NATIONAL GEOGRAPHIC

From the Editor

A MAP SCALE of one to one million doesn't sound all that big—but it resulted in what may well be the largest flat paper map ever produced. The 135-by-66-foot monster covered the basketball court at the University of Maryland's Cole Field House when we assembled all 720 tiles for our "Revolutions in Mapping" story.

It was the culmination of a three-year project to computerize all the Society's priceless mapping data, most of which had been stored on bulky, deteriorating film sheets.

Maps have always been a big part of National Geographic. They are an unparalleled teaching tool, and that's why we are delighted to announce the Society's plans to distribute some 112,000 laminated world maps free of charge to every public and private school in the United States. This monumental one-million-dollar effort is being spearheaded by our Education Foundation, which is celebrating its tenth anniversary.

Major funding will come from the Foundation, the Society, and a new group of corporate sponsors, the National Geographic Millennium Partners.

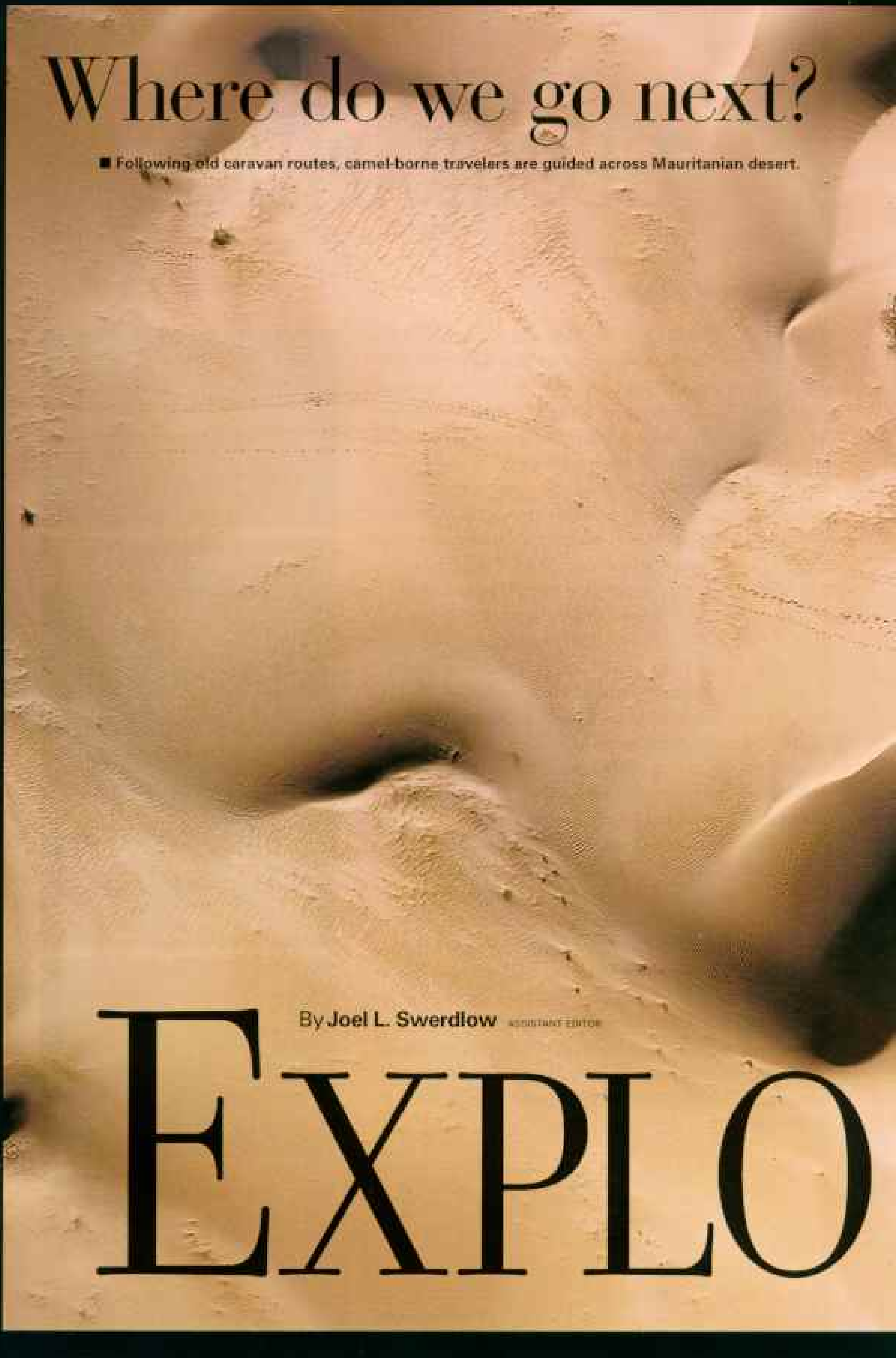
These visionary corporations—Subaru of America, the American Plastics Council, the Eastman Kodak Company, and State Farm Insurance Companies—are also contributors to another groundbreaking Society initiative: the commitment of a million dollars a year to support our new Committee for Exploration. The committee will weigh grant applications with an eye not only to whether they will yield new knowledge but also to how the projects capture the spirit of human adventure.

Some say the world is fully explored. But thanks to our generous new partners, the adventure may well be just beginning.

BOB SACHA

Where do we go next?

■ Following old caravan routes, camel-borne travelers are guided across Mauritanian desert.



By **Joel L. Swerdlow** ASSISTANT EDITOR

EXPLO

We shall not cease from exploration
And the end of all our exploring

BASIC GEOGRAPHY is known. On our maps what Joseph Conrad called the blank spaces of "delightful mystery" seem filled in, creating the impression that there's little left to explore. The following stories show, however, that as technology expands our capacity to reach out, we can explore more than ever. ■ If there are no blank spaces left, why are maps increasingly useful? As John Noble Wilford discusses in "Revolutions in Mapping," a map is no longer a flat piece of paper that tells us where we are and where we might go. Virtually any kind of data can be entered into a computer, displayed on an electronic map in relation to other data, and instantly updated as changes occur. Patterns and trends can be charted over time, enriching our notion of "place." A map of a city, for example, can reveal the relationship between police patrols and reported incidents of crime. ■ Just as maps convey more information, so information increasingly drives exploration. Priit Vesilind's "Why Explore?" demonstrates how exploration feeds our insatiable need to know. Vesilind descends to the bottom of the Mediterranean Sea with Bob Ballard, who argues that "if you're not doing worthwhile science, you're not an explorer." ■ But exploration in the quest for knowledge sometimes serves as a prelude to—and excuse for—exploitation. There is already talk of natural resources on Mars—even suggested use of greenhouse gases to trap the sun's heat, change the Martian atmosphere, and make it easier for humans to live there. In this way Mars (and our own oceans, for that matter) is the modern-day equivalent of what the Americas and Australia once seemed—vast frontiers waiting to be tamed. ■ Exploration for the sake of science pushes us into new realms of the unknown. We've had maps of Amazonia's rivers for more than a hundred years. But how much do we know about ecological relationships there or about the lives of the native peoples? "The only true voyage of discovery," Marcel Proust wrote in his *Remembrance of Things Past*, "is not to go to new places, but to have other eyes." ■ If exploration means having new eyes, we can all be explorers. My son Paul's fourth-grade teacher recently explained that her class will be studying the great explorers so the children will believe they "can go anywhere and do anything." But if we can all be explorers, then who are our heroes—the people whose daring takes us to places we could never go ourselves? Maybe we need a more specific word

Will be to arrive where we started
And know the place for the first time. —T. S. ELIOT

for those who—propelled by adventure, sport, and glory—risk their lives to experience extraordinary places. George Leigh Mallory, the British alpinist who disappeared on Mount Everest in 1924, felt compelled to climb the world's highest mountain "because it is there." In 1996 Jon Krakauer saw five friends die on Everest. Seven months later he climbed Rakekniven, "the Razor," in Antarctica's Queen Maud Land. He reports here on that experience. ■ Such risktaking was incomprehensible to me until I thought about my work for this magazine. In journeying to places like the rock nearly 700 feet beneath New York City, I've known the private thrill of standing where few people ever go. Similarly, how many of us pause in the woods or some other isolated place and savor the thought that maybe no one has stood on that spot? ■ Krakauer and his colleagues accomplish this through athletic ability and courage. They climb a 2,000-foot vertical chunk of granite in Antarctica and achieve nothing more—or less—than doing what no one has done before. Theirs is a triumph not of science but of the human spirit. ■ Triumphs of this kind may make us feel good but can endanger the places we visit. To minimize their impact, Krakauer and teammates airlifted all their waste out of Antarctica. Such concern about contamination distinguishes the new era from the old. From the 15th to the 19th centuries, diseases brought to the Americas by Europeans killed at least half and perhaps as much as 95 percent of the native population. As recently as 1969, when men first landed on the moon, scientists didn't worry about contaminating it. But today's designers of probes for Antarctica, Mars, and Jupiter's moon Europa try to prevent their machines from introducing alien microbes. ■ Indeed, modern explorers often try to protect the territory they study. Luis Marden's profile of Jacques-Yves Cousteau captures Cousteau's transformation from underwater pioneer to crusader for oceans free from pollution. Cousteau and the other explorers we meet in these articles lead us to the same fundamental question: What is our relationship to nature? Is what we find there for us to conquer, master, and use, or is our prime duty to admire and preserve? ■ As we begin to explore the new millennium, whether we can find the proper balance may be the most important issue. □

For more on the millennium, visit www.nationalgeographic.com.

The millennium series continues in May with the Physical World.

Revolutions

By John Noble Wilford

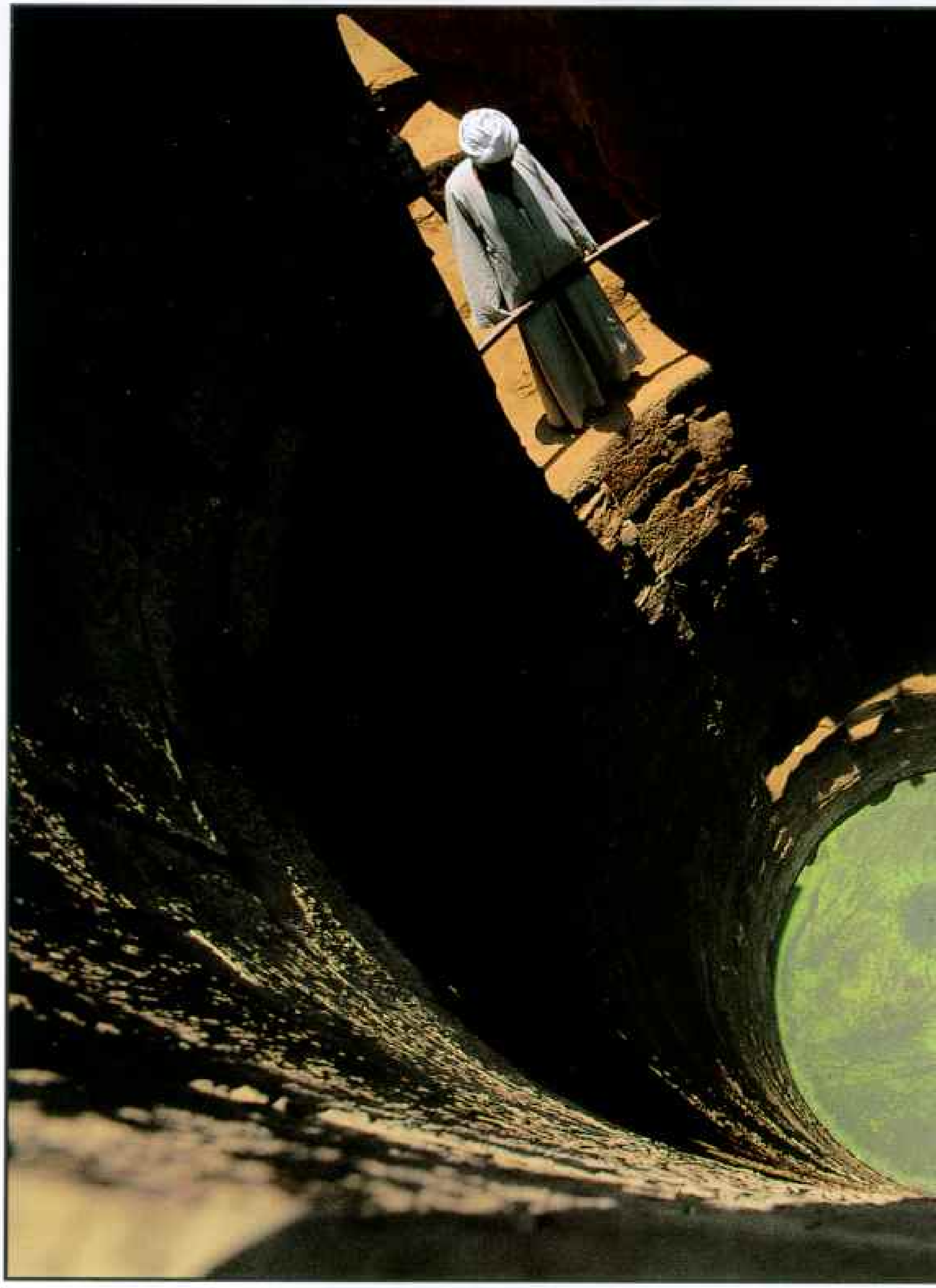
Brightening with each swipe of a workman's cloth, stained glass in the Christian Science Mapparium in Boston, Massachusetts, shows political boundaries and

in Mapping

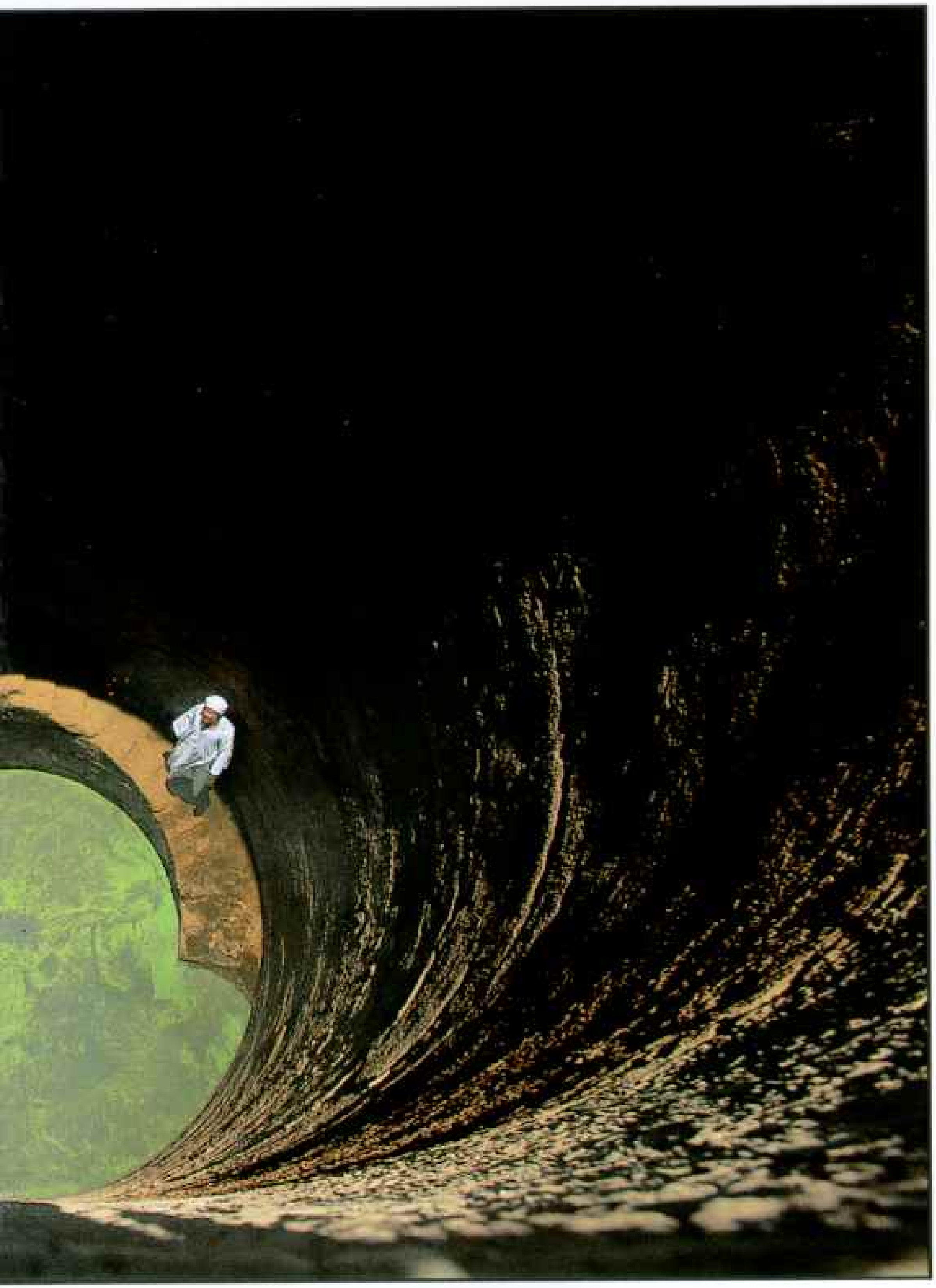
Photographs by Bob Sacha

coastlines charted after millennia of mapmaking. Twentieth-century tools allow cartographers to look beneath forest and ocean and to glimpse deep into the universe.

Circular Logic



Several stories down but still sunlit, the waters of an ancient well near Aswan, Egypt, mark the arrival of the summer solstice. In the third century B.C. in Alexandria, the Greek scholar Eratosthenes relied on both geometry and reports of the sun's annual appearance almost



directly over Aswan to calculate Earth's circumference, arriving at an estimate close to the actual distance. His successors put the figure at far less, giving Columbus the mistaken idea that India lay half as far from Portugal if traveling west across the Atlantic as east across land.

Cardinal Directions

Like points of a compass, four officials of the Vatican Secret Archives stand silhouetted below the Tower of the Winds, built during the Renaissance. The room's ceiling bears Latin and Greek names of 12 winds, personified in puffed-cheeked figures blowing into the center along

golden lines joined at a star. There a pointer connected to a rooftop weather vane shows the direction of breezes outside. Before they knew magnetic north, sailors navigated by the winds, which charts showed radiating out from what came to be called a compass rose.

"It is a strange thing . . . that of this globe of the Earth . . . only

AT THE OFFICES of the United States Geological Survey in Reston, Virginia, John Kelmelis, chief scientist for geographic research, sits at his computer, and sections of the upper Mississippi River floodplain come into view before him. "See that levee," he points to the screen. "What if I took it away or built it higher, what would be inundated?"

One by one, maps fill the screen with answers. A swath of blue spills over the land, covering fields of corn, even whole towns. The computer program is drawing on detailed models of the area's elevations and river volume and flow rates, as well as on the nature and uses of land along the banks. Such maps helped identify sites on higher ground for relocating the town of Valmeyer, Illinois, which was almost destroyed in the flood of 1993.

Next Kelmelis calls up green-and-blue Landsat images of the Missouri and Mississippi Valleys before the 1993 flood, when water stood from bluff to bluff. Computer maps made from these satellite images help guide engineers and policymakers concerned with river-basin management. "This is the future of mapping," Kelmelis says. "For many uses it no longer suffices to make a static map."

Sighting Gibraltar, ancient boundary of the Mediterranean world, a sailor grasps a copy of a 1559 portolan chart that traces the coast. Drawn from observation,

On the threshold of a new millennium, the making and use of maps is in the throes of revolution. So profound are the changes taking place that historians and cartographers look as far back as the Renaissance of the 15th and 16th centuries for precedent. But, in pace and magnitude, the current revolution may be truly incomparable. More than ever the celebrated achievements of cartography's greats—Eratosthenes and

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JOHN NOBLE WILFORD is a veteran science correspondent for the *New York Times* and author of *The Mapmakers*. This is his first story for the magazine. BOB SACHA photographed China's Three Gorges Dam for the September 1997 issue.

the half part up to our time has been traveled and known."

—PETER MARTYR, REPORTING ON COLUMBUS, 1493

PORTOLAN, GEOGRAPHY AND MAP DIVISION © LIBRARY OF CONGRESS, WASHINGTON, D.C.

such charts—which failed to account for Earth's curvature—allowed mariners to navigate close to shore but could send a ship off course in vaster waters beyond.

Ptolemy, Mercator and the Cassini family—seem as quaint as cherubs puffing winds from the margins of old maps. Generations of compasses, T squares, quadrants, and theodolites appear almost Paleolithic compared with today's computers, cameras, multispectral scanners, satellites, and the Global Positioning System.

No longer is the mapmaker's vision confined to what the human eye can see. The perspective of mapmaking has shifted from the crow's nest, mountaintop, and airplane to orbital heights. Seismic probes reveal Earth's underground topography. Imaging radar, which bounces microwave radio signals off a given surface to create images of its contours and textures, penetrates jungle foliage and has produced the first maps of the plains and mountains of cloud-shrouded Venus. A radar system carried by space shuttles has revealed ancient waterways buried beneath the desert sands of Egypt, directing archaeologists to sites occupied by early humans. And a combination of sonar and radar produces charts of the seafloor, putting much of Earth on the map for the first time.

"Suddenly it's a whole different world for us," says Joel Morrison, chief of geography at the U.S. Bureau of the Census. "Our future as mapmakers—even ten years from now—is uncertain."

THE WORLD'S LARGEST collection of maps resides in humble quarters at the Library of Congress in Washington, D.C. In the basement of the James Madison Memorial Building, Ralph Ehrenberg presides with a quiet, scholarly air over the Geography and Map Division, a buried treasure of 4.6 million map sheets and 63,000 atlases. In a humidity-controlled vault Ehrenberg pulls out bound collections of elaborate maps—the pride of the golden

"Some do understand that the knowledge of the longitude might

age of Dutch cartography. We admire a 12-volume set printed and hand-painted by the Blaeu family. Gerardus Mercator's final contribution to cartography was to give such books the name they go by today—"atlas," for the legendary astronomer-king who created the first celestial globe.

In the reading room scholars examine other old maps with magnifying glasses, and genealogists search for ancestral towns. They wear thin cotton gloves to protect the fragile sheets from body acids, which corrode paper. Across the room people are hunched in front of computer screens. They too are studying maps, and in some cases generating their own in the time it must have taken early chartmakers to draw a single rhumb line, or line of constant compass direction.

With their prodigious memories, computers hold all manner of data about people, places, and environments—the stuff of maps—and make them readily available to anyone initiated in cyberspace.

Click. Almost instantly information is displayed on the screen in the desired geographic context, by city block, county, state, or nation. Click. A printout of the map appears. Another disc in the drive, more clicks. A map of the land comes on the screen and, with a few more commands, is stripped of everything except the road and trail to your favorite trout stream. Or its scale is reduced or enlarged. Even the perspective can be shifted, transporting you to the other side of a mountain or down into a canyon, looking up.

"Today you can put a CD-ROM into the computer, and with each image that comes on the screen, you are creating a new map," Ehrenberg says. "To me that's revolutionary."

NO ONE WILL EVER KNOW when or where or for what purpose someone got the first idea to draw a sketch to communicate a sense of place, some sense of here in relation to there. Before Europeans reached the Pacific, Marshall Islanders lashed sticks together to depict prevailing winds and wave patterns. Prehistoric Europeans drew sketch maps on cave walls, and the Inca made elaborate relief maps of stone and clay. In 1805, when the

be found, a thing doubtless greatly to be desired."

—RICHARD EDEN, 1578

explorer Meriwether Lewis arrived at a Shoshone camp in the Rockies and inquired about the way ahead, the chief drew a wavy line on the ground to represent the river and piled mounds of sand on either side to show the mountains it ran through.

Measuring the spherical Earth ranks as the first major milestone in scientific cartography. It was the achievement of a Greek scholar, scientist, theater critic, and librarian named Eratosthenes. He lived in the third century B.C. and was a luminary at the famous Alexandrian Library. He knew of a well up the Nile at Syene (the Greek name for Aswan), where at midday on the summer solstice, June 21, sunlight beamed straight down to the bottom. If Earth is a sphere, he reasoned, then sunlight at the same moment must strike different parts of Earth at different angles, casting measurable shadows. Since Alexandria was assumed to be due north of Syene, here were two places, separated by a known distance (paced off by camel caravans), lying on the same north-south meridian of longitude.

Without leaving the library grounds, Eratosthenes examined the shadow cast by a column at noon on the solstice. Its angle measured about one-fiftieth of a circle. Multiply the distance between Alexandria and Syene by 50 and you get Earth's circumference—which he figured at 25,200 miles. Despite the fact that Alexandria and Syene are not exactly on the same meridian and caravan measurements could not have been precise, the librarian's calculation was remarkably accurate—the longitudinal circumference is known today to be 24,860 miles.

Even before Eratosthenes, astronomers had looked to the sun for

Illuminating an imaginary line, lightbulbs strung through England's Greenwich Park mark the prime meridian just north of the Royal Observatory. Mariners guessed at longitude until 1765, when the chronometer allowed exact measures of time, and thus of east-west distance. Zero degrees longitude was fixed here in 1884, an acknowledgment of Britain's domination of shipping and charts.

Aided by a costumed soldier, a visitor to the Colosseum scans another legacy of Rome—a street map. Turning Greek theory to practical ends, the Romans mapped property boundaries, towns, roads, and journeys, using cartography to administer their far-flung empire.

cartography's primary lines of reference. The sun's annual movement in relation to Earth's surface yielded the Equator and the Tropics of Cancer and Capricorn, which correspond to the highest and lowest extremes of the sun's apparent seasonal migration.

Often borrowing ideas of his predecessors, the astronomer and geographer Ptolemy in the second century A.D. spelled out a system for organizing maps according to grids of latitude and longitude. Today parallels are often spaced at intervals of 10 or 20 degrees and meridians at 15 degrees, which is the basis for the width of time zones. Because Earth rotates 360 degrees every 24 hours, it turns 15 degrees every hour.

Another legacy of Ptolemy's is his admonition to cartographers "to survey the whole in its just proportions." That is, to scale. Distance on today's maps is expressed as a fraction or ratio of the real distance. But mapmakers of Ptolemy's time lacked the geographic knowledge and measuring know-how to live up to Ptolemy's scientific principles. Not that absolute precision can ever be attained. Even now, when surveyors achieve accuracies down to inches and satellites can plot potential missile targets within feet, maps are not true pictures of reality. Each

map is a product of compromises, omissions, and interpretations. Even a good map, says Mark Monmonier, a geographer at Syracuse University, "tells a multitude of little white lies."

After Christian mobs sacked the Alexandrian Library in 391, Ptolemy's ideas were lost to the Western world for a millennium. In the Middle Ages Europe turned mapmaking over to Christian monks, who illustrated theology more than geography.

Typical are their T-O maps, in which the known land is surrounded by ocean—the O. Within a circle lie Africa, Asia, and Europe, separated by bodies of water and drawn in the shape of a T. On these maps Jerusalem is often given prominence at the center, for it was written in Ezekiel 5:5: "I have set it [Jerusalem] in the midst of the nations and countries that are round about her."

In England's Hereford Cathedral is a 13th-century map that is the epitome of medieval cartography—with a practical touch. A number of well-traveled routes to the Holy Land are shown, revealing the cartographer's familiarity with road maps, a legacy of the Roman Empire.

Since all roads were said to lead to Rome, the Romans had naturally been among the first to produce extensive road maps. In the time of Christ, Augustus Caesar's son-in-law Marcus Agrippa is said to have directed a 20-year survey over thousands of miles of roads from Britain to the Middle East. His master map, engraved in marble and set up near the Forum in Rome, became a source of information and an object of patriotic pride. Parchment copies, modified and enlarged over the years, were rolled up and carried by generals and travelers.

Sailing handbooks called portolanos, from the Italian word for harbor guides, marked a sharp tack in Western mapmaking and the most useful innovation in the Middle Ages, perhaps as early as the 13th century. T-O maps might be good for the soul, but seamen wanted to find their way to port—let heaven wait.

At the Library of Congress I examine an anonymous Catalan portolan chart of the Mediterranean, circa 1350. The chart evokes an image of the mapmaking craft as plied then. A solitary scribe, bent over a table in some seaport studio, perhaps in Barcelona or on Majorca, traces a shoreline with steady hand. He draws networks of straight lines by which mariners could find their way along the coast using the newly introduced magnetic compass. So familiar were these crisscrossing rhumb lines that they would later inspire Shakespeare to write in *Twelfth Night*, "He does smile his face into more lines than is in the new map, with the augmentation of the Indies."

If the compass improved navigation and created demand for useful charts, the printing press put maps in the hands of more people and began to take their production out of the hands of monks. Oceangoing ships launched an age of discovery and empire, enlarging both what could and needed to be mapped. An awakened intellectual spirit, the engine of the Renaissance, whetted appetites for knowledge of the world.

Inspired by the rediscovered Ptolemy, whose writings had been preserved by Arabs, mapmakers in the 15th century gradually replaced theology with knowledge of faraway places as reported by captains under Portugal's Prince Henry the Navigator and traveling Venetian merchants like Marco Polo and Niccolò de' Conti.

Poring over these new maps, savants in Florence recognized the ocean not as a barrier but as a navigable waterway *(Continued on page 26)*

Expanding Images of Earth

"Maps, like faces, are the signature of history," wrote historian Will Durant, and early cartographers, starting with the Mesopotamians, left pictures of their times. Maps from ancient Babylonia and 12th-century China showed those civilizations filling the Earth, with other known peoples at the margins or missing entirely. In Europe medieval maps of the world were usually oriented east, toward Paradise, with Jerusalem at the center, and monsters and marvels populating the regions beyond Christendom. From ancient times to the Renaissance, Greek, Roman, Islamic, and European maps were bounded by the limits of recorded exploration.

But the writings of Greek scientists, preserved by Islamic and Byzantine scholars, laid the basis for a tradition of mathematical cartography that would measure and encompass the globe. In the second century A.D., Ptolemy described a system for mapping the world on a grid of lines of latitude and longitude curved to compensate for Earth's spherical shape. More than 12 centuries later his theories were rediscovered in western Europe, just as mariners, navigating by compass and charts webbed with rhumb lines, sailed to lands Ptolemy never knew, plotting observations of headlands and estuaries.

From the 15th century on, European empires pushed the boundaries of maps east and west, north and south, until they finally covered the inhabited continents, and cartographers stood poised on vast new projects—mapping the interiors of India, the United States, and Brazil and tracing the coastline of Antarctica. All the while, Europeans spread the Western tradition of cartography everywhere, until mapmakers around the globe worked from the same set of methods and knowledge, speaking the common languages of mathematics, science, and geography.

An early world map, circa 600 B.C., shows Babylon as a rectangle intersected by two vertical lines representing the Euphrates River. Small circles stand for surrounding kingdoms, and an ocean encircles the world.

270 B.C.
Timosthenes of Rhodes adds two winds to the ten named by Aristotle, creating directions that become the 12 original compass points.

CIRCA 240 B.C.
Eratosthenes, while head of the Alexandrian Library, estimates Earth's circumference to within 340 miles.

CIRCA A.D. 21
At the order of Augustus, a map of the world based on the empire's road system is created and displayed near the Forum in Rome.

150
Claudius Ptolemaeus, or Ptolemy, compiles centuries of Greek learning in his book *Geography* but underestimates Earth's circumference.

1119
The Chinese invent the magnetic needle. In Europe the compass appears on ships soon after and by the late 1400s in land surveys.

1136
Continuing a cartographic tradition dating from the third century B.C., a "map of Chinese and foreign lands" is cut into a stone, showing rivers and what would become the Great Wall, bordered by text giving place names, descriptions, and history. On the other side of the stone is engraved a second country map, for centuries the world's most accurate.

1154
Al-Idrisi, an Arab geographer in the court of the Norman King Roger II of Sicily, makes a world map influenced by Ptolemy.

1280
An English priest creates the Hereford Mappa Mundi. Following medieval custom, he shows the world as a circle surrounded by an ocean and divided into three parts—Europe, Africa, and Asia—by the Mediterranean Sea and the Don and Nile Rivers.

1482
A world map based on Ptolemy is published in Ulm, Germany. As his work is rediscovered in western Europe, it introduces what author Peter Whitfield calls "a dispassionate sense of geographic reality." However, the known world covers too many degrees of longitude.

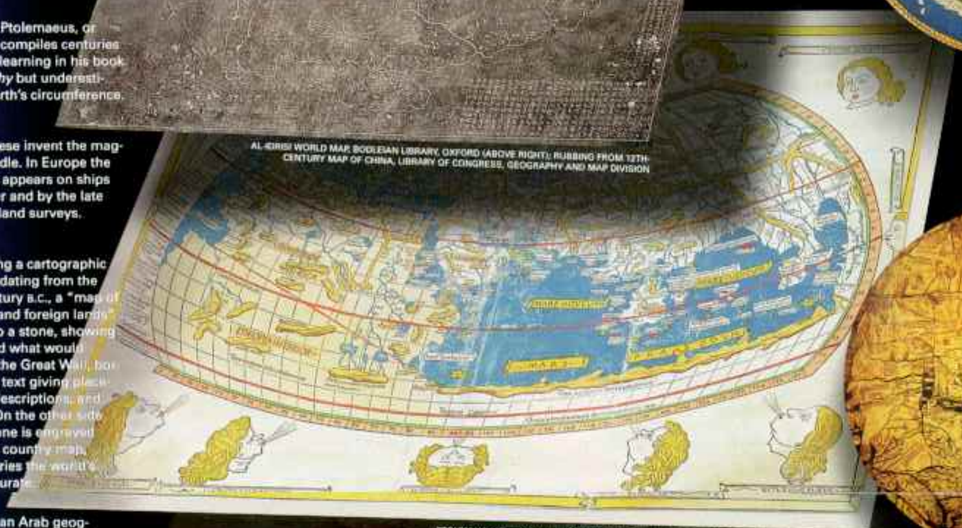
1492
Martin Behaim of Nürnberg creates a terrestrial globe, the oldest surviving. It shows the world before Columbus's voyages, with only a narrow sea separating Cape Verde from Japan. In the words of a 13th-century text: "A man could go round the earth as a fly crawls round an apple."

1500
After crossing the Atlantic, Spanish navigator Juan de la Cosa draws a portolan chart, the first Old World map to show the New World.

1507
Impressed with Amerigo Vespucci's argument that Columbus reached a new continent and not the eastern tip of Asia, Martin Waldseemüller, a German, prints the first map with the term "America."

1569
Flemish cartographer Gerardus Mercator publishes his new projection of the world, with parallels of latitude and meridians of longitude that can serve as lines of constant bearing for mariners using compasses. In order to portray the spherical world on a flat map, Mercator's system exaggerates the size of landmasses toward the Poles.

AL-IDRISI WORLD MAP, BODLEIAN LIBRARY, OXFORD (ABOVE RIGHT); RUBBING FROM 12TH-CENTURY MAP OF CHINA, LIBRARY OF CONGRESS, GEOGRAPHY AND MAP DIVISION



PTOLEMAIC MAP FROM ULM, GERMANY, THE BRITISH LIBRARY (ABOVE); HEREFORD MAPPA MUNDI, THE DEAN AND CHAPTER OF HEREFORD AND THE HEREFORD MAPPA MUNDI TRUST

JUAN DE LA COSA PORTOLAN, MUSEO NAVAL, MADRID (ABOVE); MARTIN BEHAIM GLOBE, GERMANISCHES NATIONAL MUSEUM, NÜRNBERG

MARTIN WALDSEEMÜLLER WORLD MAP © 1997, WYCHWOOD EDITIONS; DISTRIBUTED BY INTERARTS/GEOSYSTEMS

GERARDUS MERCATOR 1569 MAP, BIBLIOTHÈQUE NATIONALE, PARIS

The View From Above

Two centuries ago a pair of earthbound cartographers named Jacques and César-François Cassini relied on what their eyes could see across the curving surface of France to collect the most accurate survey measurements of a nation up to that time. A century ago mapmakers ascended in balloons to record bird's-eye views of the land with a new invention—the camera. Forty years ago as airplanes, then rockets, lifted human vision higher and higher, the U.S. Navy coined the term "remote sensing"—examining Earth from a distance.

High-altitude photographs and satellite images give cartographers views of a world they have never seen in its entirety. Digital images, many at wavelengths invisible to humans, instantly provide information that would once have taken lifetimes to collect, if it could have been gathered at all. For the first time cartographers can "see" through desert sands and polar ice. They can map the hole in the ozone layer and the health of trees in a rain forest. They can look through night and clouds using radar or create mosaics of the globe by piecing together satellite and sonar images to produce the views of land and ocean floor below.

Computer-based geographic information systems (GIS) let cartographers manipulate such data, layering information to create maps that answer questions in visual terms and illustrate hidden relationships between geographic phenomena. With such knowledge comes power—power to exploit or conserve resources and to detect environmental threats long before they become apparent on Earth.

NG MAPS

Eyes in the Sky

Distant geostationary satellites orbit 22,300 miles up, rotating with Earth for a constant view. Low-altitude satellites pass over the Equator and polar regions many times a day, eventually viewing most of the planet turning below.

Coming Into Focus

Details surface as spatial resolution increases in computer-generated images based on an aerial photograph of the U.S. Capitol in Washington, D.C. From bottom to top, they simulate the 30-, 15-, 10-, and 1-meter resolution possible by commercial satellites.

AERIAL PHOTOGRAPH BY NATIONAL CAPITAL PLANNING COMMISSION AND DISTRICT OF COLUMBIA; PROCESSED BY PHOTO SCIENCE, GAITHERSBURG, MARYLAND

1676
Jean-Dominique Cassini perfects a means of using Jupiter's moons to determine longitude. It is applied to a world map and a survey of France.

1765
John Harrison's marine chronometer, which allows sailors to measure exact longitude at sea, is approved by the British government.

1793
Jacques-Dominique Cassini, Jean-Dominique's great-grandson, publishes an atlas of France.

1858
Gaspard-Félix Tournachon takes the first known aerial photograph, from a balloon over a village near Paris.

1884
Delegates at an international conference in Washington, D.C., accept the Greenwich prime meridian as standard.

1914-1918
Both sides in World War I use airplanes and cameras for aerial mapping of battlefields.

1920s
Working with custom-designed cameras and airplanes, the Fairchild company pioneers aerial surveys in the United States.

1946
At White Sands, New Mexico, U.S. Army scientists take the first photographs from rockets, using V-2s captured from Germany.

1950
First computer-generated map is published. It shows the weather in Europe and North America.

1959
The U.S. launches the first weather satellite, Explorer 6, which sends televised pictures back to Earth.

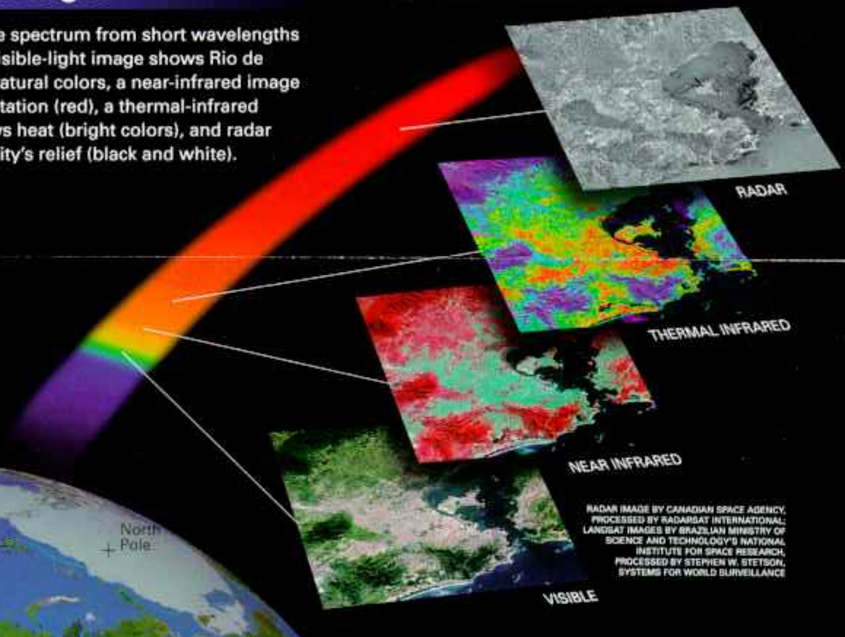
1960s
A California company produces Geodolites—laser instruments that remain unsurpassed for measuring distance.

1965-1966
Gemini astronauts take photographs from orbit that show geologic features on Earth.

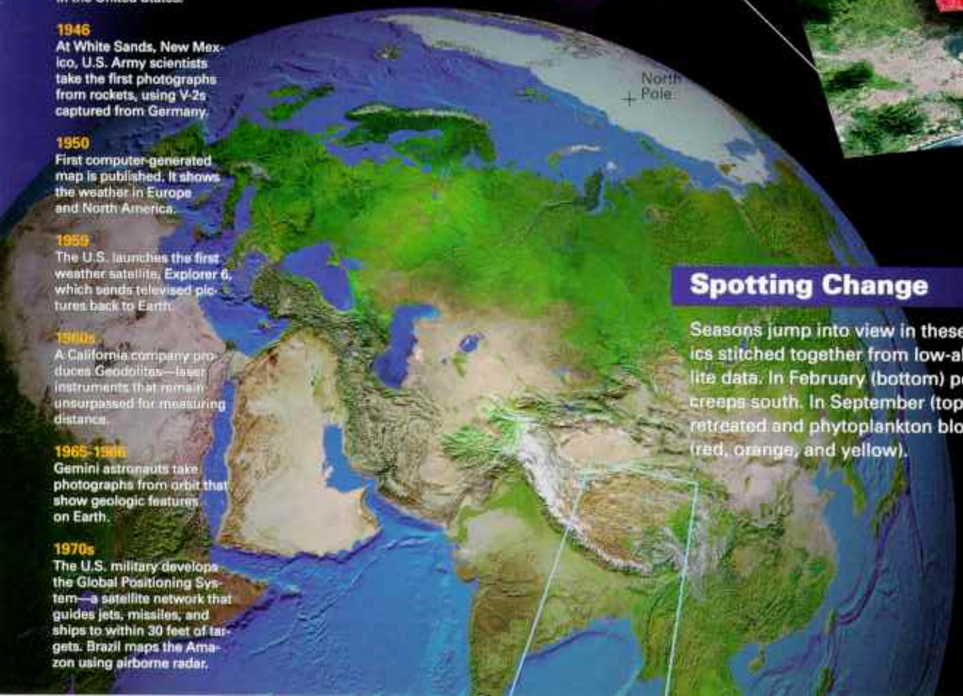
1970s
The U.S. military develops the Global Positioning System—a satellite network that guides jets, missiles, and ships to within 30 feet of targets. Brazil maps the Amazon using airborne radar.

Range of Sight

Crossing the spectrum from short wavelengths to long: A visible-light image shows Rio de Janeiro in natural colors, a near-infrared image shows vegetation (red), a thermal-infrared image shows heat (bright colors), and radar etches the city's relief (black and white).

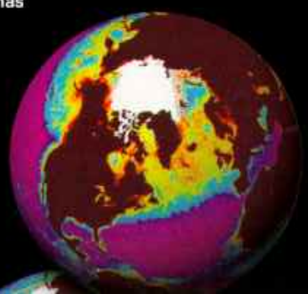


RADAR IMAGE BY CANADIAN SPACE AGENCY, PROCESSED BY RADARSAT INTERNATIONAL; LANDSAT IMAGES BY BRAZILIAN MINISTRY OF SCIENCE AND TECHNOLOGY'S NATIONAL INSTITUTE FOR SPACE RESEARCH, PROCESSED BY STEPHEN W. STETSON, SYSTEMS FOR WORLD SURVEILLANCE



Spotting Change

Seasons jump into view in these map mosaics stitched together from low-altitude satellite data. In February (bottom) polar ice (white) creeps south. In September (top) ice has retreated and phytoplankton blooms (red, orange, and yellow).



1972
NASA launches the first Landsat satellite, with a multispectral scanner, which can measure four different wavelengths of reflected energy.

1978
NASA launches the Nimbus 7 satellite, which carries a spectrometer to measure the ozone hole over Antarctica and a scanner to detect chlorophyll concentrations in the ocean.

1982 and 1984
The U.S. launches Landsat 4 and 5, with the Thematic Mapper, which sees details as small as 30 meters and measures seven wavelengths, including one that can penetrate to a depth of ten meters in clear water.

1986
France launches the first SPOT satellite, with resolution as fine as ten meters.

1995
India launches a satellite with resolution to 5.8 meters.

1998
Space Imaging EOSAT, an American company, prepares to launch a satellite offering one-meter resolution—fine enough to distinguish bushes and tennis court lines and create images equivalent in detail to maps drawn by the U.S. Geological Survey.

AREA ENLARGED BELOW

NOAA AVHRR IMAGES PROCESSED BY ROBERT STACEY, WORLDSAT INTERNATIONAL, AND JIM KNIGHTON

NIMBUS IMAGES PROCESSED BY LABORATORY FOR OCEANS AND ICE, GODDARD SPACE FLIGHT CENTER, NASA

NOAA AVHRR IMAGES PROCESSED BY WORLDSAT INTERNATIONAL; TYPHOON DATA RENDERED BY LABORATORY FOR ATMOSPHERES, GODDARD SPACE FLIGHT CENTER, NASA

Layered Look

One atop the other, digital images create a map of a 1991 typhoon over the Bay of Bengal. Topographic data are overlaid with a natural color image, political boundaries and labels, and a thermal image of the storm.

Plotting a course across his Illinois farm, Doug Harford demonstrates his use of the Global Positioning System—a satellite network that gives precise geographic coordinates. Detailed maps can target areas of low yield (right, red and yellow) for applications of costly chemicals.

(Continued from page 17) connecting all parts of the world. By some accounts their liberating concept emboldened Columbus, who likely used only a single chart and the advice of a cosmographer to plot his course, to undertake his Enterprise of the Indies.

Ultimately, though, Columbus would be ill-served by mapmakers. On a 1507 map Martin Waldseemüller wrote across the southern continent of the New World, in the region of Brazil, the word "America," after another explorer, Amerigo Vespucci. The name stuck; such is the power of maps.

IN THE VATICAN MUSEUMS I join a throng of tourists headed for the Sistine Chapel to have their breath taken away by Michelangelo. The way leads us through the Gallery of Maps, an ornate corridor longer than a football field. Commissioned by Pope Gregory XIII, Egnazio Danti, a cosmographer and the papal architect, designed the cycle of Italian wall maps beginning in 1580, while also directing a revision of the calendar in the Vatican's Tower of the Winds. Much of the actual work was done by mannerist painters, working mainly from existing maps and drawings. To a remarkable degree the shapes represent reality.

"These maps are not there to get you to the autostrada," says Arnold Nesselrath, the museums' director of Byzantine, medieval, and modern

art. The frescoes, he explains, served an important political purpose in a turbulent century of imperial expansion, Reformation, and Counter-Reformation. To map a territory was tantamount to possessing it.

In the centuries following the Renaissance, exploration, empires, and the rise of nation-states inextricably linked mapping with possession. And new tools of surveying greatly enhanced cartography's utility.

Gerardus Mercator, the foremost cartographer of the 16th century, developed a technique of arranging meridians and parallels in such a way that navigators could draw straight lines between two points and steer a constant compass course between them. This distortion formula, introduced on his world map of 1569, created the "Greenland problem." Even on some standard maps to this day, Greenland looks as large as South America—one of many problems that occur when one tries to portray a round world on a flat sheet of paper. But the Mercator projection was so practical that it is still popular with mariners.

Scientific mapping of the land came into its own with the achievement of the Cassini family—father, son, grandson, and great-grandson. In the late 17th century the Italian-born founder, Jean-Dominique, invented a complex method of determining longitude based on observations of Jupiter's moons. Using Cassini's technique, surveyors were able to produce a more accurate map of France, but King Louis XIV was not pleased. Upon seeing a country smaller than he'd imagined, he exclaimed, "Your work has cost me a large part of my state!"

The family continued to map the French countryside, applying a basic geometric principle: If you know one side and two angles of a triangle, you can determine the properties of the rest of the triangle.

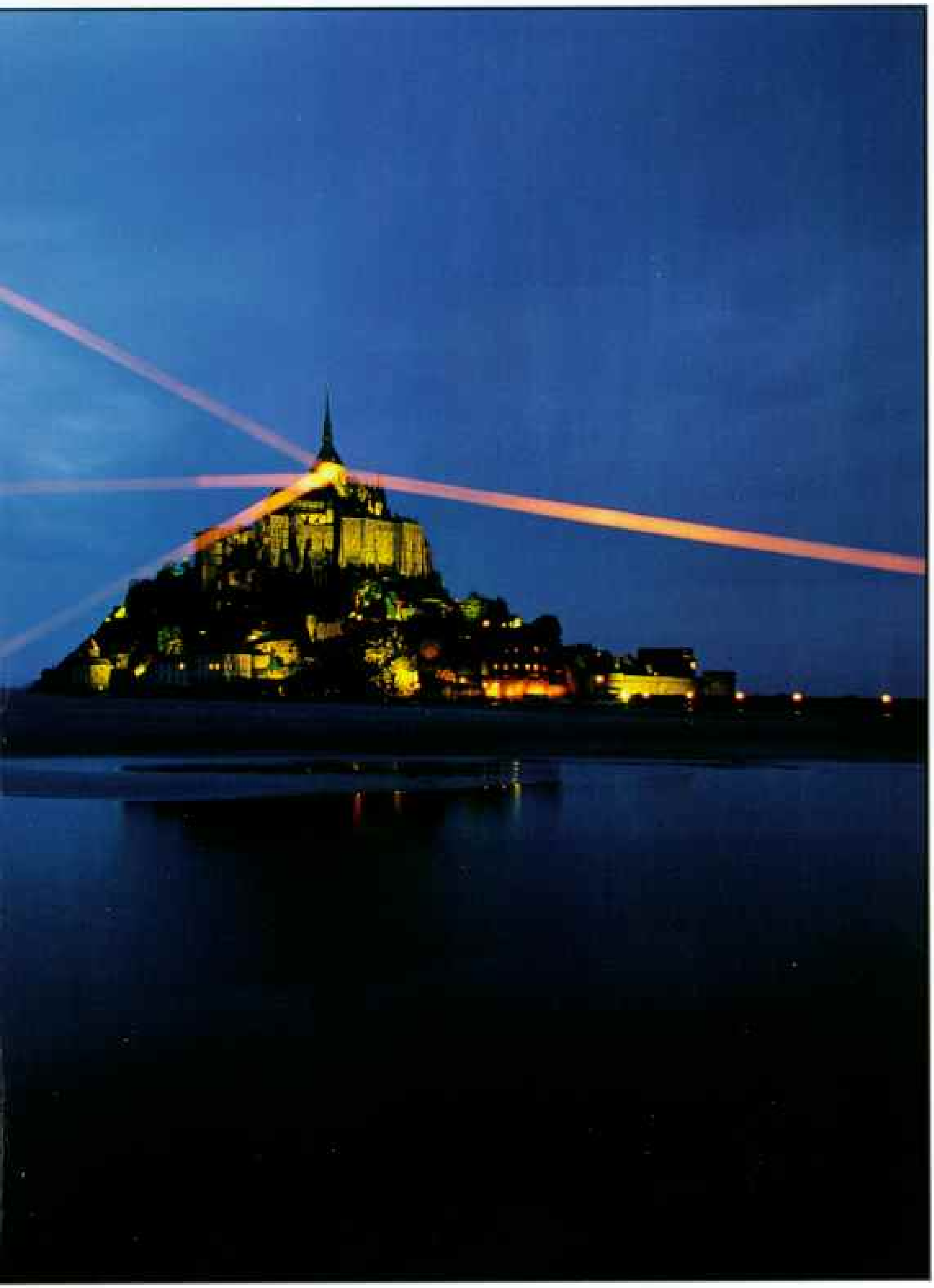
They would measure the triangle's baseline. From the two ends of that line they would sight on a distant object, a mountaintop, or tower. Lines drawn from these two points give two known angles. The intersection of the lines at the remote object closes the triangle and, with some calculation, gives the lengths of the other two sides. It is thus possible to determine the distance to remote places without going there.

Jacques-Dominique de Cassini, Jean-Dominique's great-grandson, finally published the map in 1793, in the midst of the French Revolution. Its 182 sheets when assembled measure some 36 by 36 feet. But if the map lacks the artistic flourishes and aesthetic appeal of earlier ones, the Carte de Cassini is the model of a topographic map. It shows roads, rivers, canals, towns and hamlets, abbeys, châteaus, vineyards, lakes, even windmills. With this achievement, France became the first country to be completely mapped by scientific methods.

By that time maps had begun to depict more than the landscape. The man who is usually associated with comets also earned a place in cartographic history by making the first maps illustrating wind patterns and magnetism. In 1686 Edmond Halley drew what is considered the first meteorologic map, showing the directions of prevailing winds in a

Turning Point

Light reflected from nylon thread near Mont-Saint-Michel illustrates triangulation, the method Jacques Cassini and his son César-François used to survey 18th-century France. Starting from the Paris meridian, they sighted off high landmarks to accurately measure distance.



At Mont-Saint-Michel, lines of sight from four vantage points met in the apexes of three triangles at the steeple of the medieval abbey. By 1744 the Cassinis had crisscrossed the country with 400 such triangles.

Ricocheting off a retroreflector at Holloman Air Force Base in New Mexico, a laser beam bounces back to a Geodolite, which calculates distance to within one millimeter. Such measures serve as standards against which distances from missile guidance systems are checked.

way that "may be better understood, than by any verbal description whatsoever." A few years later, after a two-year expedition in the Atlantic, he prepared a map showing variations of the compass needle from true north, as plotted over the expanse of the Atlantic.

Another early application of thematic mapping solved a medical mystery. In 1854 a physician named John Snow prepared a map of London on which a dot marked the site of each death from cholera, and a cross identified each water pump. The map made everything clear: The incidence of cholera occurred only among people who drank from the Broad Street pump.

Thematic mapping has come a long way from dots and crosses. Twice a week officers and precinct commanders from the New York Police Department meet in the command and control center on the eighth floor of Police Headquarters in downtown Manhattan, where computer maps are projected on a huge screen. With a system called Compstat, for computer statistics, everything about any crime of murder, rape, robbery, or drug dealing is available in an instant, much of it plotted on a computer map. One look and patterns become apparent: two shootings

and a robbery a week and a block apart in Washington Heights or the fact that several recent shootings in a Brooklyn neighborhood were committed by young men on bicycles.

"We don't solve any crimes in this room," says Deputy Police Commissioner Edward Norris. "But this is how we are able to manage our resources better and decide where and how to deploy our forces."

Take, for example, the rash of bicycle shootings. As soon as police recognized the pattern on the computer maps, they swept into the neighborhood and stopped bikers violating any law, like going the wrong way on a one-way street. "In these encounters we discovered 18 handguns," Norris says. "Within a short time the shootings went away."

THE MERGER OF PHOTOGRAPHY AND AVIATION, which began in World War I, speeded up mapping and gave cartographers access to terrain that had defied the most intrepid surveyors. It foretold today's revolution, which is driven by Cold War technological hand-me-downs. Variations of space satellites developed for military reconnaissance enable mapmakers to measure and image more in hours than they once could in weeks or years or ever.

Today's surveyors rarely go into the field without electronic instruments linking them at any one time to four or five navigation satellites of the Global Positioning System (GPS). Their handheld GPS receivers are the most familiar of the new mapping technologies. Developed and still operated by the U.S. Defense Department, the satellite system that fixes missile targets and keeps track of troops and ships to within a few yards is increasingly used by surveyors. Even ordinary hikers, sailors, and explorers can tap into it for data telling them where they are. Simplified civilian versions of the receivers are available for a few hundred dollars. They are also the heart of electronic map displays available in some cars.

Without extremely accurate GPS measurements, surveyors from USGS and the U.S. Army Corps of Engineers could not hope to map Florida Bay and the Everglades in the time and at the precision demanded by the Everglades Restoration Project. The object of the project is to manage the sluggish flow of water through this 2,117-square-mile wetland in an attempt to restore its plumbing to more natural conditions. Because the slope from Lake Okeechobee to the Florida Keys 107 miles south is no more than 50 feet, an understanding of complex drainage patterns requires surveyors to produce maps on which elevations are plotted to an accuracy of a couple of inches.

"This is very nonstandard work," Greg Desmond of USGS tells me as we head out for another day in the field in Key Largo. His surveyor-speak means that his crew must exceed the usual precision in establishing the positions and elevations of benchmarks along the Florida Keys. Sometimes the work is easy. The crew starts from benchmarks previously measured to a high degree of accuracy, one at the town of Flamingo on the mainland and another in the backyard of Audrey Woodward, who lives in the town of Tavernier.

Woodward enjoyed hearing that her home's exact place in the world is aligned by sightings on quasars at the edge of the universe. (More than ordinary stars, quasars are so far away that they never seem to change position and thus serve as fixed points of reference fundamental to modern mapping systems.)

"No longer does the engineer hew his way through brake and

From a "control point" like the brass disk in Woodward's yard, surveyors fan out to make GPS measurements at other sites nearby. Each measurement records the distance and direction of a site from Woodward's cottage as well as its exact longitude, latitude, and elevation. Though each reading may take only a minute or two, the work demands patience and fortitude.

On Lower Matecumbe Key we wait out a shower and contend with winds that seem to stop pelicans in mid-flight. In afternoon heat we slog through mangrove thickets to fix one more control point in one more line of measured sites.

"Surveying is like a spider spinning a web," Brian Shannon of the Corps of Engineers says at the end of the day. "You're moving back and forth, building something one line at a time until you have a complex network that captures a place."

Not that GPS has the solution to every question of location, as I learned a few years ago while on a paleontological expedition in the Gobi of Mongolia. Thanks to our GPS receiver, we always knew the coordinates of our fossil beds and the distance and direction to the next destination. Still, we got lost. In a land without roads or good maps, we could never be sure whether the best way forward, to avoid uncharted obstacles like ravines, was to the south, north, or straight ahead. We could only head for the nearest *ger*, engage the Mongol herder in palaver about his horses and sheep, and finally get to the point. Though the herder could only shake his head in wonderment over the peculiar device in our hands, he alone could tell us the surest way to get where we were going.

Overlapping photographs of Route 99 south of Sacramento, California, record a strip of land first surveyed from the air in 1930 by a custom-fitted airplane like the vintage Fairchild at left. Industrialist Sherman Fairchild

REMOTE SENSING takes mapping into even more unexplored terrain. In 1995, when the Navy declassified secret radar charts, David Sandwell of the University of California at San Diego and Walter Smith of the National Oceanic and Atmospheric Administration prepared a comprehensive, highly accurate map of the ocean floors for nonmilitary use. They combined years of echo soundings by ship surveys and altimeter readings from satellites to trace underwater topography in striking detail. High ridges and deep rift valleys stood out in stark relief. These maps promise to yield insights into

brush, but today . . . takes unto himself wings."

—THE FAIRCHILD AERIAL SURVEYS, INC., 1938

BOB EACHI WITH CHIP KALLEN

pioneered aerial surveying after World War I. Today helicopters with cameras like the one that made these photographs fly low and slow over aging highways to map them for repair.

forces driving the motions of continents and triggering earthquakes.

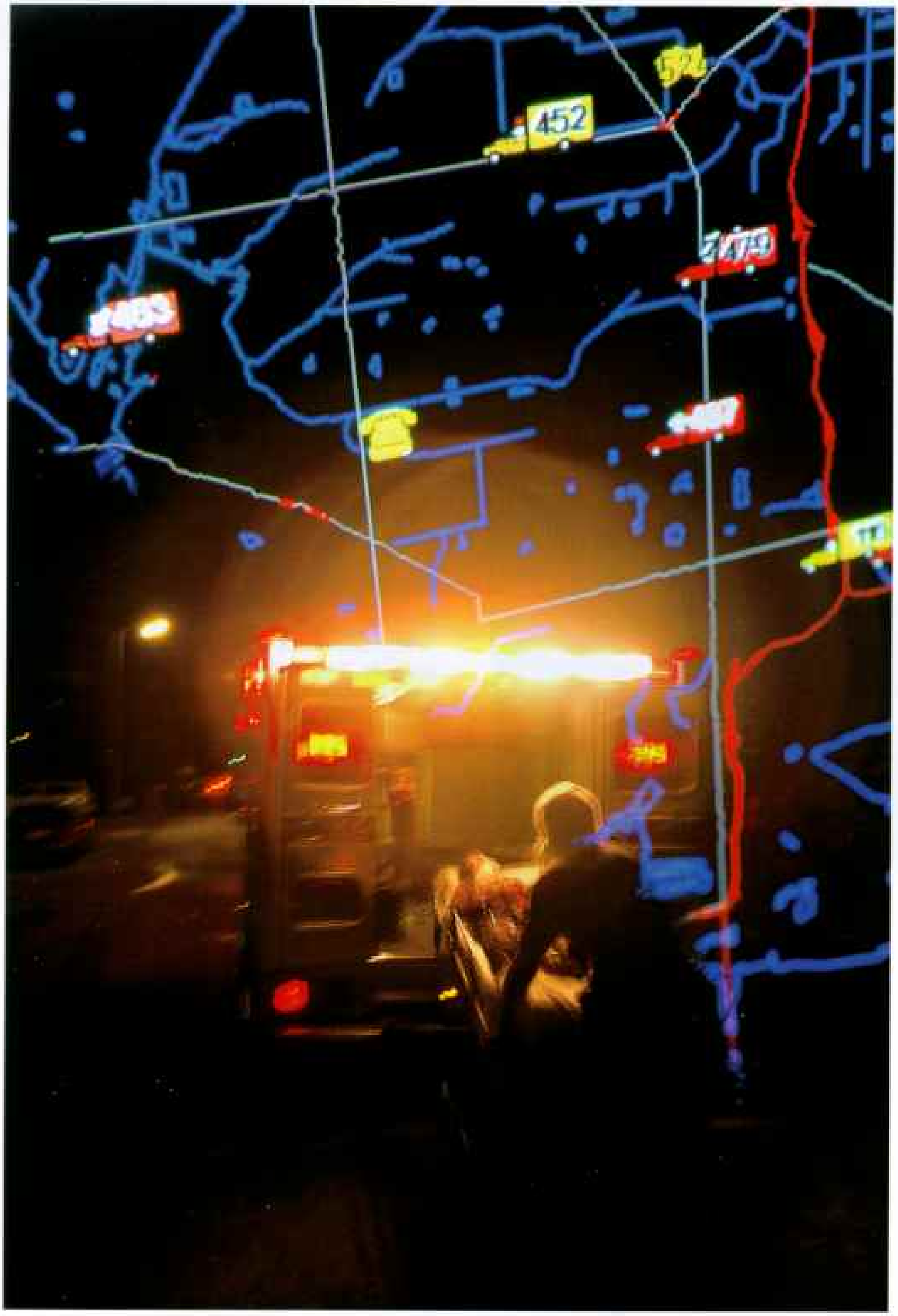
Joel Morrison, the geographer at the Census Bureau, looks back to 1972 as a turning point in applying remote sensing from space to mapping. That was when NASA initiated the Landsat program for surveying Earth with multispectral scanners, another military by-product. "Landsat," Morrison says, "represents the beginning of the systematic mining of this new source of raw materials for cartographers."

Multispectral scanners can distinguish several visible colors and invisible infrared radiation reflected from Earth's surface. Researchers have learned to interpret these spectral signatures to chart the variety and health of trees and crops, pollution in streams and the spread of plankton in the sea, and earthquake fault lines and potential mineral deposits. The result: a new capability to produce thematic maps almost instantly and keep updating them as conditions change.

Images from Landsat and the French SPOT are now used in more general mapping, though their resolution (30 meters for Landsat, 10 meters for SPOT) limits their utility. India has a satellite that can gather images of objects as small as 5.8 meters in width. Secret military satellites can do much better, and three private U.S. companies plan to launch and operate small commercial satellites that they claim will deliver images at resolutions of three meters or less, at costs of a few hundred dollars each. The companies are betting there is a market worth several billion dollars a year for such images in urban planning, agricultural and environmental monitoring, making and revising maps, and perhaps cut-rate espionage. Some people may even want to buy images of their home as seen from space or of what is on the other side of that fence around a neighbor's yard.

"Some of us are skeptical that there is a big enough market, especially for three companies," says Stephen Guptill, a geographer at USGS. "But the technology is there."

THE NEW SATELLITE REMOTE-SENSING SYSTEMS have one thing in common: Their data and images are collected and transmitted in digital form. That means they can be readily stored in computers, then processed and converted to maps. Collections of this processed digital data are the foundation of many geographic information systems (GIS), which were developed by the



Charting emergency calls, a computer-assisted dispatch system in Largo, Florida, cuts response times for ambulances like the one in the double exposure above. Natural disasters can force rescuers to turn to more traditional means. Floating through East Grand Forks, Minnesota, a Coast Guardsman follows submerged streets on a rental-car map—the only one at hand.

government and have become another bustling business for small software companies.

One of the most comprehensive of these databases is the Census Bureau's TIGER (for topographically integrated geographic encoding and referencing). Every highway and street in the country is in the file, along with the addresses on each side. All new census results are keyed to this file. Much of the data is available to anyone, as are demographic and geographic databases of other government agencies. Software companies increasingly obtain such data, then process and sell them for use in making maps flashed on desktop computers. Such maps are used for everything from planning new store openings to marketing campaigns to routing deliveries by trucks equipped with GPS receivers.

In such computer mapping, think of each layer of data as a sheet of clear plastic bearing a distinct set of information. The bottom sheet might be a map of political boundaries and streets. On top of that could be placed other layers keyed to the base map: education levels, buying power, just about any demographic information you could want.

"We overlay one set on another, sometimes things you couldn't conceive of mapping before," explains John Kelmelis at USGS. "If done by hand, this might have taken a whole career. And it was virtually impossible then to keep up with changes in the data over time."

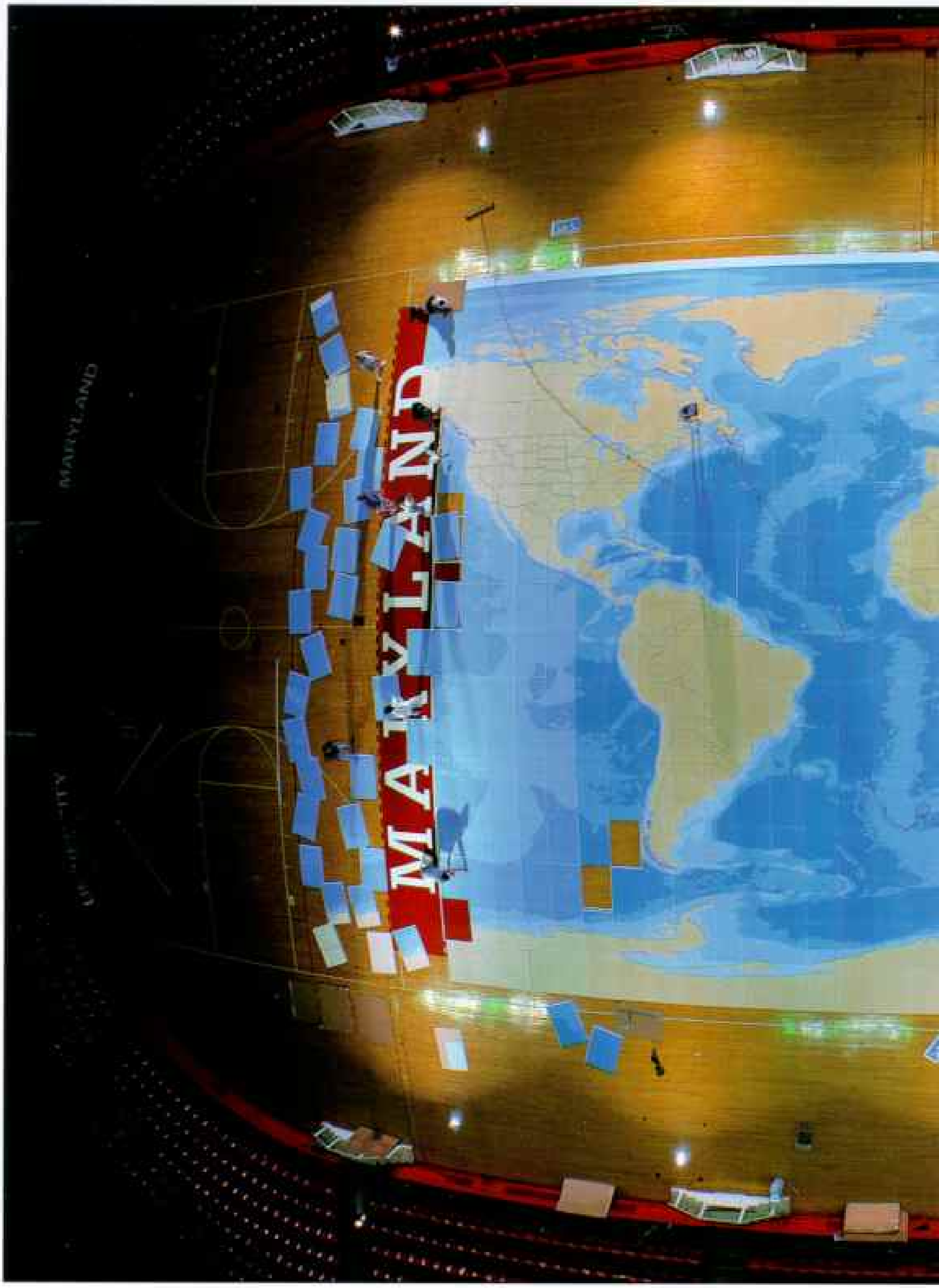
With digital mapmaking available to just about any computer user, the character of cartography is changing. "With previous technology," says Joel Morrison of the Census Bureau, "you wanted introverted individuals who worked alone and came up with the best design, almost a work of art. Today technology allows groups of people to sit around and interactively produce maps as a team."

National mapping agencies may continue to play major roles in collecting map data. But they are being forced to adapt to the revolution. The Defense Department's National Imagery and Mapping Agency is offering free mapping software for viewing many of its comprehensive data files. USGS makes available much of its invaluable map data on the World Wide Web. It is also experimenting with producing printed maps at something like a money machine, perhaps at kiosks in shopping centers. Insert some money, punch in the topographic map you want, and out comes the map. "Instead of a huge warehouse of maps," Kelmelis says, "we'll have small warehouses of data in computers from which maps can be produced on demand, instantly."

As they scurry to keep pace with the revolution, cartographers occasionally cast a wistful eye to the past, though bearing in mind how much easier some of their work is now.

"When I started in cartography," Morrison recalls, "the first decision you made was the scale of the map you intended to draw. That determined the size of the sheet, how much of the world you could get in. Now we don't care that much about scale. Put it on the screen, blow

Center Court



Awash in a sea of data, John F. Shupe, chief cartographer for the National Geographic Society, lounges in the Indian Ocean on the University of Maryland's Cole Field House floor. A team of 15 people worked eight hours to piece together the computer-generated map using 720

printouts that barely tapped the geographic data on two CD-ROMs. Creating a world map at this scale—135 feet by 66 feet, or 16 miles to the inch—would take a cartographer years working by hand, says Shupe, and even then it would not present as accurate a rendition.

"Of meridians, and parallels, man hath weaved out a net, and

it up or reduce it in an instant."

Kelmelis grins at the suggestion that the familiar wrinkled road map is headed for oblivion. "Until we can fold up computers as we fold up maps," he says, "I don't think we'll see the end of paper road maps."

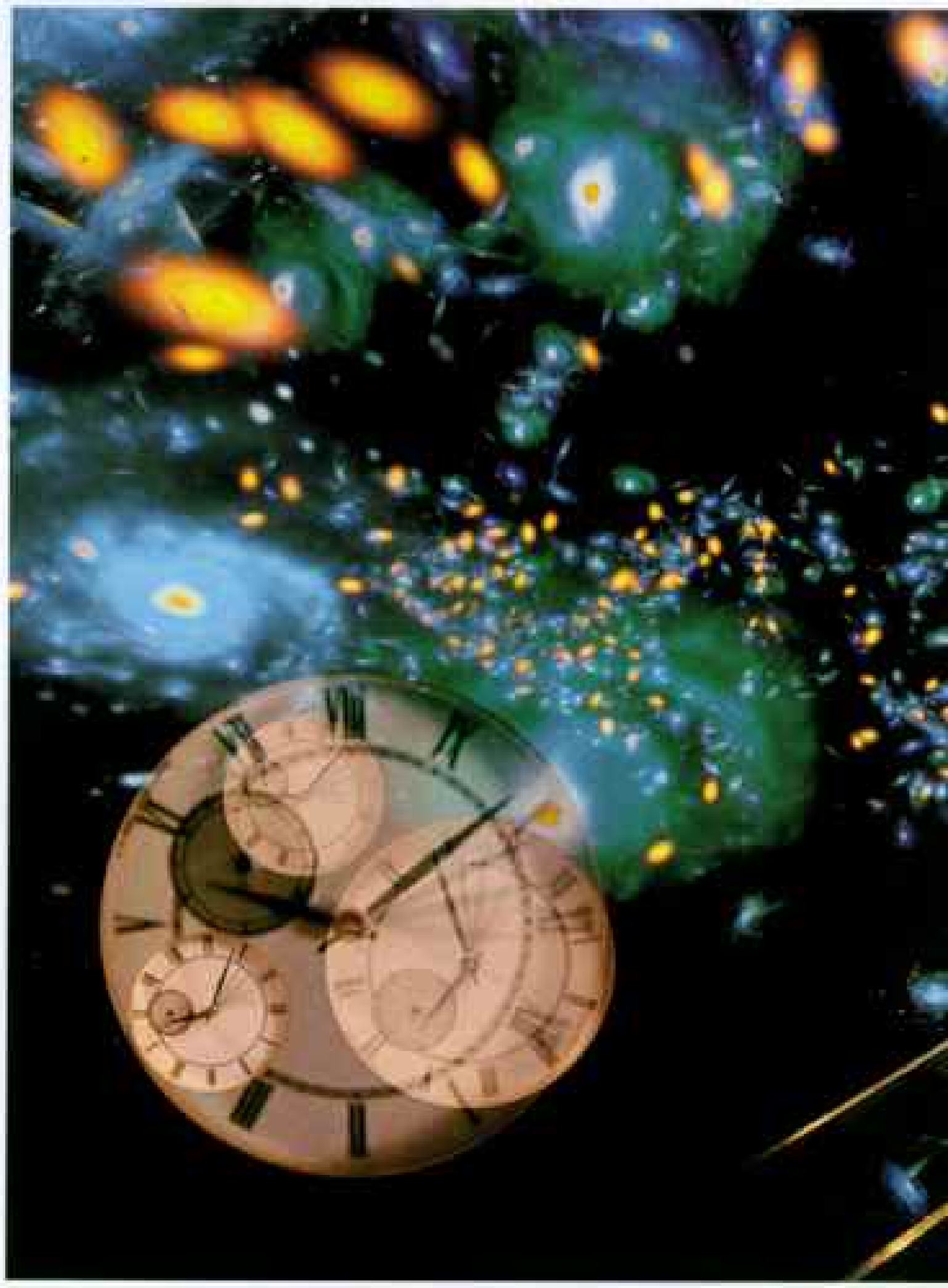
Sitting under a replica of a stick map of the Marshall Islands in his office at the University of Wisconsin, David Woodward, a historian of cartography, takes the changes in stride. If anything, he says, the glut of data provided by the new technologies will ensure a future for maps in all forms. "The more data we have, the more maps we'll need to make sense of the stuff."

EARTH IS TOO SMALL to contain the mapping compulsion, the universe too vast to be comprehended without the mapmaker's talents for clarifying spatial relationships. Cartography is pressing on to cosmic frontiers, but its objective is unchanged: to communicate a sense of here in relation to there, however far away there may be.

On the day before they made history in 1969, the astronauts of Apollo 11 were orbiting the moon. Someone on the radio to Mission Control said, "We'll get out the map and see what we can find out around Aristarchus." Later an astronaut asked, "Could you give us a time of crossing [the moon's] prime meridian 150 west?"

Only a world that had been charted could be discussed in such language. Places had names. Their positions were fixed by latitude and longitude. This marked a reversal in the usual link between maps and exploration. Explorers used to go to a remote place, then map it. But through telescopy, photography, and the remote sensors of robotic spacecraft, cartography had preceded human exploration of the moon.

Margaret Geller at the Harvard-Smithsonian Center for Astrophysics



"You kind of feel you can climb into the universe," says astrophysicist Margaret Geller, amid an image of clusters of galaxies plotted with a telescope that looks back

this net thrown upon the heavens, and now they are his own."

—JOHN DONNE, 1611

GRAPHICS BY E. PAECH AND M. BAXTOR, AT NATIONAL CENTER FOR SUPERCOMPUTING APPLICATIONS
© SMITHSONIAN ASTROPHYSICAL OBSERVATORY, CAMBRIDGE, MASSACHUSETTS

hundreds of millions of light-years. Little of Earth remains to be mapped, but planets and stars and galaxies and voids across the infinite universe wait to be charted.

calls herself a cosmic cartographer. She peers into the depths of the universe and prepares maps on a scale rendering Mars and Earth invisible. On these maps—originally produced with astronomer John Huchra—galaxies are like tiny islands, enormous clumps of them surrounded by veritable seas of empty space. Yet what should emerge from these maps but an unsuspected pattern to the universe; contrary to theory, the distribution of galaxies is far from uniform. The maps reveal, in particular, an irregular sheet of interconnected galaxies that stretches more than half a billion light-years across space, a stunning feature astronomers have dubbed the Great Wall.

Geller identifies with her terrestrial counterparts in ancient Babylonia, with all cartographers who have had to make do with insufficient surveys. Even the best telescopes give a limited view of the heavens.

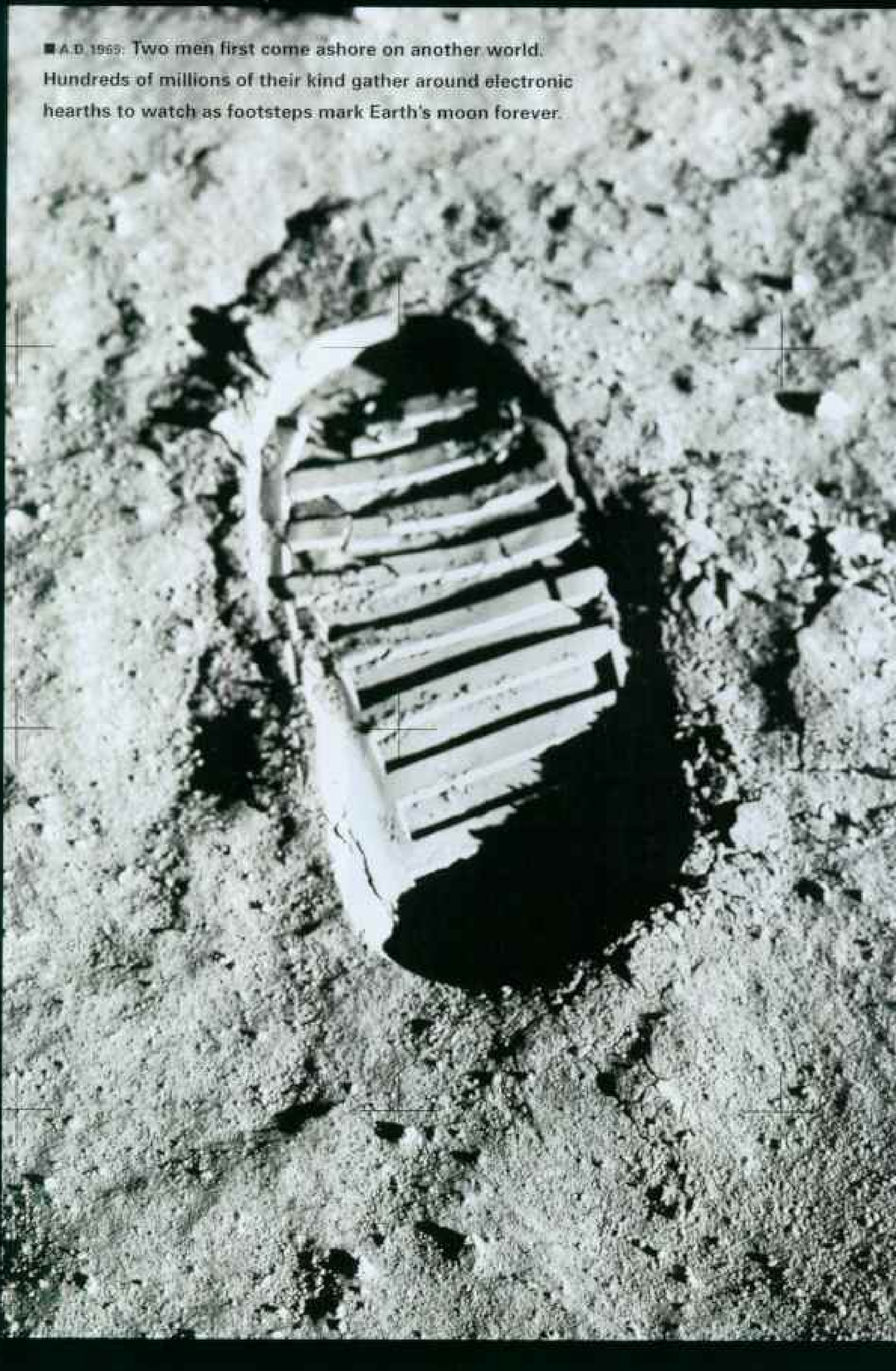
"Cosmic mapping today," Geller says, "is like trying to picture the whole world from a survey of Rhode Island. But a century from now the entire visible universe may be mapped."

She recalls Ptolemy's admonition "to survey the whole in its just proportions" and to represent "in pictures the whole known world together with the phenomena contained therein." With a figurative interpretation of "world," she says, "Ptolemy's statement is a remarkably apt description of the aspirations of those of us who are now mapping the universe."

Or of any mapmakers who, responding to the revolution around them, strive through maps to encompass that which is known and to perceive that which may be worth knowing. □

Learn more online about how police use maps to help fight crime at www.nationalgeographic.com.

■ A.D. 1969: Two men first come ashore on another world. Hundreds of millions of their kind gather around electronic hearths to watch as footsteps mark Earth's moon forever.



The Millennium Series

Why explore?

By **Priit J. Vesilind**
NATIONAL GEOGRAPHIC SENIOR WRITER

WE ARE A DIM and lonely star in the darkness of the deep-sea floor, where no other light has shone. I am on my belly in a submarine, 2,800 feet *down*—where the water pressure would crush the lungs of an unprotected human being—peering through a porthole. Our lights pick up mostly sediment across the antiheavens of the Mediterranean Sea. Only the occasional grouper peers back.

I am on the NR-1, a U.S. Navy research submarine, Jules Verne's *Nautilus* come to reality. Nuclear powered, it can stay submerged indefinitely. A robotic arm with steel fingers protrudes from its bow. Retractable wheels emerge to let the vessel roll along the bottom like a slow and silent midnight train.

This summer the Navy has leased the NR-1 and its 11-man crew to a team of techno-archaeologists who have been exploring 2,000-year-old trade routes for shipwrecks. As I watch through the porthole, we reach the remains of a Roman-era cargo ship: silt-covered piles of amphorae—graceful clay pots for shipping wine or oil—copper kettles, an anchor.

Back on the nearby *Carolyn Chouest*, a surface support ship for the NR-1, Robert D. Ballard of the Institute for Exploration in Mystic, Connecticut, savors this latest offspring of antiquity and high tech. Dr. Ballard, leader of the expedition, seems wired with an impatient and playful energy, as if born with an extra battery pack.

He and a cadre of technicians, computer scientists, and archaeologists are operating the expedition's other underwater vehicle, the unmanned *Jason*, which is equipped with sonar, television, still cameras, and excavation tools and driven through fiber-optic cables from the *Carolyn Chouest*. The team has already discovered and mapped eight wrecks. Archaeological exploration has never been attempted this deep, on such a scale, and with such a multidisciplinary team.

"The limit of scuba divers and most marine archaeologists is 200 feet," Ballard told me when I returned to the mother ship. "But 97 percent of the ocean lies *below* 200 feet. Some 10,000 ships have sunk in this area of the Mediterranean alone. Most shallow-water wrecks have already been looted, but the wrecks we're finding here are pristine."

Archaeology is a new discipline for Ballard, who pioneered journeys to the Mid-Atlantic Ridge, discovered new life-forms around hydrothermal vents in the Galápagos, and located the *Titanic*. He describes his work as a series of quests, like the ones undertaken by the original Jason in pursuit of the Golden Fleece.

"Exploration is still the epic journey," he said, "to dream, to prepare yourself, to assemble your team of argonauts, to go forth to be tested mentally and physically by the gods. To pass the test, be given the truth, and then come back and share the new wisdom."

For Ballard the spirit of exploration is an integral part of being human. "Everyone is an explorer," he said. "How could you possibly live your life looking at a door and not go open it?"

But meaningful exploration today takes more than courage and ambition. It often requires specialized education and expensive hardware—not an undertaking for everyman.

NEIL A. ARMSTRONG, NASA

Since Galileo the things that we've been seeing are beyond

"The key is science," said Ballard. "Science gives legitimacy and worth to exploration. You see a lot of stunts today, but if you're not doing worthwhile science, you're not an explorer. You're just wandering around."

Is there still a place for argonauts, or have they been supplanted by machines and a technical elite? And if exploration still carries personal glory and national prestige, what journeys are legitimate? Why do we explore?

To take stock, I visited four professionals who have come to symbolize achievement in the three arenas of exploration: Ballard in the sea, Richard and Meave Leakey, paleoanthropologists, on land, and Neil Armstrong, former astronaut and lunar pioneer, in air and space.

I found that exploration is a passion that is intertwined with our search for origins and destiny. It demands good science, and it celebrates the human spirit.

A THOUSAND YEARS ago the world known to Western civilizations centered on this Mediterranean Sea. It extended to China in the east, the Baltic Sea to the north, Saharan Africa and India to the south. Westward lay the vast and dreaded "green sea of darkness," and farther south smoldered a semi-mythical terra incognita, a land where, it was said, men turned permanently black.

Societies lived in mutual ignorance of one another. The French did not know of the Inca, and the Songhai of Africa had no inkling of the Inuit. "The unknown and the forbidden were thought to be the same," writes historian Daniel Boorstin, and better left to priests and wizards. The explorer stood apart as someone with a touch of madness.

Norseman Leif Eriksson reached North America around the year 1000, but the momentum to explore built slowly. It would be five centuries before other Europeans landed on that continent.

Why were Europeans the ones to push to the Americas? The Chinese and Arabs had the resources and technology to leap the seas, and both plied the Indian Ocean and the Asian Pacific for trade. But exploration? By the mid-15th century China had withdrawn into traditional Confucian isolationism. The Arabs, with access to the minerals and spices of Africa and the Far East, saw no need to journey into the unknown.

Europe, on the other hand, needed gold and silver; its mines could not keep pace with the demand for coinage. Ottoman Turks blocked the overland routes to Asia. Only the sea held the promise of new wealth.

Christianity reconciled profit with piety. God had commanded the human race to subdue the Earth, and Christianity valued individual action; exploration would glorify God. The Portuguese and Spanish, when they tested the Atlantic, were still imbued with medieval chivalry and the fervor of the Crusades. If Africans or Native Americans were killed or enslaved in the process of their conversion, it was a small price to pay for eternal life.

With the return of Magellan's ship in 1522 from its circumnavigation of the globe came the confirmation that the oceans were interconnected, boosting the age of discovery. National rivalries propelled the brave and ambitious. The English, as well as the Spanish, Portuguese, and French, became obsessed with finding the "river of the west" through North America to the Orient.

It was not until the 1700s that intellectual curiosity emerged as a primary motivation for European explorers. From 1768 to 1779 English Captain James Cook charted the waters of the Pacific and upgraded the standards of exploration forever. By 1800 most of the seas had been explored and roughly mapped.

The voyage of the British Navy's H.M.S. *Challenger* from 1872 to 1876 was the first devoted to studying the world's oceans, but 120 years later oceanography, like astronomy, has touched only the fringes of its science.

"It's mind-boggling," said Bob Ballard. "It's almost the year 2000, and we're probing the moons of Jupiter, but most of the ocean floor remains totally unexplored.

"The land surface beneath the sea is 71 percent of the Earth," he said, "and the

human understanding or comprehension. —NEIL ARMSTRONG

life-form they think they may have found in a meteorite from Mars is similar to one we found in the vents around the Galápagos. Such vents may be the site of the origin of life on our planet."

IN THE ARID SAVANNA of Kenya, near the Equator, the sun plummets behind the acacia trees and the stars explode like fireworks. Mars glows amber, and the sky is so transparent that even the blackness between each point of light is sprinkled with a fine stellar dust, each grain another unfathomably distant star.

Lions don't come around the camp much, says my host, Richard Leakey, so I drag my bed outside the tent and lie beneath the stars, too awestruck to sleep. The light from those stars in the Andromeda galaxy left some two million years ago, when the hominid called *Homo erectus* strode two-legged across this very river valley. From Africa the first explorers reached out and eventually populated the Earth.

Richard Leakey is the maverick son of Kenyan paleoanthropologists Louis and Mary Leakey, a man who refused a college education and became one of the world's experts on early humans. He and his wife, Meave, sustain a family legacy of research that is now, with the work of their daughter Louise, three generations deep.

Since the continents have been mapped, exploration of the Earth is largely left to those who look inside—geologists, paleontologists, archaeologists—scientists traveling through layers of time instead of distance.

"To me it's a question of being able to look backward and give the present a root," Richard said. "To give meaning to where we are today, we need to look at where we've come from."

Richard, who flew me here in a four-seat Cessna from Nairobi, lost both legs below the knees as a result of an airplane crash four years ago. A fearless man, he regards this as just a nuisance. As we circled the site in the Great Rift Valley where Meave has been excavating four-million-year-old fossils, he adjusted his prostheses to make sure the shoes sat firmly on the brakes before we roared down to the crude earthen strip and rattled to a halt.

He looked over and grinned: "Bet you've never been flown by a double amputee before!"

Grandson of missionaries, Richard explores in part to bring credit and dignity to Africans. Since his work has been validating the theory of evolution, he has problems with some religious views, particularly with regard to the issue of our origins.

"This is an enormously important issue for me," he said. "It seems so totally wrong that the African people are lacking the real sense of being important to the planet. Here is a continent that should be looking at its prehistory and saying, 'This is where everyone began.'"

The irony is that religion and scientific exploration attract equally ardent disciples. "In both, if you have total belief in the righteousness of your cause," said Richard, "you will do extraordinary things and take enormous risks. As a scientist you can do it because you desperately want to know. That is what is driving Ballard to the bottom of the sea, and people into space, and people to live in really rough conditions year after year, digging in the ground, because they want the truth. They want to know what is there."

Said Meave Leakey, "Exploration is an obsession. The more I discover, the more I want to know. Unfortunately I will not discover everything I want. One can never, never find all the answers."

Most of the world was finally linked in the 19th century, as technological advances energized the expansion of the United States and the colonization of Africa by Great Britain, France, Germany, and Belgium.

European explorers knew they were not "discovering" these lands that others had occupied for centuries but bringing knowledge of them into a shared record. "Unknown to science" was the new criterion for discovery, and scientific explorers felt they were assembling an inventory of Earth.

The polar regions were last to be defined, and their mapping ended the era of nationalistic land exploration. The Antarctic Treaty of

1959 turned that continent into an international scientific preserve, shared today by 43 nations. The Poles still attract adventurers eager to test their endurance, but scientists there proceed systematically, using the most advanced technology. The *answer* is their Golden Fleece.

BEYOND THE HAZE of atmosphere, astronauts say, stars do not twinkle—they remain constant—their steadiness mocking the paltry distances humans have traveled. Stars are in fact unspeakably hostile to life, immense and ravenous. But to explorers, from Argonauts to astronauts, they have been a comfort. Michael Collins, who was the navigator on Apollo 11, man's first landing on the moon, wrote of the stars: "Even today, when I fly in the night sky . . . I look up and experience an almost physical wave of nostalgia. There are my old friends . . . with friendly yet mysterious names."

Collins's Apollo 11 crewmate Neil Armstrong has never written a book about himself or the flight, humankind's most significant journey. Nor has he publicly philosophized about the heavenly bodies. His passion was to meet the technical challenge. "There was plenty of romance for everybody," he told me, "but not everybody could make it happen." He chose to be a doer.

Armstrong is careful to protect his privacy, so I met the first man on the moon in a hotel room near Cincinnati's international airport, a world of thundering jet engines: his kind of world. "I'm an explorer but not a discoverer," he said bluntly. "I've gone to places, but I haven't found anything that was previously unknown."

NASA astronauts are explorers of a different ilk, tethered to a vast bureaucracy for which the unknown is anathema. All uncertainties are to be avoided, or planned for.

Armstrong is an unassuming man from a small town in Ohio. He is armed with a crooked, boyish grin but suffers no fools. He deflects most publicity with an engineer's cool logic. "I was trying to follow NASA's stated mission: Investigate the problems of flight and seek solutions to those problems. I was trying to find methods of making craft that would expand the human envelope."

But the motivation to send humans into space was not primarily technical or scientific. It was national pride, part of a high-stakes Cold War battle of ideologies.

The first man to orbit Earth, on April 12, 1961, was Russian cosmonaut Yuri Gagarin, followed in August by cosmonaut Gherman Titov. Titov tweaked American sensibilities when he told an interviewer, "I looked around and didn't see . . . God or angels."

So President John F. Kennedy's exhortation that year to land a man on the moon before the end of the decade could be compared to the Spanish call to rise against the Moors.

In December 1968 Frank Borman, Jim Lovell, and Bill Anders finally broke free of Earth's gravity in Apollo 8 and moved into lunar orbit.

On Christmas Eve, while circling the bleak satellite, the U.S. astronauts answered Titov by reading from Genesis. Anders began: "In the beginning God created. . . ." And Borman finished, ". . . and God saw that it was good."

"It's often been said, I think correctly," said Armstrong, "that Apollo 8 was the spirit of Apollo—leaving the shackles of Earth and being able to return." The moonwalk, he said, was simply another element of that concept.

Apollo 11 came the next year, and only 66 years after the Wright brothers at Kitty Hawk. Lunar scientists hoped that manned exploration would resolve competing theories about the origins of the moon and of Earth itself.

Some critics charged that the costs were unacceptable while economic disparity still plagued the U.S., but most of the world hailed the achievement. Despite the two-nation struggle, the Outer Space Treaty of 1967, patterned after the Antarctic Treaty, stipulated that "The exploration and use of outer space . . . shall be carried out for the benefit and in the interests of all countries. . . ." No one could own the moon.

"We came in peace for all mankind," reads the plaque that Armstrong and Buzz

It's almost the year 2000, and we're probing the moons of Jupiter, but most of the ocean floor remains totally unexplored.

—ROBERT BALLARD

Aldrin left on the moon's surface.

"Do you feel you went for all mankind?" I asked Armstrong.

"I think so," he answered, after rolling the question over in his mind. "The information gathered, scientific and general interest, was returned to all countries, friend and foe. NASA never held anything back. That's about as close to 'for all mankind' as one could reasonably hope."

Exploration is an obsession. The more I discover, the more I want to know. Unfortunately I will not discover everything I want.

—MEAVE LEAKEY

FIVE HUNDRED YEARS before space flight, learned men thought the sun and planets revolved around the Earth—the center of the universe—until astronomer Nicolaus Copernicus advanced the astounding idea that the Earth rotates on its axis and revolves around the sun.

The theory made sense to Galileo Galilei, an Italian mathematician. He constructed a 20-power telescope in 1609 and lifted it to the heavens.

When Galileo attempted to reinterpret the Bible using Copernican theory, the Roman Catholic Church condemned the theory. In 1633 the Inquisition sentenced Galileo to life-long house arrest for attempting to prove the theory to be true. But it could not stem the ascent of logic that spurred a revolution in science. Scientific exploration elevated humankind but toppled us from the center of the universe. Our struggle ever since has been to understand where and how we fit.

"Since Galileo the things we've been seeing are beyond human understanding or comprehension," said Armstrong. "No question. A cloud that's three light-years tall? Human beings don't like to be considered small."

Today's most profound destinations are the infinitesimal or the infinite. Biologists explore microworlds, and the Hubble telescope, our bright eye beyond the atmosphere, sends back vivid and stunning images.

Now a new program has revived enthusiasm for on-site space exploration. Last July 4 NASA landed the three-foot-high Pathfinder on Mars. Cushioned with air bags, it bounced like a basketball, dribbled to a halt in freezing darkness, and opened like a tulip. When the sun energized its solar panels, out rolled a wagonlike vehicle called *Sojourner*, named for Sojourner Truth, the 19th-century abolitionist.

On July 8, I turned my computer to the Internet, put on cardboard 3-D glasses, gripped the mouse, and embarked on a Mars walk. My visit was one of nearly 47 million hits on the Mars site that day. For one giddy week we all became explorers.

Why were we on Mars again after 21 years? To see if there is evidence of life. The mystery of genesis runs wistfully but powerfully through exploration. Pathfinder landed in a region once swept by catastrophic floods, where layers of rocks are exposed as clearly as those in the Great Rift Valley.

In September another NASA probe—the Mars Global Surveyor—went into orbit around the planet for a two-year mapping mission. The agency plans to send pairs of spacecraft to Mars every two years and foresees a manned mission early in the 21st century. Maybe a human being, feet planted firmly on the planet, can determine if Mars indeed hosted life.

And if life once thrived on that dusty planet and died, what of life on Earth? Can we expect to be overtaken someday by the natural evolution of heavenly bodies—to have been just a wink in time? Humans are egocentric, fearing extinction as much as cosmic loneliness. Driven by reason from the center of the universe, we still search for who we are, exploring deep-sea vents, the valleys of prehistoric rivers, the floodplains of distant planets.

"Are we alone in the universe?" I asked Neil Armstrong.

"Well," he answered, "we've seen a substantial change in the confidence that there are planetary systems outside our own. It was strictly a hypothesis when I was a child."

Even if we are alone, the Apollo explorations showed that Earth need not be the final tomb for humankind. If we can reach beyond our planet, we may ensure survival. We can dream of immortality. We can strive to touch the stars. □

Priit Vesilind reports further on sea exploration at www.nationalgeographic.com.

Aspiring to climb where no one has climbed before, two members of a six-man mountaineering expedition reconnoiter Rakekniven—"the Razor." Towering half again as tall as the World Trade Center, it is one of scores of never scaled peaks crowning this Antarctic frontier.

On the Edge of Antarctica
Queen Maud Land

By **Jon Krakauer**
Photographs by **Gordon Wiltsie**

SIX HUNDRED FEET UP the cleanly hewn face of a mountain called the Razor, the wind gusting off the polar plateau coated my beard with frost. I paused in mid-ascent, dangling from a bight of half-inch-thick rope, and attempted to shake the cramps from my aching forearms. The Antarctic ice cap lapped like a ghostly white sea against the base of the rock face, far below. On the horizon huge, jagged peaks bristled like granite quills from the vast sprawl of ice. Nowhere in all those frozen miles could I detect a sign of life. Never had I laid eyes on such a stark, barren—or beautiful—piece of Earth. It seemed like a waking dream. Hypnotized by the immensity and austerity of the landscape, I found it hard to stop goggling at the view and resume climbing.

I was jolted back to the task at hand by a rain of pebbles clattering down from the vertical expanse above. Craning my neck, I watched Alex Lowe ascend into uncertain terrain some 300 feet higher up, spidering gingerly over the lip of a formidable overhang while Conrad Anker payed out rope from below. "I'm into some more of that funky orange rock," Alex shouted over the wind. "Looks like it's gonna be kind of loose and gravelly for a little while."

Six of us were attempting this unclimbed mountain, a towering blade of granite in a corner of Antarctica known as Queen Maud Land. After a Norwegian expedition surveyed the region between 1956 and 1960, the improbably slender tower was christened Rakekniven—"the Razor" in the surveyors' native tongue. It jutted 2,000 vertical feet from the ice cap in a sheer, breathtaking thrust of stone.

Why had we traveled such a great distance to climb a mountain so obscure that only a handful of people have ever heard of it? Early in the 20th century the legendary Irish adventurer Ernest Shackleton called Antarctic exploration "the last great journey left to man." Now, as both the century and the millennium are drawing to a close, his words ring more true than ever.

My companions and I, like Shackleton, had come to Antarctica seeking a blank spot on the map. Unfortunately for us modern adventurers, jet airplanes, satellites, and sophisticated radar imagery have charted the last of the planet's unexplored tracts. But a few places are still sufficiently rugged and isolated to retain a bracing aura of terra incognita: pockets of central African rain forest, remote escarpments in Tibet and Sichuan, parts of the Canadian Arctic. Nowhere on Earth has the terra remained more incognita than Antarctica—and perhaps nowhere in Antarctica is the aura more palpable than in the mountains of Queen Maud Land. The route we hoped to follow to the summit of Rakekniven led into a vertical wilderness about which almost nothing was known and through which safe passage was far from certain.

Our expedition was the brainchild of photographer Gordon Wiltsie, a veteran of eight trips to this icebound continent. Mike Graber and Rick Ridgeway had signed on to make a film of the climb. As the only member of the team who had never been to Antarctica, I was present to help with the grunt work—hauling some of the 500 pounds of hardware and supplies that would accompany us up the wall—and to document the deed for the pages of this magazine.

With nothing but empty air beneath his boots, Conrad Anker ratchets himself up Rakekniven using a rope-ascending device. Anchored ropes left in place provided a shortcut for going up and down the mountain—plus a lifeline to the ground should a sudden storm threaten to trap the team on the exposed wall.

"It seemed like a waking dream."

I had mixed feelings about ascending Rakekniven. The last mountain I'd climbed had been Mount Everest. Seven months earlier I'd stood atop the world's highest peak, but five friends perished in a ferocious blizzard during the descent. In the aftermath of that calamity I wasn't sure that I would ever climb again, or should. When Gordon invited me to join this expedition, I accepted—but not without much self-doubt and trepidation. Now that I was here, I tried to

banish those doubts and contribute what I could to the climb.

As for actually forging a route up Rakekniven's dizzying vertical acreage, the team relied utterly on Alex—a 38-year-old Montanan considered one of the world's finest all-around climbers—and Conrad, 34, a strapping Californian with thinning blond hair whose alpine résumé was nearly as impressive as Alex's. Without Alex and Conrad, who took turns at the "sharp end" of the rope, we wouldn't have a prayer of reaching the top.

From base camp—a cluster of yellow tents huddled on the glacier, 15 minutes on skis from the foot of the climb—Rakekniven loomed as a giant, mottled megalith that blotted out much of the sky. Its northeast face was pale gray, streaked with distinct bands of darker, rust-colored rock that glowed orange when it caught the morning sun. But as soon as we began our climb, we discovered that although the gray rock was "as solid as the church," as Mike put it, the orange-hued granite was weathered, crumbly, and dangerously unreliable. Hand- and footholds frequently broke off under our body weight. The slightest touch could send stone blocks hurtling down the wall.

JON KRAKAUER's most recent book, *Into Thin Air*, recalls the tragic events that befell climbers on Mount Everest in 1996. GORDON WILTSIE has been a mountain guide, writer, and photographer for 20 years. He lives in Bozeman, Montana.

Explorers may have sighted Queen Maud Land's coast in 1820, but its grand mountains, such as the Troll Castle (above), remained unknown until 1939, when Germans made aerial photos. Today the region's virgin peaks and otherworldly terrain exert a magnetic pull on top climbers. "The landscape looks so alien we felt as if we should be wearing space suits," says author Jon Krakauer (above left), here crusted with ice during a ski trek.

Holtedahl Peaks

■ Blue 1 runway
(42 miles to Rakekniven)

Ulvetanna Peak
9,616 ft

Fenriskjeften Peaks

Vinje Glacier

Rakekniven

Queen Maud Land

ANTARCTICA

South Pole

Vinson Massif
16,067 ft

Kubus Mt.
9,733 ft

Trollslottet
(The Troll Castle)
8,580 ft

Rakekniven
(The Razor)
7,759 ft

Filchner Mts

All but 2,000 feet of Rakekniven lies beneath the ice

Kobusdalen

Djupedalen

Habermehl Peak
9,662 ft

Kyrkjeskipet Peak
10,115 ft

N

Jokulkyrkja Mountain

Peaks climbed by author's team shown in red.

Scale varies in this perspective.

NATIONAL GEOGRAPHIC MAPS
PAINTING BY BOB PRATT

On our second day of climbing Conrad was delicately working his way up a semidetached slab of orange rock when he dislodged a fist-size fragment as Rick and I ascended directly beneath him. Hearing the rock whizzing toward me, I pressed tightly against the wall and tried to make myself tiny. Rick, a hundred feet lower, glanced up to see what the commotion was about. Just as he did, the small granite missile smashed into his upturned face.

"Rick!" I shouted, "Are you OK?"

"I'm not sure," he replied in a shaky voice. "There's a lot of blood. Hang on a minute." When he managed to climb up to my stance, I was shocked to see that blood covered Rick's entire face, had plastered his hair against his head, and was streaming down his neck. We were a long way off the ground, in one of the most remote places on Earth, and the chartered airplane that had flown us to Antarctica wasn't due to return for four weeks.

But despite all the gore, a close inspection of the wound revealed it to be a relatively minor injury: The falling rock had merely sliced some flesh from the tip of Rick's nose, releasing a lot of blood but doing no lasting damage. After ten minutes, smiling through red-stained teeth, Rick declared that he felt fine, and we continued climbing.

Now, a day later, Alex was in the lead, puzzling his way up more of that dubious orange geology, while the rest of us watched anxiously from below. He tried to safeguard his passage by placing an aluminum cam into a natural fissure, but the badly weathered granite crumbled away and repeatedly spit out the hardware. The wall leaned so far past vertical that the rope trailing from his waist hung freely in space, not even touching the rock. His progress slowed to a crawl.

Then, without warning, Alex's voice erupted into a chilling, banshee-like howl, prompting me to recoil involuntarily and cower against the rock. But I had misinterpreted the tenor of his exclamation: "I'm back into the gray rock!" Alex shouted down with unmistakable glee. "This is just so cool up here! It's finally starting to feel steep! I love it!"

SOME OF THE MOST CELEBRATED, most remarkable adventures in the history of exploration have taken place in Antarctica—the expeditions of Scott, Amundsen, Shackleton, and Mawson are the stuff of fireside lore the world over. But mountain climbers were slow to arrive here. The highest Antarctic summit, the 16,067-foot Vinson Massif—a sprawling hulk that requires little technical expertise—wasn't scaled until 1966. And in the years since, relatively few climbers have visited the bottom of the world. The overwhelming majority have been content with Vinson.

The scarcity of mountaineering expeditions to Antarctica in general and Queen Maud Land in particular is not due to a lack of impressive mountains. Antarctica—a continent larger than the United States and Mexico combined—is home to thousands of magnificent peaks, including some of the comeliest and most formidable mountains on the planet. To a certain degree the dearth of climbers merely reflects the harshness of the Antarctic environment: In a land where the wind sometimes reaches 100 miles an hour and even in the warmest months the air temperature often falls below zero degrees Fahrenheit in the continental interior, most adventurers manage to find challenge enough without leaving flat ground. But historically the greatest

Hurricane-force wind rails against workers stockpiling fuel prior to the expedition (right). The daunting logistics of polar transport makes fuel "more expensive than fine whiskey," says photographer Gordon Wiltsie.

While treacherous weather came as no surprise, a seal carcass (above), found more than 100 miles from the coast, did. Mummified by the arid, cold climate, it may be centuries old.

barrier to mountaineering here has not been the savage climate, it's been the staggering logistic and financial hurdles that must be overcome to mount any kind of private expedition to Antarctica.

The team that first scaled Vinson in 1966, a group of American climbers largely funded by the National Geographic Society, received logistic support from the National Science Foundation (NSF) and the Navy. But shortly thereafter government officials decided that they'd established an unworkable precedent. Although NSF (which funds and manages American programs in Antarctica) has a network of research stations, aircraft, ships, and fuel depots on the continent, maintaining this elaborate infrastructure in such an isolated, inhospitable land is extremely expensive, and the official mission of NSF is to support scientific research, not mountaineering jaunts.

So NSF withdrew its support of private expeditions, mountaineering or otherwise—an action endorsed by Britain and New Zealand. And because NSF believed that only governments had the wherewithal to operate safely in Antarctica and there was a legitimate concern that private expeditions might get into trouble and have to be rescued by NSF, further disrupting scientific research, the agency went to great lengths to block private expeditions from visiting the continent altogether.

Standing in for Santa on Christmas Day, Alex Lowe (above right, at left) shares a card he brought from home. Playing his role, ecologist David Rootes (top right) takes soil samples at the foot of Rakekniven, which rears 2,000 feet above the mile-high base camp (above). Rootes's mission: to measure the impact of visitors on this pristine ecosystem.

Enter John Edward Giles Kershaw. Born in India in 1948, Kershaw is esteemed as the boldest, most accomplished, most visionary pilot ever to fly in Antarctica. For five years in the late 1970s he flew for the British Antarctic Survey, or BAS (the British equivalent of NSF), but quit to freelance for private expeditions. In 1980, after parting company with BAS, he flew a small plane a thousand miles from the South Pole to Queen Maud Land, at great personal risk, to save the lives of three stranded South African scientists—a heroic act for which he received the Sword of Honour from the Guild of Air Pilots and Air Navigators.

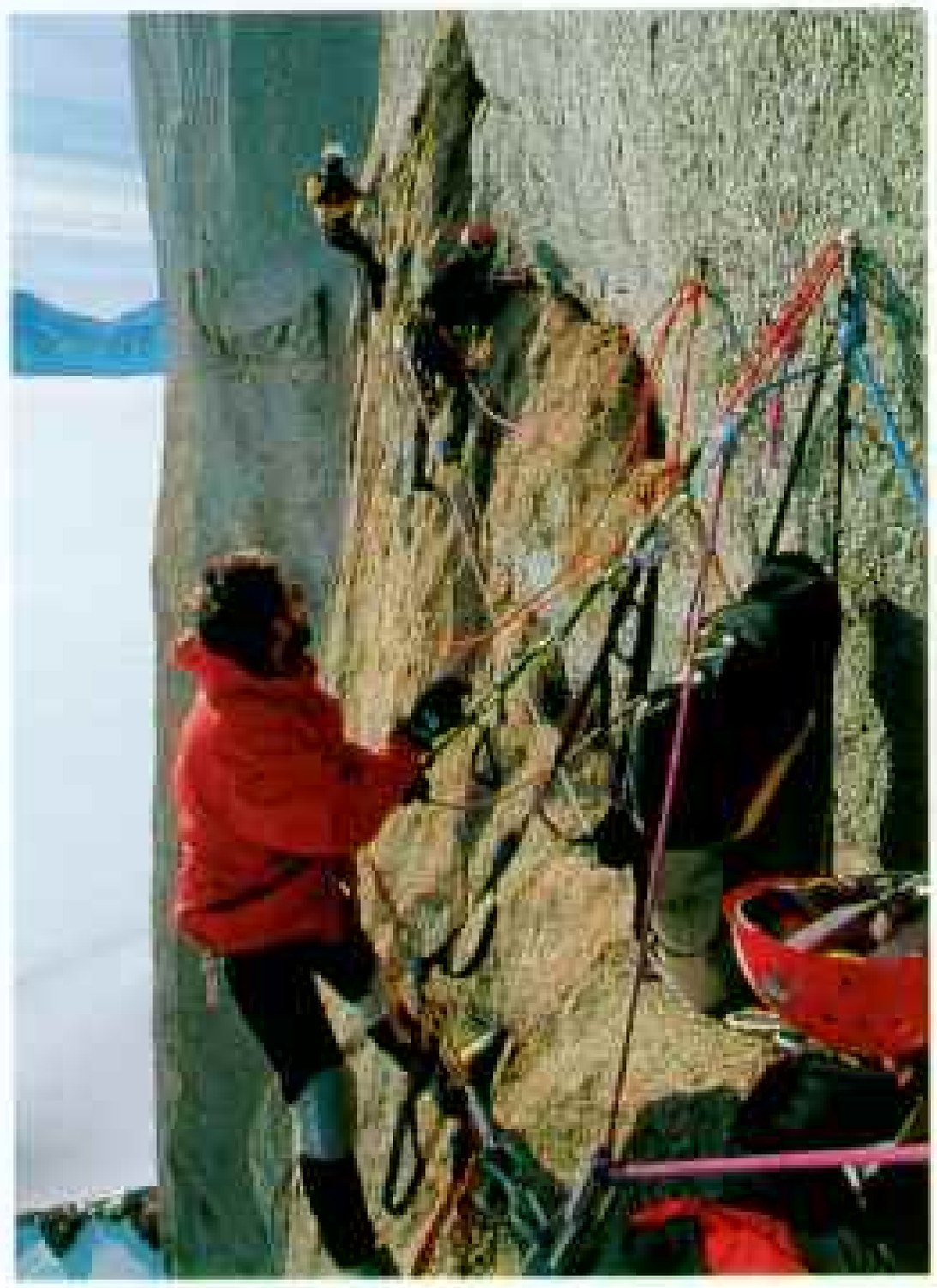
In 1985, with two Canadian partners, Kershaw incorporated his shoestring operation as Adventure Network International (ANI), specifically to carry private mountaineering expeditions to the Vinson Massif. It operates the continent's only commercial airline. Scores of grateful mountaineers were given the chance to climb in an astonishing land, and, thanks to Giles Kershaw's brilliant flying, the airline didn't lose a single passenger. Then in 1990, on a lark, Kershaw decided to join some American friends who were shooting a film on the Antarctic Peninsula—a group of climbers that included Mike Graber, my teammate on Rakekniven. On March 5, Kershaw was taking off in a kit-built Gyrocopter when something went wrong and the flying machine

Coming to grips with unreliable rock, Conrad gropes for solid handholds while free climbing Rakekniven. A veneer of weathered granite covers this and other parts of the tower, often sloughing off under body weight.

"My hands . . . were bleeding and swollen."

smashed into a glacier. Giles Kershaw was dead at 41.

VINSON MAY BE the highest mountain in Antarctica, but to a certain type of climber it is by no means the most stirring. Seeking a greater challenge, in the austral summer of 1993-94 a Norwegian expedition ventured to an all-but-unknown range some 1,700 miles northeast of Vinson, where they climbed a number of striking granite spires. The photographs they published on their return, in a book titled *Queen Maud Land,* quickened the pulse of ambitious climbers from the Alps to Yosemite. The area was revealed to have dozens of fantastic virgin summits. Many speculated that these cold, wind-racked ranges would be the next big thing in mountaineering. After getting a look at the Norwegians' pictures, said Wiltsie, "I realized how little of the region had been explored. The climbing potential was huge and untapped. I'd never been so excited in my life. I vowed to put together a team and do whatever it took to climb there."



Human cliff-hanger. Conrad (above, at middle) inches along a ledge as Mike Graber (in distance) shoots video and the author belays. Living on the edge requires lots of strong rope—and steady nerve. "In the day-to-day world you can sleepwalk through life," says Jon (facing page), peering from a wall tent slung 1,500 feet up. "You can't afford to do that here."

Queen Maud Land, named for the beloved Norwegian monarch who was the daughter of Britain's Edward VII, is considerably more difficult to reach than the area around Vinson. In the late 1970s Giles Kershaw and the eminent British glaciologist and explorer Charles Swithinbank had first discussed using conventional wheeled aircraft, without skis, in Antarctica. This would enable private expeditions to reach the continent more efficiently and economically, by allowing them to use common cargo planes for transport. (Ski-equipped C-130 Hercules planes are flown only by the military.) The key to this brash scheme was finding places where high winds kept the ice cap bare of snow, which in theory would enable a wheeled plane to land on a swath of hard blue ice and then, no less important, lift off for the return flight.

According to Swithinbank, a lanky, silver-haired man whose patrician manners mask a contumacious nature, he and Kershaw were convinced that "bare ice landing strips would benefit government operators as much as [private expeditions]. But it was clear that no government would commit transport aircraft to landing on icefields until the concept was proven."

In 1987 Kershaw resolved to prove the radical concept by dispatching an ordinary Douglas DC-4—a four-engine airliner without skis—from Chile to a blue-ice runway he and Swithinbank had reconnoitered in the Patriot Hills near the Vinson Massif. The U.S. government attempted to scuttle the flight by prevailing upon the head of the

". . . above it was nothing but cold blue sky."

Chilean Air Force to ground the DC-4 in Punta Arenas. But Swithinbank happened to be a friend of the Chilean general, and the ANI plane was allowed to take off for Antarctica.

Eleven hours and 43 minutes later, the wheels of the DC-4 met the gleaming blue ice of the Patriot Hills, and the airplane completed an uneventful landing.

By late 1996, as our own expedition prepared to embark for Antarctica, ANI had made more than a hundred successful wheeled landings at Patriot Hills, and another possible runway had been discovered in the heart of Queen Maud Land. Giles Kershaw's widow, Anne—a petite blonde Scotswoman with formidable resolve who had taken over the day-to-day management of ANI after his death—assured us that ANI could fly to this new runway, dubbed Blue 1, no problem.

"A mountain this size doesn't get climbed by one person," asserts Alex (facing page), here placing a camming device into a crack to secure safety ropes. "It gets climbed by people who pool their talents and spirits." As the climbers crest Rakekniven's summit, camaraderie turns to celebration (above).

TWO HOURS BEFORE MIDNIGHT on December 18, 1996, an ANI Hercules landed on the slippery surface of Blue 1, and Gordon, Alex, Conrad, Rick, Mike, and I stepped out of the airplane into the eerie twilight of the Antarctic summer. A piercing wind drove the cold through my parka. Stretching into the distance, peaks jutted from the ice cap like a flotilla of granite sailboats plying a frozen ocean. Gordon pointed to a handsome mountain with a distinctive profile about 40 miles to the southwest. "That's where we're headed," he said. "That's Rakekniven."

Alex, who has climbed in exotic places around the globe, exclaimed in a voice edged with awe, "This is one of the most amazing places I've ever seen." Seventy-two hours later we were camped below Rakekniven's northeast face, passing around a bottle of Wild Turkey to commemorate the summer solstice, toasting Giles Kershaw beneath a midnight sun.

The day before we arrived at base camp, we came across the mummified carcass of a crabeater seal. How, or why, it had traveled more than a hundred miles from the sea was a mystery. Remarkably well preserved, it looked as if it had perished recently. "Perhaps," said David Rootes, an ebullient English biologist employed by ANI, "but things are so slow to decay in this cold, arid climate that it's easy to be fooled." Carbon dating on the remains of another mummified seal found in a nearby part of Queen Maud Land revealed it to be millennia old.

"Anywhere else on Earth these peaks would be a national park," says Gordon of the crags of Fenriskjetten—"the Jaw of Fenris" in Norwegian. Evoking a row of flesh-tearing teeth, they get their telling name from a fierce wolf in Norse myth.

ANI had hired Rootes to conduct a baseline environmental survey of the area around Rakekniven to assess the impact of expeditions on the ecosystem. Although at first glance the icebound landscape appears devoid of life, it is actually home to lichens, algae, tiny arthropods, and a few hardy species of birds. Some rock outcrops just 50 miles to the west even shelter a breeding colony of 250,000 petreis. In accordance with the Antarctic Treaty's 1991 environmental protocol, we had to have "less than a minor or transitory impact." Before embarking, we signed documents pledging to remove all our waste from the continent when we left; even our feces would be flown back to South Africa for disposal.

The morning after we set up base camp, we put hand to rock and were soon making steady progress up the preposterously steep wall. With Alex and Conrad in the lead, each day we'd gain an additional 300 to 400 feet of altitude before descending to base camp, leaving a line of ropes in place for regaining the high point. After five days of climbing, our ropes extended 1,500 vertical feet above the glacier, and it had become impractical to rappel to the bottom of the wall each night, so we decided to establish a camp high on the dizzying face. Because the wall had very few natural ledges, we would have to sleep suspended in nylon cocoons called porta-ledges. From this

Cocooned against sub-zero cold, the team welcomes the sun's return after a sleepless, shivering "night" on the side of the Troll Castle. "The sun never set," says Gordon. "It just circled behind the mountain—and we froze." Warming to their work, Alex, Conrad, and Jon (above right) close in on the Castle's summit with the help of an ice ax.

hanging encampment we would launch our summit push.

Stormy weather kept us on the ground for a spell during the week after Christmas, but when the blizzard broke on December 31, Conrad, Mike, and I headed up the ropes with 250 pounds of gear and supplies—half of what we would need to eat, sleep, and live on the rock for the five or six days we estimated it would take to finish the climb. Alex, Rick, and Gordon would come up the ropes a day later—New Year's Day—with another 250 pounds of impedimenta.

Nearly half our collective burden was ice, laboriously chopped from the glacier, to be melted for drinking water. That we had to haul a back-wrenching load of ice up a mountain in Antarctica seemed a cruel irony. But the face was so sheer that virtually no snow or ice accumulated on our route, so we were forced to carry part of the glacier with us if we wanted to have anything to drink.

"This is work," said Conrad from a six-inch ledge, huffing loudly as he reefed on a rope attached to two 80-pound duffels.

"Yeah," Mike agreed. "To climb a wall like this, you want big biceps and a tiny brain. You need to be able to bench-press twice your IQ." A thousand feet off the ground, he pulled a snapshot of his baby daughter from a pocket of his jacket and stared at it wistfully. "What kind of bonehead would rather spend Christmas freezing his butt on the side

"We laughed . . . and soaked up the sun-dazzled view."

of a goddamn rock," he asked rhetorically, "instead of being home with his wife and little girl?"

AT 1 A.M. ON JANUARY 3, our third night at our hanging camp, my wristwatch alarm beeped me awake inside the claustrophobic confines of the porta-ledge, which had somewhat less living space than the average refrigerator carton and functioned as kitchen, bedroom, bathroom, and dining room for two people. When I opened my eyes, Conrad's feet were in my face and his knees were jabbing me in the ribs. My hands, covered with abrasions from the gritty rock, were bleeding and swollen. Dangling directly overhead was the porta-ledge that Gordon and Alex called home; I could hear them melting ice on their small butane stove. "Let's drink a lot of coffee and get after it!" Alex called down cheerfully. "It's about time we got to the top!"

By the time I'd laced my boots and slithered out of the porta-ledge into the morning chill, Alex, Rick, and Conrad were ascending the wall above at a frenzied pace. I caught up to them 200 feet below the summit, where the network of fissures we'd been following dead-ended beneath an overhang that protruded 30 feet from the vertical face.

Hoping to discover a path around this obstacle, Alex was lowered a short distance, then swung like a human pendulum around a sharp-edged corner. This maneuver enabled him to reach another crack that appeared to lead over the daunting granite eaves, but as Alex climbed higher, his rope was pulled taut against the bladelike corner, threatening to sever it. "That pitch was really sketchy," he confessed after he arrived at a ledge and anchored another line for the rest of us to follow. "I didn't like the way the rope ran over that edge, but once I'd moved around the corner I didn't have much choice but to keep going and make sure I didn't fall."

The gamble paid off: Shortly thereafter, Alex muscled gracefully over the square-cut brow of the overhang to find an easy, low-angled slab. And above it was nothing but cold blue sky. At 9:40 a.m. Gordon, Alex, Conrad, Mike, Rick, and I arrived on the narrow crest of snow that marked Rakekniven's loftiest point, and we hugged each other in a heartfelt, scrumlike embrace.

It was satisfying to be the first climbers to reach this slender summit—although our overblown sense of self-importance was deflated when Conrad pointed out bird tracks speckling the snow at our feet. Visiting the top of Rakekniven was apparently no big deal to a petrel. We laughed at our vanity and soaked up the sun-dazzled view. In all directions stretched the desolate beauty of Queen Maud Land, mantled with a mile-thick carapace of ice. Countless other granite towers shouldered out of the pale glacial plain.

"We may have been the first to climb this mountain," mused Gordon, gazing covetously at our next target, a nearby cluster of spires called the Troll Castle, "but I guarantee we won't be the last." □

Exulting in the view from 9,793-foot Kubus, Conrad surveys the visible tips of mountains that lie buried beneath an ice sheet perhaps 5,000 feet thick. Owned by the elements, Queen Maud Land beckons a new breed of climber who comes to witness and wonder, not conquer and claim. "This really is no-man's-land," Conrad says. "We are very much guests on this continent."

Learn more about this expedition at www.nationalgeographic.com and on National Geographic EXPLORER's "Antarctic Challenge" on TBS in March.

The Millennium Series

YOUSUF KARSH, WOODFIN CAMP & ASSOCIATES
(FACING PAGE) CHUCK DAVIS, COUSTEAU SOCIETY

MASTER OF THE DEEP

BY LUIS MARDEN

Jacques-Yves Cousteau
1910–1997

"If we didn't see," Jacques-Yves Cousteau once said, "we would not appreciate life as we do." Cousteau expressed his appreciation of undersea life in award-winning films and television programs, best-selling books, and a dozen articles for National Geographic. A decorated naval officer, the spare Frenchman invented the modern free diver's breathing apparatus in 1943 and went on to become the world's best-known aquatic explorer. His expeditions probed Bahamian caves (left), excavated Mediterranean wrecks, and captured images of sleeping sharks. Captain Cousteau died last June, but his boundless vitality still inspires underwater photographer Chuck Davis: "I remember him, in his late 70s, jumping into a Zodiac and zooming over the waves. Cousteau never quit."

THE WRIGHT BROTHERS enabled man to fly with the birds. Jacques-Yves Cousteau enabled man to swim with the fishes. When in 1961 Captain Cousteau received the Special Gold Medal of the National Geographic Society from the hands of President John F. Kennedy, it bore an inscription I had asked to write:

To earthbound man he gave
the key to the silent world.

Jacques-Yves Cousteau, a member of the Académie Française, died in Paris in the early morning of June 25, 1997, and was accorded a memorial Mass attended by French President Jacques Chirac at the Cathedral of Notre Dame in Paris, an honor usually reserved for heads of state.

A new era of exploration of the strange and wonderful world covering nearly three-fourths of our planet had begun in the summer of 1943 in a secluded French Riviera cove when Cousteau, the Adam of a submerged Garden of Eden before the Fall, first slipped into the sea wearing his Aqua-Lung, the simple but elegant invention that enabled humans to take their breath with them beneath the sea.

Cousteau had dreamed, literally, of flying free under water, swimming horizontally like a fish, weightless, and maneuvering easily in three dimensions. He wanted nothing to do with the divers in standard diving dress, whom the French called *pieds-lourds*, heavy feet, with their rubberized canvas suits, copper helmets, and lead-soled boots, making their ponderous way across the seabed, dragging their lifelines and air hoses behind them. He knew what he wanted, but it did not exist: self-contained compressed-air cylinders and a valve with hoses and mouthpiece that would feed him air only on the intake, at the ambient pressure of the surrounding sea, shutting off the flow when he exhaled. Taking his idea to Paris engineer Émile Gagnan, he was astonished when Gagnan showed him a Bakelite valve, saying: "Something like this?" It was the demand valve for the *gazogène*, a device to enable cooking gas to be burned in motor cars in gasoline-scarce wartime France.

COUSTEAU FAMILY PHOTOGRAPH

For human use the pioneers designed a spring-loaded diaphragm open to the sea. As the diver descended, increasing sea pressure automatically released air at greater volume and pressure, keeping the diver safely and comfortably in equilibrium with the sea. Today millions of divers don this device without a thought, but at the time the Aqua-Lung was epic-making. It opened the submarine world to a new age of discovery.

"At night I had often had visions of flying

LUIS MARDEN was a NATIONAL GEOGRAPHIC staff member for 42 years before his retirement in 1976. A writer and pioneer in underwater photography, Marden contributes his 61st article to the magazine with this issue.

by extending my arms as wings," Cousteau wrote. "Now I flew without wings. (Since that first aqualung flight, I have never had a dream of flying.) . . . I experimented with loops, somersaults and barrel rolls. I stood upside down on one finger and burst out laughing, a shrill distorted laugh. Nothing I did altered the automatic rhythm of air. Delivered from gravity and buoyancy I flew around in space."

When World War II ended, Cousteau and other French naval officers continued their exploration of the ocean depths, eventually using a wooden-hulled, U.S.-built former minesweeper, the fabled *Calypso*.

Shortly before the appearance in 1953 of his book *The Silent World*—a publishing sensation that sold five million copies and was translated into 22 languages—Cousteau approached the National Geographic Society for support, initiating a series of grants that totaled close to a half million dollars.

I had begun to experiment with underwater color photography, so NATIONAL GEOGRAPHIC assigned me to sail with Cousteau in 1955 on a four months' expedition to the Red Sea and Indian Ocean. Cousteau would film a full-length motion picture.

When I joined *Calypso* at the French naval base at Toulon, I saw at once that she was a well-organized ship. She carried two tons of red wine in stainless steel tanks and twenty tons of fresh water. With irrefutable Gallic logic, the water was rationed but the wine was not. During the four months' cruise we dived three to five times a day and bathed in seawater. I soon became sick of the taste of salt and brushed my teeth in the wine.

We were 27 on board, 26 men and one woman, Simone, the captain's petite wife, affectionately known as *La Bergère*, the shepherdess, from the maternal eye she kept on the crew. Not that she coddled us; far from it. I have heard this salty descendant of admirals refer to an errant helmsman in terms that would have blistered the shell off the crustiest sea dog. Elegant on land, at sea she usually wore a pullover and woolen watch cap while expertly working the winch or conning the ship from the bridge.

Those were halcyon days when the undersea world was new and lay all before us, waiting to be discovered. Every dive was like a visit to another planet: The landscape, the flora, the fauna, even the atmosphere, all were alien. At several uninhabited islands we were the first to breach the water film, and every dive might yield something new.

Calypso had no proper darkroom, and eventually thousands of feet of exposed but undeveloped motion-picture film and 1,200 unprocessed still pictures had to be stored in a refrigerated compartment, awaiting a return to France. For four months we were shooting blind.

Sixty feet down on one reef in the Red Sea, I saw a sea anemone with spherical tentacles like bunches of grapes that glowed neon red. I made

CHUCK DAVIS

Scuba gear based on the Cousteau-Gagnan Aqua-Lung liberated divers from helmets, weighted boots, and surface-tethered hoses (above). Cousteau's wife, Simone, and sons Philippe and Jean-Michel shared the exhilarating escape (opposite). The "first family of the undersea world" joined in creating stories and images that helped make free diving irresistible to millions.

To earthbound man he gave
the key to the silent world.

Supported by a National Geographic Society grant, Cousteau filmed a 1959 Caribbean test of his Diving Saucer. Equipped for photography and specimen collection, the water-jet-propelled vehicle allowed two divers to spend six hours as deep as a thousand feet.

JACQUES ERTAUD, COUSTEAU SOCIETY

STEPHEN KIPPHUTH, COUSTEAU SOCIETY

Cousteau described feeding sharks as "terrifying and loathsome" in 1963. Many years and many dives later he argued that our regard for nature should be measured by our treatment of such fearsome predators. Would we despise and destroy or respect and preserve them?

a flash photograph but did not see the result until my return to the United States months later. To my dismay the brilliant red tentacles had photographed a dull brown. I was puzzled until the reason dawned: The anemone, reacting to the prevailing blue-green daylight, was *fluorescing* bright red. The flashbulb, which emits all colors of the spectrum, had overwhelmed the anemone's dim fluorescence.

Cousteau had the most original mind I have ever encountered. He would say: "Why don't you do it this way?" outlining his own unique approach to a problem. This was before the days of submarine electronic flash, and I used caseloads of magnesium flashbulbs. In the high pressure of deep water they tended to leak around their brass base, causing the bulbs to misfire. Cousteau's solution was inspired. At the base of each bulb the ship's engineer drilled two small holes. The cook melted wax in the galley, and the ship's surgeon, using a hypodermic syringe, injected the liquid wax into the bulbs' bases. When the wax solidified, *voilà*, it assured lightning below.

At the upper end of the Red Sea we dived on a British freighter that had been sunk in 103 feet of water by a German aircraft during the Second World War. Strapped down on her well deck were two railway tank cars. In the four atmospheres' pressure at that depth the steel cylinders were crushed like thin-walled aluminum beer cans, yet we naked Aqua-Lung divers swam beside them without discomfort, the most graphic example I have ever seen of the way Cousteau's revolutionary device automatically pressurizes the human body according to depth.

Cousteau's demand regulator has been refined in design but remains

unchanged in principle, and it continues to place in the hands of uncounted millions the key to the silent world.

By the end of the cruise we had sailed nearly 15,000 sea miles, traversing the Mediterranean, the Red Sea, and the Indian Ocean. It had been an exploration of a pristine world, a learning cruise, shining in memory with the light of discovery, a paradigm for later voyages over the world. In a bound copy he presented to me of 12 articles he wrote for the GEOGRAPHIC, Cousteau inscribed: "I will never forget the happy times we shared in the Red Sea." Nor shall I.

IN FOLLOWING YEARS Cousteau developed a miniature submarine—the Diving Saucer—built underwater dwellings for prolonged diving, and kept *Calypso* almost constantly at sea, producing a series of television films that would make him one of the world's best known faces. But as the years passed, he began to notice something disquieting. In many places fish were growing scarce, formerly crystalline waters were increasingly murky, and once richly carpeted bottom now lay bare. Alarmed, he began a survey of the Mediterranean Basin, testing water quality, analyzing bottom sediments, and observing with Aqua-Lung and Diving Saucer. Everywhere the message was the same: The Mediterranean was moribund. Overfishing, industrial and human pollution, and unrestrained "development" of the shores had reduced its marine life by 30 to 40 percent, Cousteau estimated.

The Mediterranean is an enclosed, nearly tideless, sea with many of the characteristics of a lake, so that any environmental insult would not take long to show itself. But when Cousteau went on the high seas, returning to Assumption Island in the Indian Ocean, where many years before we had filmed much of *The Silent World*, he was horrified to find the same creeping sickness. What had been a drowned paradise, pulsating with life and ablaze with color, was nearly lifeless.

Appalled and angered, Cousteau the diver and filmmaker became Cousteau the environmentalist. In 1973 he founded the Cousteau Society to publicize and support his advocacy of the seas, and he took *Calypso* to Africa, Amazonia, North America, the Pacific, documenting the unchecked sacking, as he termed it, of the ocean environment and river systems, everywhere talking to fishermen, farmers, industrialists, presidents, prime ministers, and dictators.

Unlike many brilliant men, Cousteau was supremely articulate and conveyed his compelling ideas with eloquence. I have heard him lecture without notes in both French and English, and his vivid imagery in both tongues would have delighted García Lorca.

Jacques-Yves Cousteau—JYC (Zheek) to his friends—spent the rest of his life in tireless advocacy of the sea and its interdependent landmasses, becoming the clearest voice for the sane use of Earth's finite resources, culminating in his attendance at the United Nations Conference on the Environment and Development at Rio de Janeiro in 1992, where delegates and more than a hundred heads of state conferred and deliberated but failed to emphasize the chief cause of the planet's troubles: gross overpopulation.

Some scientists have calculated that the planet can support in relative comfort only one billion to two billion. There are now nearly six billion people on Earth, of whom half live in poverty, and that figure is expected to increase by half—perhaps even to *double*—by 2050.

Looking ahead from the relative abundance of the mid-19th century, a prescient economist wrote: "We must bring our numbers into rational adjustment with the Earth's bounty." More than a century later we have yet to learn that lesson.

WHO WILL CARRY ON Jacques-Yves Cousteau's work? It is hard to be the son of a famous father, harder still to be the son of a famous Frenchman. John Donne preached that "No man is an island." He cannot have known many Frenchmen, the most self-contained and individualistic people on Earth. At a dinner in Washington at the National Geographic Society, Cousteau turned to a close friend seated beside him and said, with a wry smile, "My son Philippe has challenged me, just as an old bull sea lion is challenged by the young bulls when they come of age and want to prove their mettle."

He did not know that the same friend had a short while before heard Philippe relate that when he had tried to strike out for himself, Cousteau had opposed his using even films Philippe had made on his own, obliging him to return to his father's employ.

Philippe, Cousteau's younger son, had become indispensable, flying the Cousteau Society's amphibian and gyrocopter and doing much of the filming, until his untimely death in a plane crash in 1979.

At Cousteau's urgent call elder son Jean-Michel left his teaching and filmmaking career to work with his father. Years and 59 films later the old bull felt challenged again, and the two separated. In 1990 Simone died, and JYC remarried.

Today Jean-Michel is the sole survivor of the first family of the undersea world and the founder of his own environmental organization, the Jean-Michel Cousteau Institute. He says: "My father was my inspiration in life, my instructor in the meaning of life. On my office wall I keep something he wrote to me:

> *Happiness, for the bee as for the dolphin, is to exist.*
> *For man, it is to know existence and to marvel in it.*

"In that spirit, he helped to illuminate the more than 70 percent of our planet that is beneath the sea and to foster an appreciation of all living things. People protect what they love, and he made people love the ocean.

"Humanity has run out of time. Cooperation must replace confrontation if we are to provide future generations with a fighting chance of survival."

On Captain Cousteau's death he left his widow, Francine Cousteau, as president of the Cousteau Society. I asked Mme Cousteau if the society would go on.

"Of course," she said, "we are going to carry on. That was the wish of the Captain. We understood that he had established the territory of the

CHUCK DAVIS (ABOVE); DENIS LITTLEFIELD, NGS

ocean in the public mind. In the beginning, when people met him on the street, they would say, 'Oh Captain, I saw your film on sharks; it was great.' In these last years they would say, 'Thank you for what you are doing for future generations.' "

I asked about *Calypso*. "She is in Marseille, slowly rotting away. We want to bring her to Paris, to fresh water, where marine borers can no longer eat away her timbers, to exhibit her as a national monument. I have alerted President Chirac, and it appears the government will help to bring *Calypso* to Paris.

"The new *Calypso II* exists only on paper, but her design was chosen by the Captain. We have to launch a campaign to pay for the ship, which will cost some 30 million dollars. If the Captain were here, it would be easier to ask the public for support, but we are never going to clone Captain Cousteau. It would take ten people to replace him.

"The Captain's name will always be linked with water, water of the ocean, water of the continents. He will be remembered for his ability to communicate, with his taxi driver or with the President of the United States. He loved people. That is why he could make everyone understand what he was saying."

Having opened the door to the undersea world, Jacques-Yves Cousteau for more than half a century eloquently and tirelessly explored, portrayed, and defended the beauty, richness—and fragility—of that silent world for which he became the voice. □

Rejecting exploration by remote-controlled devices, Cousteau (opposite) launched a "sea house" in which oceanauts lived for weeks deep in the Mediterranean and sent scooter-propelled divers curving through the Pacific in gleaming synchrony. Cousteau's motto was "Il faut aller voir—We must go and see."

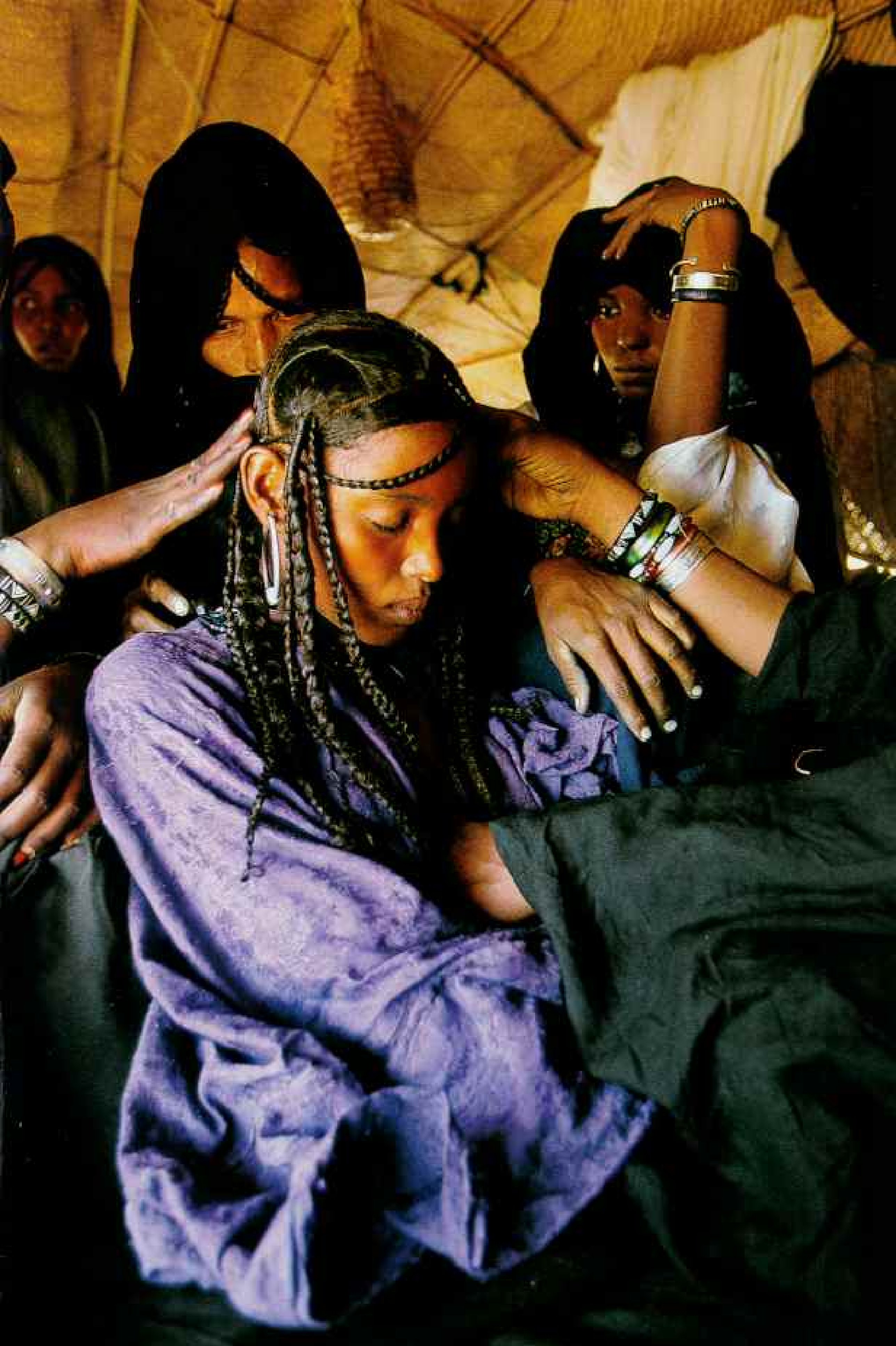
For more about Captain Cousteau read Jean-Michel Cousteau's reflections on his father's life and work at www.nationalgeographic.com.

Drums rouse wedding guests to mount camels and donkeys to reach the bride's home in In'Takhlamt, nine miles from the groom's camp. Most marriages are celebrated from July to September, a peak social season when caravans return from trading expeditions and rain transforms patches of the Sahara into fragrant pastures.

Brides *of the* Sahara

Cloaked in hope and her ceremonial indigo scarf, an unmarried Tuareg woman looks for prospects at a wedding in the Aïr region of Niger, where her people celebrate love after years of drought and war.

Veiled in haze, the Aïr massif marks the way for a contingent of friends from the groom's camp. The desert silence is broken by groaning camels and the chatter of women eager for the festivities to begin.



By CAROL BECKWITH and ANGELA FISHER

The bride sits silent as female relatives and artisans attend to her (left), making sure every hair is in place for the first day of her wedding celebration. A class of blacksmiths believed to possess mystic powers, the artisans smooth an aromatic pomade containing a fine black sand through 15-year-old Assalama's intricately braided hair.

Such attention is new for the young bride, who, in the custom of girls of the semi-nomadic Kel Nagourou group, has spent most of her time tending her mother's goats and sheep. It was only by chance that she was reunited with her 25-year-old cousin Mohamed a month earlier. Just back from five years in Libya, where he earned money to make up for losses suffered during long droughts and a failed Tuareg rebellion for secession from Niger, the caravanner spotted a grown-up Assalama as she drew water from a communal well. "I knew from that moment that I wanted to marry her," he says.

Wasting no time, he asked for her hand, she accepted, their families approved, and wedding plans began.

Following Tuareg tradition, marabouts perform the marriage rite at a nearby mosque in the presence of only the couple's parents; Assalama and Mohamed are absent. A few days later, as the time for celebration approaches, ululating and drum-beating artisans announce the marriage to arriving guests.

Draped in incense-infused robes, female guests add last-minute touches of beauty—a red powder called *ekawel* in Tamashek, the language of Niger's 700,000 Tuareg. For a week they and some 500 other wedding guests cheer their champions in camel races, laugh at the antics of singing artisans, and feast on rice, dates, and roasted meat in an oasis of tents under Saharan stars.

Carol Beckwith and Angela Fisher will include Tuareg weddings in their book *African Ceremonies*, to be published by Harry N. Abrams, Inc., in 1999.

Calm hands help Mohamed wrap his *tagelmust*, the ceremonial turban-veil worn by Tuareg men. The fabric is brought by caravan from Nigeria. Indigo dye, beaten into the cloth until it shines, rubs off on the skin, which earned the once fierce Saharan warriors the title "blue men of the desert."

Over time the tagelmust, worn to reveal only the eyes, has become more to the Tuareg than just a screen for desert sand and sun. As a show of respect, men rarely remove it in front of others. Covering

the nose and mouth, they believe, also keeps out *jinn*, or evil spirits.

Symbol of purity and fertility as well as a jinn repellent, henna is applied to Mohamed's feet and hands, a ritual reserved for a man's first marriage.

Surrounded by the groom's male friends and family, female artisans, or *tchinaiden*, wrap Mohamed's hands and feet in plastic tied with palm fronds. When the covering comes off in two or three hours, his skin glows a reddish brown from the henna, which will protect him for months.

Building the framework of a happy marriage, Tuareg women erect an *ehan*, or nuptial tent, for Assalama and Mohamed. Women traditionally dismantle and reassemble the tent every day of the wedding celebration to make it larger, symbolizing the stages of the festivities and of the marriage itself.

Covered in palm-frond mats and blankets from Algeria, the tent gives shelter to the bride, who lies shrouded in white next to her closest friend (right). Throughout the week-long celebration, Assalama may not show her face or speak to anyone except her husband, her best friend, her mother, and the artisan who attends her.

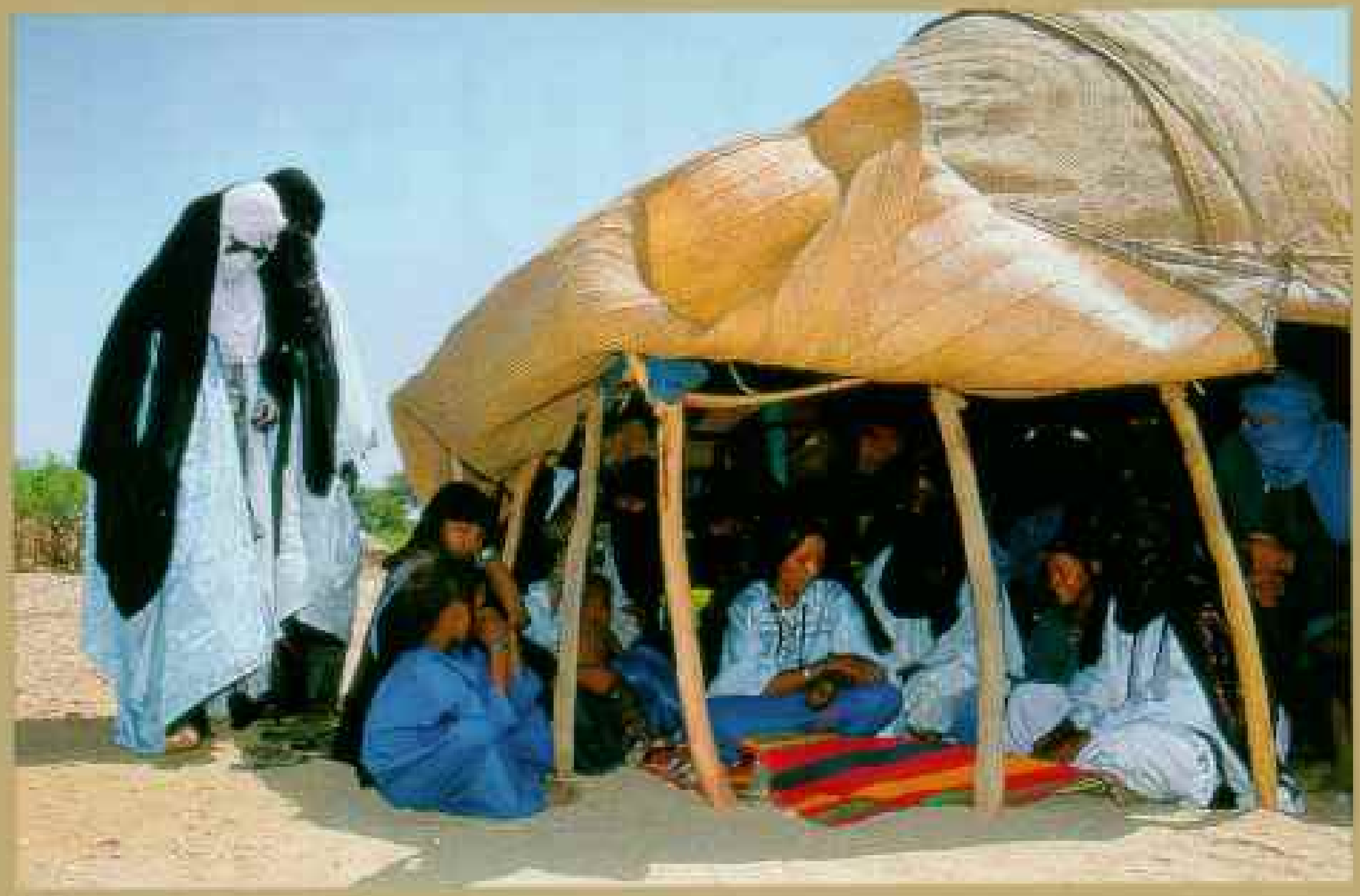
As with Mohamed, she must never be left alone for fear that jealous spirits will harm her. Both remain protected when she spends each night alone in the tent with her husband, who leaves before sunrise.

With most of the ritual behind them, Mohamed and his best friend pass the seventh day with a still secluded Assalama and her family and friends (top right).

As wedding guests return to their camps, Assalama and Mohamed prepare to spend the first year of their marriage with her family. Mohamed will offer displays of respect to his in-laws, working hard to win their approval.

Once that is accomplished, Mohamed may take Assalama to his camp at Arawat. As the years go by, she will settle into the tasks of Tuareg women, pounding millet, caring for children, and tending her animals. He will ready his caravan and set out across a sea of sand, eyes fixed on the ever receding horizon. □

TEXT BY CASSANDRA FRANKLIN-BARBAJOSA



REMEMBER THE MAINE?

Blasted to bits one moonless night in the harbor of Havana, Cuba, the U.S.S. *Maine* sparked the Spanish-American War when blame was laid on a mine. Now, a century later—and 86 years after its hulk was towed to sea and buried (above)—the question lingers: "What *really* sank the *Maine*?"

LIBRARY OF CONGRESS

BY **THOMAS B. ALLEN**

PHOTOGRAPHS BY **IRA BLOCK**

ON FEBRUARY 2, 1898, on board the U.S.S. *Maine* in Havana harbor, Lt. John J. Blandin wrote a letter to his wife, Corinne, and Ordinary Seaman Bill Gorman, captain of the ship's baseball team, wrote to his widowed mother. Both men were looking forward to February 15, when they expected the battleship to sail off to New Orleans and Mardi Gras. "Everything is quiet here, and no trouble is looked for," Blandin wrote. Gorman also said that Cuba was quiet, but he had heard that Cuban guerrillas were killing Spanish troops with dynamite mines.

The guerrillas, fighting for independence from Spain, had won American hearts. Clara Barton, Angel of the Battlefield during the Civil War and founder of the American Red Cross, went to Cuba at President William McKinley's request to distribute food to the starving. At least 100,000 Cuban civilians had already died—many in concentration camps. Spain was softening its long, murderous rule in reaction to McKinley's pressure. But life was still harsh. An American woman in Havana wrote of an "anemic, expiring people, whose gaunt forms were lying by the wayside with glassy eyes upturned, too weak even to extend an imploring hand for charity."

Unrest in restless Havana had led McKinley to dispatch the *Maine* to Cuba to show the flag and protect Americans and American interests. "I hope, with all my

heart, that everything will turn out right," Secretary of the Navy John D. Long confided in his diary after ordering the *Maine* to Cuba.

Long's hope would be dashed. On February 15 an explosion ripped through the *Maine*'s hull, taking 266 lives and sparking a crisis that swiftly led to the Spanish-American War. The cause of the explosion has been a mystery for a century. In 1898 a U.S. Navy court of inquiry ruled that a large mine blew up beneath the ship. A second investigation in 1911 blamed a smaller mine farther aft. But an authoritative report in 1976, sponsored by Adm. Hyman G. Rickover, declared that the blast had been an accident probably started by a fire in a coal bunker.

To examine the evidence from a new perspective, the National Geographic Society last year commissioned Advanced Marine Enterprises, a marine engineering firm used by the U.S. Navy, to perform computer modeling and simulations unavailable to earlier investigators. These simulations included both accidental fires and acts of war. The report adds new information to the debate about the tragic sinking of the *Maine* (see pages 102-107).

THE AMERICAN WARSHIP had entered Havana harbor on January 25, 1898. As a Spanish pilot navigated the ship through a narrow channel leading to the harbor, a crewman looked up at the guns of Morro Castle and said aloud, "We'll never get out of here alive." The pilot guided the ship to a mooring at buoy No. 4 in an area of the busy harbor said to be reserved for warships. Moored about 250 yards to starboard of the *Maine* was the Spanish cruiser *Alfonso XII*.

Enlisted men were confined to the ship for their own safety. So Gorman's team, recent winner of the all-Navy baseball championship, would not get a chance to practice. Officers could go ashore but only in civilian clothes, to avoid provoking anti-American incidents. One day Capt. Charles D. Sigsbee, the commanding officer of the *Maine*, was on his way to a bullfight when someone handed him an anonymous propaganda sheet, probably produced by *peninsulares*, Spaniards who supported a strong Spanish rule in Cuba. Ranting about "these Yankee pigs who meddle in our affairs," the sheet declared that the "moment of action has arrived. . . . Death to the Americans!" Sigsbee shrugged off the threat, confident that his precautions—armed sentries, an extra watch at night—would protect his ship from harm.

MUSEUM OF THE CITY OF HAVANA

When February 15 dawned, the *Maine* was still moored at buoy No. 4, and dreams of Mardi Gras had faded away. John Blandin, whose watch began at 8 p.m., collected routine reports, including one on the state of the coal bunkers.

Blandin, who had entered the Naval Academy 20 years earlier at the

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TOM ALLEN has written or co-authored 23 books, many on military history, including *Rickover: Controversy and Genius*. Before his freelance career, Tom served for 17 years as a writer and editor of National Geographic books. This is photographer IRA BLOCK's 14th assignment for NATIONAL GEOGRAPHIC.

THE GRANGER COLLECTION

"The chosen of the flock" is how Capt. Charles Sigsbee (above, at top right) described the ship under his command, which steamed into Havana harbor on January 25, 1898 (opposite), to protect U.S. citizens and property amid growing unrest over Spain's brutal occupation of Cuba. Less than a month later the Maine *was gone, destroyed by a massive—and mysterious—explosion.*

age of 15, was already a hero. Nine years before, during a Pacific typhoon, he had climbed into the topmost rigging of the U.S.S. *Trenton* and, with a cigarette between his teeth, lighted a rocket that sent a rescue line to a sinking warship, saving nearly all hands. Tonight, as he routinely performed the duties of the officer of the watch, he was feeling glum because he had yet to receive his promotion to full lieutenant, which would get him off the *Maine* and home to his wife and four children in Baltimore.

On the berth deck, well toward the bow and two decks above the powder magazines, Bill Gorman and most of the other 327 sailors and marines swung up into their hammocks. At 9:10 Gorman's teammate, Marine bugler and third baseman C. H. Newton, began to play taps. Sigsbee, aft in the captain's suite, was writing a letter. An aloof and

Of the 266 men who lost their lives on the U.S.S. *Maine*, nearly all were enlisted men. Many were young immigrants who saw enlistment in the Navy as a move up in the world. The crew was also racially diverse, experienced, and high in morale.

A BRIEF HISTORY OF THE SPANISH-AMERICAN WAR

January 25, 1898
The *Maine* anchors in Havana harbor.

February 15, 1898
The U.S.S. *Maine* explodes.

March 22, 1898
A Navy board of inquiry concludes that the *Maine* was destroyed by a mine.

April 1898
President McKinley requests—and Congress passes—a declaration of war against Spain.

May 1, 1898
Commodore George Dewey destroys the Spanish fleet in Manila Bay.

July 1, 1898
The U.S. Army wins the Battle of San Juan Hill in Cuba, then lays siege to Santiago, which Spain surrenders two weeks later.

July 26, 1898
Spain sues for peace.

December 10, 1898
Signing the Treaty of Paris, Spain turns over Puerto Rico, Guam, and the Philippines to the U.S. and relinquishes control of Cuba.

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unemotional man, Sigsbee was unexpectedly moved this night by the bugle's slow, sweet sound. He put down his pen and listened as Newton, who liked to produce fanciful effects, paused between notes so that taps echoed and reechoed through the stillness of the ship.

"Hardly anything was moving in the harbor, and the wind was still," as Lt. John Hood later remembered. "A more perfect scene of peace and rest could hardly be imagined." Hood, an ordnance officer, sat in a chair on the port side of the quarterdeck, smoking a Cuban cigar and looking at the lights of Havana. It was 9:40.

AS HOOD WALKED OVER to speak to Blandin, they both heard and felt the death of the *Maine*—"a shock and a sound" to Hood and "a dull, sullen roar" to Blandin. Looking forward, Hood saw "the whole starboard side of the deck, with its sleeping burden, burst out and fly into space, as a crater of flame came through, carrying with it missiles and objects of all kinds, steel, wood, and human." After a few small explosions—scattered ammunition, Hood surmised—"all was still except for the cries of the wounded, the groans of the dying, and the crackling of flame in the wreckage."

The explosion tore out the berth deck. Men in their hammocks were vaporized, ripped apart, or hurled into the night. Many were trapped in the shattered bow, their dying cries muted to a murmur as the hulk quickly sank. In the main sleeping area, only two men survived. One, Coal-passer Jeremiah Shea, had no idea what had happened. "I think I must be an armor-piercing projectile," he said. The other, Boatswain's Mate 1st Class Charles Bergman, heard "a terrible crash" and was flung into the water, encased in a piece of sinking wreckage. When it struck

Crossed by ferries then as now (below), Havana harbor was tranquil the night of February 15, 1898. Could a passing boat have planted a mine? After the Maine exploded, a Cuban ferry ignored the search for survivors. A Spanish Navy ship and a U.S. passenger ship, anchored nearby (map), joined the rescue. The Maine's auxiliary wheel remains in the Museum of the City of Havana.

bottom, Bergman freed himself and bobbed to the surface.

At the moment the *Maine* blew up, the lights went out in Sigsbee's suite, well aft and inside the superstructure. Groping through the smoke and darkness, he collided with his orderly, Marine Private William Anthony, who, summoned by duty, had left the safety of the open deck to find his captain in the wrecked cabin. Saluting, Anthony said, "Sir, I have to inform you that the ship has blown up and is sinking." Sigsbee followed the marine to the starboard side of the main deck.

Sigsbee, stunned, stood for several seconds, water rising over his ankles, and looked toward an "immense dark mass that loomed up amidships." Sigsbee ordered the magazines flooded. Lt. Cmdr. Richard Wainwright, the executive officer, said, "There's no use flooding the magazines, Captain; the ship is sinking."

HOOD, MEANWHILE, had helped get a boat into the water to pick up survivors. By now boats from the *Alfonso XII* were also pulling men from the sea. So were boats from the *City of Washington*, a passenger steamer moored nearby. Hood next climbed to the poop deck and volunteered, with others, to go forward, past the wrecked bridge, to see what was left. "We crawled forward . . . looking carefully for signs of life and finding none," Hood later wrote. "We proceeded till we reached the point where the ship had been literally blown away, and

THE MAINE AS SHE NOW APPEARS IN THE HARBOR AT HAVANA

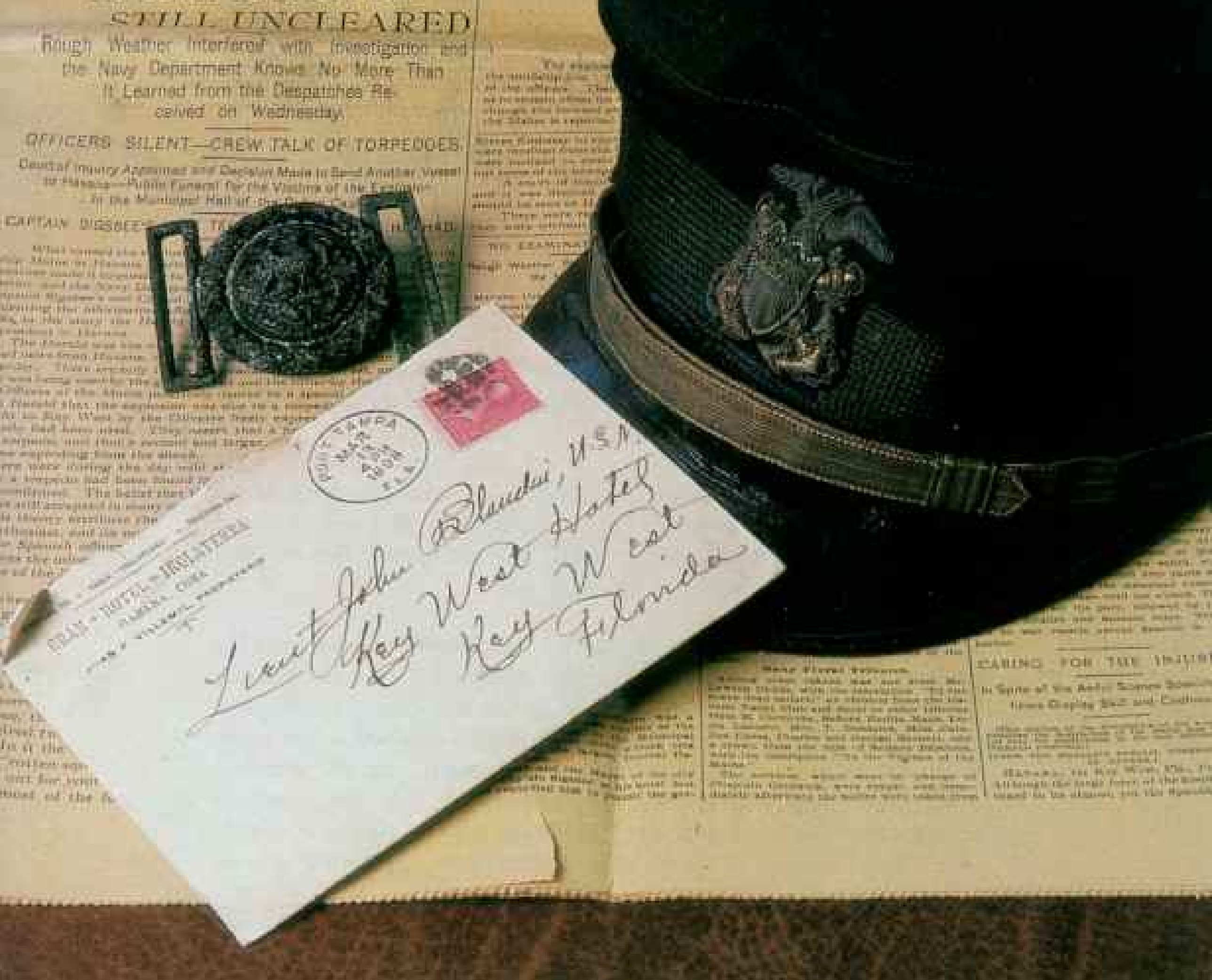
MYSTERY OF THE MAINE DISASTER STILL UNCLEARED

Rough Weather Interferes with Investigation and the Navy Department Knows No More Than It Learned from the Despatches Received on Wednesday.

OFFICERS SILENT—CREW TALK OF TORPEDOES.

Court of Inquiry Appointed and Captain Marix to Send Another Vessel to Havana—Public Funeral for the Victims of the Explosion in the Municipal Hall of the

CAPTAIN SIGSBEE



CARING FOR THE HEALTH

In Spite of the Best Known Sanitary Conditions Disease Will Crop Out

Deck officer the night the Maine *went down, Lt. John J. Blandin was struck on the head by debris but was able to testify before the official inquiry in Key West. Five months later he died. Blaming the head wound, Blandin's daughter asked the Navy to add his name to the monument in Havana (below). Today his family preserves a hat, belt buckle, and letters—mementos of a career cut short.*

could go no farther, and looked down on a mass of wreckage, floating debris and foaming water, in which some men were still struggling and calling for help."

Sigsbee, at the quiet suggestion of Wainwright, abandoned ship and, the last man to leave the *Maine* alive, followed Wainwright into the captain's gig, a small, oar-powered boat. Someone handed him his dog, Peggy, found by a sailor. Sigsbee ordered the gig to circle the wreckage and look for survivors. An officer shouted, "If there is anyone living on board, for God's sake say so!" The only answer was an echo.

The gig headed for the *City of Washington*, where many survivors had been taken. Only 88 men out of a complement of 26 officers and 328 sailors and marines had survived. Two officers and 250 enlisted men had been killed, including teammates Bill Gorman and bugler C. H. Newton; among the 22 black sailors who died was the star pitcher, William Lambert. The only surviving member of the *Maine*'s championship baseball team was right fielder John Bloomer, one of 59 men injured.

Eight men died soon of injuries, and another six lingered awhile before they, too, died. Lt. John Blandin (above), who said he saw scenes of that terrible night every time he closed his eyes, lived in a state of melancholy after he arrived home in Baltimore. He seemed ever to be back in Havana, calling out to Sigsbee that the *Maine* was under attack. On July 16 Blandin would die in a coma. Not initially listed as a casualty, but surely a victim, was Sigsbee's haunted marine orderly, private William Anthony. On November 24, 1899, a New York City police officer found him sitting on a bench in Central Park, dying of a cocaine overdose.

ON THE MORNING AFTER THE DISASTER Sigsbee looked out from the deck of the *Washington* and saw the remains of the *Maine*, settling in the mud of the seafloor. The tilted aft mast thrust from the wreckage, a mop, thrown up by the explosion, hanging in its rigging.

Sigsbee quickly decided that a mine had blown up his ship. But he kept his suspicions to himself. In a cable to the Navy Department, hastily written aboard the *Washington*, he said, "Public opinion should be suspended until further report." *(Continued on page 108)*

NEW INTERPRETATION THROWS OPEN THE QUESTION OF CAUSE

Using computerized technology unavailable to earlier investigators, a National Geographic study reveals that the explosion aboard the U.S.S. *Maine* could have been caused by either a mine or an accidental fire. The new study revives old questions for those seeking to lay to rest the mystery of the *Maine*.

ART BY **DON FOLEY**

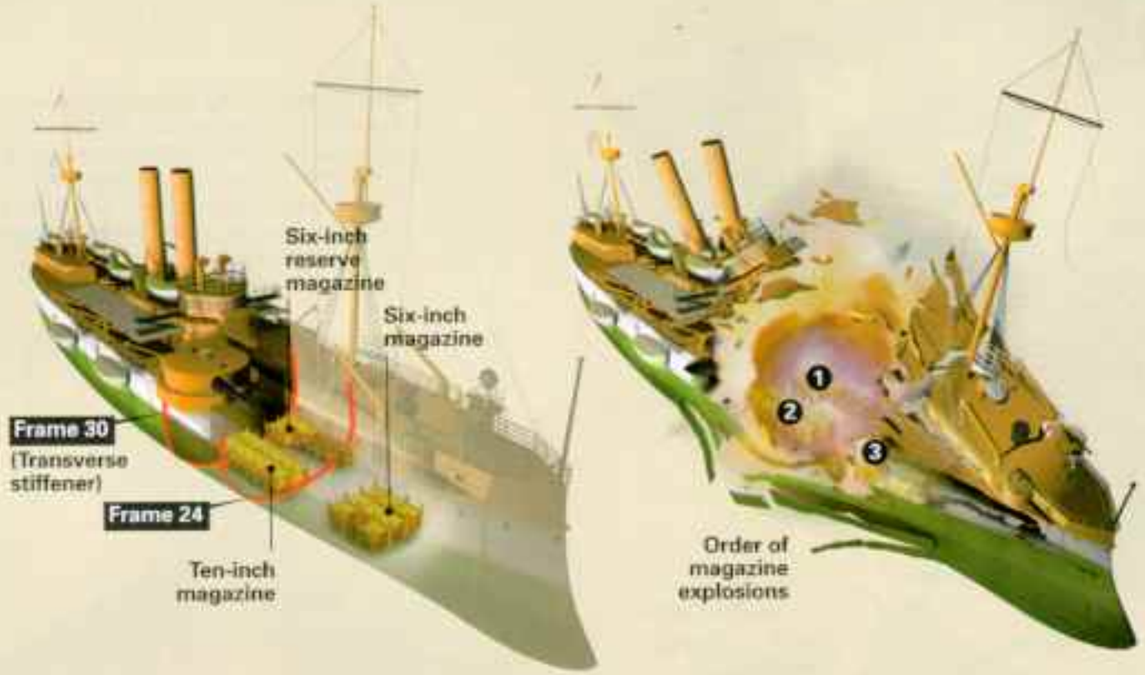
Who—or what—caused the explosions that sank the *Maine?* If it was a mine, the Spanish-American War was launched by a mass murder. If an accident destroyed her, the battle cry of that war—"Remember the *Maine!*"—should never have been shouted.

In the days after the tragedy, both the U.S. Navy and Spanish officials sent down divers to probe the wreckage. The Spanish found no evidence of a mine. The Americans did. The ship's keel was bent up into an inverted "V," and as one Navy diver told the 1898 U.S. naval court inquiry, "The skin of the double bottoms is curled over like a sheet of paper, inboard." Assuming that the extensive damage meant an external explosion, the court said that a large mine, placed by persons unknown, blew up the *Maine*. In 1911 salvage operations by the U.S. Army Corps of Engineers completely exposed the wreck, revealing the tangled mass of the bow. Analyzing hundreds of photographs for clues, investigators again blamed an anonymous mine, but one smaller and farther aft.

In 1976, however, Adm. Hyman G. Rickover, "father of the nuclear navy," surprised the public with a contradictory report. His team theorized that a plate (right, shown in green) had been bent inward by the "dynamic effects" of an internal explosion and showed no marks from the blast of a mine. They concluded that the most likely cause of the disaster was a spontaneous fire in a coal bunker adjacent to a powder magazine.

Now, a hundred years after the loss of the *Maine*, the National Geographic Society has commissioned a new study by Advanced Marine Enterprises, which conducts warship-design studies for the U.S. Navy. Using computer modeling, engineers performed a heat-transfer analysis to see if heat from burning coal could pass through a bulkhead and ignite a powder magazine. Then they performed a blast analysis to find out if an underwater mine could cause the bottom to fail, push the inner bottom plating into a magazine, and ignite the powder. The results are presented on the following pages.

NATIONAL ARCHIVES (80-G-7)



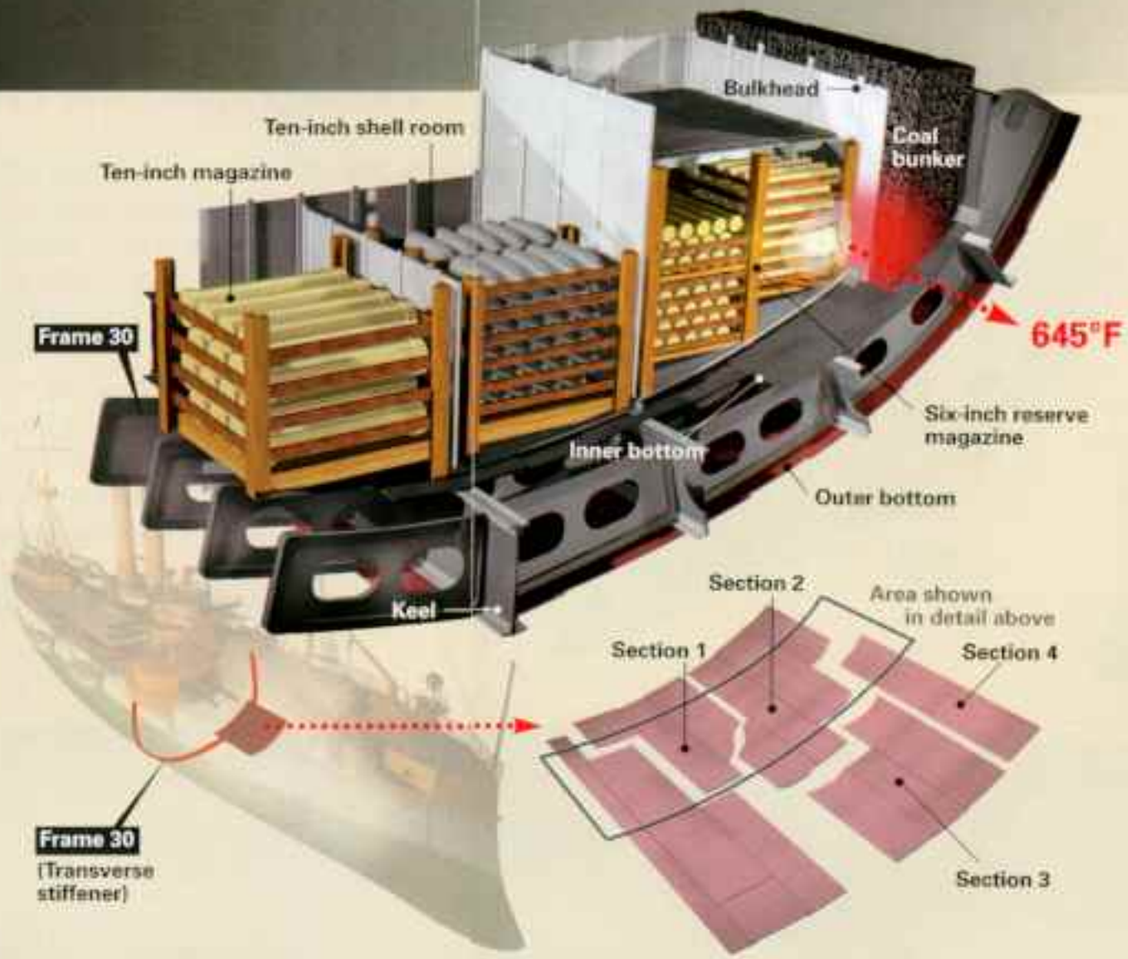
Photographs: the evidence at hand

In 1911 the U.S. Army Corps of Engineers built a massive cofferdam around the wreckage of the *Maine* in Havana harbor, first sinking huge pylons and then pumping out seawater to expose the wreck (bottom far left). Since the *Maine* had been sinking deeper into the ooze for 13 years, engineers had to clear tons of mud from the wreck as they probed for the most telling wreckage at the bottom of the ship. Once the hull and inner and outer bottoms were exposed, Naval Constructor William B. Ferguson had key pieces of wreckage numbered and photographed. Months passed as the engineers tried to determine what had brought down the *Maine*. Once satisfied, the Navy had much of the key wreckage cut up, hauled out to sea, and sunk, leaving Ferguson's photographs as the only evidence of the scene at the bottom of the *Maine*. For Rickover's team and for engineers working on National Geographic's study, the photographs turned out to be a star witness.

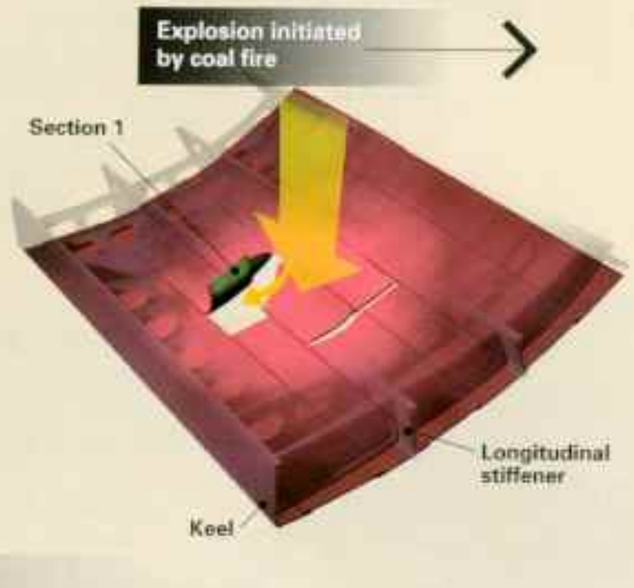
1911 photograph looking toward stern along inner bottom of hull
(colors added)

Was It an Accident?

Strongly argued in a 1976 study led by the late Adm. Hyman G. Rickover, this theory asserts that the *Maine* was destroyed from within, perhaps when a fire triggered by spontaneous combustion broke out in a coal bunker abutting a storeroom for powder. Coal fires were relatively common aboard steam-powered ships in the 1880s and '90s, sometimes smoldering for hours before detection. Studies of heat transfer commissioned by National Geographic show that within four hours a fire in the *Maine's* coal bunker could have raised the temperature of the nearest canister of gunpowder (a mere four inches away on the other side of a quarter-inch-thick steel plate) to more than 645°F—hot enough to ignite the powder, triggering a chain reaction in the adjacent magazines.



Most of the debate about the destruction of the *Maine* focuses on a portion of the ship's hold and outer hull just beneath the six-inch reserve magazine, where canisters of gunpowder were stacked like wine bottles.

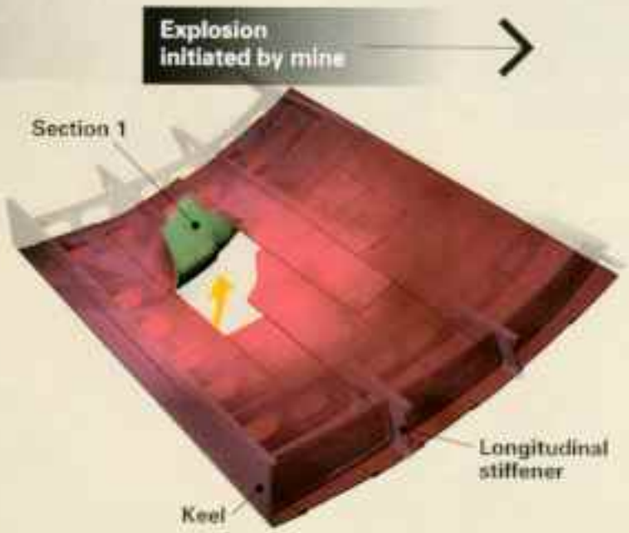


In this scenario the first explosion would have occurred aboard the *Maine*, when a powder canister was ignited by heat from a coal fire, touching off an explosion inside the adjacent six-inch reserve magazine, where more than 10,000 pounds of gunpowder was stored.

Was It a Mine?

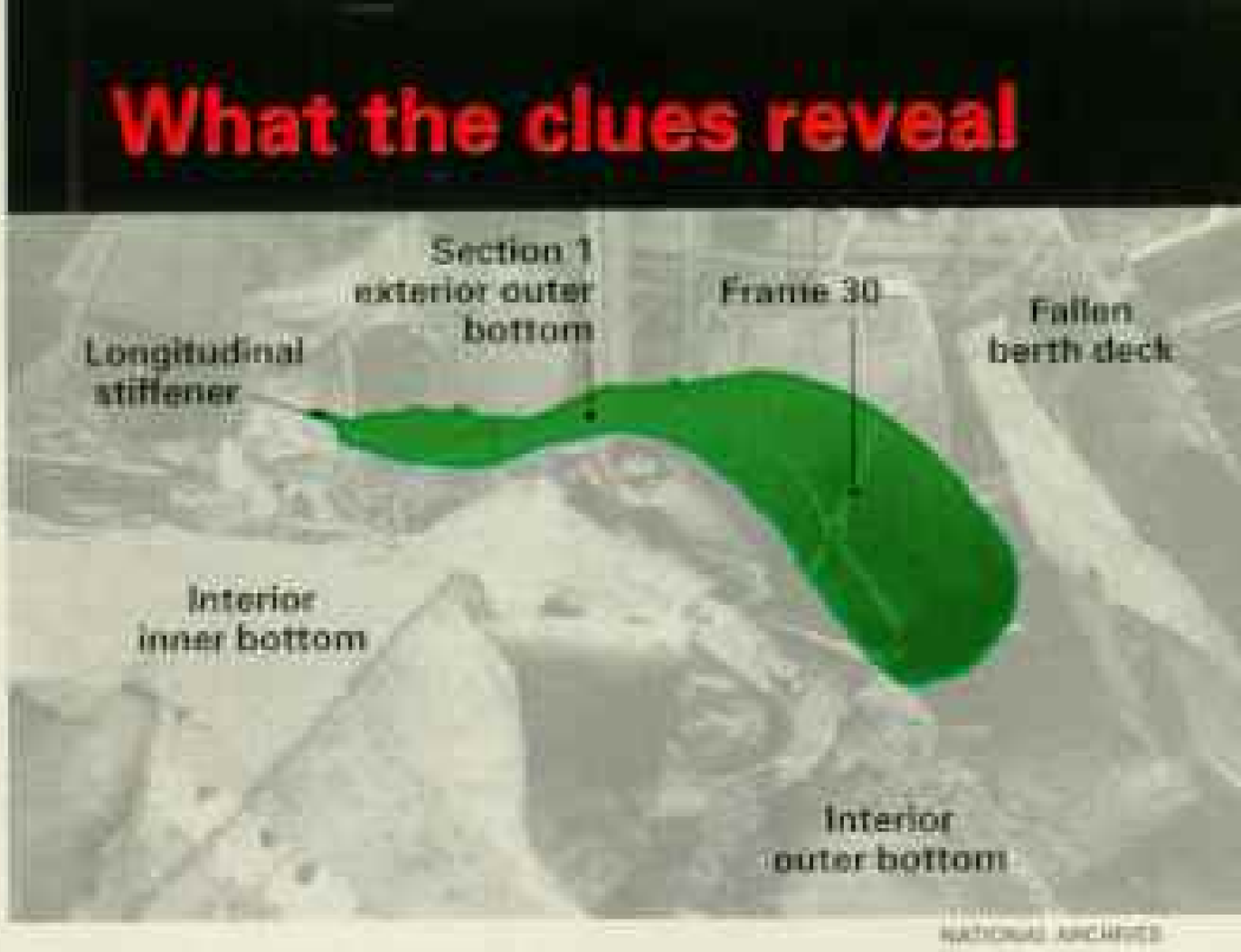
The traditional view, first advanced by Navy investigators in the 1898 inquiry and reiterated in 1911, is that the *Maine* was the target of a mine, planted by unknown conspirators in Havana harbor. This conclusion was suggested by physical evidence found by divers in 1898—including damage to the ship's keel. And when, during the 1911 excavation, engineers found a piece of the ship's hull (section 1) dented from the outside and bent inward, it seemed to confirm the presence of a mine, although a smaller one. The list of suspects includes the Spanish government, *peninsulares,* who supported strong Spanish rule, and Cuban patriots whose goal—independence from Spain—might have been advanced by starting a war between the United States and their colonial master.

Studies suggest that a very simple mine of the day—a wooden keg filled with a hundred pounds of black powder, ignited either on contact or by wire from shore—could have sunk the *Maine*. If so, the mine must have been perfectly placed, which under the circumstances would have been as much a matter of luck as skill.



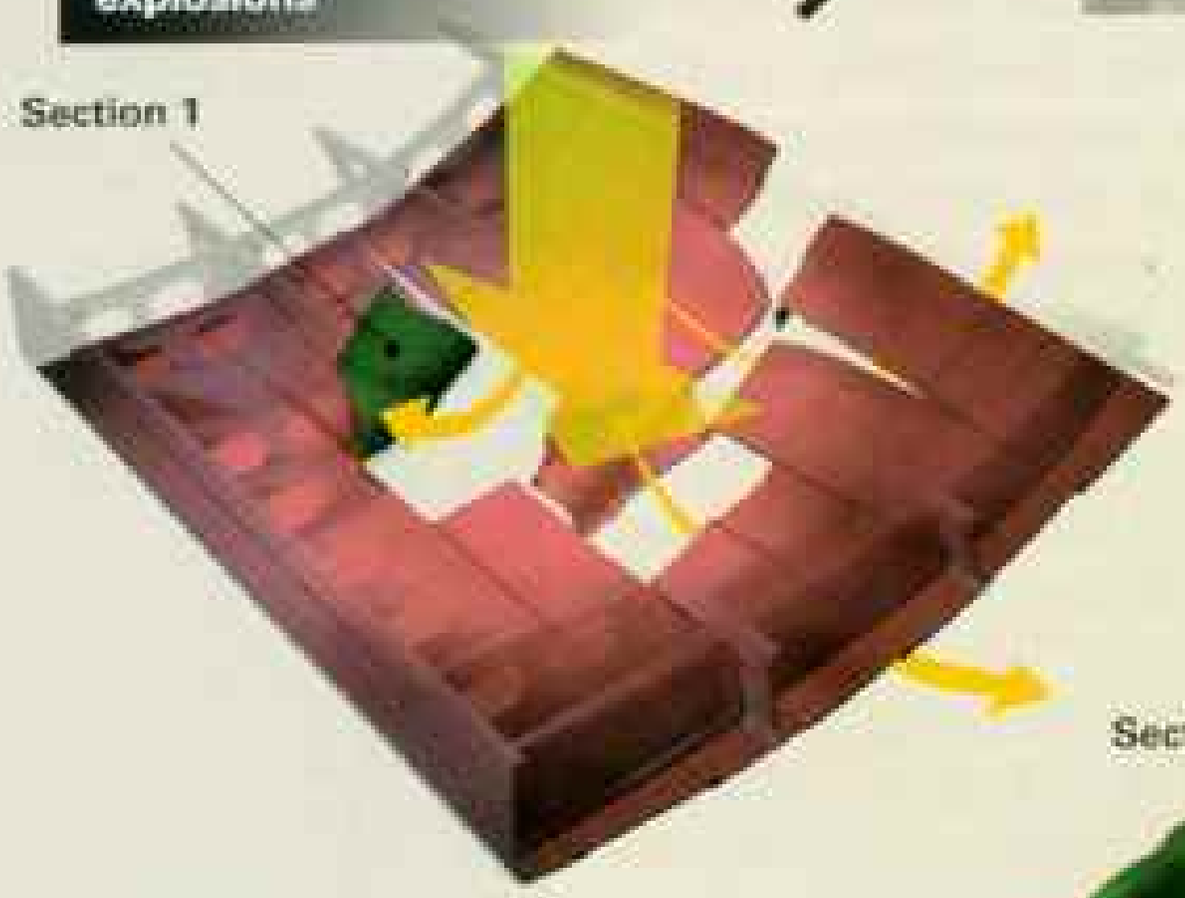
This theory argues that the first explosion took place in waters below the *Maine's* port side, when a mine detonated beneath the ship's outer hull. If the hull structure had been blown up and inward, it might have ripped into the six-inch reserve magazine, setting off the powder-filled canisters.

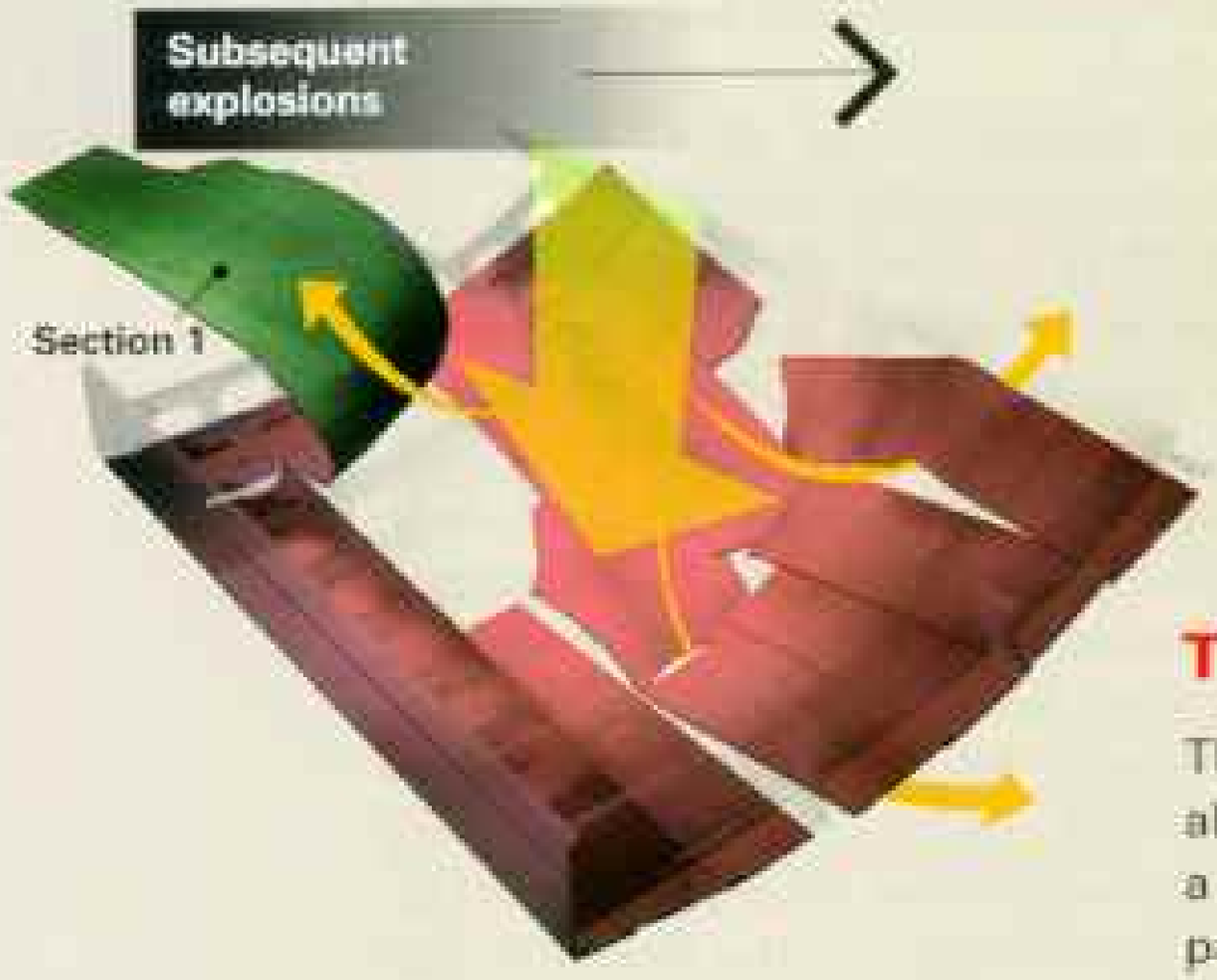
Within milliseconds, the exploding six-inch reserve magazine would have touched off a hellish chain reaction—massive explosions inside the ten-inch and other nearby magazines, unleashing the power of several World War II-era bombs. According to this theory, the expanding gas generated by the explosions could have been driven outward through the exploding hull, then back in by the enormous pressure of water, bending the telltale section of the outer hull, section 1, inward as water rushed in behind.



NATIONAL ARCHIVES

Section 1 (green), pushed upward and inward, suggests an explosion outside the ship. Coal fire advocates argue that a mine large enough to have penetrated and ignited the six-inch reserve magazine would have inflicted much more damage to the exterior of the ship.





The explosion in the six-inch reserve magazine would have instantaneously triggered other, much larger explosions in nearby magazines. This monster explosion would blast the hull apart from the inside out, leaving only the bent-in metal of section 1 to tell the tale of what really caused the disaster.

The case remains open

This study does not settle the issue once and for all but rather moves the century-old debate to a new level of scientific detail. Computer models patterned on the condition of the *Maine* before and after the explosion show that a fire in the coal bunker could have generated sufficient heat to touch off an explosion in the adjacent magazine. On the other hand, computer analysis also shows that even a small, handmade mine could have penetrated the ship's hull and set off explosions within. On what might have caused section 1 to buckle inward, the evidence is inconclusive. And since that telltale scrap of metal is now buried in mud somewhere off the shores of Cuba, the mystery of the *Maine* remains.

(Continued from page 101) The wildly irresponsible newspapers published by William Randolph Hearst and his rival, Joseph Pulitzer, continually drummed the claim that a mine destroyed the *Maine*. On February 17 Hearst's *New York Journal* proclaimed THE WARSHIP *MAINE* WAS SPLIT IN TWO BY AN ENEMY'S SECRET INFERNAL MACHINE. Spread across the front page was a seven-column drawing that portrayed a ship anchored over a mine, with a diagram showing wires connecting the mine to a Spanish fort.

BUT IF A MINE DESTROYED the *Maine*, who could have set it? The Spanish government, which did not want war with the United States, seems an unlikely suspect. Queen Regent Maria Cristina desperately tried to stave off war. Many disgruntled peninsulares, however, seethed over what they saw as U.S. interference in Cuba. They wanted war for reasons of national honor, and an incident that could trigger a war would serve their aims.

Cuban freedom fighters had been struggling against Spain for decades, with arms and explosives supplied by American gunrunners. In New York City their "junta," run by the insurgent underground, churned out propaganda eagerly published by U.S. newspapers. The *Maine* entered Havana harbor as a new Spanish government was hoping to negotiate an end to the rebellion while keeping Cuba as a "self-governing" colony. Guerrillas, seeking full independence, could have planted the mine to produce an incident that would inflame Americans against Spain. Then the Yankee liberators would do what the guerrillas had not been able to do: drive Spain out of Cuba.

Some Navy officials, dismissing Sigsbee's claim of a mine, believed that an accident destroyed the *Maine*. When she was commissioned in 1895 as a second-class battleship, she was, at 319 feet in length, the largest ship ever built in a U.S. Navy shipyard—and, said critics, a ship with a dangerous design flaw.

Coal bunkers lined much of her hold. And eight of the bunkers were next to magazines where powder was stored in copper containers. An investigative board, reporting on spontaneous coal fires to the secretary of the navy on January 27, 1898, had warned of bunker-to-magazine fires, which had been discovered—in time to prevent disaster—on the *New York* and the *Cincinnati*.

Despite lingering doubts about the cause of the explosion, politicians and much of the public accused Spain of treachery. "Remember the *Maine*. To Hell With Spain!" became a battle cry, amplified by Hearst, Pulitzer, and jingoistic congressmen.

On April 2, President McKinley, trying round the clock to avert war through diplomatic maneuvers, took time out from the crisis to attend a reception for Sigsbee, an inventor of deep-sea sounding apparatus,

One hundred years after toppling in Havana harbor, the foremast of the U.S.S. Maine *rises at the U.S. Naval Academy in Annapolis, Maryland. Also on display is the class ring of the ship's junior engineering officer, Darwin Merritt (class of 1895), recovered in 1911. "We still think about those guys on the* Maine," *says Midshipman Liz Henning (above, at right). "Navy people never forget."*

sponsored by his fellow inventor Alexander Graham Bell, President of the National Geographic Society. Bell praised Sigsbee for the "prompt, energetic and wise action [that] held in check the popular excitement which threatened to precipitate war between friendly nations."

War, however, was imminent. Everywhere, Americans were remembering the *Maine*. The battle cry rang from pulpits and podiums. Peppermint candies carried the message. Music hall singers crooned "My Sweetheart Went Down With the *Maine*." By April 21, McKinley, sleepless and worn, could hold out no longer. He ordered a naval blockade of Cuba, an act of war that Congress then formally declared.

Less than a month later Sigsbee again was in command of a warship in Cuban waters. This time he was hunting down a Spanish squadron. But neither on his *St. Paul* nor on any other U.S. Navy ship did the war cry "Remember the *Maine!*" send men into battle because, as Sigsbee put it, the cry "savors too much of revenge, too much of evil for evil." What should be remembered, he said, are the brave men of the *Maine*.

An Eagle in Havana: A Tale of Ups and Downs

After the Spanish-American War was over and the *Maine* had been buried at sea, Cuba built a monument to the men who lost their lives on the battleship. Crowned by an eagle with its wings spread wide, the soaring 40-foot-high monument was dedicated in 1925 on the Malecón, the plaza-like promenade overlooking the Havana waterfront. Relations between the United States and Cuba were warm, and when a 1926 hurricane toppled the bird, the statue was moved to the garden of the U.S. ambassador and was replaced by a larger, more aerodynamic version of America's national symbol.

But beginning in 1959, when Fidel Castro overthrew Cuban strongman Fulgencio Batista, things went rapidly downhill as Castro embraced the United States' Cold War nemesis, the Soviet Union. Anti-American rallies (below) became commonplace around the *Maine* monument. During a demonstration in the early 1960s, after the failed Bay of Pigs invasion, the second eagle was toppled and broken. Later a group of Cubans delivered the head of the fallen statue to what had been the U.S. Embassy, where Swiss caretakers hid it away. The body of the eagle disappeared, then resurfaced later in the Museum of the City of Havana (below far right), where it remains. Today the eagle's head is again on display, in a small cafeteria of the United States Interests Section in Havana (below center). Chief of the section, Mike Kozak (far right), who lives in the former ambassador's residence, notes that the *Maine* monument still stands in Havana (above right). "And a lot of Cubans look forward to the day when the body and head of the eagle are reunited." □

BOYD MA

AUSTRALIA BY BIKE

Part Two

Over the

By ROFF MARTIN SMITH

Photographs by R. IAN LLOYD

Why ride a bicycle all the way around Australia? In my case the reasons were personal: My marriage had just fallen apart, and 15 years after moving here from the States, I didn't know what to do next. So I hit the road. Sweating it out southwest of Darwin, with 4,000 miles behind me and another 6,000 to go, I had plenty of time to find out what my adopted country really meant to me.

Top

Monday, October 21
Darwin, Northern Territory

It's one of those evil-tempered afternoons, the kind they get up here in the Top End during the buildup to the monsoon, when police blotters fill with drunken assaults and steaming sidewalks make New Orleans in summer seem like a sweet wish. I'm sitting shirtless at a table in a youth hostel on Mitchell Street working on a three-aspirin headache and a fading sense of humor—about par for Darwin, late October. Yet for all my grumblings I'm pleased to be here. Those turquoise waters off the esplanade are the Timor Sea—tangible evidence of the 3,900 miles I've come since I left Sydney three months ago today.

I'm now at the northernmost point in my journey—about 13 degrees south of the Equator—and if I don't get a move on before the "wet," I could be stuck here until March.

First I need to do a bit of work on the bicycle: new tires, replace the chain, lubricate anything that moves, tighten anything that's loose. Ahead of me are the most godforsaken stretches of highway in Australia—2,600 miles down the remote west coast. I'll be riding into summer, and any water in the riverbeds will have dried up—unless those rains come. I've read the flash-flood warnings, heard how the Fitzroy River can turn from a trickle to a surging tide, wider than the Mississippi, sweeping away anything in its path. Out there, the old-timers say, a man can drown or die of thirst in the same spot.

With luck, I should make Perth before Christmas.

One lightning bolt or stray cigarette butt can turn the outback into an inferno at the end of the dry season. This blaze west of Halls Creek was so hot I thought my scalp had melted. Soon the monsoon would sweep in, dousing the flames, but not me. I kept moving.

Tuesday, November 12
near Turkey Creek, Western Australia

I left Kununurra in thunderous glory, a helicopter throbbing just above my head as I rolled along the highway thinking: If this guy sneezes, I'm lasagna. Looking up, I could see Ian Lloyd inside the bubble aiming his camera at me. The pilot, Howard James, does a lot of work for the big stations up here—million-acre properties that use helicopters to muster cattle. It's dangerous flying. "Cattle don't always look up," Howard had explained earlier. "You have to fly right in at eye level to get them to move." I'd hoped to see a bit of heli-mustering while I was up this way, but I hadn't expected to see it from the cow's point of view.

It's good to be back on the road after ten days waiting in Kununurra for Ian to arrive. To kill time, I did a little melon picking at one of the irrigated farms on the edge of town, riding out to the fields at the crack of dawn with about 20 other pickers crammed like refugees in the back of the farmer's truck. He had a sticker on his rear window that read: "If you drink and drive you're a bloody idiot, but if you make it home alive you're a legend."

Forty years ago Kununurra didn't exist. It's the product of an ambitious government project to tame Australia's remote northwest frontier by damming the Ord River and using irrigation to turn desert into garden. Now there's an oasis town of about 6,000, with caravan

parks bustling with melon pickers looking for ten dollars an hour.

One afternoon I went hiking in Hidden Valley in Mirima National Park—a maze of weirdly eroded crags near town that resemble beehives. This is the eastern edge of the Kimberley, a 375-million-year-old landscape of rough sandstone, deep gorges, and boab trees. It's dry almost year-round, then deluged with rain during a short, violent wet season anytime from November to March, when cliff faces turn to waterfalls and rioting cane grasses can grow ten feet high in less than a month.

Last night I'd hoped to show Ian the magic of camping in the Kimberley. The sky is deeper and the stars brighter than anyplace I've ever seen, and I'd raved about the tranquillity. Instead Ian learned where Australians store their irony when they're not using it. The bush is thick with it. You want magic? A poisonous centipede thick as a finger, long as a hand, scuttled past the toe of Ian's shoe. Tranquillity? A colony of fruit bats woke in a nearby tree and began their evening's foraging, their leathery wings *whump-whump-whumping* in the darkness. More tranquillity? A feral donkey began braying somewhere, its nocturne cut short by two quick blasts of a road train's horn and a terrible bang.

Wednesday, November 20
Broome, Western Australia

I got here a few days ago; glad to shake the desert out of my sneakers for a few days.

This old pearling port was one wild town in the days before World War II, a place right out of a Joseph Conrad novel, with its smugglers and pearling luggers and its swirl of Malays, Japanese, Europeans, Chinese, Javanese, Aborigines—almost anybody chasing some fast money. The Japanese cemetery alone has more than 900 graves of pearl divers, mostly men in their 20s, killed by storms, drowned, or dead of the

bends. The old sailing luggers are gone, but pearling endures. Broome is still a town of frontier contrasts. You can buy a $200,000 string of matched pearls at the Paspaley showroom—hushed and sweetly air-conditioned—or grab a drink just around the corner at a rough-as-guts pub reeking of spilled port, stale beer, and sweat. A notice tacked on the wall outside prohibits prostitution, fighting, and obtaining liquor by begging.

Ian's back home in Singapore now, and I'll catch up with him again in Perth. It's been enjoyable having someone to talk to on the road, especially a fellow expat, but I'm glad to have my solitude again—although with the community of drifters sliding down the coast I'm not alone. There are familiar faces in Broome, people I've met in roadhouses and hostels and pubs miles ago: Garry, a mechanic I met up in Kununurra is here; so is Bernadette, a Perth pastry chef looking for work on one of the stations, and Ian and Karen, a couple from Melbourne who put all their possessions in a truck and headed for the Kimberley to find a new life.

Bill Withers was once a member of parliament, but in 1982, at the age of 51, he resigned to pursue a different path. Now he grows organic mangoes and vegetables in Kununurra and relishes his freedom. I ran across that independent streak all along Australia's western flank. Miners, pearlers, laborers, missionaries—they all have faith they can make a life on this thin edge between desert and wide-open sea.

The monsoon continues to tease with towering thunderheads and sheet lightning at night, and I hear rain's been bucketing down in Kununurra. But Broome is a seductive place. Fresh sea breezes, peacock blue waters as warm as a bath, ripe mangoes plopping down in an abandoned orchard opposite my hostel. You can even get a decent cappuccino. Some nights I go over to the Sun Picture Gardens, an outdoor cinema built by a pearling master in 1916, kick back in a canvas sling seat, and watch a movie. Eat popcorn. Ignore the occasional fruit bat flying in front of the screen. Saturday night they're showing W. C. Fields and Mae West in *My Little Chickadee*.

`Thursday, November 28`
`Great Sandy Desert, Western Australia`

`It's ten o'clock in the morning, and the battered thermometer hanging in the shade` already reads 102 degrees. This is the most abandoned stretch of highway I'll see on my journey—a searing 400-mile ribbon of bitumen across the olive-drab scrub of the Great Sandy Desert. Out here it takes more than 50 acres to support one cow. I'd ridden hard, about 60 miles since sunup, to get to Shamrock, a 430,000-acre station, before the sun could really bite. Just made it. My face was flushed, my throat cracked and dry as an outback riverbed.

I thought of my last phone conversation with Laura, my four-year-old, who told me: "I've been thinking, Daddy; I've got a bike and I

Soaking up the scenery, tourists on Cable Beach in Broome follow Laurie Argyle, who leads camel rides to earn money for a trip overseas. It's odd—when I was in my 20s I ached to go to Australia, but she can't wait to get out. She talks of staying away for years, but I wonder if she knows what that really means.

could come out there and help you. I'd be a big help." I still smile at the thought of her legs churning madly on her tricycle heading into the thunderstorm that hit me out of Broome yesterday afternoon.

Now I'm sitting in a rough shed with a pannikin of cold water at my elbow. Across the table, Jay Simms, the owner of Shamrock, is making calculations in a worn ledger. He's a big gruff man, dressed in khaki—a former New Mexico cattleman who came out here in '68 because "it was the farthest and loneliest place I could think of where they still spoke English." Now he's counting watermelons, not cows. He found water beneath the sands on his property and, with outback ingenuity, decided to try his hand at horticulture in the desert, plowing furrows and rolling out cheap plastic irrigation hose. It worked. "It's like hydroponic farming," he says. "The sand just supports the roots, while we pour on the fertilizer and water."

Every day a road train pulls up to the station to take on a load of melons or sweet potatoes for the 1,400-mile haul to Perth. "We're the loneliest market garden in the world," Jay likes to say. "But it's worth it. Our watermelons come on ahead of everybody else's, and for a few weeks around Christmas we've got the Perth market almost to ourselves. Easier money than cattle and a lot more pleasant—no watermelon ever stomped me into the dust."

Jay's partner in this enterprise is a former Roman Catholic lay missionary named Danny Fyffe, who used to work at the Bidyadanga Aboriginal Community. Bidyadanga started out back in 1931 as a government-run feeding post to assist the Karajarri, a local Aboriginal people. In 1955 the Catholic church took over, running the post until 1984, when administration was handed over to the Aboriginal council.

"It's an interesting community," Danny said. "If you like, I'll call up Father Matt and ask if he can put you up for a few days." Father Matt

was agreeable, and I'm to be at the Bidyadanga turnoff, about 12 miles down the road, in a couple of hours.

FATHER MATTHEW DIGGES—*Japulu*, or "spiritual leader," to the Karajarri—is a sandy-haired, athletic-looking man in his early 30s who comes from New South Wales. "Want to know how remote we are out here?" he asked. He led me into his study and pointed to a framed photo of a younger self meeting Pope John Paul II during a papal visit to Sydney. "Some of the guys out here saw that and wanted to know who was the bloke talking to Japulu."

About 600 people live at Bidyadanga, a collection of concrete houses and corrugated iron sheds near Lagrange Bay. I'm resting beneath a mango tree in the drowsy heat of a Sunday afternoon. A car's running rough somewhere, dogs are barking in the distance, a quarrel breaks out down by the store. I'm regarded with a mixture of curiosity and good-natured tolerance: Japulu's friend—he must be OK.

This morning at Mass I shared a hymnal with a fine old gentleman named John Dodo, at 86 the oldest person in the community and one of the last repositories of Karajarri culture. He knows several Aboriginal languages as well as English. Mass was sung today in his native Karajarri, a soft, musical language that sounds almost Italian. After the service we stood outside talking. He was happy to discuss events of the day, even touch on Aboriginal politics, but when we strayed into deeper waters, like the Karajarri's relationship with the land, he firmly but graciously steered the conversation back to the shallow end.

There aren't many elders like John Dodo left. The kids at Bidyadanga seem to drift in a sea of borrowed pop culture. They hang around the basketball court decked out in American-team gear. The girls favor the Charlotte Hornets; the boys, the Chicago Bulls. When they heard I was from the States, there was a rush of questions: "Hey, man, do you know Michael Jordan? Shaquille O'Neal? Ever been to Hollywood?" And my favorite: "Ever gone out with Pamela Anderson?"

This is the first time I've stayed in an Aboriginal community. It is one thing to read about the poverty and the killing diet of cigarettes and alcohol, but it's quite another to stand in a weedy graveyard in a far corner of the outback, as I did this afternoon, reading birth dates like 1969, 1972, or 1977 on concrete crosses already crumbling in the monsoonal heat.

If cyclists have a personal god, then he was looking down kindly upon me. My bike bore a heavy burden—up to 40 pounds of water, plus me and my gear—yet so far I had suffered only two punctured tires. Prepared for all sorts of repairs, I rarely did much besides top off my tires with air (below). Another blessing was those magical places—like a point near Broome (opposite)—where the road kissed the coast and the water glowed as if lit from within.

Wednesday, December 11
Port Hedland, Western Australia

Arrived in town caked with dust and mad as a cut snake: My first cold drink in three days was delayed by a mile-long ore train coming in from the desert, hauling tens of thousands of tons of iron-rich hematite from the giant

Mount Whaleback mine. I straddled my bike as the train rumbled by, looking over a charmless landscape of blistered rock, high-tension lines, soulless industrial parks, and loading docks shimmering in a haze of humidity off the Indian Ocean. About 350 years ago Dutch merchantmen sailed up this coast but shrugged it off as worthless. How could they guess at the treasures of iron, gold, and copper in these rocks or the billion cubic feet of natural gas under the Timor Sea?

There's only one reason anybody comes up here in the 1990s, and that's dollars: a job with company housing at one of the big iron mines or the huge North West Shelf gas project in Karratha. It's a young man's game, a unionized gold rush. They stick around for a few years, then head south with enough loot to start a business or buy a house. Rumors are rife. "Hedland's off the boil now, mate. It's all down in Karratha." Then someone else says just the opposite. The latest whisper: They're looking for 200 "sparkies"—electricians—for the new hot-briquetted iron plant being built near Hedland.

I took a shower at the Ampol Roadhouse and settled in with the local newspaper to sit out the heat and escape the flies. Scanning the classifieds, I saw that a woman who calls herself Shagsie is in town, up from Perth, taking out ads to let "all you bikers and Harley Riders" know what dates she's available. So many lonely $80,000-a-year pay packets up here. "Meet me at Gecko's!"

Wednesday, December 18

Nanutarra Roadhouse, Western Australia

These deserts never seem to end: the Kimberley, the Great Sandy, the parched rimrock of the Pilbara. I've come 300 miles south of Port Hedland, and every bloody one of them grinding down one abandoned stretch of highway after another, the tedium of earth and sky relieved only by occasional columns of dust hundreds of feet high swirling in the distance. Willy-willies, the Aborigines call them, and they can flip over a car.

Worst of all are the flies, thousands of them, all seeking moisture in my eyes, nose, ears, at the corners of my mouth. They're so bad that it's better to ride through the heat than stop and have their loathsome little feet all over my face. Sometimes my panniers are so thick with flies they look as if they've got black lace doilies draped over them.

I wish I could say I filled these miles with ennobling introspection, but the outback has long since beaten that out of me. I pass the time trying to remember the lyrics to songs—from heavy metal to Cole

Porter—reciting dialogue from movies, or listing state capitals, Presidents, the starting lineup of the '69 Cubs. One game I like to play is making up a guest list of six people—anybody, past or present—I'd like to invite to lunch. Anything to escape the here and now, the thirst, wind, and loneliness. And yet, strangely enough, part of me likes this duel. We meet at dawn, the desert and I, to see who'll come out on top by the end of the day.

As the hours pass, I find myself thinking more and more about my native New England, images of cool green villages, pretty back roads canopied with leaves, the brook that runs past my family's old farmhouse in New Hampshire. My thoughts always seem to circle back to water. Cold sweet water. In a tall glass beaded with moisture. The reality here is grimy water bottles cooked by the sun until the liquid inside is as warm as stale tea and tastes nauseatingly of soft, heated plastic. Even so I suck it in greedily, up to a quart every ten miles. I buy distance with water. By ten in the morning the heat is usually so intense that it's poor economics to keep pedaling. I curl up in whatever scraggly bit of shade I can find and stay still, rationing my sweat.

Today, though, I pressed on an extra couple of hours in the hope of making the Nanutarra Roadhouse—and its air-conditioned diner. I'd already come 70 miles, and the temperature in the sun must have been crowding 140 degrees. The last of my five-gallon water supply ran out three miles shy of the roadhouse, and I stumbled in a lifetime later.

A riverbed gasps for water during the "dry" near Karratha. The heat gave me an excuse for a midday siesta, like most living things in the desert. I'd find a scrap of shade, roll out my mat, sip some water, and stare at the ants, who looked pretty burned out too. Later I'd pack up and head down the road, which I swear had been wavering just a few hours before.


BRAMBLES
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crazed with thirst. I slumped into a chair, set up 24 dollars' worth of bottled water and sports drinks in front of me (that's about one and a half gallons of liquid), and returned the stare of a road-train driver at the next table. He spoke: "Mate, you know there's a cyclone coming?

"Tropical Cyclone Ophelia," he said, cutting a corner off his steak. "A Cat Three storm coming in fast off Christmas Island. Expected to hit the coast near Karratha sometime tomorrow. Hope you're heading south. I gotta drop a load off in Hedland tonight, but then I'm turning around as fast as I can and hauling ass out of there. A storm can cut the highway for weeks. Christmas is coming, and I really want to be with my family. Know what I mean?"

Yes, I know what he means. Ophelia be damned. I'll rest here a bit longer, watch the cricket match on the TV by the "truckers only" table, then push on. I feel like a punch-drunk boxer answering the bell for round 16.

Thursday, December 19
Minilya Roadhouse, Western Australia

It's been cooler today, no more than 95 degrees, thanks to a high, thin veil of cloud that crept over the sky early this morning as stealthily as a cat on a mantelpiece. The winds slacked off too. I rode hard and made good time. The first thunderheads didn't catch me until about 30 miles ago, and I arrived at Minilya under a drenching storm, the first rain I've seen since Kununurra. I've come 130 miles, and my legs are so tired I can hardly stand.

Now I hear on the radio that my heroics were for nothing. Ophelia broke up. Modest squalls are all we'll get. The rain has freshened things up, and I ought to make hay while the sun doesn't shine. They say a hot front's moving in tomorrow. When I groaned about the constant head winds, a road-train driver laughed: "Mate, they're going to get a lot worse around Geraldton. You'll have winds every inch of the way. It's bad enough in a rig. You must be mad to tackle this on a bike."

Seven hundred miles to Perth.

Wearing the latest NBA basketball gear, kids at Bidyadanga, a former Roman Catholic mission, also favor Western music. It's an uneasy mix of Dreamtime beliefs and modern Dream Team culture.

Why do some folks around the Sandfire Roadhouse have one sleeve missing? After donating money to the local air-ambulance service, they tear 'em off just so you'll ask. It's a raggedy ad for this outback lifeline.

ROB MARTIN SMITH (BOTH)

Monday, December 23
Billabong Hotel

These past 24 hours have shown me the best and the worst of the outback. It started yesterday at the Wooramel Roadhouse, when I rode up around noon, baking in the 113-degree heat. I circled the building, wondering if it was open. There were no cars, no people, just the hum of a diesel generator. I tested the door. It slid open, and I walked into the dim coolness of a diner. A woman stood behind the counter, arms crossed,

Riding into the glass-and-steel canyons of Perth was a bitter-sweet pleasure. Much as I miss the freedom of the desert, I've never been happier to be surrounded by civilization. While it may be the outback that makes Australia unique, I suspect you have to be born to it to make a life there.

glaring at me with a face as hard as a coin. I ordered a meat pie and a Coke and asked where I could fill my water bottles.

"We sell water here," she snapped, pointing to a fridge: "Four dollars a bottle."

This was a first. It was about 50 miles to the next roadhouse, so I sat down to estimate how cheaply I could get there in this heat. The woman stared at me some more. A lean, sour-faced man stepped out of the kitchen. While the two of them were glaring at me, a woman with two small kids drove up in a steaming Holden. "Can you please help me?" she asked. "My car's overheated and I need—"

"We sell water here."

She couldn't afford their water, and because she wasn't buying anything else, they asked her to leave. She and the children waited outside in the heat until another motorist gave her water. More cars pulled up outside. There was a sudden flurry of activity in the diner. While the woman jotted down lunch orders, the surly manager glanced in my direction.

"What are you looking at?"

"I'm not looking, I'm staring." Suddenly I felt too far from home. He ambled over to my table with a false smile, like a hangman sizing me up for the drop. "Yeah? Guess what? I don't want you around. Get out."

"Why so unfriendly?"

"That your bike out front? I'm going to smash it."

I followed him out the door. He looked over his shoulder and ducked out of sight. I saddled up and rode.

I hadn't gone two miles when a four-wheel-drive vehicle pulled up beside me. It was Dave Steadman, who with his wife, Margot, owns Wooramel Station, a 400,000-acre sheep station nearby. "I'm awfully sorry about that back there," he said when he heard of my departure. "I wouldn't want you to get the wrong impression of us out here just because of him. I'd like it if you'd stop by and spend the night with us. What do you say?"

Turned out that Dave and Margot were no strangers to NATIONAL GEOGRAPHIC—they'd put up Robyn Davidson, the camel trekker, in 1977 when one of her camels took sick. They'd just finished the shearing and spent yesterday moving sheep by road train. With Christmas coming, there was a restlessness in the air. Margot was off to Carnarvon in the morning to do her shopping. Kimberley Elliott, the head stockman, left last night to visit his brother in a mining town about 400 miles east, and Neil Smith, a redheaded giant of a farmer who moonlighted as a road-train hauler, was looking forward to getting back to his wheat farm near New Norcia for Christmas and the harvest.

This morning Dave put a call through to his mate Don Stone

A fashion contest is just a sideshow for the main event—the horse race for the Perth Cup, held every New Year's Day. The betting is heavy at Western Australia's premier horse race, but with my luck on horses, I'd better stick with bicycles.

("Boulder" to those in the know), the publican at the Billabong Hotel, to tell him I'd be passing through. "He's my representative in that part of the world," Dave explained to me. "He'll look after you." Sure enough, Boulder met me with a plate of sandwiches and a cold beer. He pointed out back. "The swimming pool's over there."

Wednesday, December 25
Walkaway, Western Australia

Fifteen years in Oz, and I still can't accept the idea of Christmas falling in the middle of summer. Christmas is frosty nights, icicles, blankets of snow over steepled villages—not a beach picnic on a sweltering afternoon, listening to Bing Crosby dreaming of a White Christmas while smearing zinc cream on your face to protect against UV readings beyond extreme. The only sign of the season I saw out here was refrigerated trucks from Carnarvon zooming down the highway with fresh lobsters for family lunches in Perth.

I spent the afternoon lying, exhausted, on a park bench in Geraldton. I made a hundred miles yesterday against head winds so strong that cars were running out of gas trying to buck them. I called Laura and Ethan to wish them Merry Christmas. Laura again wanted to know why I couldn't be with them on Christmas Day. I explained that this kind of thing happened in a lot of families. "Ohhh. And then the daddies have to go off on bicycles," she said. The child's view. Families drift apart—daddies pedal into the sunset, and mommies buy an old stone cottage and a horse.

Thursday, December 26
Eneabba, Western Australia

For the past thousand miles I've been blasted by winds that feel like a hair dryer set on scorch. I've ridden the last 50 of them with one eye closed and raw, pushing toward Eneabba, a sand-mining town where I hoped that, despite this being Boxing Day, there'd be a district nurse on duty so I could get the grit out of my eye. The nurse's office was on a backstreet. Her name was Enid.

"You don't have any grit in your eye," she told me. "You've got raging conjunctivitis. And it's starting in the other eye as well. It's the flies and dust that's doing it." Enid peeled back the eyelid and squirted in some antibiotic ointment. I felt my eye glue shut. She gave me the tube. "Put that in your eye twice a day, and when you get to Perth, stay off the bike for a while."

I creaked toward the door, feeling twice my age. "It'll be a pleasure." Back outside the hot winds were blowing, flies hummed in the eddies, and I could see the line of rolling sand hills I'd have to cross to get to Perth.

Riding my bike was the purgatory I endured until I settled under the stars each night. I loved camping, squirreling myself away in the scrub, far from the road, and imagining the Europeans who ventured into the outback in the early 1800s. They lashed their horses to logs, while I lean my bike against a spinifex bush, but not much else has changed. I wonder if I have.

Wednesday, January 1, 1997
Perth, Western Australia

I woke this morning with a start; then I heard the sound of traffic on William Street and almost cried with relief at not having to face another day of those hideous winds. When I glanced at my face in the mirror, I saw the leathery, windburned features of a stranger. These past few weeks in the desert have been the toughest in my life. I've discovered reserves of mental and physical strength I never dreamed I had.

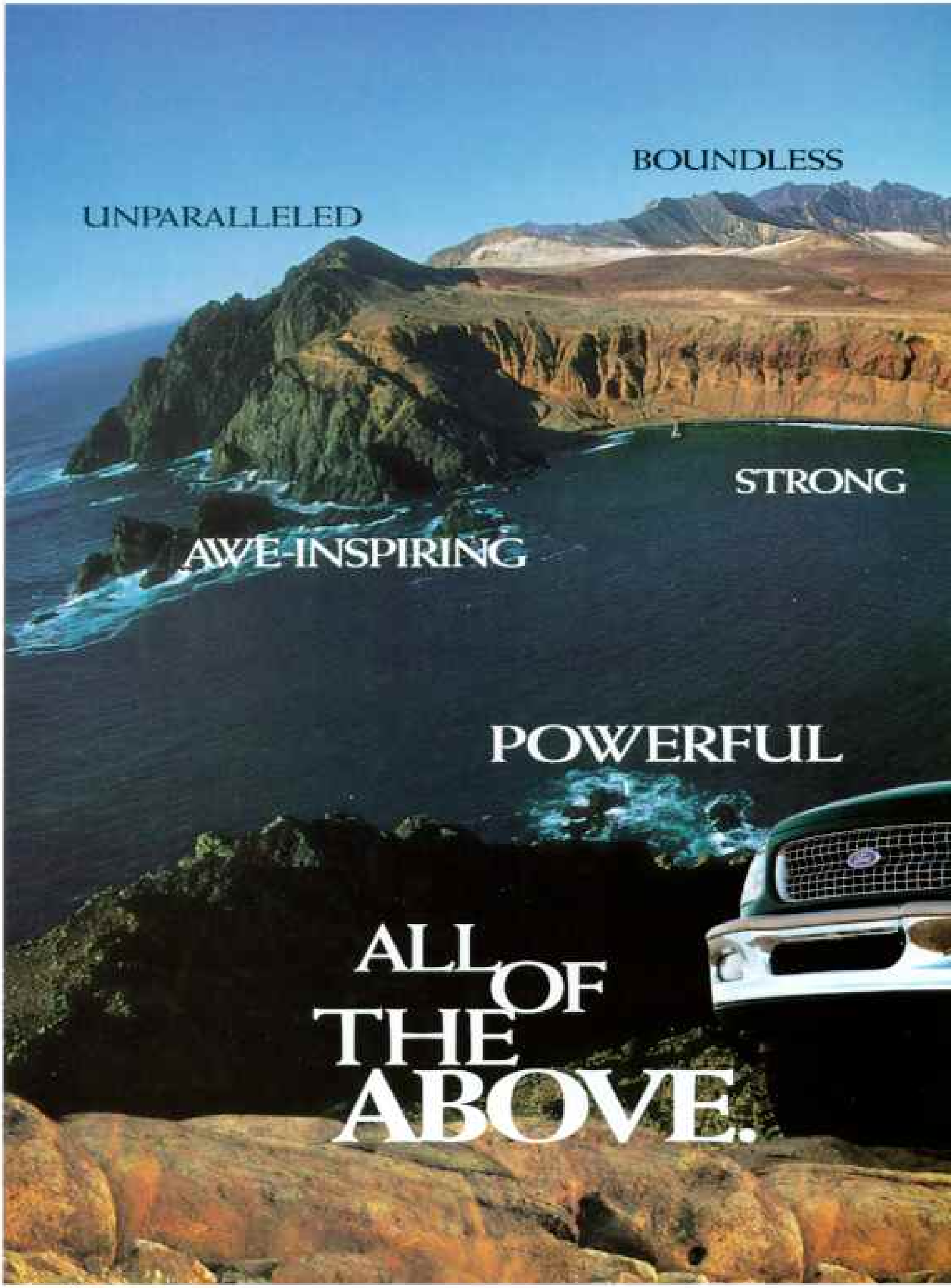
After a few easy days in the city, I'm doing better. Two things. (Three things if you count my visits to the all-you-can-eat salad bar—my first fresh greens in months.) One: Ian came in with his brace of cameras, a bottle of duty-free Scotch, and some novels for me to read. The second was someone I met at breakfast the other day. Her name is Cheryl.

Would she care for a cup of coffee? "No, thank you," she smiled, "I prefer tea. I am English, you know." A few months ago she'd left her London job as a business analyst, sold her treasured MG, slung a knapsack over her shoulder, and set out to see the world—Indonesia, Australia, the South Seas, Alaska.

We swapped adventures, falling into the easy chatter of old friends, more like catching up than just making acquaintance. We've met for tea and poppy-seed cakes a couple of times, and it looks as if our paths might cross again in Tasmania. It's just under 3,000 miles to Hobart; there must be someplace along the way I can pick up a packet of English breakfast tea. □

COMING IN APRIL

On a back road south of Perth, I crash and spend four weeks convalescing. Battered and tired, I still have the Nullarbor Plain ahead of me.



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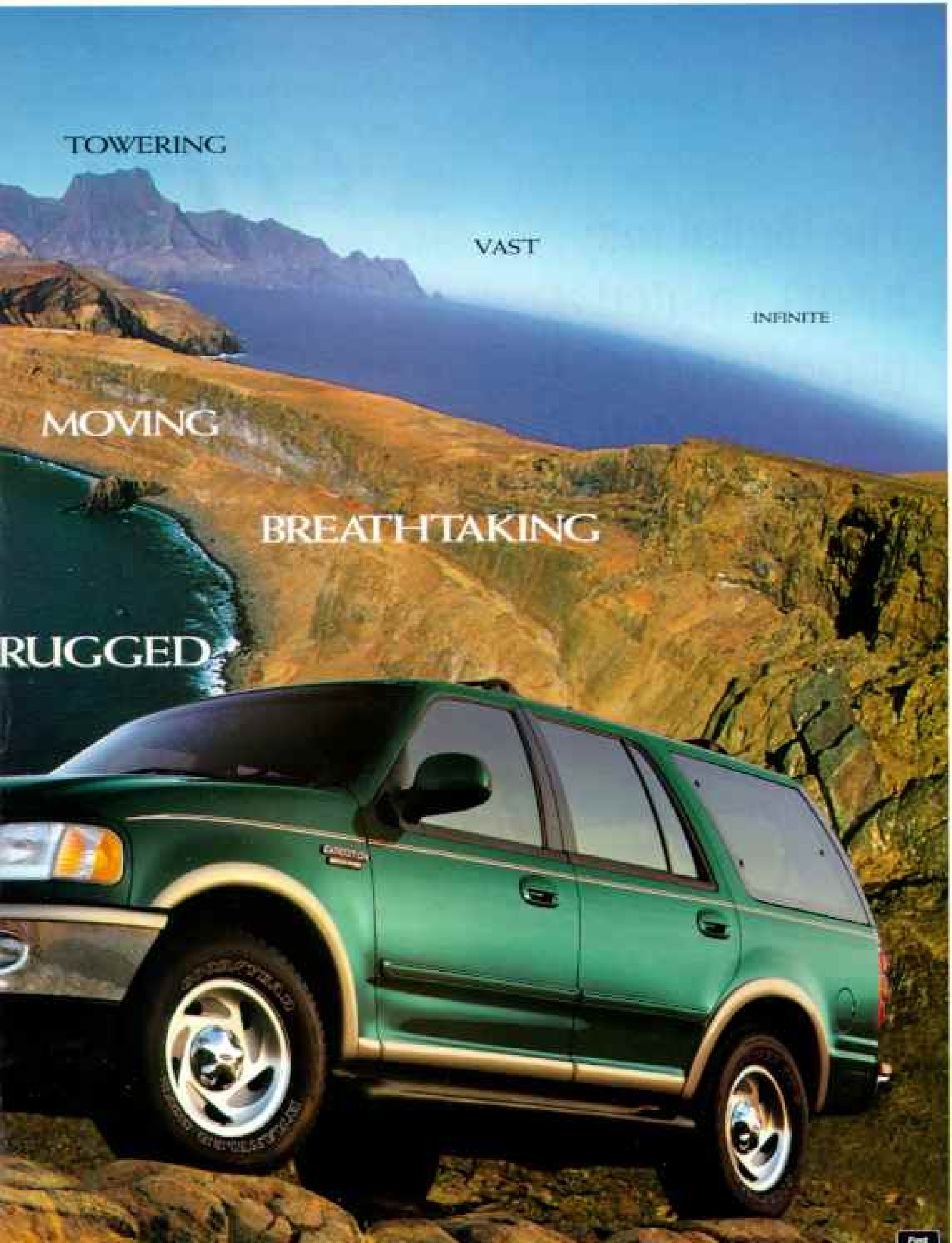

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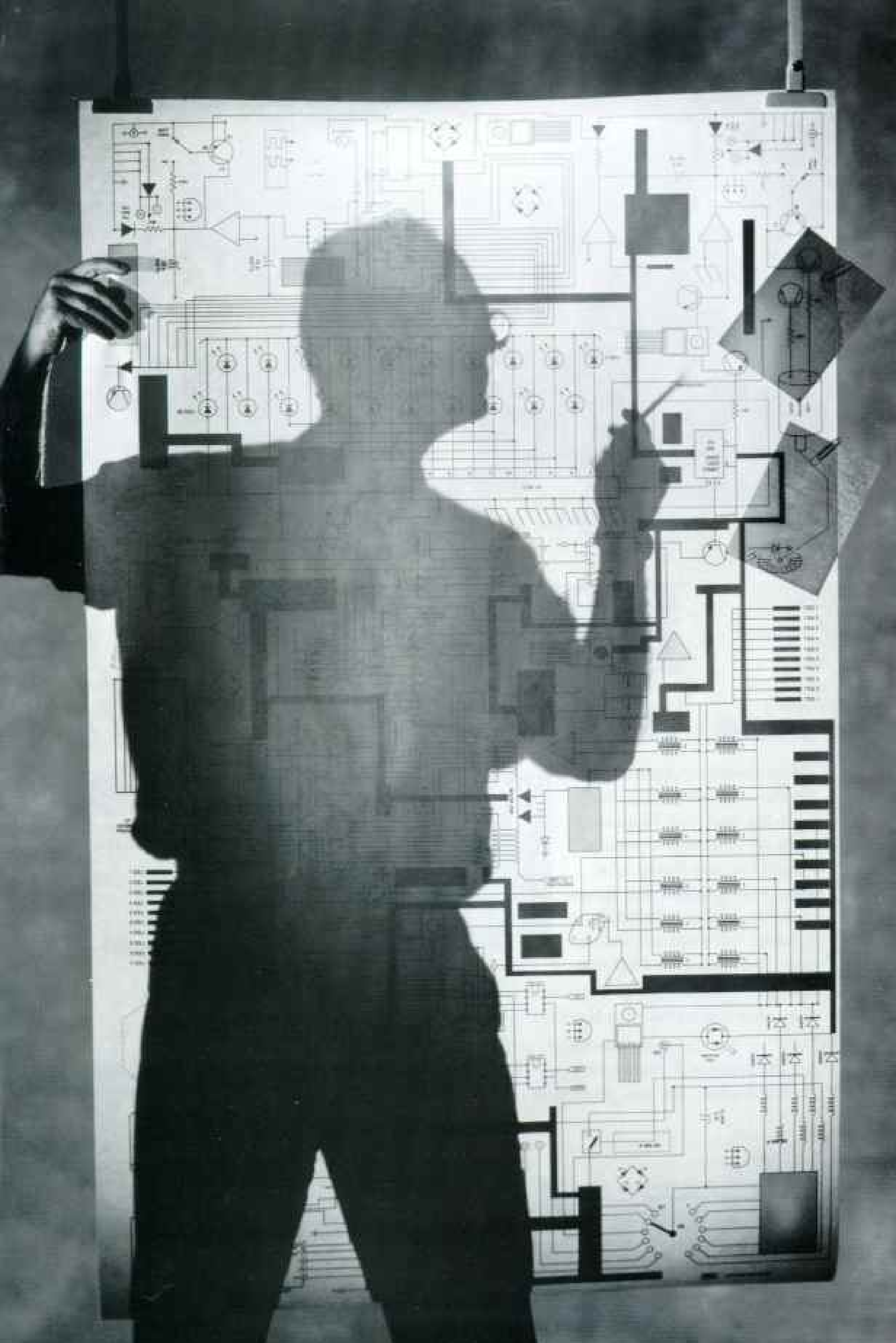

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NATIONAL GEOGRAPHIC

FEBRUARY 1998

The Millennium Series/Exploration

Departments

The Cover

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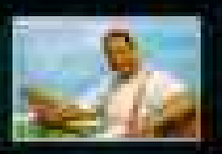

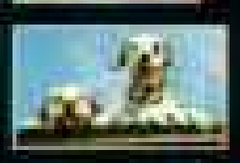

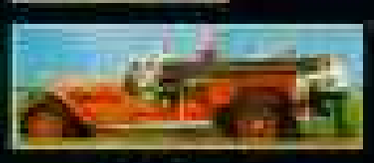

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NATIONAL GEOGRAPHIC'S

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Our Explorations Begin

When ten men—and two dogs—set out for Alaska territory in June 1890, they were also on their way to a place in history. Theirs was the first of more than 6,000 expeditions and research projects sponsored by the National Geographic Society over the past century. Geologist Israel C. Russell led the group on a three-month scientific mission to map and study the glaciers of Mount St. Elias on the Alaska-Canada border. They also brought back news of a peak they named Mount Logan, which at 19,551 feet would prove to be the highest in Canada.

Russell's first-person report on the trip's accomplishments, remarkable for its detail and humor, appeared in our May 1891 issue. "Some of the party found relief from the glare of the snow by blacking their faces with grease and burnt cork," he wrote, "but one experiment with that method is usually enough."

His account of the expedition rang with practical advice. Russell recommended useful camping supplies and warned of problems encountered as though speaking to fellow explorers who might soon follow in his footsteps. Hundreds of explorers have indeed followed and reported in these pages ever since. This month's Millennium Moments features some of the most memorable.

ROBERT E. PEARY, ROBERT E. PEARY COLLECTION

TO THE NORTH POLE
"Mine at last," wrote Robert E. Peary of the North Pole in April 1909. Though doubts dogged his first-there claim, a 1989 Society-funded study found that Peary, Matthew A. Henson, and an Eskimo crew probably got as close as navigational gear then allowed—within five miles of the Pole.

RAY V. GARIS

DOWN INTO CARLSBAD CAVERNS
Giving an overview of the underground, geologist Willis T. Lee reported on the first major scientific study of New Mexico's Carlsbad Caverns in our January 1924 issue.

UP INTO THE STRATOSPHERE
In 1934 U.S. Army officers Albert W. Stevens and William E. Kepner escaped from *Explorer I* when its gasbag ripped and its gondola plummeted into a Nebraska cornfield. Third crew member Orvil A. Anderson had already parachuted to safety. The next year Stevens and Anderson set an altitude record of 13.71 miles in *Explorer II*.

PAINTING BY TOM LOVELL

HIRAM BINGHAM

THE LOST CITY OF THE INCAS
In 1911 Yale professor Hiram Bingham walked into the ancient Inca city at Machu Picchu, "perched on a mountain top in the most inaccessible corner of the most inaccessible section of the Urubamba River," he wrote, with some hyperbole. Over the next four years, with the help of a Society research grant, Bingham's crews cleared centuries of growth from the site, then mapped and photographed the ruins. Our entire April 1913 issue was devoted to the story and to Bingham's further travels in the Peruvian Andes.

AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK CITY

DISCOVERING DINOSAUR NESTS
"It was evident that we had discovered one of the richest and most important fossil fields in all the world," wrote Roy Chapman Andrews (above, at right) in our June 1933 issue. His finds in the Gobi desert included the first known nest of fossilized dinosaur eggs. Another first: Andrews rejected the region's usual pack camels for his five expeditions between 1922 and 1930, using instead a caravan of cars to cross the desolate Mongolian outback.

EXPLORING CHINA AND BEYOND
Leader of two Society expeditions to the unmapped Tibetan borderlands, writer-photographer Joseph F. Rock was "Our Man in China." In the July 1931 issue he described his travels through the mountains of southwest China. There he camped unfazed by visits from local bandits, having made fast friends with the region's king. A self-taught botanist, Rock was also a linguist; his dictionary of Naxi, an ethnic minority language, was published posthumously in 1963.

JOSEPH F. ROCK

Exploration Milestones

■ **1000-1100**
Sailing from Greenland about the year 1000, Norseman Leif Eriksson makes the first European landing on mainland North America.

■ **1100-1200**
Arab geographer Al-Idrisi uses observations from his travels to create a world map for King Roger II of Sicily in 1154. Extremely popular, it was copied as late as 1620.

Spanish Muslim poet Ibn Jubayr writes a travel journal of his 1183-85 pilgrimage to the holy city of Mecca.

■ **1200-1300**
Marco Polo returns to Venice in 1295 after 24 years in Asia and dictates his memoirs.

■ **1300-1400**
Muslim scholar Ibn Battuta in 1325 begins a journey of 75,000 miles through Asia, Africa, and Europe, recording his adventures in a detailed account.

■ **1400-1500**
Prince Henry of Portugal finances the first of many trade voyages along the west coast of Africa in 1418.

From 1432-33, on the last of seven voyages, Admiral Cheng Ho sails a flotilla of more than 300 vessels with 27,500 men to Sumatra, India, and Africa to advertise Chinese wealth.

Seeking the East Indies, Christopher Columbus makes landfall in the Bahamas in 1492.

In 1497 John Cabot becomes the first European since Leif Eriksson to land on the North America mainland. His reports of abundant cod launch European fishing on the Grand Banks.

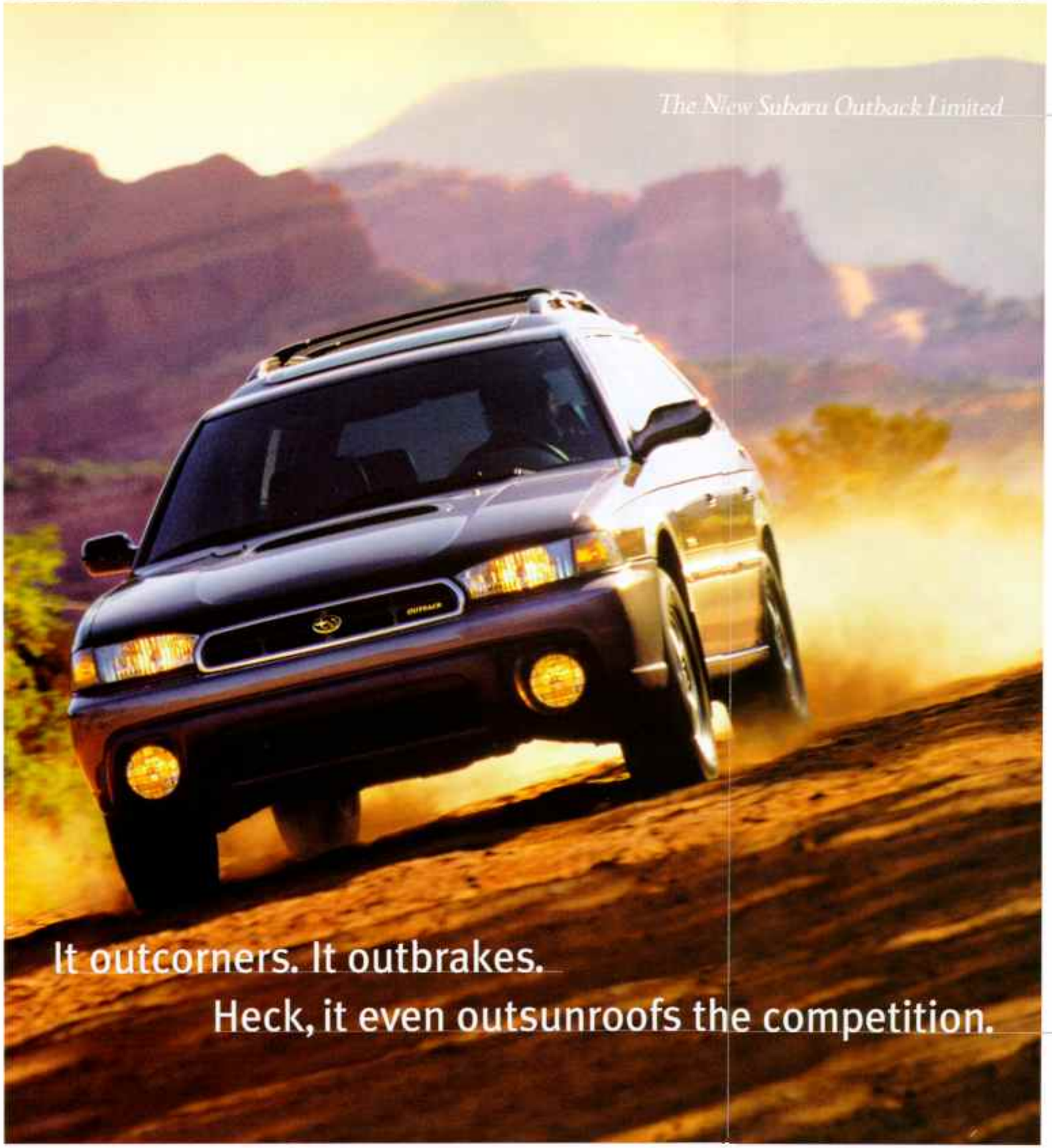
■ **1500-1600**
Portugal's Pedro Álvares Cabral lands on the Brazilian coast in 1500.

In search of gold, Juan Ponce de León makes the first Spanish landing on mainland North America, in Florida in 1513.

Ferdinand Magellan's Spanish expedition completes the first circumnavigation of the globe in 1522.

Spanish conquistador Hernando de Soto in 1541 becomes the first European to see the Mississippi River.

1993 Chevy Blazer turning stability data based on GMAC certified dry barrel accelerometer test. 1997 Ford Explorer braking comparison based on GMAC certified dry stopping 60-0 braking. Grand Cherokee fuel economy comparison based on 1997 EPA estimates of city/highway. ® & © Subaru and ®, © Jeep Grand Cherokee. The ABC's of Safety. Air bags. Buckle up. Children in back.



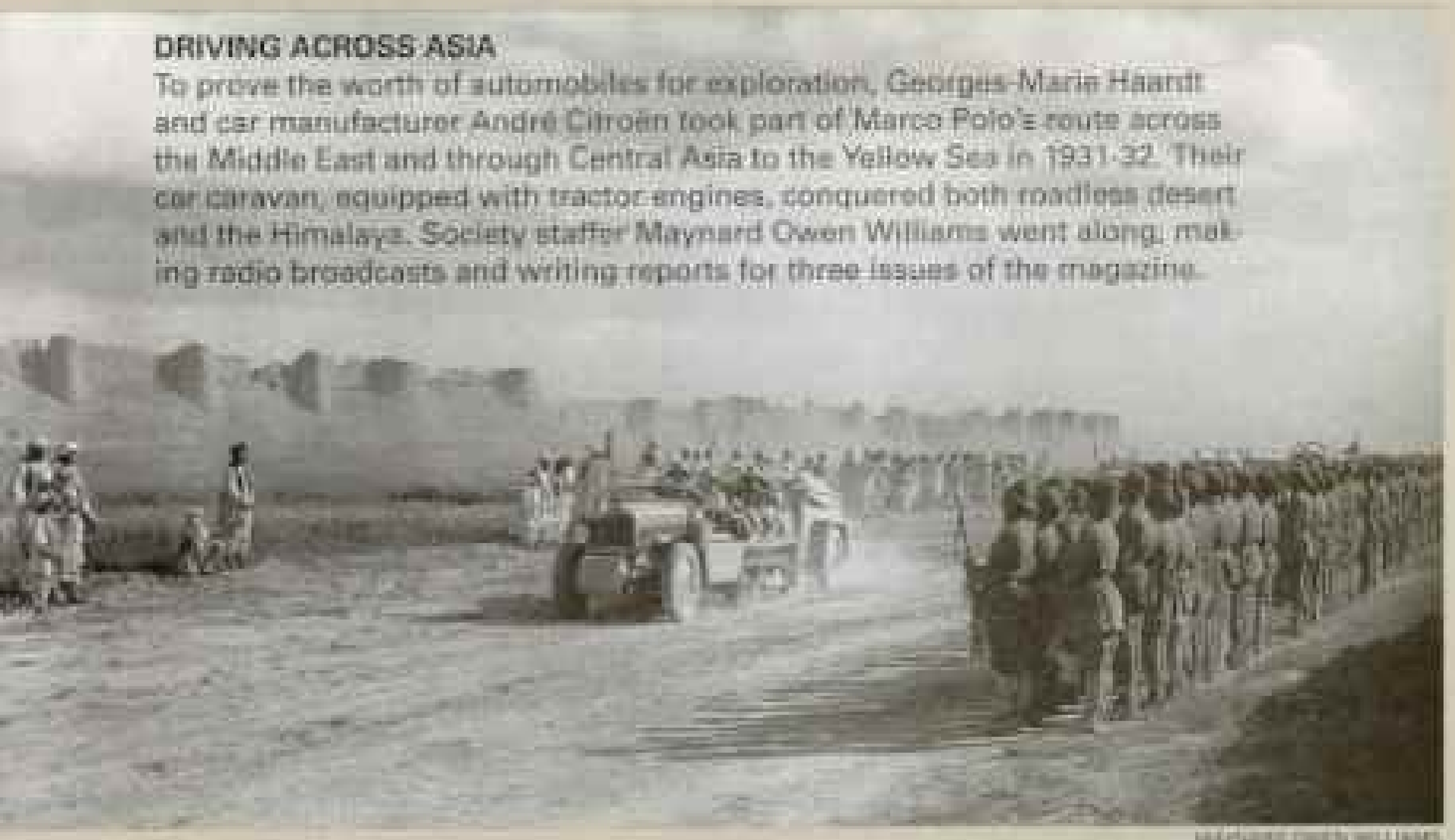
First, it whipped the Blazer in a test of turning stability. Then it topped the Explorer in a test of braking. Soon thereafter, it beat the Cherokee with its superior fuel economy. Now, the Subaru Outback* outshines these competitors in yet another arena: luxury.

Our new Outback Limited offers all the creature comforts of your finer sport-utilities, like soft leather seating, woodgrain patterned trim and alloy wheels. It also offers something these competitors don't: the added luxury of two sunroofs. To test-drive this outstanding All-Wheel Drive vehicle, stop by your nearest Subaru dealer, call 1-800-WANT-AWD or visit our website at www.subaru.com

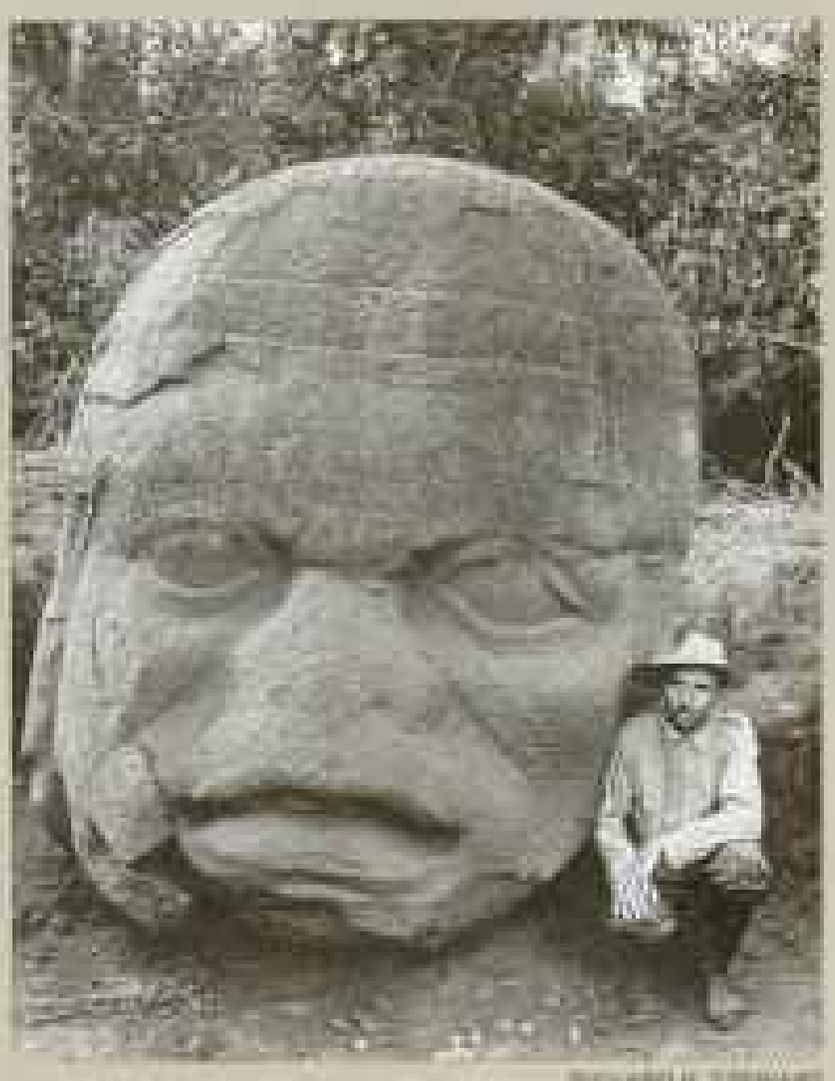
SUBARU

The Beauty of All-Wheel Drive.®

DRIVING ACROSS ASIA
To prove the worth of automobiles for exploration, Georges-Marie Haardt and car manufacturer André Citroën took part of Marco Polo's route across the Middle East and through Central Asia to the Yellow Sea in 1931-32. Their car caravan, equipped with tractor engines, conquered both roadless desert and the Himalaya. Society staffer Maynard Owen Williams went along, making radio broadcasts and writing reports for three issues of the magazine.



MAYNARD OWEN WILLIAMS



RICHARD H. STEWART

DESCENDING TO THE DEEP
William Beebe and Otis Barton set a record depth of 3,028 feet off Bermuda in August 1934 in their bathysphere, entering a realm so dark "it seemed as if all future nights in the upper world must be considered . . . twilight," wrote Beebe in our December 1934 issue.

UNCOVERING 20-TON OLMEC HEADS
Between 1938 and 1946 archaeologist Matthew W. Stirling led eight expeditions to southern Mexico to study Olmec and Maya sites. In 1940 near Veracruz, he and his wife, Marion, excavated La Venta, a thousand-year-old Olmec ruin memorable for its massive and mysterious carved basalt heads.

MELVILLE B. GROSVENOR

SEEKING OUR ANCESTORS
In Tanzania's Olduvai Gorge in 1959 Louis S. B. Leakey and his wife, Mary, found fossil evidence of hominids living 1.75 million years ago, including a new species called *Homo habilis*, thought to be the first toolmakers.

■ **1660-1700**
In Virginia, John Smith founds North America's first permanent English colony in 1607.

English navigator William Baffin discovers an entrance to the long-sought Northwest Passage in Lancaster Sound in 1616.

Charles II of England grants a charter to the Hudson's Bay Company in 1670, opening up the exploration of Canada.

English explorer Henry Kelsey travels the Canadian prairies in 1690-92.

■ **1700-1800**
Vitus Bering, a Dane in the Royal Russian Navy, finds in 1728 that a strait separates Asia and North America and locates the Aleutian Islands in 1741.

Exploring Yemen for Denmark in 1761-63, German Carsten Niebuhr makes the first detailed map of the southwestern Arabian Peninsula.

Between 1768 and 1779 James Cook makes three voyages to the Pacific, charting vast areas and improving the science of navigation and discovery.

Scottish explorer Alexander Mackenzie makes a coast-to-coast crossing of Canada in 1792-93.

Mungo Park, another Scot, locates the Niger River in 1796.

■ **1800-1900**
German naturalist Alexander von Humboldt in 1800 begins the first scientific study of the Orinoco River.

Meriwether Lewis and William Clark set out in 1804 to explore America's new Louisiana Purchase and the territory beyond to the Pacific.

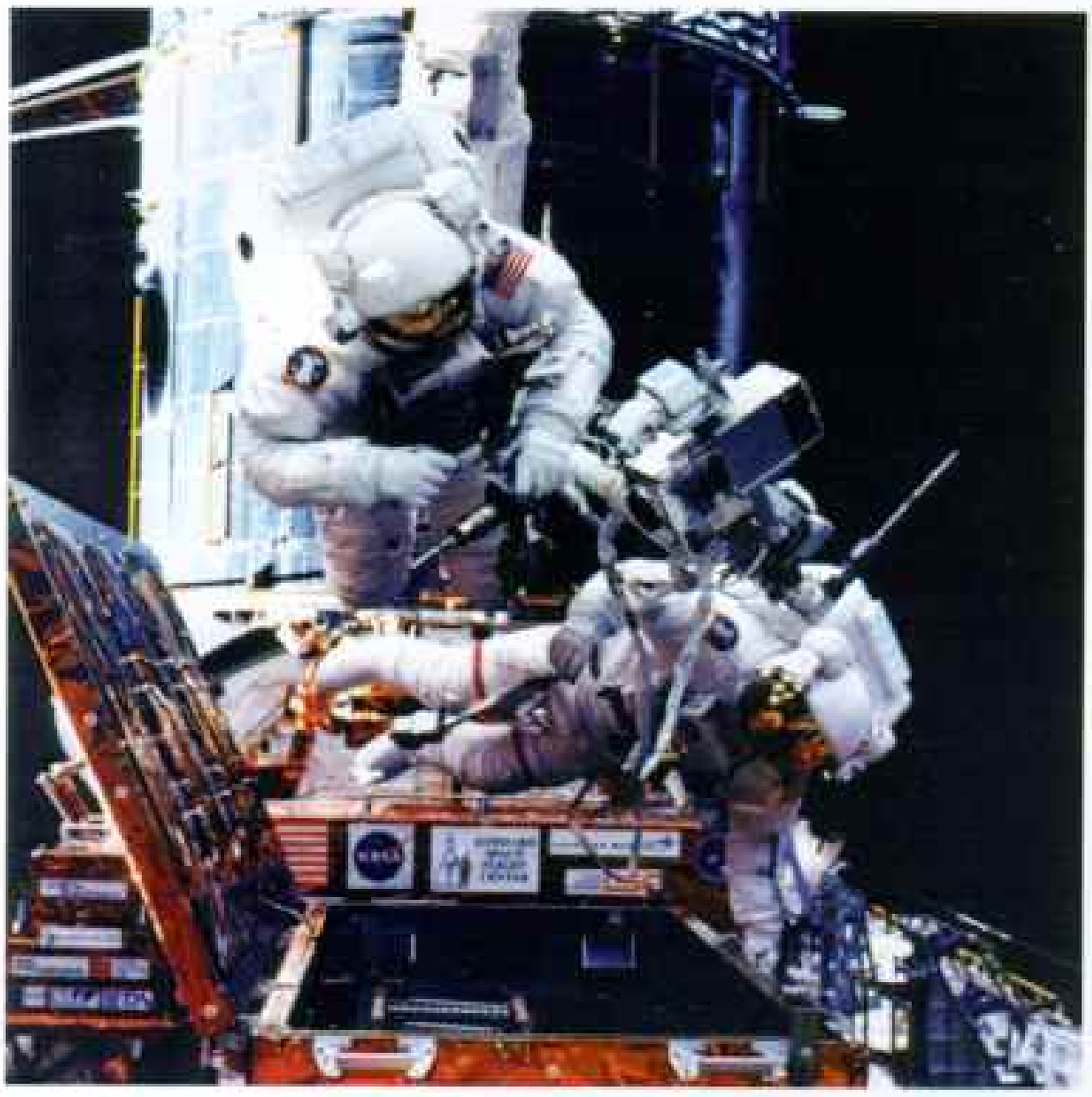
In the search for the great "southern continent," Russian Admiral Fabian von Bellingshausen circumnavigates Antarctica in 1819-21.

German scholar Heinrich Barth surveys much of West Africa in 1850-55.

Scottish missionary David Livingstone spends much of his life exploring the African interior; in 1855 he becomes the first European to see Victoria Falls.

Formation of the Alpine Club in London in 1857 to promote mountain exploration is soon followed by ascents of the Matterhorn in the Alps, Chimborazo in the Andes, and Mount Kenya in East Africa.

Inner Space to Outer



Outer space. Ocean depths. Frozen polar expanses. Reaching our universe's uncharted realms relies heavily on the unique qualities of plastics.

Astronauts could not be astronauts without the high technology products that plastics make possible. Today's space suit is actually a layering of suits within suits all performing separate vital functions — a uniform, office, bathroom, spacecraft and air conditioner. NASA and its suppliers developed this incredible plastic and man-made fiber clothing to protect astronauts from deadly temperature ranges that can vary from -250° F to +350° F. All of these suits are contained within a plastic Thermal Micro Meteoroid Garment (TMG) that retains heat and helps protect astronauts from space debris.

Top it all off with a tri-layer helmet made of space-age plastic materials, slip on multi-layered polymer-based gloves, and one long-distance traveler has been equipped for the rigors of space.

Our world's oceans remain a constant source of intrigue for pleasure seekers and those dedicated to unlocking its mysteries and

APC is proud to participate in the National Geographic Millennium Partnership

Space and Beyond

exploring its uncharted depths. Plastics and polymer-based fibers have made possible new equipment and design features that take both amateurs and professionals closer to these goals.

The marriage of aircraft design techniques with plastics' versatility may have led to the next generation of submersible vehicles. Hawkes Ocean Technologies has designed Deep Flight I, a 13-foot-long research submersible, with an 8-foot wingspan that promises important advances compared to other contemporary submersibles. Owing in part to the use of highly engineered plastics in its pressure hull and wing design and a thick acrylic observation dome, Deep Flight I greatly reduces the time to depth and resurfacing. This submersible can carry its lone pilot to depths of 1,000 meters five to ten times faster than conventional submersibles, reducing exploration costs by as much as 50 percent. This significant design achievement may help oceanographers, marine biologists and archaeologists both discover and better explain many of the ocean's mysteries.

Explorers are reaching into uncharted realms with the help of a material we call plastics. The knowledge they bring back helps us all.

TAKING TO THE SKIES
Flying a figure eight around two pylons half a mile apart, clearing a ten-foot-high obstacle at start and finish, Bryan Allen in 1977 piloted *Gossamer Condor*, the first human-powered plane to pass this test. The flight team, led by designer Paul MacCready, won the $87,000 Kremer prize for the feat. In 1979 they won again when their *Gossamer Albatross* crossed the English Channel, as we reported in November of that year.

ALBERT MOLDVAY

TO THE OCEAN FLOOR
"A rush of bubbles cascades past my face like blue champagne," wrote oceanographer Sylvia Earle in our May 1980 issue. She descended a hundred feet a minute into the Hawaiian Pacific wearing a special high-tech diving suit called Jim, previously used only on oil rigs and in commercial salvage operations. Earle enjoyed the suit's mobility in its first scientific use, observing the ocean floor from a fish's view 1,250 feet down.

LUTHER G. JERSTAD

ROBERT D. BALLARD AND MARTIN BOWEN © WOODS HOLE OCEANOGRAPHIC INSTITUTION

ASCENDING EVEREST
Seated so that 70-mile-an-hour gusts wouldn't knock him over, staffer Barry C. Bishop posed on top of Mount Everest in 1963 on the first American expedition to summit. He reported on the adventure, and his bout with severe frostbite, in the October 1963 GEOGRAPHIC and later presented this American flag to President John F. Kennedy.

FINDING *TITANIC*
The long-lost wreck of R.M.S. *Titanic* came to light in our December 1985 issue, when oceanographer Robert D. Ballard described his search team's use of deep-sea sonar and video technology to pinpoint the ship's grave 13,000 feet deep in the North Atlantic.

Robert Burke and William Wills in 1860-61 make the first south-to-north crossing of Australia by white men but perish on their return.

In 1872 H.M.S. *Challenger* begins the first large-scale oceanographic study of the world's seas.

English writer Mary Kingsley travels through western and central Africa to study native religions in 1893-95.

■ **1900-2000**
Norwegian Roald Amundsen sails through the Northwest Passage from 1903-06 and in 1911 is first to reach the South Pole.

Americans Robert E. Peary and Matthew A. Henson claim the North Pole in 1909.

In 1910 oceanographers John Murray and Johan Hjort undertake the first deep-sea research expedition of the North Atlantic.

English archaeologist Gertrude Bell makes desert treks through Arabia and other Middle Eastern lands, beginning in 1913.

Americans Richard Byrd and Floyd Bennett fly over the North Pole in 1926; Byrd flies over the South Pole in 1929.

Swiss physicist Auguste Piccard ascends to a record ten miles in his stratospheric balloon in 1931.

New Zealander Edmund Hillary and Sherpa Tenzing Norgay reach the summit of Everest in 1953.

Jacques Piccard and Don Walsh descend 35,800 feet in 1960 in the bathyscaph *Trieste* to reach the floor of Mariana Trench, the ocean's deepest point.

Submarine U.S.S. *Triton* circumnavigates the globe without surfacing in 1960.

Soviet cosmonaut Yuri Gagarin becomes the first human in space in 1961, completing one orbit of Earth. His colleague Valentina Tereshkova is the first woman in space in 1963.

In 1969 Apollo 11 becomes the first manned mission to land on the moon; American Neil Armstrong takes the first steps there.

First Pole-to-Pole circumnavigation of the globe is led by British explorer Ranulph Fiennes, from 1979 to 1982.

NASA's Pathfinder lands on Mars in 1997. The lander and its rover, *Sojourner*, send images of the planet's surface back to Earth.

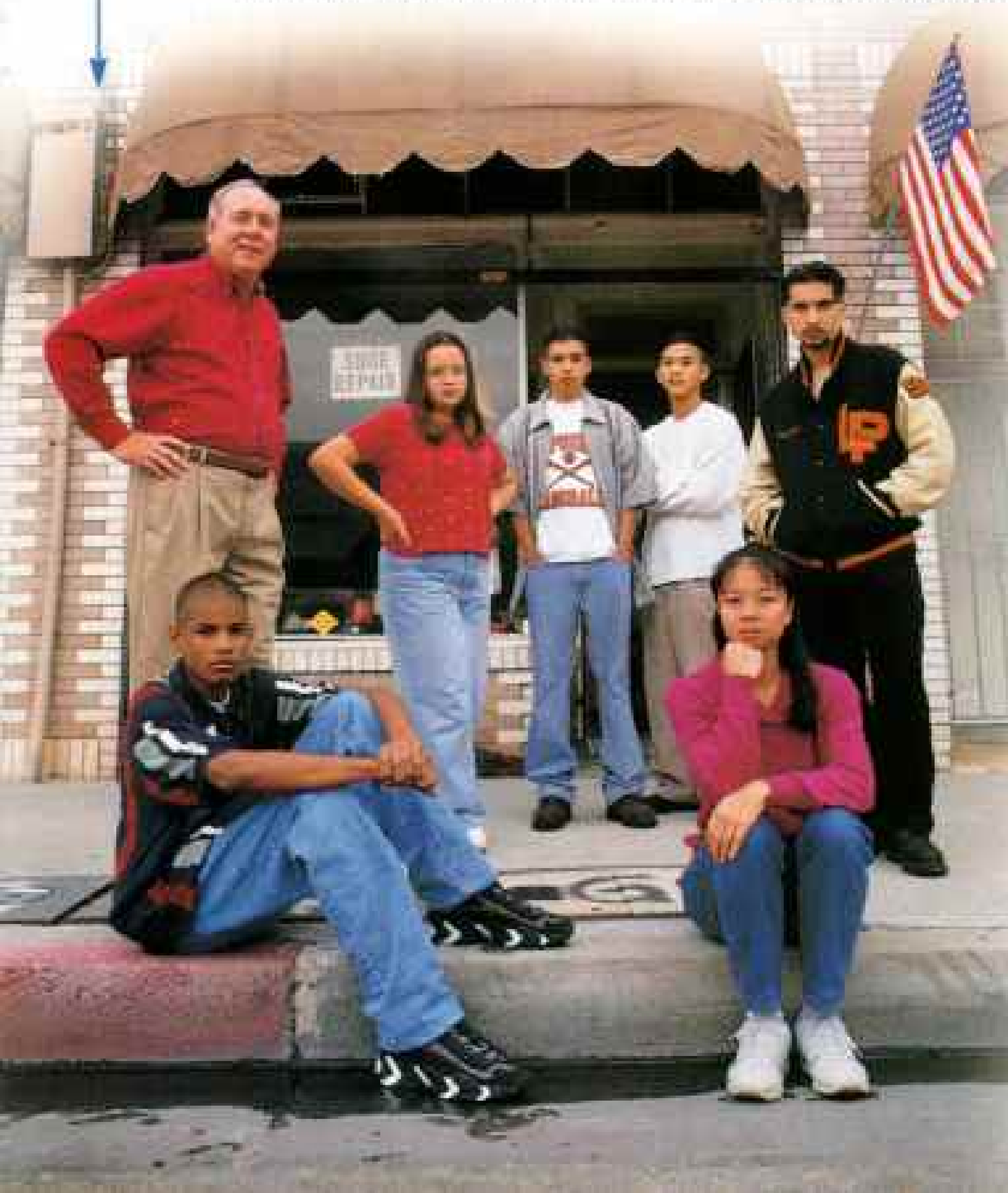
Mr. Slakey's ninth graders told the town of La Puente where to go.

They meant no disrespect. They were merely presenting their class project: a 20-year general plan outlining where La Puente should be heading in the next century.

During the project Mr. Slakey's geography class walked the square-mile downtown area talking to citizens and photographing forms of land use. They also studied maps and urban-planning documents. Their finished plan was presented before a panel of professional city planners, and then entered in a national contest.

This plan not only gave town leaders practical ideas on land and water use, public housing, and traffic flow, it also taught students the value of critical thinking and teamwork.

For teaching his students that the study of geography goes far beyond the boundaries of charts and maps, State Farm is proud to present Stephen Slakey with our Good Neighbor Award and to donate $5,000 to La Puente High School in California. We're sure his students have great plans for it.



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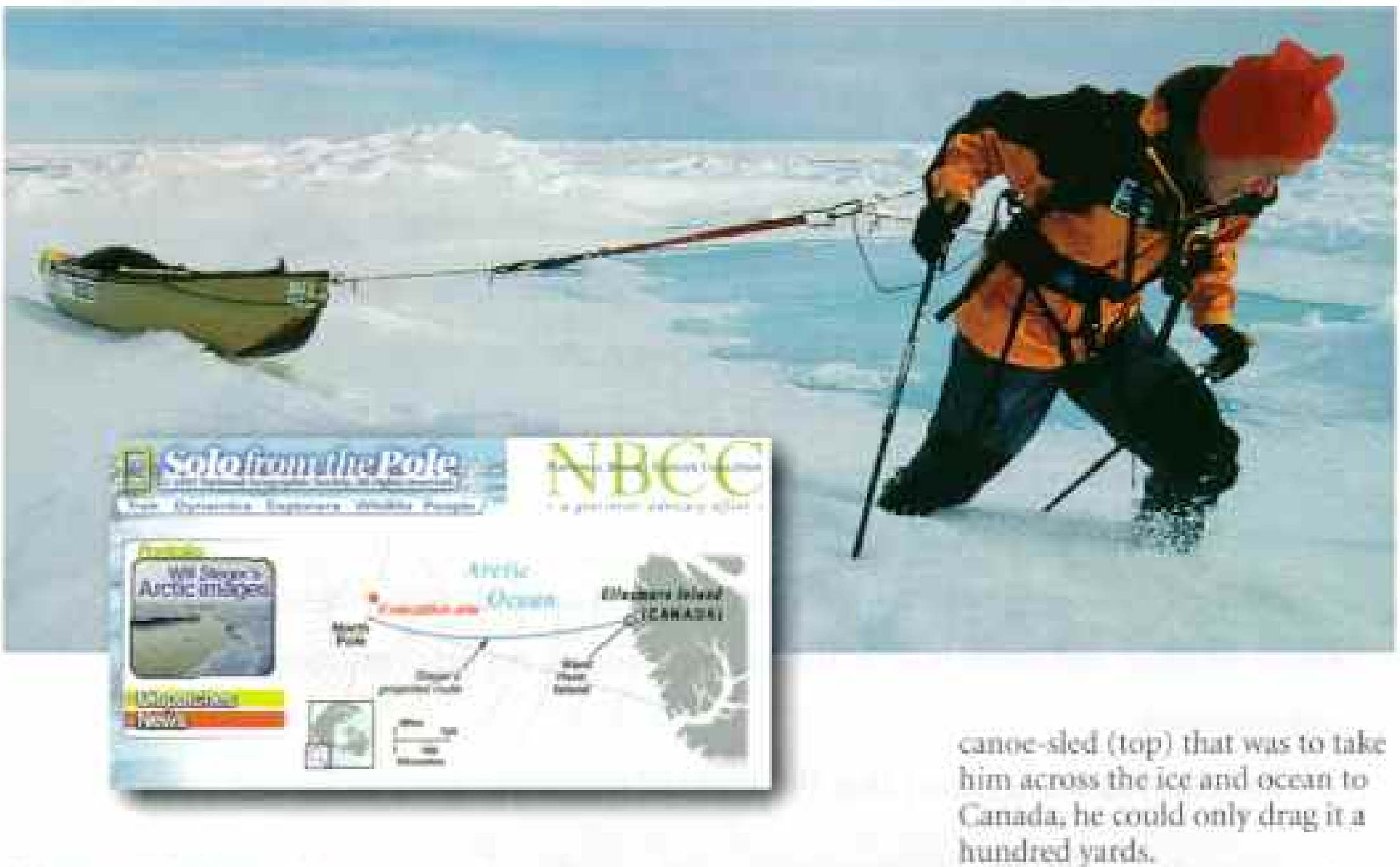
LA PUENTE

NATIONAL GEOGRAPHIC

Behind the Scenes



canoe-sled (top) that was to take him across the ice and ocean to Canada, he could only drag it a hundred yards.

Will made his decision without a lot of soul-searching: "Solo from the Pole" was over.

"I could easily get myself into a situation requiring a very difficult rescue that would endanger others," he wrote back in one of his daily e-mail dispatches to our website (inset, above left). Will finally was retrieved on July 24 by a Russian helicopter, after 12 days alone on the ice. His return, on the same icebreaker that had caused him such misery at the start, took another week.

"If you take a risk and don't make it," says Will, "at least you tried. The important thing in setting goals is the process of doing." Still, he won't attempt another "Solo from the Pole." Will says the whole point of the expedition was to raise awareness about the Arctic and the environment. In that sense, it was a success.

Giving Up but Not Giving In

"It was too risky to continue," explains Will Steger of his decision to end early his "Solo from the Pole" trek—planned as an unprecedented 50-day, 500-mile journey from the North Pole across the Arctic Ocean to Canada.

Will had worked for more than two years to prepare for the trip and was in top physical condition when he left his home base in Minnesota last July. But even a 20-year veteran of polar exploration can't prepare for some things. The seven-day voyage on a Russian icebreaker to his North Pole starting point, where these photographs were taken, was more difficult than Will had ever imagined. The incessant banging of the ship through the thick ice kept him from any restful sleep. When the ship dropped him off on the ice, alone, the troubles continued.

Already exhausted, Will soon felt congestion creeping into his lungs. The Arctic's summer dampness increased his distress.

PER BREINHAGEN (BOTH)

He rested five days in his camp, disheartened by illness, dense fog, and problems using his satellite communications equipment (above). When he finally attempted to pull the gear-laden

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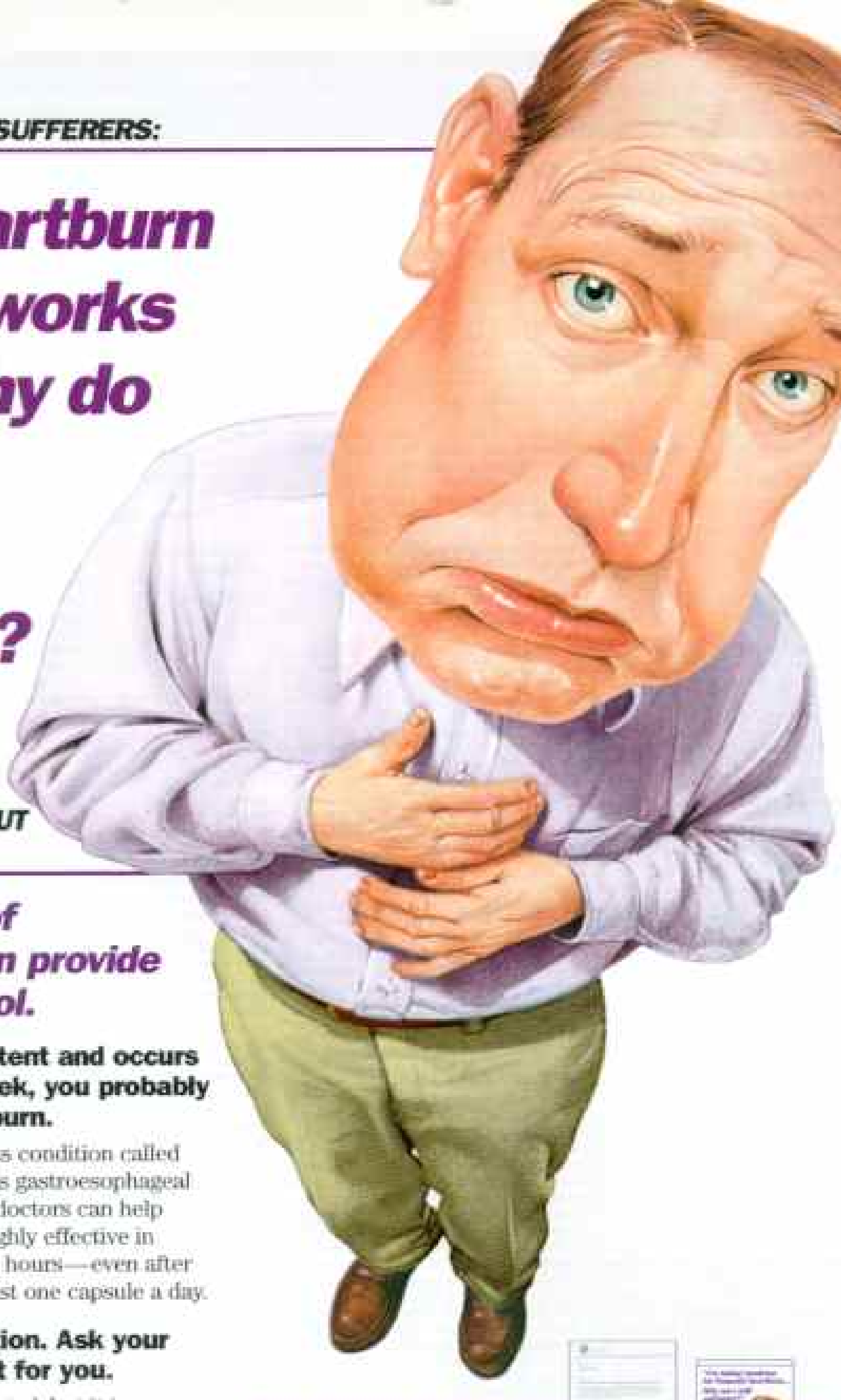

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Just one capsule of PRILOSEC daily can provide 24-hour acid control.

If your heartburn is persistent and occurs on two or more days a week, you probably don't have ordinary heartburn.

You may have a potentially serious condition called acid reflux disease (also known as gastroesophageal reflux disease, or GERD). Today doctors can help by prescribing PRILOSEC. It is highly effective in controlling acid production for 24 hours—even after meals, and all night, too—with just one capsule a day.

Available only by prescription. Ask your doctor if PRILOSEC is right for you.

PRILOSEC is generally well tolerated, but it is not for everybody. The most common side effects are headache (6.9%), diarrhea (3.0%), and abdominal pain (2.4%).

Please read important information on the adjacent page and discuss it with your doctor.

www.acidcontrol.com

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You will receive FREE: a brochure about frequent heartburn, acid reflux disease, and PRILOSEC; plus, a personal heartburn diary, and a symptom questionnaire to help your doctor help you.

JUST ONE CAPSULE DAILY FOR 24-HOUR ACID CONTROL

PRILOSEC® *(OMEPRAZOLE) 20 MG ONCE DAILY*

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Please read this summary carefully, and then ask your doctor about PRILOSEC. No advertisement can provide all the information needed to prescribe a drug. This advertisement does not take the place of careful discussions with your doctor. *Only your doctor* has the training to weigh the risks and benefits of a prescription drug for you.

PRILOSEC®* *(OMEPRAZOLE)*

Delayed-Release Capsules

BRIEF SUMMARY

CLINICAL PHARMACOLOGY Pharmacokinetics and Metabolism: Omeprazole – In pharmacokinetic studies of single 20 mg omeprazole doses, an increase in AUC of approximately four-fold was noted in Asian subjects compared to Caucasians. Dose adjustment, particularly where maintenance of healing of erosive esophagitis is indicated, for the hepatically impaired and Asian subjects should be considered.

INDICATIONS AND USAGE Duodenal Ulcer: PRILOSEC is indicated for short-term treatment of active duodenal ulcer. Most patients heal within 4 weeks. Some patients may require an additional 4 weeks of therapy. PRILOSEC, in combination with clarithromycin, is also indicated for treatment of patients with H. pylori infection and active duodenal ulcer to eradicate H. pylori. Eradication of H. pylori has been shown to reduce the risk of duodenal ulcer recurrence. In patients who fail therapy, susceptibility testing should be done. If resistance to clarithromycin is demonstrated or susceptibility testing is not possible, alternative antimicrobial therapy should be instituted. (See the clarithromycin package insert, MICROBIOLOGY section.) **Gastric Ulcer:** PRILOSEC is indicated for short-term treatment (4-8 weeks) of active benign gastric ulcer. ***Treatment of Gastroesophageal Reflux Disease (GERD): Symptomatic GERD*** – PRILOSEC is indicated for the treatment of heartburn and other symptoms associated with GERD. **Erosive Esophagitis** – PRILOSEC is indicated for the short-term treatment (4-8 weeks) of erosive esophagitis which has been diagnosed by endoscopy. The efficacy of PRILOSEC used for longer than 8 weeks in these patients has not been established. In the rare instance of a patient not responding to 8 weeks of treatment, it may be helpful to give up to an additional 4 weeks of treatment. If there is recurrence of erosive esophagitis or GERD symptoms (e.g. heartburn), additional 4-8 week courses of omeprazole may be considered. ***Maintenance of Healing of Erosive Esophagitis:*** PRILOSEC is indicated to maintain healing of erosive esophagitis. Controlled studies do not extend beyond 12 months. **Pathological Hypersecretory Conditions:** PRILOSEC is indicated for the long-term treatment of pathological hypersecretory conditions (e.g., Zollinger-Ellison syndrome, multiple endocrine adenomas and systemic mastocytosis).

CONTRAINDICATIONS Omeprazole: PRILOSEC Delayed-Release Capsules are contraindicated in patients with known hypersensitivity to any component of the formulation. **Clarithromycin:** Clarithromycin is contraindicated in patients with a known hypersensitivity to any macrolide antibiotic. Concomitant administration of clarithromycin with cisapride, pimozide, or terfenadine is contraindicated. There have been post-marketing reports of drug interactions when clarithromycin and/or erythromycin are co-administered with cisapride, pimozide, or terfenadine resulting in cardiac arrhythmias (QT prolongation, ventricular tachycardia, ventricular fibrillation, and torsades de pointes) most likely due to inhibition of hepatic metabolism of these drugs by erythromycin and clarithromycin. Fatalities have been reported. [Please refer to full prescribing information for clarithromycin before prescribing.]

WARNING: Clarithromycin: CLARITHROMYCIN SHOULD NOT BE USED IN PREGNANT WOMEN EXCEPT IN CLINICAL CIRCUMSTANCES WHERE NO ALTERNATIVE THERAPY IS APPROPRIATE. IF PREGNANCY OCCURS WHILE TAKING CLARITHROMYCIN, THE PATIENT SHOULD BE APPRISED OF THE POTENTIAL HAZARD TO THE FETUS. [See WARNINGS in prescribing information for clarithromycin.]

PRECAUTIONS General: Symptomatic response to therapy with omeprazole does not preclude the presence of gastric malignancy. Atrophic gastritis has been noted occasionally in gastric corpus biopsies from patients treated long-term with omeprazole. **Information for Patients:** PRILOSEC Delayed-Release Capsules should be taken before eating. Patients should be cautioned that the PRILOSEC Delayed-Release Capsule should not be opened, chewed or crushed, and should be swallowed whole. **Drug Interactions: Other** – Omeprazole can prolong the elimination of diazepam, warfarin and phenytoin, drugs that are metabolized by oxidation in the liver. Although in normal subjects no interaction with theophylline or propranolol was found, there have been clinical reports of interaction with other drugs metabolized via the cytochrome P-450 system (e.g., cyclosporine, disulfiram, benzodiazepines). Patients should be monitored to determine if it is necessary to adjust the dosage of these drugs when taken concomitantly with PRILOSEC. Because of its profound and long-lasting inhibition of gastric acid secretion, it is theoretically possible that omeprazole may interfere with absorption of drugs where gastric pH is an important determinant of their bioavailability (e.g., ketoconazole, ampicillin esters, and iron salts). In the clinical trials, antacids were used concomitantly with the administration of PRILOSEC. **Combination Therapy with Clarithromycin** – Co-administration of omeprazole and clarithromycin may result in increases in plasma levels of omeprazole, clarithromycin, and 14-hydroxy clarithromycin. [See CLINICAL PHARMACOLOGY, *Pharmacokinetics: Combination Therapy with Clarithromycin* in full Prescribing Information.] Concomitant administration of clarithromycin with cisapride, pimozide, or terfenadine is contraindicated. There have been reports of an interaction between erythromycin and astemizole resulting in QT prolongation and torsades de pointes. Concomitant administration of erythromycin and astemizole is contraindicated. Because clarithromycin is also metabolized by cytochrome P450, concomitant administration of clarithromycin with astemizole is not recommended. [See also CONTRAINDICATIONS, Clarithromycin, above. Please refer to full prescribing information for clarithromycin before prescribing.] **Carcinogenesis, Mutagenesis, Impairment of Fertility:** In two 24-month carcinogenicity studies in rats, omeprazole at daily doses of 1.7, 3.4, 13.8, 44.0 and 140.8 mg/kg/day (approximately 4 to 332 times the human dose, based on a patient weight of 50 kg and a human dose of 20 mg) produced gastric ECL cell carcinoids in a dose-related manner in both male and female rats; the incidence of this effect was markedly higher in female rats, which had higher blood levels of omeprazole. Gastric carcinoids seldom occur in the untreated rat. In addition, ECL cell hyperplasia was present in all treated groups of both sexes. In one of these studies, female rats were treated with 13.8 mg/kg/day omeprazole (approximately 35 times the human dose) for 1 year, then followed for an additional year without the drug. No carcinoids were seen in these rats. An increased incidence of treatment-related ECL cell hyperplasia was observed at the end of 1 year (94% treated vs. 10% controls). By the second year the difference between treated and control rats was much smaller (85% vs. 39%) but still showed more hyperplasia in the treated group. An unusual primary malignant tumor in the stomach was seen in one rat (2%). No similar tumor was seen in male or female rats treated for 2 years. For this strain of rat no similar tumor has been noted historically, but a finding involving only one tumor is difficult to interpret. A 78-week mouse carcinogenicity study of omeprazole did not show increased tumor occurrence, but the study was not conclusive. Omeprazole was not mutagenic in an *in vitro* Ames Salmonella typhimurium assay, an *in vitro* mouse lymphoma cell assay and an *in vivo* rat liver DNA damage assay. A mouse micronucleus test at 625 and 1250 times the human dose gave a borderline result, as did an *in vivo* bone marrow chromosome aberration test. A second mouse micronucleus study at 2000 times the human dose, but with different suboptimal sampling times, was negative. **Pregnancy: Omeprazole: Pregnancy Category C** – In rabbits, omeprazole in a dose range of 3.4 to 85.1 mg/kg/day (approximately 17 to 172 times the human dose) produced dose-related increases in embryo lethality, fetal resorptions and pregnancy disruptions. In rats, dose-related embryo/fetal toxicity and postnatal developmental toxicity were observed in offspring resulting from parents treated with omeprazole 13.8 to 138.0 mg/kg/day (approximately 35 to 345 times the human dose). There are no adequate or well-controlled studies in pregnant women. Sporadic reports have been received of congenital abnormalities occurring in infants born to women who have received omeprazole during pregnancy. Omeprazole should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus. **Clarithromycin: Pregnancy Category C** – [See WARNING (above) and full prescribing information for clarithromycin before using in pregnant women]. **Nursing Mothers:** It is not known whether omeprazole is excreted in human milk. In rats, omeprazole administration during late gestation and lactation at doses of 13.8 to 138 mg/kg/day (35 to 345 times the human dose) resulted in decreased weight gain in pups. Because many drugs are excreted in human milk, because of the potential for serious adverse reactions in nursing infants from omeprazole, and because of the potential for tumorigenicity shown for omeprazole in rat carcinogenicity studies, a decision should be made whether to discontinue nursing or discontinue the drug, taking into account the importance of the drug to the mother. **Pediatric Use:** Safety and effectiveness in children have not been established.

ADVERSE REACTIONS: In the U.S. clinical trial population of 491 patients (including duodenal ulcer, Zollinger-Ellison syndrome and resistant ulcer patients), the following adverse experiences were reported to occur in 1% or more of patients on therapy with PRILOSEC* (omeprazole). Numbers in parentheses indicate percentages of the adverse experiences considered by investigators as possibly, probably, or definitely related to the drug.

	Omeprazole (n=491)	Placebo (n=64)	Ranitidine (n=100)
Headache	6.9 (2.4)	6.3	7.7 (3.0)
Diarrhea	3.0 (1.3)	3.1 (1.6)	2.1 (0.0)
Abdominal Pain	2.4 (0.4)	3.1	2.1
Nausea	2.2 (0.8)	3.1	4.1 (0.0)
URI	1.9	1.6	2.0
Dizziness	1.5 (0.4)	0.0	2.0 (1.0)
Vomiting	1.5 (0.4)	4.7	1.5 (0.5)
Rash	1.5 (1.1)	0.0	0.0
Constipation	1.1 (0.8)	0.0	0.0
Cough	1.1	0.0	1.0
Asthenia	1.1 (0.2)	1.6 (1.6)	1.5 (1.0)
Back Pain	1.1	0.0	0.5

The following adverse reactions which occurred in 1% or more of omeprazole-treated patients have been reported in international double-blind and open-label clinical trials in which 2,931 patients and subjects received omeprazole.

Incidence of Adverse Experiences ≥ 1% Causal Relationship not Assessed

		Omeprazole (n=2931)	Placebo (n=100)
Body as a Whole, site unspecified	Abdominal pain	5.2	3.3
	Asthenia	1.5	0.0
Digestive System	Constipation	1.5	0.0
	Diarrhea	2.7	2.5
	Flatulence	2.7	0.0
	Nausea	4.0	6.7
	Vomiting	3.2	10.0
	Acid regurgitation	1.9	3.3
Nervous System/Psychiatric	Headache	7.9	7.5

Additional adverse experiences occurring in < 1% of patients or subjects in domestic and/or international trials, or occurring since the drug was marketed, are shown below within each body system. In many instances, the relationship to PRILOSEC was unclear. *Body As a Whole:* Fever, pain, fatigue, malaise, abdominal swelling. *Cardiovascular:* Chest pain or angina, tachycardia, bradycardia, palpitation, elevated blood pressure, peripheral edema. *Gastrointestinal:* Pancreatitis (some fatal), anorexia, irritable colon, fat/anorexia, fecal discoloration, esophageal candidiasis, mucosal atrophy of the tongue, dry mouth. During treatment with omeprazole, gastric fundic gland polyps have been noted rarely. These polyps are benign and appear to be reversible when treatment is discontinued. Gastric carcinoids have been reported in patients with ZE syndrome on long-term treatment with PRILOSEC. This finding is believed to be a manifestation of the underlying condition, which is known to be associated with such tumors. *Hepatic:* Mild and rarely, marked elevations of liver function tests [ALT (SGPT), AST (SGOT), γ-glutamyl transpeptidase, alkaline phosphatase, and bilirubin (jaundice)]. In rare instances, overt liver disease has occurred, including hepatocellular, cholestatic, or mixed hepatitis, liver necrosis (some fatal), hepatic failure (some fatal), and hepatic encephalopathy. *Metabolic/Nutritional:* Hyponatremia, hypoglycemia, weight gain. *Musculoskeletal:* Muscle cramps, myalgia, muscle weakness, joint pain, leg pain. *Nervous System/Psychiatric:* Psychic disturbances including depression, aggression, hallucinations, confusion, insomnia, nervousness, tremors, apathy, somnolence, anxiety, dream abnormalities, amnesia, paresthesia, hemifacial dysesthesia. *Respiratory:* Epistaxis, pharyngeal pain. *Skin:* Rash and, very rarely, cases of severe generalized skin reactions including toxic epidermal necrolysis (TEN, some fatal), Stevens-Johnson syndrome, and erythema multiforme (some severe). *Skin Hypersensitivity:* urticaria, angioedema, pruritus, alopecia, dry skin, hyperhidrosis. *Special Senses:* Tinnitus, taste perversion. *Urogenital:* Interstitial nephritis (some with positive rechallenge), urinary tract infection, microscopic pyuria, urinary frequency, elevated serum creatinine, proteinuria, hematuria, glycosuria, testicular pain, gynecomastia. *Hematologic:* Rare instances of pancytopenia, agranulocytosis (some fatal), thrombocytopenia, leukopenia, anemia, leukocytosis, and hemolytic anemia have been reported. **Combination Therapy with Clarithromycin:** In clinical trials using combination therapy with PRILOSEC and clarithromycin, no adverse experiences peculiar to the drug combination have been observed. Adverse experiences that have occurred have been limited to those that have been previously reported with omeprazole or clarithromycin. Adverse experiences observed in controlled clinical trials using combination therapy with PRILOSEC and clarithromycin (n=346) which differed from those previously described for omeprazole alone were: Taste perversion (15%), tongue discoloration (2%), rhinitis (2%), pharyngitis (1%), and flu syndrome (1%). For more information on clarithromycin, refer to the clarithromycin package insert, ADVERSE REACTIONS section.

OVERDOSAGE: Rare reports have been received of overdosage with omeprazole. Doses ranged from 320 mg to 900 mg (16-45 times the usual recommended clinical dose). Manifestations were variable, but included confusion, drowsiness, blurred vision, tachycardia, nausea, diaphoresis, flushing, headache, and dry mouth. Symptoms were transient, and no serious clinical outcome has been reported. No specific antidote for omeprazole overdosage is known. Omeprazole is extensively protein bound and is, therefore, not readily dialyzable. In the event of overdosage, treatment should be symptomatic and supportive.

DOSAGE AND ADMINISTRATION Duodenal Ulcer: *Short-Term Treatment of Active Duodenal Ulcer:* The recommended adult oral dose of PRILOSEC is 20 mg once daily. Most patients heal within 4 weeks. Some patients may require an additional 4 weeks of therapy. [See INDICATIONS AND USAGE.]

Reduction of the Risk of Duodenal Ulcer Recurrence: Combination Therapy with Clarithromycin

Days 1-14:	Days 15-28:
PRILOSEC 40 mg q.d. (in the morning) plus clarithromycin 500 mg t.i.d.	PRILOSEC 20 mg q.d.

Please refer to clarithromycin full prescribing information for CONTRAINDICATIONS and WARNING, and for information regarding dosing in elderly and renally impaired patients. PRECAUTIONS: General, PRECAUTIONS: Geriatric Use and PRECAUTIONS: Drug Interactions. **Gastric Ulcer:** The recommended adult oral dose is 40 mg once a day for 4 to 8 weeks. [See INDICATIONS AND USAGE: Gastric Ulcer.] ***Gastroesophageal Reflux Disease (GERD):*** The recommended adult oral dose for the treatment of patients with symptomatic GERD and no esophageal lesions is 20 mg daily for up to 4 weeks. The recommended adult oral dose for the treatment of patients with erosive esophagitis and accompanying symptoms due to GERD is 20 mg daily for 4 to 8 weeks. [See INDICATIONS AND USAGE.] ***Maintenance of Healing of Erosive Esophagitis:*** The recommended adult oral dose is 20 mg daily. ***Pathological Hypersecretory Conditions:*** The dosage of PRILOSEC in patients with pathological hypersecretory conditions varies with the individual patient. The recommended adult oral starting dose is 60 mg once a day. Doses should be adjusted to individual patient needs and should continue for as long as clinically indicated. Doses up to 120 mg t.i.d. have been administered. Daily dosages of greater than 80 mg should be administered in divided doses. No dosage adjustment is necessary for patients with renal impairment, hepatic dysfunction or for the elderly.

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NOTE: This summary provides important information about PRILOSEC. If you would like more information, ask your doctor or pharmacist to let you read the professional labeling and then discuss it with them.

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He Takes the Prize

Paleoanthropologist Lee Berger (below) has won the first annual National Geographic Society Research and Exploration Prize. The $100,000 no-strings-attached award honors both the accomplishments and potential of its recipients. Berger, of South Africa's University of the Witwatersrand, is investigating numerous hominid sites in southern Africa. His work was featured in the February and September 1997 issues of NATIONAL GEOGRAPHIC.

KENNETH GARRETT

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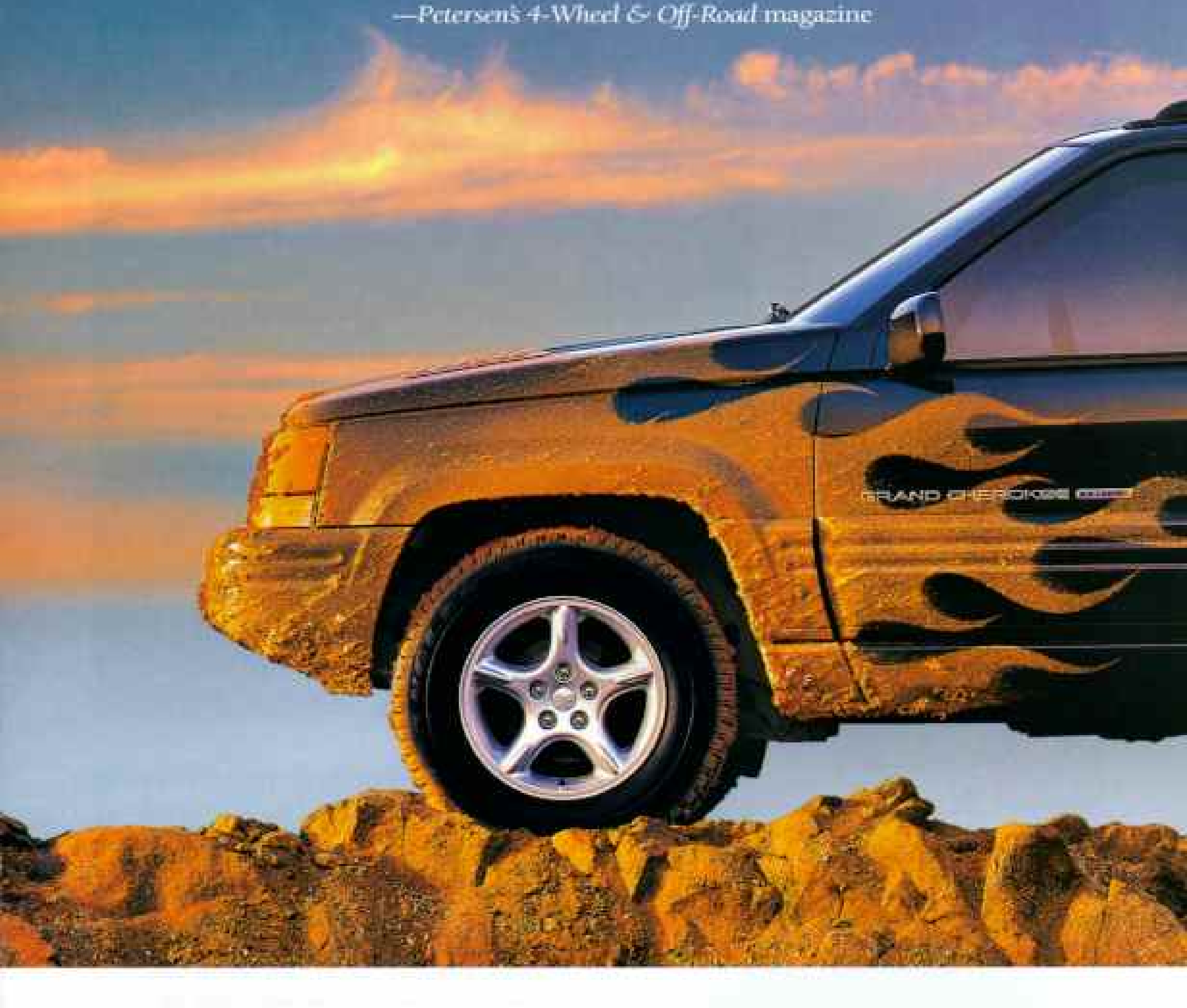
PIERRE GOURE, COUSTEAU SOCIETY

The Unsinkable Mr. Marden

He retired in 1976, but who can tell? Writer-photographer Luis Marden, at right, with his friend Jacques-Yves Cousteau aboard *Calypso* in the Indian Ocean in 1955, still keeps office hours, 64 years after joining the GEOGRAPHIC staff. Luis, who has contributed 61 articles to the magazine including this issue's Cousteau tribute, was a pioneer of color and underwater photography. He says finding the *Bounty* shipwreck off Pitcairn Island in 1957 was his happiest career moment. So far.

TEXT BY MAGGIE ZACKOWITZ

1998 4x4 OF THE YEAR
—*Petersen's 4-Wheel & Off-Road* magazine



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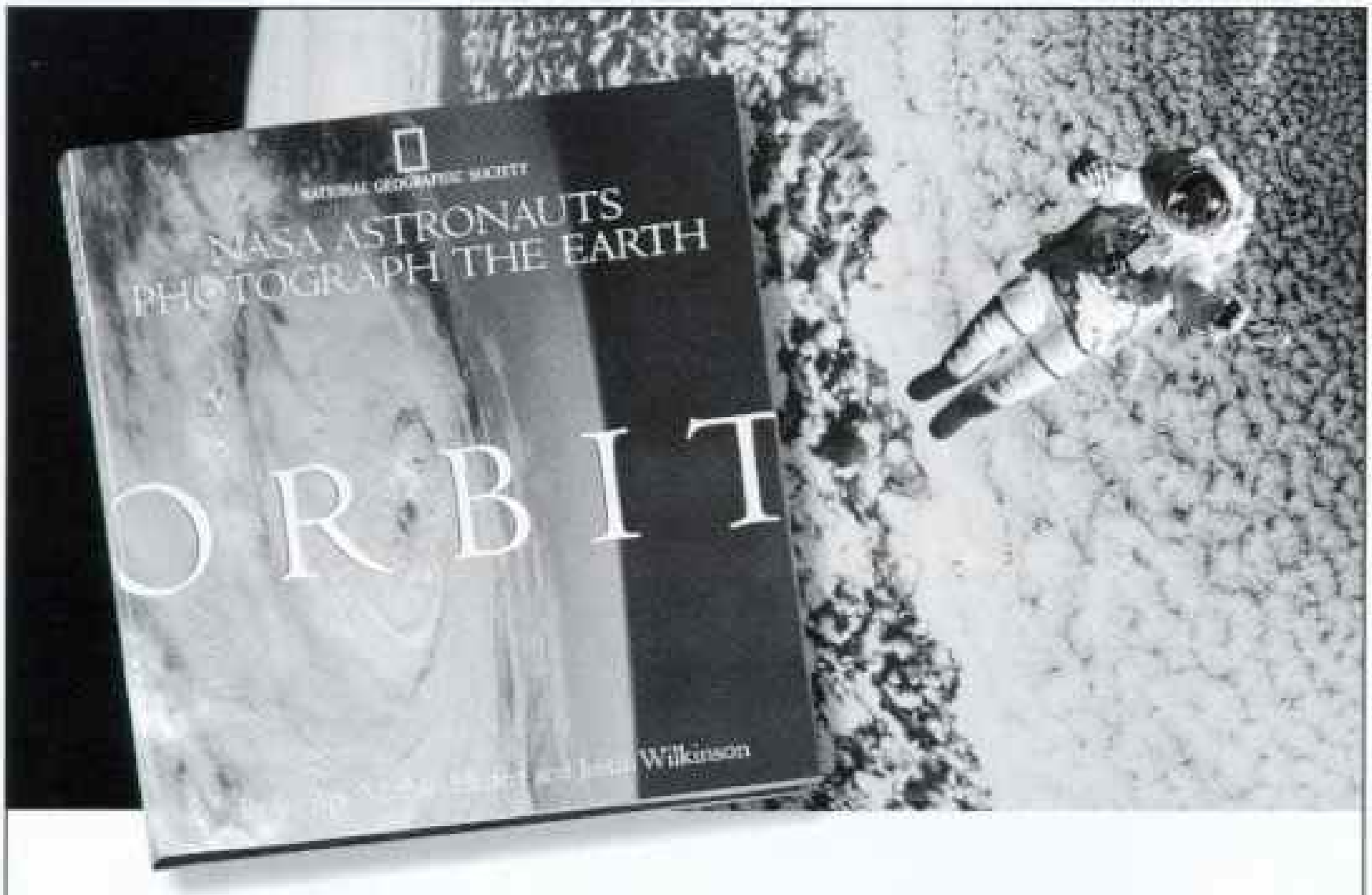

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Forum

In our October 1997 issue our treatment of the artist van Gogh brought raves—and a number of alternative diagnoses for his mental instability. Pakistan and parasites also generated strong interest.

Down the Zambezi

Your article brought back memories of the hours spent on this beautiful river when I was posted in Zambia from 1965 to 1969 as part of the Zambezi River Transport, operating from Livingstone. Our three 80-ton-capacity barges, along with pushers, passenger boats, trucks, and trailers, operated 24 hours a day, seven days a week. Downstream cargo was teakwood railway ties; upstream was food and miscellaneous goods. Political, military, and operating problems were constant, but traveling the ten hours downriver by barge was always interesting: stopping to pick up passengers at small villages, very clear water, lots of hippos, birds, and an occasional croc. Last year I was back in Livingstone and could find only one elderly man who remembered this unusual operation; a road is now used. Livingstone looks almost the same as it did 28 years ago.

THOMAS A. CRAIG
Fresno, California

The author mentions drinking the river water not once but twice, with no ill effects. There is nothing to fear but years of excruciating pain and misery. Many travelers have encountered severe diseases from journeys all over the world, diseases that have not been correctly diagnosed until months if not years later. NEVER drink the water. Rely on sealed bottled water purchased from reputable dealers in large cities before the adventure begins.

JOHN AND PATRICIA FUHRBACH
Amarillo, Texas

As a rule your warning is correct. Author Paul Theroux found it impossible to carry enough drinking water in a canoe for the length of time he was on remote parts of the Zambezi. He often boiled the water.

It's refreshing that there are still adventurous, intelligent men who communicate so descriptively that they put me on the Zambezi. I had fun!

ERNIE JOHNSON
Columbus, Ohio

County Fairs

I have been in 4-H since I was nine, and I am almost 16 now. Your paragraphs about fair time had me crying my head off because it's so true. I have shown livestock (cows and goats) and am now showing llamas. Fair time is so much fun, even if you don't win a ribbon; it's a time of competition, herdsmanship, public relations, and so many memories. When I'm an old grandma, fair time will be my main childhood memory.

BETH HEARNESBERGER
Elma, Washington

I spent three years researching fairs for my Ph.D. dissertation. Elkanah Watson claimed to be the father of agricultural fairs, but the roots of fairs began before his efforts. He was part of a larger movement already in motion, so he should not be given so much credit.

CATHY AMBLER
University of Kansas
Lawrence, Kansas

I applaud John McCarry for capturing the evolution of one of America's most treasured pastimes. I vividly recall the smell of cotton candy and caramel popcorn that permeated the carnival while I launched a softball at the teasing milk bottles. It's nice to see that the county fair still offers a celebration of our agrarian roots.

JEFF WASSERMAN
Gettysburg, Pennsylvania

The Promise of Pakistan

My parents migrated to Pakistan after partition, and I grew up here. Though space constraints did not permit the author to portray the richness and cultural diversity of Pakistan's 140 million people, he put across wonderfully well their warmth, hospitality, and aspirations for the future.

RATOOL MAHMOOD
Karachi, Pakistan

I was somewhat perturbed by your choice of photographs depicting the abuse of women, though such conduct is certainly reprehensible. The highlighting of such images reinforces negative stereotypes. Perhaps it would have been useful to also show Pakistani women driving cars, seated as judges in the supreme court, flying planes of our national airline, and running for public offices.

SALEEM H. ALI
Cambridge, Massachusetts

Parasites

I often use your articles as teaching tools in my freshman biology course for their ability to educate and enthrall students of natural history; this article is no exception. I would add the example of the only known vertebrate parasite on man: the candiru, or vampire fish of the Amazon. It works its way up the urinary openings of bathing humans to lodge in the urinary tract by erecting a row of rear-pointing spines. The fish gorges on blood of the hapless victims. Often surgery is required to extract it.

RAGUPATHY KANNAN
Westark Community College
Fort Smith, Arkansas

INTRIGUED? A QUICK GLANCE. YOU IMMEDIATELY NOTICE THE CATLIKE EYES, THE MUSCULAR LINES. FURTHER INVESTIGATION REVEALS A SLEEK INTERIOR DESIGN, CONTOURED SEATS. IF YOU CHOOSE, LEATHER TRIM AND A PREMIUM BOSE® AUDIO SYSTEM ARE AVAILABLE. THE HOOD HIDES A 195HP V6. THE HIGH PERFORMANCE SUSPENSION SYSTEM LIES WAITING FOR THE NEXT CURVE. YOU STARE, KNOWING THAT ONLY WHEN YOU DRIVE IT WILL ALL ITS SECRETS BE TOLD.

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I read the article with fascinated, squeamish horror. I myself had a horrendous episode of microscopic mites or something after an ill-fated vacation in the Ozarks, and I had to coat my body, neck to toe, with a killer cream the dermatologist prescribed. Worst thing I've been through yet.

ALISON E. SWINNERTON
Angola, New York

I am a farrier and a horse owner and faithfully worm our horses. I never realized though that the worms are so vicious. I hope that more horse owners and all animal owners read your article and then think about their pets and animals.

MIKEL DAWSON
Lintrup, Denmark

The map on page 84 shows Madagascar outside the malaria zone. Tragically malaria is still endemic in most of the island. Visitors should take anti-malarial drugs and avoid mosquito bites by using repellents and sleeping under bed nets.

LON KNIGHTLINGER
Antsiranana, Madagascar

The Most Ancient Americans

Monte Verde is an important site because of its age and the preservation of bone, wood, and hide, but it is not the only pre-Clovis site in the Americas. You mention other sites that are "possibly more than 12,000 years old." We have two pre-Clovis sites in Virginia with solid radiocarbon dates that predate Monte Verde. Saltville, southwest of Blacksburg, dates from around 13,800 years before the present. The Cactus Hill site on the Nottoway River south of Petersburg has yielded hundreds of thousands of Archaic period artifacts. A Clovis hearth there produced a date of 10,920±240 BP and has a stratum below it dated at 15,070±70 BP. Chile is fine and Monte Verde is unique, but we have some pretty fantastic stuff right here in our own backyard.

JAMES H. BROTHERS IV
Midlothian, Virginia

Here in Washington State on the Strait of Juan de Fuca, we have been finding ice age artifacts and fossils for decades. The ice ages occurred over a long period of time and varied in temperature. During some periods the sea was down 400 feet and grasslands extended across the strait and offshore north to Alaska. According to fossil finds, bananas were growing in Oregon.

RICHARD DOBBS
Sequim, Washington

Vincent van Gogh

Following in the footsteps of van Gogh, Joel Swerdlow manages to capture the shadow of an elusive brilliance. The black-and-white photographs by Lynn Johnson, posing an antithesis to Vincent's vibrant world of colors, convey the same fight between darkness and light that inspired van Gogh a hundred years ago.

VASILEIOS ASSIKIS
Chicago, Illinois

The article mentions that numerous diagnoses have been advanced regarding van Gogh's progressive mental instability. Has heavy-metal toxicity been considered? Artists' pigments have included compounds of lead, chromium, cadmium, mercury, and other metals, and van Gogh has been depicted in at least one biographical film with paint coating his lips and surrounding skin as a result of putting brushes in his mouth.

DONALD R. CLARK, JR.
North Zulch, Texas

I find the student's comment that van Gogh "never gave up" incredible. He gave up on almost all aspects of life. He certainly gave up on supporting himself; what would he have done without his brother's support? He gave up on marriage and fatherhood. He even gave up on what he could do best—paint—when he took his own life. I am sure the student can find someone else to admire for not giving up.

RONALD CHARLES KAISER
Port Orange, Florida

In at least two portraits van Gogh portrayed his subject with foxglove, a plant that contains the ingredient used in the drug digoxin. Some believe he used the plant to help control seizures. The side effects include blurred vision and changes in color perception. It is possible that van Gogh's paintings reflect a drug-altered view of the world.

GREG PHILLIPS
Durango, Colorado

Part of our affection and sympathy for Vincent derives from the simplicity and directness with which he describes his moments of inspiration or despair in his letters to his brother Theo. If Vincent and Theo were alive today, they might be corresponding by e-mail, and scholars would be robbed of the invaluable insights provided by their letters. We are all benefiting from digital technology, but we must be aware that there is a counterbalancing downside of a magnitude yet unclear.

ALAN WATERS
Braintree, England

Letters for FORUM should be sent to National Geographic Magazine, Box 98198, Washington, D.C. 20090-8198, or by fax to 202-828-5460, or via the Internet to ngforum@nationalgeographic.com. Include name, address, and daytime telephone. Letters may be edited for clarity and space.

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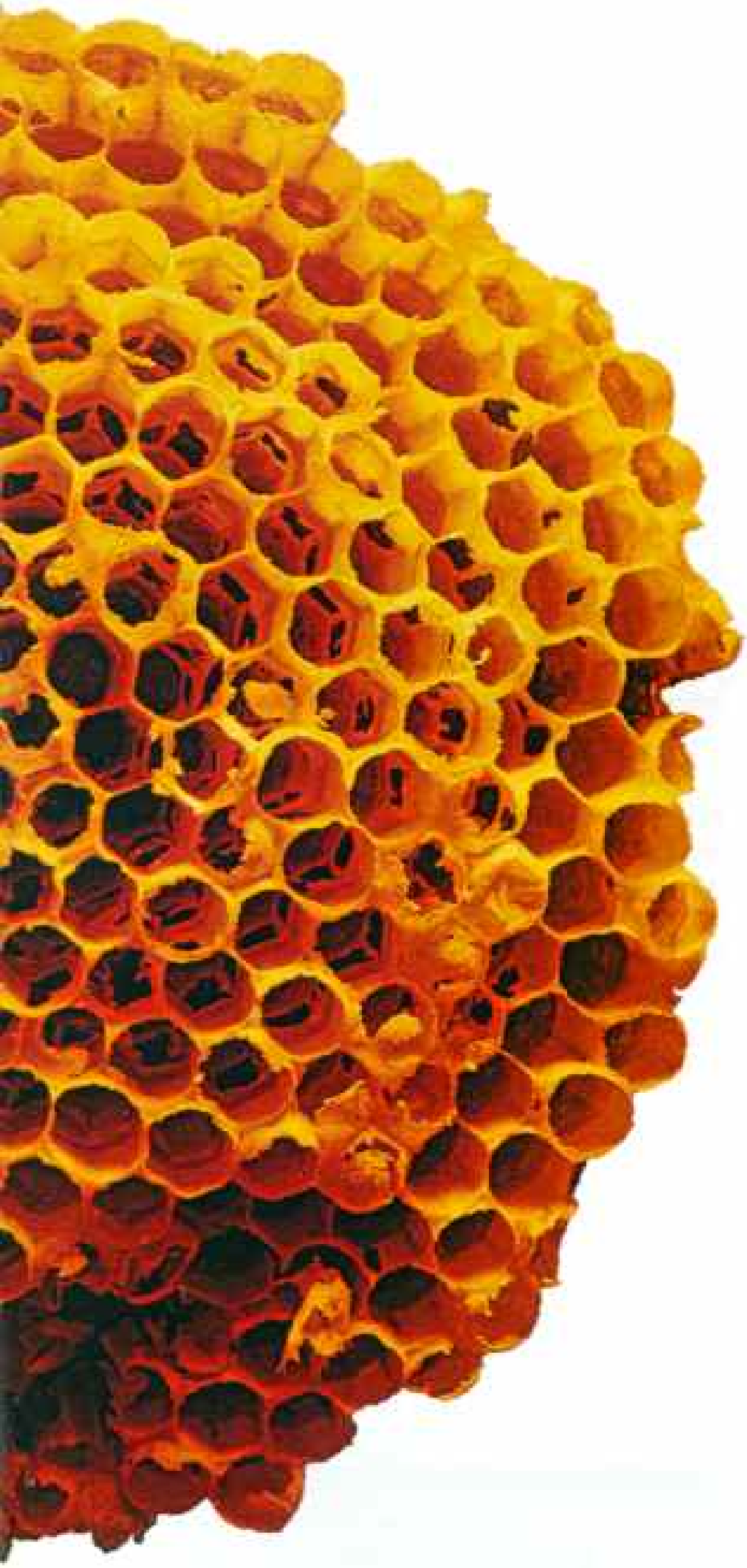

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Insidious Insects Wage War on New Orleans

The Second Battle of New Orleans: That's what Edgar Bordes calls the latest invasion of his city. But this time "the enemy doesn't wear red coats and march in a straight line."

The new foe is the Formosan termite, which entered the continental U.S. from Asia on ships probably in the 1940s. It has caused so much damage to Greater New Orleans buildings and trees—at least 300 million dollars a year, says Bordes, director of the city's Mosquito and Termite Control Board—that the National Trust for Historic Preservation put the region on its list of most endangered historic places last year.

© ANDREW BOYD

This most destructive termite species can penetrate asphalt, plastic, even lead to get at wood and build nests. It readily leaves the ground; entomologist Ed Freytag (above) found this infested board in a dormer of the 19th-century Presbytère, at rear, on Jackson Square in the French Quarter. One ravaged library harbored 60 to 70 million insects. Attorney Camille Jones Strachan turned up damaged cypress wood in her Lower Garden District laundry room. At a neighbor's house, termites nibbled their way through the floor, then ate through a rug. "They're insidious, and ecumenical in their taste," she says.

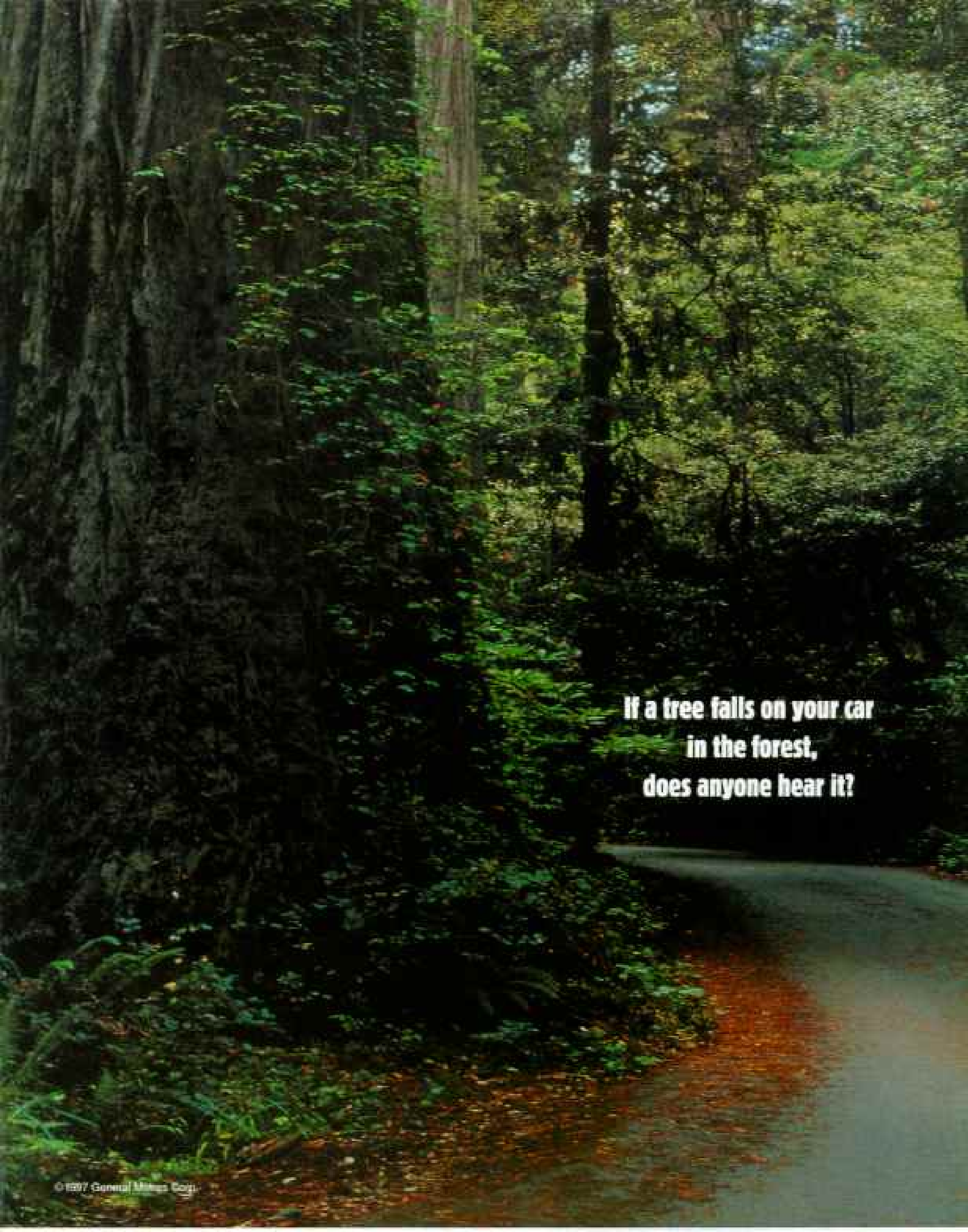
With its damp climate and warm temperatures, New Orleans is "termite heaven," according to Bordes. His teams are fumigating, laying poisoned bait, drumming up citizen support, and seeking millions of dollars to try to conquer their enemy.

KENNETH GARRETT

Maya Ruins Get a New Day in the Sun

Artfully carved, this Maya stone mask was part of a temple wall that came tumbling down in a long-forgotten earthquake. Last year the mask was unearthed at Río Amarillo by Harvard graduate student Bill Saturno (left), who quickly recognized it as a duplicate of a mask found at Copán, 12 miles to the west.

Excavating the little-studied site in Honduras, Saturno has learned that such duplication was common. Though Río Amarillo's culture flourished separately from the larger city of Copán, its sculptors included some artisans who worked there, he believes. "They brought in sculptural motifs from several different Copán buildings and put them on this one," says Saturno. "It's gaudy, even for the Maya." The mask's design represents *witz*, the Maya word for sacred mountain.



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Black-faced Lion Tamarin (Leontopithecus caissara) **Size:** Head and body length, 26 cm; tail, 34 cm. **Weight:** Approx. 600 g. **Habitat:** Primary lowland coastal forest in southeastern Brazil. **Surviving number:** Estimated at fewer than 300

Photographed by Luiz Claudio Marigo

WILDLIFE AS CANON SEES IT

Discovered only in 1990 by Brazilian biologists, the black-faced lion tamarin is one of the rarest of Neotropical primates. A golden coat and black mane distinguish this lion tamarin from three previously known species, all of which live in Brazil's Atlantic forest. Bounding through the rain forest, these squirrel-sized monkeys forage for insects, small vertebrates and fruit; elongated fingers skillfully probe and extract prey. At night, they find a hollow tree for sleeping. Protection of the diminishing Atlantic forest is vital to this lion tamarin's survival. As a global corporation committed to social and environmental concerns, we join in worldwide efforts to promote greater awareness of endangered species for the benefit of future generations.

RICHARD THOMPSON

Did Gout Really Get to *T. Rex?*

"If you step on a needle, that's painful," says Bruce Rothschild of the Arthritis Center of Northeast Ohio. "Imagine what it's like stepping on thousands of needles: That's gout." Now imagine the pain endured by a dinosaur with gout.

Looking at a cast of the forelimb bones of a *Tyrannosaurus rex* in the Denver Museum of Natural History, Rothschild saw lesions that signal the ailment's presence, then found others in a bone of a tyrannosaur at Canada's Royal Tyrrell Museum—the first time gout has been detected in dinosaurs.

Gout is caused by excess uric acid deposits that form needlelike crystals; it can be brought on by lead poisoning or by eating foods high in biochemicals called purines. High levels of purines occur in a major component of the diet of the carnivorous dinosaurs: red meat.

Sharp Weapons in the Mating War

An old joke holds that porcupines mate very carefully. Well, that's not quite right: Males, like this one below, are not careful at all in winning the right to mate. They often end up impaled by the quills of their rivals.

During breeding season, a female porcupine's loud, high-pitched yowls attract males who battle ferociously for the right to guard her until she's ready to mate. Even winners have skin torn out or pierced by an opponent's quills, says Richard Sweitzer, a researcher at the University of California at Davis who studied porcupines for five years in the Granite Range of northwestern Nevada. But they all keep fighting, no matter how badly they're hurt. And the battlers are large, mature males, indicating that smaller, younger ones don't even bother to try.

Females do the final choosing. Sweitzer believes that something about a male's quills, or perhaps his scent, leads a female to pick him out of the crowd.

TIM DAVIS, PHOTO RESEARCHERS

MICHAEL STEPHENS, PA NEWS PHOTO LIBRARY

Surprise Catch at London's Tower

A yeoman warder casts a curious glance at a wicker fish trap unearthed from what was the moat surrounding the Tower of London. That protective waterway, once linked to the Thames, probably provided meals for medieval royals and their sometimes unwilling guests behind the walls.

The trap, held in place by flint weights on each side of its open end, turned up in fragile but good condition during the largest archaeological excavation ever carried out at the Tower (GEOGRAPHIC, October 1993). "It dates from about 1500, when Henry VII ruled England," says Graham Keevill, the dig's director. Few such traps have survived because wicker disintegrates when exposed to air for long periods. "Here, in waterlogged clay with no oxygen, it was preserved perfectly," Keevill says.

Fish swam in the moat from the 13th until the 19th century, when it became so fetid that it was filled in. The excavation will help determine if it's feasible to dig out and refill the moat with water.

TEXT BY BORIS WEINTRAUB

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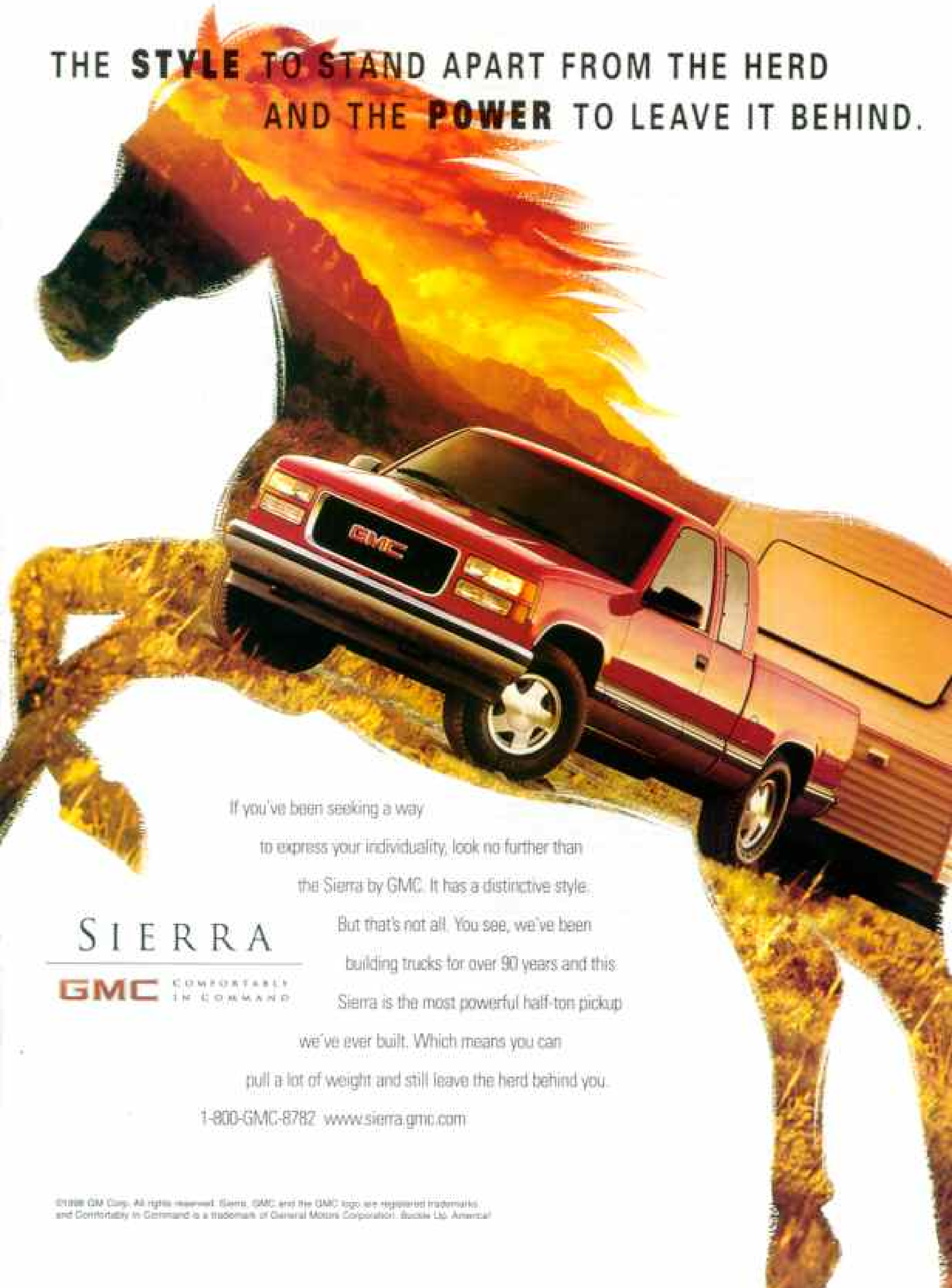

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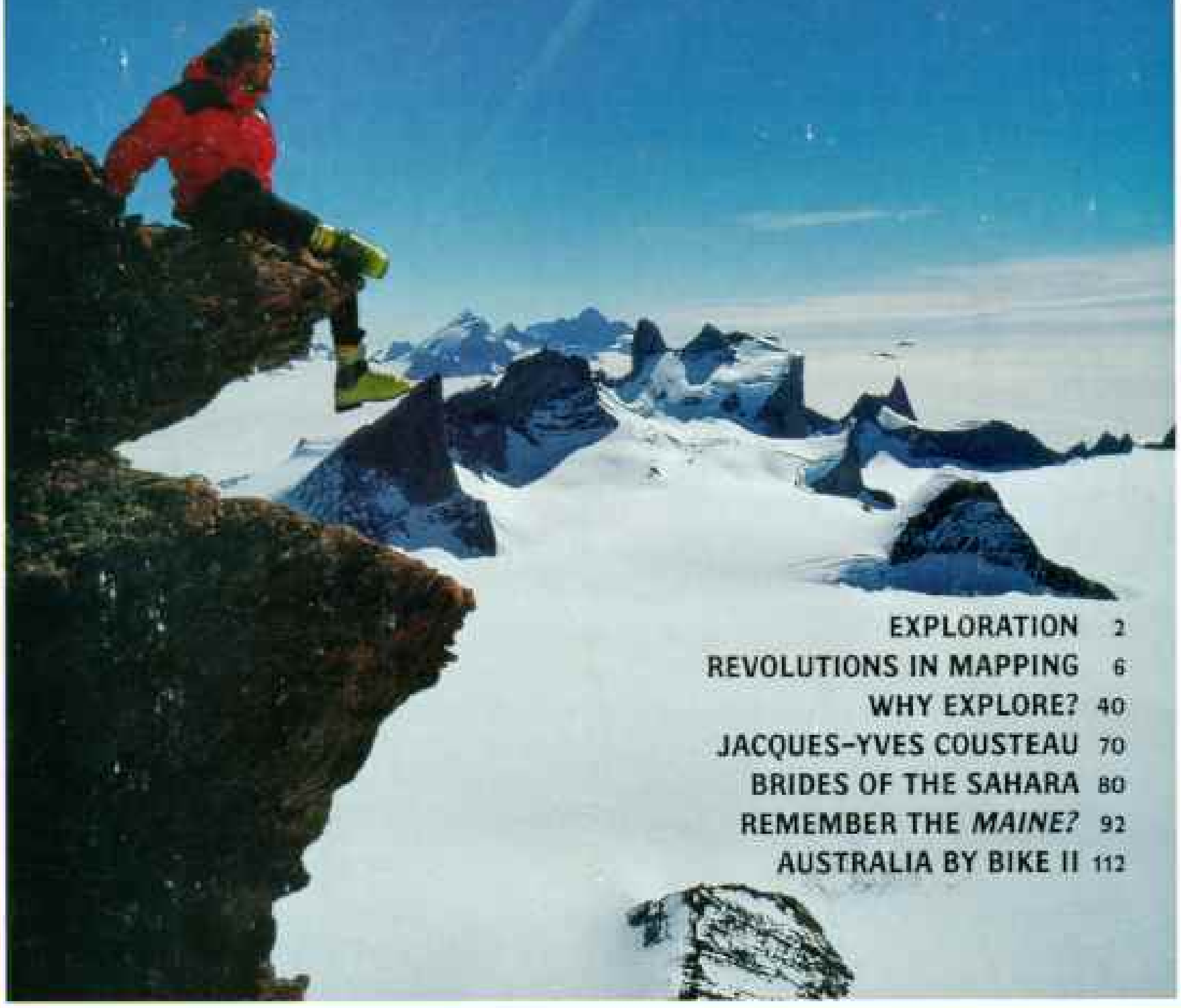

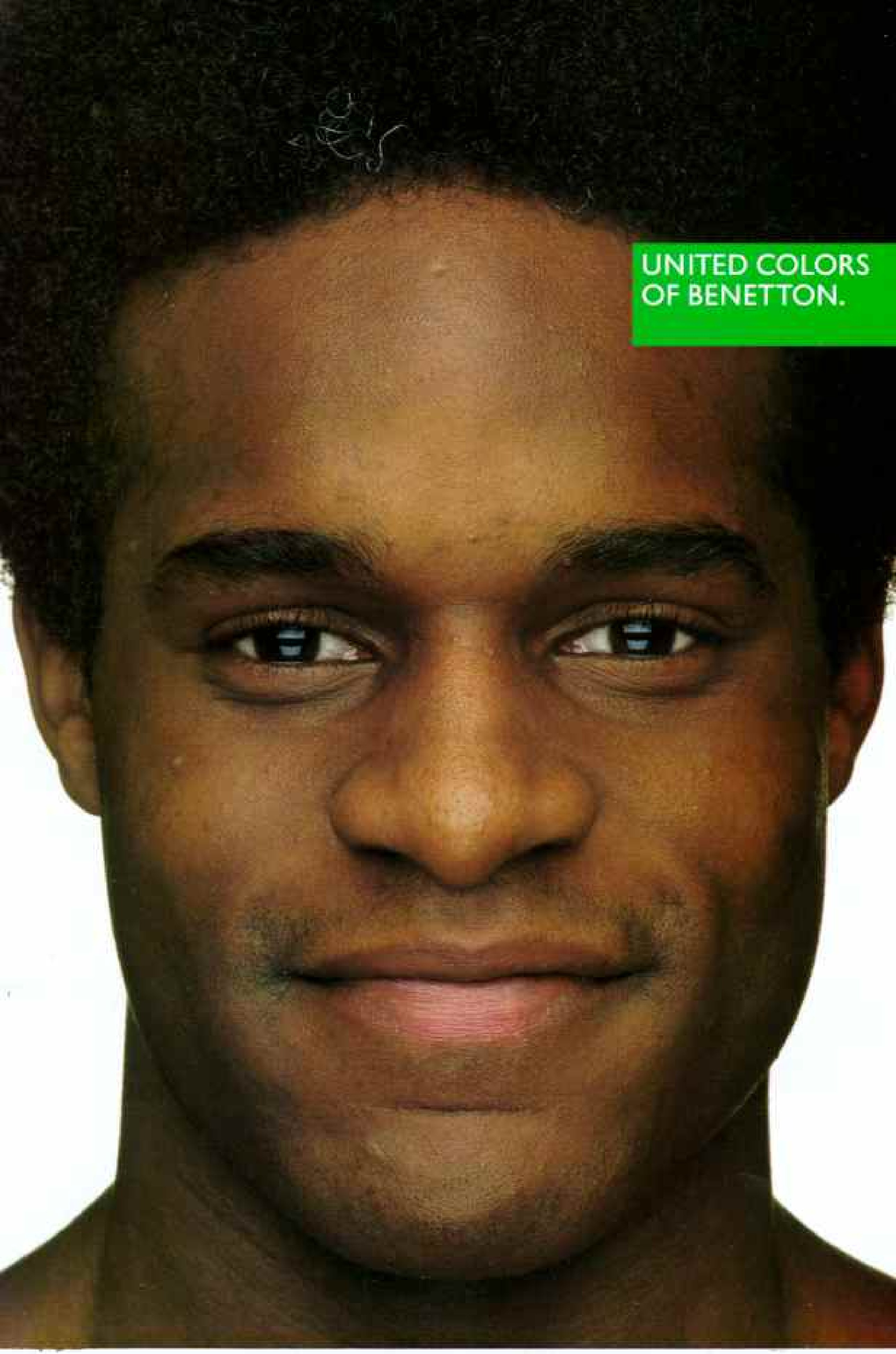
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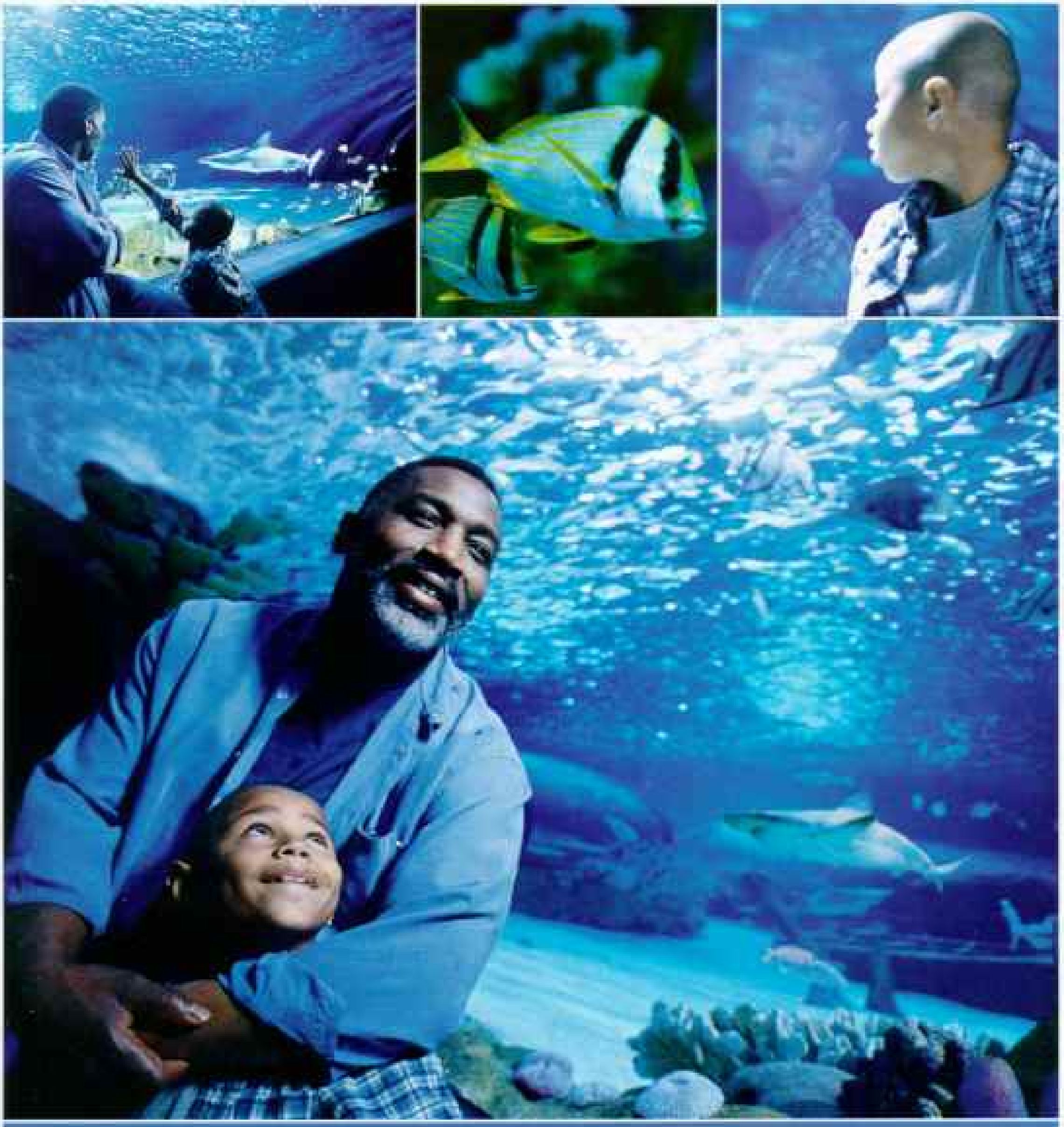

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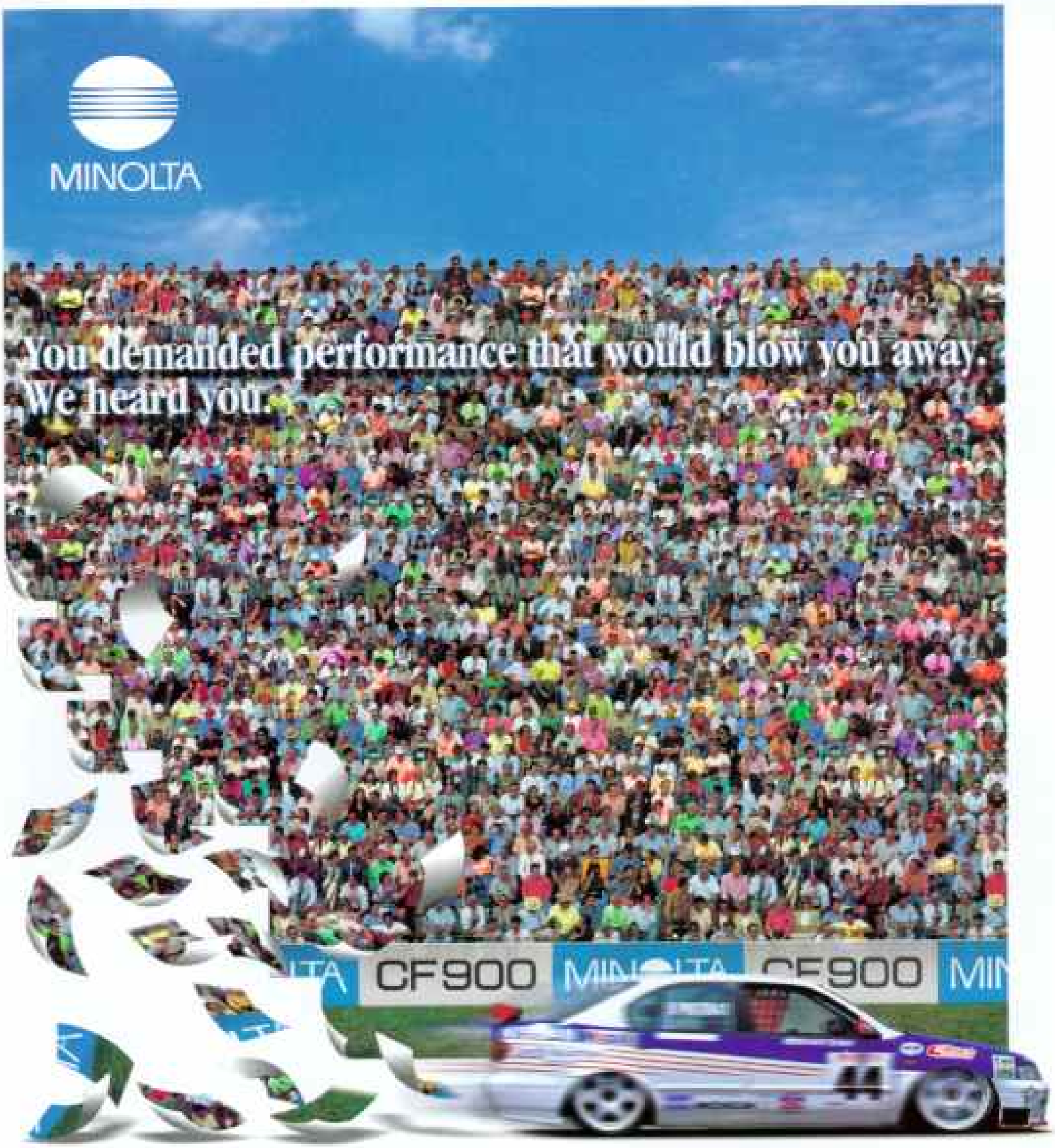

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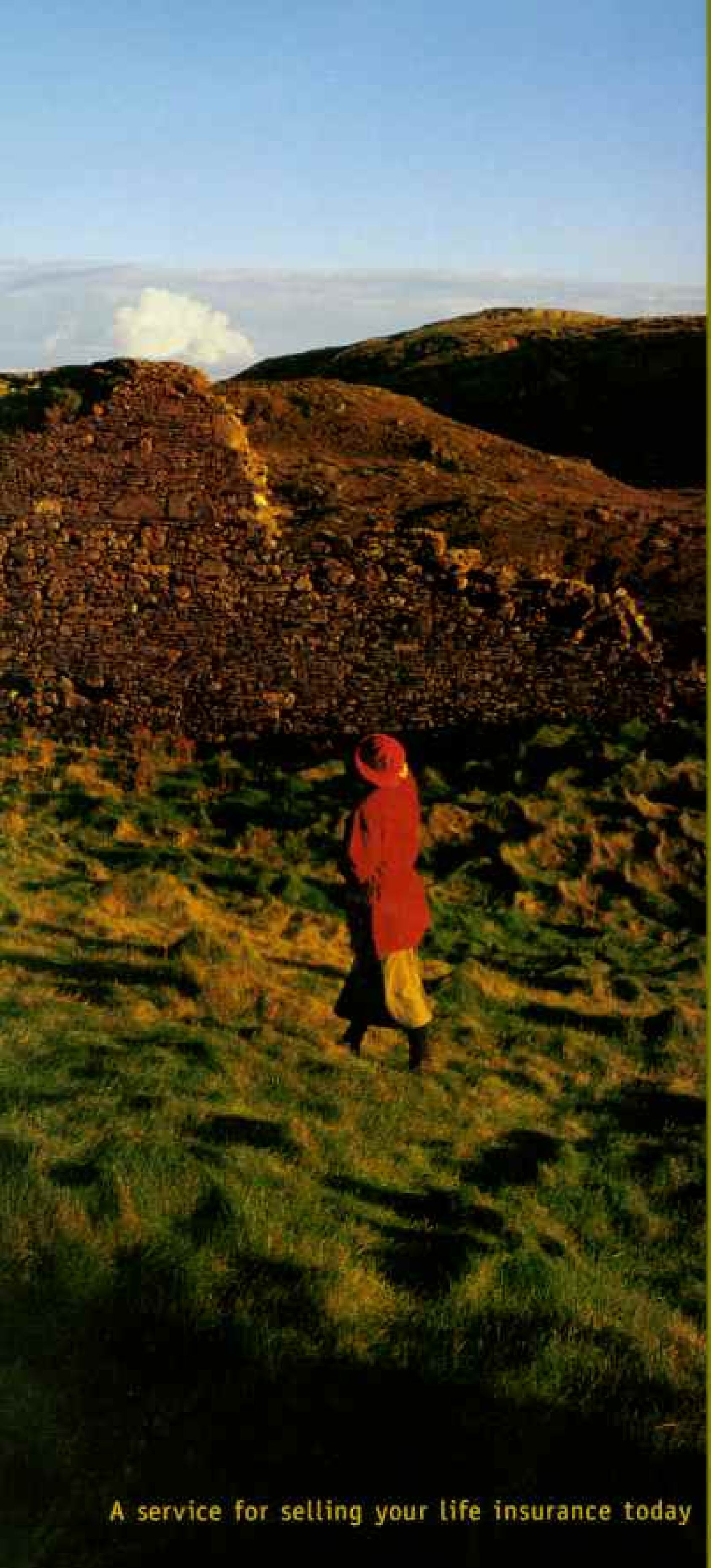

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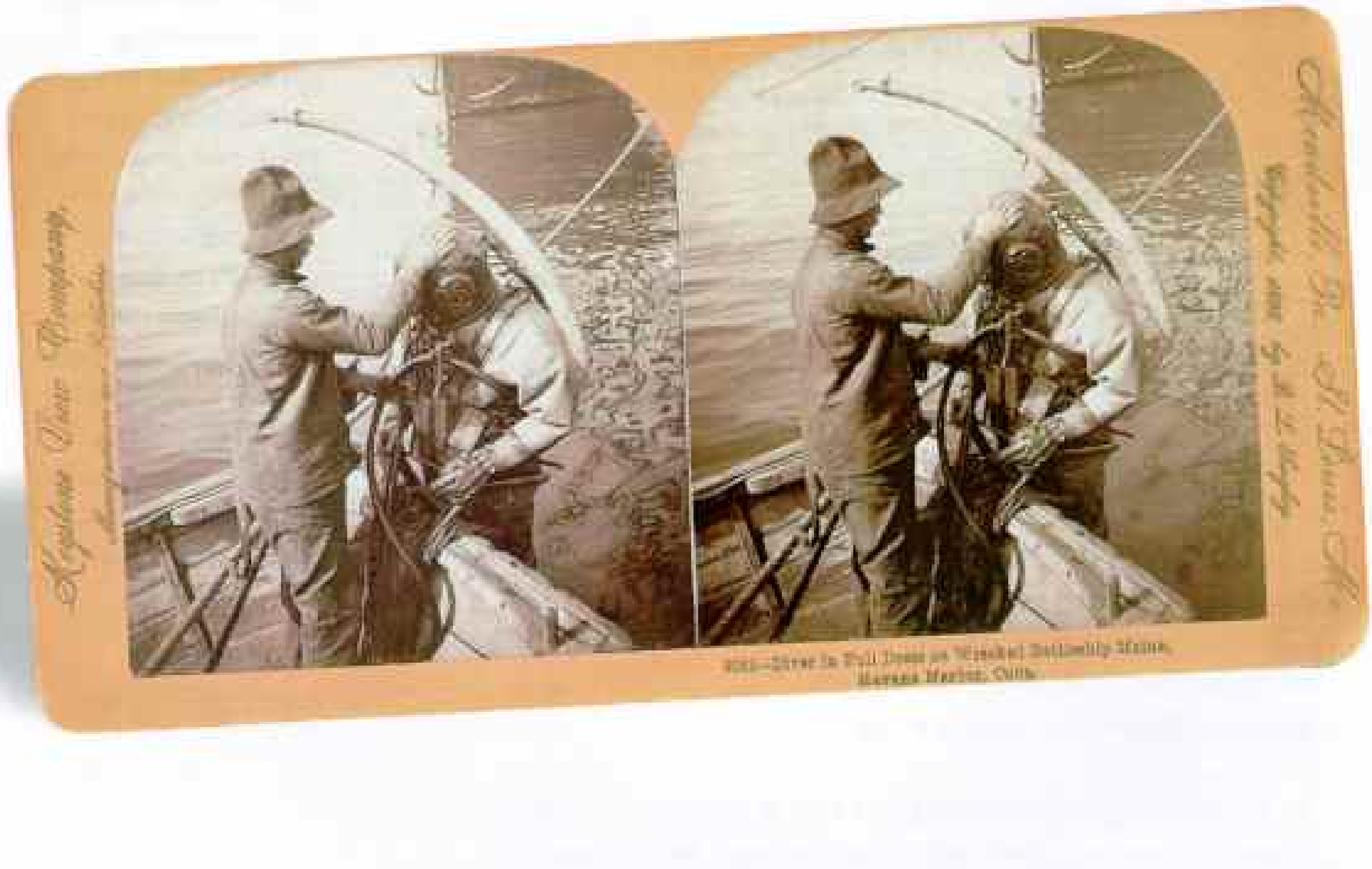

■ FROM THE GEOGRAPHIC ARCHIVES

The *Maine* Event

The sinking of the U.S.S. *Maine* in Havana harbor was the big news in 1898. Because newspapers of the day rarely printed photographs, many Americans sought copies of stereographs—dual images mounted on cardboard that slid into a stereoscope for a three-dimensional effect. Stereographs provided some of the first widely circulated pictures of important events. Viewers must have felt they were on deck as this diver descended to the wreckage of the *Maine*; this scene was not published in our magazine.

The GEOGRAPHIC, too, remembered the *Maine*—and its surviving commander, Capt. Charles D. Sigsbee. An expert on ocean mapping and a longtime Society member, "Captain Sigsbee himself, by the admirable self-restraint and judicial temper which he displayed in the most trying of all conceivable circumstances, has won 'golden opinions from all sorts of people,'" said our May 1898 tribute—part of an issue devoted to Cuba. The articles examined the island's geology, trade, indigenous birdlife, and more: "The women," noted contributor Robert T. Hill, "have the highest type of beauty."

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POINT OF VIEW

JOHN MCELDREY (ABOVE) BOB SACHA

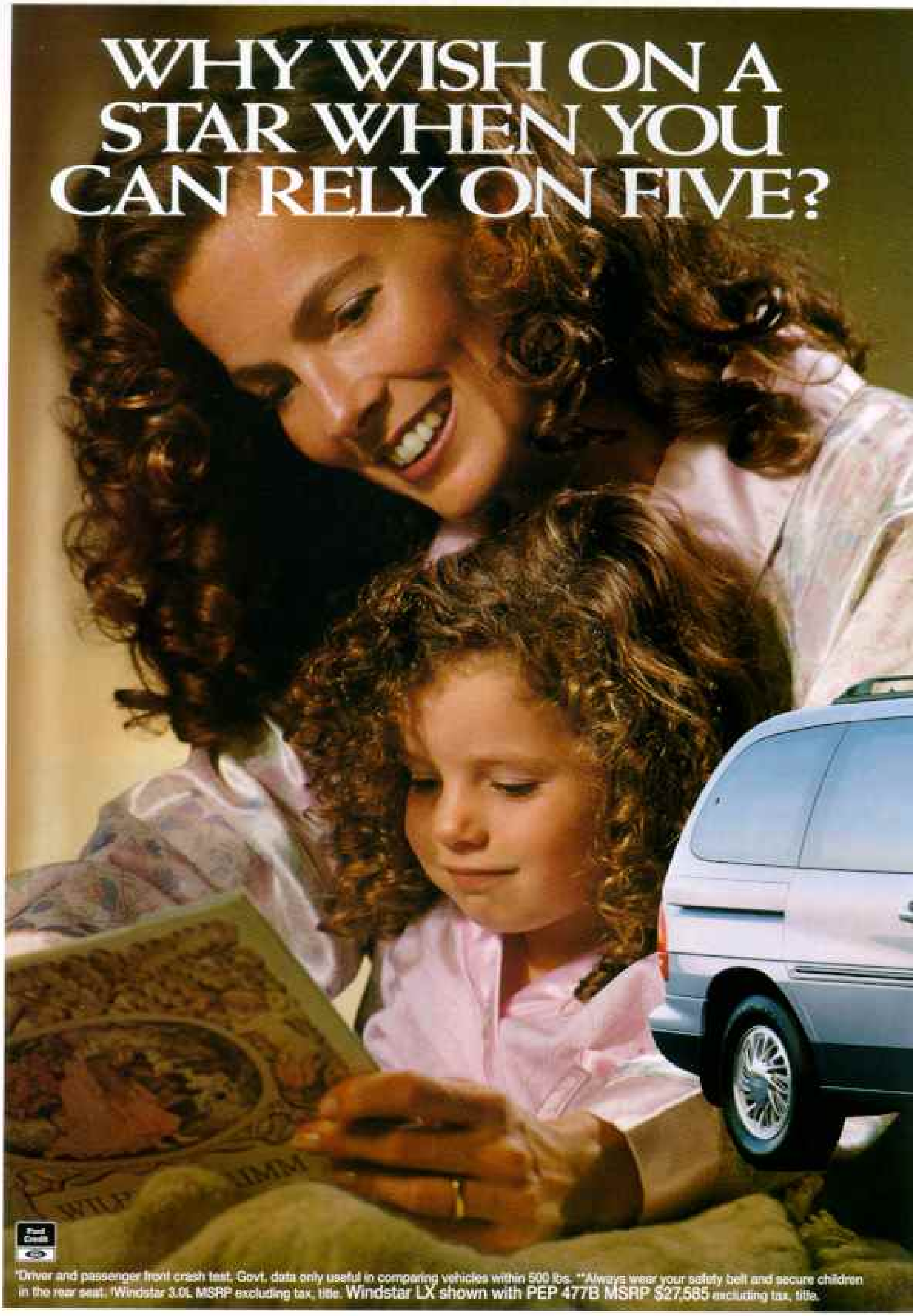
To Fly the Prime Meridian

Anywhere I'm working in the world, I check the prime meridian. I use it to determine Greenwich mean time, so I can tune my radio to the comforting English voices of the BBC.

Like the voices coming out of my radio, a photograph of the prime meridian seemed to require magic: I wanted to draw the line—seen only on maps—across the green of Greenwich Park, and I wanted to make my camera fly above it for a bird's-eye view (pages 14-15).

I drew my line with a string of 600 40-watt lightbulbs powered by a generator. A small helium balloon barely lofted my camera with its 8-mm fish-eye lens. Geographic technician Kenji Yamaguchi (above, dark shirt) and I maneuvered the balloon like an unruly kite. I tripped the shutter with a handheld transmitter to the disappointment of these local boys, who had offered to fly aboard the balloon to fire the camera for me. Now that would have been magic.

—BOB SACHA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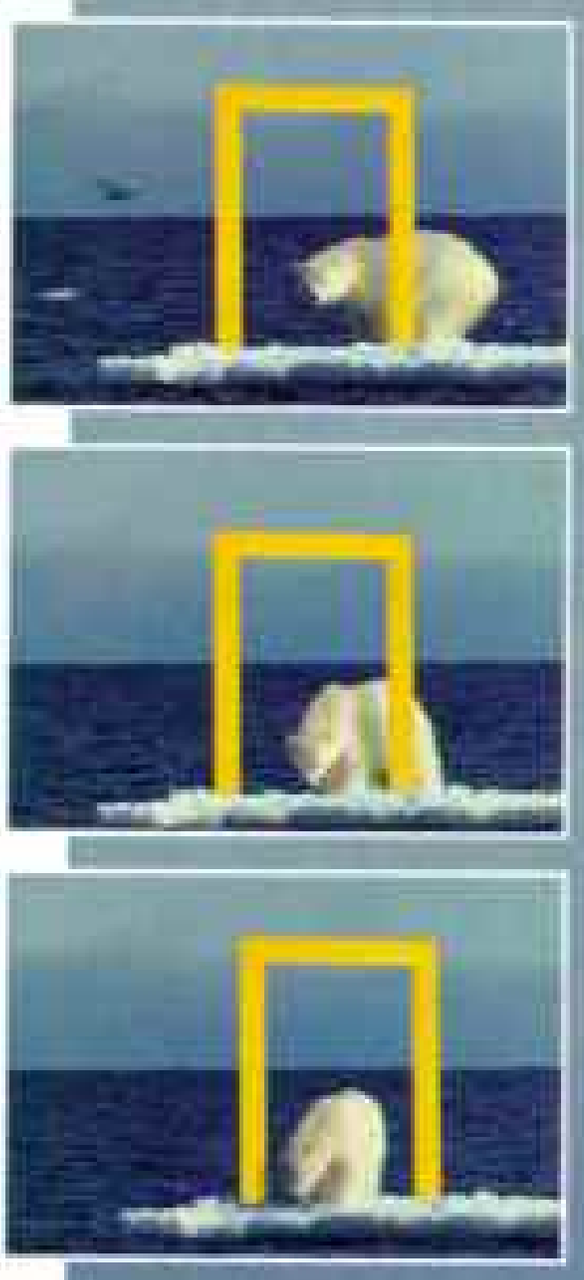

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Earth Almanac

Greening of the Great White Way

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JOCK PITTLE: KEYD

JOHN HARE

Former Nuclear Test Site Becomes Camel Sanctuary

Forty-five times since 1964 the desert of Xinjiang Province has thundered during Chinese nuclear tests. Between 1982 and 1996, when tests stopped, all devices were detonated underground. In the same area live some 120 Bactrian camels, among perhaps 800 that survive in China and Mongolia, the only wild Bactrians in the world.

The security had deterred most desert dwellers seeking camel meat, but now outsiders, who moved in illegally to mine gold and iron, are hunting the protected camels. "Some miners have planted explosives near water holes to blow up camels," says John Hare of the Wild Camel Protection Foundation, in Benenden, England. Last year he persuaded Chinese authorities to establish a 42,000-square-mile sanctuary with checkpoints to limit unauthorized entry.

CAMERON DAVIDSON

Too Many Canadas: Their Goose Is Cooked

Conservation has worked too well for Canada geese that reside in the U.S. year-round, a population distinct from Canadas that migrate to northern Quebec. U.S. wildlife managers introduced the resident birds in the 1960s and '70s; now they have exploded to a million in eastern states, gobbling grass, creating airport hazards, and fouling reservoirs. When deterrents failed, officials tried relocation; the birds pictured above were moved from eastern to central Virginia in 1994. But last summer, out of room, wildlife managers killed about 2,000 birds and donated the meat to food banks.

A hunting ban protects migrants, about 300,000 on the East Coast. September hunts cull residents before migrants arrive.

NATASHA KARNAN

Vivid Sea Fleas Bedeck Australian Reefs

TONY KARACSONYI

Curiosities of coral communities, Australian red sea fleas glow as if electrified. They're not really fleas—these inch-long marine invertebrates are part of the large order Amphipoda. Found only between Brisbane and Adelaide, "they belong in the genus *Annaryllis*, a beautiful name and not hard to get your tongue around," says Jim Lowry of the Australian Museum in Sydney. He will soon publish his work on this new unnamed species and about 20 other Australian amphipods. He believes the sea fleas graze on lacelike bryozoans and polyps of soft corals. Their arresting color may warn fish or other predators to avoid a bad-tasting meal.

CARE for a Forest

The few thousand Kirk's red colobus monkeys live only in Zanzibar's 1,480-acre Jozani Forest, where they feed on leaves and fruit. Surrounding them are poor villagers who clear homesteads and eke out a living cutting firewood, thus felling the monkeys' habitat. Now the primates are damaging village crops. To ease the conflict, a plan worked out by CARE allots a portion of forest visitor fees to the villagers.

TEXT BY JOHN ELIOT

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■ ONLINE

Talking With Explorers About Snow, Sea, Memories

Swirls of snow and worry filled Gordon Wiltsie's 1996 reconnaissance of Queen Maud Land in Antarctica for the expedition covered in this issue. Yet the photographer was able to capture the rugged terrain on film and locate a stretch of ice where a support plane could land. Planning paid off. The 1997 expedition ran without a snag—in near-perfect weather. Now Wiltsie, along with filmmaker Rick Ridgeway and climber Alex Lowe, discusses the future of climbing in Antarctica with Peter Miller, the magazine's expeditions editor. Click through a portfolio of Wiltsie's images, and post your ideas and questions at *www.nationalgeographic.com/features/2000/exploration/maudland.*

■ "Underwater is the forbidden place," says explorer Bob Ballard (right), "more hostile than Mars." He talks about sea exploration with GEOGRAPHIC writer Priit Vesilind, who sails us along a time line of maritime history, starting with Southeast Asian explorers. Set a course for a watery adventure at . . . */exploration/sea.*

■ "My father was my inspiration in life," says Jean-Michel Cousteau, who offers an intimate look at the life of legendary explorer Jacques-Yves Cousteau at . . . */exploration/cousteau.*

■ What drives explorers? Are the risks worth it? Read "Why Explore?" in this issue and weigh in with your ideas at . . . */exploration/forums.*

PRIIT VESILIND, NGS STAFF

■ FOR INFORMATION

Internet: www.nationalgeographic.com

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GORDON WILTSIE

■ QUEEN MAUD LAND

Hanging Out in Antarctica—and Seattle

"I'd go anywhere with them again," says photographer Gordon Wiltsie (right) of his climbing team, the first to reach the summit of Antarctica's Rakekniven, "and I probably will. It's rare for climbers to work so closely on a project and still enjoy each other's company when it's done." Gordon, writer Jon Krakauer (above), and lead climber Alex Lowe will meet again, in Seattle, on February 20 at the University of Washington for a National Geographic lecture featuring Gordon's photographs of their adventure. Call 206-624-5677 for information.

RICK RIDGEWAY

■ REVOLUTIONS IN MAPPING

For Bob, Finding His Way Is Child's Play

"The first thing I do when I land in a strange place is buy a map," says freelance photographer Bob Sacha. He had one handed to him at a meet of the Chicago Area Orienteering Club. Bob, here contemplating his compass, joined more than 200 enthusiasts gathered for the outdoor competition, which combined swiftness of foot with navigational skills over unknown terrain.

"I didn't get too lost," he claims, recalling the demanding experience. "I was always reasonably sure I was still in Illinois."

"I've been in love with maps since childhood," admits Bob, whose friends recently helped him celebrate his 40th birthday with a series of maps detailing his life. New York State figured prominently: He was born in Buffalo, graduated from Syracuse University with degrees in both photojournalism and psychology, and now calls Manhattan home.

"I've gone around the globe," he says, "to photograph the world I dreamed about when I looked at maps as a child."

STEPHEN MALLON

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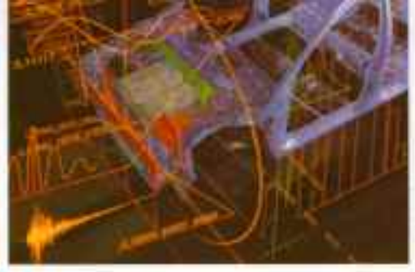



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