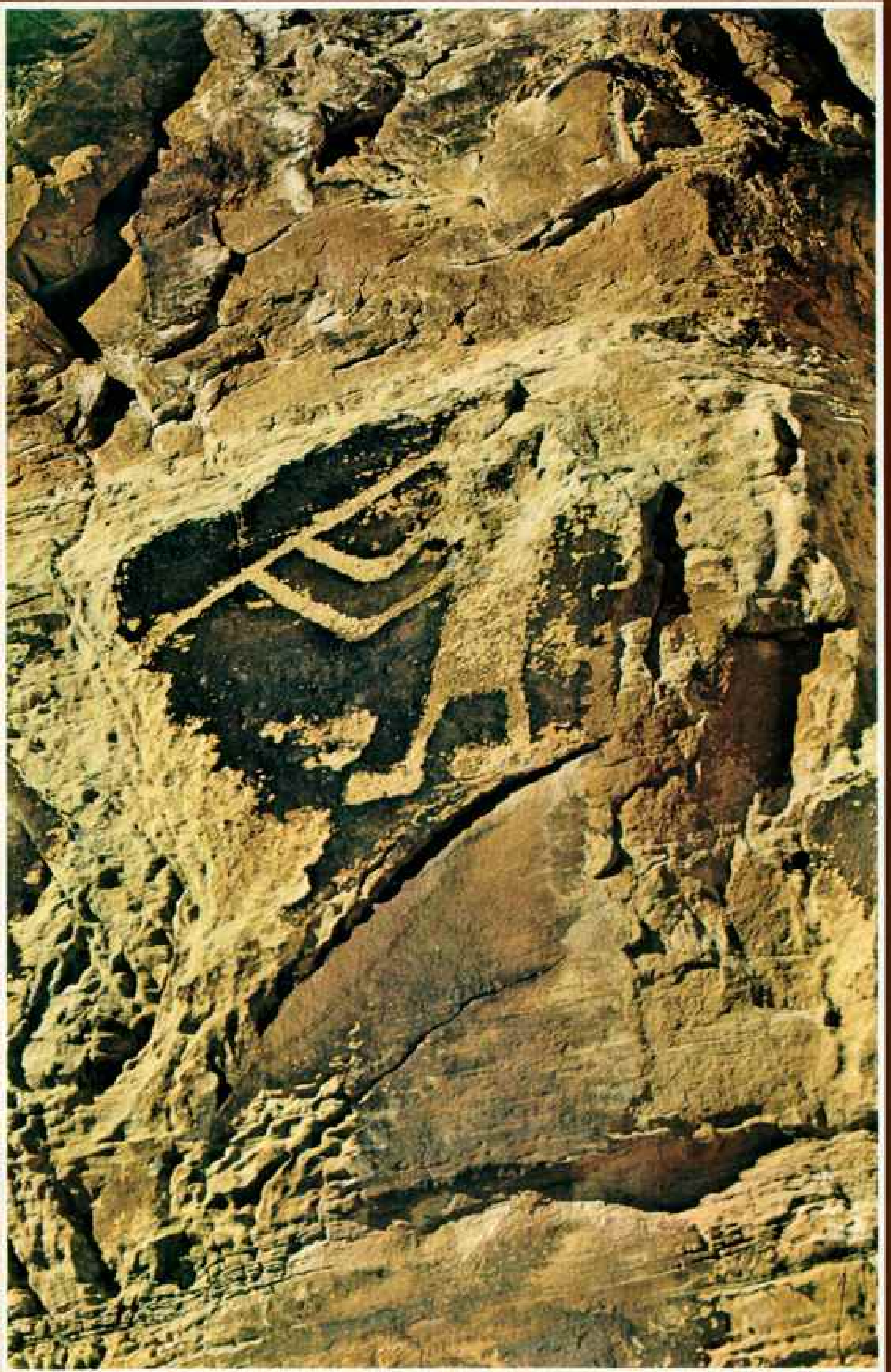


a soul to the spirit world after death.

"This crossing is difficult," writes Mircea Eliade, a scholar of primitive

religion. "Demons and monsters seeking to devour the soul must be faced."

Arms raised, the figure appears to be doing just that.





**A** FELLOW ITINERANT serenaded me from the rocks with his flute just about everywhere I went. Nothing could stem his song, not even erosion on a rock near Jensen (*far left*). Sometimes I took out my guitar and serenaded him right back.

Along the San Juan River he sprouted antennae and exaggerated genitals (*top*). Near the remains of a granary in the Grand Gulch Primitive Area he leaned forward (*center*) to play to a bighorn sheep elsewhere on the rock. Many times he appeared as a humpback, a symbol of the supernatural.

Yet this versatile charmer swaggered a bit as he led a chorus line of dancers northwest of Monticello (*bottom*).

Today he also resides in the Hopi Indian pantheon where, as a kachina – spirit figure – named Kokopelli, he serves as an intermediary between men and the gods.

Indian friends tell me the ancient Kokopelli carried seeds and played his flute to provide warmth for their germination. He is thus a mythological cousin of other fertility figures such as Pan and Orpheus, also musicians.

Play on, Kokopelli.



**THE THREE KINGS”** transfix onlookers with regal stares from their perch more than 100 feet above the ground on a ranch near Vernal.

These classic Fremont figures were carved, then painted; some of the original hematite pigment remains. The figure at the right is done in rare bas-relief.

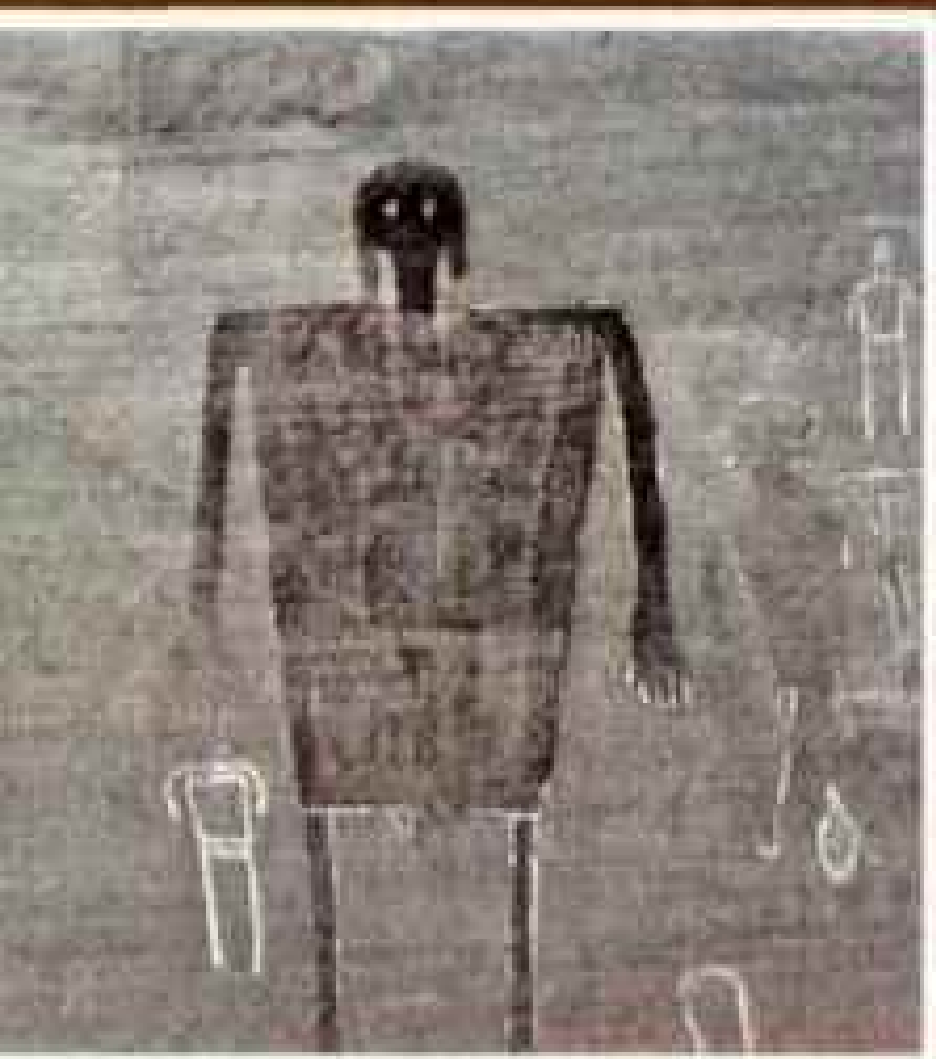
For 47 years the ranch’s owner, Sadie McConkie, has watched over this and other panels like a mother hawk, guarding them from vandals. In 1975 Utah recognized her efforts by making her property a historic site.

Figurines a few inches tall found by Clarence Pilling on a ranch near Price in 1950 (*far right*) have the elaborate necklaces and belt sashes typical of Fremont art.

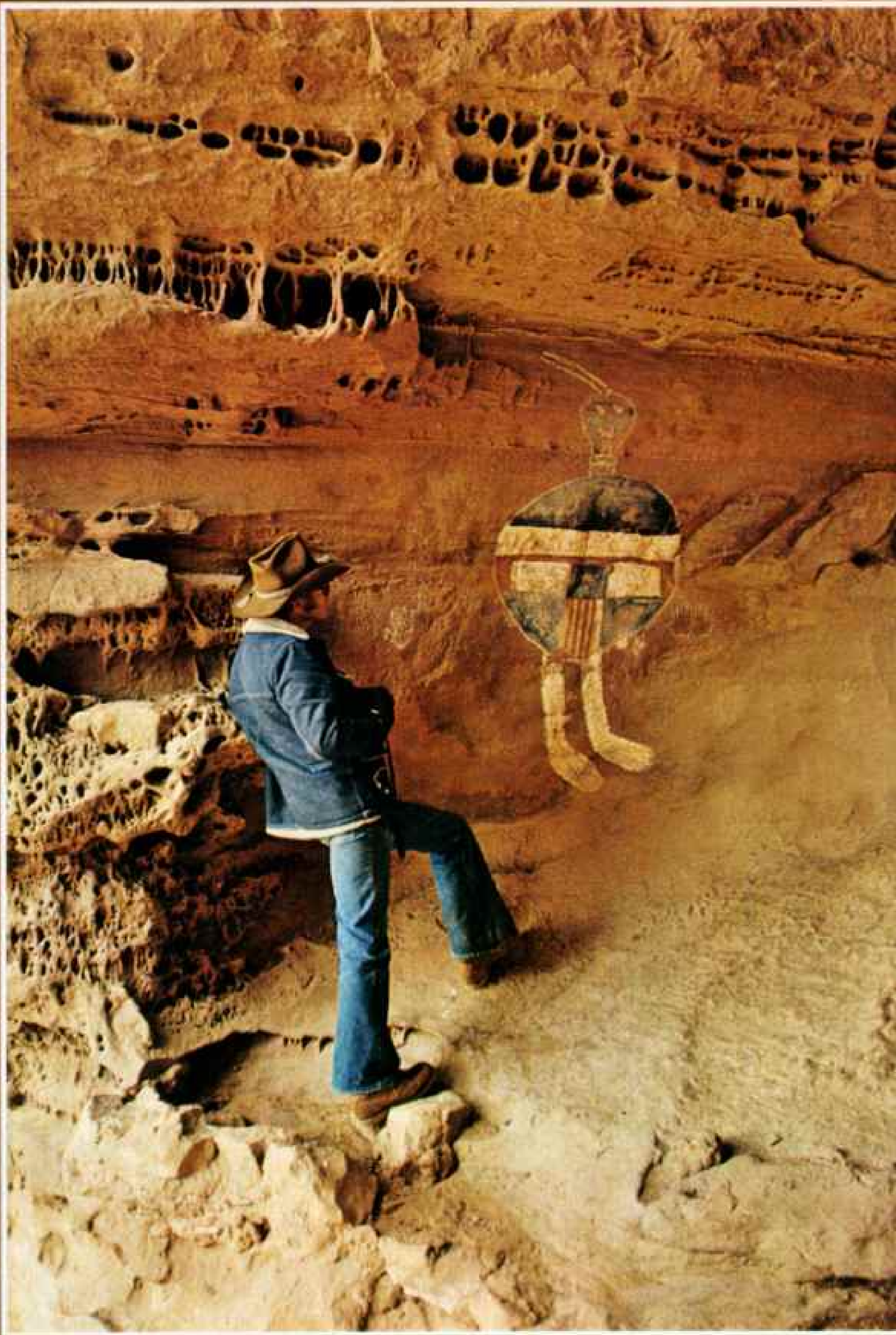
Anasazi Basket Maker figures (*right*) reflect a culture that preceded the Fremont by about 500 years. The figure at the left was outlined not long ago with white paint daubed on by a passerby.

“You might as well try to touch up Michelangelo,” says Polly Schaafsma.











**R**ED, WHITE, and blue, the "All American Man" still stands ramrod straight on a cave wall near Salt Creek.

In 1975 the authenticity of the pictograph became an issue in a court case surrounding the absorption of the Salt Creek property into Canyonlands Park.

During the trial a U. S. attorney insinuated that the painting had actually been done recently – a hoax. When an archaeologist testified to its probable authenticity, the government, which had been seeking to lower the land's valuation, dropped that part of its case.

Now mystery swirls around the painting. Though the shield stamps it as Fremont in style, the painting is in an area south of the Colorado River associated with the Anasazi Pueblo, another prehistoric agricultural people. One of their ruins juts from the wall. Who, then, was the artist?

I feel it was a Pueblo who borrowed Fremont motifs. I've walked the paths between Fremont and Pueblo sites many times; Pueblo potsherds litter the routes.

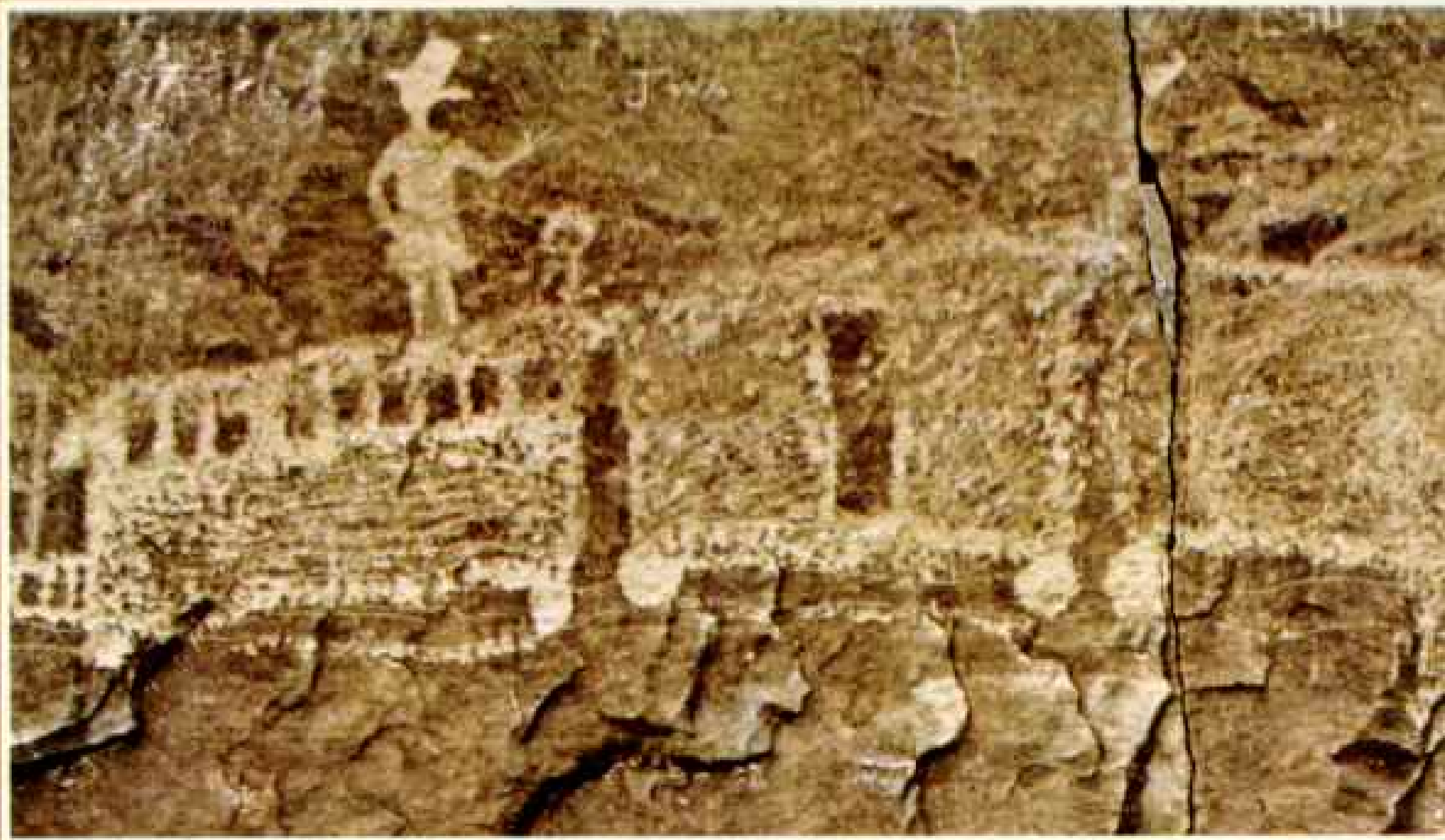
And yet, the "All American Man" smiles an enigmatic smile.

**R**OARING across a rock near Vernal, a railroad train carved by a Ute Indian has the flavor of a child's cartoon (*below*). Nearby, another petroglyph recounts the slaughter of the buffalo (*bottom, left*).

Viewing other railroads

and other riflemen, I realized what a shock it must have been for primitive people to be suddenly confronted with the technological baggage brought westward by the white man.

Their art shows that to a



great extent they abandoned their metaphysical intuitions and became observers of implements and events. One of this century's supreme achievements was even recorded in words on a rock near Tuba City, Arizona (*bottom, right*).

That's getting too literal for me. Fortunately, many examples of Barrier Canyon mysticism and Fremont magnificence remain in other corridors of this desert museum, rockbound masterpieces to be added to the gallery of the human spirit. □





HE WAS no ordinary traveler, this Berber, perched atop a saddle of rugs and tent poles, riding along a dusty mountain track in Morocco (right). His carefully wound white turban with a square of cloth hanging behind marked him as a bachelor eager to wed. The suitcase he clutched was filled with other wedding clothes.

The prospective groom prodded his donkey with special urgency as he neared the Imilchil plateau where his people were gathering for the annual festival, or *moussem*. Here in the Atlas Mountains I have attended many country moussems—those wonderful Berber fairs that combine a local saint's day with a regional trade market. But only at the September moussem of Imilchil have I seen such a pageant of public courtship, instant engagement, and immediate exchange of marriage vows. Thus it has become known as the bridal fair of Imilchil.

Marriageable young women of the region's dominant tribe, the Ait Hadiddou, are the object of the bridegroom's haste. They conceal their reputed beauty under heavy capes and spangled headdresses (left). The veil places a bride-to-be at a distinct advantage in discreetly surveying the prospects during the three-day festival.

The fair is an integral part of the marital customs of the Berbers. Ordinarily, families arrange marriages back in the village in the best interests of the community and with the consent of the betrothed. When these matches do not work out, divorce is commonplace. In fact, Ait Hadiddou women are free to divorce as often as they wish and to remarry whom they like. Thus at the Imilchil moussem, divorced and widowed women are in the majority, a status easily identified by the pointed headdress they wear (pages 122-3).

The independent farmer-herdsmen of the Ait Hadiddou strike me as the most Berber of all Berbers. They have occupied the rugged mountains since before the Muslim Arabs swept in from the east in the eighth century. The Berbers adopted Islam as they had previously taken to Christianity, but it was not a total embrace. Their religion combines Islamic and older tribal beliefs. Even the word Berber is foreign; they call themselves Imazighen—men of the land.

# berber brides' fair

By CARLA HUNT

Photographs by NIK WHEELER

BLACK STAR

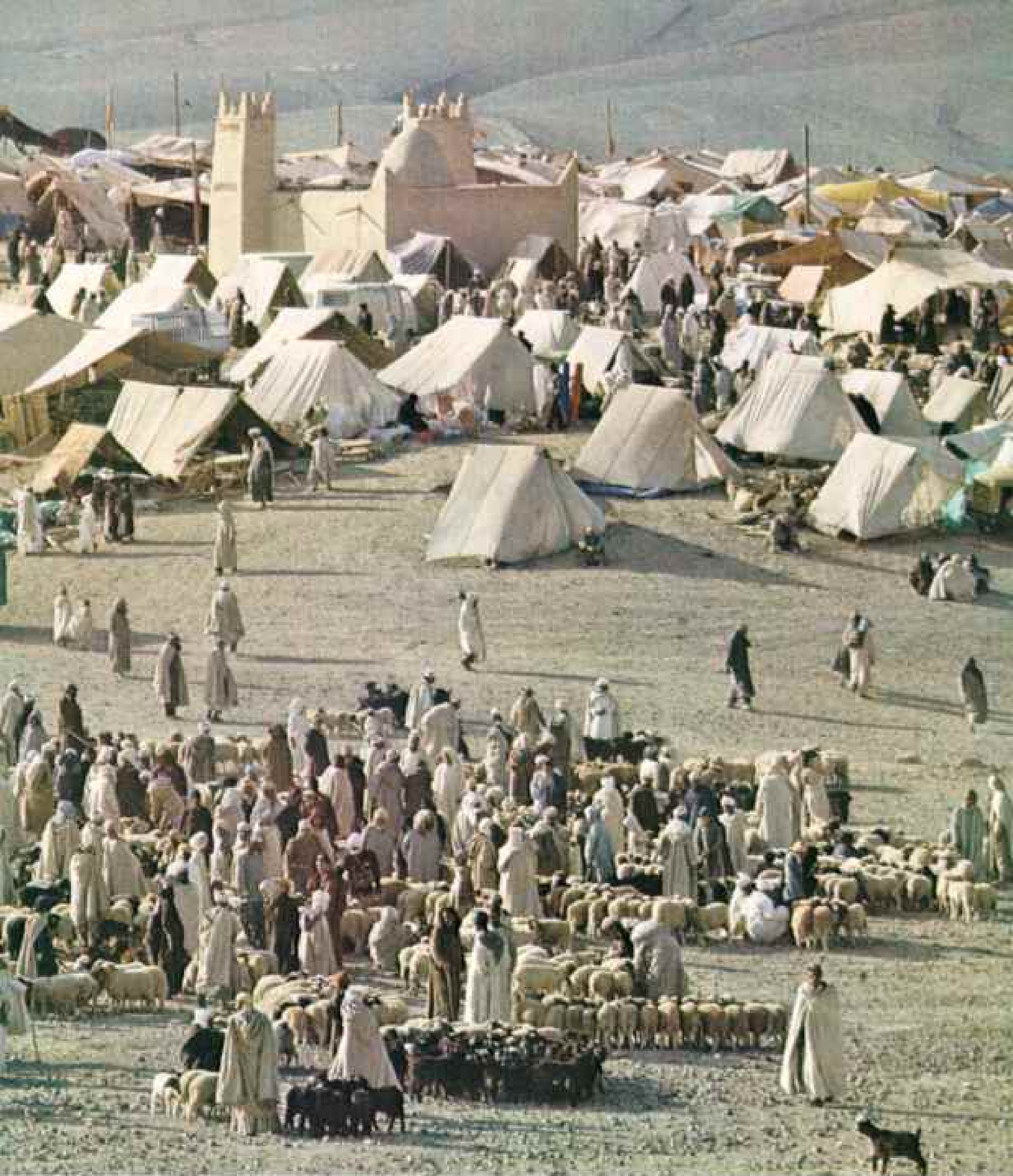




NATIONAL GEOGRAPHIC ART DIVISION



**L**OOMING FIRST as if a mirage, then as a blockade, the festival grounds lie on a crossroads of dirt tracks south of Imilchil. At dawn of opening day, the tribal families with their herds pour through mountain passes and stream across the valley onto the barren plateau. From distant villages they bring the year's surplus of



wool, meat, grain, and vegetables to sell or barter. Tradesmen group their white tents by product: pottery, pots, rugs, locks, tools, and books; butchers keep a distance. Larger dark tents house officials.

Devotional and social activities center on the beehive tomb, or marabout, of holy man Sidi Mohammed el Merheni, center. The Ait

Hadiddou do not recall precisely when this remarkable man guided human affairs; they know only that the marriages he blessed were happy ones, and believe his spirit lives on in the shrine—dispensing grace. I watched a groom enter the holy enclosure to pray; later a bride tucked a handful of tomb dust—a portable blessing—into her robes.





**T**HE COURTING GAME involves the family, I learned when I accepted an invitation to drink mint tea in the goat-hair tent of Moulay Mouha. His oldest daughter, Yatto, prepares her divorced 18-year-old sister Aicha with traditional beauty aids. As their mother watches, she rubs saffron-colored powder into Aicha's eyebrows (*upper left*); kohl outlines the eyes, and carmine rouges the cheeks.



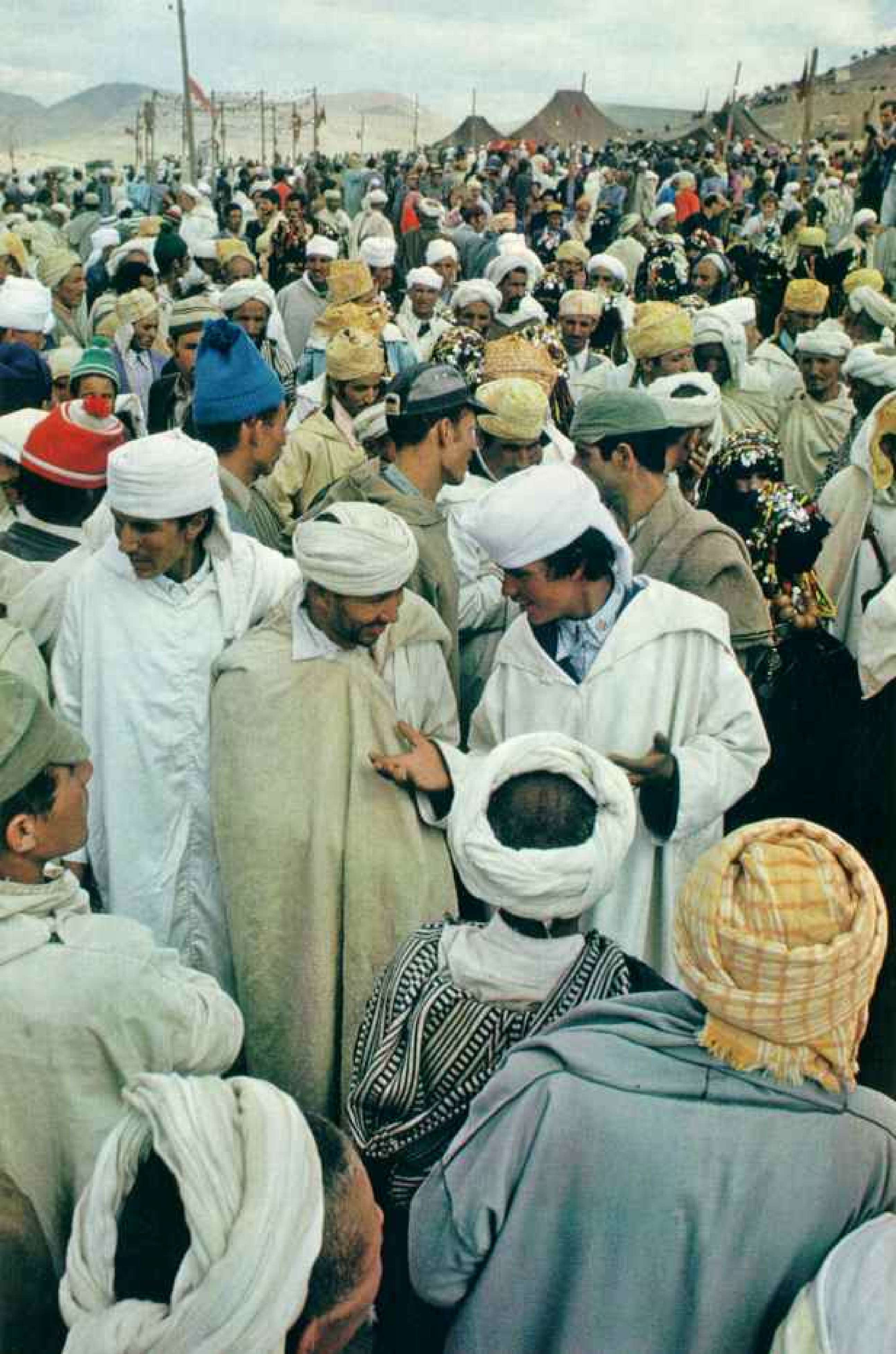
A wool cape striped in tribal colors will cover the white dress. Then the pointed headdress is assembled over a stiffened cone held by loops of tasseled and spangled wool. A well-to-do friend wears a necklace of silver, glass, and amber (*lower left*). I gave Aicha the thin silver chain I was wearing, since silver brings good luck, Berbers believe.

Unlike many brides, Aicha has already selected her husband-to-be. Their marriage

vows will be formalized during the moussem. He has provided her wedding clothes, "worth at least 200 dirhams [\$50]," her father tells me, proudly. Westerners mistakenly think men purchase wives at the fair, but actually marriage depends on mutual consent and family approval.

Here come the brides (*below*), now in full regalia; they will sit gossiping near the shrine, waiting to choose and be chosen.







**T**HE LANGUAGE of gesture is as clear as the spoken word to these Berbers. Their own tongue, Tamazight, is totally unlike Arabic, the official language of Morocco. The prospective grooms—kinsmen who may meet only once a year—have much to discuss (*left*). They greet each other with smiles and open arms.

A groom (*above*) gains courage by having a confidant help him choose—perhaps from no more than a silhouette, two dark eyes, a voice—which bride will be the most desirable wife.

All day, two by two, men weave in and out of the clusters of brides. Then, welcomed by a glance or a nod of reserved assent, a man will stop to speak to a woman, encouraged by a friend's reassuring hand (*upper right*).

A groom holds his prospect's hand as an expression of intention, promise, and then—with the holy man's blessing—of final accord (*lower right*).





**R**OMANCE is a sometimes rocky road. With both hands, an eager groom excitedly grasps a bride whose male relatives accompany her, lending advice, making judgments (*above*). His enthusiasm is not well received; rejection is signaled by the broken handclasp (*right*). It's time to look elsewhere.

When a bride does consent, she speaks the magic phrase, "You have captured my



liver." A healthy liver aids digestion and promotes well-being, so it and not the heart is considered the location of true love.

"Marriage by mutual consent and divorce when there is disharmony are central to the social system evolved by the Ait Hadiddou," a Moroccan ethnologist told me. "Despite their reputation for being fierce and warlike, they have evolved *paix chez eux*, peace at home. Often snowbound behind village

walls six months a year, families must live in harmony."

Perhaps the romantic courtship of the *moussem* serves to temper the harsh reality of daily life. During the half year when men move with their flocks to upland pastures, women run the villages, plant crops, weave rugs, and guard the granaries. It would be hard to dispute the proverb: "A woman is the ridgepole of the tent."





**W**HEN THE COURTING is over, the hours of waiting begin. The betrothed line up (*above*) to enter the wedding tent after answering to the official scribe who writes the marriage application in Arabic (*left*).

With it, the couple goes inside to be presented to the qadi, a representative of the Ministry of Justice in Rabat. This judge, though informal and good humored, does not automatically endorse every union. Certain standards must be met by both families. He quickly disapproves, for example, the marriage of a child of 8 or 9, posing as 18.

When the marriage contract is approved,

the groom pays the state twenty dirhams (\$5) and gives his bride fifty dirhams. First-time brides leave the moussem with their fathers to be welcomed by the grooms' families at a feast later in the year. Newlywed divorcées and widows go directly to live in the village of their new husband.

By uniting couples under civil law, the Moroccan Government seeks to integrate the isolated Berbers into the national society. Eventually, this may happen, *Inshallah*—as God wills. But for now, little matters to the Ait Hadiddou beyond the tribe, with its council of elders, local saint, and ancient rituals. □





Photographs by **BIANCA LAVIES**  
NATIONAL GEOGRAPHIC PHOTOGRAPHER

Text by **CHARLES R. MILLER**

# LIFE AROUND A LILY PAD



NEWT, *NOTOPHTHALMUS VIRIDESCENS*, ABOUT 4 IN LONG; WATER LILY, *NYMPHAEA COORATA*

**A** SPRING DAY in a pond is a lively affair, especially for a pair of red-spotted newts with eyes only for each other during their courtship ritual (*left*). Except for such diversions, pond creatures spend their time in an endless search for food.

Above the pond, dragonflies hover and dart about, intercepting smaller insects in midflight. On the bottom, half a teaspoon of mud may contain a million bacteria. The water itself teems with thousands of organisms, from diatoms to tadpoles to snapping turtles.

Like different cities, no two ponds are alike, but many contain the water lily (*above*). Moored to a thick rootstalk by a sturdy stem, lily pads are custom built for floating, with a water-repellent surface. The broad leaves spread flat on the water to soak up maximum sunshine.

For some creatures a lily pad is just a stopover between flights. For others it may be a dinner table or even dinner itself. For still others it is a nursery. When the female of those loving newts, for example, lays her eggs, she may choose the lily pad for their bassinet.



**C**OUCHED ON A PAD, a tadpole keeps a watchful eye for predators (*above right*). Equipped with gills and a tail fin, it resembles a fish. As the tadpole grows, however, hormones trigger secretions from the



thyroid, causing radical changes in body structure. Buds of hind legs appear. Gradually the intestine shortens to adjust to a carnivorous diet, and lungs replace gills. The eyes begin to bulge, front legs emerge, the tail gradually vanishes,

and the creature becomes a frog.

Newly hatched tadpoles (**above left**) hang with specialized suckers from the underside of a pad for protection. But predators are everywhere: Sunfish cruise among the weeds below.



FAMILY RESIMNIBAE (RIGHT), ABOUT 3 IN LONG; TURTLE (PAGES 136-7), CHELYDRA SERPENTINA, ABOUT 2 FT LONG

**A**T FULL TILT, a barnstorming dragonfly (*facing page*) veers over a pad. For two to eight weeks, dragonflies take to the air to mate. They die after eggs are laid.

Before flight, dragonflies spend a year underwater as nymphs (*above*) that breathe through gills and capture prey with an extendable lower lip tipped with teeth. To

change form, a nymph climbs above the water (*below left*), splits down the back, and emerges as a new, winged creature, leaving behind a ghostly shell (*below right*).

A nymph is a quick meal for a snapping turtle prowling amid bits of plants and algae (*pages 136-7*). Snappers sit comfortably on top of the food chain. When mature, they have no dangerous enemies in the pond.













GENUS GERRIS, 1 1/2 IN LONG



FAMILY CHIRONOMIDAE, 1 1/2 IN LONG

**I**RIDESCENT colors shine from the wings and antennae of an adult midge (*left*). Hatching from eggs laid in ribbons within gelatinous masses, midge larvae are crucial to the diet of fish, frogs, and predatory insects.

In oxygen-poor water, some midge larvae are colored blood-red by hemoglobin, a pigment that speeds the diffusion of oxygen and enables the larvae to survive.

A young water strider clasps a fly in a death embrace (*above*), draining its victim of body fluids.

Striders detect prey by sensing light reflected off water when it ripples. Aided by tiny waterproof hairs on their spindly legs, they skate on the water's surface film to the source of the disturbance—often caused by a dead or dying insect.

**S**URVEYING her handiwork, a *Donacia* beetle (*right*) pauses over the hole she has just chewed in a lily pad.

She then lowers her abdomen through the opening, gluing her eggs in concentric arcs to the underside of the pad (*right center*).

After about ten days the larvae hatch and make their way underground, where they latch onto plant stems and roots and hack them open with sharp spines. The larvae breathe the air in the stems, using them as giant snorkels. The photographer opened a stem to reveal one such larva encased within (*right bottom*).

When full grown, the larva will spin a cocoon stocked with air from the stem. When the adult beetle emerges, silken hairs on its body trap enough air to breathe as it crawls to the surface.



GENUS DONACIA, 1/2 IN LONG

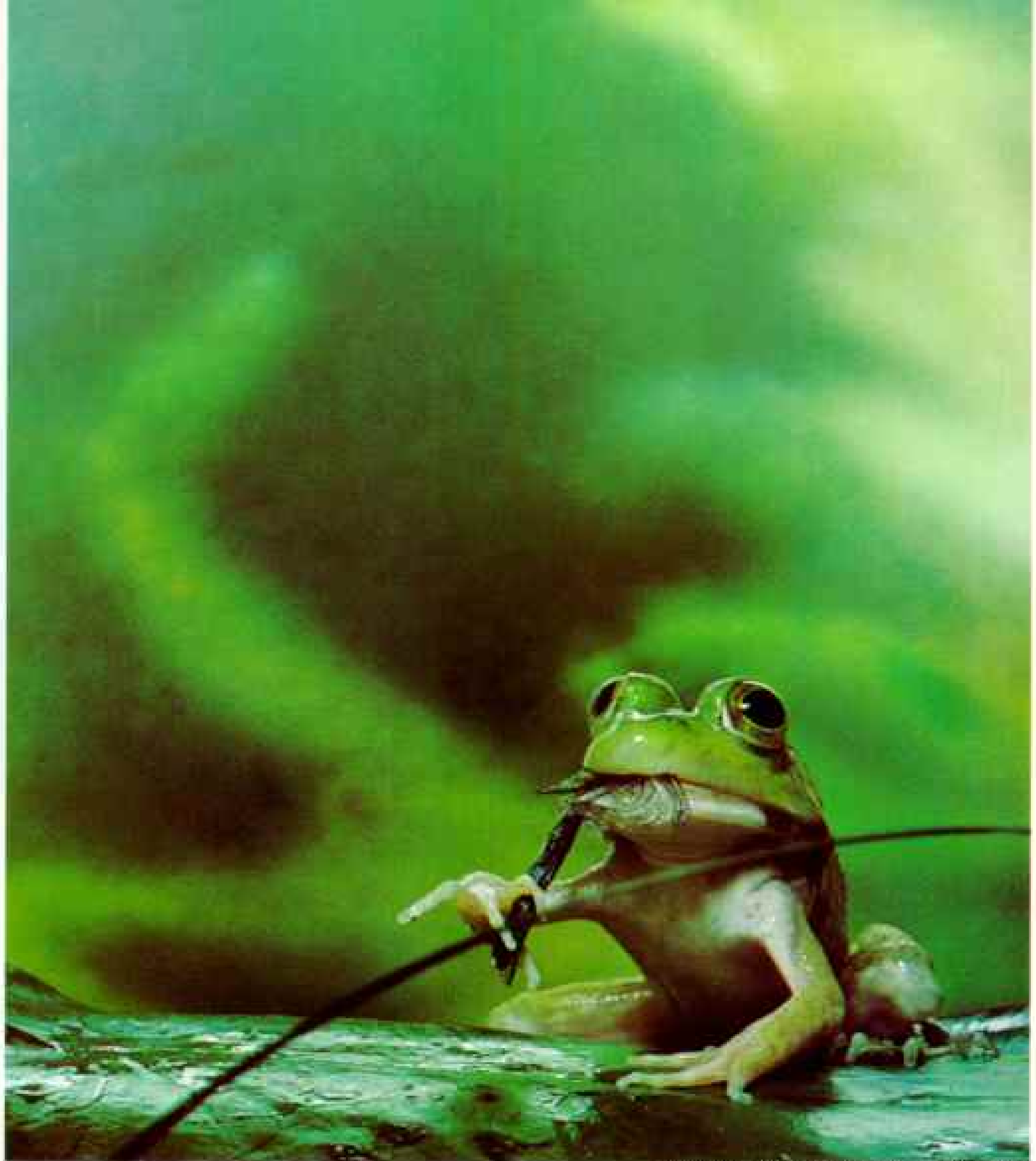


PLACOBDELLA PARASITICA, 2 IN LONG

*The infamous leech* sucks the blood of man and beast alike. This turtle leech (*above*), its young still attached to its underside, feeds mainly on snappers.

*Life Around a Lily Pad*





BARA PALLETIERE (FACING PAGE), NANA CRESCIANO (ABOVE)



ITLA CHERRA

**L**IFT-OFF from a floating launchpad sends a pickerel frog high over a dragonfly (*facing page*). Pickerel frogs exude a poisonous chemical from their skins, protecting them from predators. Insects are a staple for most frogs, like this young bullfrog (*above*) munching on a freshly snagged dragonfly. Bullfrog diets later expand to include fish, baby turtles, and even newborn ducks. Mature frogs may grow eight inches long and live six years.

Body and toes tensed, a green tree frog lashes its tongue at a damselfly (*left*). Since the frog's eyes retract when its tongue shoots out, it must judge the distance to its dinner with absolute precision. The sticky tongue nabs the prey and snaps it back to the frog's mouth, where taste buds quickly determine edibility.



EPHELITA OBLITERALIS, 1/2 IN LONG

**S**CRIBING A CIRCLE of lily pad, a water-lily leaf-cutter caterpillar (**top**) prepares its home. After cutting a piece of pad, the caterpillar drags it to the edge and floats away (**above**).

Soon it will cut another leaf and sandwich itself in between, sewing the edges together

with silk. During its occupancy, the caterpillar will feed on lily pads and other aquatic plants it encounters. Eventually it will attach itself to a plant and spin a cocoon. An adult moth will emerge to lay eggs, completing the insect's cycle—another episode in the ever renewing seasons of the pond. □



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H. EDWARD RYAN, NATIONAL GEOGRAPHIC STAFF

## The GEOGRAPHIC: background for the news

OVER THE YEARS the NATIONAL GEOGRAPHIC has covered the Republic of Korea in considerable depth, and significant events have often coincided with the publication of our articles. In June 1950, a report on Korea was in members' homes even as some 90,000 North Korean troops crossed the 38th parallel. Two months after

a subsequent article on Korea appeared in May 1953, the armistice was signed at Panmunjom.

Another critical event barely preceded our publication last month of "Seoul: Korean Showcase." As the December issue was being bound, word came of the assassination of South Korean President Park Chung Hee (above, standing

at right in the lead car).

In a world of fast-breaking incidents, NATIONAL GEOGRAPHIC articles provide readers with invaluable background for greater understanding of the nations in the news.

Share this knowledge with your friends by nominating them for Society membership on the form below.

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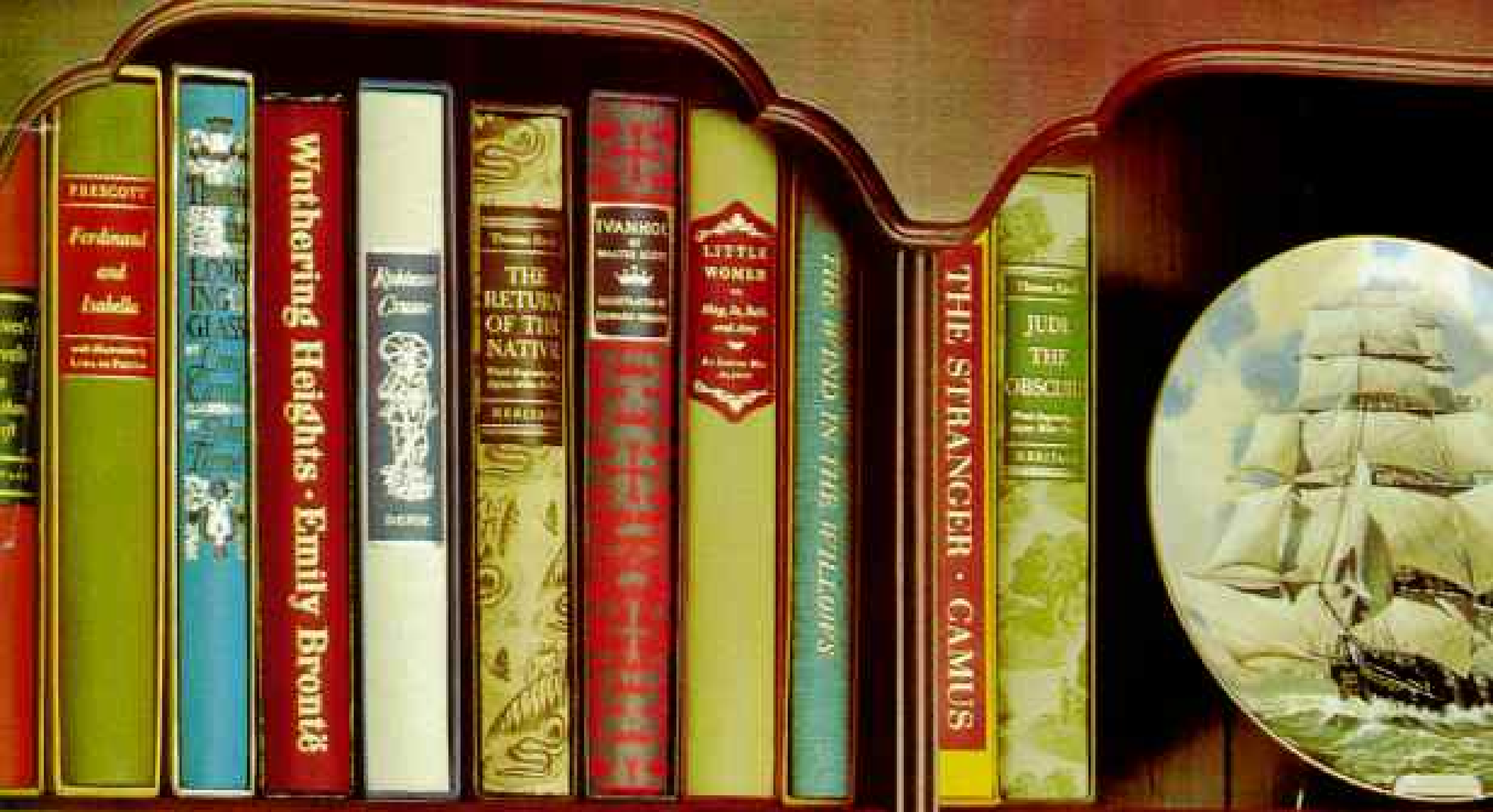
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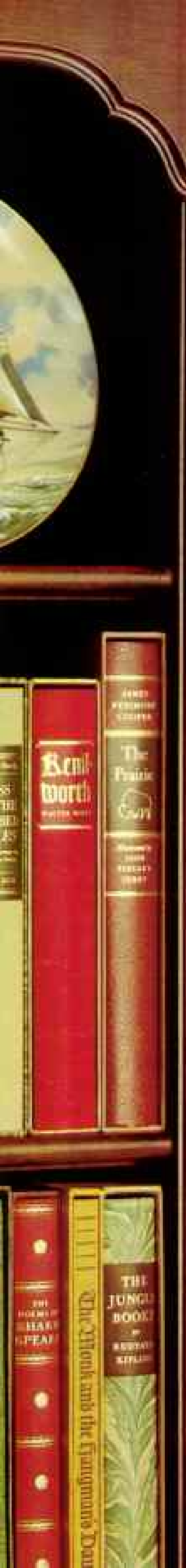
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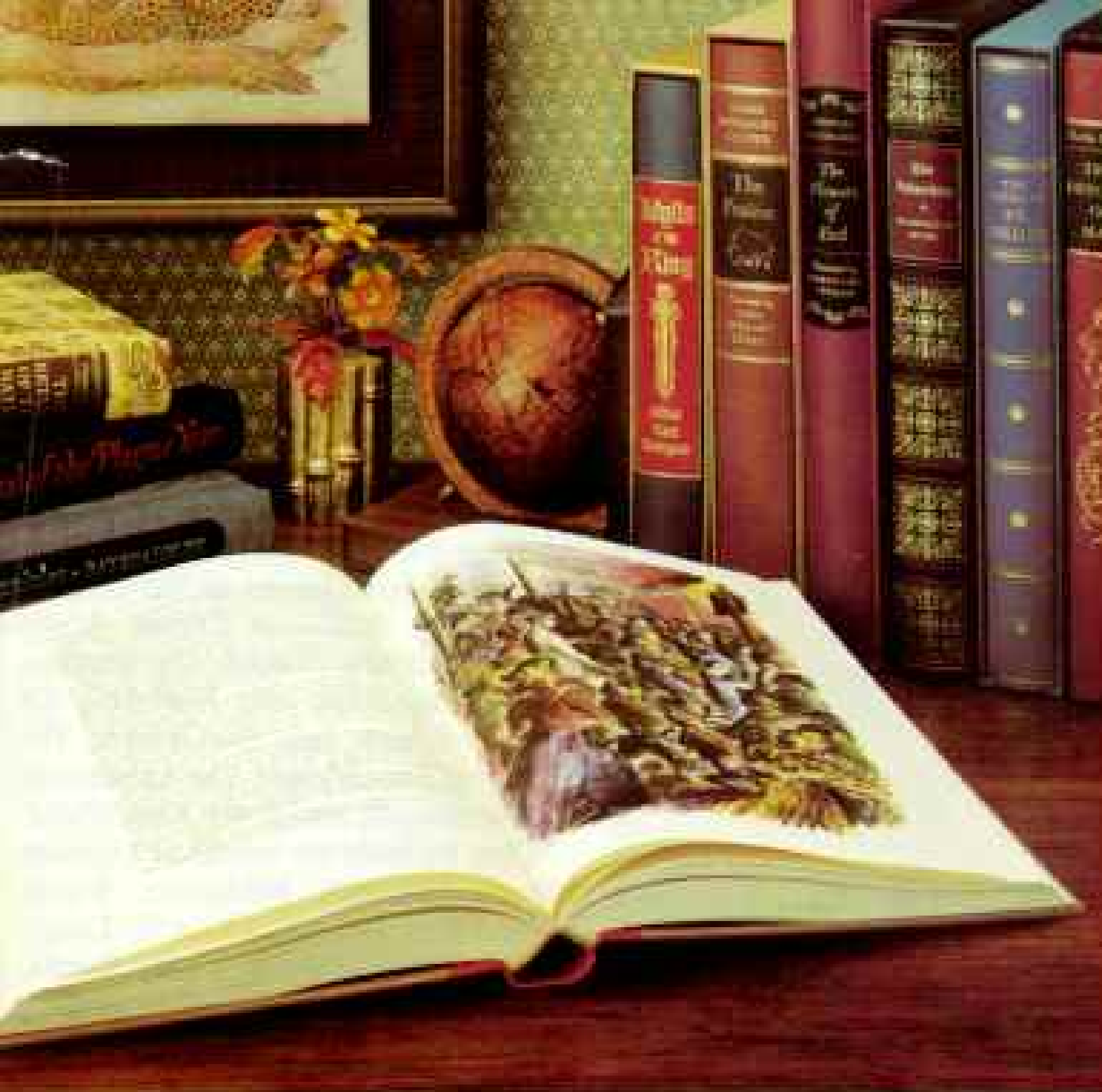
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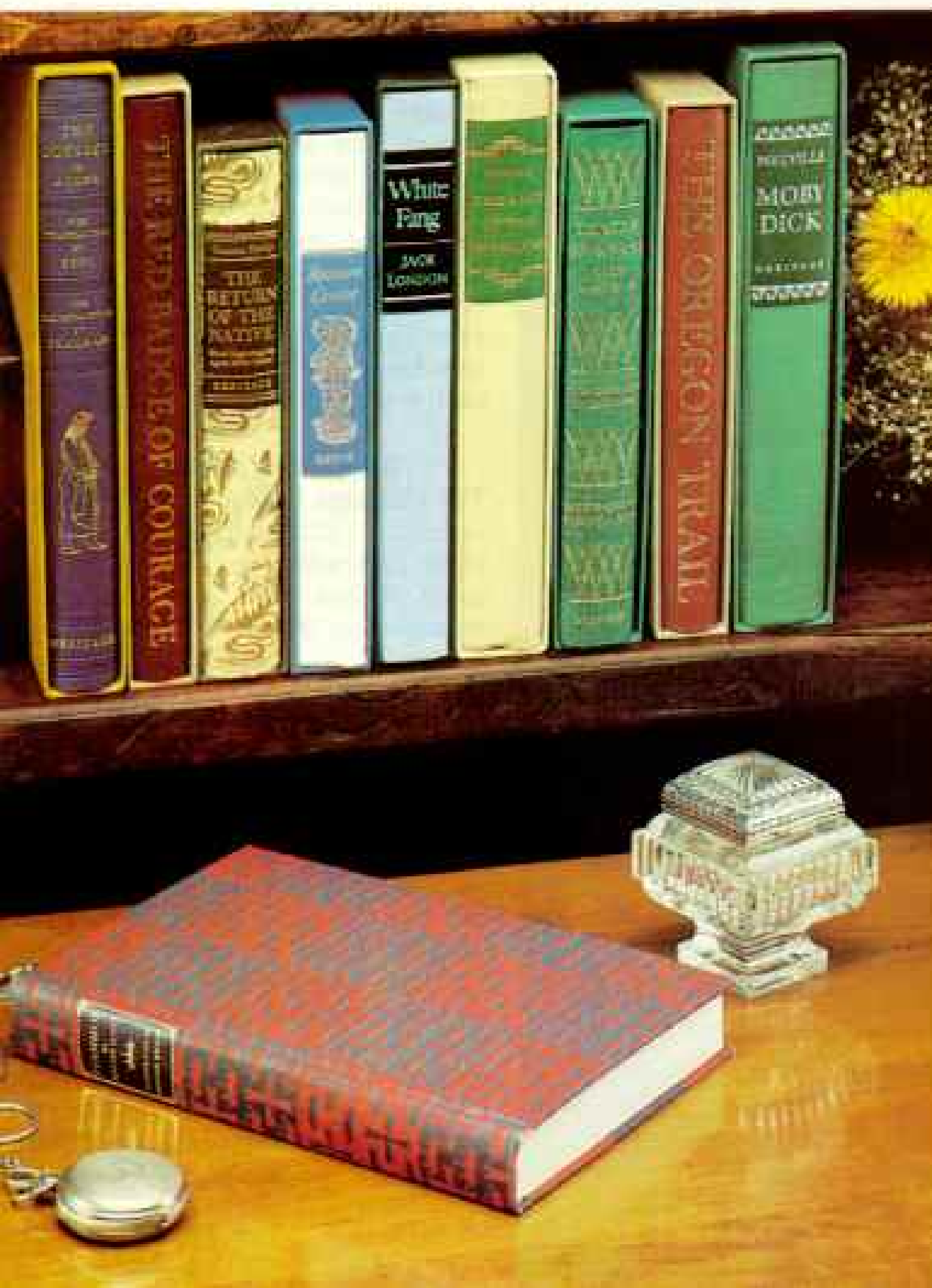
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# HOW AND WHY TO BUY THE RIGHT ENGINE OIL

FOR BETTER PERFORMANCE, USE OIL OF THE RIGHT QUALITY AND VISCOSITY.

Without enough oil in an engine, parts such as the pistons and bearings can literally melt from the heat caused by friction. Using the wrong kind of oil can also have a destructive effect. Either way, the engine can be seriously damaged.

**A simple check of the oil level can prevent engine damage.** If you're down one or more quarts, the engine will probably keep running for a while. But the shortage puts an extra burden on the oil that's left: it'll get dirty faster, reducing engine performance and increasing wear.

You'll get the most accurate results if you check the oil level after you've driven the car a fair distance. But wait at least a few minutes to allow the oil to drain back into the pan.

How often you need to add oil varies according to the age of your car, as well

as how and where you drive. For example, new cars (those that have been driven less than 4,000 miles) may consume a little more oil until parts are broken in. Driving at high speeds, particularly in very hot weather, can also consume more oil. To be on the safe side, check the oil level every other time you get gas.

**When you need oil, be sure to buy oil marked with the letters "SE."** "SE" oil meets quality standards required by a GM engine: it has just the right mixture of base oil and additives.

It's generally all right to mix brands and to shop around for the lowest price as long as you stick with "SE" quality oil.

**The viscosity of the oil can make a big difference in engine performance.** Oil that's too thick won't flow properly, making it difficult to start the engine in cold weather. Oil that's too thin won't do the job right, either. Temperature affects viscosity: oil thickens in winter and thins in summer.

In most climates, it's best to use 10W30 or 10W40 SAE viscosity oil that you can leave in your car year-round.

Change the oil and the oil filter at the intervals recommended in your GM Maintenance Schedule. Engine oil contains detergents that pick up particles of dirt and sludge. If the oil isn't changed periodically, extensive damage can occur. Remember, if you're pulling a trailer or driving in abnormally dusty conditions, change the oil more often.

We're designing engines that require less routine maintenance. But some things are still up to you. A well-maintained engine will be more reliable, last longer, and probably make your car worth more when you decide to trade it in or sell it.

*This advertisement is part of our continuing effort to give customers useful information about their cars and trucks and the company that builds them.*

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People building transportation  
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**There is music in all of us.**

There is music inside you. It may be the melody of your childhood lullaby or a jazz solo. It may be an aria from *Madame Butterfly* or a passage from a Chopin prelude. It may be the remembered sounds of a September twilight. But it's *your* music. The sounds you hear in your head when you're alone with your thoughts and memories. When you're riding a bike, or walking near a whispering sea.





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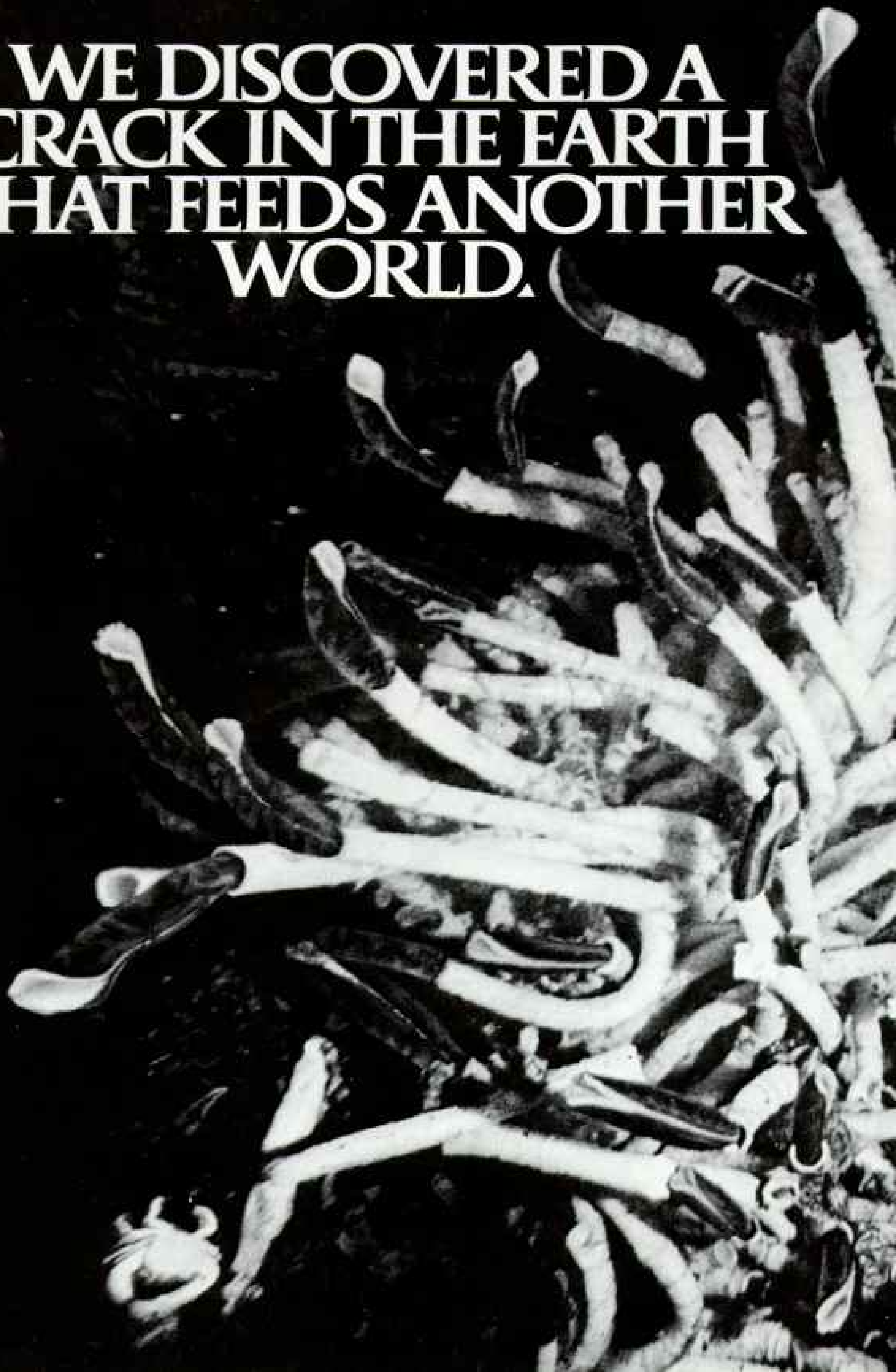
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Special cameras show the find in extraordinary detail.

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It's breakthrough television for the entire family.

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That's when Gulf joined with the National Geographic Society and the Public Broadcasting Service to present quality, American-made Public Television.

Together, we've set Public Television viewing records.

In fact, the documentaries are consistently the highest-rated specials on PBS.

For an hour of discovery television, remember the first Monday of January, February, March, and April.

Join us and enjoy great television that explores passing worlds, small worlds, the world inside your head, and a new world at the bottom of the Pacific.

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Watch *Dive to the Edge of Creation*  
Tues., January 8 at 8 p.m. 7 Central on PBS.

Check your local listings.



Gulf Oil Corporation



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Sharing a wonderful story with your children is a special kind of experience. One that families need today more than ever.

PBS-TV's "Once Upon A Classic" helps fill that need. It's a series of classics, stories parents can relive with their children and, in a way, pass along to them. Favorites like "Rebecca of Sunnybrook Farm," "The Prince and the Pauper," and "Connecticut Yankee."

That's why in 1976, McDonald's® Local Restaurants Association began underwriting this quality TV series.



Since its premiere, the series has won three ACT (Action for Children's Television) awards, and one Gabriel award, for excellence in children's TV programming. Plus a Peabody award for production excellence and 13 Emmy nominations.

These awards are satisfying, but thousands of families enjoying a great TV show together is the award we prize the most. As Marsha Allen, Tempe, Arizona, puts it, "Thank you so much for these high quality shows. My husband, my four children, we love them!"

### Once upon a Classic presents **LEATHERSTOCKING TALES**

The life of an heroic frontiersman in the days when Americans, French and Indians were battling for possession of the American wilderness. Starts the week of Jan. 19. Check your local PBS TV listings.

Presented on PBS by WQED/Pittsburgh with a grant from McDonald's Local Restaurants Association.

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## GONNA DRIVE YOU LIKE YOU'VE SPORTIEST WAY TO GO 28 MILES IN ONE GALLON FLAT.\*

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Introducing the youngest Datsun yet: the new 200-SX. Datsun dedicates it to every driver who'd love to watch the tachometer but has to watch the gas gauge. Because - incredibly - the new 200-SX delivers both breathtaking acceleration and brilliant gas mileage.

**GONNA FLY YOU PAST THE PUMPS**  
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skyroof to let the sunshine in. Even a sports package to put your 200-SX on power steering and cruise control.

**GONNA SURROUND YOU WITH LUXURY** and comfort you totally in reclining buckets up front, split fold-down seats in back (Hatchback model), room all around. There's more headroom, hiproom, stretchout room everywhere — including 40% more trunk room than last year. And more sound insulation, too, to keep the outside world outside. You'd never guess a car this

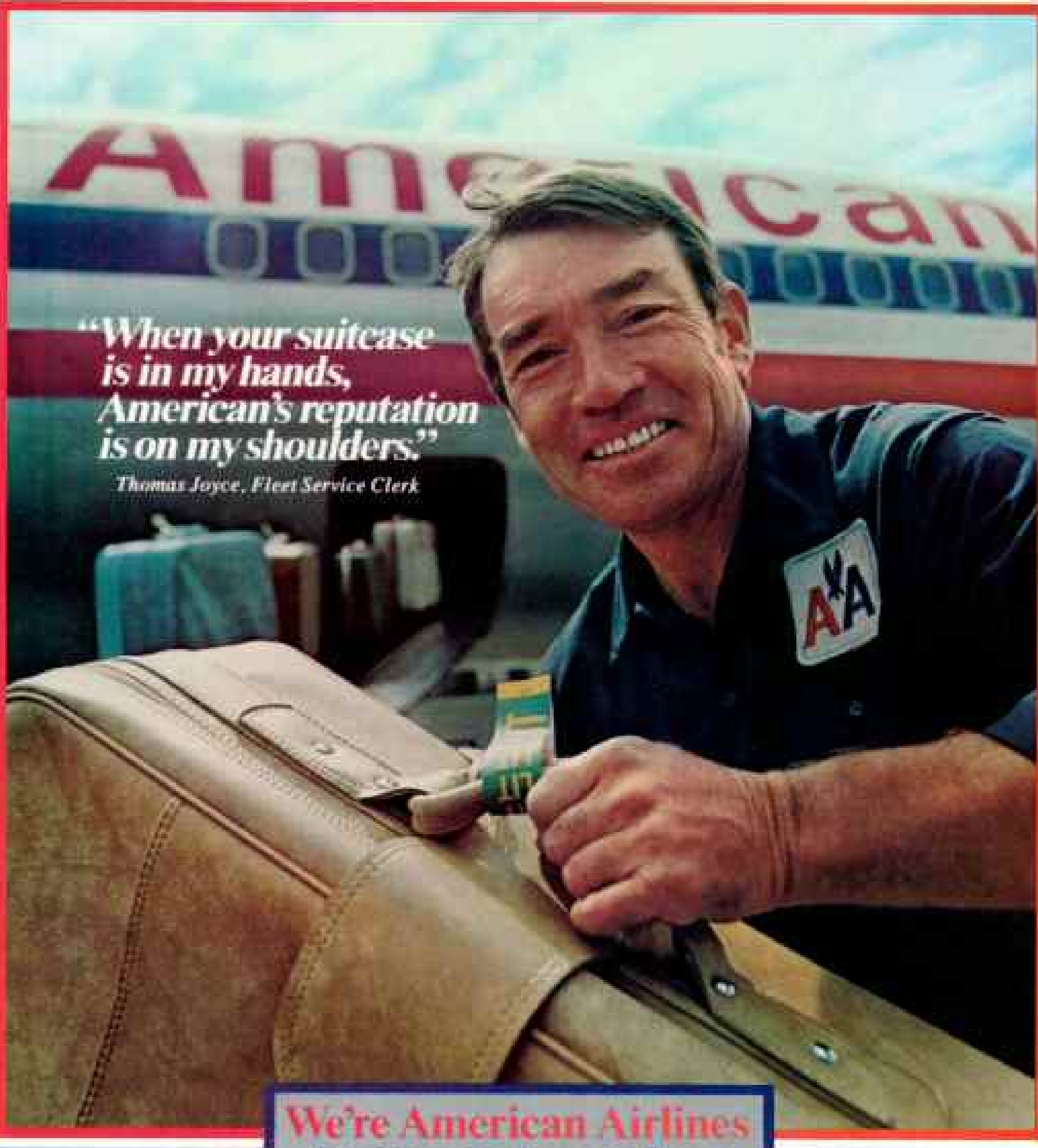
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# DATSUN WE ARE DRIVEN

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is in my hands,  
American’s reputation  
is on my shoulders.”***

*Thomas Joyce, Fleet Service Clerk*

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Doing what we do best**

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And now we’ve got a great way to *return* it.

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# LOOK

The General Motors Continuous Protection Plan offers comprehensive protection against major repair bills. But look carefully for our name. There are other repair plans available which may not offer the same protection.

# COMPARE

Check out any other plan you may see. Compare it point-by-point to the GM Plan using the checklist below.

# TEAR OUT

Take this page to your dealer to be absolutely sure you get the comprehensive repair protection of the genuine GM Continuous Protection Plan.

For 3 years or 36,000 miles – whichever comes first, the General Motors Continuous Protection Plan pays major repair bills for 78 components of nine major assemblies. And GM provides a car rental allowance if your car becomes inoperative requiring overnight repair for any condition covered under the General Motors new vehicle limited warranty – and after the

warranty for failure of any components covered by the Plan. And there are other important features. Compare it with other plans and we're sure you'll choose GM peace of mind. Take any other plan you may be considering, read it carefully and fill in its coverage in the blanks on the checklist below. We don't think you'll find another repair plan that even comes close.

## COMPARE THE GM CONTINUOUS PROTECTION PLAN WITH ANY OTHER REPAIR PLAN

Use this chart to check the coverage of any other repair plan you may be considering	GM Continuous Protection Plan Coverage	Other Plans Coverage (Enter YES or NO)
<u>Covers up to 78 components</u>	<b>YES</b>	_____
<u>Major assemblies covered:</u>		
Engine	<b>YES</b>	_____
Transmission	<b>YES</b>	_____
Front Wheel Drive	<b>YES</b>	_____
Rear Wheel Drive	<b>YES</b>	_____
Steering	<b>YES</b>	_____
Front Suspension	<b>YES</b>	_____
Brakes	<b>YES</b>	_____
Electrical System	<b>YES</b>	_____
Air Conditioner	<b>YES</b>	_____
<u>Additional Coverage:</u>		
Honored at over 15,000 dealers in the U.S.A. and Canada	<b>YES</b>	_____
Rental car allowance for any warranty condition requiring overnight repair due to vehicle disablement	<b>YES</b>	_____
\$25 towing allowance for any reason during warranty	<b>YES</b>	_____
60-Day money-back trial offer	<b>YES</b>	_____

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# CHEVY'S MID-SIZE MALIBU WAGON. Mileage better than many compact cars is just one of its hidden surprises.

## The efficiency and power of a contemporary V6 engine.

New for 1980: an efficient but frisky 229 Cu. In. V6 helps give Malibu responsive performance along with highly respectable EPA estimates.

20 EPA estimated MPG, 26 highway estimate with standard 3.8 Liter V6. In California, 19 EPA estimated MPG, 26 highway estimate.

Remember: Compare estimated MPG (circled) to that of other cars. Your mileage may vary depending on speed, trip length and weather. Your

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## 2 side compartments plus one under the floor.

Malibu gives you room to stash small valuables.

Available security package puts locks on all three, covers on the side compartments.

## The convenience of a 2-way hatchgate.

Window swings up for easy

loading in tight parking places. Gate drops down for loading bulky cargo.

With the rear seat down, you have about six feet of floor for cargo plus an opening over four feet wide for easy loading.

About 72 cubic feet of load space.

## A trim and stylish mid-size wagon with room for 6.

It's a new-size wagon, trim and timely for today. Yet on the inside, six people can ride in comfort.

Talk to your Chevy dealer about buying or leasing America's favorite mid-size wagon.

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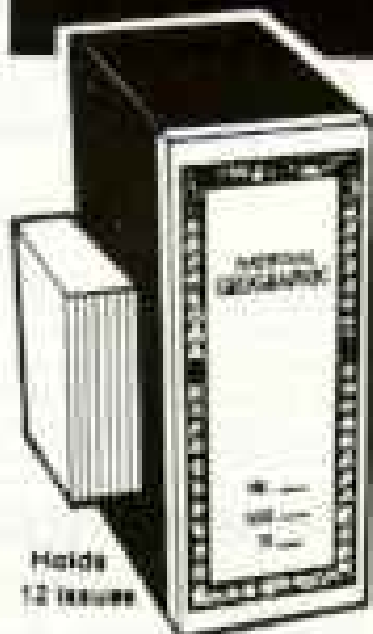
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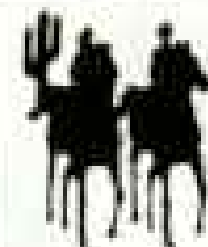
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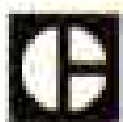
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