SUPPLEMENT: EARTH'S DYNAMIC CRUST/THE SHAPING OF A CONTINENT

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NATIONAL GEOGRAPHIC

A jilleroo rests her horse in the Snowy Mountains, source of Australia's Murray River.

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"I WEPT. . . ." "My husband cried. . . ." "The pages were wet with my tears. . . ." "I was crying and didn't know why. . . ." "It was the first time I cried over this war, and it felt good."

So wrote five members. They symbolize the hundreds who felt compelled to respond to the articles about the Vietnam Veterans Memorial in our May issue. The reader response may eventually be the largest in our magazine's history; there is no question that it is already the most intensely personal.

Almost all reported the articles brought tears, and then told us something about themselves. Some who had served in Vietnam expressed guilt that they had survived when friends did not. Others expressed guilt that they had not served. Still others said they had resisted the war.

Many noted that they were too young to have known the war but still were touched by the articles. Many mentioned people they had known who had been lost; others had lost no one they knew. Foreign members wrote, especially Canadians. All were moved by the story of the memorial.

So touching was this outpouring of emotion that we decided to devote this month's entire Members Forum to the response.

Here are tears not only of sadness and remorse but also of anger and rage, frustration and futility. Though the war had been brought to the world's living rooms daily by live television, and was the most reported and studied of all wars, it was little understood, unpopular, and divisive. Americans' sense of invincibility and of always being on the "right" side was badly shaken. The Vietnam conflict led to distrust of civilian and military leaders.

In retrospect, we seem to have stumbled both into the war and out of it. There was no purging, no expiation, no exorcism, no liberation, no parade, no end—just repressed frustration and a gnawing sense of futility.

Ten years later the memorial became our parade, and the tears came at last. One reader called it America's Wailing Wall.

Common to most letters were anger and sadness and guilt over the treatment of the Vietnam veteran. Many readers said that they understood for the first time the veterans' frustration with what seemed an ungrateful *(Continued in Members Forum)*

NATIONAL GEOGRAPHIC

August 1985

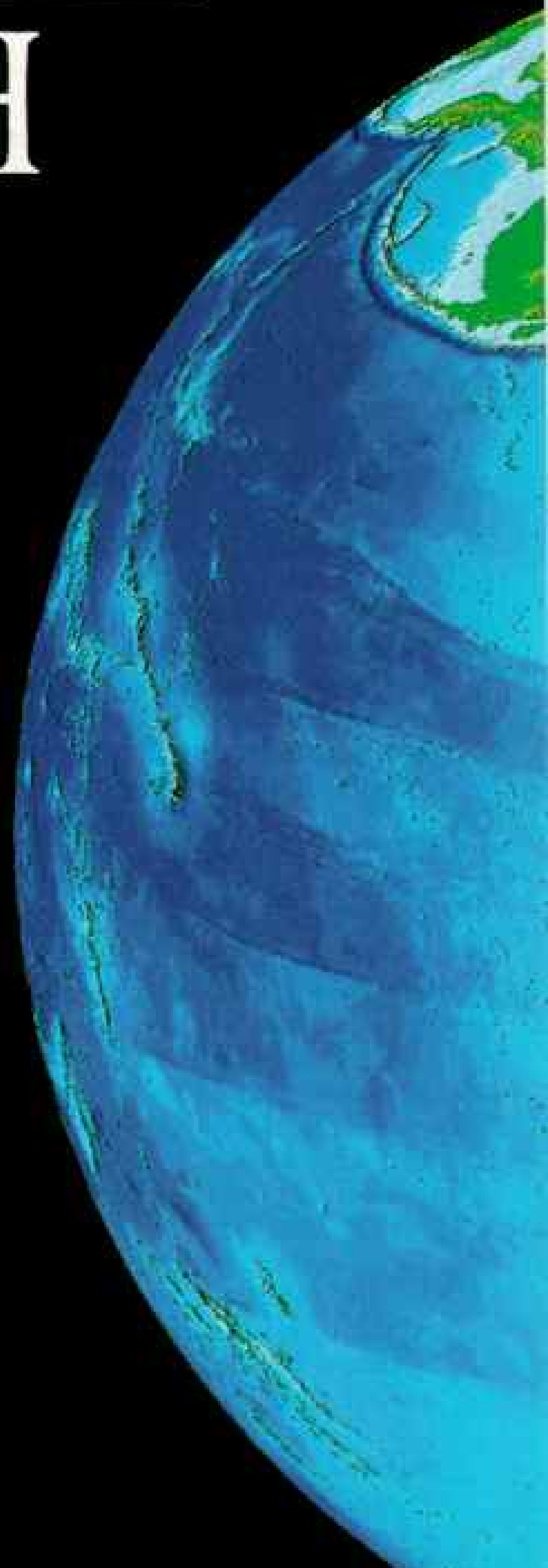
COVER: *Cowhand Kay Sinclair takes a breather near the source of the Murray River. Photograph by David Robert Austen.*

OUR RESTLESS PLANET

EARTH

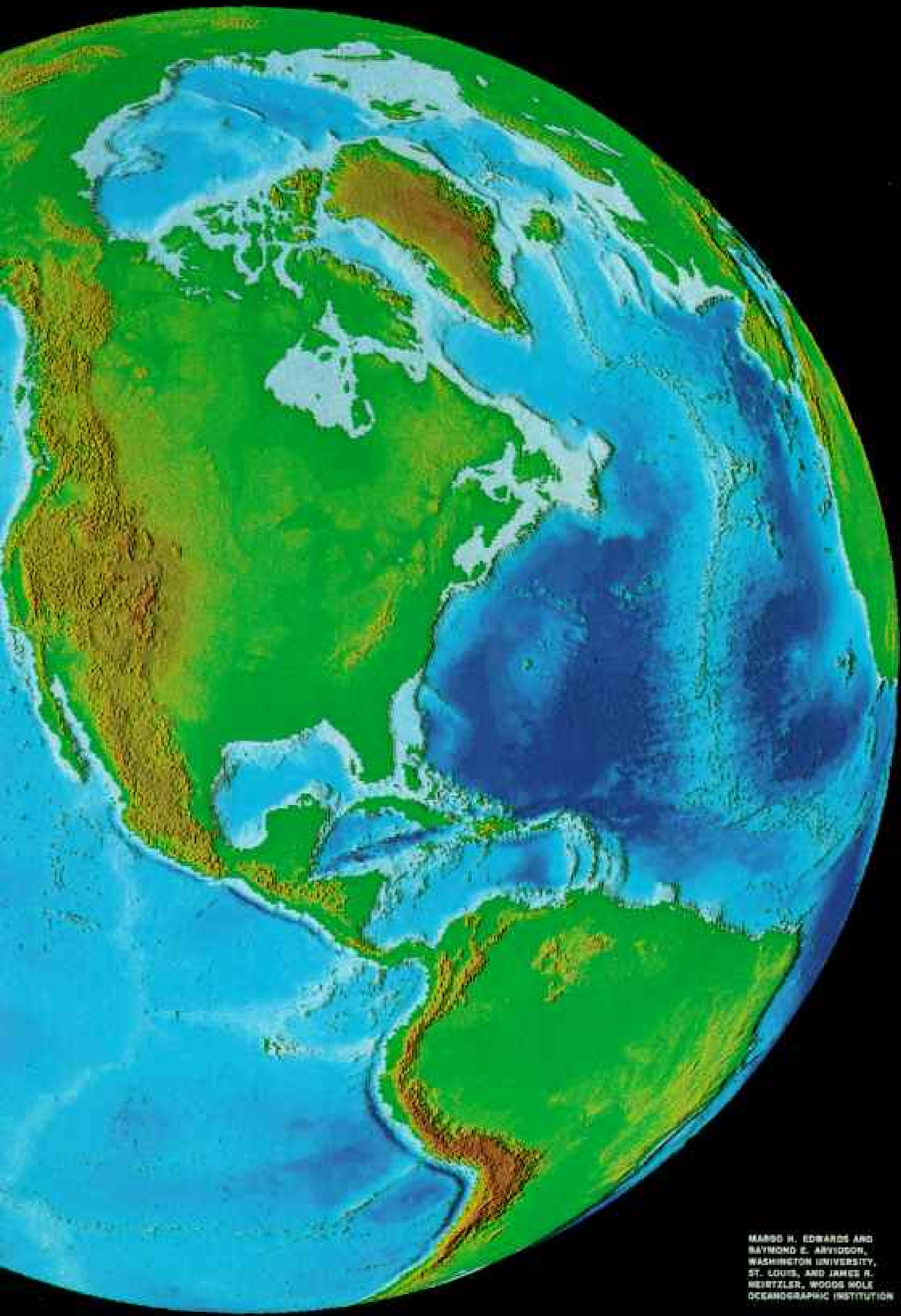
Far more dynamic than ever imagined, our mother planet constantly renews her surface and changes her face in vast movements hidden in time from our short-lived species. Now space-age tools help explore the massive advances of crustal plates and the creation of new landforms as we discover a "new" planet under our own feet.

In this computer-generated image, Earth appears as she would if stripped of her oceans. Because different elevations are assigned specific colors, the shallow areas off Florida and the Bering Strait appear above sea level—which they were during the last glacial age. Deep ocean trenches off South America and Alaska's Aleutian Islands show as dark blue where oceanic plates plunge into Earth's hot mantle.



By RICK GORE
NATIONAL GEOGRAPHIC SENIOR WRITER

Photographs by
JAMES A. SUGAR
BLACK STAR



MARGO H. EDWARDS AND
RAYMOND E. ARVIDSON,
WASHINGTON UNIVERSITY,
ST. LOUIS, AND JAMES R.
HEIRTZLER, WOODS HOLE
OCEANOGRAPHIC INSTITUTION

FIERY LAVA FOUNTAINS spew from Hawaii's Kilauea volcano. Hyperactive vent for one of Earth's hot spots, it has erupted every few weeks for nearly three years.

CONTINENTS ADRIFT; LIFE'S TRIUMPH

WHILE LIFE EVOLVED at sea, Earth's continents formed. Riding crustal plates over a plastic mantle, they would assemble into supercontinents, only to split apart and reassemble in new ways. A giant landmass **1** dominated the southern seas as multicelled animals diversified dramatically. Soft-bodied creatures like sea pens and jellyfish **2** were followed by animals with hard exoskeletons such as trilobites **3**. Then came animals with backbones, the early fishes—some to sprout legs and venture ashore as the first amphibians **4**. Plants came ashore 50 million years earlier, followed by the ancestors of insects, and were already producing wood, paving the way for the swampy forests that would yield today's great coal deposits.

As the supercontinent Pangaea assembled **5**, amphibians gave rise to early reptiles, which in turn sired dinosaurs and mammals. The dinosaurs ruled the planet for 140 million years and included plant eaters of awesome size like *Brachiosaurus* **6** and savage carnivores like *Tyrannosaurus* **7**.

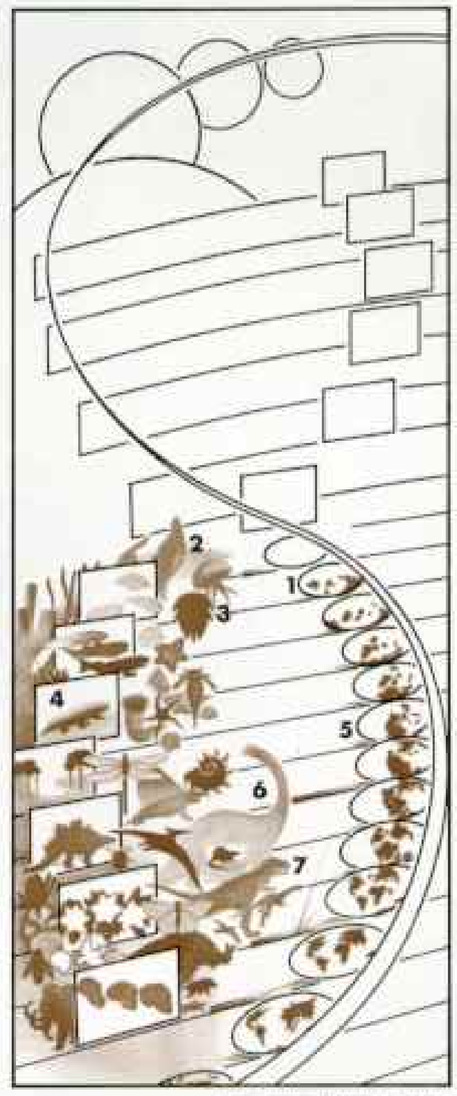
Then, in a geologic minute, dinosaurs and many other species were swept into the fossil record by forces no one can positively identify. However, highly specialized dinosaur offspring had sprouted wings and feathers about 100 million years earlier and survive today as birds.

The first ice age occurred perhaps 2.5 billion years ago, long after the planet had cooled. Scientists do not yet know why, but successive great epochs of ice, millions of years in duration, are punctuated by ebbs and flows, at least nine of which have occurred in the past million years alone.

With the appearance of flowering plants, insects underwent a second great diversification. From pollinators to parasites, they now account for the majority of all animal species.

Free from the dinosaurs' shadow, mammals came into ascendancy, reaching their greatest variety 25 million years ago with the spread of grasslands. Then, about 2.5 million years ago, a family of upright, walking primates began making tools of stone and launched a line of human development extending to modern man. Armed with a lethal intelligence, our species has had a devastating effect on Earth's other species. The demise of the woolly mammoth, the saber-toothed tiger, and many other large mammals in the Western Hemisphere some 12,000 years ago is widely associated with the influx of hunters from Asia.

Today, while animals continue to disappear, untold numbers of plant species are imperiled by destruction of the world's tropical rain forests. Regardless of whether human intelligence proves to be its own undoing, as many fear, continents will continue to drift, with Africa and California splintering and the Mediterranean disappearing. And living things will continue their rise and fall through a timescape we barely comprehend.



KEY DRAWINGS BY MARK SEIDLER

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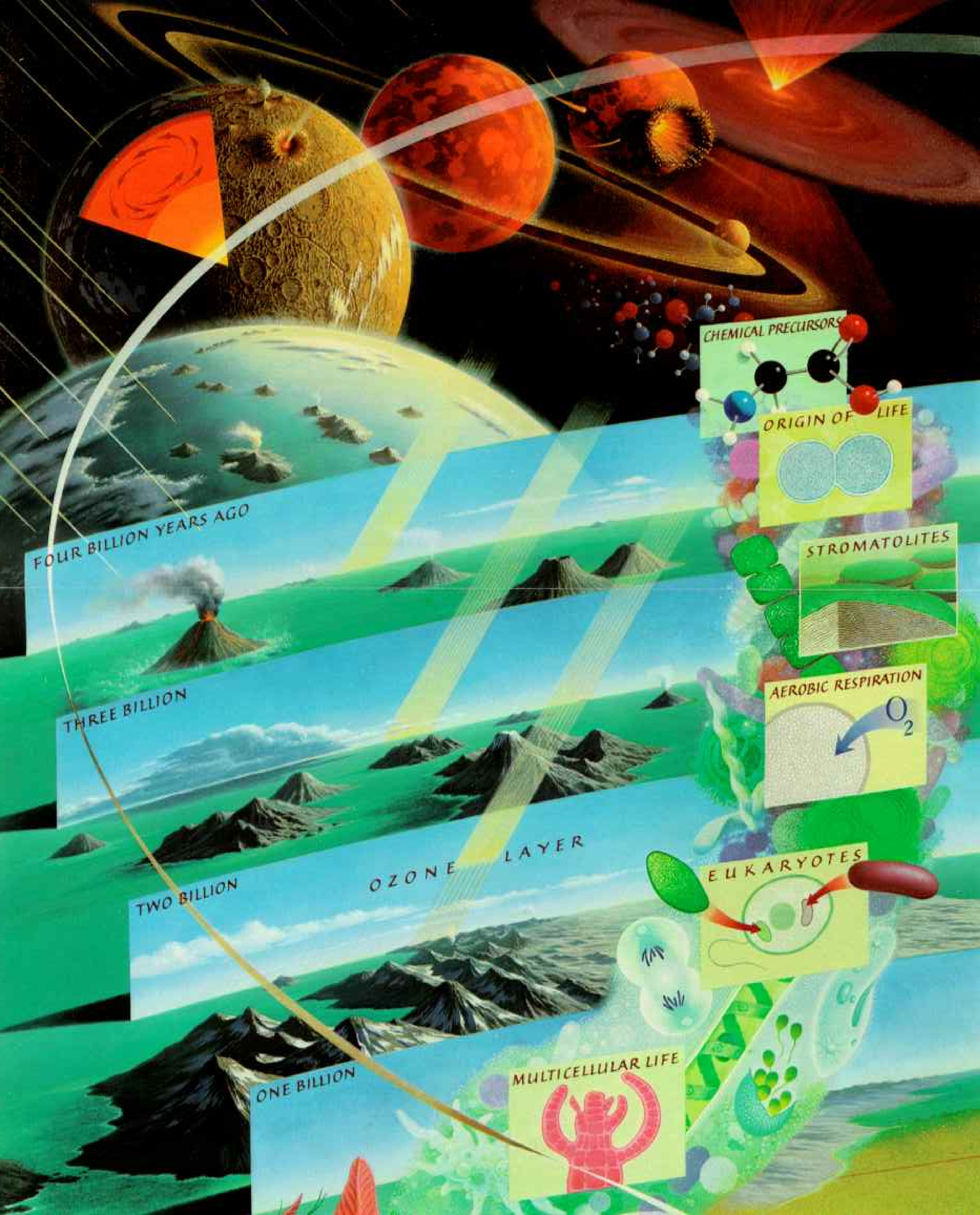

CHEMICAL PRECURSORS
ORIGIN OF LIFE
STROMATOLITES
FOUR BILLION YEARS AGO
AEROBIC RESPIRATION
O_2
THREE BILLION
EUKARYOTES
OZONE LAYER
TWO BILLION
MULTICELLULAR LIFE
ONE BILLION

DIVERSIFICATION OF ANIMALS

EARLY VERTEBRATES

VERTEBRATES INVADE THE LAND

COAL SWAMP FORESTS

DINOSAURS

FLOWERING PLANTS

EMERGENCE OF MAN

MAMMALS

650 MILLION YEARS AGO

MASS EXTINCTION

560

500

420

360

300

230

MASS EXTINCTION

180

120

65

MASS EXTINCTION

TODAY

MAN-INDUCED EXTINCTIONS?

60 MILLION YEARS FROM NOW

FOLD OUT; READ LEFT PAGE SECOND

ORIGIN OF EARTH AND LIFE

EARTHLY TIME LINE: Four and a half billion years of geologic and biologic history are here depicted along the twining strands of a double helix—the structure of DNA, the chemical code for life.

Born like the other planets from the gas and dust of the early solar system **1**, Earth was bombarded for its first 700 million years by countless smaller bodies. One of those, the size of Mars, is now thought to have struck Earth **2** and thrown enough debris into orbit to have created a disk around the planet, from which the moon accreted **3**.

Glowing from energy of millions of impacts and radioactive decay, the young planet Earth would soon be covered with oceans of magma and rafts of solid matter. As the surface cooled, these rafts cohered into a solid crust over a molten mantle.

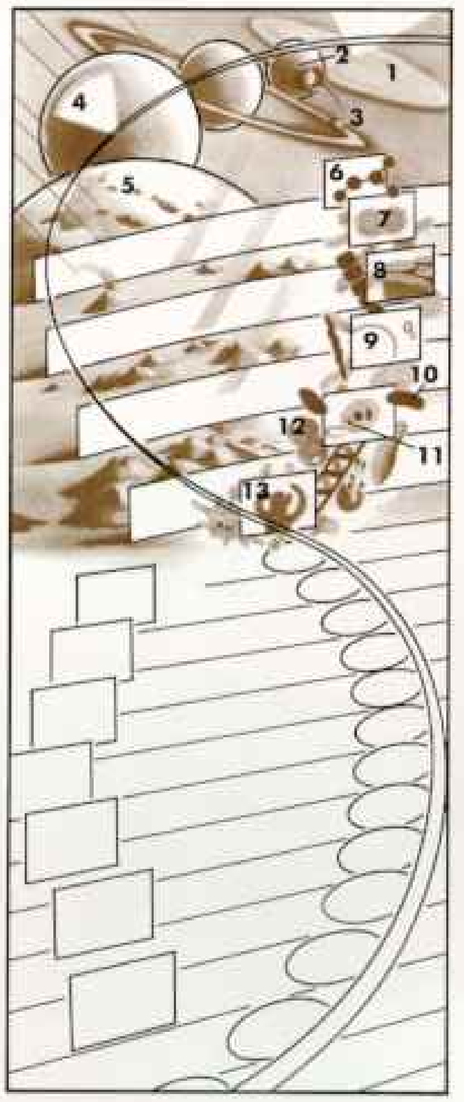
Meanwhile, the planet's interior was busily sorting itself out **4**. Iron and nickel sank to the core, while lighter elements rose to the surface. An atmosphere formed rich in water and carbon dioxide (CO_2) but lacking free oxygen. Water returned to the surface as rain, forming the first oceans **5**.

Enriched by meteorites and comets, the shallow waters around thousands of volcanic islands were laden with chemical compounds **6**, especially of carbon, the most essential element for life. From this primordial soup life would emerge in the form of single-celled bacteria capable of reproduction **7**. Vast communities built up semi-submerged mounds called stromatolites **8**. Formed of successive layers of sediment trapped by microorganisms, these structures dominated the tidal flats ringing Earth's developing continents.

Using sunlight for energy, bacteria through photosynthesis released oxygen that saturated the oceans and began to build up in the atmosphere. There, an ozone layer was also forming that would shield life on the surface from dangerous ultraviolet rays.

Organisms evolved that could use oxygen to break down organic matter for energy—a process known as aerobic respiration **9**. Other organisms, for which oxygen was poison, retreated to oxygen-free environments such as mud. Others still, in an evolutionary leap, incorporated useful guests. Purple bacteria **10** became mitochondria, able to metabolize oxygen for their hosts. Chloroplasts **11** used sunlight for food production and would eventually paint the world green. Forerunners of plants and animals, eukaryotes also arranged their genetic material in enclosed nuclei, wherein chromosomes were structured for mitosis. This elaborate process of division **12** opened the way for sexual reproduction and a vastly greater diversity of life.

More than half a billion years passed before these single cells began to organize into cooperative, multicelled organisms **13**. Marine algae and other plants emerged first, followed by animals less than 100 million years later.



Painting by NED M. SEIDLER • Text by LARRY KOHL
BOTH NATIONAL GEOGRAPHIC STAFF

EARTHQUAKE RISK

RED MEANS DANGER *in this computer-drawn view of seismic-risk areas, based on 350 years of historical data. A ridge of red marks the San Andreas Fault, while the Cascade Range and Yellowstone area contribute other hazard zones. Though more quiet, eastern seismic zones can produce real devastation. The 1811-12 earthquakes at New Madrid, Missouri, were felt in Canada.*

VOLCANIC RISK

EARTH'S HEAT VENTS, *volcanoes usually lie near plate perimeters. Part of the Pacific "Ring of Fire," active areas are highlighted in relief, according to frequency and size of eruption and vulnerability to ashfall. White areas indicate zones of risk from lava flows, both recent and prehistoric—the latter as shown from Idaho to New Mexico.*

MOST OF THE NATION'S *active volcanoes lie in Alaska and Hawaii. Major earthquakes have occurred in both states.*

MELVIN PRUETT, LOS ALAMOS NATIONAL LABORATORY; U. S. GEOLOGICAL SURVEY; AND JAMES MELLETT, NEW YORK UNIVERSITY

ON A CLEAR DAY from the top of Twin Peaks in San Francisco, you can sometimes see the Farallon Islands emerging from the Pacific Ocean like passing ships of granite. In fact, those islands, some 40 kilometers offshore, are itinerants. Born far to the south, they have been working their way up the coast for millions of years. Their speed is imperceptible. A runner moving at their pace would take 170,000 years to finish a ten-kilometer race. Yet in the time scale on which our 4.5-billion-year-old planet evolves, the Farallons are dashing toward Alaska.

Islands on the move. How most geologists would have scoffed at that idea just 20 years ago. But how little we knew then about the way our planet really works. No one understood why volcanoes arise. Or how mountains or even oceans are made. Nor did science realize that Earth's surface is broken into seven major and many minor plates: slabs of rigid rock averaging 100 kilometers (60 miles) thick that ride like icebergs in a more fluid layer of hot rock below. Twenty years ago few scientists dreamed that the continents rode those plates—growing, rifting, and colliding as they drifted.

Bits and pieces *of ancient landforms, the San Francisco area is a jigsaw of terranes in this computer-drawn map. In a process still active, moving ocean plates have been plastering North America's west coast with wayward crustal blocks for 200 million years. Today, west of the San Andreas Fault and its subsidiary Hayward Fault, terranes are moving north about six centimeters (two inches) a year.*

MARIN HEADLANDS, *small blocks 90 to 180 million years old on the California coast, are deep oceanic crust thrust up onto the land.*

YOLLA BOLLY, *130-to-150-million-year-old chert and sandstone, was once buried in a deep subduction zone but has mysteriously resurfaced.*

ALCATRAZ, *about 130 million years old, is a small remnant of a continental margin, most of which has disappeared.*

Now we have entered a new era of geology. Especially in the past decade a wave of high-tech geoscientists, schooled in the principles of plates and drifting continents, have been rapidly unraveling the evolution of our planet. And on a clear day from the top of Twin Peaks, not just the Farallons but the entire San Francisco Bay area spreads out like a textbook in this new geology.

"We are taking California apart piece by piece," says Clark Blake of the U. S. Geological Survey (USGS). "We are finding it's made up of many packets of far-traveled real estate.

"This city below us is built on three different and distinct rock units that have come rafting in from somewhere in a proto-Pacific Ocean," Blake continues. "See Nob Hill and all those buildings downtown? They are in the Alcatraz block. Its rocks are sandstone. They were made underwater from sediments eroded off some mountain range like the Sierra Nevada. But the composition of the rocks tells us it wasn't the Sierra. We don't know what it was, or just where it may be now."

When the Alcatraz block hit the coast, it thrust across the block on which we are now

SALINIA AND PERMANENTE, *two terranes, joined together 2,000 kilometers to the south before drifting north.*

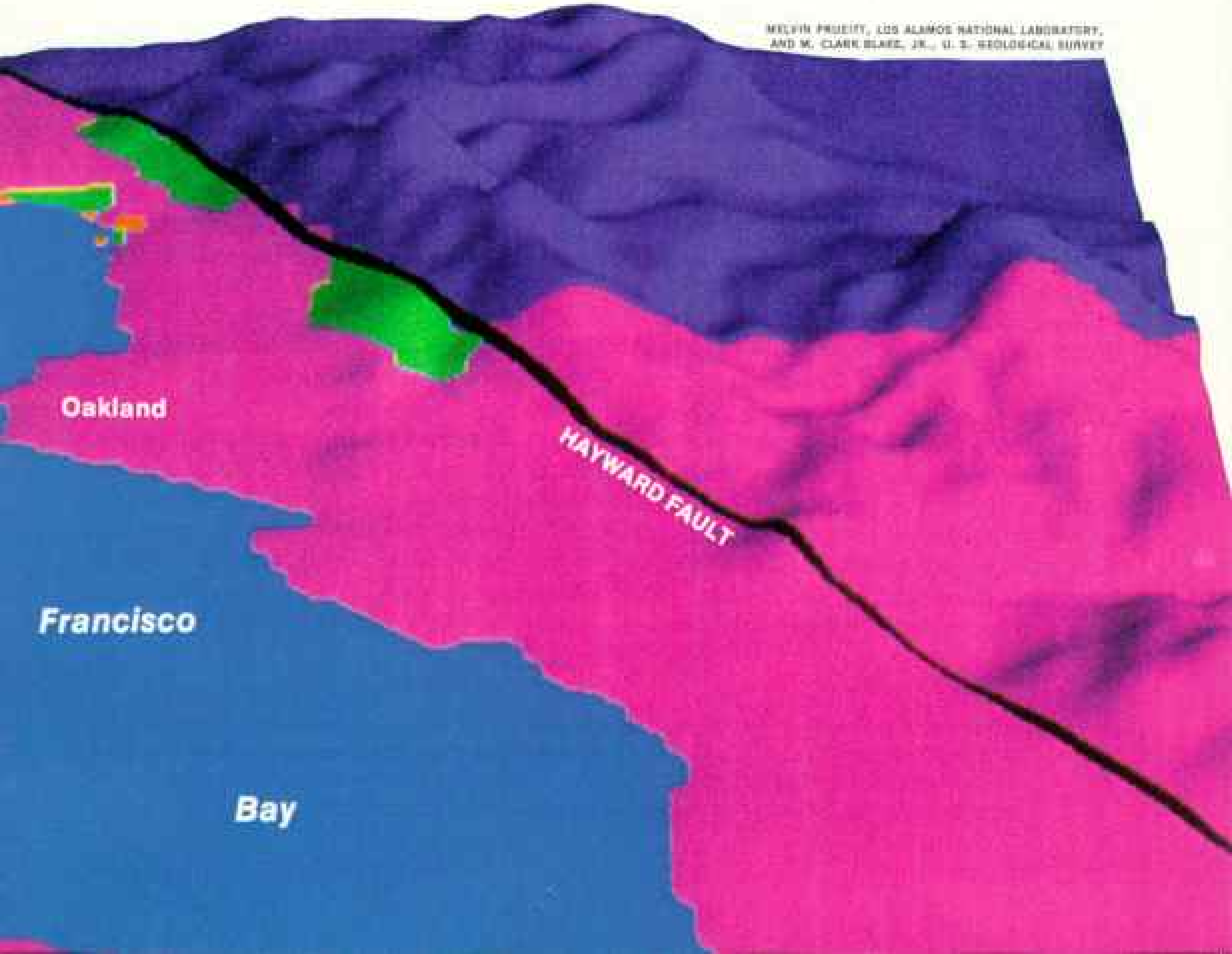
SAN BRUNO MOUNTAIN, *with no fossil record to date it, is sandstone and shale, probably from a deeply eroded continent far to the south.*

NOVATO QUARRY, *70 million years old, is sandstone and shale probably from an unknown continental margin far south of California.*

CENTRAL TERRANE *is a mélange of foreign terranes and local rocks, with chaotic, mangled structure.*

GREAT VALLEY, *60 to 140 million years old, is native sandstone and siltstone deposited on the old continental margin of California.*

CENOZOIC ROCKS, *as old as 50 million years, obscure early accretions and are being displaced by the San Andreas Fault system.*



standing, called the Marin headlands. The headlands, which continue from Twin Peaks on across the Golden Gate, were born of volcanism deep underwater in the tropics about the same time the Alcatraz block was forming. San Francisco's third block, the San Bruno, runs south of Twin Peaks, below the Cow Palace, and on across the bay. Its rocks are sandstone like Alcatraz. But they derived from yet another piece of a lost continent.

CONSERVATIVE geologists call Blake and his cohorts terraners, after the concept of "suspect terranes." That phrase was coined in 1975 by University of Arizona geologist Peter Coney. Its implications have since thrown conventional geology into turmoil.

"Geologists have used the term 'terrane' for decades," says Coney. "It means a three-dimensional block of crust, versus a 'terrain,' which implies topography, like rolling hills. A terrane is suspect if we are not certain it formed where we find it today."

The terraners were launched in the early 1970s when microscopic fossils of tropical sea creatures that lived about 250 million years ago were found in rocks in British Columbia. The only other places on Earth those particular fossils had been found were in China, Japan, and the East Indies.

"We had to ask ourselves how you get those fossils all across eastern Asia as well as North America," says Coney. "You can't. Unless there are a lot of terranes moving all over the place."

Meanwhile, geologist David Jones of USGS was using new techniques to identify and date the fossils of thousands of other extinct microscopic sea creatures. Each of those creatures, known as radiolarians, lived in a specific oceanic environment at a specific time during the past few hundred million years. When they died, their shells were incorporated into chert and other rocks that form from seafloor sediments. Thus those tiny remnants of life gave geologists a way to date and analyze the environment in which terranes had been born.

Also, scientists had developed a technique to analyze the paleomagnetism—or ancient magnetic alignment—of rocks. As molten rocks cool and solidify, magnetic minerals within them line up with Earth's magnetic field at that time. They are thus imprinted with an inner compass that specialists, who have been nicknamed "paleomagicians," can read. This compass reveals how far a rock was from the North Pole when it was born.

Armed with those techniques, Jones, Coney, and other terraners flocked to Alaska in the late 1970s. There, in the glacier-scoured Wrangell Mountains, they began finding rocks identical to those on Vancouver Island and Hells Canyon in Idaho. They deduced that a huge terrane, one that had been born 300 million years ago as an arc of volcanic islands in an ocean that predated the Pacific, had skittered up the west coast of North America and had splintered into pieces as it was plastered onto the continent. (See **Earth's Dynamic Crust** and **The Shaping of a Continent**, a supplement to this issue.)

PIECES of Wrangellia today sit amid a cluster of other terranes that have assembled in southern Alaska. Wrangellia has been profoundly transformed from its youth, when its volcanic rocks resembled those of the Fiji Islands. With glacier outfitter Bob Jacobs I fly east from Anchorage and encounter its peaks one by one. The entire range, including 4,317-meter-high (14,163-foot) Mount Wrangell, is now locked within titanic, unrelenting masses of ice.

We head south over the Alexander and Chugach terranes, other late arrivals to the coast. Our goal is Mount St. Elias. In 1890 the first expedition sponsored by the National Geographic Society was an ascent of this 5,500-meter peak, fourth highest in North America. Today Mount St. Elias illustrates beautifully how Alaska is being built from

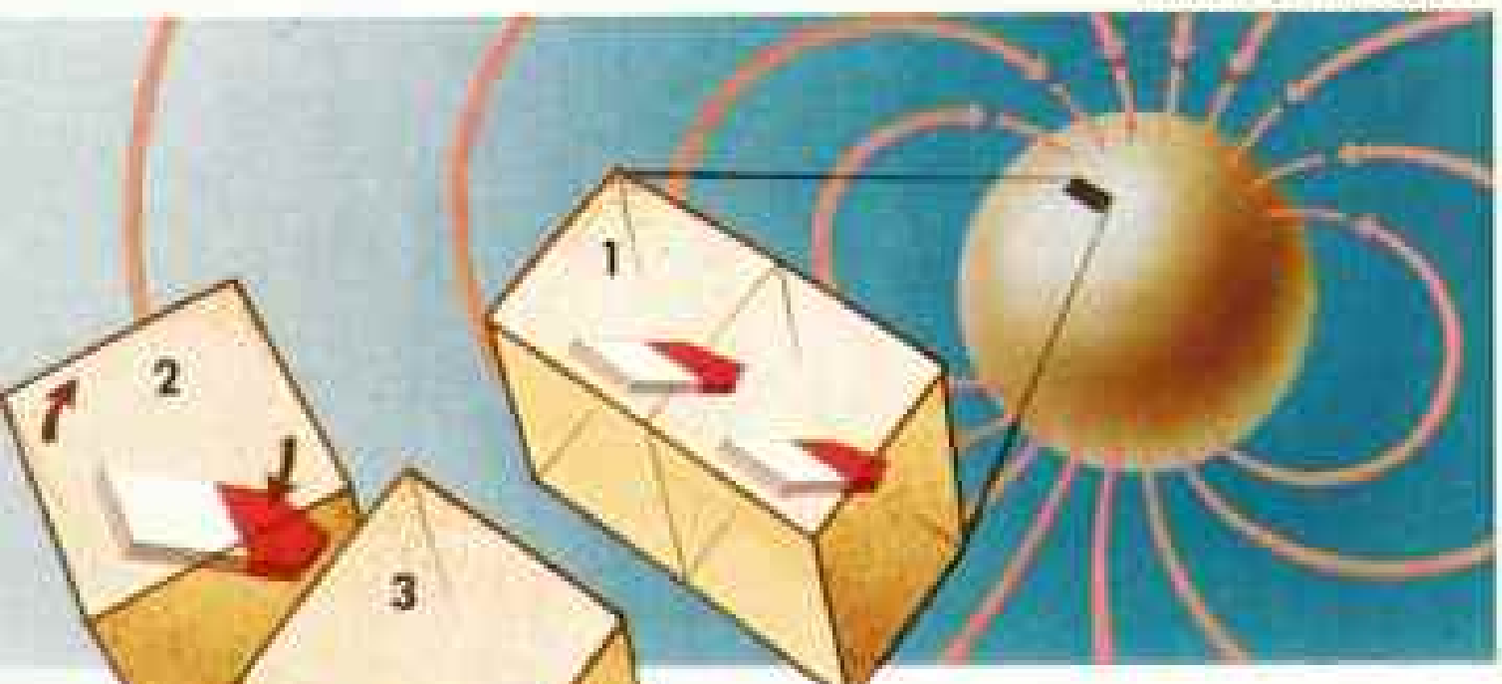
***Where armies clashed** but an instant ago—in World War II—plates have been converging for millions of years, building island arcs from the Aleutians to New Zealand. Rising from the depths west of the Mariana Trench, a volcano on Pagan has recently come back to life and now fumes behind an abandoned Japanese antiaircraft gun.*

suspect terranes. As terraner David Jones had told me in Anchorage: "Alaska didn't even exist 150 million years ago. Every piece of it has come in from somewhere else."

We approach Mount St. Elias. Our plane seems a mere gnat in the audacious mountain's shadow. St. Elias's jutting presence is due to yet another terrane, the Yakutat block, which is still docking to the south of Mount St. Elias. About 50 million years ago that Yakutat terrane, laden with tropical coral-reef fossils, may have been off southern California. Like the Farallon Islands, it has been riding the Pacific plate north. Now the plate is trying to shove the Yakutat block underneath the Chugach terrane, on which Mount St. Elias sits. The Pacific plate's thrust jacks up the mountain five centimeters (two inches) a year.

Our ski-plane drops us off on a glacier at St. Elias's base, then disappears into Alaska's midnight twilight. Only echoes of avalanches break the silence of this immense snowfield. However, the suite of mountains that surrounds us, the continent's greatest concentration of peaks exceeding 4,400 meters (14,500 feet), are companions enough. I cannot sleep in their presence. At three in the morning I watch dawn play on these peaks and read about humans who have confronted this terrain, at first in dogsled safaris across frigid, crevasse-laden ice fields, and in the last decade in helicopters, bearing rock hammers and collecting bags.

PAINTING BY MARK SEIDLER



"Paleomagicians," *U. S. government geologists Ray Wells and Mike Kelly remove a core of basalt near Cape Meares, Oregon (**above right**), to study its paleomagnetism. Like frozen compass needles, magnetic particles align with Earth's magnetic field as hot lava cools* **1**. *Such cores reveal that the coast has rotated clockwise 20 degrees* **2** *in the 15 million years since the lava flowed. The source is 480 kilometers (300 miles) to the east and remains unperturbed* **3**. *"Because the degree of inclination*

I also recall a very different night only six weeks earlier, when I lay sleepless on an island named Pagan, watching a volcano steam and flash fire into moonlit Pacific skies. There, on the opposite end of the Pacific plate, 500 kilometers north of Guam amid the far-flung Mariana Islands, I was witnessing the same process that had made Wrangellia so many millions of years earlier.

I HAD FLOWN into Pagan with marine geologists Don Hussong and Patty Fryer of the University of Hawaii, who were about to begin an oceanographic cruise off the Marianas. Pagan and its fellow islands are just the visible tips of a largely submarine island arc.

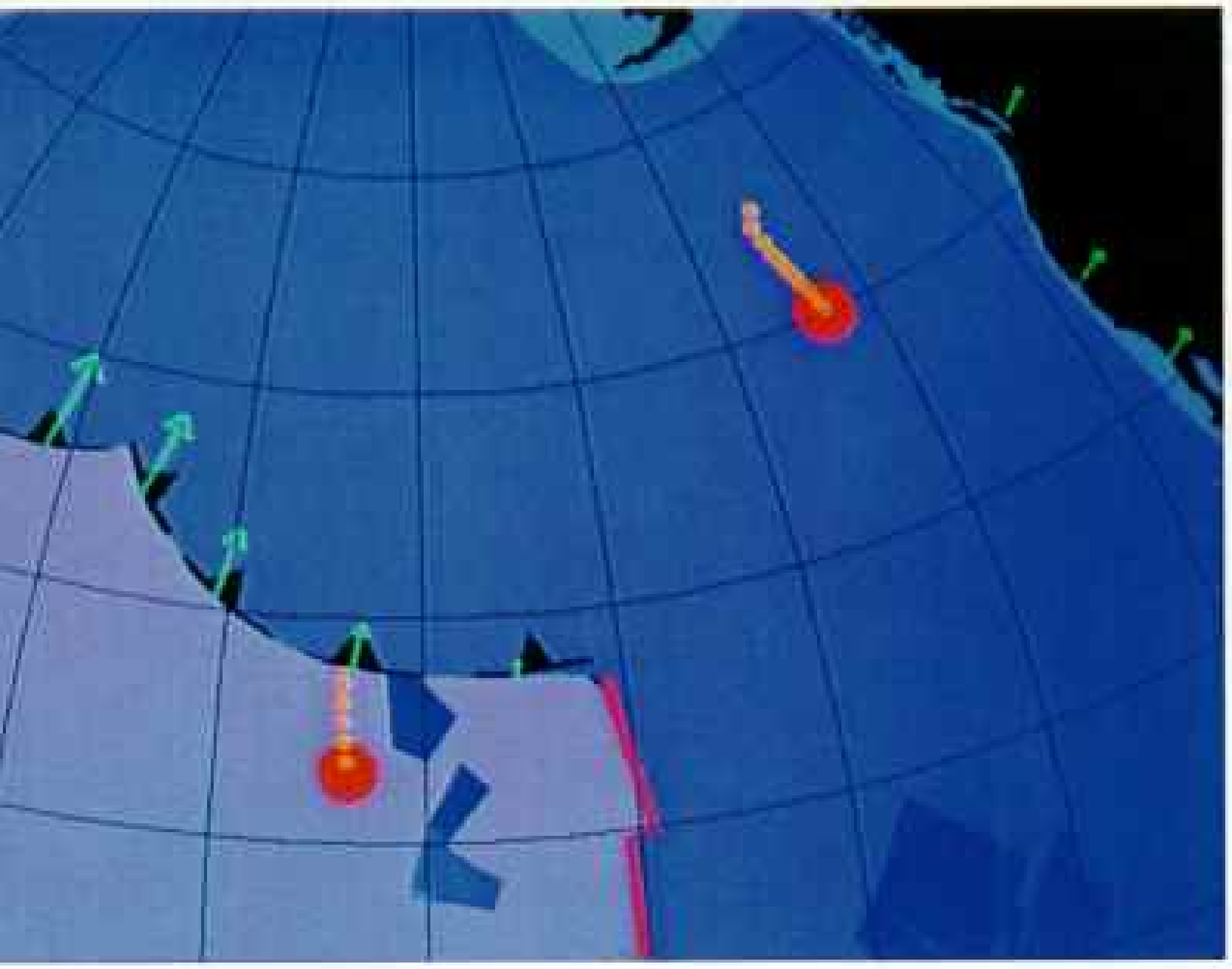
We knew that a volcano on Pagan had been erupting frequently for three years, since an initial blast in 1981 had forced the island's 54 residents to flee. Hussong and Fryer wanted to climb the volcano to compare its recent lava flows with those they soon would be examining with sonar on underwater volcanoes. But as we approached Mount Pagan, we saw a huge ash-laden cloud roiling out of the crater. We had arrived in time for another eruption.

We circled the fuming crater. Its northern flank lay smothered under flows of lava. Denuded, ash-blasted palm trees stood like gray skeletons on the fringes of this surge.

In the island's abandoned village we met the former schoolteacher, Ben Aldan, who

*reveals the latitude of rock formation, we can also tell how far north terranes travel," says Wells, at left. At the U. S. Geological Survey in Menlo Park, California, Bonnie Murchey (**facing page**) helps date foreign terranes by isolating fossil radiolarians—single-celled animals, enlarged on her wall. Dozens of species of the grain-size, elaborately shaped organisms might be found in a small sample of chert, the deep-sea sediments that pepper many terranes.*

Appearances deceive. *A hot spot now located under Yellowstone National Park (**right**) appears to have moved northeastward, but it is actually the continent itself that has moved—at the rate of two centimeters a year. The continent's journey across the stationary hot spot, begun 50 million years ago, is marked by a volcanic trail. A similar path marks the movement of a plate across the Hawaiian hot spot, lower left. The computer image also highlights fracture zones and seafloor ages, progressively younger toward the coast. Another map (**below**) shows both hot spots 100 million years ago, each with a trail of seamounts.*



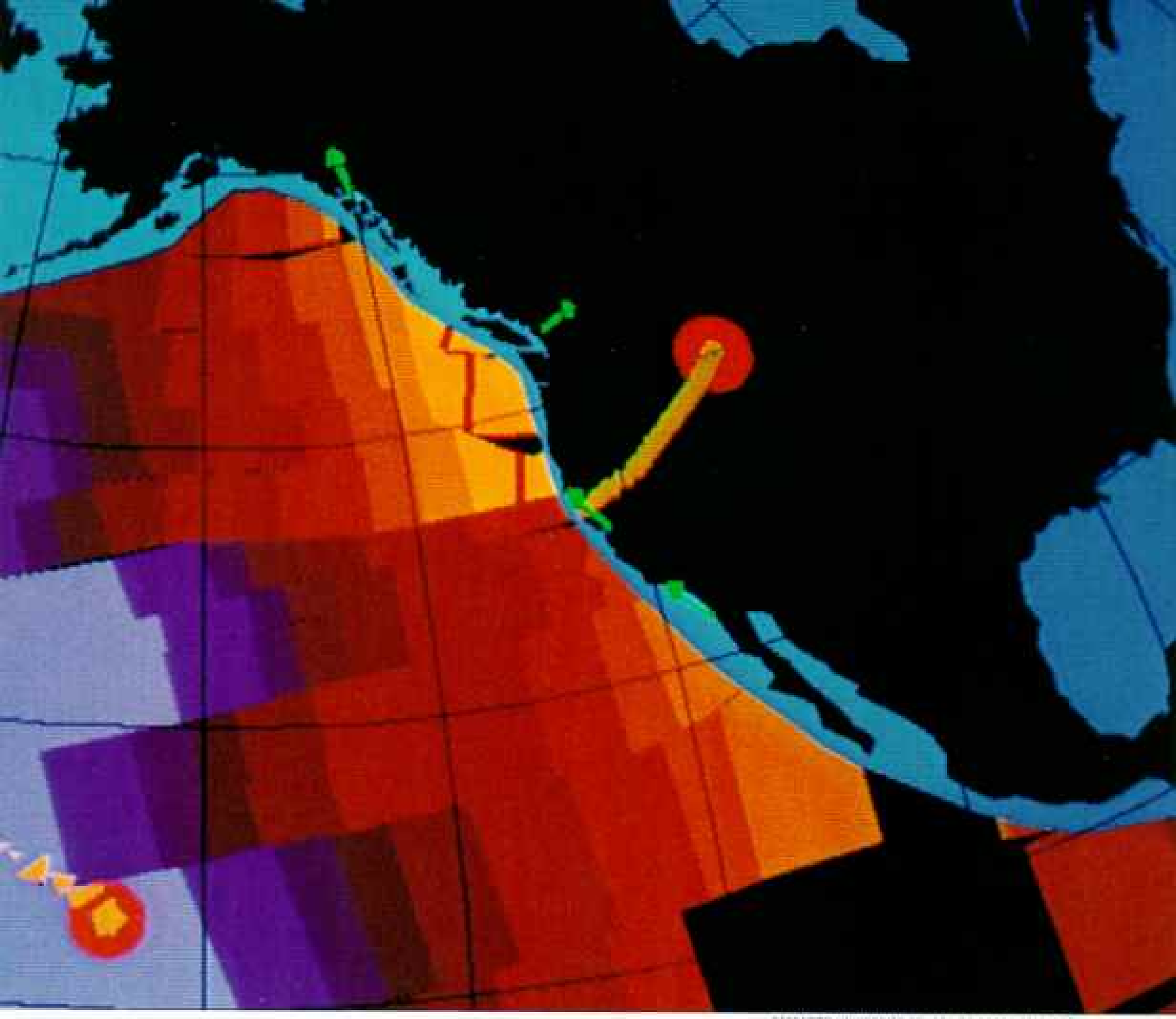
had returned for a brief visit. He described how in 1981 this long-tranquil volcano began to shake the island with tremors.

"I was sitting in my coconut hut, writing down the time of each quake," he recalled. "Suddenly the volcano boomed. A cloud of black smoke poured out. People started running for the beach. I took off in my canoe. I thought we were all going to die."

Fortunately, the blast passed north of the village, sparing all inhabitants.

Besides a surge of fiery ash, that eruption sent tongues of lava down the slopes. We hiked briefly across one of these black flows, but its jagged protrusions and the sweltering midday heat forced us to turn back. This harsh lava was the stuff of an infant terrane. Moreover, it had been made through the processes of plate tectonics—the theoretical underpinnings of the new geology.

The Marianas illustrate plate tectonics elegantly. About 200 kilometers east of Pagan two plates, the Pacific and the Philippine, are converging. Both are considered oceanic plates because they bear mostly the dense basaltic lava typical of seafloors. One of the basic realizations of the plate tectonics revolution is that all our seafloors are young—200 million years old at most. Oceanic plates are continuously being extruded along volcanic ridges that extend for thousands of kilometers through our oceans. New Pacific seafloor, for instance, is now oozing out of a ridge that sweeps from just south of Baja California to below New Zealand. As if on a conveyor belt, the new crust rides the moving Pacific plate toward the Aleutian Islands and Japan. Likewise a ridge down the mid-Atlantic is excreting new seafloor as North America and Europe move farther apart.



STANFORD UNIVERSITY SCHOOL OF EARTH SCIENCES

This process is called seafloor spreading.

"Seafloor spreading happens pretty fast for a geologic process," explained Don Hussong. "It happens at about the same rate your fingernails grow."

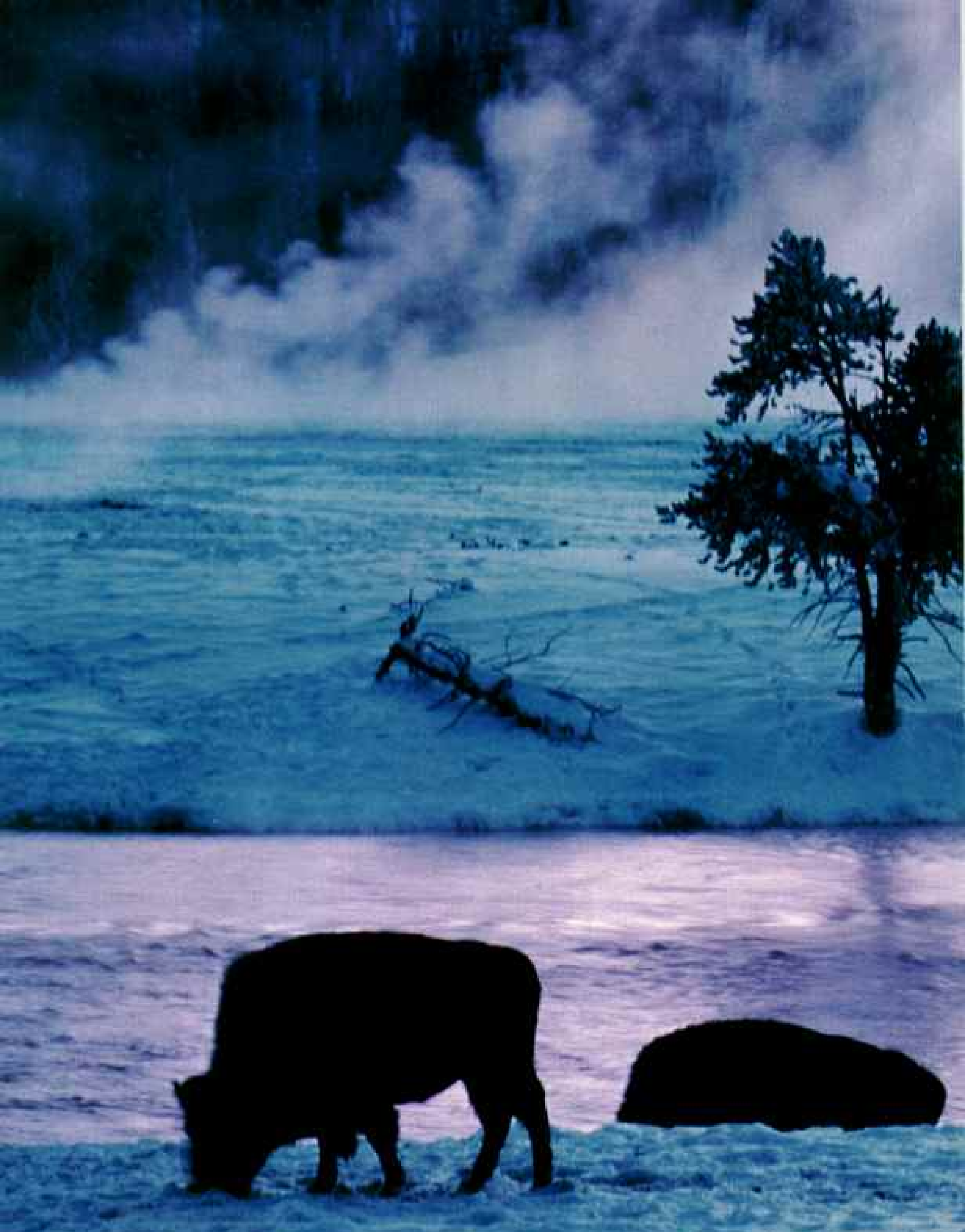
The edge of the Pacific plate approaching Pagan is Earth's oldest ocean floor. It has been traveling for so long that it has grown cold, heavy, and loaded with sediments. Gravity has pulled it ever deeper. Thus, where it encounters the Philippine plate, upon which Pagan rides, the Pacific Ocean reaches its greatest depth—10,915 meters (35,810 feet). Since the Pacific plate is older and denser than the Philippine plate, the Pacific subducts, or dives at an angle, beneath the younger plate.

As the Pacific plate angles down, its descent triggers a melting of rock. Pools of molten, and thus lighter, rock begin to rise toward the surface, generating the magmas that have been bursting out of Pagan.

IN THE MIDDLE of the Pacific, volcanism of a less explosive sort is building another set of terranes. Shortly before flying to Pagan, I had watched the first major eruption since 1950 of Mauna Loa, the largest volcano on Hawaii's Big Island.

Enough lava to fill 100,000 dump trucks an hour raced down the volcano's flank like a wild river. After a few days the eruption ended, and the Big Island had grown a bit bigger. A million years of such eruptions have built the island.

Rather than a subducting plate, the architect of Hawaii is one of Earth's 30 or more hot spots. Like blowtorches beneath the drifting plates, hot spots continuously pump heat from unknown sources perhaps several



Drawn to the warmth *of Yellowstone's geysers and hot springs, bison forage for winter food while the steaming earth conjures images of the planet in its youth. Subterranean heat, which keeps the park on low simmer, may eventually cause an eruption far exceeding that of Mount St. Helens—just as it has every*

600,000 years or so. Hawaii's volcanoes, lying atop thinner ocean crust, erupt more or less continuously. The source of the hot spots that stoke these mid-plate volcanoes is far from clear: Hot spots are concentrations of Earth's inner radioactive heat, but scientists debate why and where they originate.

thousand kilometers beneath the surface. Hot spots also underlie Tahiti, Samoa, Iceland, the Azores, and Réunion Island. New Hampshire's White Mountains and Bermuda may be remnants of the North American plate's passage over a now extinct hot spot.

Northwest of the Big Island lie Maui, Molokai, Oahu, Kauai, and Niihau. Each island had its day above the Hawaiian hot spot. Each is subsiding and eroding as it rides ever farther from the hot spot.

But the Hawaiian Islands do not end at Niihau. With U. S. Fish and Wildlife Service escorts I flew across open ocean to French Frigate Shoals, a ring of reefs 900 kilometers northwest of Honolulu. There a 40-meter-high pillar, La Perouse Pinnacle, rises out of the sea. It is the last visible remnant of an island that ten million years ago was behaving like the Big Island.

This atoll scarcely seemed a volcano's domain. Monk seals and sea turtles basked on white sands alongside squawking albatross chicks. Yet beneath the reefs, with their balmy surf and sandbars, a 4,600-meter-high extinct volcano sits. Lost from view, an entire chain of such underwater islands continues on to Midway Island. West of Midway the chain bends north and heads toward trenches off Siberia and the Aleutians, where the Pacific plate is subducting.

ALSO HEADING NORTH in the Pacific is a third type of terrane, whose rocks can be seen by anyone who walks the Earthquake Trail at Point Reyes National Seashore north of San Francisco. The trail follows a stretch of the infamous San Andreas Fault, and thereby

BOB CATANACH, WOODS HOLE OCEANOGRAPHIC INSTITUTION (ABOVE); BOBB CARSON, LEHIGH UNIVERSITY (BELOW)

"Totally unexpected" *were the strange creatures that LaVerne Kulm (**right,** at left) and Erwin Suess discovered off the coast of Oregon last year—a few frozen specimens of which they display in their lab at Oregon State University in Corvallis. While surveying the subduction zone of the Juan de Fuca plate in the small research submarine Alvin (**left**), the oceanographers happened upon several communities of tube worms (**lower left**) in the sunless depths of 2,000 meters. Similar creatures were discovered in 1977 on the Mid-Ocean Ridge west of the Galápagos Islands. But the Oregon worms are different, says Suess. "At the ridge, hydrogen sulfide provides the basis for life. Here methane is generated from subducted organic matter—detritus from the Columbia River. Methane-eating bacteria are probably hosted by the worms, which in turn feed off the bacteria."*

straddles two plates. The fault marks the boundary zone, where, rather than subducting, the Pacific plate is grinding past the North American plate. The rocks east of the fault still belong to North America proper. Those to the west on the Point Reyes Peninsula have been ripped off the continent.

The trail passes two sections of an old fence that now sit five meters apart. They were separated in the 1906 San Francisco earthquake, when the Pacific plate lurched all five meters in moments. The plate will surge again. Thus, in 50 million years Point Reyes may well be docking off Anchorage, thrusting up a new Mount St. Elias.

"AT LAST COUNT Alaska is made of 50 terranes," says David Jones when I rejoin him in Anchorage. We drive north into Alaska's heart, past Mount McKinley to Fairbanks, encountering terranes one after another. None of these old Hawaiis, chips off lost continents, or errant archipelagoes has a single rock in common. And most likely none was even made on the current Pacific plate.

Most of Alaska's terranes are probably flotsam and jetsam scraped off of at least two great plates that predated the Pacific. One of those plates, called the Kula, has disappeared entirely beneath Alaska. Most of the other, the Farallon plate, has vanished under western North America. Only two small segments of the Farallon remain. One piece is still driving beneath the Pacific Northwest. Its subduction generates Mount St. Helens and the rest of the Cascade volcanoes. The other remnant is diving beneath Central America, where it fires such volcanoes as Mexico's El Chichón.

Jones and I continue our Alaska survey, flying across tundra to the rumpled, moody Brooks Range. Over the Gates of the Arctic we circle a jagged black peak called Doonerak. This, says Jones, may be part of Alaska's spine, the core terrane against which

USGS/EROS DATA CENTER, ANCHORAGE

Seen as never before, *Mount McKinley and its colossal cohorts fill a 120-kilometer-wide panorama of the Alaska Range in this view featured in the National Geographic's forthcoming Atlas of North America. By computer blending of elevation data with the visual truth of a Landsat image, scientists at the U. S. Geological Survey produced a vivid oblique view far beyond the capability of an ordinary camera lens. Combining the most advanced mapping techniques with dozens of remote-sensing satellite images, the new atlas paints a space-age picture of our continent.*

Remnants of ancient landforms, 50 terranes plastered one upon another, form Alaska—which did not exist 150 million years ago. Each new collision left its mark in the buckled landscape, from the Brooks Range to the southern Panhandle.

the rest of the state docked. Doonerak is made of rocks like those I saw on Pagan.

"We are in the heart of a continent," says Jones. "Yet Doonerak had to have been an island once. Some people believe it's always been an appendage of North America. I think it rafted in from somewhere near Kamchatka. If we really knew how complex this state is, we'd pack up and go home.

"But we are convinced that when we see all these pieces that have been swept together, shoved up, and thrust over one another, we are looking at the way all continents form. That's the beauty of Alaska."

Indeed, geologists have found some 200 terranes in western North America alone.

HOW LONG has plate tectonics been going on? We cannot trace plate movements back with any confidence much further than about 570 million years, to the onset of the Cambrian period. The paleomagnetic signatures of older rocks cannot be interpreted reliably, and in Precambrian rocks the fossil record almost disappears. Not until the Cambrian period did creatures evolve hard body parts, whose forms could be preserved in rock. Unfortunately, the Precambrian covers 90 percent of the planet's lifetime.

The onset of the Cambrian was, until only 150 years ago, the dawn of time to students of the budding science of geology.

In the 1830s Professor Adam Sedgwick, one of geology's gentlemen pioneers, discovered marine fossils atop the wild mountains of Snowdonia in northern Wales. Sedgwick was not as much a fossil man as his rival, Sir Roderick Murchison. He was more interested in reporting back to the Geological Society of London that he had located the oldest rocks yet known to man. Nevertheless, Sedgwick's discovery fortified his belief that the Cambrian rock sequence, which he had named for the Latin word for Wales, recorded the creation of life.

Murchison contended, however, that life originated in his favorite period of rocks, also in Wales, which he called the Silurian, after an old Welsh tribe. He claimed, moreover, that many of Sedgwick's Cambrian sites in fact belonged in the Silurian. The two scientists argued bitterly for years over what the sequence of rocks in Wales said about the history of Earth.

One legacy of that debate is the system of elegant names we still use to divide recent geologic time. After Sedgwick and Murchison died, a third time period was set up to cover the fossils in question. The new period was called the Ordovician, for the Ordovices, a particularly warlike people.

In retrospect the confusion is understandable. Wales is geologically a mess, while most of England is as orderly as the Royal Navy. Like a layer cake on its side, England displays ever older epochs of rocks, laid down one after another, from London northwestward into Wales.

The fossil record left in these rocks helps explain how plate tectonics has been shaping the continents in relatively recent years.

For instance, I take the London subway to meet geologist Andrew Beckly, who will escort me to Wales. I whiz underground through the London clay, which was laid down 50 million years ago in the Eocene epoch, when the London basin was covered by a muddy sea.

Ancient spine *of North America, perhaps once as mighty as the Himalayas, the Appalachian Mountains have eroded to a polished glory—vividly captured in this Landsat 4 image of southern Virginia. The cordillera began to form 450 million years ago, when terranes accreted and South America and Africa collided with North America and Europe, forcing the continental margin into parallel folds. An optical illusion caused by shadows may require turning the page upside down to distinguish valleys from ridge tops.*

GENERAL ELECTRIC SPACE SYSTEMS DIVISION

Schooled in plate tectonics, I know today what Sedgwick did not. Before the London clay was deposited, Earth's landmasses had been assembled for millions of years in a supercontinent called Pangaea—Greek for "all lands." The London clay was laid down while the North Atlantic was opening, finishing the breakup of that supercontinent and separating Europe from North America. Britain then lay well to the south off a swampy coast.

Beckly and I drive north—and back through time. We soon find ourselves in rocks of the Cretaceous period, when high sea levels inundated much of the world. During this period, some 70 million years ago, the remains of millions of generations of shelly sea organisms were deposited atop submerged England. They formed a chalk deposit, whose most famous exposure is the White Cliffs of Dover to our south.

We head on through rolling Jurassic hills, deposited between 138 and 205 million years ago, when England was a series of fern-covered islands lying well north of the Equator. On land, rat-size mammals scurried in the shadows of dinosaurs, while winged reptiles, the pterodactyls, ruled the air.

HOW DIFFERENT was this emerald England in the older rocks we encounter next. During most of the Triassic and the preceding Permian, England was in the dry heart of Pangaea, and desert conditions predominated.

Prior to that, in the Carboniferous, some 290 to 360 million years ago, warm shallow seas had advanced across growing Pangaea, creating multiple islands. Life was also advancing on the land. Trees had evolved, and the planet's first dense tropical forests covered the Carboniferous British Isles. The sea repeatedly flooded these forests. The rotting vegetation became the Welsh coalfields that later fueled the British Empire. In those forests lived primitive insects and spiders.

Entering Shropshire, we encounter the Devonian period, which ran from 360 to 410 million years ago. During the Devonian, life exploded onto the land. This explosion, first by plants and later by fish-like amphibians, coincides with the birth of Pangaea.

Early geologists knew that during the Devonian Britain had been part of a large, hot,

and semiarid landmass. They called that land the Old Red Continent. It shed sediments, the Old Red Sandstone, that dominate much of southwest Britain. Those geologists did not know, however, that their Old Red Continent had formed by the collision of a proto-North America and Europe.

Before that collision parts of Scotland and Ireland lay in what is now North America. As the pre-Pangaea landmasses rammed together, they thrust up a mountain belt, whose remnants persist as the Appalachians and the Caledonian mountains of Wales, Scotland, and Scandinavia. Now oceans apart, they were once the same high range.

THAT COLLISION ZONE marked the end of the orderly world the Victorian gentlemen geologists had observed. Beckly and I cross the Welsh border and see the geologic chaos that confronted Sedgwick and Murchison.

We stop outside Llangollen to view a scarp of whitish limestone. "That's the Carboniferous," says Beckly. "It's sitting right on top of Murchison's Silurian. We have entered the great unknown of Wales."

Across the road lies typical Silurian gray rock. It is twisted, broken, and deformed. How alarming those agonized contortions must have been to minds that had never dreamed continents could collide!

All these confounding rocks, Beckly explains as we hike one of the mountainsides Sedgwick surveyed, were on the seafloor during the Cambrian, Ordovician, and Silurian. Their fossils record a magnificent sequence of submarine evolution, from trilobites and clam-shaped brachiopods to squid-like cephalopods, sponges, graptolites, and the first fish. (See "Fossils: Annals of Life Written in Rock," beginning on page 182.) Then as proto-North America and Europe approached each other, all that intervening seafloor was crunched up against England.

The mud eventually became slate and shale. Throughout the Victorian age, as British cities expanded, fortunes were made by mining this Cambrian and Ordovician slate. It makes superior roofs. Today great hills of rubble surround the lonely, outmoded quarries, but I can still imagine hundreds of workers scaling those high, shaly cliffs with chisels in the cold rain of past Welsh winters.

Beckly finds the trilobites in these shales just as valuable a resource. "Certain animals lived in certain environments at very certain times," he says. He talks on excitedly about how their fossils are letting him work out with great precision the puzzling history of one former patch of Ordovician seafloor.

A few months earlier I had walked into a Salt Lake City hotel with my friend Andy Knoll, a paleontologist at Harvard. Immediately he began scouring the marble columns for fossil brachiopods. Now, as Beckly and I return to London, we stop at the ruins of Tintern Abbey. While I admire the medieval architecture, Beckly can see only the stones themselves. "They are superb Old Red Sandstone, with fantastic cross-bedding," he says.

EVEN THOUGH Earth's history had been divided into a series of periods, 19th-century members of the Geological Society had no idea how far back in time the Cambrian actually began. We now believe that Earth was born as a glowing fireball, the product of catastrophic collisions of asteroid-like debris left over from the sun's formation. But not until the late 1960s, after dating meteorites and moon rocks, did scientists conclude that Earth, like the rest of the solar system, was born more than 4.5 billion years ago.

Science has yet to cast much light on Earth's earliest days. As Oxford University geologist Stephen Moorbath puts it: "We have this embarrassing little gap. We can't find any rocks older than 3.8 billion years."

Without rocks to analyze, geologists can only speculate on Earth's early evolution. We are like Sedgwick and Murchison confronting our own great unknown. The rock record was destroyed in part as meteorites and comets, late arriving building blocks, continued to bombard the planet. Many left craters as large as Montana. Any one spot on Earth was probably obliterated by a visitor from space every 350 years.

Earth's earliest surface was probably a scum-like crust, broken frequently by lakes of red-hot magma and enshrouded in steam. That steamy atmosphere gradually rained out the oceans, which helped the young

A mock sun *circling a lode of molecules helps Cornell University chemist David Usher (**right**) re-create chemical events that may have led to the origin of life four billion years ago. Experiments 30 years ago showed that a chemical soup of organic molecules could be made from inorganic ones. Today Usher and others are trying to learn how proteins, lipids, and nucleic acids—the building blocks of cells—arose from that soup. Probably lost forever in Earth's recycled rock are the first living organisms. The earliest fossils date back 3.5 billion years to stromatolites similar to this modern sample from a Mexican bog (**below**).*

planet's thin crust cool and thicken. But early Earth's interior was even hotter than today's. Any thin little protoplates that formed during the first 700 million years were probably broken up and dragged under by the planet's churning innards.

Some of the young planet's intense internal heat had been buried within by the collisions from which Earth formed. More heat was added as radioactive elements, such as uranium, decayed into stable forms, such as lead. Enough of this atomic energy still reaches the surface each year to hypothetically raise the Rocky Mountains 10 meters (33 feet). That energy would equal the explosion of 250,000 one-megaton nuclear bombs.

Today Earth sheds the bulk of that heat through volcanism, especially by extruding hot new seafloor along the Mid-Ocean Ridge. Many geoscientists argue that such plate tectonics were operating in some form even in Earth's earliest days. The only way to settle that controversy is to find rocks older than 3.8 billion years.

THOSE OLDEST KNOWN rocks were found at Isua in Greenland and identified by Stephen Moorbath and Vic McGregor in 1971. For more than a decade the two held the record for discovering Earth's most ancient relics.

But in 1983 a spirited group of Australians with a novel rock-dating machine called an ion microprobe set out to find something even older. The group, headed by Bill Compston of the Australian National University in Canberra, sent graduate student Derek Froude to scour the outback of Western Australia. Froude brought back bags of 3.1-billion-year-old sedimentary rocks. Perhaps, the Australians reasoned,

the river sands and sediments from which this sandstone formed included remnants eroded from rocks made prior to Isua.

The group dissected the sandstone samples, plucking out tiny crystals called zircons. Zircons are common minerals; they abound on most beaches.

In his lab Compston shows me one of these zircons. Orange and smaller than a grain of salt, it scarcely dazzles. But when Compston places the zircon beneath the ion beam of his microprobe, its beauty emerges. The beam of charged atoms begins blasting millions of isotopes from the zircon's core.

Isotopes are atoms of the same element with slightly different masses. The isotopes Compston's machine is collecting, however, are special. One, called uranium 238, is radioactive. It decays into another isotope, lead 206, at an exact rate. Since a zircon would have had no lead 206 when it formed, scientists measure how much it has today and can calculate how long it took to make that amount.

Thus in Canberra, minutes after the isotopes have been blasted off, a computer prints out the zircon's age: 4.2 billion years.

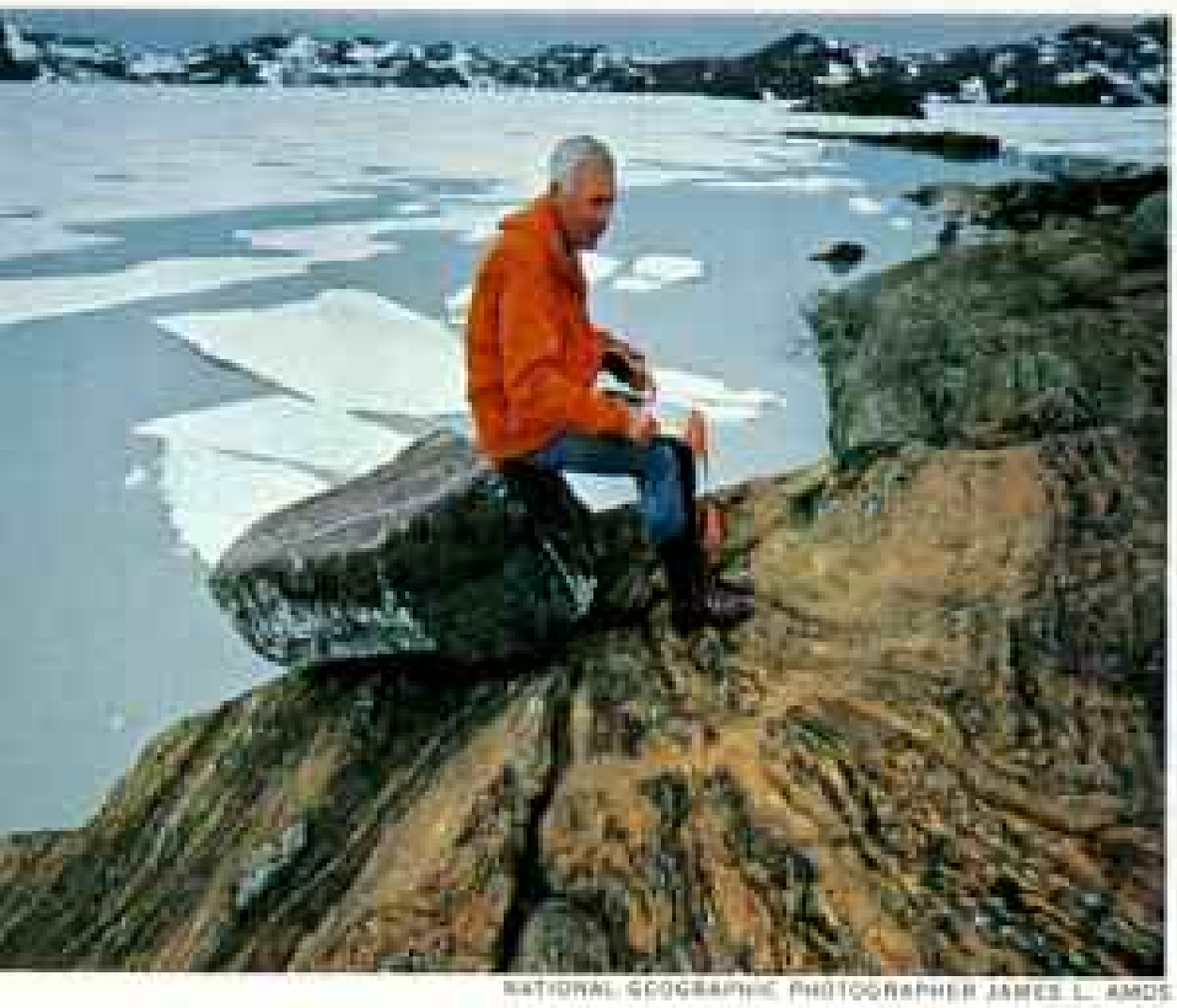
Why are these fragments of rock important? "There's every reason to believe," says Compston's colleague Ian Campbell, "that when the first zircons were forming, the first continental rocks were too." Since continents today evolve through plate tectonics, the zircons hint that at least a primitive form of those processes was operating back in the great unknown.

BUT NOT until the time of Isua—400 million years after the Australian zircons formed—had continental material grown substantial enough to survive. Isua marks the onset of the Archean eon of geologic time. Over the following 1.3 billion years, more than half our current continental mass formed.

What inspired this burst of continent building? Had Earth's surface cooled enough to create the thick, rigid plates our modern system needs? Or did another heat-shedding process, now extinct on our planet, trigger the rapid growth of Archean continents? Last year an enterprising graduate student found a critical clue in the diamond mines of South Africa.

South Africa is built around a geologic formation called the Kaapvaal craton. Planet Earth has about 20 such cratons, which are our oldest chunks of continent. North America's craton, for instance, underlies the upper Midwest and Canada, a region known as the Canadian Shield. These cratons, in fact, may have been Earth's first true continents—island arcs swept together. Or they may be fragments of a single primordial supercontinent that broke up. No one knows. What is certain is that cratons are the best places to look for diamonds.

Not far from the Kalahari Desert, on the ancient Kaapvaal craton, I stand at De Beers's Finsch diamond mine, looking down into a hole ten football fields across. I never knew digging diamonds was such an inelegant business.



NATIONAL GEOGRAPHIC PHOTOGRAPHER JAMES L. AMOS

Fragments *from Earth's infancy, though scattered and few, are giving scientists clues to the planet's first billion years or so of history. At Isua in west Greenland, New Zealand geologist Vic McGregor* ***(above)*** *sits atop the world's oldest known rocks, which he and fellow geologist Stephen Moorbath identified in 1971. This formation has been dated at 3.8 billion years and was believed for more than a decade to be Earth's oldest matter.*

Then in 1983 the record moved to Australia, where geophysicist Bill Compston and a group of students from the Australian National University had been collecting and analyzing ancient sandstone from the Western Australia outback. Using an ion microprobe in his Canberra laboratory ***(above right)****, Compston found that tiny crystals of zircon embedded in the rock are an amazing 4.2 billion years old.*

Though their age has long been a mystery, diamonds have recently been shown to be among Earth's oldest minerals, thanks to the work of geochemist Stephen Richardson ***(left)*** *at the Massachusetts Institute of Technology. By smashing the stones and liberating inclusions of garnet, which contain radioactive isotopes, he has been able to date diamonds from as far back as 3.3 billion years.*

Eaters of rocks, *drinkers of oil, our species joins plate tectonics as a recycler of Earth's minerals. To find these resources, a knowledge of Earth's geologic development is vital, since the minerals are deposited in largely predictable locations. Between 2.5 and 1.8 billion years ago, as oxygen-producing bacteria proliferated, an "oxygen revolution" rusted Earth's surface, and most of the great iron-ore deposits were laid down—like those of the mammoth Hamersley Iron works in Australia (***above***).*

*Goliath in the fog, a 22,000-ton oil rig is ferried beneath the Golden Gate Bridge for duty off the coast of southern California (***top right***). Many of Earth's petroleum fields formed only 100 million years ago, when weak ocean currents allowed organic debris to accumulate in unoxygenated offshore waters.*

*Though ubiquitous in Earth's crust, gold in minable concentrations is rare. South Africa's vast deposits, which once littered the surface, were buried by sediments and lava. Now in the world's deepest mines (***right***) the bounty—two-thirds of the Western world's gold—is freed.*

*Not all mineral wealth lies in ancient deposits. In Indonesia nearly pure sulfur, product of recent eruptions, is mined from the edge of Java's Kawah Ijen volcano (***middle right***).*

DAVID AUSTEN (ABOVE); NATIONAL GEOGRAPHIC PHOTOGRAPHER JAMES L. STANFIELD (BELOW)

Below me huge earthmoving machines prowl the depths of this hot and dusty hole, scooping out 12-ton bites of blasted rock.

"Only one part in five million of that shovelful is diamond," says Finsch's resident geologist, Paddy Lawless, as we watch one of the mechanical monsters drop its bite into a dump truck. "If we're lucky, that shovel may have ten carats, mostly tiny stones. We produce less than a ton a year of what we're looking for."

A ton a year, nevertheless, is about 10 percent of the world's diamond supply. And in 1983 De Beers sent a batch of diamonds to geochemist Stephen Richardson, then a graduate student at the Massachusetts Institute of Technology. Those diamonds contained tiny garnet impurities, which last year let Richardson answer a long-standing question: How old are diamonds? Unlike pure diamond, garnet contains radioactive isotopes, whose decay rates can be used to date the garnet and thus the diamond.

After laboriously crushing more than 1,000 diamonds and extracting the garnets, Richardson determined that the diamonds were an astonishing 3.3 billion years old. Anyone wearing a diamond ring is thus flashing one of Earth's oldest souvenirs.

TO EARTH SCIENTISTS the beauty of this diamond discovery goes deeper. They have long known that diamonds can form only at depths of 130 kilometers (80 miles) or more, roughly the base of a continental plate. There, the intense heat and pressure of Earth's uppermost mantle forge carbon, which is graphite under less extreme conditions, into enduring crystals of diamond.

Geologists also knew that diamonds reach the surface in a rare and outrageously fast type of volcanism, called a kimberlite intrusion, that shoots diamonds up like cannon shrapnel. But no one knew whether diamonds were young, forming as part of the kimberlite process, or were ancient accidental passengers in the kimberlite magma.

Richardson's work implies more than the antiquity of diamonds. It also suggests that, since diamonds form at depths equivalent to the thickness of a modern plate, Earth's skin was thick enough for plate tectonics 3.3 billion years ago.

What was this Archean world like? Life was absent from the land, but evidence is accumulating that geologically we would find the Archean surprisingly familiar. Archean continents, for instance, probably supported mountains just as high as today's.

But the magmas that built those mountains were most likely much richer in precious metals. For example, as the primeval mountains of the Kaapvaal craton eroded, they shed great concentrations of gold into a basin known as the Witwatersrand. Today South Africa supplies 62 percent of the Western world's gold. Most comes from mines in the "Wits," a region nearly the size of West Virginia.

"Our economy lives on our gold mines," says Ian Watson, mine manager at the Kloof Mine, one of the Wits's richest.

Soon we are zooming deep into planet Earth aboard the fastest elevator I have ever ridden. Our goal is the Ventersdorp Contact Reef, a layer of gold-rich sedimentary rock, which here lies more than three kilometers underground. The reef probably was deposited by an ancient river that scoured mountains similar to our Sierra Nevada. It was later covered by lava and capped by a great depth of limestone. How odd, I think, as we plummet down in the dark, that we have to descend so far to reach what was on the surface 2.5 billion years ago.

We reach bottom and walk through long, dark corridors. The rocks down here are hot. Without ventilation mine temperatures could reach 54°C (129°F). Even so, the heat and 96 percent humidity are stultifying.

Finally, we encounter the reef—a gray-and-white layer of pebbles and quartz about a man's height. Black workers with head lamps and noisy pneumatic drills glisten with sweat, but I can see no hint of glitter in this rock. Yet once the rocks of this thin reef are blasted loose, crushed, smelted, refined, and poured into bars, they will underwrite the national debts of the world. As sweat saturates my overalls and rolls over my eyes, I know I'll never look at a gold bracelet, never enter the refined air of Tiffany's again, without recalling this source.

After the Archean, planet Earth deposited gold to be sure—usually in veins near the edges of continents where plates have subducted or collided. But during the Archean

the planet seemed to disgorge gold as part of its evolution. Deposits as huge as the Wits may have been common then. If so, they were eroded and recycled. The South African craton apparently found a stable niche in the Earth's surface, one that kept its treasures buried and safe from tectonic attack. As South African geologist Carl Anhaeusser explains it: "Our good fortune is that we haven't been eroded."

That stability also has preserved in South Africa a suite of metals—from manganese to tin, titanium, and vanadium—which evolved in the Precambrian and are essential to our modern world. For instance, the enormous Bushveld complex, a single ore deposit half the size of Wisconsin, holds 75 percent of the world's chromium and platinum-group metals.

FEW, IF ANY, other spots on planet Earth have enjoyed as much geologic serenity as has South Africa. At one time or another, most of the continents have been wracked by the kinds of tectonic processes that have been reshaping the western United States in recent geologic time. Until 250 million years ago the western edge of North America ended near Salt Lake City. Then some unknown force initiated a global realignment of plates. Soon a series of terranes began arriving and were plastered onto the margin of the continent. About 85 million years ago, as the North Atlantic was opening, North America began driving rapidly westward against the Farallon plate, which until that time had been large and thriving. The Farallon was consumed so swiftly beneath North America that the continent above buckled. Great sheets of crust five kilometers or more thick thrust eastward over today's Rocky Mountain region.

Then, starting about 45 million years ago, as North America's rapid movement across the Farallon plate relaxed, paroxysms of magma created a time of unimaginable volcanics. Enormous calderas blanketed much of the West with volcanic debris two kilometers thick in places.

In Colorado's San Juan Mountains I travel into one of these ancient calderas with Peter Lipman of the USGS. We pass through towering walls, the record of monstrous glowing avalanches that roared for 100 kilometers out of this La Garita volcano. Its caldera alone was more than one-third the size of Rhode Island.

"Imagine pictures you've seen of Mount St. Helens erupting," says Lipman. "La Garita was 1,500 times bigger."

Caldera eruptions like La Garita do not necessarily belong to the remote past. With University of Utah geophysicist Bob Smith I fly over Yellowstone National Park. "Once there was a mountain range as big as the Grand Tetons here," says Smith. "It all went in one colossal eruption of the Yellowstone caldera. That eruption equaled a thousand Mount St. Helenses."*

Like Hawaii, Yellowstone is generated by a hot spot. That hot spot 65 million years ago was probably off the Oregon coast, making islands that now underlie the Coast Ranges. As the continent passed over it, the hot spot has left a trail of volcanic rock across the West. "There was a Yellowstone at Boise, a Yellowstone at Twin Falls and at Pocatello," says Smith. "If you wait a few million years, there may be one at Billings."

Yellowstone has erupted catastrophically about every 600,000 years. Thus we are about due. Recently the caldera floor has begun rising at an increased rate.

There should be adequate warning before any major eruption. But as another Yellowstone expert, Bob Christiansen of USGS, puts it: "People should realize we live on a very unstable planet."

NEW MEXICO, for instance, is bisected by the great Rio Grande Rift (following pages). Most residents of Santa Fe or Albuquerque are unaware they live atop a crack in the planet perhaps six times deeper than the Grand Canyon. Sediments and lava have largely filled up this rift. Geologist Scott Baldridge of the Los Alamos National Laboratory takes me to a panoramic lookout, where I can indeed see how the vast desert between the Colorado Plateau and the Sangre de Cristo Mountains is dropping away. "That's a hell of a hole," says Baldridge. "It may be nine kilometers deep, and it's growing a bit wider each year." Similar rifts are now breaking up much of the West.

*See articles on Mount St. Helens by Rowe Findley in the January and December 1981 issues.

"Fifteen million years ago Salt Lake City and Reno were 200 to 300 miles closer together," says Utah's Bob Smith.

The two cities are pulling apart because the Great Basin is being heated from below. The crust is thinning and stretching. Just what causes that heating is controversial. It may be the melting of the old subducted Farallon plate below. Whatever the cause, as the crust stretches, large blocks of land subside. Where they drop, they create valleys next to mountain ranges. The entire region from the Wasatch Range that overlooks the Great Salt Lake to Death Valley and the Sierra escarpment is a series of deepening basins interspersed about every 25 kilometers or so with mountains. The valleys of this so-called Basin and Range region do not subside gently.

JUST AFTER DAWN on October 28, 1983, Lawana Knox of Challis, Idaho, was hunting with her husband, Bill, not far from Borah Peak, the highest mountain in Idaho. She had won the right to hunt elk there that season in a special drawing. "It was a once-in-a-lifetime opportunity," she recalls.

Actually the opportunity was once in a hundred lifetimes. For at 8:06 a.m., before Lawana Knox's eyes, the mountain across from her cracked along a fault, as it does

Spanning the horizon *in northern New Mexico, the Rio Grande Rift is concealed by deep sediments and capped with a layer of basalt. Its prominent namesake river flags its presence. The rift, running from Colorado into Texas, continues to widen as the crust is thinned by local volcanic activity and plate motion originating as far away as the San Andreas Fault.*

about every 10,000 years, and dropped nearly three meters (ten feet).

"I heard a noise like a sonic boom," she says. "The earth began to sway and ripple. I didn't have time to be scared. I just grabbed a sagebrush and held on. I'm sure that bush still has five fingerprints pressed into it."

As Lawana was hugging the ground, seismometers across the West reported that a 7.3 Richter-scale earthquake had struck this sparsely populated section of the Basin and Range. Similar faults and basins underlie numerous western cities. Should the nearly identical Wasatch Fault in Salt Lake City slip, the result could be catastrophic.

Geologists debate whether the Basin and Range will rift enough to open a new ocean. If it does, the West Coast would become a free-floating continent.

WEST COAST residents have more imminent hazards to worry about. From the Sierra to Seattle, volcanoes long thought to be dormant are showing signs of life. Since 1978 California's Long Valley caldera, which once dropped ash on the East Coast, and Mount Shasta have both seen swarms of earthquakes. And, of course, in 1980 Mount St. Helens proved categorically that the Cascade volcanoes are indeed active.

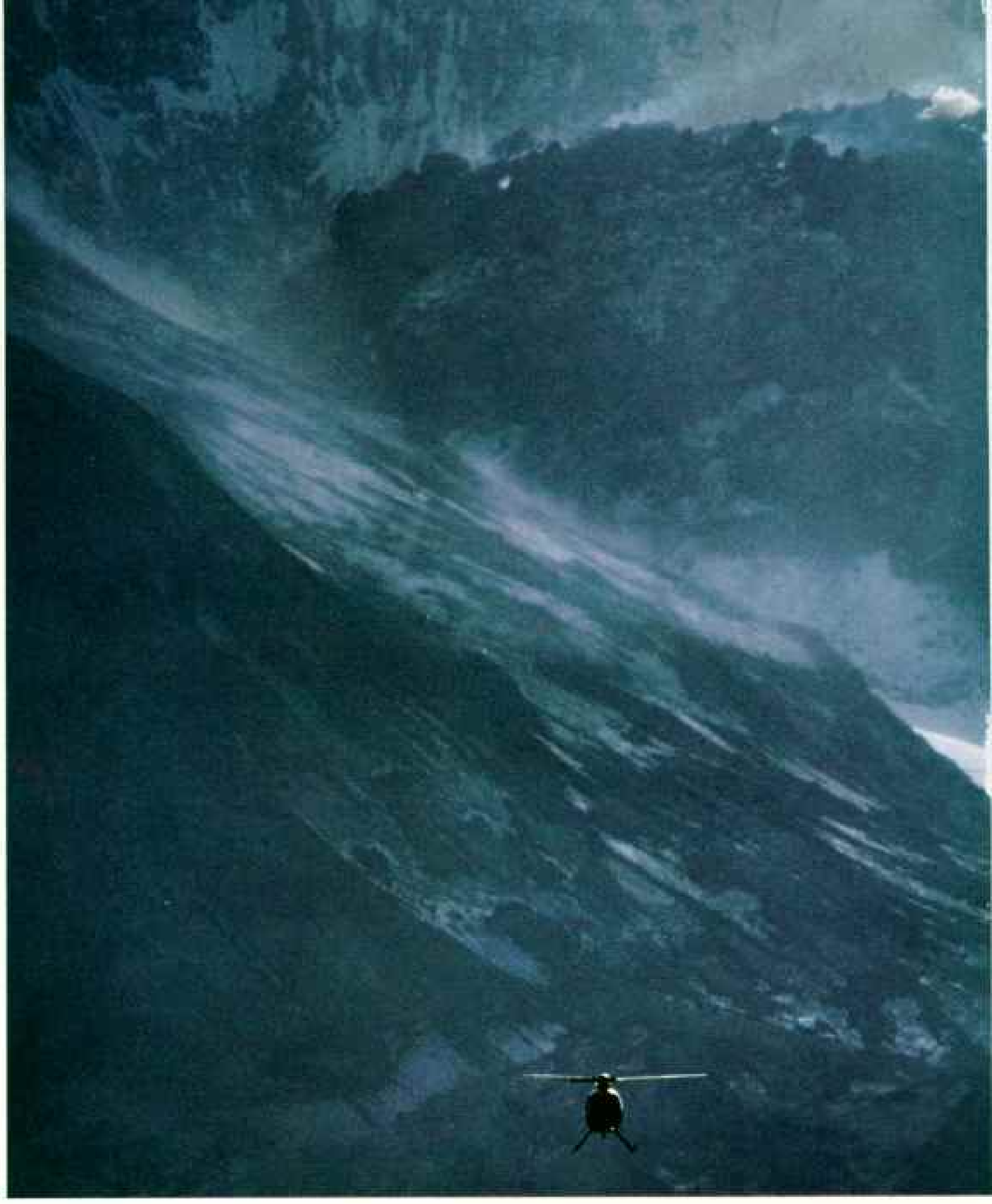
"Mount St. Helens had been silent for 123 years," says USGS volcanologist Dan Miller as we drive along the Cascades. "It blew only seven days after we noted its first earthquake. Any of these Cascade volcanoes—Mount Rainier, Mount Shasta, Mount Hood, Crater Lake—could do the same."

We turn a bend and suddenly confront the shattered face of Mount St. Helens. No picture I have seen, no description I have read, prepared me for the devastation. Thick gray ash flows still cover all I can see. Forests of denuded trees lay neatly toppled, as if a huge comb had passed through them.

"In three minutes all this happened," says Miller. "Some 600 square kilometers were totally destroyed. I worked here and saw it happen. I still can't believe it.

"It may look sinister and depressing," he continues. "But to geologists it has its own beauty. It holds promise that we may be able to understand how these things happen."

The site *is* oddly inspirational. For the volcano is rebuilding. A dome of oozing magma is refilling its crater. Earth is renewing itself, making new continent before my eyes. As Miller says, "That volcano is telling us Earth is alive and kicking."



Sign of indigestion *from a nearly consumed ocean plate far below, a rapidly swelling dome is filling the crater of Mount St. Helens, which erupted violently in 1980 and five years later was still sending ominous signals. Though often a danger to her inhabitants, Earth's flexings and fumings are the vital signs of a vigorous, ever changing planet.*

ON THE LAST DAY of my field-work I drive along the Rio Grande Rift in northern New Mexico, passing the white Abiquiu formations that drew Georgia O'Keeffe and myriad other artists to this landscape. So much of the planet's history, so much time gone by, has been eroded into this valley. It is filled with what O'Keeffe calls the "unexplainable thing in nature that makes me feel the

GEOFF MANASSE

world is big far beyond my understanding."

I ascend the Valles Caldera and slip into a remote hot spring. I let the warmth, generated by the continuing digestion of the Farallon plate below, relax me. I revel in this soothing heat; it is what drives all the wondrous things I have seen. If the heat turned off, the continents would quickly stop moving. All mountains would erode. Flatness and monotony would rule.

So here, in this pocket of a minor lava flow, I soak up all I can of my brief day in that heat and ponder how much longer it will continue engendering Hawaiis and Yellowstones and assembling masterpieces like Alaska. Geophysicists say the heat will hold out until the sun inevitably expands, some five billion years from now, and incinerates the planet. Five billion more years. Not even half the story has been told. □

ANNALS OF LIFE WRITTEN IN ROCK

FOSSILS

Photographs by JAMES L. AMOS
Text by DAVID JEFFERY
BOTH NATIONAL GEOGRAPHIC STAFF

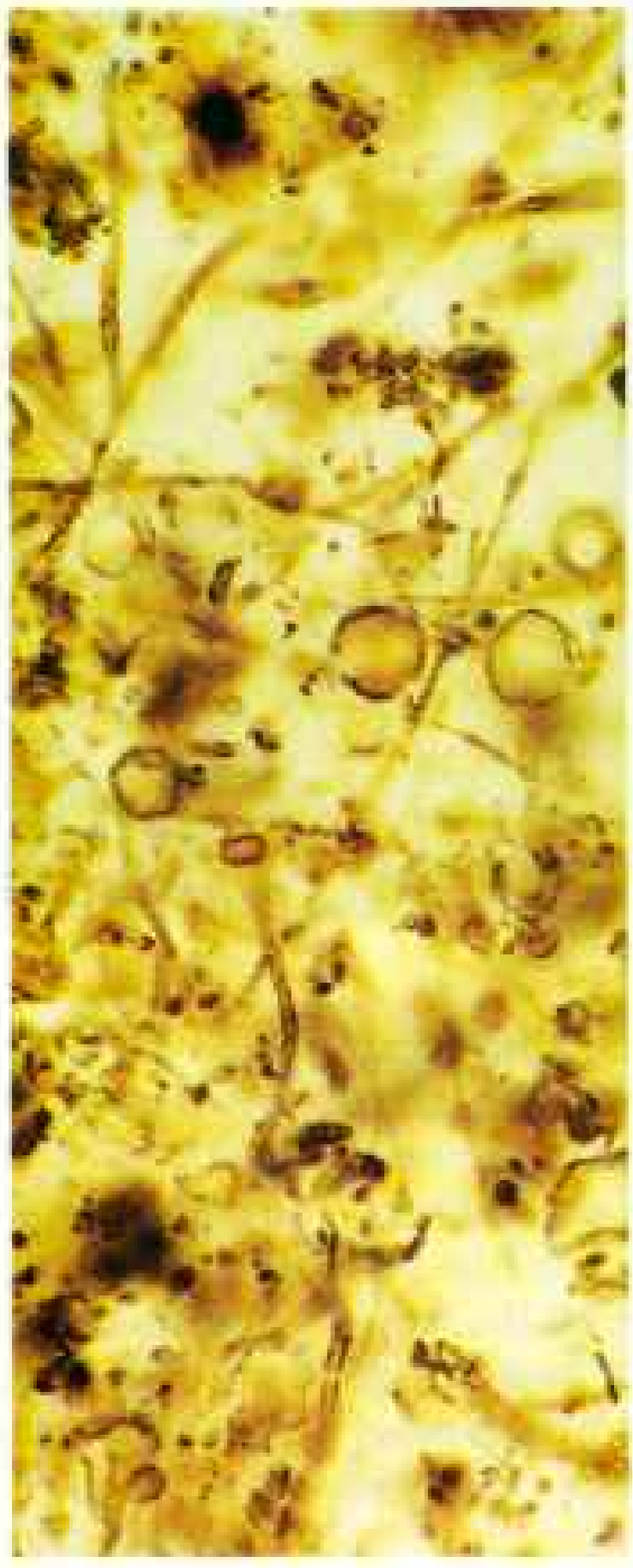
HOW ANCIENT is life on Earth? One problem in trying to answer that question is Earth's habit of rearranging its crust. Only a few fossil-bearing rock formations have survived undisturbed from early times.

Among the oldest is a Fig Tree Group formation in South Africa, whose sedimentary rocks have been dated back 3.4 billion years to an era when Earth was about one-quarter its present age. Ultra-thin rock sections reveal the remains of microscopic, single-celled marine organisms smothered by mud in the midst of a life-essential function—reproduction (***top***).

On the north shore of Lake Superior the Gunflint formation, about two billion years old, is rich in a variety of fossilized single-celled organisms, including spheroids and stringy, or filamentous, types (***right***).

Though more than a billion years apart, fossils in the two formations are mineralized remains of prokaryotes—bacteria lacking nuclei and cell parts called organelles.

Half a billion years after the Gunflint bacteria, a new type of cell begins to appear in the fossil record, the eukaryote, characterized by a cell nucleus and organelles. Eukaryotes are ancestral to all more complex life and depended on the production



by prokaryotes of oxygen as a by-product of photosynthesis. Oxygen makes fuel—including food—burn efficiently, but it can be highly toxic. Various prokaryotes may have associated symbiotically and later given rise to eukaryotic cells that could use—and control—oxygen.

Earth was more than four-fifths its present age before even the simplest multicelled organisms appeared in the sea. Why life took so long to reach that step is a question as perplexing as another: What caused episodes of mass extinction? Impacts from meteorites or comets? Climatic changes? Inability to survive more efficient predators?

Ammonites were mollusks with shells whose mother-of-pearl layer can still glow after 65 million years (***right***). They persisted for 300 million years, becoming extinct about the same time as did the dinosaurs —for reasons that may be related but are not yet clear.

As for the descendants of the earliest known form of life: Bacteria remain by far the most abundant organisms and are essential to, for example, digestion, soil chemistry, and regulation of the atmosphere's gas content.

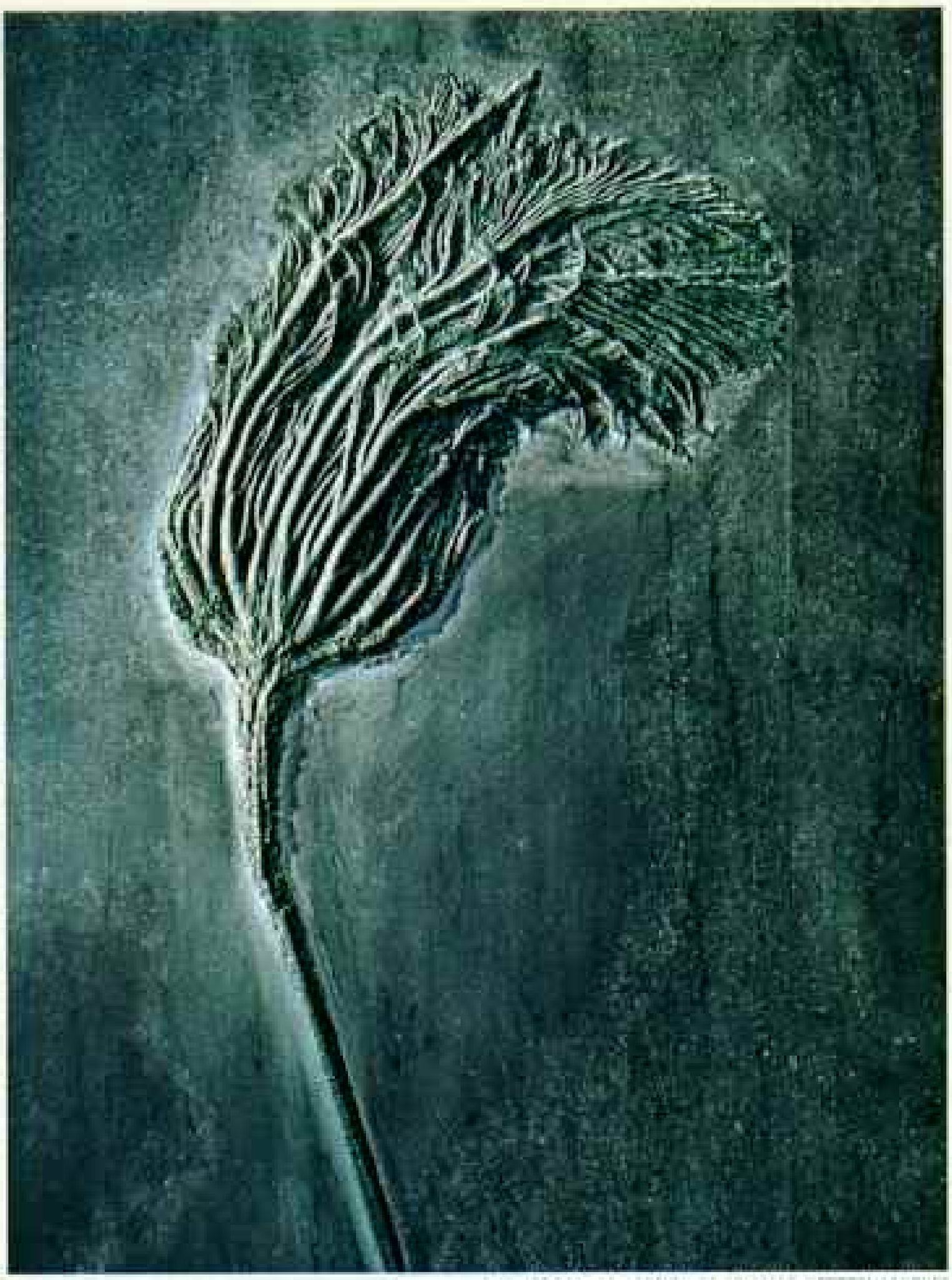
SPHEROIDICUS LENTICULARIS, ×4 IN, AND NOVOFILAMENTUS NICOLETTI, 8 IN (RIGHT), PHOTOGRAPHED AT BLACK HILLS INSTITUTE OF GEOLOGICAL RESEARCH, INC; PROKARYOTES, MAGNIFIED 700 TIMES (LEFT) AND 5,000 X (UPPER LEFT), PHOTOGRAPHED BY ANDREW H. KNOLL, HARVARD UNIVERSITY

PHACOPS RANA, 2 IN AVERAGE (OPPOSITE); ANGULARIA STELLATA, 6 IN HIGH (BELOW)

PRIMITIVE ARMOR in the form of an external skeleton served to protect the trilobites, which appeared 570 million years ago and soon became the dominant animals, diversifying into some 10,000 species before decline and extinction 340 million years later. This notable assemblage (***left***), on loan to the Smithsonian's National Museum of Natural History, was found in an abandoned Ohio cement quarry by collector Thomas T. Johnson. Johnson's interest in trilobites began at age eight, and he pursued it as an amateur, going into it full-time after quitting his job on a Cadillac assembly line. While single specimens are priced "from 50 cents to 20,000 dollars," Johnson reserves his best for museum displays.

The demise of trilobites, related to insects and spiders as well as crustaceans such as crabs, may be connected with the spread of jawed fishes. A giant example from 350 million years ago, *Dinichthys terrelli* (***above***), being examined by Raymond Rye, of the Smithsonian's Department of Paleontology, grew to 30 feet in length and may have preyed on smaller fishes that perhaps fed on trilobites. Its fangs were not true teeth but part of inch-thick armor plating that extended over and behind the skull. Likely a poor swimmer, it may have waited for its prey to blunder into range.

By *Dinichthys*'s time plants had taken to land, and within 90 million years forests that would become vast coal deposits were thriving. Among those seedless trees, calamites grew in swamps, leaves splaying like rays from upright stems (***right***).



8 IN ACROSS. COLLECTION OF VOLKMAR WENTZEL (ABOVE)

POINT and counterpoint in the fossil record have been the persistence of some life forms and the evolution of others into myriad types to exploit diverse environments.

Except to the expert, stalked crinoids, relatives of starfish, look little different whether 200 million years old (***left***), or 500 million, or a month old and alive in today's seas.

By contrast, a 200-million-year-old marine reptile (***below***) came from a lineage that included land reptiles, amphibians, and fishes.

It is challenging to infer the likely behavior of extinct animals. John R. Horner of Montana State University studied eggs laid in compact nests by small dinosaurs (***right***) and the larger egg and hatchling, casts of which he holds, of the slow-moving, duck-billed dinosaur, which grew to more than 30 feet. The defenselessness of the latter's newborn suggests the necessity for parental care and supervised foraging.

PACHYPLEUROSAURUS EDWARDSI, 8 IN (ABOVE). PHOTOGRAPHED AT GEOLOGICAL ENTERPRISES; NEST, FAMILY HYPSILOPHODONTIDAE, AND HATCHLING, *MAIASAURA PEEBLESORUM* (RIGHT)

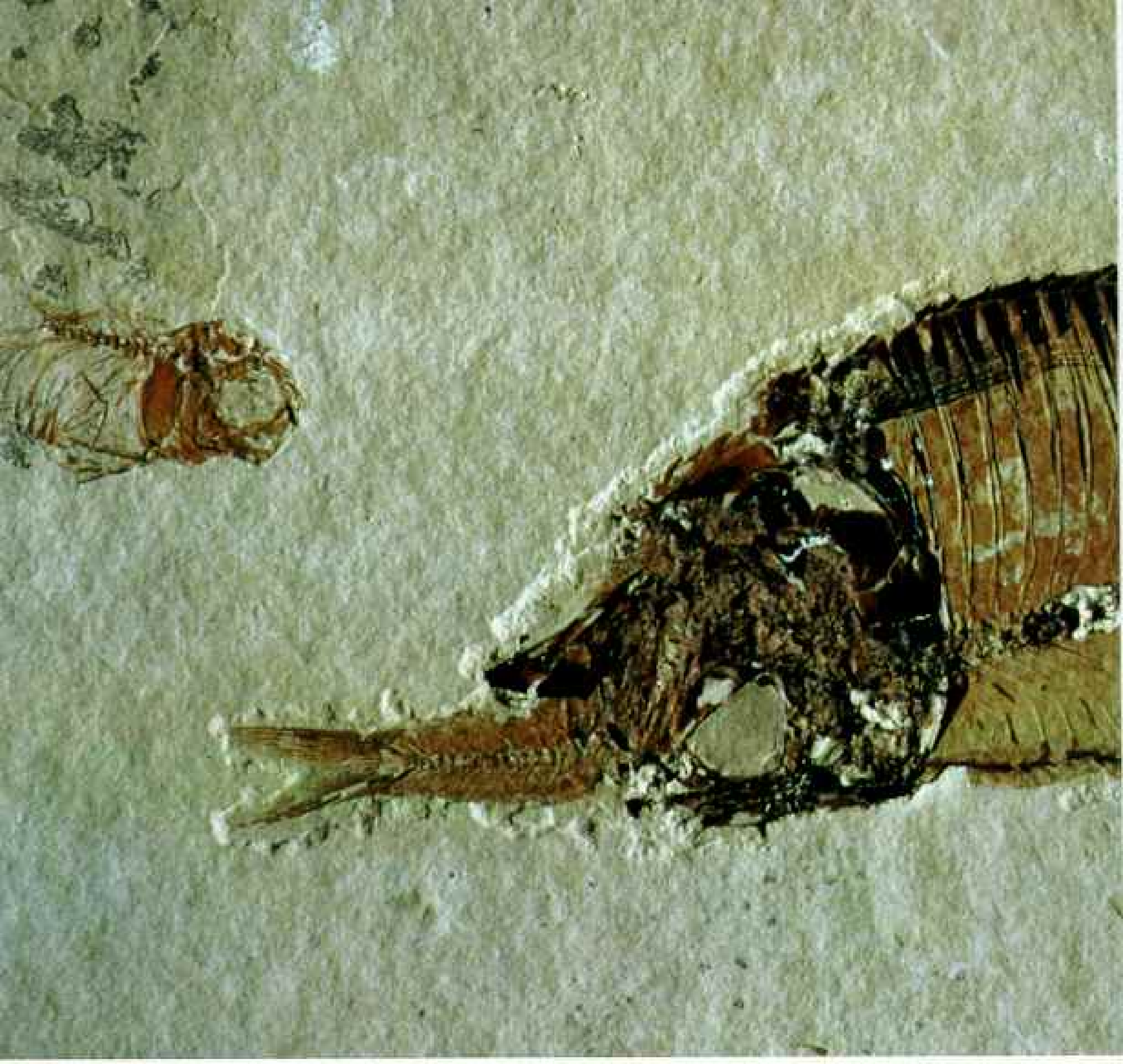
THE SHORES of Fossil Lake 50 million years ago might seem familiar. Flowering plants flourished; mammals dominated the land. A lure cast into the lake might tempt a plump fish or, worse luck, snag a palm frond lying on the bottom.

This once subtropical fishing hole lies in basin

FISHES, GENUS PRISCACARA, 6 IN. AND GENUS DIPLOMYSTUS, 6 IN. COLLECTION OF ROBERT L. LYNCH

country on the Wyoming-Utah border. It is part of a series of freshwater lake-bed sediments turned to rock and called the Green River formation, which covers 25,000 square miles to a depth of 2,000 feet.

This specimen was found and prepared by Carl Ulrich, who quarries near Fossil Butte National Monument in Wyoming.



THE FISH-EAT-FISH world of the Green River some 50 million years ago saw an end to both a hungry three-inch adult *Gosiutichthys parvus* and its prey, a juvenile of the same species (**above**).

The anatomical study of fossils, combined with the geochemical analysis of the rocks in which they are embedded, has permitted reconstruction of the chronology of life for three-fourths of planet Earth's history.

The evidence for that history is far from completely known. Nor can it be, given Earth's record of remaking its surface and thereby erasing chapters of its own chronicles.

Perhaps in unanswered questions lies the fascination for scientist and amateur alike, that and the sense of still vivid drama that can rivet a child before the skeleton of a great dinosaur.

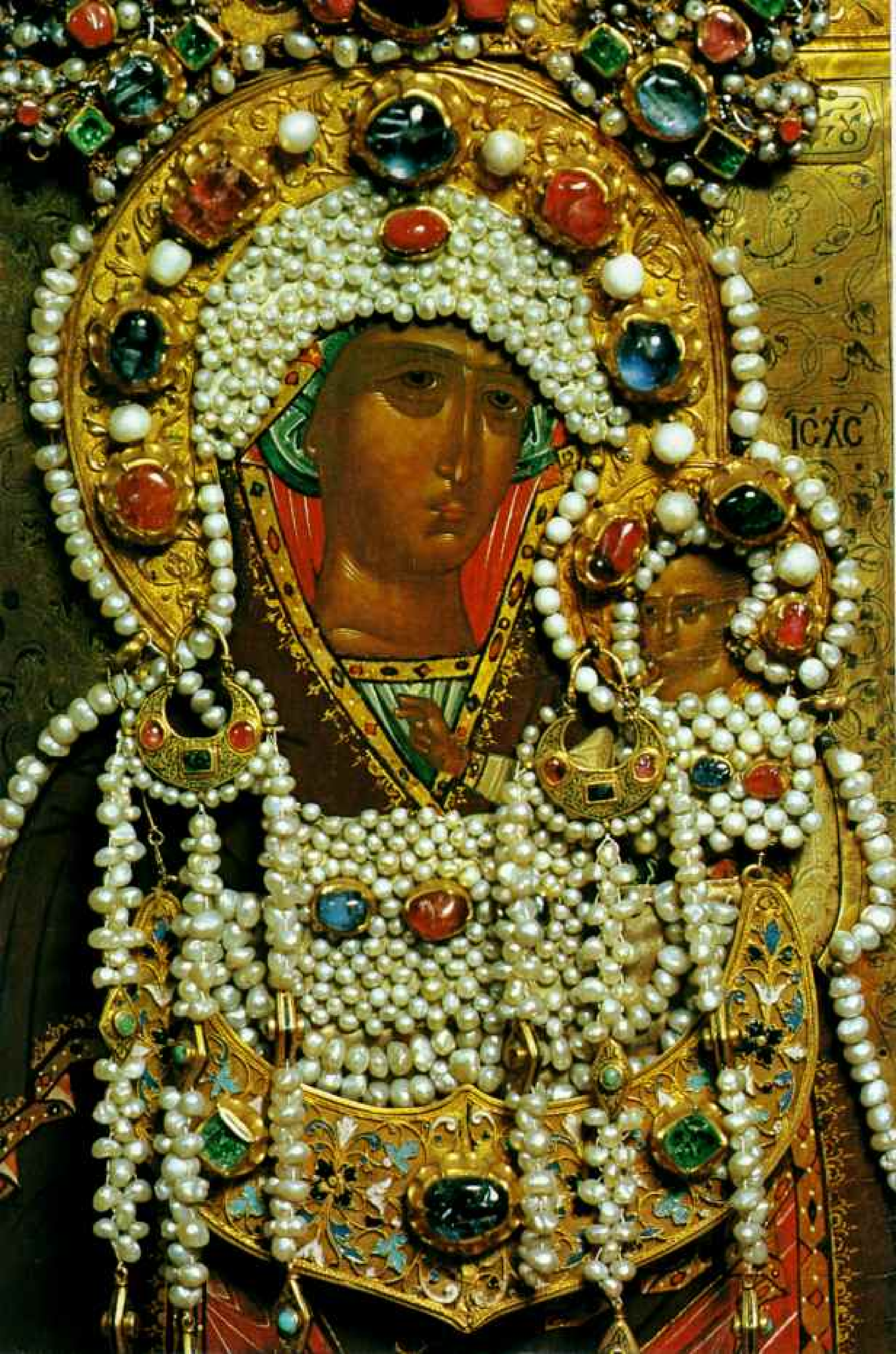
Paleontologist Loren Eiseley, who called himself a "bone-hunting man," helped excavate the 25-million-year-old remains of two saber-toothed cats locked in combat (**right**).

One had bitten deep into the leg bone of the other, a thrust that trapped both in a common fate. The cause of the death of the two cats is as clear as the causes of the extinction of their species are obscure.

Eiseley, essayist and poet as well as scientist, considered that larger question and wrote:

. . . I wondered why
such perfect fury had been
swept away, while man,
wide-roaming dark assassin
of his kind,
had sprung up in the wake
of such perfected
instruments as these. . . . □

PHOTOGRAPHED AT BLACK HILLS INSTITUTE OF GEOLOGICAL RESEARCH, INC. (ABOVE); NIMRAVUS MAJOR (BELOW), PHOTOGRAPHED AT UNIVERSITY OF NEBRASKA STATE MUSEUM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The Pearl

ARTICLE AND PHOTOGRAPHS BY
FRED WARD
BLACK STAR

Again, the kingdom of heaven is like unto a merchant man, seeking goodly pearls: Who, when he had found one pearl of great price, went and sold all that he had, and bought it. MATTHEW 13:45-46

THE EARLY AUTUMN AIR was chill and crisp, and we hoped a clear sun would soon warm us. In the distance a few birds made their statements, but the overpowering sounds were from an endless series of tugs dragging their barges downstream and the droning "thump-thumps" of our gasoline dive compressor. Sitting across from me in a flat-bottomed boat in the middle of the Tennessee River, John Latendresse, thinning hair slicked back, cigarette in one hand and his third Diet Coke of the morning in the other, was the very picture of a man with a mission. Considering the chocolate-colored water, the president of both the Tennessee Shell Company, Inc., and American Pearl Farms accurately observed, "I don't suppose this looks too much like pearl country."

John, as wily, dedicated, and opinionated an entrepreneur as any Yankee trader, manages his global affairs from Camden, a tiny backwater Tennessee town. Ironically, in a business conceived and controlled by Japan and tightly guarded as a national secret, the very heart of cultured saltwater pearls *(shinju)* is a purely American product.

Cultured pearls represent a somewhat forced partnership between man and mollusk that exploits the creature's ability to secrete concentric micro-layers of protective coating around foreign material. Implanting a shell nucleus and live tissue stimulates the production of the coating, called nacre, in the same way that mollusks form mother-of-pearl and natural pearls. "And I sell 60 to 65 percent of all shells used for those cultured-pearl nuclei," John said. "It's kinda satisfying, walking anywhere in the world, looking at a woman, and knowing that most of the necklace she's wearing came from right here."

*"**The hidden soul** of the oyster" to an ancient Chinese scribe, the pearl was among the first gems to adorn mankind. In the great religions it stands as a symbol of virtue, wisdom, and wealth. A veil of more than 700 natural pearls proclaims adoration for Madonna and Child on a 16th-century Russian icon (**facing page**).*

*Today the culturing of pearls makes them more available and affordable. Still, this exceptionally fine clutch of large cultured pearls and smaller natural finds from Australia (**above,** actual size) carries a price tag of $90,000.*

ICON: TREASURY OF THE MUNICH RESIDENCE, 35.5 BY 27.5 CM

"Right here" means the muddy bottoms of the Tennessee and Mississippi River Valleys, where divers crawl visionless in water so murky that counting their own fingers is impossible. John picked up an eight-inch-long washboard mussel the diver below had just tossed up. "The Japanese keep telling the world their nuclei by law have to be from the American pigtoe mussel, and that's bunk," John emphasized as he pitched the shell aside for another. "We haven't used those in quantity in years, since the agricultural pesticides got to 'em. We sell ten different mussel species [family Unionidae] and depend on four. The washboard alone is 50 percent or more of the business, and here's the reason." He grabbed an opened shell between thumb and forefinger. "See how thick this part is, nearly an inch, near the hinge? No others in the world have such composition and thickness. Ha, you can bet the Japanese wish there were. They must depend on the U. S. and on me because there's no other source. They can get up to 20 high-quality nuclei, or *kaku*, from each shell."

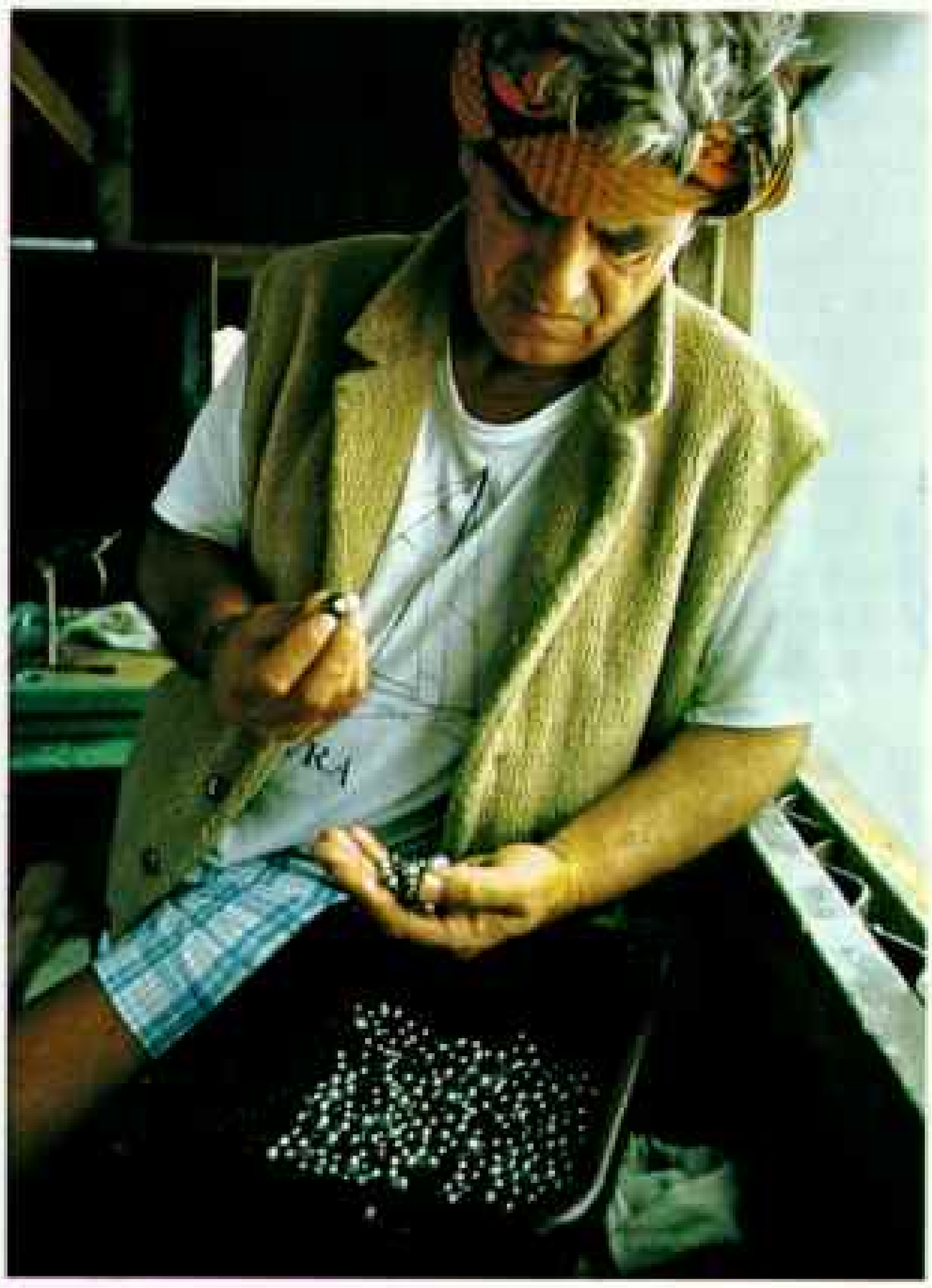
Needing John's American shells is relatively new because until this century all pearls, whether saltwater or freshwater,

were natural. Maurice Shire is a New York gem dealer with a lifetime of pearl experience. Courtly, gray-haired, and relaxed in a loose blue sweater at his Fifth Avenue office, he quickly warmed to the subject of naturals, obviously a first love.

"In the 1920s there were over 300 U. S. natural-pearl dealers. By the 1950s we were down to six, and now none. With no supply and no market, the business is dead." Maurice explained: "A natural pearl is pearl throughout, but a cultured pearl is mainly shell-bead nucleus with a very thin pearl coating. Look at an X ray to see just how

Tending a precious crop, *divers scrub garlands of* Pinctada margaritifera*—the black-pearl oyster of French Polynesia—here suspended in the lagoon of Marutea, an atoll 990 miles southeast of Tahiti. The pearls they hold, like virtually all sold today, are cultured. Using a process developed in Japan at the turn of the century, technicians earlier inserted shell beads that the oysters coat with nacre—the substance that also lines the shell as mother-of-pearl. Worldwide, of 100 oysters seeded, half may die or reject the bead. With luck, 20 of the harvested pearls will be marketable. Fewer than five will be gems.*

Beauty within the beast, *a 14-millimeter black pearl, shown life-size, emerges after two years in Marutea's lagoon. Reaching a foot in diameter, South Sea oysters produce pearls as large as 20 millimeters. Only a few species of oysters and freshwater mussels create quality pearls. Although color normally reflects the mother-of-pearl, variations abound. Pearls from the black-lipped oyster range from greenish black to light gray. And a single oyster can create pearls of different hue.*



Thousands of dollars in hand, *Jean-Claude Brouillet* ***(top)****, proprietor of Polynesie Perle on Marutea, examines part of his 1984 harvest of 22,000 black pearls. Oysters are hoisted ashore* ***(above)*** *during the winter, when nacre production slows and color and luster improve.*

little pearl there is compared to bead. Genuine pearls—caused by an irritant such as a piece of shell, a snail, but probably not sand—are true accidents of nature that have a depth and luster and orient seldom found any more. But such treasures were always rare. Thousands of oysters had to be collected to produce only a handful of naturals, and most of them were off-color and not round."

Accumulating enough for a matched necklace used to take years. Trish Grey, an Australian pearl farmer, later emphasized that her firm once brought up a hundred tons of shells for mother-of-pearl sales without finding a single natural worth $100.

PEARLS are among the oldest and most universal of gems, indicators of wealth in the Bible, the Talmud, and the Koran. Unlike precious metals worked from ore or stones that needed to be faceted and polished, pearls arrived in an already beautiful form that ancient peoples could use. As I was to discover, Japanese technology and business drive have combined to alter nature's product considerably.

Before 3500 B.C., when American Indians and European tribesmen huddled in caves, civilized Mideast and Asian societies treasured pearls as supremely valuable possessions, rhapsodizing over them as symbols of purity, chastity, and feminine charms. Later, from the financial and marketing center in Bombay, the jewels found their way into royal collections throughout India, Persia, Egypt, and beyond.

Not all uses were so esoteric. American Hopewell Indians collected freshwater pearls by the thousands, to adorn themselves and to accompany the dead in crematory basins (page 221). Accidentally cracking their teeth when feeding on north-coast oysters caused Australian Aboriginals to consider pearls an inconvenience. Their children used the "worthless" nuisances as marbles. For thousands of years, until oil

Cradle of the cultured pearl, *Japan's Ago Bay remains a lifeline of many pearl growers, whose bamboo rafts anchor baskets of akoya oysters. Japan guards culturing as a national resource and controls most of the pearl market.*

operations replaced pearling after World War II, the Persian Gulf provided most of the world's saltwater gems, and the small island of Bahrain, with its thousands of divers, was the industry's center.

WITH TODAY'S PEARLS available to almost any working woman, it is practically impossible to comprehend the extraordinary values our ancestors placed on the oyster accidents. Contemporary strands are relatively inexpensive because they are made from plentiful cultured pearls, which Bert Krashes of the Gemological Institute of America calls "semimanufactured products." Compared with other gems, the average cultured pearl is not costly. A necklace for $1,000, which may seem high, might have 56 beads, thus retailing at under $18 a pearl. Pricing was quite different with the

ancients, who had no regular supplies. Pearl fever reached its height in Rome. The historian Suetonius reported that the Roman general Vitellius paid for an entire campaign by selling just one of his mother's earrings. Pliny the Elder wrote in his *Historia Naturalis* that by the first century B.C. pearls were first in value among all precious things.

The craze reached its zenith at a remarkable banquet where Cleopatra is said to have wagered Marc Antony that she could give the most expensive dinner in history. As the astonished foreigner watched, the queen sat before an empty plate and a goblet of wine (or vinegar). Removing one of her huge, matched-pearl earrings, she crushed and dissolved it in the liquid, then drank. When she offered Antony the remaining earring, the bet was declared won. Pliny wrote that those pearls then were worth 60 million sesterces, or 1,875,000 ounces of fine silver.

The whole world of pearls changed between 1920 and 1930 as cultured pearls from Japan almost totally replaced naturals. Over the centuries many had tried to entice oysters to make more and better gems, but the encrusted mollusks held their secrets as tightly as their locked shells. The Chinese were successful with their famous pearl Buddhas, a steady product from the 12th to 20th century (page 216). Several small Buddha carvings of ivory, wood, stone, or metal castings were left cemented to the insides of freshwater mussel shells until they were coated with nacre, a technique used today in salt water to make *mabes*, or half-pearls.

The oyster's tantalizing mystery remained until the turn of this century, when three Japanese, working alone, almost simultaneously discovered secrets to pearl culturing that made the entire business possible. Tatsuhei Mise, a teenage carpenter,

With the deftness of surgeons, *operators nucleate three-year-old akoya oysters at the Mikimoto pearl farm in Ago Bay (**left top**). After being crowded on a rack, an oyster relaxes and opens when alone. A wedge holds the gap until a clamp pries it wider for the insertion of a shell-bead nucleus (**left**) in a tiny slit made in the body. A snippet of another oyster's mantle must also be inserted to start nacre production. Weakened by being raised in captivity, few akoyas can now take beads larger than eight millimeters.*

Japan's freshwater-pearl culturing began in Lake Biwa in the late 1920s. Implants of mantle in the mantle of the ikecho *mussel (**top right**) yield pearls of nearly solid nacre in three years. Opened here, the mussel is usually parted less than an inch for the implant.*

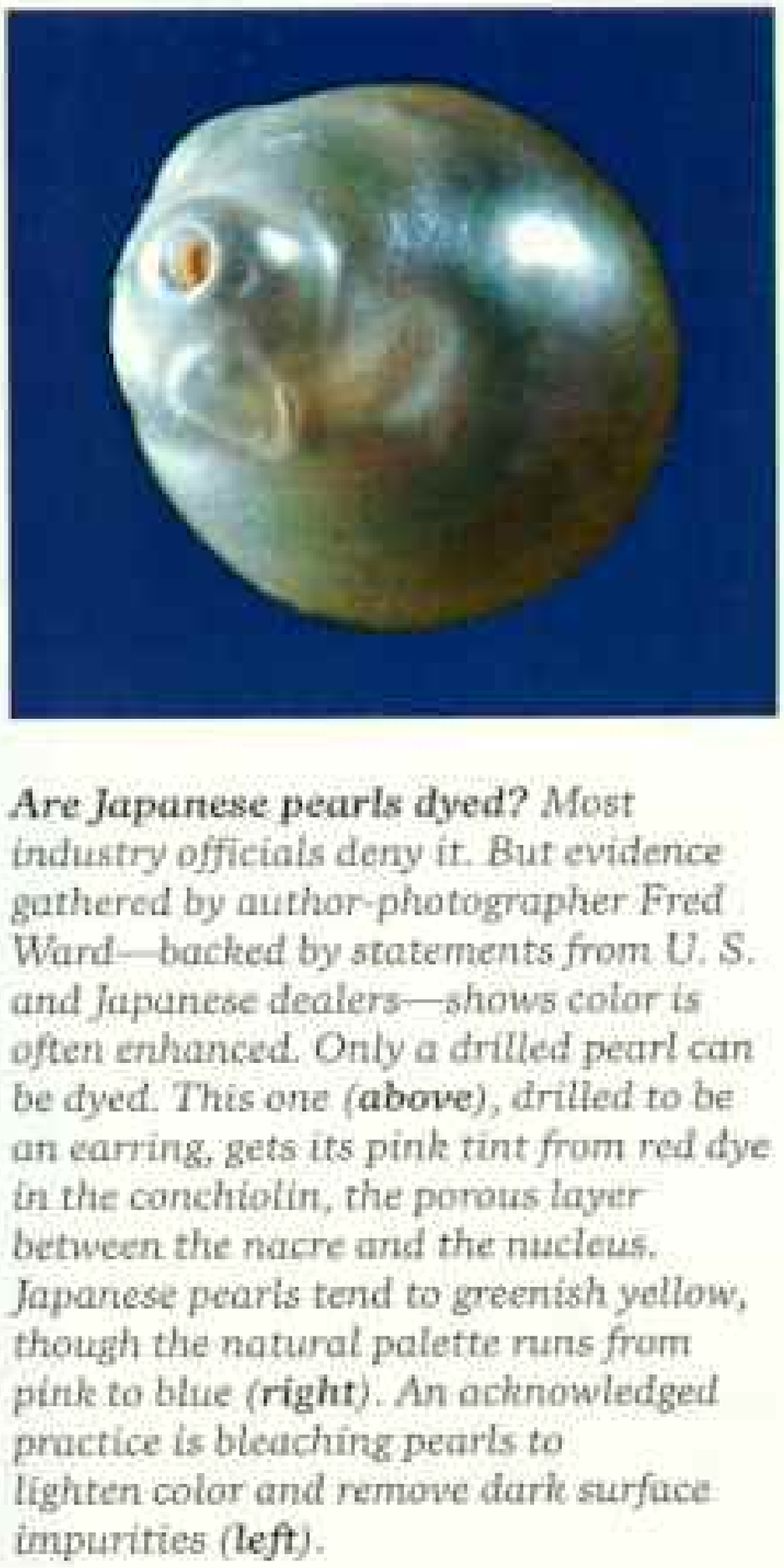
*In the Shintone River, far from increasingly polluted Lake Biwa, innovative pearl farmer Syoichi Kitao has married the two culturing techniques by also nucleating mussels with shell beads for South Sea-size pearls (**right**). This one of ten millimeters might bring $1,000. His record is 17 millimeters.*

and Tokichi Nishikawa, a government marine biologist, separately reached the same vital conclusion: Excretions from the oyster's mantle tissue create mother-of-pearl. Imitating nature, these two experimenters inserted small mantle particles along with nuclei. Amazingly, their oysters yielded round pearls. So, after centuries of trials, the enigma was deciphered in less than a decade in a single feudal country.

The extraordinary work of both men was totally eclipsed by the flamboyance of the most famous pearl farmer of all time, Kokichi Mikimoto, son of a noodle vendor and founder of a cultured-pearl business that at its height had more than 12 million oysters producing 75 percent of the world's pearls. Facing financial ruin and community ridicule (serious indeed in Japan), Mikimoto and his wife, Ume, struggled doggedly in the 1890s, stuffing a great variety of possible irritants inside their oysters. Then in 1905 he found his first spheres. He had neither discovered the oysters' secrets nor had he repeatedly duplicated the effect, but his was success enough to receive a 1908 Japanese patent for the world's first cultured round pearl, even though Mise and Nishikawa preceded him.

A master showman, Mikimoto cultured oysters by the millions, met with the emperor, created incredible pearl concoctions in the shapes of Mount Vernon, the Liberty Bell (page 213), and pagodas for international expositions, and strove constantly to get his products accepted as real pearls.

Except for the astronomical figures Romans were willing to spend on pearls, the natural gems were never higher prized or priced than in the 1920s, just as the new cultured products were becoming available. World War I was over, times were good, and women decorated themselves with all the pearls they could afford. Cartier even acquired its Fifth Avenue headquarters by trading two strands of naturals (priced then



Are Japanese pearls dyed? *Most industry officials deny it. But evidence gathered by author-photographer Fred Ward—backed by statements from U. S. and Japanese dealers—shows color is often enhanced. Only a drilled pearl can be dyed. This one (***above***), drilled to be an earring, gets its pink tint from red dye in the conchiolin, the porous layer between the nacre and the nucleus. Japanese pearls tend to greenish yellow, though the natural palette runs from pink to blue (***right***). An acknowledged practice is bleaching pearls to lighten color and remove dark surface impurities (***left***).*

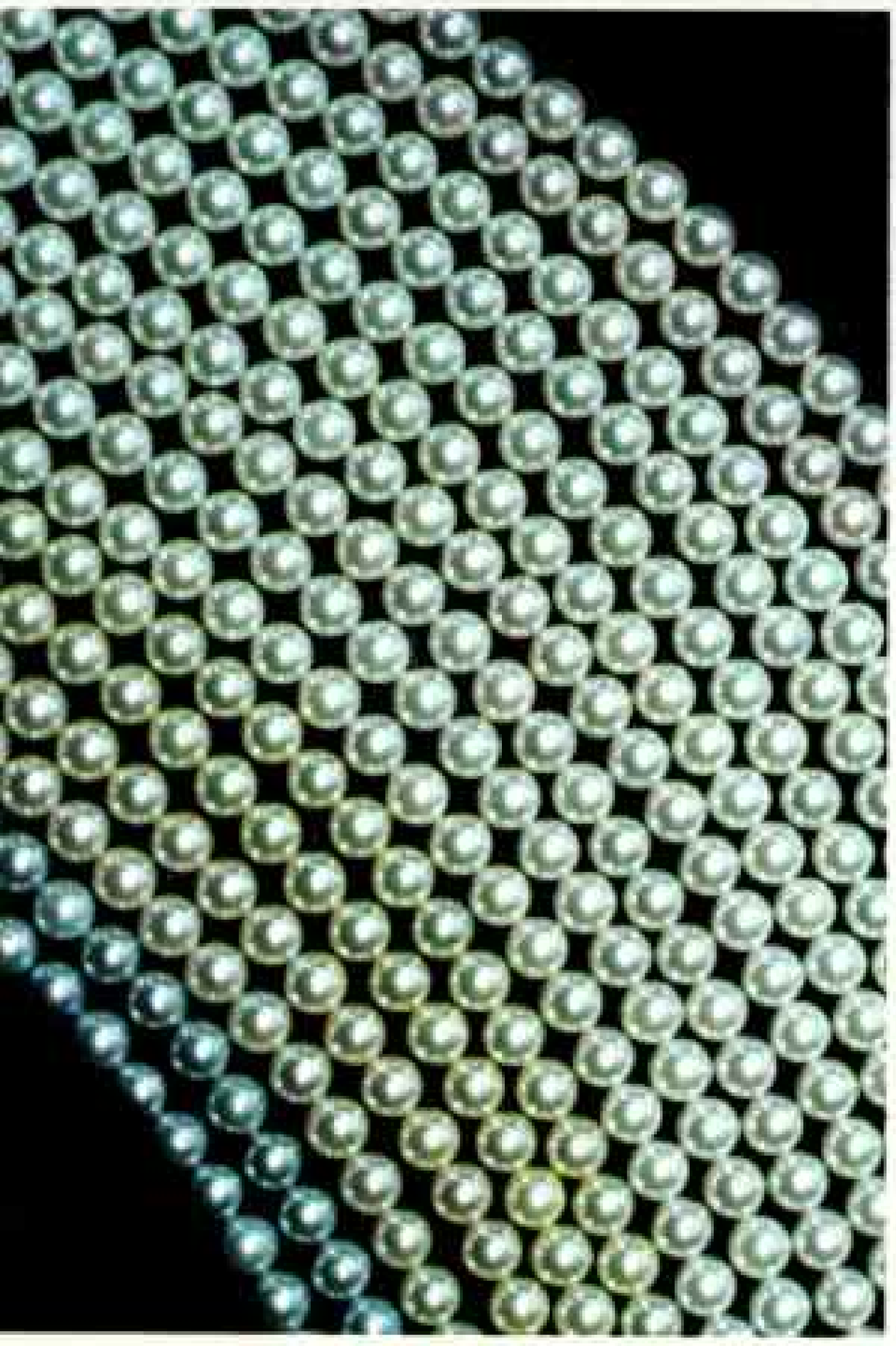
at more than a million dollars) for a matron's town house. After the stock-market crash, the "pearl crash" of 1930 collapsed natural prices. The Depression stifled America's wealthy, and World War II stopped production of both natural and cultured varieties. Naturals never resumed as the world turned entirely toward cultured pearls in the 1950s.

THE LOCAL ELECTRIC TRAIN that commutes between Nagoya and Toba whisked me past the marine scenery where Japanese pearl culturing began. Beside me, Toyohiko Kasuga, from the Mikimoto company's overseas operations, chronicled an oyster's year. "We used to use *ama*, the women divers, to supply new oysters for implanting, but now everyone grows spat, or baby oysters, in tanks, and puts them out into the bay in cages after 60 days. Only when they're three years old are they large and strong enough for the implanting operation." Rolling into Toba, we looked across at Pearl Island, the spot offshore where Mr. Mikimoto made his first pearls, now a tourist attraction. "This was his home," Mr. Kasuga continued, "but the waters were unsuitable for his culturing work, so he moved a little south to Ago Bay, which had ideal conditions."

Mikimoto's company is no longer alone either at Ago Bay or in pearls. Bamboo rafts with suspended oyster baskets *(kago)* fill so much of the available space that boats have to wind through the artificial islands (pages 198-9). Workers in baseball caps, windbreakers, and rubber boots dashed across the narrow stalks with no apparent fear of misstep as Mr. Kasuga finished his chronology. "Each oyster can tolerate one to six nuclei. We implant April to June, and harvest a year and a half later between November and January, because cold water makes better color and luster. Mr. Mikimoto left his implanted oysters in the water more than three years for maximum nacre thickness, and for decades other Japanese farmers followed, but things are changing now."

How much and how fast pearls are changing became more apparent to me over the next few weeks, as I realized shortcuts are being made both in culturing times and by artificial coloring. Shigeru Miki, an elderly adviser to Mikimoto's management, told me in Kobe, Japan's pearl-marketing center: "The most important quality of a cultured pearl is thickness of the nacre. It gives color, luster, and appearance. Pearls are among the softest of all gems [about 3 on the Mohs hardness scale of 1 to 10], and normal body fluids, as well as contact with perfumes, hair sprays, and acids, reduce the nacre. A thinly coated pearl won't last many years."

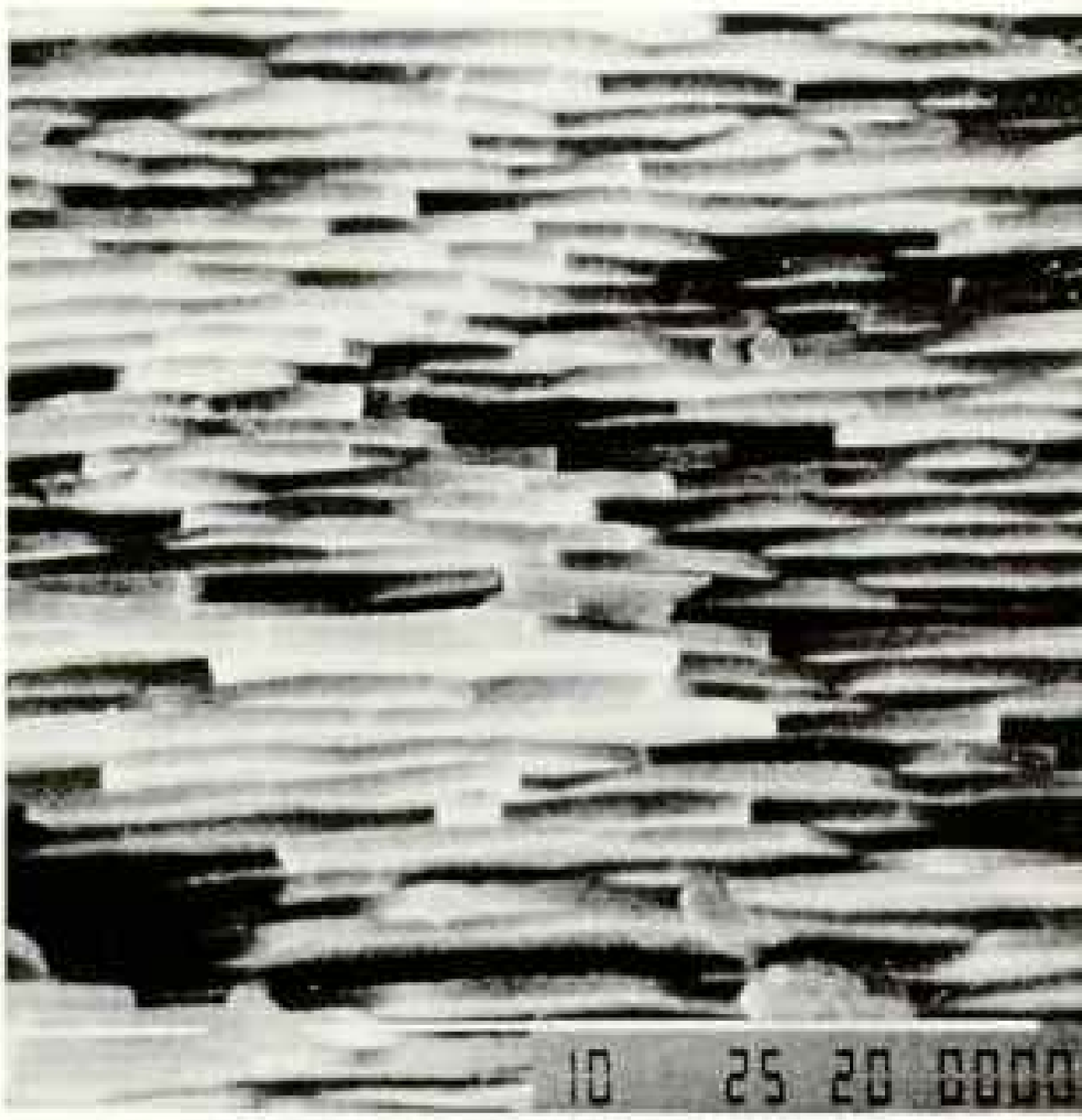
I visited the company's Tokyo research lab, where manager Hiroshi Komatsu said, "Our tests show the best luster [*teri*] and color occur with at least .35 millimeters of nacre, and Mikimoto pearls are always thicker. More nacre makes pearls stronger and gives depth, but it appears that only the top 200 micro-layers are actually visible. Less than 0.3 millimeters and you look through to the shell nucleus inside the pearl. We've found that in Japan we get about 0.2 millimeters of nacre growth in the first six months, so the new short-culture pearls should not pass the export inspection."



IN 1952 JAPAN established export-inspection offices in Tokyo and Kobe for the ostensible purposes of protecting the reputation of Japanese cultured pearls and improving quality. In the Kobe office my eyes adjusted to the darkened one-window viewing room with its deep gray walls, floors, and ceiling. Chief inspector Yasuhiko Funahara told me, "Pearls brought here by exporters are either passed or failed. The ones we don't accept are supposed to be sold in Japan only or destroyed."

A government official* in Tokyo was more forthright: "There is no actual standard. Colored and dyed pearls are passed, and there is little worry about trash pearls with thin coatings. It's such a small thing that we don't bother with them." Earlier, in a Hong Kong jewelry store, I had seen some truly horrible pearls with almost no nacre. I sought out one of the colony's leading gem importers, who laughed when I asked about the awful pearls I had just seen. "The whole idea of the Japanese export-inspection offices is a joke. Hong Kong gets junk Japanese pearls by the ton. We have no laws against them, and neither does the United States. A customer is free to buy what he sees and pays for. If a Japanese pearl farmer or exporter has bad pearls that either don't pass or are never presented for inspection, he just ships them here."

*Because of fear of economic reprisal, several of the author's sources asked that their names not be used.



Just a few meters across from Ago Bay's Tatoku Island, where Mikimoto established the world's first culturing enterprise, Hirao Hamaguchi nimbly moved over his rafts at Yamakatsu Pearl Company. Although most Japanese pearl operators vigorously deny quality is diminishing, Mr. Hamaguchi freely discussed the changes. "Sure we culture less than a year. The medium-size beads we insert between April and June, we'll harvest in December. We even have a new business of letting seaweed farmers use our buoys between December and April, since we have no oysters suspended then."

When I expressed surprise at the revelation, Mr. Hamaguchi continued with a look at the recent past. "Before 1960 we kept the

Brothers in business, *wholesalers of the Japan Pearl Export and Processing Cooperative Association trade goods at a congenial monthly auction in Tokyo* ***(above left).***

Dealers worldwide are alarmed by the shrinking nacre thickness on pearls as some growers rush culturing time. Enlarged cross sections ***(above)*** *compare an acceptable pearl with 0.5-millimeter nacre after 18 months' growth, at right, with the 0.2-millimeter nacre achieved in little more than six months—increasingly common in Japanese pearl production.*

Magnified 5,600 times ***(top)****, nacre reveals its concentric layers of aragonite calcium carbonate. This growth pattern makes cultured and natural pearls feel rough when rubbed on the teeth.*

oysters in the water for two and a half years. Then we dropped the time to one and a half years and held there until 1979. Now the culture takes six to eight months. It's all a matter of time and money."

None of this surprised industry insiders in the U. S., which buys three times as many pearls as any other country. Richard Reuter, president of the Cultured Pearl Association of America, a group of about 50 pearl dealers, observed, "Nacre thickness is almost all we ever talk about. Most of us simply can't understand what's going on. The Japanese support a huge public relations effort to link the mystique of pearls with Japan. In a country that's made its successes with quality and confidence, why are they damaging their reputation by making inferior goods? Thinly coated pearls won't last long enough to pass along to daughters. They'll crack, discolor, and become worthless."

I heard his opinion echoed during a pearl-grading seminar conducted for jewelers by the Gemological Institute of America. Several jewelers, who complained about rapidly climbing Japanese prices, told me pearls were a significant portion of their monthly sales. G.I.A. pearl instructor Jill Fisher was even more concerned about quality. "It is just a crime. The pearls are getting worse and worse as the nacre gets thinner. The coatings will crack and give way around the drill holes."

IN WHAT LOOKED like a preposterous game of marbles at Mikimoto's Toba factory, buckets of pearls were poured onto an inclined glass table for shape sorting. Only the rounds, called *happo-koro-gashi*, or eight-way-rollers, reached the far end. Most pearls are slightly oval. Teardrop or pear-shaped pearls, valuable for earrings, toppled off the table into side chutes. Because rounds are the most popular, they are also the most expensive. Baroque, or uneven, pearls are often the choice of young women who find their convolutions interesting or artistic and their prices lower.

The more lustrous a pearl, the more valuable. After looking at hundreds of thousands of pearls and watching expert graders, I followed their examples. With a light at my back I studied the reflections on a handful of saltwater pearls. The more finely detailed and sharper the images of the light, the higher the luster. Viewing nacre by microscope, I saw that even deposits of hexagonal aragonite crystals of calcium carbonate give the best color and luster, whereas round or cracked crystals cause duller finishes.

A pearl's size is determined by the diameter of the nucleus inserted and its culture time. Before this century natural pearls might have grown for 10 to 20 years. Consequently, a few became quite large, sometimes over an inch long. Today's cultured pearls are made to fit the market and oysters available. Japan's *akoya* oysters, *Pinctada fucata* (Gould), measure only about four inches across since coastal waters have become polluted and tank breeding reduces hardiness.

Kimihiko Onishi, who manages an Ago Bay pearl farm, fingered a three-year-old oyster, pressing its yielding shells. "We used to get our akoya from the sea, which bounced the shells around a lot. They were tougher and healthier, so they could hold ten-millimeter pearls. Now we have trouble getting any over nine millimeters." I watched women operators insert seven- to eight-millimeter shell nuclei to get eight- to nine-millimeter pearls, allowing about 0.5 millimeters of nacre on a side. Equivalent-quality eight-millimeter necklaces generally sell for two to three times the cost of seven-millimeter strands. All sizes are made, down to two millimeters, and one oyster can culture several of the smaller pearls.

Saltwater pearls produced outside Japan also use nuclei cut from U. S. shells. Thriving in warm waters closer to the Equator, huge South Sea oysters, often over a foot in diameter, nurture the grandest pearls. In Broome, Australia, I walked among thousands of silver-lipped shells, *Pinctada maxima*, the world's largest pearl oyster, where nuclei as large as 12 millimeters culture pearls up to 20 millimeters. South Sea white pearls come from Burma, Thailand, the Philippines, Indonesia, and Australia. Iridescent peacock-hued Polynesian black pearls are the exotic creations of black-lipped oysters, *Pinctada margaritifera* (pages 196-7). So rare are large high-quality South Sea pearls, white or black, that they can sell for $4,000 to $40,000 each, making a necklace of 30 or so very expensive indeed.

Like nacre thickness, color has become a controversial issue in world pearl markets. Kunz and Stevenson could write in their 1908 epic work, *The Book of the Pearl*, that nothing was needed to enhance a pearl's beauty. But since then, men with their science have conspired to try. Some original Persian Gulf naturals were slightly altered by bleaching them in the hot Arabic sun after harvest. Not satisfied with nature's speed or consistency, Japanese technicians have perfected a system that even the Chinese want to follow. One South Sea pearl farmer described the processes as we examined some of his crop. "I would say that *all* Japanese pearls are bleached in hydrogen peroxide to clear spots and make them whiter. Then almost all of them are dyed to the colors that will sell."

*"**I owe my fine health** and long life to the two pearls I have swallowed every morning," claimed Kokichi Mikimoto, father of the cultured-pearl industry, who died in 1954 at age 96. The pharmaceutical branch of his company now grinds pearls and shells into calcium carbonate tablets for "pregnancies, weak bodies, tooth cavities, stomach acid, and allergies." Tons of pearls too flawed or tiny for jewelry go into medicines, cosmetics, and toothpaste in Japan and China.*

Vigorously denied by practically every pearl representative I saw, the fact remains that pearl dyeing is common in Japan, and no harvest has anywhere near as many pink pearls, or pearls so pink, as those displayed in showrooms. A Tokyo pearl company official told me that information is unavailable because Japanese take an oath not to reveal the culturing operation or discuss pearl alterations between oyster and market.

A few people in the business have decided it is time the public knows Japanese pearls are colored artificially. Hidesaburo Mogi is sales chief for Uyeda Jeweller, one of Tokyo's finest pearl shops. As we left the government pearl-inspection station one fall morning, he confided: "If you're talking about selling pearls just as they come from the oysters, I would have to say there are no Japanese pearls like that. Although I've been in the pearl business here for over 20 years, color treatment is the one thing I have never seen. It is a secret with every company, and no one will allow outsiders in."

JOHN LATENDRESSE, who with his Japanese wife, Chessy (page 218), is going to intensify competition with Japan by taking the first crop of Tennessee, Louisiana, and Texas freshwater pearls to market in 1987, says, "The Japanese used to soak pearls in a Mercurochrome solution, but the color faded in three to five years. Now they use a mixture of medicinal dyes. The dye seeps through the drill hole into the conchiolin layer between the shell nucleus and nacre. The color then shows through the pearl's translucent surface [page 202]."

Richard Reuter of the Cultured Pearl Association remains more concerned about nacre thickness than coloring, and even sees a positive side for his import business. "If the Japanese pearls weren't bleached and tinted, in a few years the necklace would be totally unmatched and unacceptable, and there would be no pearl business. We realize all Japanese cultured pearls are bleached and stabilized. What my company won't handle are artificial-looking pink colors."

Natural works of art, *needing no polishing or faceting to reveal their beauty, pearls were valued above all gems until diamonds gained top status in the early 19th century.*

Before cultured pearls captured the market after World War II, the Persian Gulf supplied most of the world's natural saltwater pearls. Divers also wrested pearl oysters from the Indian Ocean, the Pacific, and the waters of the New World—touted as "the land of pearls" in 16th-century Spain.

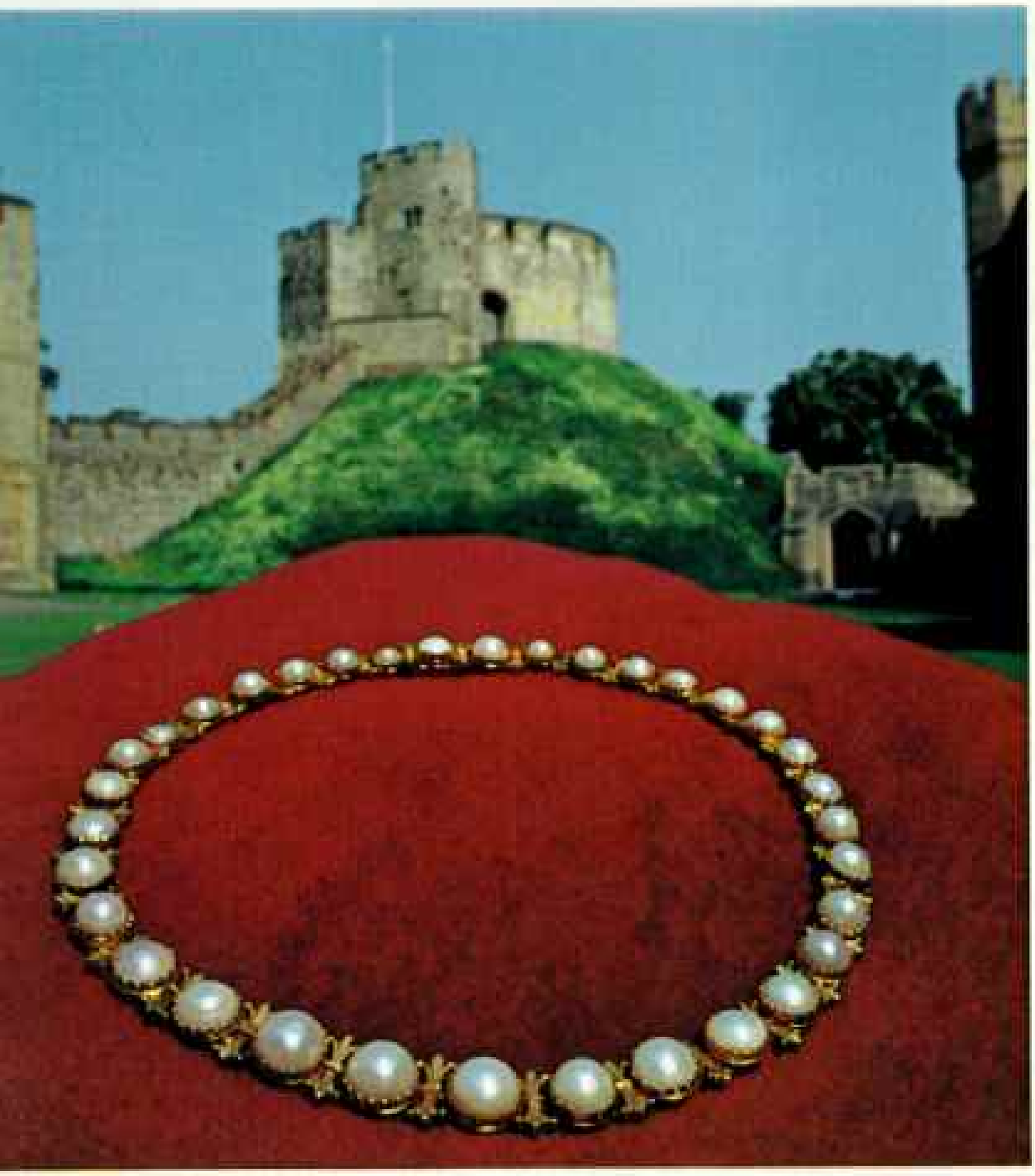
Pearl mania reached its height during the Roman Empire. Quipped the satirist Seneca of the gem's popularity, "The lobes of our ladies have attained a special capacity for supporting a great number." An Egyptian earring of Greco-Roman design ***(top right)****, once fitted with a fourth pearl in its gold rosette, would have been in style at the legendary first-century B.C. banquet where Cleopatra impressed Marc Antony by crushing and drinking a costly pearl.*

From the Roman Empire to the Renaissance, rulers issued edicts—in vain—to curtail wearing of pearls. In the hands of a late 16th-century artisan, a stupendous baroque pearl became the torso of a fighting merman ***(left)****. Later the pendant reached India, where its dangling ruby floret was added.*

Reflecting the vogue for naturalism in mid-19th-century England, fruits of the sea were transformed into clusters of grapes for the centerpiece of a necklace ***(right)****.*

MERMAN: VICTORIA AND ALBERT MUSEUM, HEIGHT 10 CM
EARRING: NATIONAL MUSEUM, CAIRO, HEIGHT 2.6 CM
GRAPES: VICTORIA AND ALBERT MUSEUM, 8.9 CM

One thing is sure: Cultured-pearl colors are routinely altered to improve sales. Japanese cultured pearls may be silver, cream, pink, yellow, green, blue, or black. Many Japanese pearls have an inherent greenish yellow pigment that scientists strive to lessen with genetic engineering and better dyes. The actual cause of pearl color remains a mystery, even after 80 years of study. Numerous pearl farmers and operators told me the same story. Take one oyster and insert five shell nuclei from the same



Bounty of the Persian Gulf, *strands collected by the shahs of Iran still help back the nation's currency as part of the state jewels (***right,** *photographed in 1977). Pearls dominate a crown (***top***) created in 1806 for Caroline of Baden, wife of Bavaria's first king, Maximilian I. Freshwater half-pearls from Scotland ring a late 16th-century choker probably owned by Mary Queen of Scots and recall the story passed in Rome that Julius Caesar invaded Britain "by hope of getting pearls."*

batch combined with five pieces of mantle sliced from one sacrificial oyster, then place the implanted oyster back into the sea. After a year, open it and find five different-colored pearls. Ask why, and no one knows.

Since the Japanese commercialized cultured pearls, they have dominated the market. It is no accident that only Burmese whites, a few Australian pearls, and some Polynesian blacks are sold outside the firm lock of Japan's exporters. Japan has tightly held the procedures for implanting nuclei, refusing to reveal them to foreigners, even though the Australian government asked.

Sea-weathered Bruce Farley of Roebuck Deep Pearls wiped a steady spray from his face as we headed for Broome. Pounding through offshore swells on a falling 30-foot tide over his five-square-mile ocean lease, he described how the Japanese tie up the world market. "If a country or individual wants to go into pearl farming, he gets the whole Japanese package. Japanese technicians do the operating and often tend the oysters,

CROWN: TREASURY OF THE MUNICH RESIDENCE, 17 BY 17 CM; CHEST: NATIONAL JEWELS OF IRAN, TEHRAN, LENGTH 42 CM, WIDTH 32 CM, HEIGHT 20 CM; CHOKER: DUKE OF NORFOLK, KG, ARUNDEL CASTLE, WEST SUSSEX, ENGLAND

Japanese harvest and sort the crop, and Japanese control the value of the pearls as they are shipped off to Japan for processing and marketing to the world. It's a take-it-or-leave-it proposition. Usually you buy the whole deal, as I do, or you get nothing."

The outback never seemed farther out or back than in wild and woolly Broome, on Australia's northwest corner, center of the country's pearling industry for nearly a century. In a time warp I climbed onto the planked porch of the green stilted Roebuck Bay Hotel and bar, accompanied by my anachronistic hostess, the smartly tailored co-director of Roebuck Deep Pearls, Trish Grey. We pushed through the swinging saloon doors, ambled by two suspended stuffed groupers, and moved out to the open-air dance floor featuring an abandoned Vietnam boat people's hull as a bandstand. With no apparent sense of understatement, Trish observed, "Broome is a little different from other towns."

"There's no other place in the world like it," confirmed Rand Dybdahl, pearl research officer with the Western Australian Marine Research Laboratories. "Almost all its history, however, has been with mother-of-pearl. Although they were valued, pearls were still considered by-products for over a century."

By the 1900s remote Broome was selling more than 75 percent of the world's mother-of-pearl, or "MOP." With a trio of favorite pastimes (drinking, gambling, fighting), it richly earned a raucous renown. Regular Sunday afternoon bare-knuckle fights rigidly followed the "Marquess of Queensberry Rules": No hitting below the belt, eye gouging, biting, kicking, or striking while down. Nine-pins was the game of preference, using real glass champagne bottles as pins. Naturally a case of the imported bubbly had to be consumed before the game could begin.

Broome changed its emphasis in 1957, with the first cultured-pearl production up the coast at Kuri Bay. "No one stayed just in MOP when millions might be made in pearls," Rand Dybdahl said. As he and others told me, there is trouble in paradise. First, Australian law requires any pearl licensee to be a British Commonwealth subject, but the Japanese barely tolerate anyone in pearls except themselves. They use front organizations in packaged, turnkey deals. An Australian gets the license and takes his share at the end, but Japanese companies do all the technical work and ship the entire crop to Japan. All but one or two of Australia's pearl farms are tied to the Japanese. And now there is a growing fear of oyster piracy.

"Am I worried?" asked Trish Grey. "Yes, because what Australia has are huge, wonderful white shells that make gorgeous pearls without bleaching or dyeing. If someone steals away with our live oysters to a cheap labor market and starts producing large white pearls, we will be ruined. The horror is, I think they'll do it too."

THE LITTLE seven-seat Piper banked over another of the doughnut-shaped atolls marking our way from Tahiti. Below, the purplish blue richness of the South Pacific changed abruptly to a thin circle of coral that encompassed an incredibly transparent, aquamarine lagoon. Beside me, tiny, French-speaking Véronique Ma'Arop, a vice president of Van Cleef & Arpels, Inc., and Essie Posin, vice president of Assael International Inc., shared a window. "The waters here are as beautiful as the pearls they produce," Véronique ventured. "I love big pearls. I get all I can every year. A single, high-quality 13-millimeter-or-larger round easily sells for $10,000. I still buy big white pearls from the Burmese February auction. But since the government nationalized the business and expelled the Japanese, their quantity and quality have been down. Now I look elsewhere. Besides, some of our special clients adore Polynesia's black pearls."

After six hours we landed at the home of Polynesie Perle on Marutea, a ten-mile-long atoll about a thousand miles southeast of Tahiti in the Tuamotu Archipelago. Alternately videotaping and waving at the end of the coral strip was the island's splashy French proprietor, Jean-Claude Brouillet, complete with orange and black bandanna, red Polynesian print shorts, thongs, and a smile as big as his ambitions.

Over the next hour, in heavily accented English, the burly raconteur, hotelier, author, former pilot, and African airline owner bubbled with enthusiasm about his

favorite subjects: women and black pearls. He laughed, told stories, poured drinks, directed the Polynesian cooks, debriefed our pilot, sent instructions to the Tahitian divers, spoke to his teenage son Vladimir about fresh seafood from the reef, cuddled his ten-year-old half-Tahitian son Toriki, directed manager Yannis Thomas about the next day's tasks, and thoroughly entertained Véronique, Essie, and me. We rested in the open-sided coral-and-shell-graveled public area beneath Jean-Claude's hut, a communal center that serves as kitchen, dining, and living rooms for the remote atoll visited by a supply ship only once a month.

MIKIMOTO PEARL ISLAND MUSEUM, TOBA, JAPAN. BELL HEIGHT 85.8 CM

To woo the world to his cultured pearls, Kokichi Mikimoto designed creations such as this replica of the Liberty Bell, studded with 12,250 pearls and 366 diamonds, for the 1939 New York World's Fair. He received a patent for the round cultured pearl in 1908, though two other experimenters had earlier successes. First widely sold in the 1920s, cultured pearls stirred debate among jewelers and scientists: Were they really pearls? Winning court cases and public opinion, Mikimoto ultimately triumphed.

Later, warming to his after-dinner audience, Jean-Claude described Marutea's mixed blessings, while I lifted my sandaled feet to let the dozens of hermit crabs work over the floor for scraps. "Women are *mad* for black pearls now, and this atoll is *perfect* for them. We are in the middle of the ocean, *far, far* from any pollution, from pirates, or from temptations. The only problem is expense. I have to bring in everything for 35 staff members. That costs me a *million and a half dollars* a year. We had two *devastating* hurricanes within 12 weeks in 1983, rebuilt the entire camp twice, and that cost a *fortune*. But the island is perfect for pearls, with its lovely, clean lagoon, nine by sixteen kilometers that could be *filled* with oysters."

Next morning Yannis and I dived 40 feet into the clear lagoon to see his two holding systems for 65,000 nucleated oysters. Relaxing in our boat between dives, he noted, "We do full two-year cultures and aim for 1.5 to 2.5 millimeters of nacre on our black pearls, which range from 10 to 16 millimeters."

That evening, over a sumptuous dinner of stone crabs, spiny lobsters, and fresh fish speared on the reef by Vladimir, Jean-Claude reveled in his successful year. "We finish our annual harvest tomorrow," he boasted proudly, "22,000 black pearls. But even a *madly* independent Frenchman like me still has to deal with Japanese technicians, although my pearls all go to New York City to be sold."

That U. S. connection is unique in the industry. Salvador Assael, president of Assael International, is credited with creating the world market for black pearls. He says, "Jean-Claude has restructured Polynesie Perle, but we'll still import the whole crop. We buy a great many pearls inside and outside the Japanese cartel, but what I'm proudest of is to be the first American to crack their pearl monopoly."

JUST HOW COMPLETE *is* the large-pearl Japanese monopoly? I paid a visit to the dull gray walk-up office of the Japan Export Overseas Pearl Producers' Association near Tokyo's Ginza. Managing Director K. Ishizuka readily admitted the association's 14 members handle nearly all the world's South Sea pearls. He carefully explained: "Cartels are

The land of the Pearl River *revived its tradition of pearl cultivation in the late 1960s, and today China leads the world in production of freshwater pearls—50 to 80 tons this year. The pearls of myriad colors and shapes from its native sankaku and kurasu mussels have made a splash in the U. S. market, and Japan will buy as many as 12 tons to augment its dwindling freshwater harvest, only about five tons in 1984.*

Criticized for stressing quantity over quality, the government-controlled Chinese industry works to improve culturing methods and has built an artificial lake for research 60 kilometers southwest of Shanghai. Low-tech, labor-intensive operations characterize China's pearl business. When not fish-farming, Han Gen Sheng ***(below)*** *tends his crop of 7,000 mussels—each hanging from its own string—on a pond in a hamlet near Shanghai. After two years the mussels are returned to a government center for pearl harvesting.*

Most of the country's pearls are sorted, drilled, and strung in four Shanghai factories. Teenage workers do some of the drilling with metal bit and bow saw ***(right)****, economical because they are paid 16 cents an hour.*

Early clues to culturing *emerged in 12th-century China when tiny figures of Buddha, cemented onto the inner shell of freshwater mussels, were coated with nacre. Valued as amulets and temple decorations, pearl Buddhas* ***(above)*** *were grown into the 20th century.*

Similarly, half-pearls sometimes grow naturally in response to inhaled irritants or parasites that bore through the shell. Women of ancient Rome used such knobbed shells for carrying perfume. Today half-pearls are cultured mainly in mabe oysters by gluing a plastic or shell hemisphere to the mother-of-pearl. The resulting dome of nacre is later drilled away ***(below left)****. Usually filled with epoxy and backed by mother-of-pearl, a mabe graces an ear* ***(below right)****.*

normally illegal in Japan. We are a legal cartel, formed in 1964 to avoid competition between Japanese akoya pearls and the fewer, but larger, South Sea pearls [*nanyo-dama*] from other countries. And we set prices. Government policy decreed that Japanese dealers bring 100 percent of the pearls back to Japan for marketing and only make pearls over 10 millimeters [to avoid competition with the home pearls]. The policy also stipulated that we could not leak or divulge the Japanese secrets of pearl production to anyone. For our part, we meet and agree to a floor price for South Sea pearls." The only other business receiving government protection for price-fixing in Japan is rice production.

South Sea pearls are intriguing because of their sizes and monopolistic marketing, but they amount to only 5 percent of Japan's pearl exports. Akoya pearls, the ones from two to ten millimeters cultured in Japan's *Pinctada fucata* oysters, are the backbone of the cultured-pearl business, accounting for 60 percent of the exports. Pearls are sold by weight, using the old unit *momme*, which is 3.75 grams. A thousand *momme* is a *kan*. Japan reached its record high production, more than 39,000 kan, in 1966.

Hidenobu Ogawa, managing director of the Japan Pearl Exporters' Association in the Kobe Pearl Center, described what's happened since then. "Basically, when we overproduced to benefit from high prices, we killed our own market. Then the waters here also got more polluted. Production has steadily fallen to near 18,000 kan. That's about 150,000 pounds of pearls, and we export 60 percent of what we make here, grow in the South Seas, and buy from China." Quantities are down, but prices are up, rising 30 percent in 1984, mainly because of demand in the U. S., which buys about half of all Japan's pearls. Pearls are now Japan's largest single marine-product export, worth more than 300 million dollars annually.

I drove from ancient Kyoto to Lake Biwa —the historical home of Japan's freshwater pearls—passing more than a thousand years of history in an hour. A solid phalanx of apartments, restaurants, massage shops, love hotels, and pachinko parlors blocked the lake's southern resort shore from view. Wedged between rice fields, Omi Pearls Limited Company operates on a little over three acres.

Chojiro Hamada, president of the company and director of the Shiga Prefecture Pearl and Fishermen's Union, walked with me to where three women operated on black mussels. Since the shells can only be opened less than an inch without damage, I could see that fine surgical skills were necessary to cut numerous small slits in the thin flesh. Hamada explained: "Unlike saltwater pearls, the usually less expensive freshwater pearls are as close to naturals as you can get. Instead of starting from shell nuclei, freshwater pearls are seeded with pieces of mantle tissue placed directly into the mussel's own fleshy mantle. Each mussel yields between 30 and 50 solid pearls with no nuclei, often enough for a 16-inch strand."

Outside, on the wooden dock, Hamada voiced concern: "Lake Biwa is getting more polluted all the time. Pesticides and fertilizers are our worst enemies. We can't even get our young mussels from the lake any more. And tank-grown mussels are weaker."

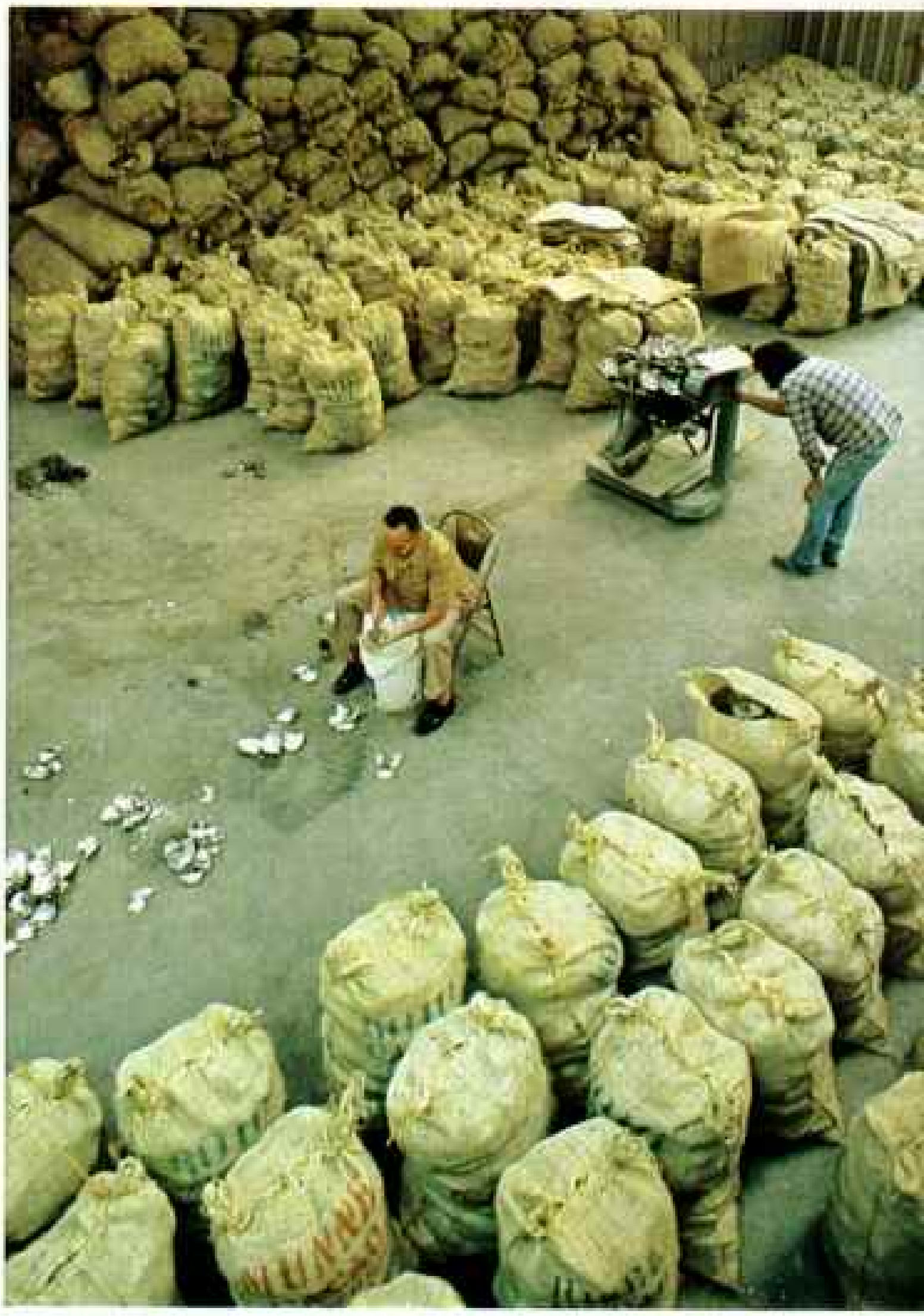
ONE unusually innovative Japanese decided on bold, individual action to save his pearl farms. Standing shoulder-deep in the fast-moving channelized Shintone River two hours north of Tokyo, Syoichi Kitao is the antithesis of committee thinking. Pulling up heavy baskets laden with mussels ready for harvest, the deeply tanned pearl farmer recalled, "I left Lake Biwa for clean water. In 1971 I came to this river and started the Daiko Pearl Company. Here I grow all the young mussels I need. Just look at the size and condition of these," he said, thrusting a net of six toward me. We took them up the levee and across the road, where his wife and two co-workers operated.

Severing the adductor and retractor muscles that hold the shells together, Kitao spread the mussel flat, saying, "The strong current carries plenty of food. My animals grow far bigger than they would lying in a still lake. See the 30 pearls here in the mantle. Now I'm going to show you something I've never shown anyone from the outside."

With that, my revolutionary friend dug his fingers deep into the mussel's body, and plucked a spectacular round, pink,

In praise of American pearls, *Chessy and John Latendresse of Camden, Tennessee (**left**), design and sell jewelry from their renowned collection of U. S. natural freshwater gems. But they decline offers, as high as $150,000, for this graduated strand of pearls gathered from the Tennessee River over a 25-year period. Few natural freshwater pearls are harvested today. Disturbed by river damming and pollution, mussels are seldom able to produce sizable pearls.*

Nevertheless, the U. S., predicts John, "is the future of cultured freshwater pearls." After decades of research, the Latendresses' American Pearl Farms will in 1987 start marketing large, round



*pearls from up to 24 species of nucleated mussels. Taught by Chessy, who learned culturing in her native Japan, employee Tammy Story, 16, practices nucleation (**right**). Cultivated largely in the Mississippi and Tennessee River Valleys, mussels suspended from plastic pipes are cleaned periodically of algae (**above left**).*

*The heart of saltwater cultured pearls is already an American product. Beads used for nucleation are carved in Japan from the shells of mussels found in the Mississippi River basin. John Latendresse supplies more than 60 percent of the mussel shells and here checks for quality (**above right,** at left).*

14-millimeter beauty from its unalluring origin. "I've married two cultures, freshwater mussel with South Sea oyster techniques. Instead of just traditional mantle-tissue nucleating with mussels, I'm inserting shell-bead nuclei inside their bodies, just as farmers do with saltwater oysters."

As Kitao hunkered amid the shells outside his small operating room, filling a plastic cup with his cache, I marveled at his accomplishment. With characteristic modesty, he admired one of the large beauties, saying, "I never use a nucleus more than nine millimeters, so these pearls have thick nacre, not like the akoyas. Once I made a 17 millimeter. My ambition is to be first to culture a round 20-millimeter freshwater pearl. When I get that, I will present it to the President of the United States, not the emperor. Why? Because the U. S. is my best customer, and I'm going to say 'Thank you.'"

RECENTLY, China has exploded onto the freshwater-pearl market. Isedor Slutsky, through his August Corporation, started buying early and is among the largest U. S. importers of the Chinese goods. From his office in New York, he remembered: "The Japanese were caught totally off guard. The first marketable Chinese crop came in 1970, and this year they will culture 50, maybe even 80, tons of pearls, far outpacing the Japanese, who will make no more than three to five tons themselves. However, the Japanese will still market 15 tons of freshwater pearls, 80 percent of which they will buy from China and sell as theirs."

Isedor's admonition that "things are really chaotic over there right now" didn't fully prepare me for the disarray I found in the People's Republic. As China races toward a new capitalism, pearls, perfect for earning foreign exchange, have gotten the green light for expansion. In a drab hamlet about 30 kilometers west of Shanghai, standing with farmer Han Gen Sheng and surrounded by fishponds and rice fields, I sensed that a pearl farm in China can be different from a pearl farm anywhere else. It is sometimes a nondescript pond or small patch of irrigation-canal shoreline tended by a worker designated by the local commune. Han, in the faded blue uniform of China's peasants,

HOPEWELL PEARLS: FIELD MUSEUM OF NATURAL HISTORY, CHICAGO. LARGEST PEARL, 1.5 CM; SNAIL: JOHN LATENDRESSE COLLECTION, 3.0 BY 1.6 CM

Adorning the dead, *freshwater pearls* ***(top)*** *were buried in the funeral mounds of Hopewell Indians in Ohio during the early centuries A.D. "Pearl rushes" were common in the U. S. into the 20th century, and some of the best finds went into the crown jewels of Europe. X rays of an Indiana pearl more than an inch long* ***(above)*** *reveal a tiny snail. Its shroud may have been 70 years in the making. The varied shapes of Asian cultured freshwater pearls* ***(facing page)*** *reflect the implanter's skill.*

spends half his time fish-farming and half watching over 7,000 mussels, each suspended from its own string in the muddy stream just in front of his home (pages 214-15). Later as we poled past the graceful draped curtain of thousands of lines, Han said through a translator, "I receive mussels implanted by the government and keep them two years. Then I turn them back for harvesting and get a new batch."

On shore, Sheng Yu Lin, manager of Jinpu County's Fish and Agriculture Cooperative office, opened a shell we had collected. "China can make many pearls very cheaply, but they're still not very good," he observed, fingering a few of the 15 small rice-shaped freshwater pearls from each side of the slick mantle tissue. "We need better techniques, instead of just more quantity, which has hurt us in the world market."

Like other peasants, pearl farmers tend to keep any of their harvest above their quota. Since China has virtually no pearl market except for medicine and cosmetics, the assumption was that surpluses would be sold to the government at a fixed price. Instead, Sheng said, "The farmers resorted to smuggling. Local dealers rendezvous with Hong Kong buyers who usually trade TV sets, radios, watches, and other hard-to-get items."

Pearls from dozens of nearby farms are processed in a gray concrete factory I visited in Shanghai. On the top floor, above a sweater-knitting operation, crew-cut manager Yao Yun Xie showed me through two bleak rooms filled with girls who sort, drill, and string about 3,000 kilograms (6,614 pounds) of pearls annually. Watching a teenager saw away with a primitive bow and twine, hand-spinning a sharpened bit that serves as a drill, I wondered how such a labor-intensive operation could possibly compete in world gem markets. Yao then described their salaries: 60 yuan a month for a six-day week, 183 hours a month, or 16 U. S. cents an hour.

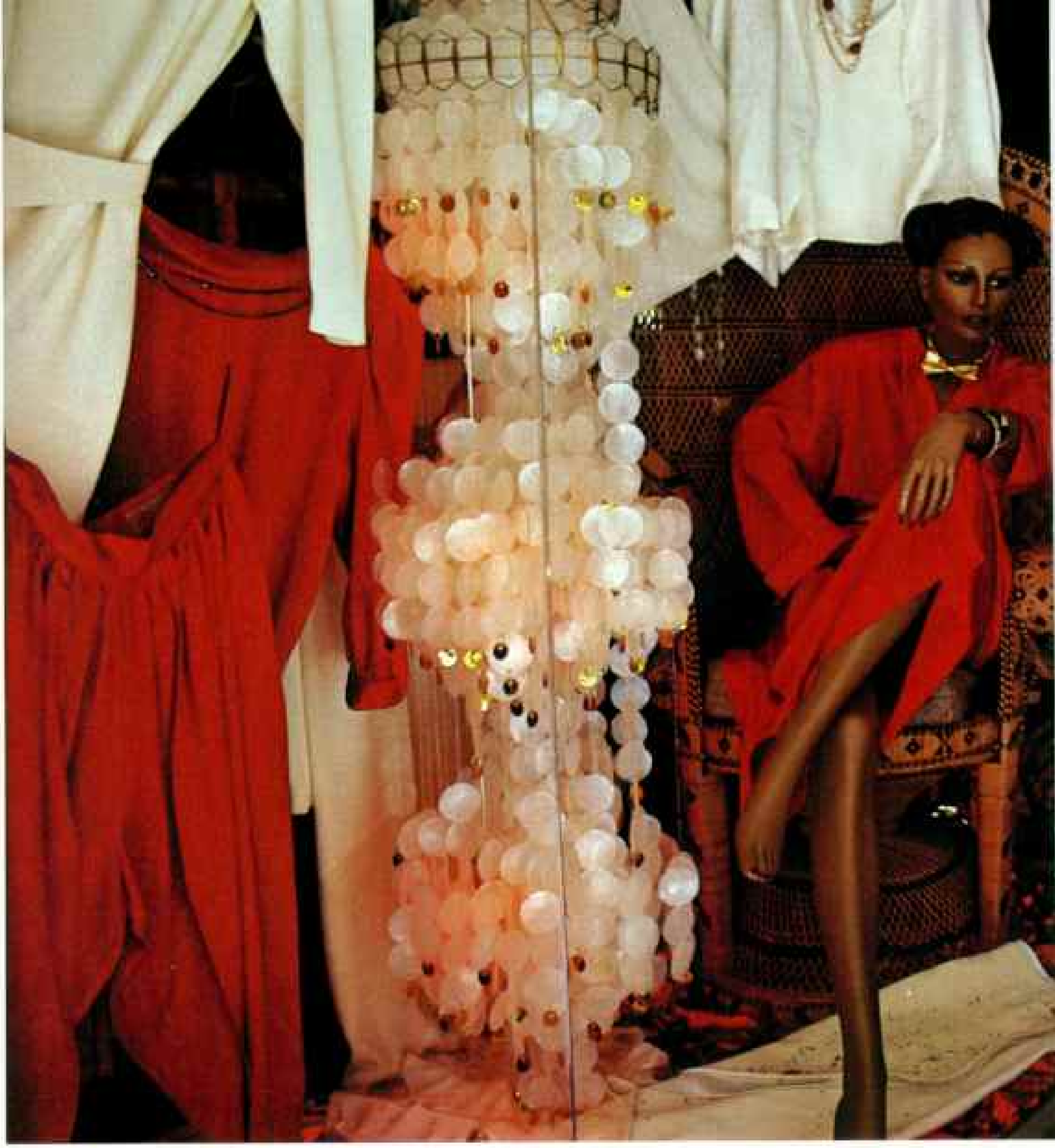
John Latendresse also played a role in China's current success. Back in Tennessee, he recalled, "I went to China first in 1967 to advise them on how to culture, and in return I got a worldwide exclusive to sell their pearls. The fourth year they harvested 11 tons. I couldn't handle that much, so they went to other people."

Like an Oriental potentate, John poured a tableful of huge natural baroques before me: "The U. S. is the future of cultured freshwater pearls. Look at these colors and shapes, all from American rivers and lakes. China has only two mussels that produce pearls, and outdated technology. The Chinese are too much in a hurry for cash to make a good product. The Japanese, also with two pearl-producing mussels, have ruined their fresh water. We have at least 24 acceptable mussels, great color variety, and vast clean-water resources." Gazing into his treasured "Pearl of Many Colors," John predicted, "We will be the center of this business soon."

PERHAPS. But the Japanese have decades of labor experience and public acceptance of their products. Pearls have never been more popular, because they are affordable jewels, and 1980s free-form fashions encourage wearing them at any hour with any clothes. Recent changes in Japanese pearls do indicate this is a time to be cautious. As Richard Reuter says, "Good pearls are still plentiful. Buy from a trusted jeweler, ask about nacre thickness, and stay away from those obviously dyed. Keep them clean, and restring regularly for years of enjoyment."

A woman who wears and loves pearls is in good company. I was thinking about history's queens who coveted them as I sat with one of today's film royalty, Elizabeth Taylor. Surrounded by her Impressionists and looking out over Hollywood, she fondled La Peregrina, her fabulous inch-long natural pearl, and summed up the eternal appeal of pearls in her surprisingly small voice. "I love to hold them, feel them, touch them. For women, pearls are feminine and warm, and very romantic." And so they are. □

Passport to freedom *for the slave who found it off Panama in the mid-16th century, the storied inch-long pearl called La Peregrina, "the wanderer," passed through the hands of European rulers such as Mary Tudor until purchased by Richard Burton for Elizabeth Taylor in 1969 for $37,000. Cartier designed for her the necklace and matching earrings.*



Senegambia—A Now and Future Nation

ARTICLE AND PHOTOGRAPHS BY
MICHAEL AND AUBINE KIRTLEY

French panache *and British propriety are respective colonial legacies of the West African nations of Senegal and the Gambia. In Senegal's capital, Dakar, women admire a display of Parisian couture* ***(above)****. One hundred miles south, in Banjul, the Gambia's capital, bewigged magistrates gather for a Legal Day celebration* ***(left)****. Despite different colonial backgrounds, the two countries share common cultural bonds, a commitment to democratic ideals, and an alliance known as the Confederation of Senegambia.*

Misunderstandings don't exist;
only the failure to communicate exists.

—SENEGALESE PROVERB

"WHERE ELSE IN AFRICA have you seen the government so freely criticized?" asked Dial Lahi Thiaw, a friend and religious leader with a biting wit. Now he was serious, pointing to headlines that leaped from a roadside newsstand: Dead Men Voted; President Should Resign; Democracy Dead; Elections Rigged.

Dial continued: "I myself oppose the ruling party. But at least in Senegal we have 15 parties, and we can lampoon our president on the cover of a street-corner magazine." He indicated a caricature of the president as a witch doctor.

After 13 years of African travel I knew well that I was in one of Africa's few remaining true democracies. Although other countries justifiably claim certain advances, Senegal and her partner, the Gambia, are an oasis of hope for human rights, personal freedom, and the democratic process.

As photojournalists, my wife, Aubine, and I recently spent six months in these two small, drought-plagued West African nations. The terrain and people are similar; Senegal and the Gambia were respectively the first French and British outposts in all of black Africa.

Both became independent by the mid-1960s. In 1982 they proclaimed the Confederation of Senegambia, an important step toward unity under one flag. Aubine and I were there to document this bold initiative to overcome three centuries of "colonial heresy," as one official called the strange configuration of the Gambia: It pokes like a crooked finger into Senegal for 200 miles, though it averages but 18 in width.

During numerous trips throughout the region, we discovered that colonial legacies prevail. Many Senegalese consider themselves authentic Frenchmen, while Gambians play cricket, enjoy teatime, and call the Senegalese "those French."

"Look at Dakar [Senegal's capital]," a Gambian merchant declared. "A beautiful French city. Now look at Banjul, our capital—a shantytown! The British left us nothing but cricket and the Anglican Church!"

Outside the urban areas, however, Aubine and I found that most Senegambians have similar life-styles, hopes, and problems, with flavorful nuances. Above all, we found that respect for family ties is their common denominator.

"On my trips to Europe and America," wealthy Senegalese importer Aita Diaw told us, "I am always shocked that you judge someone by what he possesses. Here, poor relatives from the bush come to me often. I give them beds; then they tell me their problems. Life is hard—the rains weren't good. I send them back with enough food for several months."

She took us behind her ultramodern house into the courtyard—a kind of outdoor dormitory where a dozen families camped. She explained that this kind of pipeline exists in all good families. "Our dream is always to have enough wealth to redistribute. Here we are judged by how we treat our kinfolk."

Both Senegal and the Gambia take their names from rivers; both are predominantly

Michael and **Aubine Kirtley** have contributed several articles to NATIONAL GEOGRAPHIC, among them "The Ivory Coast—African Success Story," in the July 1982 issue.

Senegal and the Gambia

AN ENGAGEMENT with no set date for permanent union, the Confederation of Senegambia, created in 1982, merges communications, transportation, and defense operations of Senegal and the Gambia but respects the sovereignty of each. Economics remains a sticking point. The Gambia's low-duty policy on imports fosters a smuggling trade that deprives Senegal of millions of dollars in tariffs each year.

REPUBLIC OF SENEGAL:
AREA: 196,192 sq km (75,750 sq mi). **POPULATION:** 6,700,000. **CAPITAL:** Dakar, pop. 1,300,000. **RELIGION:** Muslim, Christian, traditional. **ECONOMY:** Peanuts, fishing, phosphate mining, cotton. **PER CAPITA INCOME:** $440.

REPUBLIC OF THE GAMBIA:
AREA: 10,403 sq km (4,017 sq mi). **POPULATION:** 800,000. **CAPITAL:** Banjul, pop. 44,500. **RELIGION:** Muslim, traditional, Christian. **ECONOMY:** Peanuts, fishing, palm products. **PER CAPITA INCOME:** $290.

Muslim and extremely poor. Together they are Africa's largest exporter of peanuts, shipping more than half a million tons annually. They must borrow money to survive economically, but both believe that costly dams across their namesake rivers would solve their future development problems.

Both countries are modern-day African legends. Author Alex Haley found his famous "roots" in the Gambia, while Senegal is renowned for its international diplomacy. Additionally, thanks to former president Léopold S. Senghor, Senegal is an African fountainhead of culture.

"The future lies in *metissage*, the blending of cultures," declared this professorial poet-president when we met at his Dakar retreat. "Remember, Picasso and others were inspired by African art. In Senegal I tried to blend Greco-Roman science with the black man's natural affinity for rhythm, creativity, and imagination."

Everywhere we traveled in Senegal, people were concerned for the future. Their confidence had been eroded by the drought, negative economic growth rate, inefficient bureaucracy, and low peanut prices and harvests. Even the amount of financial gain from the best tourist industry in West Africa has been disappointing. The economy of Senegal is in severe difficulty.

In the Gambia, on the other hand, there is an even larger consideration: whether the country will keep its way of life after being swallowed by its giant neighbor.

Despite all this, Senegambians maintain a firm belief in an adage of the dominant Wolof people: *Ndank-ndank mooy japp golo ci nyaay*, meaning "Little by little, the hunter catches the monkey in the forest."

In fact, Senegambia is more stable than most African nations; it has little trouble getting outside help. Not only is Senegal among West Africa's largest recipients of foreign aid, but it also is the model of the U. S. Agency for International Development program to French-speaking countries.

"SENEGAL has a state within a state," a development official told us one day. "The Muslim brotherhoods really call the shots. To understand what I mean, go to Touba, the holiest of Senegalese cities to the Mouride brotherhood." He explained that the Mourides make up about a third of the population and consider Touba, not

Capital assets *of Senegal's Dakar* ***(below left)*** *include more than a million residents and a typically French layout of gracious boulevards and plazas. Founded as a military post in 1857, Dakar became the political and cultural center of French West Africa. The Gambia's Banjul* ***(left)*** *bears its dusty, unassuming appearance with a stiff upper lip. Britain's imprint on the Gambia, its first African foothold, remains in rites like afternoon tea and cricket.*

Dakar, the real national capital. Aubine and I visited this small desert city during the Great Magal, an annual pilgrimage.

When we arrived, Touba was choking in 110°F heat and the dust stirred up by half a million faithful. They were commemorating the death of Amadou Bamba, who founded Mouridism about 1900. Over the flat plains they swarmed in, riding boxcars, trucks, and buses, in donkey carts, by Mercedes-Benz, and on foot. These disciples, or *talibés*, were answering the call of the Grand Caliph, the chief marabout, or holy man, of the Mouride theocracy, which is based on obedience and hard work.

In the distance the white minarets of Touba's mosque rose like some heavenly castle above the hubbub and the grit. The mosque was our destination, but we advanced at a snail's pace behind an unruly mass of human beings. Suddenly the crowd parted around a bull of a man dressed in a patchwork cassock who flourished a bludgeon high over his head. Then, poised like a statue, he abruptly crouched and lashed the club against his back, to the awe and approval of the crowd. Other men, dressed like him, chanted in a circle while he repeatedly clubbed his back, his foot, his hand.

With a start I realized that I knew him—he was Mahmadou Diop, a friend from Dakar. Known to thousands of soccer fans as Zorro, he had left the game and stardom to join the Bay Fall, the zealots of Mouridism. Zorro was now completely entranced, foaming at the mouth, sweat beading on his long, matted braids. Awakening, he saw us, not three paces away.

"Aubine, Michael!" With dignity he arose, touched our hands to his forehead in

typical Bay Fall greeting. In impeccable French he explained that he had just arrived at Touba after walking the 110 miles from Dakar. I looked at his bleeding feet.

"Barefoot?" I asked. "You walked here barefoot?"

"Barefoot, of course," he smiled.

"Why?"

"For paradise, and for my marabout."

ZORRO'S FERVOR was mirrored in the passion of every Mouride we met, though the Bay Fall were the most extreme. "The talibé is to his marabout as his marabout is to Allah," Zorro told us. "The caliph has but to say the word and I would slit my throat—or yours!"

At odds with orthodox Muslim teachings, the Islam of black Africa blends magic with a reliance on clergy and the veneration of saints. Islam teaches that Allah is directly accessible to each believer, but Senegalese Muslims hold that one is also linked to the Almighty through his marabout.

"No one high or low would make a major decision without a consultation," a presidential adviser informed us. "Even in Europe you find hundreds of marabouts serving the immigrant population."

During the Magal the faithful made it

In bountiful harvest, *peanuts are loaded on the Gambia River near the village of Juffure* ***(below)****. In Senegal peanuts are processed into oil and*

clear that we would be denied admission to holy places and treated with disdain in the streets unless we first obtained the Grand Caliph's benediction.

We quickly sought an audience with him. Past straining disciples, we were escorted through the palace gates to the sanctum. There we were warned to remove our shoes, avoid movement, and not to approach the caliph. An old man, he was seated behind the bars of a protective wooden cage on the other side of the room. He was corpulent and swaddled in deep folds of indigo cloth.

His gaze fastened on a little window to the outside world, past which filed his talibés. Each brought a gift—often money, or a goat or hen—which he slipped through the aperture; the caliph then chanted the briefest of prayers and spat into his disciple's upturned hands, as a sign of blessing.

I was spellbound by the burning hope in each talibé's eyes as he lingered to touch the old man's hands, stealing an extra half second with the divine. Then a policeman would shove him aside. Again and again the ritual was repeated. The silence and sanctity mesmerized me. I scarcely knew I was being ushered out of the room. Without speaking a word, I was assured, we had received the caliph's blessing!

*pellets for cattle feed (**right**). The 175-million-dollar combined crop provides 65 percent of the Gambia's export earnings and 25 percent of Senegal's.*

ARTHUR TRESS, MAGNUM (LEFT)

A scalloped hem of ocean *drapes the fishing village of Kayar, 25 miles northeast of Dakar. During the fishing season from October to July, the population of the*

village doubles. Commercial fishing and processing are burgeoning industries in Senegal, which exports some 150 million dollars' worth of seafood annually.

WHAT KEEPS the faithful coming to Touba? In colonial times the marabouts cooperated in developing a peanut-based economy. In return, the lands of the marabouts were rewarded with public works projects, such as roads. Their talibés became the most successful farmers in Senegal. Eventually the Mourides and other brotherhoods replaced the tribe in society's power structure.

After the Magal, a devoted Mouride named Ibrahim N'Jaye, owner of a seven-acre peanut farm, took me to his fields, where his two sons and other relatives were hoeing the dry soil. Times had not been good, he said. "We harvested only about $750 worth of peanuts last year." His sons supplemented this income by driving a bush taxi. "Of course," Ibrahim went on, "I give part of the harvest to my marabout. That way I am sure he will pray for me."

"You mustn't forget," historian Mohamed Mbodj cautioned on our return from Touba, "that Islam is on the move worldwide. Today's born-again Muslims perceive independence as an empty word, insofar as Senegambia is still dominated by Western interests. For them, Islam is a refuge from Western values."

Islam entered Senegambia in the 11th century. Little is known of earlier times. In the northern Gambia River basin, hundreds of megalithic circles dating from around A.D. 500 stand Stonehenge-like as testimonials to the pre-Muslim era.

In 1444 the region was discovered by the Portuguese. As the black Africans closest to Europe and the Americas, Senegambians soon attracted Dutch, French, and English raiders. All vied for the lucrative trade from Europe to Africa to America and back to Europe. They trafficked in ivory, gold, ebony, skins, but mainly slaves—labor for the New World. In exchange they offered trinkets, alcohol, old muskets, ammunition, and cheap cloth.

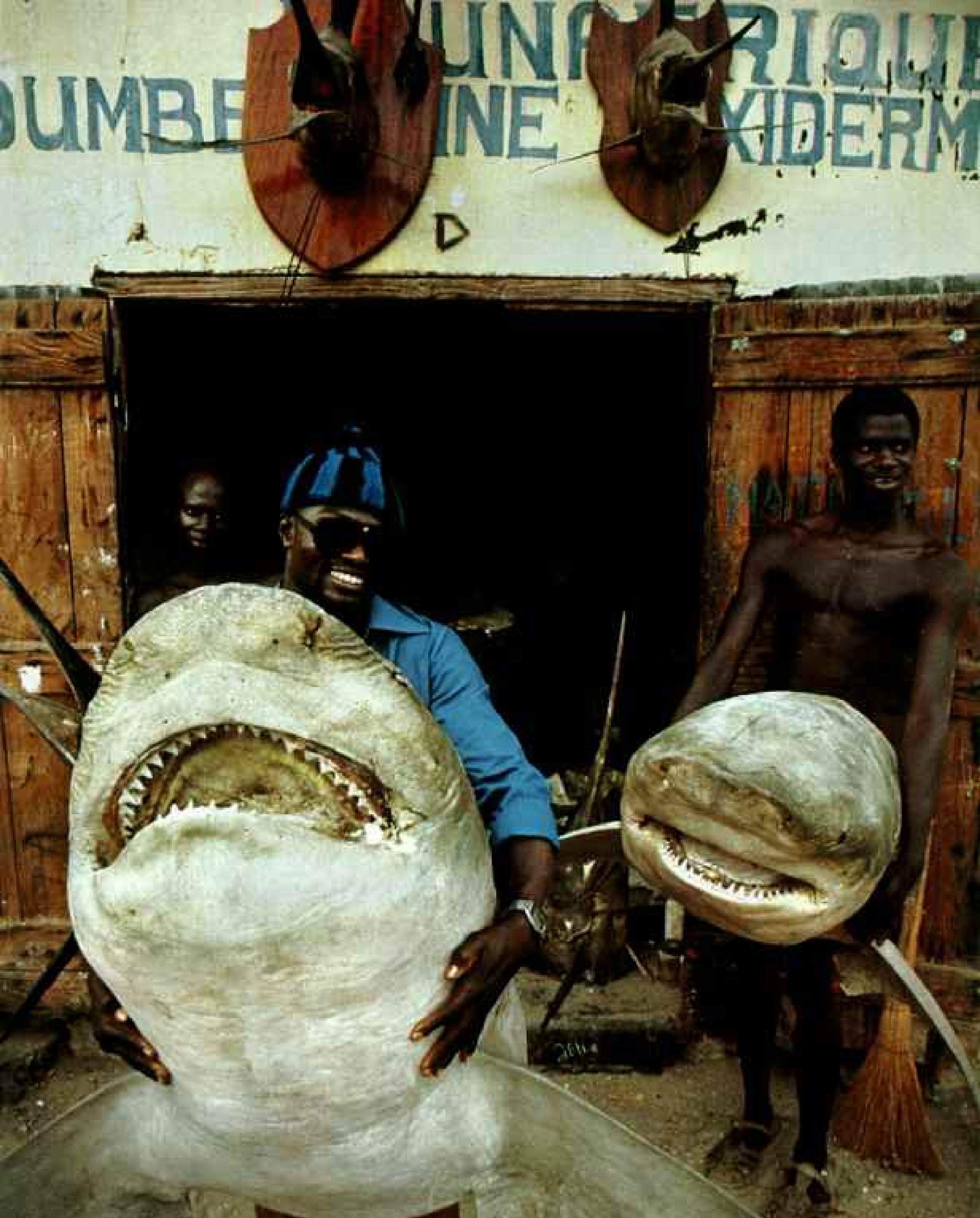
Around 1750 an obscure Mandinka village in the Gambia called Juffure may have given birth to a now world-famous native son, Kunta Kinte.

"The importance of Alex Haley's book *Roots* is bigger than the facts," asserted the Reverend Reginald Dalton, a North Carolinian we met in Banjul. He was referring to the belief of many historians that the African segment of the book was more fantasy than fact. "For us American blacks who cannot trace our exact ancestry, Juffure now symbolizes a collective hometown, a focal point within the immensity of Africa."

On a muggy August morning Aubine and I accompanied Mr. Dalton and his companions to Juffure. The village was like the others we had seen along the road: corrugated

Catch them if you can! *A taxidermist shop in Dakar* ***(right)*** *stuffs practically any trophy, including this pair of sharks. Big-game fishing for swordfish, tuna, and blue marlin helped lure 250,000 visitors—mostly Europeans—to Senegal last year.*

The Gambia, hoping for a greater share of the tourist trade, has established a hotel training school near Banjul with aid from the West German government. Here students learn the art of preparing and serving drinks ***(left)****. Last year the country's sunbaked beaches attracted some 35,000 tourists.*



Getting to the roots of Roots, *heritage hunters from the United States flock to Juffure in the Gambia* ***(above)****, where American writer Alex Haley traced his lineage to Kunta Kinte, the ancestor-hero of his book. In the center of the crowd sits Binte Kinte, widow of the storyteller whose narratives tied Haley's history to that of Juffure. A visitor flourishes a picture of a People magazine cover featuring Binte Kinte and Haley. The village of several hundred has become a Gambian national monument and mecca for black Americans seeking their cultural homeland in Africa.*

Island of shame and sorrow, Gorée ***(right)****, a 20-minute ferry ride from Dakar, was a transshipment point for tens of thousands of African slaves bound for the Americas. Discovered by the Portuguese in 1444, the island became part of the tragic history of slavery for more than 300 years. Today the island is crowded with pastel houses, some dating from the 17th and 18th centuries, and boasts several hundred inhabitants. In streets that once witnessed a commerce in human lives, women bargain for freshly caught fish* ***(above right)****.*

roofs atop whitewashed brick houses inside dusty compounds. A swarm of children assailed us as we arrived. The *alkalo*, or headman, was seated alone in the open.

He greeted us and summoned the villagers. Then two distant cultures melded in an instant of shared ancestry. Beneath a spreading mango tree, Americans and Mandinkas fraternized to crescendoing drumrolls; everyone was amused when the heavyset Mr. Dalton danced opposite a skinny native woman. As we left, his eyes filled with tears. "My life would have

***To nourish a taste** for life in the wild, Dutch researcher Marian Mensink demonstrates a tree pod's edibility to a gorilla in a rehabilitation program for captive-born primates in the Gambia's Abuko Nature Reserve.*

been incomplete without this day," he said.

With the abolition of the transatlantic slave trade in the early 1800s the French and British sallied inland, put down resistance, and relied on the peanut to make the colonies profitable. The British practiced indirect rule, while the French made Senegal a showcase for Gallic assimilation, whose goal was gradually to turn the Africans into good French citizens.

"When I was a boy, I used to tease my Senegalese cousins," said S.A.T. Wadda, the Gambian ambassador to Senegal, at his Dakar office. "Their schoolbooks told them that their ancestors were blond, blue-eyed Gauls. I told them, 'Why not? My great-grandmother was Queen Victoria!' "

After World War II, momentum for independence grew. Both Senegal and the Gambia built on their democratic experience to effect smooth transitions; Senegal gained independence in 1960, the Gambia in 1965. Then both halfheartedly worked toward closer cooperation until 1981, when a Marxist-bred putsch almost toppled the Gambian government. Invoking a mutual defense agreement, President Dawda Jawara asked Senegal for help, paving the way for the Confederal Pact of 1982. Today several protocols have been signed, uniting communications, transportation, and defense. Next will be economic union.

Aubine and I interviewed the two Senegambian presidents. The Gambia's Jawara is a grass-roots politician who has held power since independence. A former veterinarian, with penchants for gardening and golf, he is unassuming and down-to-earth. Predictions about the success of the confederation would be premature, he told us, though he felt optimistic in view of the nations' shared culture. "Economic union," he said, "will be the hardest to achieve."

Our first minutes with Jawara's counterpart, Senegalese President Abdou Diouf, were strained; initially he would not allow his eyes to meet ours. He has said that such reticence results from his school-days embarrassment over his six-foot-six-inch frame. When he spoke, though, Diouf was intense, confident, and cagey.

Readily admitting that the problems facing the confederation are delicate, he said that he preferred to emphasize generalities. "The small states of Africa are not viable entities," he declared. "We are an example for union on a much larger scale."

FROM THE MINUTE I met old Jobe, my Gambian driver, I liked him. But his way of speaking embarrassed me: He always called me master. It wasn't that he felt subservient—as former heavyweight wrestling champ, he was probably the best known sports star in the Gambia. No, his "master" was just his way of showing courtesy.

Doudou Jobe is the image of his countrymen—pragmatic, humble, polite. In fact, before the attempted coup of 1981, the Gambia was so peaceable that it had no standing

army, and police on the beat carried no guns.

One day I found myself with Jobe and our Land-Cruiser on the north bank of the Gambia River, destination Banjul, the nation's capital city, on the other side. Jobe looked glum. "I don't think master will catch the ferry today," he said ruefully. "It's broken down." I scanned the interminable queue of vehicles, sensing their drivers' frustration.

No bridge spans the river, which splits the country along its entire length. There are but two main ferry crossings within those 300 miles of river. Exasperating waits are common.

"They say maybe tomorrow morning," ventured Jobe. Maybe? I considered driving to the next crossing, 70 miles upriver, but settled for a motorized canoe. I'd worry later about the car.

ABOARD THE DUGOUT I stewed amidst motley passengers who seemed to take things in stride. Gradually the scenery soothed my irritation. The setting sun glowed warmly over the mangroves west of Banjul and created dazzling reflections off hundreds of metal roofs. To the east, gulls flew lazily along the flat gray horizon. A larger canoe loomed ahead; I noticed it carried stacks of boxes with Japanese trade names: Pioneer, Akai, Sony, Sanyo—part of the booming contraband, or "re-export," trade of low-tariff goods into Senegal.

I leaned into the spray and mused about a confederation between countries that have no uninterrupted overland link between their capitals. A confederation where it takes longer to phone Banjul from Dakar, or vice versa, than to call Washington, D. C., from either one; and where a major portion of the commerce is illegal. I asked Jobe what he thought about this.

"I think that master is concerned about things for presidents to decide," he replied. "For me the Banjul ferry is not important—Senegambia is the reality. We Gambians all have families in Senegal; when we want to see them, we go as we please. On many roads there are even no official border crossings."

Other Gambians don't see the union quite so philosophically. An official of the Gambian Chamber of Commerce called the confederation a catastrophe for Gambian businessmen, who are afraid that uniform customs duties will spell doom for their re-exports. But even he looked upon the union as inevitable.

"It's coming, and we're not prepared," he moaned. "We'll just become another Senegalese province, and a poor one at that!"

Not necessarily, claimed Gambian entrepreneur O. B. Conateh, who owns a seafood factory outside Banjul. He urged his fellow businessmen to be more aggressive. "I started out just a few years ago," he told us. "Now I export frozen fish and shrimp throughout Africa and Europe. We must learn to compete. I offer superior services at better prices, and I'll go nose to nose with anyone in the business!"

As we traveled about the Gambia, we often had the feeling of being inside a fairy-tale land, where lilliputian questions became gargantuan when put into local perspective. Officials were concerned that we speak of the modern buildings in Banjul, not just the metal-roofed variety. Though on an international scale it may seem insignificant, Gambians are justly proud that the 35,000 European tourists who flock yearly to the Gambia's sunny beaches make it one of West Africa's most popular vacationlands.

Gambians see the Senegalese as great bluffers, slightly arrogant, but generous. And they disdain the bureaucracy and protocol of their francophone cousins. "We're simply not as British as the Senegalese are French," the head of a women's group in Banjul told Aubine. "However, we Gambian women can certainly benefit from Senegalese organizational skills. We hope that the framework of Senegambia will allow us to share the best of both worlds."

THE MAGIC DRUM boomed in the sacred forest for the first time in 25 years. It summoned people of Brinndiago, in Senegal's Casamance region, to celebrate Bukut, the mysterious initiation ritual of the Diola, largest ethnic group in the region. Many more years would pass before the village would hold its next initiation. Celebrants came from afar to send the candidates off for two months into the sacred wood, where they would learn tribal customs and lore.

"On this day, status counts for nothing," declared our companion, Jean-Bernard

Passage to manhood *in a Diola village occurs once every 15 to 30 years. The Diola occupy the Casamance region in southwest Senegal. The ceremony, known as Bukut, is announced by a sacred drum played by an elder. Before the rites begin, a male relative shaves each initiate's head* ***(right)****. Later, villagers and guests form a circle around the initiates, and dancing erupts* ***(below)****. The boys are led to a sacred grove, a spot at least a few hundred yards from the village. They undergo circumcision and spend two months learning the responsibilities of adulthood. A hunter figure* ***(facing page)*** *sweeps a cutlass over his tongue, apparently without injury, to demonstrate to initiates the power of their coming rites and as a tactic in teaching them to face their fears.*

Shriveled by drought, *cattle carcasses belonging to a Fulani herdsman bleach on parched land near St. Louis in northwestern Senegal (**above**). The Sahel, or desert borderland, suffers from intermittent drought that turned catastrophic in 1983. Dams planned for the Senegal and Gambia Rivers could supply water to land along their banks, but controversy hampers the projects. Critics worry that the dams may jeopardize the ecology, cause colossal resettlement problems, and exacerbate the spread of disease from stagnant water backed up behind them. Near Senegal's northern border a tent shelters two children (**left**), refugees from even worse devastation in neighboring Mauritania.*

Coly, a Diola dancer and drummer, member of the Gambian National Troupe. "In the eyes of the village a mature man, even a high functionary, is on the same level as the little boys who will also be initiated; until all have finished, we cannot consider them adults."

We stopped opposite a line of men who blew shrill whistles and stomped their feet as they advanced.

Following them to a crowded field, we fastened our attention on 30 or so men and boys who were crouching with arms stretched high. Their naked torsos glistened with sweat. "Candidates for initiation," Coly explained. "They are offering a prayer to their ancestors."

Krr-boom! . . . Krr-boom! Huge balls of musket smoke wafted skyward. Musketeers staggered, stunned by the force of their own detonations. Others pointed shotguns at the ground—Krr-boom! Men and earth rebounded in black plumes of smoke.

Next to me, women sang and clanged on hoes and sickles. Magicians tested their flesh with sharp blades; children shrieked; drums and guns boomed. The effect was numbing. Coly screamed in my ear, "Today is finished. Tomorrow the candidates will enter the sacred wood!"

MORNING. The candidates huddled together silently under an open hut while their aunts prepared their last meal. Men arrived to shave the candidates' heads. Then others wrapped them in thick vines and dragged them over the ground. Demonstrating courage and willpower, the initiates resisted, tried to break free. Flesh torn, they must not complain or utter a word.

"The infant must disappear," Coly told us. "A grown man must emerge. Some may not return. Some may die from the transition or be trapped by evil spirits."

The villagers ate in silence while time slogged in the murky heat. It started to drizzle. From somewhere afar we heard a faint drumming and gunfire.

The crowd erupted with shrieks and whistles, and the candidates danced from their compound, running out into the fields. Hands restrained me; I could only watch from a distance.

The initiates wound ever closer to the

The magnetism of faith *draws thousands to Yoff, a village north of Dakar, where adherents of the Layenne sect gather to celebrate the last day of Ramadan* ***(above)****. The brotherhood, founded in 1883, is centered in the Cap Vert region. The Layenne proclaim a belief in both Christ and Muhammad. A nearby grotto, alleged to be the place where Muhammad's spirit dwelt for 1,000 years before his reincarnation as the sect's founder, contains perfumed sands collected by believers* ***(right)****. Islam spread to Senegal in the 11th century, but widespread conversion of the populace dates primarily from the 19th century.*

Senegalese Islamic belief is perpetuated by three major brotherhoods as well as the Layenne: the Mouride,

Tijaniyya, and Qadiriyya. All stress the holiness of religious leaders, who may serve as intermediaries between the individual and Allah. Polygamy, permitted under Islamic law, is allowed in Senegal, but before marriage the groom must declare his intention to be either monogamous or polygamous. Once made, the decision is irrevocable.

Senegambia: A Now and Future Nation

entrance of the sacred wood. There they stopped, and women gave them water. This was their last libation; from here, no woman or non-initiate could proceed.

In their last act of childhood, they danced a tumultuous farewell to deafening musket fire. At sunset they entered the wood, men and older boys pushing the little ones ahead, telling them not to be afraid.

THE DIOLAS REPRESENT only 6 percent of Senegal's population but hold one of its richest regions, the isolated Casamance. It is largely underdeveloped, however, and its people feel forgotten by planners. "We are the milking cow that no one wants to feed," complained a farmer. Indeed, so strong is the frustration over Dakar's ineffectual approach that a Casamance independence movement has ignited violent riots during the past few years.

Despite ethnic and regional rivalries, we found many examples of nationwide reevaluation of past and future directions. The sense of nationhood was proving much stronger than factionalism. Austerity measures and a crackdown on corrupt officials have recently been implemented.

Perhaps the most pressing and controversial issue remains: the drought. We headed north to the Senegal River Valley, where a sweeping development program calls for construction of two dams, one at the mouth of the river and the other across the border in Mali. The dam near the ocean will combat saltwater intrusion into Senegal; the reservoirs of both, it is hoped, will rid the valley of the effects of uncertain rainfall.

Our trip began badly when I phoned Boubou Sall, then mayor of Podor, Senegal's northernmost city. He bluntly declared that he had no time for "pretty-picture takers." Then smoldering worry erupted. "We had just one rain this year, our crops have failed; in weeks our children may be dying. After that, who knows? Our wells are dry, our villagers live in despair, the state promises but sends nothing. What is here for your magazine?" He slammed down the phone.

As we moved north, it became apparent that he had not exaggerated. Forests of dead trees stood beyond the road. Herders were frantically selling their cattle at $20 a head, against the normal price of $200, for fear that entire herds would perish, leaving them nothing. We drove through a constant, wailing sandstorm that swept out of the Sahara. It battered our car and our nerves and transformed villages into eerie, silent figments, like an old-time grainy picture show.

Sometimes we saw a large water truck parked beside the road. Women and children, clothes and hair buffeted by the swirling red dust, clung to the truck holding out cups and plastic cans. The state had sent water. Another six months would pass before the next rains. Would the trucks keep coming? I wondered.

"THE ULTIMATUM is clear," declared Mansis Firmin, an official of Senegal's Delta Land Development Agency. "Unless something is done, the whole Senegal River Valley will die." His organization carves out rice fields along the delta, with mixed results. "We now import more than 35 percent of what we eat; we're counting on the dams to make us self-sufficient in food and to revitalize the north."

Unfortunately the dam system, scheduled for completion by 1988, may open a Pandora's box of problems. Diseases from stagnant water could spread. Fishing in the delta, on which the inhabitants depend for protein, will be greatly disturbed. The land to be irrigated could even prove unfit for agriculture because it is rich in salt. And, in the end, food may prove more expensive to grow there than to import.

"Clearly," said American Peter Weil, who has studied development in Senegambia since the seventies, "the most damaging result will be social upheaval. The peasants will become little more than sharecroppers

L'Afrique la chic: *Two Senegalese secretaries relax after working hours beneath a portrait of a marabout, or holy man. Their dress reflects the emphasis placed on clothes in the French-oriented culture. "Downtown Dakar is a living art show of femininity," says author Michael Kirtley.*

for huge corporations. Sadly, these farmers were never seriously consulted; they feel coerced by bureaucracy."

Weil, an anthropologist, added that policies are often generated by foreign consultants. Their programs benefit mainly the international technical firms that design them and the bureaucrats who run them.

"The state just gets itself deeper into debt," he went on. "Development has hurt people more than it has helped. For example, the life expectancy of certain Mandinka women has dropped from 45 to 38 years because peanuts have replaced the traditional crops in the uplands. The planners, strangers to Mandinka customs, called for men to grow the peanuts—women were left to raise rice, the main food crop, in the swampy fields in the lowlands, which they reach only after two or three hours of walking. They labor in very unhealthy conditions. Is this progress?"

U. S. economic aid totals 60 million dollars a year. Between 75 and 80 percent of all project funds never leaves American hands, an official of the Agency for International Development informed me. A few of the low-budget projects are doing well, he said—fisheries, crafts, forestry. But most funds allocated to large, costly projects actually are spent on U. S. infrastructure, such as consultants, technicians, and equipment.

All aboard who can squeeze aboard *seems to be the rule as a train* ***(left)*** *leaves the Mouride holy city, Touba, after the end of the Great Magal, an annual Islamic pilgrimage lasting several days. As many as half a million followers of the Mouride Islamic brotherhood gather from as far away as Paris to honor founder Amadou Bamba. Talibés, or followers, come to offer their caliph money and gifts in exchange for blessings* ***(below)****. In Senegal, where 90 percent of the people practice Islam, such sects carry significant political and economic clout.*

SOPHISTICATED DAKAR confronts these problems at long range. The city sprawls at the tip of Cap Vert. Cool ocean breezes and affluence buffer it from the desiccation and poverty of the countryside. Dakar combines the elitism of Paris with the partying atmosphere of a Riviera resort, yet also is a haven for street hawkers, beggars, and pickpockets.

Dakar is the capital of African chic. When Aubine, a smart Parisian, first arrived in the city, she felt like a hayseed amidst the exotic billowing robes and ornate tresses of Dakar women. An important measure of a man's status, she was informed, is the beauty of his wife. But I couldn't discern a wealthy socialite from a secretary. They all were elegantly garbed—and beautiful.

"Dakar women are keenly aware of one another," a women's leader told Aubine one day. "Even if we can afford help, we are very good at cooking our own meals. We don't want our husbands' eyes to roam."

Fatou Sow, a researcher at the University of Dakar, noted that Senegalese women are encouraged to obtain an education. "We have excellent examples to follow—women jurists, doctors, professors, merchants, even female members of parliament, and ministers. Of course, especially in the villages, the role of women is still greatly controlled by men."

Polygamy, permitted under Islamic law, is another factor, according to Mrs. Sow. "City women don't like the idea. I know I'd find it hard to share my husband with another woman. On the other hand, village women can sometimes use the extra help."

For all but the very poor, Dakar has distinct heartbeats, the African and the French. By day the skyscraper-ringed Place de l'Indépendance pulsates like Paris. Sidewalk cafés are filled to overflowing with businessmen; students migrate from bookstores to pastry shops. In the afternoon rush hour irate drivers honk, secretaries scream for taxis, and gendarmes blow whistles—all to little avail.

After working hours, Africa invades the city like a sigh of relief. The Place de l'Indépendance is empty. In residential areas families relax, chatting softly outside their homes, awaiting dinner. A French ambience lingers in softly lit restaurants and neighborhood theaters; by midnight it has vanished. The beat of reggae throbs in a few shops and discos, and tourists make merry at beachside hotels, but their clamor doesn't reach city streets. Mostly, African Dakar sleeps.

A Senegalese cultural philosopher named Joe Ouakam cruises Dakar's streets on his bicycle, musing on the passing scene. Goateed and pipe smoking, he has little use for the French veneer. "We're really an oral people, we Senegalese," he said to Aubine and me. "But we're caught up in the French modality, the Napoleonic logic."

He pointed down the street. "Look at those men. They are glued to their business suits, glued to appearing French. You can even tell where in France they acquired their accents." He drew on his pipe. "When we think culture," he went on, "we must stop thinking about actors on a stage or little drawings in a gallery. That's not us, not Africa. We must learn to dream differently before our country can succeed." Joe Ouakam laughed. "If I'm ever elected president, I'll transform the ministry of culture into the ministry of imagination."

Brotherly leaders: *Abdou Diouf (**above,** at right), Senegal's president since 1981, has favored union of the two nations since he helped save the Gambia from a military coup. Gambian leader Sir Dawda Jawara, left, hedges the question. Fabric worn by a mother in Banjul offers a portrait of the two (**facing page**). How interwoven their nations will become—and how quickly—remains uncertain.*

NEAR THE END of our long stay Aubine glimpsed some of that imagination. She visited Saam Njaay, a Senegalese village where former Peace Corps volunteer Molly Melching was serving as a development counselor.

"We took the slow, people-to-people approach," Molly said. "We asked what they wanted and waited patiently for the answers. The first step was to teach the villagers to read in Wolof, their native tongue. Now, two years later, Saam has a health program, vegetable gardens, a tree-planting project, experimental cook stoves, and a children's theater, all primarily financed by the people themselves."

That afternoon Aubine heard elders from Saam and neighboring villages discuss the location of a permanent health center. Each elder expressed his opinion. At the end Saam's old chieftain spoke softly. "The important thing is not where but whether the center is built. We cannot afford to fail if we wish to keep our young next to us in our villages. With determination we will succeed!"

When Aubine told me of this, I was reminded of the old Wolof saying about how the hunter catches the monkey. The key words to remember, I thought, were *Ndank-ndank*, "Little by little." □


PERSEVERANCE STREET

The Land Where the

THE MOTH HUNTERS had been going into the Snowy Mountains, the highest land on the Australian Continent, for more than 4,000 years. They went in the spring, when the fields of snow daisies bloomed on the hills and the smell of heath filled the air on warm nights.

With kangaroo skins and fine nets of bark fiber, they collected the moths by the thousands and roasted them in hot ashes. They delighted in their sweet, nutlike flavor and grew fat eating them.

On the rocky pinnacles where the bogong moths still congregate in the spring, small streams are born from rain and snowmelt. Through bogs of sphagnum moss the streams trickle down the mountains, and several always merge on Cowombat Flat, a lonely plain known mainly to cattlemen. Thereafter, this solitary stream is called the Murray.

From this inconspicuous birth at the southern end of the Great Dividing Range, the Murray River flows 1,170 miles west, forming the boundary between New South Wales and Victoria. On its lazy, serpentine journey it is joined by more than a dozen tributaries, including the Mitta Mitta, the Ovens, the Goulburn, the Campaspe, and the Loddon from the south and the Murrumbidgee and the great Darling River from the north. For its last 400 miles the Murray flows through South Australia, cutting through deep limestone canyons, vestiges of ancient seabeds, and spilling into two shallow lakes and an 80-mile salt lagoon, The Coorong. And finally, through a maze of shifting sandbars, the river meets the Indian Ocean (map, pages 256-7).

The combined Murray-Darling is Australia's greatest river system, flowing some 2,300 miles from its headwaters to the sea and draining 410,000 square miles, one-seventh of the continent. By world standards it ranks only sixteenth in length, and its average runoff is only 25,000 cubic feet a second, a small fraction of the Amazon's. In fact, on any other continent, it would be worthy of no special attention. On such a dry, flat landmass,

Reining in for a break, *cowhand Kay Sinclair relaxes in the Snowy Mountains, source of Australia's greatest river, the Murray. Nourisher and destroyer of land, the river remains indispensable—and indomitable.*

Murray Flows

By LOUISE E. LEVATHES
NATIONAL GEOGRAPHIC EDITORIAL STAFF
Photographs by
DAVID ROBERT AUSTEN

however, any river is a blessing, and the Murray-Darling is a paragon.

The Murray provides the major portion of all water used in Australia. Its basin is the nation's food and fiber basket. Half of Australia's grains, fruits and vegetables, meat and milk, and cotton come from the area, as well as 40 percent of the country's wool. In the last drought (1979-1983), one of the worst since European settlement, the river was the lifeblood of southeast Australia.*

Yet this river system is a capricious mistress. Despite man's attempts to tame it with dams and weirs, parts of the Darling ceased to flow at all in the last drought, and the mouth of the Murray silted over. Heavy rains, however, can easily cause it to spill its banks and spread for ten miles over the adjacent countryside. Its essential character is unpredictable. All life around the river has adapted to this variability.

The life cycles of native fish and waterfowl are linked not just to seasons but to floods, when food is plentiful. And, to withstand the extremes of the climate, the shells of some indigenous plant seeds have become so hard that it requires the heat of a bushfire to open them for germination.

European man has lived along the river for just 150 years. And his shell is still toughening.

***In the high and mighty country** of the Snowy Mountains (**facing page**), riders cross the headwaters of the Murray. Cattle are left to graze in summer and are herded down before the first snowfall in May. But grazing is off-limits in Kosciusko National Park in New South Wales, where a late winter snow has surprised a kangaroo and her joy (**above**).*

I HEARD Sandy's truck pull in at the homestead on the upper Murray. The sun hadn't yet peaked over the mountains. He had already been out to inspect the stock he runs at the cattle station named Tom Groggin.

"Damn dingoes," he muttered.

In the back of the truck was a dead, mangled lamb. Hardly a night had passed in this lambing season that he hadn't lost one to the dingoes or to the wild crossbreed dogs.

"They seldom eat their kill; they just do it for sport, the damn pests!"

He gave the lamb carcass to his dogs.

Sandy Frickleton, a lean man with bristly red sideburns and blue eyes, was born in southern Scotland, the son of a miner. He came to Australia in the late fifties to work on the Snowy Mountains Scheme, a huge hydroelectric and irrigation project that diverts the water of the Snowy River west into the Murray.

But he soon traded his tractor for a horse and taught himself to ride and muster cattle. At 43 he has never married, but from time to time he hires jilleroos (female station hands) who, he says, "work betta than men a' times, and make life a wee bit more interest'ng."

A jilleroo is one thing. Taking a woman

*Thomas Y. Canby told of this drought and its 2.5-billion-dollar cost to Australia in "El Niño's Ill Wind" in the February 1984 GEOGRAPHIC.

writer into the mountains to bring down the last cattle before winter is quite another. I asked him if I could go along.

"I won't hold you up," I promised.

He didn't believe me, but he didn't say no.

We headed out that morning with Rudd Ross, who is a part-time hand, and three kelpies, cattle-wise herding dogs. The sun had taken the mist off the paddocks and turned the grass emerald green. The drought had broken, and new life was returning to the earth. At the edge of the property something caught Sandy's eye.

"A brumby taken up with some o' me mares. . . ."

A wild black stallion with a long mane and sweeping tail strutted at the far end of the paddock around six of Sandy's mares. When he sensed us, he lunged into the forest. "In the spring, afta' a hard winter an' poor feed, is when ya catch 'em," said Sandy. "'Spect I've chased down near as many brumbies as old Jack Riley did in his time."

Riley, an early manager of Tom Groggin, was reputed to have been a daring horseman. A Sydney tailor, he came up to the Snowy Mountains in the 1860s, not long after the "mystery" of the westward-flowing rivers had been solved.

IN 1824 Australian explorers Hamilton Hume and William Hovell crossed the upper reaches of the main river, which was later named for Colonial Secretary Sir George Murray; Capt. Charles Sturt discovered the Darling in 1828. All hoped the

Australia's Murray River

"GOING SOU'WEST we were stopped by a river," recounted explorers William Hovell and Hamilton Hume upon discovering the Murray in 1824. The Murray and Darling Rivers are the major components of a system that drains 410,000 square miles—nearly the combined size of France and Spain. Taking its own sweet time, the Murray flows an average three miles an hour. Some 350 bird and 28 fish species, including the delectable Murray cod, depend on it. The river, in infancy a modest conjoining of snowmelt trickles, ends without fanfare. Forty miles from the Indian Ocean, it dissipates into two large lakes and an 80-mile lagoon before staggering over a series of sandbars to the sea.

rivers would lead to some great inland sea, and feverish exploration continued into the 1850s. It yielded no such prize, but reports of excellent grazing land touched off a pastoral boom.

Riley was among the first cattlemen to regularly use the high country in the Australian Alps for summer grazing. He loved to chase brumbies and once dived his horse over a cliff in a daring ride. The feat inspired bush bard A. B. "Banjo" Paterson's famous poem, "The Man From Snowy River":

There was movement at the station,
for the word had passed around
That the colt from old Regret
had got away,
And had joined the wild bush horses—
he was worth a thousand pound,
So all the cracks had gathered to the fray.
All the tried and noted riders
from the stations near and far
Had mustered at the homestead
overnight,
For the bushmen love hard riding
where the wild bush horses are,
And the stock-horse snuffs the battle
with delight. . . .

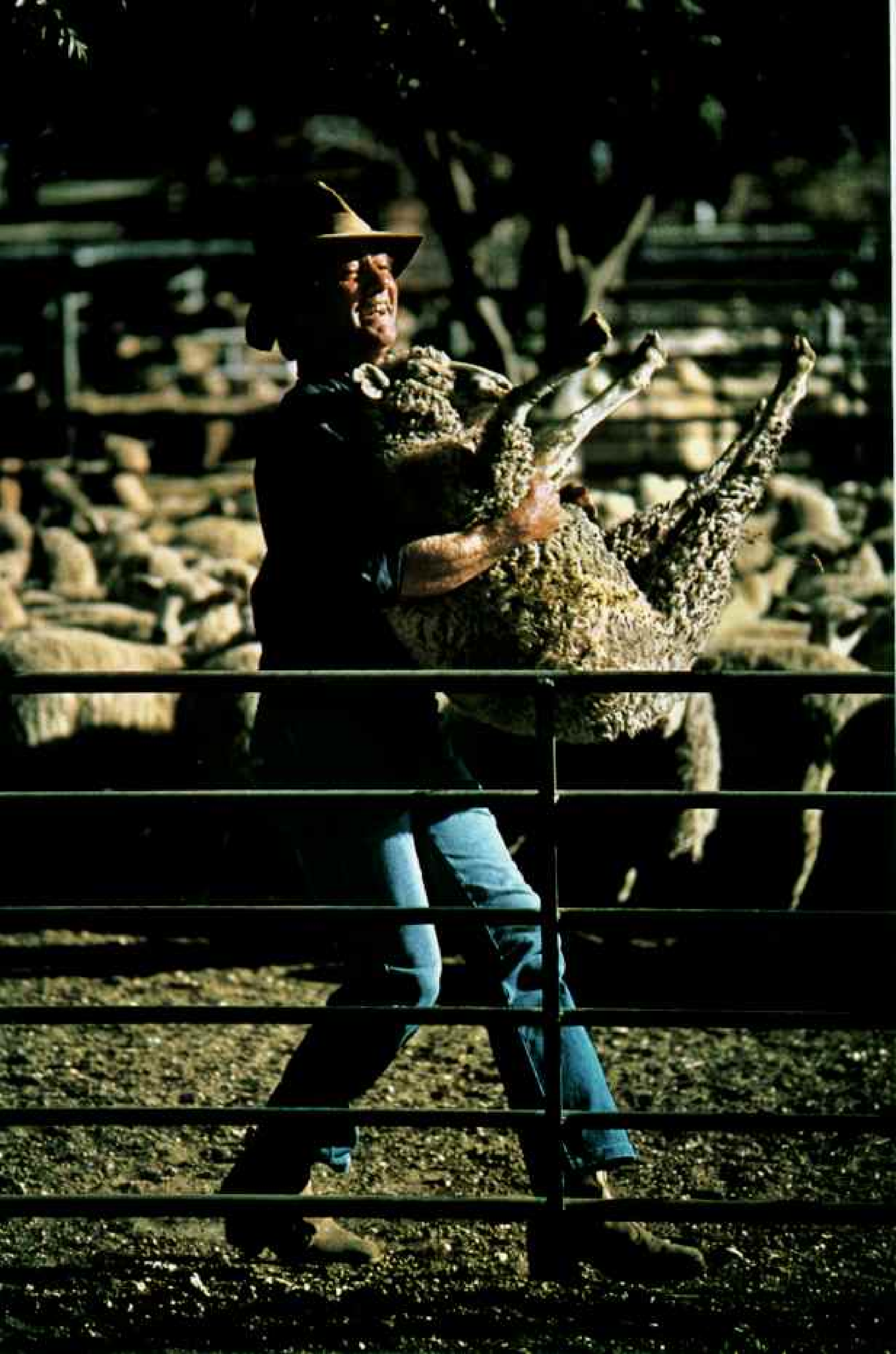
Sandy's horse pricked up his ears, eager to give the black stallion chase, but the bushman reined him toward the mountains.

"Not today, Pie."

The trail narrowed. The Murray soon flowed a hundred feet below us, a clear stream 25 feet wide, through steep ridges of

Turning every which way, *the Murray curls through an area known as the Dora Dora Flats, upstream from the Hume Dam—one of about a hundred dams and weirs that harness the water for man's use. The Murray basin contains more than 75 percent*

of Australia's irrigated land. Billabongs, or cut-off backwaters, bracket the river. So convoluted is the Murray's course that a fish headed downstream to the sea would actually have to travel three times the distance of a bird flying from start to finish.



alpine ash, peppermint trees, and thick tangles of blackberry bushes.

Sandy could sense the slightest clues—broken twigs, missing bark, patches of torn earth—to the missing cattle. I began to think he could smell them. With a sharp whistle he dispatched his dogs across the ridges; they seldom returned without a stray cow or calf, barking and nipping at its heels.

By the end of the afternoon we had collected more than 60 cattle, docile now, as if they knew the snows were coming and they'd be better off at Tom Groggin.

Night fell as we crossed the Murray. The wind picked up and sent a chill through me. "Some nights it's so cold," said Rudd, "you have to put your words into a frying pan to warm them up."

The cattle safely down from the mountains, we galloped back to the homestead, through streams, up banks, across stretches of open fields under the stars. Soon I could see nothing but the white tail of Sandy's horse in front of me. A rock or a wombat hole would have brought me and my horse to the ground. Cattlemen first learn to trust their horses. And so that night did I.

THE PROMISE of fertile land in the Murray Valley attracted men from Sydney and other coastal towns. Gold lured them as well. Edward Hargraves, an adventurous Englishman, discovered the first glimmering grains in a tributary of the Macquarie in 1851, and within a year finds south of the Murray started one of the greatest gold rushes the world has ever known.

The decade that followed, a time of high expectations and dashed hopes, created a breed of strong-willed men determined to master their own destiny. Their rebellious spirit marked the beginning of Australia's efforts to become an independent nation.

Gangs of horse-rustling bushrangers sprang up in the Murray Valley, but none achieved the notoriety of young Ned Kelly's band. Of an Irish immigrant family living south of the river, Ned was tall, handsome, a champion boxer, and a snappy dresser.

In a three-day raid on the town of Jerilderie in 1879, the gang locked the police in the jail, then proceeded to rob the bank and put on a display of horsemanship for cheering onlookers before riding out of town. For their final stand at the inn in Glenrowan, the gang forged plows into suits of armor. After a fierce 12-hour battle, all were dead except Ned. He survived his 30 wounds, only to be hanged months later in Melbourne.

Before the hangman adjusted the noose, Ned said, "Ah well, I suppose it has to come to this. Such is life." He was 25.

The land south of the Murray around Glenrowan is the center of "Kelly country," and visitors crowd the Kelly Museum in Benalla on holidays. Clearly Australians won't let the Kelly legend die.

"A small farmer was nicknamed a 'cockatoo' or 'cocky' because, like the bird, he scratched a living from the ground," said Professor Geoffrey Blainey of the University of Melbourne, historian and author. "His dream was to be his own boss, and he mistrusted authority. Ned embodied that spirit. He outwitted the police for 20 months and sometimes made them look ridiculous."

The cocky spirit is kept alive today by Australia's most beloved song, about a vagabond who steals a sheep and rather than be caught commits suicide:

Up jumped the swagman,
sprang into the billabong,
"You'll never catch me alive,"
said he.
And his ghost may be heard as you
pass by that billabong,
"Who'll come a-waltzing Matilda
with me?"

THE ADVENTUROUS cockies who settled the Murray basin soon got their taste of the capricious nature of the rivers. In 1852 a great flood burst the banks of the Murrumbidgee and wiped out the original village of Gundagai, drowning 89 of the

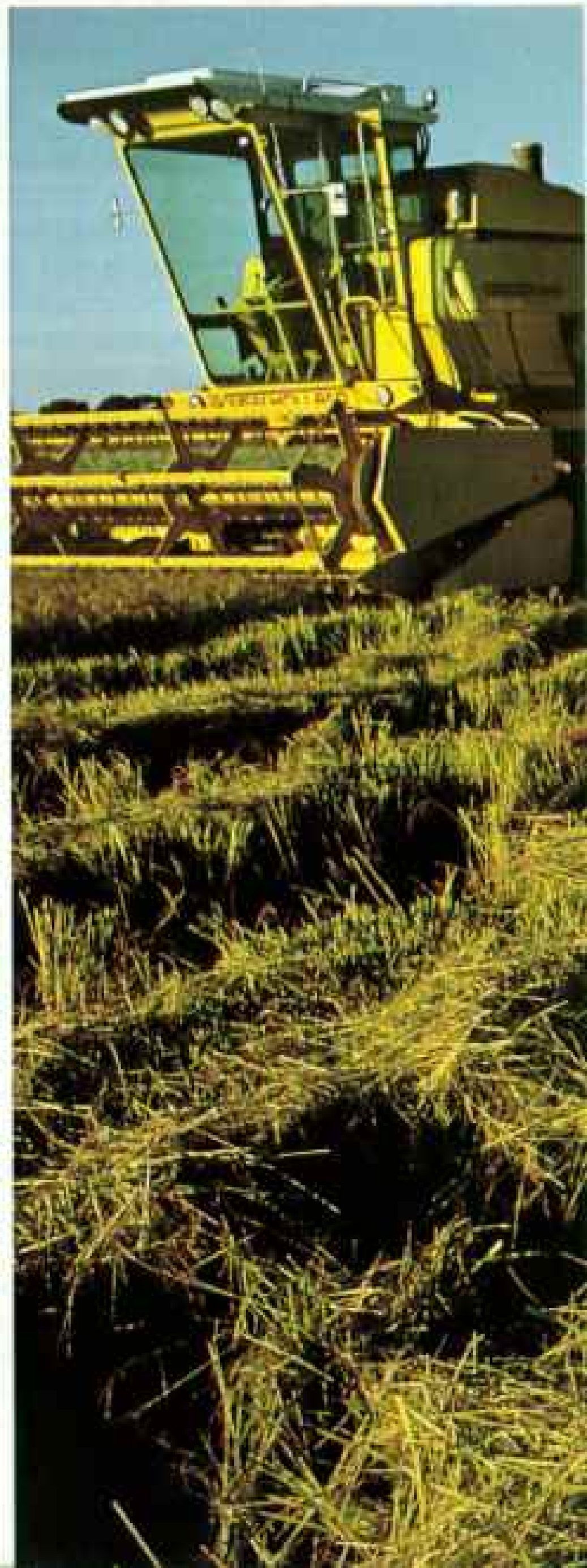
Hefting a hundred woolly pounds *over a stockyard pen, Murray Monk sorts sheep at Swan Hill's municipal sale yards. The advent of the paddle steamer in the mid-1850s reduced the cost of shipping wool. Today pastureland in the Murray basin nourishes half of Australia's sheep.*

town's 250 people. Droughts, which followed with relentless regularity, were even more devastating.

Irrigation began tentatively on both sides of the Murray in the 1880s. The Goulburn Weir was built in 1890, opening 775,000 acres of fertile land; the Hume Dam, built in 1936, impounds an inland lake six times the size of Sydney Harbour. Recently completed Dartmouth Dam, which is even larger, has, so far, assured the flow of the Murray even in droughts.

Irrigation communities expanded dra-

***High-yield harvests** are the watermark of the Murray basin, source of eight billion dollars in agricultural income—nearly half the country's production. In Barmah Forest, river red gums are sawed into crossties **(below)**. Because irrigation has disrupted seasonal flooding vital to the tree's life cycle, logging is now reduced. Janice Kernich serves tea to husband Rex **(below,** at left) and helper Paul Gibbs on their rice farm near Deniliquin. The region will produce 940,000 tons of rice this year.*



DAVID S. SEGAL

matically after both World Wars to provide homes and livelihood for returning soldiers. Today there are nearly a hundred dams and weirs along the river system, and three million acres have been opened for irrigation, 75 percent of Australia's irrigated land.

As eager farmers flooded their thirsty fields with open irrigation channels, trees—natural pumps that keep the water table down—were rapidly destroyed by lumbering or farm clearing. The pioneers soon discovered they were living over a great salt basin, left from an intrusion of the sea millions of years ago. The lower Murray is naturally salty, but wasteful irrigation all along the river raised the water table, bringing up more salt with it.

Low-lying areas went first. Trees died, then farms became fenced paddocks of dust and saltbush. In the 1930s half the pastureland around Kerang, Victoria, went out of production. Trouble also sprang up in the 1960s across the river in Wakool, New South Wales, after two decades of water-intensive rice growing, and 10 percent of the farmland became unproductive. Now

Check-in *was a century ago; now rooms at the Bridge Hotel in Echuca* ***(above)*** *are for display only. The hotel, built in 1858 by Henry Hopwood, an ex-convict, was restored and opened as a restaurant in 1975. Hopwood set up a cattle crossing near the confluence of the Murray and Campaspe Rivers in 1853, and three years later the first paddle steamers arrived. With the extension of the railroad from Melbourne in 1864 his crossing became a vital transshipment point for inland commerce, an aspiring Chicago of Australia. In 1880 Echuca's port handled some 13.5 million dollars' worth of goods; its wharves could unload seven steamers at once. But the railroad's thrust into the outback ruined riverboat trade, and Echuca became an economic backwater. In today's town of 8,400, the annual Rich River Festival celebrates Echuca's heritage with a procession of steamers. The Pevensey* ***(above, right)****, temporarily renamed the Philadelphia for its role in "All the Rivers Run," an Australian television mini-series, recalls days when paddle steamers brought wool from the outback and distributed luxuries like tobacco, beer, and pianos. Nostalgia for four-footed transportation is celebrated in Nyah, Victoria, where the annual Harness Driving Championships put horse-and-driver teams through a red-gum-marked course near the river's edge* ***(right)****.*


PHILADELPHIA

salinity endangers a quarter of the land near Shepparton, in the Goulburn Valley, a center of Victoria's lucrative dairy industry.

Henri Vegter, a farmer from Gippsland in southern Victoria, put his life savings into a dairy farm 20 miles from Shepparton and moved there with his wife and young children a few years ago.

"That first winter was one of the wettest on record, and the salt in the rising water table destroyed 15 feet of good pasture a month," he said. "I'd see the gray fingers moving across the green paddocks—and smell them. It was like rotting seaweed.

"A lot of farmers at first didn't want to admit they had a problem with salt, because their property values would fall."

Vegter organized 26 of his neighbors and succeeded in getting a commitment from the government of Victoria to put in a million-dollar drainage scheme. He has survived by cutting down his herds, leasing land, and buying feed. He's worried. Will the drainage scheme work?

Vegter bit his lower lip. "They say it will. I don't know. It must. . . ."

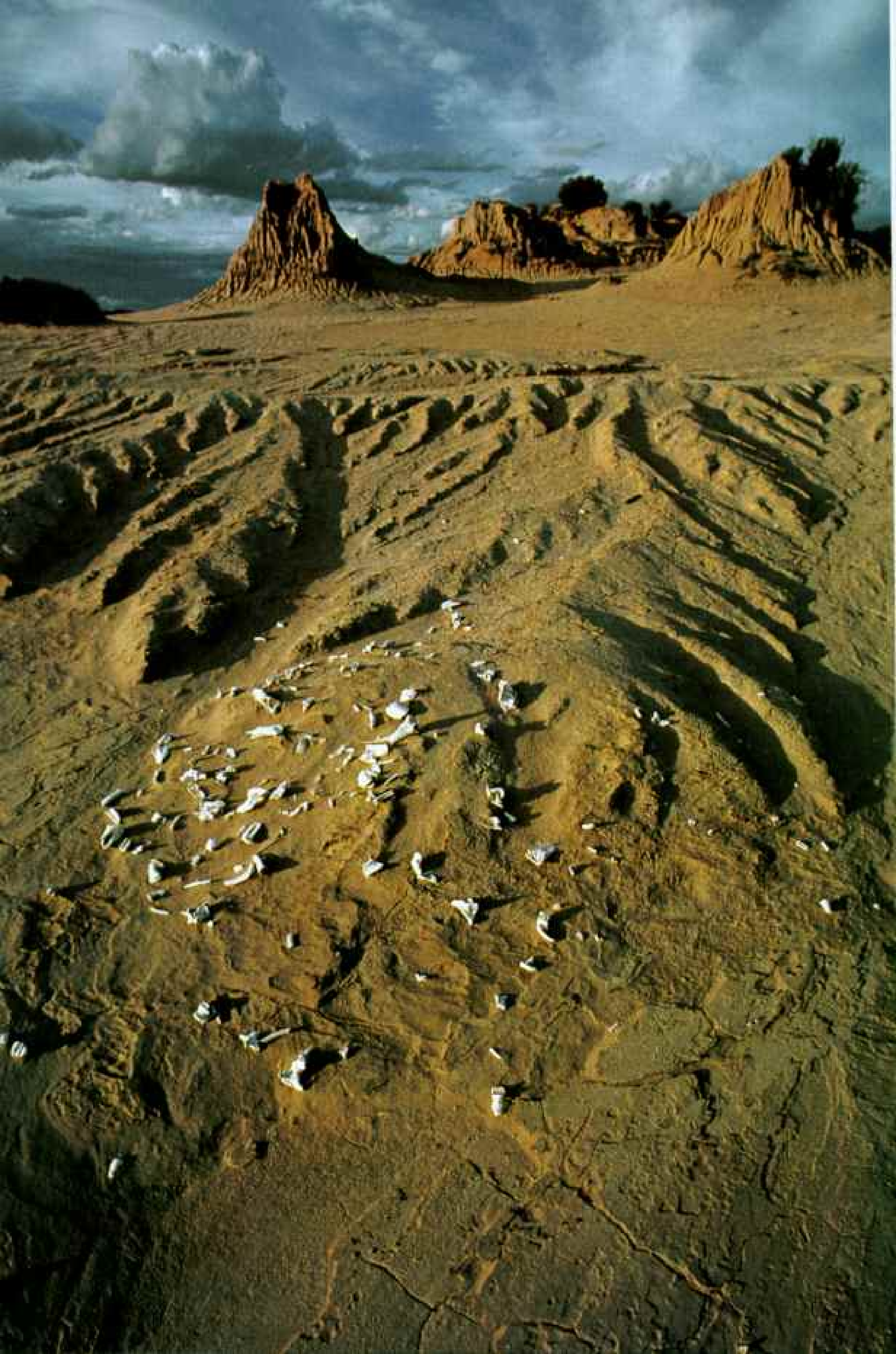
Other efforts are being made to cope with the salinity problem in Victoria and New South Wales, but some fear that the Murray won't be a viable river in 50 years. Opening of new irrigation areas has been sharply curtailed, and for the first time many Australians question whether irrigation is essential to the development of their dry continent.

Man's efforts to control the river have taken a toll on plant and animal species dependent on its variable rhythm, notably on the majestic river red gum. This towering, mottled-bark eucalyptus grows along the length of the Murray and has become its living symbol.

The red gum may live as long as 1,500 years, but a spring flood every two or three years is essential for germination of its seed. Too much water is as critical as too little, and haunting graveyards of dead trees soon appear as water is impounded after the completion of each dam. In the beautiful Barmah and Millewa Forests, the Murray's greatest stands of red gums, thousands of acres of trees have been lost.

ECHUCA'S EMERGENCE as Australia's largest inland port in the 1860s was due in part to its proximity to the Barmah Forest, whose sturdy red gums made excellent timber for paddle steamers. But mostly it had to do with its strategic location at the juncture of the Murray and Campaspe Rivers and the tenacity of Henry Hopwood, a freed convict who set up a cattle crossing there in 1853. Three years later a paddle steamer landed at Hopwood's Ferry (or Echuca as it was called by then), carrying Chinese miners on their way to the Bendigo goldfields. The quiet crossing soon became the port through which the wealth of inland Australia passed. In 1864 the railroad reached Echuca from Bendigo,

In temporary quarters, *an Aboriginal family (left) near Swan Hill awaits completion of government housing. Large Aboriginal populations once flourished near the river until contact with European settlers brought disease and bloodshed, devastating native communities. In several areas ancestral river land has been restored to Aboriginal control. This child ducks rain at a Berri rodeo.*



Early Man at Lake Mungo

*THE SANDS OF TIME near Lake Mungo contain bone fragments (**left**), remnants of an Aboriginal hearth perhaps 25,000 years old. Seventy miles northeast of Mildura, the dry lake bed was once part of the Murray-Darling system. In 1968 an expedition, led by geologist Jim Bowler, discovered the bones of a young woman. The charred remains, known as Mungo I, are 26,000 years old, the oldest known example of ritual cremation. At the Australian National University in Canberra, Bowler (**below**, at right) contemplates the restored skull of Mungo I with two colleagues, Alan Thorne, center, and Rhys Jones, who documented the findings. The thin, almost contemporary-looking Mungo skull contrasts sharply with thick, 13,000-year-old skulls found at Kow Swamp, another Murray basin site. The differently shaped skulls lead some scientists to theorize that at least 50,000 years ago two separate migrations reached these shores. In 1974 a complete male skeleton, Mungo III, was excavated (**right**). The pinkish shadow around the 30,000-year-old skeleton indicates that the body was covered with ocher, evidence of another type of ritual burial.*

WILFRED SHAWCROSS

linking the river system with Melbourne.

At that time Australia had surpassed Germany and Spain as the prime supplier of wool to Great Britain. Outback stations sent their wool to Australia's coastal cities over poor roads by slow, uncertain bullock trains. Paddle steamers changed that overnight. The river system, navigable over 3,500 miles, became the inland highway.

Graziers built permanent homes and increased their flocks. And paddle steamers brought supplies and luxuries to the stations —flour, tobacco, tea, beer, curry powder, galvanized iron, sewing machines, pianos— helping to tame the outback. Women soon followed into what had been primarily a man's country.

Between 1860 and 1880 the population of Echuca swelled from 200 to 4,800. But the railroad, Echuca's ally, soon became its bitter enemy, extending farther and farther into the Murray basin and cutting off centers served by the river trade.

"We love the river and wanted to preserve a bit of its history here," said Mrs. Helen Coulson, manager of the port of Echuca.

Mrs. Coulson helped found the local historical society, which spearheaded the town's efforts to restore the wharf area and bonded stores, and reopened Hopwood's Bridge Hotel for meals. Echuca, whose population is now 8,400, also acquired two old paddle steamers, the *Adelaide* and the *Pevensey* (pages 264-5).

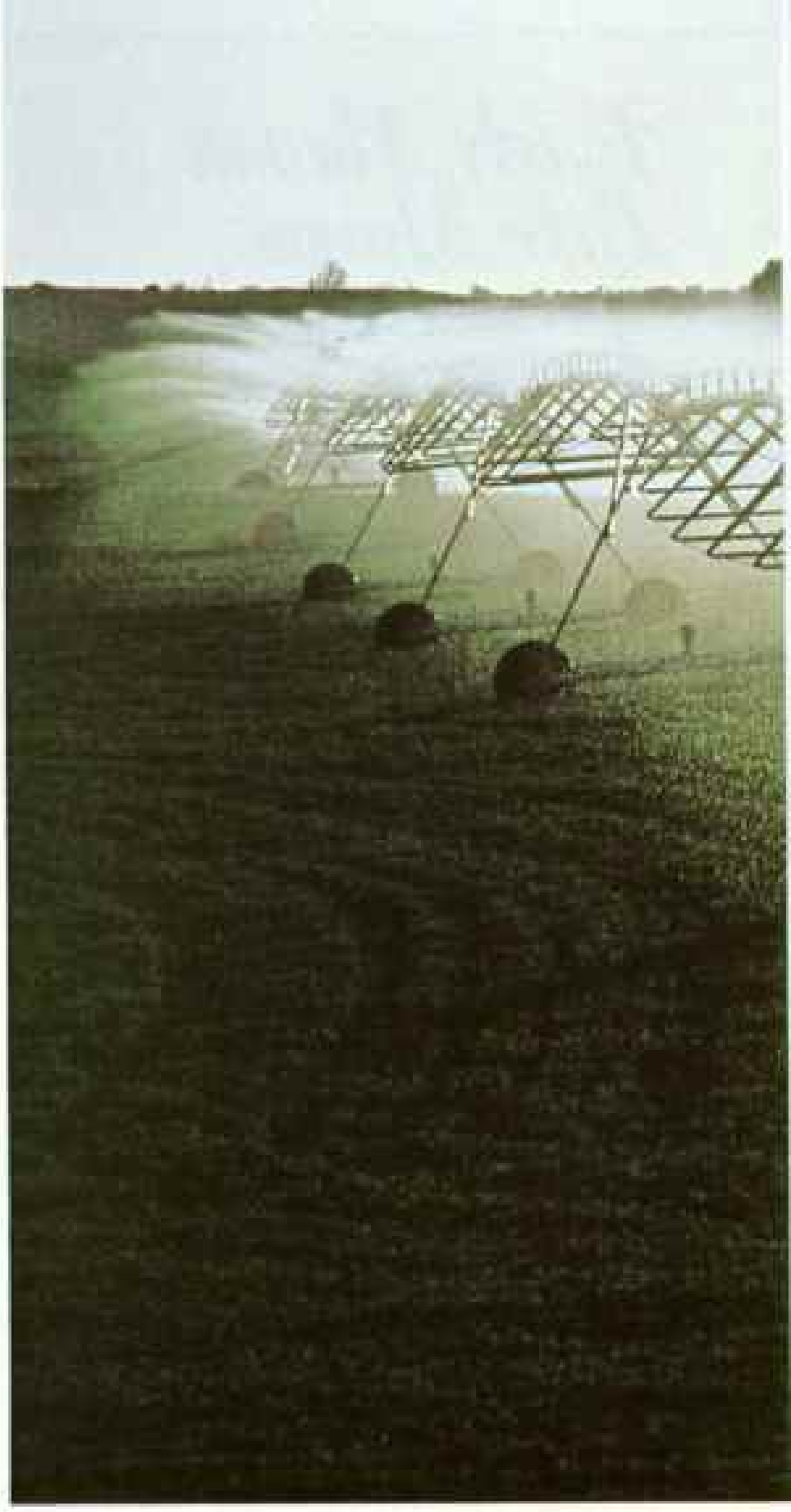
Refitting the old paddle steamers or building new ones has become a hobby of Murray enthusiasts, and more than a dozen of the graceful, flat-bottomed boats are back on the river. At the height of the riverboat days, 200 to 300 boats were registered on the Murray. Now there are close to 800, mostly pleasure craft, including a large fleet of houseboats in South Australia.

Echuca shipwright Kevin Hutchinson, a tall, strong man in his 40s, rolled a bit of oakum on his knee and then pounded it with a mallet and caulking iron between the red gum planks of the *Adelaide*.

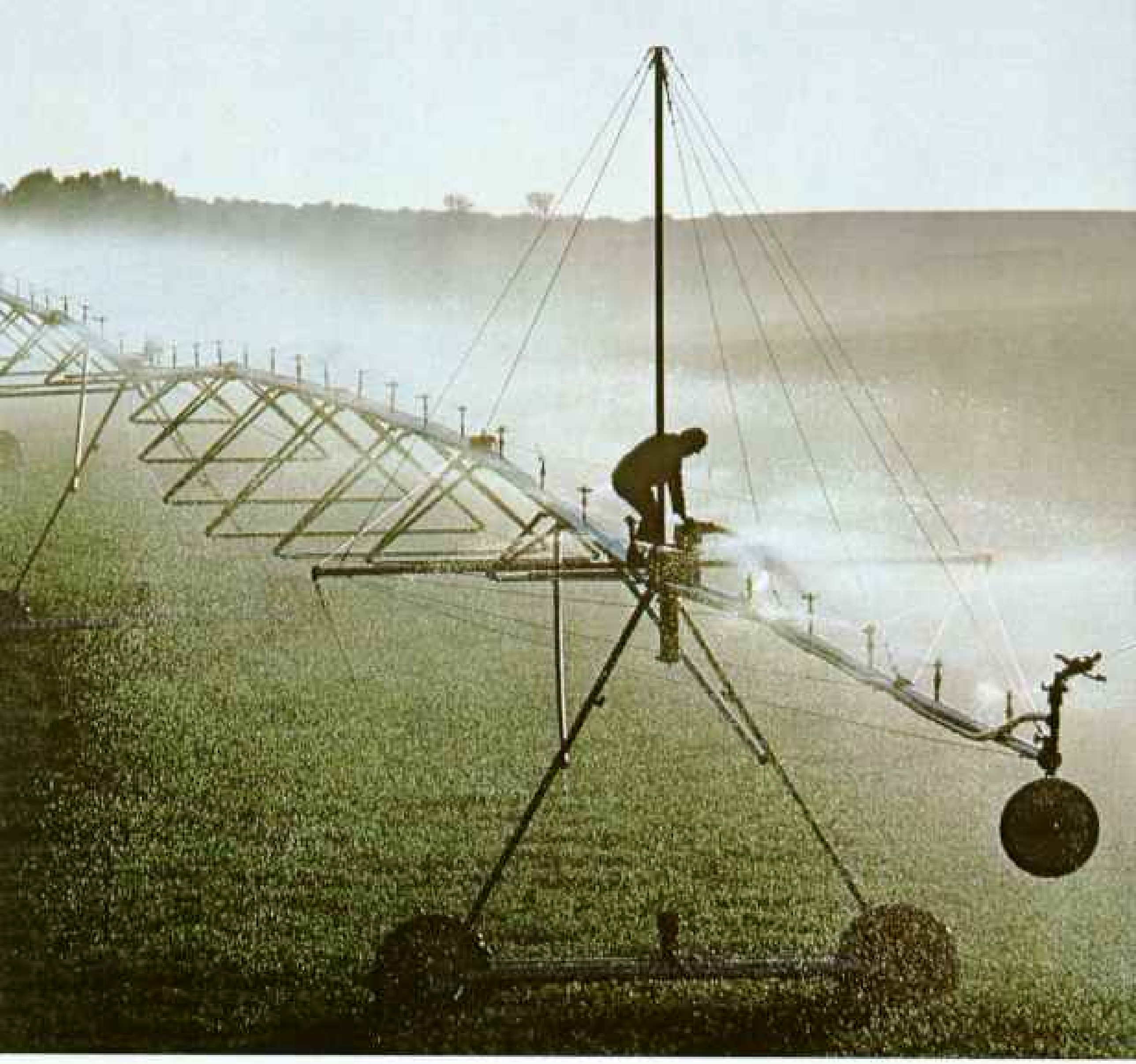
"Work at about a half inch at a time, driving the oakum back on itself," he told his apprentice, Andrew Cook, 19.

"Ah, yes," said Andrew, who was caulking the boat beside him.

"Then, you marry the oakum at the butts



Give and take. *Irrigation sprinklers green fodder acreage* ***(above)*** *near Narrung. But careless irrigation, combined with poor drainage, has unleashed a flood of salinity problems as saline groundwater rises near the surface and deadens fields. In Victoria alone, some 250,000 acres have succumbed, leaving farmers like Alex Gibson* ***(right)*** *with barren soil. "There's little to do," says Gibson, who lost 160 of his 2,500 acres. "Just turn your back and leave." Several desalination programs have been implemented, but a long-term solution remains elusive. An additional snag: Each state governs its own stretch of river; federal control is negligible. "It's in the laps of God and the politicians," one farmer told the photographer.*



like this . . . ," said Kevin, snaking the oakum in an S shape from the end of one plank around the bottom of another.

"Ah, yes?" Andrew paused and watched the shipwright work.

For three years Kevin had been restoring the *Adelaide*, a towing steamer that worked for most of her 119 years in Echuca's timber business. Last fall, finally, she was back on the Murray to serve the tourist trade.

Kevin learned his skill from some of the great captains on the river who still live downstream in Mildura and Merbein.

"The river is a mighty stream to us. It is everything," said Paddy Hogg, a trim, energetic 72-year-old, who in the 1930s was the last riverman to trade wool on the Murray. "We knew if we had a boat on the river we could always make a living and always have a place to live. There were fish and game on the river and sunsets you'd never forget. Ah, it was a beautiful life."

BY THE TIME the Murray reaches the town of Mildura, it is an intruder in the dusty outback. The red, sandy loam produces mainly oddly shaped dwarf eucalyptuses called mallee, for which the vast region from central Victoria and New South Wales to Western Australia is named.

Here temperatures range from 25 to 120°F, and sand dunes 30 feet high, pushed by a relentless wind, swallow roads and bury trees. Small marsupials can survive for long periods in the mallee on fluids they ingest from insects and seeds. The Aboriginals would cut the roots of the mallee into short pieces and let them drain overnight. By morning they had enough water for the day. They also ate the fruit and roots of garland lilies, lignums, and kangaroo apples, and hunted possums, kangaroos, wallabies, snakes, and emus.

A 19th-century journalist, however, called the mallee "a Sahara of hissing hot winds and red driving sand," and many looked to the Murray to make life possible there. One who dreamed of an oasis in the desert was Alfred Deakin, president of a Royal Commission on Irrigation and later Australia's second prime minister. He inspired two Canada-born U. S. irrigation engineers, George and W. B. Chaffey, to come to Australia, and in 1887 they began to develop the land around Mildura and Renmark as irrigation settlements.

"Few people remember that the yabbies [crayfish] undermined the earthen irrigation channels and water seeped out. The pumps broke down as well," said Freda Antcliff, granddaughter of J. J. Lever, one of the early settlers.

Lever was a newspaper editor in Lancashire, England, who brought his wife and four children to Mildura in 1890. The first apricot and peach trees they planted weren't suited to the soil, and what little fruit they did produce had no way of getting to market in the droughts of the early 1890s.

"They lived in a one-room house on ten acres, and often all they had to eat those first years were dried apricots—and rabbits, if they were lucky enough to shoot one," said Mrs. Antcliff, in the comfortable parlor of her home in the center of Mildura. "My grandmother Susannah suffered a mental breakdown during her eighth pregnancy. She lost her memory. They put her into an institution in Ballarat in 1895."

Banjo Paterson's contemporary Henry Lawson addressed the anguish of those early settlers in his poem "Past Carin' ":

Our first child took, in days like these,
A cruel week in dyin',
All day upon her father's knees,
Or on my poor breast lyin';
The tears we shed—the prayers we said
Were awful, wild—despairin'!
I've pulled three through,
and buried two
Since then—and I'm past carin'.

George Chaffey, bankrupt, returned to California in 1897, but W. B. stayed, working in his vineyard. He eventually saw the success of the settlements, whose districts

Transplanted *to Mildura from their native, war-torn Cyprus, 82-year-old Ramadan Hakmen and his wife, Rahme, 74, sometimes pick grapes on their son-in-law's farm to pass the time. Loss of the familiar is difficult, but family ties strengthen. The surrounding area is the major source of Australia's dried fruits.*

today produce much of Australia's citrus and grapes. Both Mildura and Renmark have wide tree-lined avenues, and names like Pasadena Grove and Rio Vista Park recall the Chaffeys' California associations. The area boasts more sunshine than Queensland's Gold Coast and has a 50-million-dollar annual tourist business.

Today's settlers—Italians, Greeks, and Yugoslavs who migrated to Australia after World War II, and recently arrived Vietnamese and Indians—have their own share of hardship with the troubled fruit industry. Australia's export market in canned fruits collapsed when southern European nations joined the Common Market. In the past ten years fruit production has fallen off 50 percent and several canneries, despite massive government assistance, have had trouble staying afloat. Discouraged growers have pulled up hundreds of acres of trees.

EUROPEANS SETTLING in Australia considered it their duty to claim the land and make it, in their terms, productive. Early contact with Aboriginals in the Murray Valley was often characterized by violence and bloodshed, and within 50 years of the white man's crossing of the Great Dividing Range in the 1830s, the native communities were effectively destroyed. Aboriginals who didn't die by the white man's hand or from his diseases had little choice but to live in settlements at the

outskirts of towns. Whatever skills they learned from their new masters were never enough to grant them more than an inferior status in society.

Evidence has come to light that the Murray basin supported a large Aboriginal population some 30,000 years ago.

About 70 miles northeast of Mildura, on an ancient distributary of the Murray-Darling system, are a series of lake beds that dried up during the Ice Age about 15,000 years ago. On a geology expedition in February 1968, several scholars from the Australian National University discovered on the southern end of one lake, called Mungo, the skeleton of a 20-year-old woman. Radiocarbon dating placed the age of the bones at 26,000 years, and together with subsequent finds pushed previous dates for the occupation of the Australian Continent back almost 20,000 years.

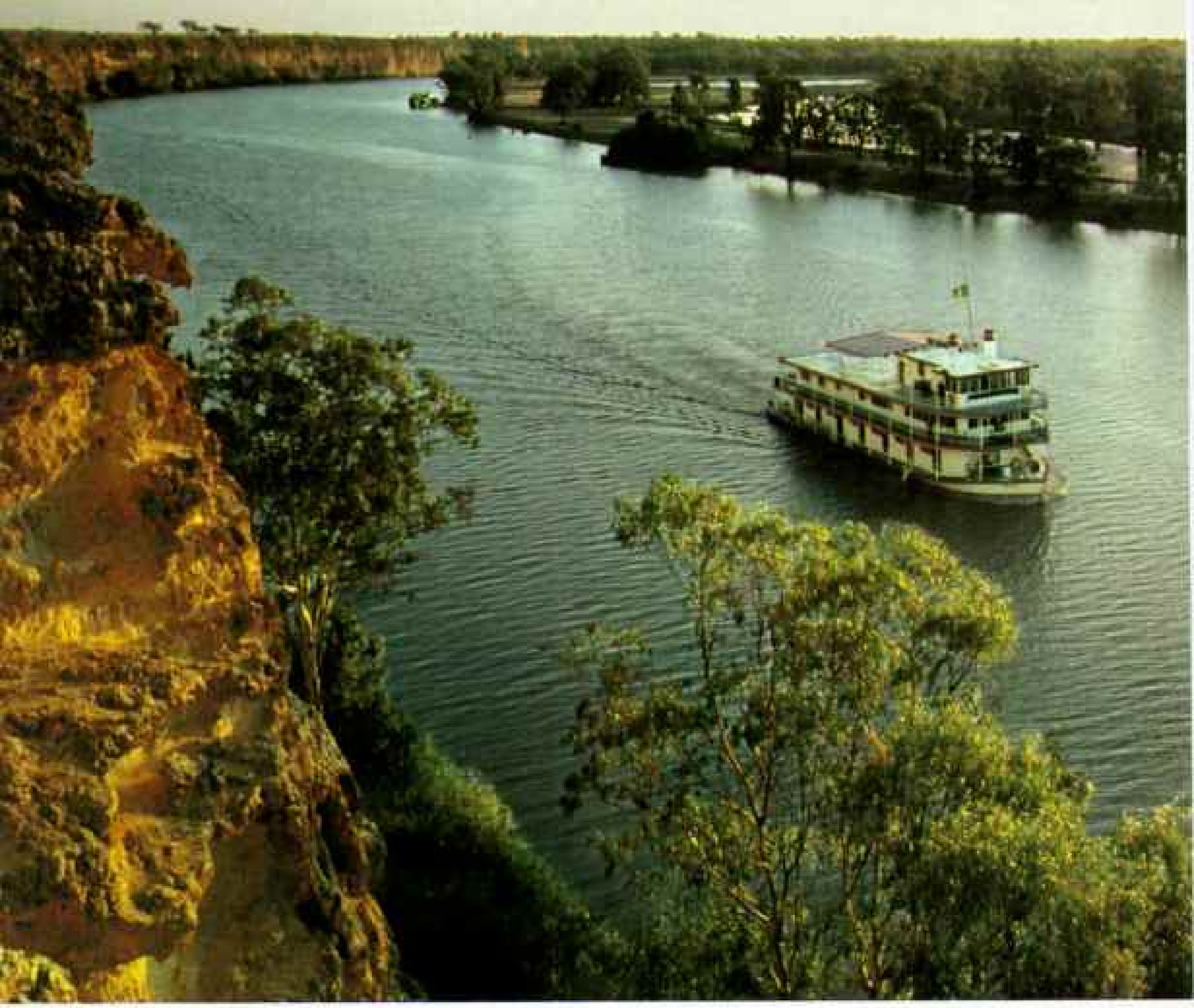
"The body was burnt, the bones broken, and the remains burnt again, suggesting some burial ceremony," said Dr. Rhys Jones, an anthropologist who was on the expedition. "It is the world's oldest evidence of ritual cremation."

Yet another skeleton, 30,000 years old, unearthed nearby, was covered with ocher. Anthropologists believe this represents an interest in art among Australia's first people as early as the Stone Age artists in the caves of France, 20,000 to 27,000 years ago.

Remains of mussel shells, fish bones,

Rustling up grub *means literally that for Peter Beattie (**above**), captain of the Gem, a paddle-steamer restaurant where his grilled witchetty grubs "have a nice nutty taste," the photographer avows.*

*Jean Cornish (**left,** from left), Dulcie Boyce, and Vera Tucker preserve peaches to benefit a historic Berri museum.*



Ruffled calm *greets the Proud Mary, a tourist boat cruising the cliff country south of Swan Reach. But the quiet belies the river's quick-change artistry: Flood,*

and versatile stone tools indicate that the Mungo people lived well on the lakes. They harvested large quantities of fish 20,000 years before man first domesticated animals and cultivated fields. Giant kangaroos ten feet tall and other marsupials as big as rhinos shared the lakeside with the Mungo people.

"The Australian Aboriginal has been written off as unimaginative and dull, but these discoveries show that their way of life was admirably suited to their environment," Professor John Mulvaney, author on Australian prehistory, has said. "They used the land more sensibly for 40,000 years than have many Europeans in the past 100."

What astonished anthropologists was that the skulls of the Mungo people were nearly as thin and fragile as contemporary man's, whereas later skulls discovered in the Murray Valley at Kow Swamp, dating from 9,000 to 13,000 years ago, were heavy and thick with large brow ridges and sloped foreheads. How could these two very different people exist so close together? Where did they come from?

"What we are piecing together is that the thick-skulled Kow Swamp remains resemble skulls found in Java, and that the Mungo people have skulls almost identical to those of early man in China from the same period," said Dr. Alan Thorne, a paleoanthropologist with the Australian National University. "It is possible that there were two separate migrations to Australia at least 50,000 years ago, when water levels of the oceans were low and distances between

drought, and hazardous currents are realities. Maker and breaker of promises and dreams, the Murray, like the land it traverses, can be restrained but never tamed.

landmasses no more than 100 miles. A bamboo raft could have made it. If this is true, they would be the world's first boat people."

THE MUDDY DARLING is nicknamed "tea with milk" and the somewhat clearer Murray "tea without milk." The two finally meet just above the Wentworth boat lock. They travel side by side for a quarter of a mile, two distinct streams, as if needing time to get used to each other. Then, tumbling down the gates of the weir, they emerge from the foam and turbulence as one river.

On the last part of its journey to the sea the Murray is alone as it wends its way through South Australia.

At Waikerie the river abruptly enters a limestone gorge. One blustery winter day I went soaring in a sailplane over the cliffs with champion pilot Sue Martin. "Powered flight is the best means of transportation," said Sue as we cut loose from our towplane, "but soaring is the best sport."

Waikerie is an Aboriginal word meaning "place of many wings," and undoubtedly the area's first people noticed eagles and pelicans catching thermals off the cliffs. In 1937 a soaring club was founded here, and the river has become a favorite spot of gliding enthusiasts from around the world. From the air I could see fields of vines and citrus groves lining the river—and ending suddenly where irrigation stopped.

"The river provides us with contrast, shifting patterns of cool and warm air," said

Sue. "That makes things more interesting."

This particular day a choppy 40-knot wind made things *very* interesting. I tightened my shoulder strap to keep from bouncing against our cockpit cover. We decided not to take another pass over the cliffs.

From Waikerie the magnificent limestone cliffs continue 150 miles downstream to Mannum. It is one of the most beautiful parts of the river. Rich in marine fossils, the cliffs rise more than a hundred feet above the river and range in color from pale yellow to deep ocher. The area's early settlers built homes of this sturdy cliff stone and fitted them with galvanized iron roofs and wide verandas for shade in the hot summers.

LIKE A CHILD last in line for a bath, South Australia must use the Murray after its big brothers, New South Wales and Victoria. Turbidity, salinity, and pollutants increase steadily as the water moves downstream. Being the driest state in a dry continent, South Australia is even more dependent on the Murray, which in some years supplies as much as 87 percent of Adelaide's water.

"South Australia is like the Mexico of the Colorado River system," said Keith Lewis, chairman of the state's Engineering and Water Supply Department. "We get about the volume and quality of water Mexico does from the Colorado River. The Mexicans threatened to go to the international courts if the United States didn't clear up the water. Unfortunately, we don't have that kind of leverage."

Management of the Murray is in the hands of four different government commissions, and each of the state bureaucracies jealously guards its power. At one time, customs posts were set up along the river, and New South Wales and Victoria were virtually separate countries. In 1917 the River Murray Commission was established to keep its hand on the tap—deciding how much water would be let out of the storage system. It now also monitors water quality, but policing powers remain with the states. When water is scarce, there is a cry for a stronger governing body on the Murray, and it usually comes from South Australia.

From the cliff country the river winds through lush pastureland and then spills into two shallow lakes, Alexandrina and Albert. South of Lake Albert, water is trapped in a lagoon called The Coorong, which extends 80 miles down the coast. The lagoon fluctuates in salinity with the seasons and is renowned for the large number of waterfowl that gather to feed on water plants, and for the good fishing. During the last drought both duck and fish populations thinned dramatically because of reduced flow of fresh water from the Murray.

Zoology students from the University of Adelaide on a field trip gathered around a lifeless yellow-eyed mullet in a shallow pond halfway down The Coorong. There was no apparent damage to the dead fish.

"Salinity?" said one of the students.

"Yes, I think so," said graduate zoologist Lance Lloyd.

For several hours the students waded through the pond dragging nets, and the only signs of life were a few small fish called hardyheads, which can tolerate up to three times the salinity of seawater.

"Why can't some flow from the Murray be guaranteed to keep the ecology of the lagoon viable?" asked student Andy Davis.

"Everyone wants water from the Murray—and the fishermen are down the list," said senior lecturer Mike Geddes.

A Victor Harbor fisherman, Alastair Wood, took me and John Parsons, of South Australia's Engineering and Water Supply Department, to the tip of the Younghusband Peninsula. By truck we drove across the sand until the dunes ended—and we were at the mouth of the Murray, barely 300 feet wide and almost shallow enough to wade across. It was an isolated place where terns nested undisturbed. The Murray begins and ends out of sight of man.

"How do you think the state would receive a proposal to increase fish breeding in the estuary?" the fisherman asked.

"I think we would be very open to the idea, if you could guarantee the benefits," said Parsons. "If we spend ten million on this project, can we get back 15 million?"

The men talked on about how they could further harness the river for their benefit. Meanwhile, the sands were shifting and the dunes were being eaten away under our feet. True to its nature, the Murray was changing. □

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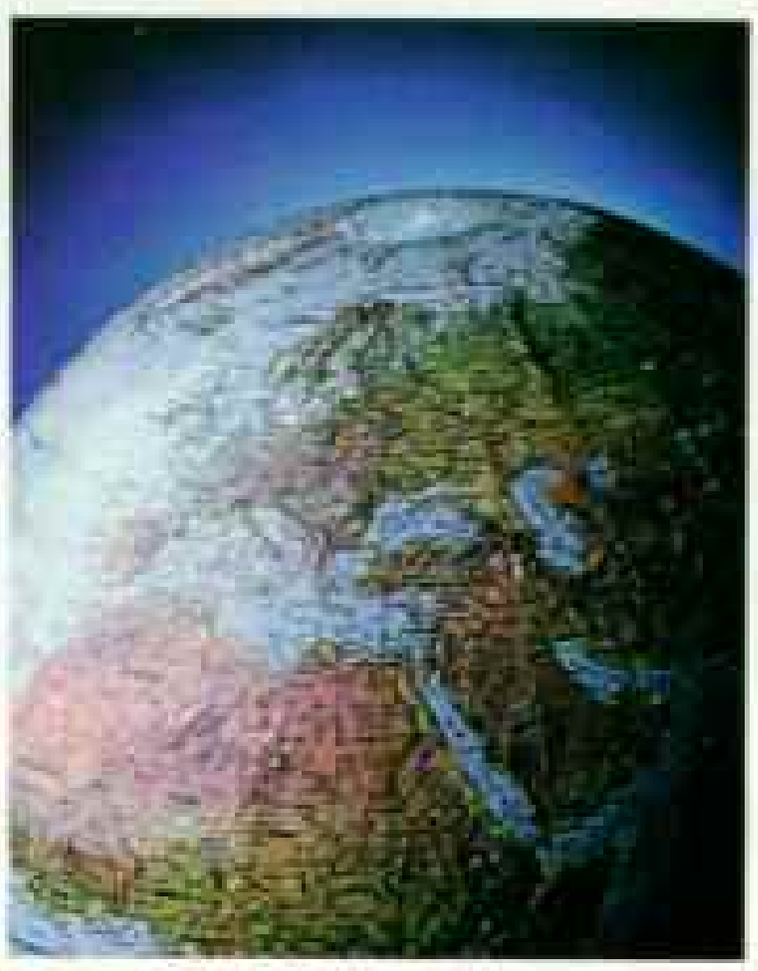

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And that's not all. You get savings along with all these services. Dial direct state-to-state Sunday-Friday from 5pm-11pm, and you save 40% off AT&T's Day Rate.

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Who says you can't have it all?

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AT&T
The right choice.

PULSAR NX

200 SX

NISSAN EXCELS IN COMPETITIVE SPORTS.

When it comes to sports, few can compete with what Nissan has to offer. Technology makes it that way. From the zippy Pulsar NX and classy 200 SX all the way up to the awe-some 300 ZX Turbo.

The unique wedge shaped Pulsar NX comes at you boasting a drag coefficient of a mere 0.37. Add front-wheel drive, 5 speeds and 4-speaker AM/FM stereo and you've got a head start on pure fun.

For good looks and performance, Nissan 200 SX Turbo, in the center lane, runs circles around anything in its class.

But, if you're a purist at heart, you'll always find Nissan 300 ZX Turbo in the fast lane. Hugging the rail like a driving glove hugs your hand. Drive it once and discover how 200 horses worth of fuel-injected V-6 can take you all the way to awesome in nothing flat.

See your Nissan/Datsun dealer today and put us to the test. Pulsar NX. 200 SX. 300 ZX. Each one a technological knockout.

The best extended-service plan available: *up to 5 years/100,000 miles. Ask about Nissan's Security Plus at participating Nissan/Datsun dealers. If you're a sports fan... The Name is Nissan.*

NISSAN

BELT YOURSELF

300 ZX

THE NAME IS

NISSAN

Geographic News Service: *journalism for journalists*

WE KNOW from your letters that our magazine goes on vacation with you, together with a few books and certainly a map or two.

Other Society voices will be going along, too, although you may not notice them as such. Snap on the radio while you sun on the beach, and you may hear the baritone voice of Bob Radcliffe interviewing Mike Edwards, just back from Nicaragua, or Allen Boraiko sizing up the hazardous waste menace, or George Stuart describing the opening of an early Maya tomb.

Pick up the local newspaper, and over breakfast you may read about slave-making ants, what wind chill is, how rural America was electrified, why Iran and Iraq suffer a traditional enmity, how the Interstate Highway System came into being, how much real estate in the United States is owned by foreign investors.

Or the article may be one in the special "Compass Point" series on the effort to clean up Chesapeake Bay, the world's ten hottest border disputes, the history of Maronite Christians, or life in Soviet Central Asia.

Or one of Barbara Moffet's "Life After 2000" series that describes how we will earn a living, where we will live, how we will farm, communicate, and travel in the not-too-distant future.

This very public voice of our Society is that of our News Service, which addresses directly the millions of readers of 1,500 newspapers and periodicals whose editors have asked for this free service, and the millions of listeners to the some 250 radio stations that regularly broadcast the feature programming named "Horizon" over the Associated Press Radio network.

Over the years names like Cousteau, Leakey, Goodall, Ballard, and Bass have entered the household vocabulary because what they did and do makes news. That news, reported to our members in the pages of the magazine, reaches a wider public through the News Service.

Last winter, for example, when archaeologist George Bass announced at a News Service press conference his discovery of a Bronze Age shipwreck off Turkey, his story was printed by 653 newspapers and periodicals read by 50 million people.

When Emory Kristof's remarkable videotapes of the wreck of the British ship *Breadalbane* under the arctic ice reached Washington, they were on the evening news telecasts of all three major networks within a few days.

COMPASS POINT
NATIONAL GEOGRAPHIC SOCIETY

Because our News Service deals in matters of moment—and its telephones are always ringing and photographs and maps are being rushed off to the wire services—it is easy to forget that it is one of the oldest divisions of the Society.

When Director Paul Sampson and his staff of ten prepare each week the interesting and accurate features on timely topics of geographic interest, they are harking back to the beginnings of the service more than 65 years ago in World War I, when names and places like Château-Thierry, Belleau Wood, and Verdun suddenly became of great interest to the home front and required "the dissemination of geographic knowledge." That was more than 16,000 news features ago. Since then many other names have flooded through current history and demanded attention and explanation.

"We will never run out of material," Paul Sampson says. "We are one division that always looks forward to change." And, judging by the response we get, millions look forward to reading about it.

Gilbert M. Grosvenor

PRESIDENT, NATIONAL GEOGRAPHIC SOCIETY

In August on Nickelodeon Cable TV: National Geographic EXPLORER

EACH SUNDAY'S PROGRAMMING IS REPEATED THE FOLLOWING SATURDAY FROM 8-11 P.M. (EDT)

Sunday, August 4

• 5:00 GUARDIAN OF THE EVERGLADES
95-year-old environmentalist Marjory Stoneman Douglas champions the cause of Florida's Everglades.

• 5:15 THE POLAR BEAR
Northern monarchs roam wild on an Arctic island.

• 5:45 WATER—A FRESH LOOK
Walter Sigl swims among piranhas and walks under ice, pursuing his hobby of freshwater filming.

• 6:45 ON ANGEL'S WINGS
Two bold hang-glider pilots and a parachutist gain a bird's-eye view of the world's highest waterfall, in Venezuela.

• 7:45 PUPPETS OF PALERMO
Lovingly crafted wooden puppets, made in Sicily's capital, wage war in the island's theaters.

Sunday, August 11

• 5:00 TAQUILE ON TITICACA
Ancient Inca traditions endure on this Peruvian island, where descendants still handweave colorful clothing and participate in communal government.

• 5:15 SONG DOG
A ten-year study in Yellowstone National Park presents fascinating new film of the life cycle of the coyote.

• 5:45 VIDAL IN VENICE
Author Gore Vidal presents an affectionate look at the history and people of his native city.

• 7:00 ANGELS OF WAR
The people of Papua New Guinea share vivid recollections of their part in World War II.

• 7:45 AVALANCHE INSTITUTE
Swiss scientists identify danger zones and attempt to free them from this moving menace.

Sunday, August 18

• 5:00 TORNADO ALLEY
Storm chasers canvas the Great Plains in search of tornadoes.

• 5:15 AMATEUR NATURALIST
Gerald and Lee Durrell visit France's Camargue, a marshland rich in wildlife.

• 5:45 BROOKLYN BRIDGE
The dramatic, often tragic history of the construction of the bridge unfolds.

• 6:45 SIGNATURES OF THE SOUL
Tattooing—one of the oldest art forms—produces spectacular images worldwide.

• 7:15 MASTERS OF MURANO
Modern glassmakers in Murano, Italy, perfect their delicate art.

• 7:45 MOHAWKS HIGH UP
Indians help build New York City's skyline.

Sunday, August 25

• 5:00 INTERPLAST
American medics in Peru share technology and expertise with local doctors.

• 5:15 THE SHRIMP FISHER
A lyrical portrait of a Dutch fisherman at work in the Netherlands' Waddenzee.

• 5:45 SHADOWS IN THE FOREST
In Rwanda's mountains man and gorilla learn to coexist.

• 6:15 LIFE BY THE FINGERTIPS
A free climber scales vertical rock with bare hands and feet.

• 6:30 AUSTRALIA: THE TIMELESS LAND
A classic National Geographic Special explores the wonders of down under.

• 7:45 LAS FALLAS FESTIVAL
Satirical plaster figures parade through Spain's Valencia.

SEE EXPLORER on Sundays:

5 p.m. Eastern
4 p.m. Central
3 p.m. Mountain
5 p.m. Pacific

and Saturdays:

8 p.m. Eastern
7 p.m. Central
6 p.m. Mountain
8 p.m. Pacific

NOTE: Some Pacific time zone subscribers receive EXPLORER 2 p.m. Sunday, and 5 p.m. Saturday. Consult local listings or call your cable operator for confirmation.

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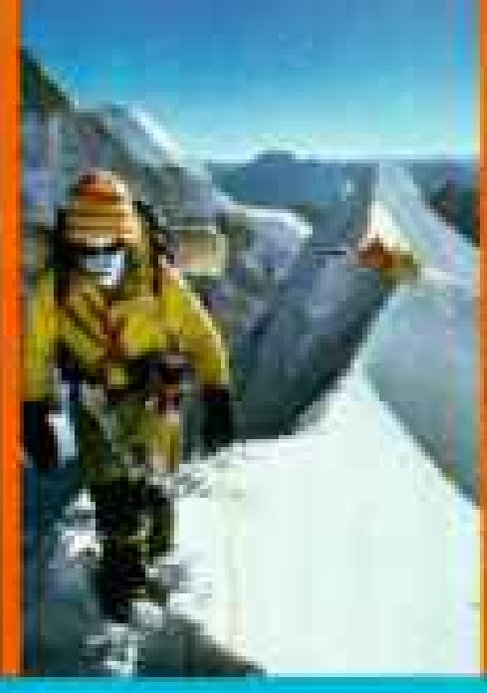
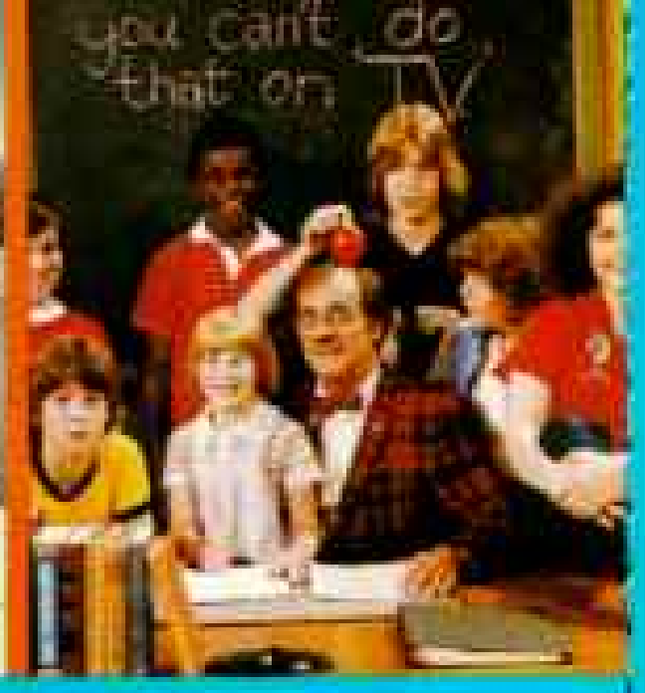




Nickelodeon, America's most respected cable network for children, is now for adults, too! We've enriched our programming with the prestigious National Geographic EXPLORER series. And thanks to the new Nick at Nite, Nickelodeon brings you quality television 24 hours a day.
To get Nickelodeon, call your local cable company.

August on Nickelodeon!

EASTERN TIME	MONDAY THROUGH FRIDAY
7:00–7:30 AM	Black Beauty
7:30–8:00	Lassie
8:00–8:30	Belle & Sebastian/Little Prince
8:30–9:00	Today's Special
9:00–2:00 PM	Pawheel
2:00–2:30	Today's Special
2:30–3:00	Belle & Sebastian/Little Prince
3:00–3:30	Black Beauty
3:30–4:00	Lassie
4:00–4:30	You Can't Do That On Television
4:30–5:30	Turkey Television
5:30–6:00	Dennis the Menace
6:00–6:30	MON-WED: Mr. Wizard's World / THU-FRI: Out of Control
6:30–7:00	Nick Rocks
7:00–7:30	You Can't Do That On Television
7:30–8:00	Dangermouse

	SATURDAY	SUNDAY
7:00–9:00 AM	Pinwheel	
9:00–9:30	Out of Control	Powerhouse
9:30–10:00	Mr. Wizard's World	
10:00–10:30	Lassie	
10:30–11:00	Little Prince	
11:00–11:30	Nick Rocks	Belle & Sebastian
11:30–12:00		Dangermouse
12:00–12:30 PM	You Can't Do That On Television	
12:30–1:00	Dangermouse	Nick Rocks
1:00–1:30	Belle & Sebastian	
1:30–3:00	Lassie	
3:00–4:00	Special Delivery	
4:00–5:00	Standby...Lights! Camera! Action!	
5:00–6:00	Live Wire	EXPLORER
6:00–6:30	Out of Control	
6:30–7:00	Nick Rocks	
7:00–7:30	YCDTOTV	
7:30–8:00	Dangermouse	

Nick at Nite™

	MONDAY THROUGH FRIDAY
8:00–8:30	Dennis the Menace
8:30–9:00	Donna Reed
9:00–11:00	Movie
11:00–12:00	Turkey Television
12:00–1:00 AM	Route 66
1:00–1:30	Dennis the Menace
1:30–2:00	Donna Reed
2:00–4:00	Movie
4:00–5:00	Turkey Television
5:00–6:00	Route 66
6:00–6:30	Dangermouse
6:30–7:00	Nick Rocks

	SATURDAY	SUNDAY
8:00–8:30	EXPLORER	Dennis the Menace
8:30–9:00		Donna Reed
9:00–11:00		Movie
11:00–12:00	Turkey Television	
12:00–1:00 AM	Route 66	
1:00–1:30	EXPLORER	Dennis the Menace
1:30–2:00		Donna Reed
2:00–4:00		Movie
4:00–5:00	Turkey Television	
5:00–6:00	Route 66	
6:00–6:30	Dangermouse	
6:30–7:00	Nick Rocks	

Schedule is subject to change without notice.

S M A L L

RCA BRINGS IT ALL INTO FOCUS

THE SMALL WONDER, AMERICA'S #1 VIDEO CAMERA, NOW HAS AUTO-FOCUS AND INCREASED LOW-LIGHT CAPABILITY.

Last year, RCA's Small Wonder Camera took the video world by storm. And no wonder—its combination of compact size and special features was unmatchable! This year's model, believe it or not, is even better. We've added an improved, solid state imager, auto-focus and 10 lux low light capability to Small Wonder's other remarkable features.* Like automatic white balance, instant review, power zoom and an amazing weight of 2.2 lbs. Of course the Small Wonder will still attach to most any VHS-VCR, portable or table model. And it's still a palm-sized piece of precision equipment. Add it all up, and the Small Wonder's differences are clear, very clear. *10 lux capability at 25 IRE.

RCA

TECHNOLOGY THAT EXCITES THE SENSES.

Small Wonder is a registered trademark of RCA.

W O N D E R

The 5-passenger sedan that absolutely refuses

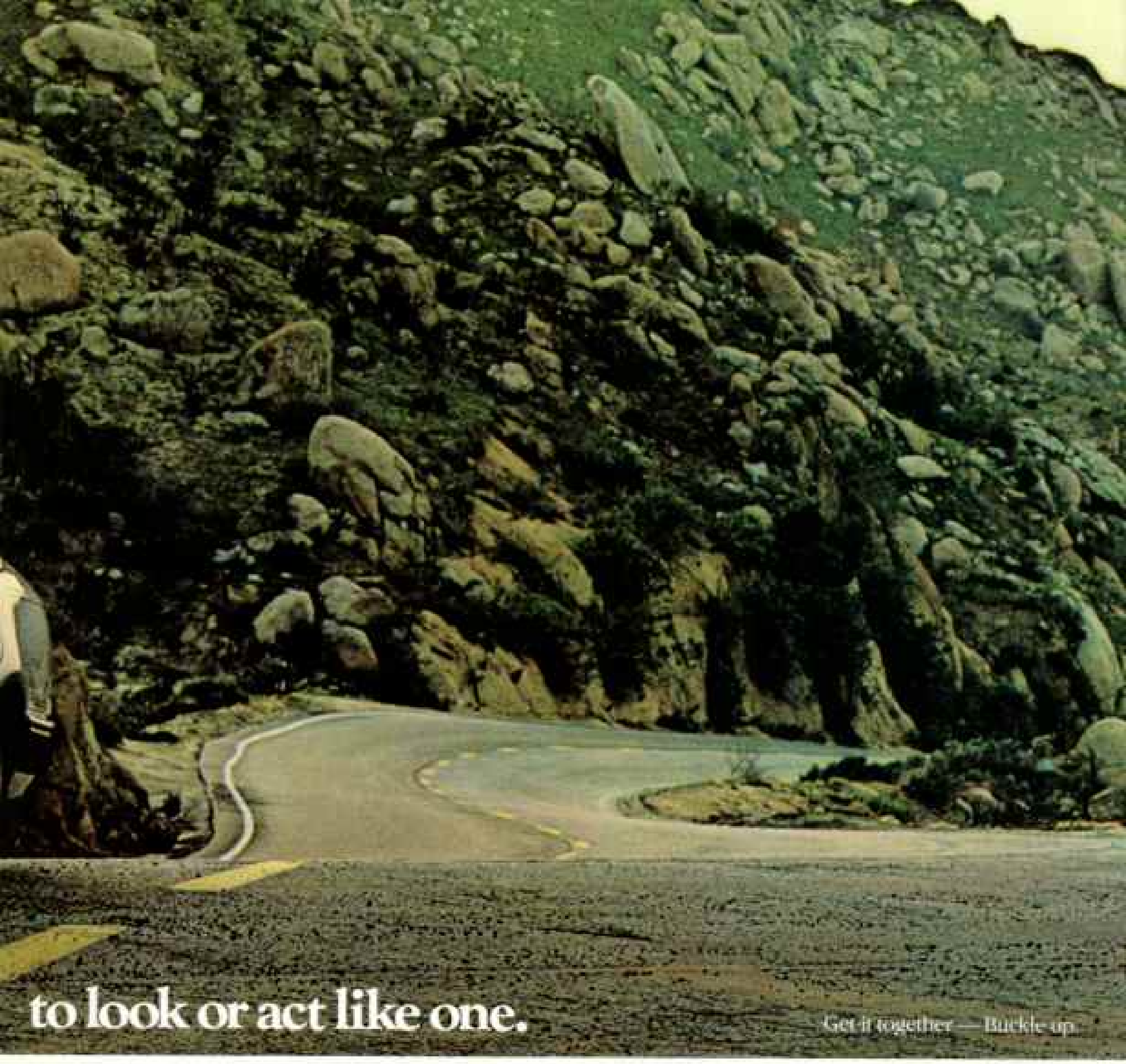
Which of today's sedans gives you more than just a comfortable ride? The answer: Ford Tempo, the forward thinking car. With good looks, precise handling, and an advanced design, Tempo is far from the typical sedan.

You first notice Tempo's distinct aerodynamic shape. You see, the way Tempo looks helps the way it acts. This shape was carefully designed to reduce lift and provide added cornering agility. Add front-wheel drive, 4-wheel independent suspension, and rack and pinion steering, and you have a car with excellent reflexes.

Tempo has shown uncommon responsiveness, too. Its 2300 HSC (High Swirl Combustion) engine was designed to produce high low-end torque for responsive acceleration in normal city driving. Which may make you think we're describing a car with unusual rewards for the driver. And you'd be right.

Most sedans seat five, but it's the way Tempo seats them that sets it apart. Tempo's interior was

Ford Tempo. The for



designed by a computer, which helped determine the best use of space. The result? Unusual comfort for passengers and an intelligent placement of driver's controls.

So it's apparent that while Tempo does offer you five passenger comfort, it's really not a typical sedan. Its good looks, precise handling, and advanced design make it anything but typical. All of which makes Ford Tempo a unique choice.

"Quality is Job 1." A 1984 survey established that Ford makes the best-built American cars. This is based on an average of problems reported by owners in the prior six months on 1981-1983 models designed and built in the U.S.

Free Lifetime Service Guarantee is available at participating Ford Dealers.

Have you driven a Ford... lately?

Ford

ward thinking car.

Members Forum

Vietnam Memorial

I was crying when I read "To Heal a Nation" (May 1985). I didn't know why, for I had lost no one to Vietnam. But then I understood. I didn't lose just anybody. I lost them all.

Vivian Kidd
Riverside, California

What can I say but "*Xin cam on ong lam*—Thank you much."

David E. Heidenreich
Veterans of the Vietnam War, Inc.
California, Pennsylvania

It took me much longer than usual to read the May 1985 magazine. All the feelings came back that I thought had been washed away by tears on a raw January day this year. A sense of duty had finally overcome my dread of approaching that black granite V. No mountain could be harder to climb than that gentle slope was to descend. Walking past the names of so many friends, I reached panel 1E. I found his name, the first of too many I know on those panels. It had been 20 years to the day since that minor skirmish outside some insignificant village near Nha Be.

The single name didn't have a footnote. No mention of Rhodes scholar. No mention of his quick mind and daunting debate skills. No mention of his deep-felt respect and affection for the Vietnamese people. No mention of lost potential for this nation. Just three words etched in a cold, black, granite panel.

William Allen
Washington, D. C.

"To Heal a Nation" told that two men from Jacksonville, Illinois, walked 818 miles [in support of the memorial] but did not list their names. I inquired and found out the former infantryman was Junior Wyatt and the former paratrooper was Kim Splain. I am proud of their efforts.

Tamara Newby
Jacksonville, Illinois

If you had any concept of the pain it causes some of us who were there to be reminded of it, you would not mention the war in Vietnam. Please let it be.

Dan Dixon
Oklahoma City, Oklahoma

I am a Canadian, 34 years old. When I was younger, I was against the war. But being so far removed, I never felt part of it. That wall. I keep thinking of those guys, most of them my age.

Normand Lepage
Sainte-Catherine, Quebec

Thank you from a person too young to understand the controversy of Vietnam but old enough to remember the sorrow.

Elaine Haralson
Seminole, Texas

I strongly object to your feature on the Vietnam Memorial. The real heroes are those who refused to go. That takes courage of a different and higher kind—moral courage. If more had done the same, there would never have been a Vietnam.

R. Metsky
Belmont, California

My son called me after receiving his May issue. He was thrilled by your Editor's column, where you said you had looked for his father's name. He was eight and my daughter four when Walt left. Though they don't remember him as well as they would like to, they loved him and are very proud of him.

Mrs. Walter H. Moon
Van Buren, Arkansas

I, too, served in Vietnam and, like others, my wounds came from "friendly forces." Their weapons were words and, just as bad, silence. I entered the ministry and have seen people healed emotionally by various means, but this is the first time I have known God to use a magazine article. Your May issue came. I read. I cried. The healing has begun.

Robert L. Rundall
Elmira, New York

There was another war with no memorial. There should be a national monument honoring those who died in the Korean War.

Marvin Block
Los Angeles, California

I wanted no reminders, no memories, no slick hype or morbid postmortems. However, your articles were not at all what my self-pity or prejudging had assessed. I *never* experienced anything quite like this emotion before. Not defeat, not elation, not pride, not anger—but a feeling of warmth and calm. It was a marvelously subdued and gracious essay to all who returned. And a warm "I love you" to those who didn't.

James B. Lyle
Cypress, California

I visited Washington in April and saw the memorial. The earth does seem to split there, mourning her dead children and weeping for the stupidness of man who starts wars.

Michael Almy
Dayton, Ohio

My son volunteered for a war he did not fully understand. He still does not talk about it. His strongest sentiment is one of guilt at survival. He has no regrets about serving his country, despite the cruel rejections when he returned home 15 years ago.

William R. Landa
El Paso, Texas

I could not keep back the tears as I read that article. It became very painfully obvious that I had totally misunderstood the reason for and necessity of having such a memorial. Thank you, from my heart, for such a fine tribute.

Charles Denhart
Cary, North Carolina

May we see more of Maya Lin in the future. She has articulated something that was impossible for so many for so long.

Judy Irwin
Enfield, New Hampshire

Letters should be addressed to ***Members Forum,*** *National Geographic Magazine, Box 37448, Washington, D. C. 20013, and should include sender's address and telephone number. Not all letters can be used. Those that are will often be edited and excerpted.*

(Continued from Editor's Column, page 141)

nation. All of us who lived through the war were scarred, but of the nine million men and women who were involved in the 18-year course of the war—nearly three million in the combat zone—thousands suffered psychological wounds that will never heal.

Robert Doubek, a leader in building the memorial, said an initial reaction by veterans to Jan Scruggs's proposal was, "We need benefits, not a memorial." It turned out that the memorial helped lead to the benefits by focusing long-overdue attention on veterans' needs and rights.

The memorial wall—and the media attention attending the tenth anniversary of the fall of Saigon—opened again wounds that had only closed over; some will now heal themselves, but others will not. Sympathetic help for those traumatized by Vietnam is still desperately needed.

Some are not aware they need counseling. Others are reluctant to ask for help. Many do not trust the Veterans Administration.

Even some mental health professionals were at first unsympathetic to the seemingly irrational behavior of Vietnam survivors, despite the lessons available from earlier, less stigmatized wars. Some insisted on looking back to the veteran's childhood for the source of behavioral problems. I find nothing unusual in veterans being psychologically ravaged by Vietnam. I'd be more surprised if they were not. I must agree with the survivor of a Nazi concentration camp who said: "An abnormal reaction to an abnormal situation is normal. . . ."

The American Psychiatric Association did not recognize post-traumatic stress disorder (PTSD) as a legitimate diagnosis until 1980. In each Congress from 1972 through 1979, the Senate passed

a bill that would permit the recognition and treatment of stress in Vietnam veterans, but the House of Representatives Veterans Affairs Committee repeatedly bottled it up. Finally, in 1979, the first VA Vet Centers opened. They have stayed open despite the Reagan Administration's attempt in 1981 to terminate storefront treatment centers. Congress will keep them going at least through 1988.

The memorial has provided the nation with a catharsis, but it would be wrong now to try to put it all behind us. There are still many who need help, and it is available. Mental health professionals now specialize in Vietnam-related problems; many of them are veterans themselves. Listed below are places where help can start. It is a small postscript to the memorial wall, a small list of names, but someone may read and remember or know a person in need.

Veterans Administration Vet Centers are listed by that name in local telephone directories. If not, look for Veterans Administration hospitals or medical centers.

The American Psychiatric Association can answer questions regarding treatment or counseling of Vietnam veterans. Write to the APA Division of Public Affairs, 1400 K Street N.W., Washington, D. C. 20005.

The Vietnam Veterans of America, 2001 S Street N.W., Washington, D. C. 20009, has 170

chapters in 40 states; some provide counseling.

Veterans Education Project, P.O. Box 42130, Washington, D. C. 20015, has guides on delayed stress, Agent Orange, and discharge upgrading.

The Disabled American Veterans, P.O. Box 14301, Cincinnati, Ohio 45214, offers a free 23-page pamphlet, "Continuing Readjustment Problems Among Vietnam Veterans," by Jim Goodwin, Psy.D.

A number of books contain guidance and information for Vietnam veterans. A sampler of current ones:

The Trauma of War: Stress and Recovery in Viet Nam Veterans, edited by Stephen M. Sonnenberg, M.D., Arthur S. Blank, Jr., M.D., and John A. Talbott, M.D. American Psychiatric Press, Washington, D. C., 1985.

Trauma and Its Wake: The Study and Treatment of Post-traumatic Stress Disorder, edited by Charles R. Figley, Ph.D.; *Post-Traumatic Stress Disorder and the War Veteran Patient*, edited by William E. Kelly, M.D., both from Brunner/Mazel, New York, 1985.

Long Time Passing: Vietnam and the Haunted Generation, by Myra MacPherson, Doubleday, New York, 1984.

Wilbur E. Garrett

EDITOR

NUCLEAR ENERGY

Is America being left behind?

In a competitive world market where abundant energy is a must, can America afford to fall behind in the very technology we pioneered?

With 94 U.S. plants now licensed to operate and 53 more being built, nuclear energy has become the second leading source of America's electricity, behind coal. But not one future nuclear plant has been planned in this country since 1978, while at least 50 have been ordered in other parts of the world.

Nuclear electricity is growing worldwide

There are now more than 340 nuclear plants producing electricity throughout the world. Japan, France, the Soviet Union, and now China are among the 40 nations committed to nuclear electricity as an economic, safe alternative to oil.

In Japan, companies are designing advanced reactors and making it possible to gain the edge in nuclear energy technology.

In France, over 55 percent of their electricity is nuclear-generated. It takes only six years or so to get a nuclear plant built there, which is half the average time it now takes to build one in the U.S.

Many countries are relying on more nuclear electricity to lessen their dependence on foreign oil. Source: International Atomic Energy Agency.

A secure America needs a balanced mix of energy sources

Our country has a lot more oil, natural gas, and coal than either France or Japan. But oil supplies are dwindling and vulnerable to foreign disruptions. Natural gas is more valuable for other uses than for burning in power plants. And coal, which already provides 56% of our electricity, can't be expected to do the job alone.

What is best for the practical generation of large amounts of electricity? The National Academy of Sciences has stated that "Coal and nuclear power are the only economic alternatives for large-scale application in the remainder of this century."

Nuclear energy for energy independence

Through the growing use of nuclear electricity, countries all over the world are reducing their dependence on oil and strengthening their position in increasingly competitive world markets. They realize that a healthy national economy needs a secure supply of electric energy.

Will we have to play a costly game of catch-up in the competition ahead? America runs the risk of doing just that—if we ignore the growing international reliance on nuclear energy, and the reasons behind that growth.

For a free booklet on America's struggle for energy independence, write to the U.S. Committee for Energy Awareness, P.O. Box 1537 (J14), Ridgely, MD 21681. Please allow 4-6 weeks for delivery.

Information about energy
America can count on

U.S. COMMITTEE FOR ENERGY AWARENESS

Photographed by Dieter Plage *Javan Rhinoceros: Genus: Rhinoceros Species: sondaicus*
Adult size: Height at the shoulder, 1.5m Adult weight: Approximately 1,580kg
Habitat: Tropical rain forests on the Ujung Kulon peninsula, western Java
Surviving number: Estimated at less than 70

Wildlife as Canon sees it: A photographic heritage for all generations.

The Javan rhinoceros once ranged over much of southeastern Asia, but today it is the rarest of the rhinos and confined to its last home, the Ujung Kulon National Park in Java. The small, protected population is scattered throughout the reserve, which is the largest wilderness area left in Java. Sighting of the solitary beast is a privilege known only to a few. With no Javan rhinos in captivity, the wild population in Java represents all that remains of this once vigorous species.

Nothing could bring the Javan rhino back should it vanish completely. And while photography can record it for posterity, more importantly photography can help save it and the rest of wildlife.

The preservation of the Javan rhino's rain forest habitat, with its abundant flora and fauna, is vital to the animal's future survival. Not only can photography offer people an otherwise unobtainable glimpse of the Javan rhino, it can also foster a better understanding of the urgent need to save this irreplaceable work of creation.

And understanding is perhaps the single most important factor in saving the Javan rhino and all of wildlife.

Canon
Images for all time

On Assignment

PHOTOGRAPH FROM STEVE McCURRY (ABOVE); OTHERS BY SISSE BRIMBERG

TEN TRIPS INTO AFGHANISTAN left free-lance photographer ***Steve McCurry*** (***left,*** standing) with memorable pictures and indelible memories—like the time Soviet helicopters attacked a village he was in. "They came in very low, like a swarm of hornets," he remembers, "rocketing and strafing everything that moved. I've never heard such noise. It was deafening." Steve's latest trip to the region produced the illustrations for our June story on Afghan refugees.

Steve spent days in water up to his armpits for the article on monsoons in December 1984. Such efforts were rewarded last February when he was named Magazine Photographer of the Year in the Pictures of the Year Competition at the University of Missouri, sponsored by the university, the National Press Photographers Association, and Canon U.S.A., Inc. His multicolumned trophy (***below left***) stands behind issues featuring his monsoon coverage and Indian railroads article (June 1984). At left is one of the World Press Photo awards won by McCurry last winter in the international contest at Amsterdam.

McCurry is the first photographer in the 28-year history of that competition to win four first places in a single year. From 55 countries, 859 photographers submitted 5,811 entries.

GEOGRAPHIC photographer Jodi Cobb (***above right***), whose pictures illustrated the magazine's articles on Jerusalem (April 1983) and Jordan (February 1984), also triumphed, earning the 1985 Photographer of the Year award from the White House News Photographers Association. Her winning portfolio included pictures she made for the Society's new book on Britain and Ireland. Cobb's interest in journalism was sparked by growing up in Iran and traveling around the world twice with her family by the time she was 12 years old.