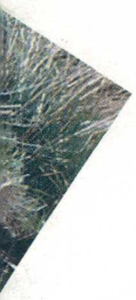
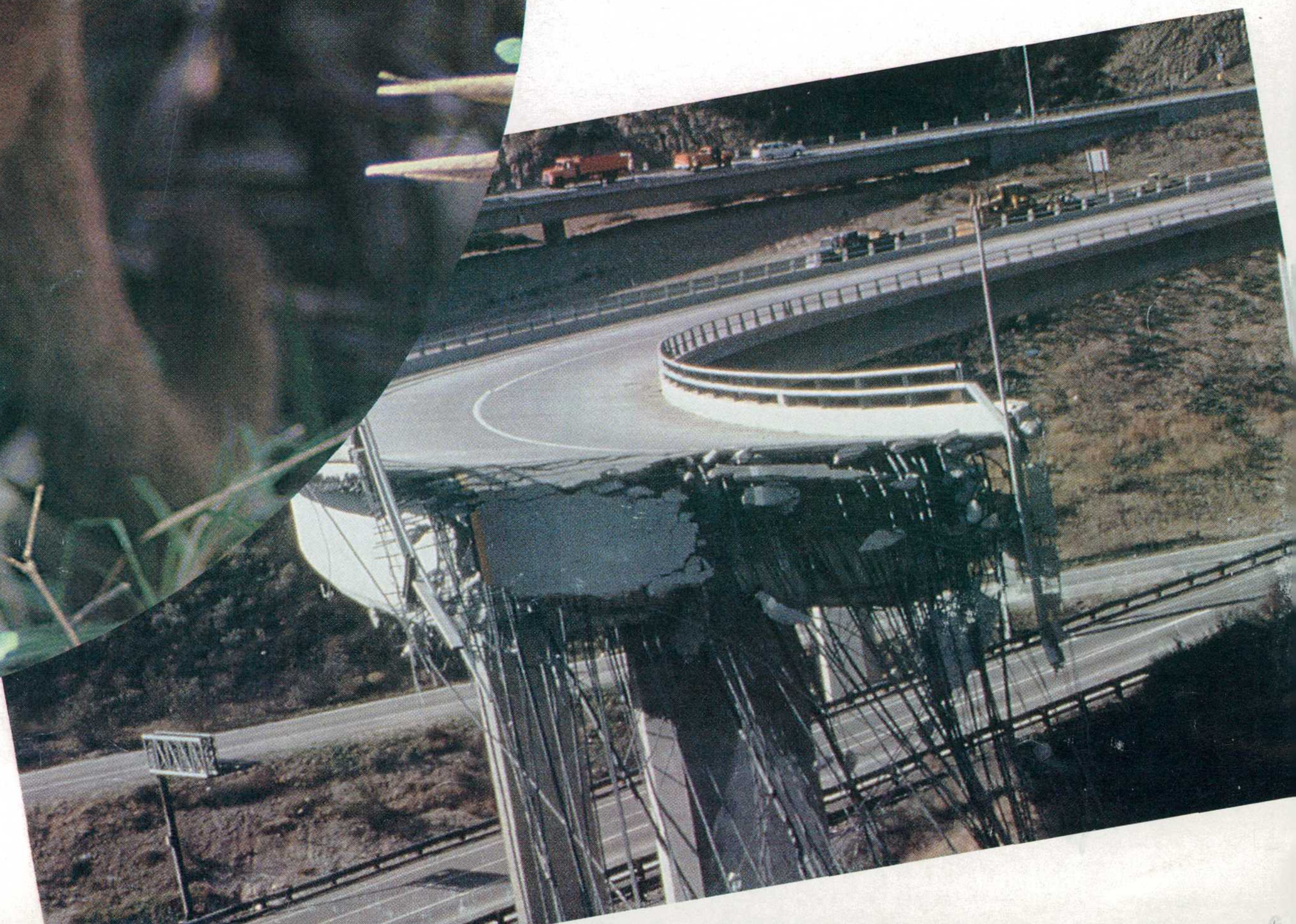
USGS
science for a changing world



Scientists in Action!

News about careers in the natural sciences —
from mapping the planets to sampling the ocean floor,
from protecting wildlife
to forecasting volcanic eruptions.



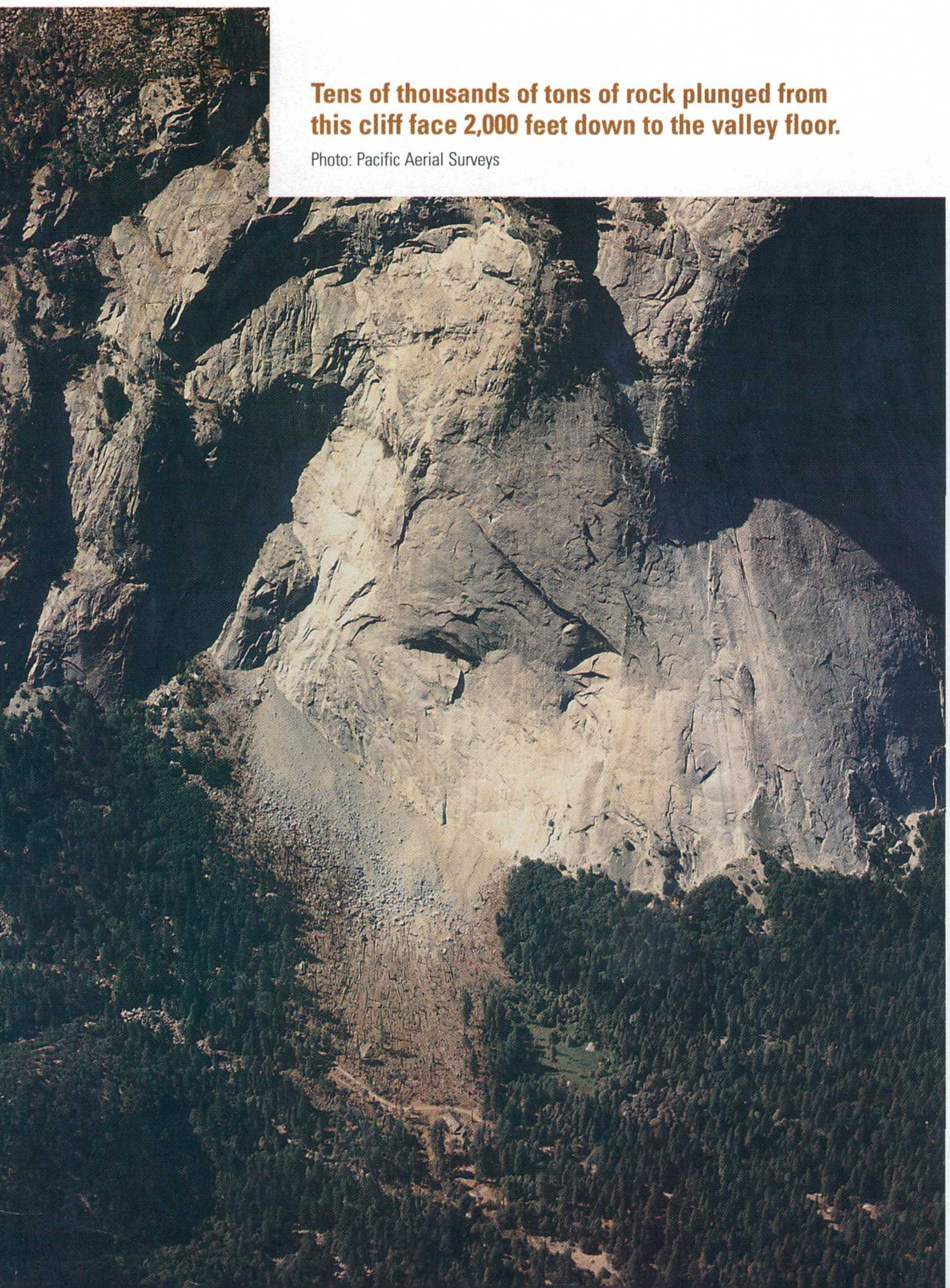
When a natural disaster threatens or occurs, scientists are among the first people to respond. While the first priority is to save human life, the next is to understand as much as possible about what happened in order to prevent or minimize the harm from future natural hazards.

Rockfall
Yosemite National Park
July 10, 1996

Trail worker Ernie Milan was out for a jog in Yosemite National Park, Calif., when he heard a loud boom. He thought a jet airplane was about to crash. Then dust started swirling around him like a tornado. Milan took cover by hugging a cliff wall. Day turned to night.

The sound and dust were caused by two massive rockfalls that occurred just seconds apart at a site in the park called Happy Isles. A giant slab of granite weighing nearly 70,000 tons fell from a cliff face more than 2,000 feet to the valley floor. As the slab hit the ground, it created a massive air blast and a dust cloud full of sharp rock particles. The air blast and billowing dirt knocked over trees, killing one person and seriously injuring several others.

When Disaster St



Tens of thousands of tons of rock plunged from this cliff face 2,000 feet down to the valley floor.
Photo: Pacific Aerial Surveys

Gerald Wieczorek of the U.S. Geological Survey (USGS) estimated that the slab of rock was traveling more than 250 miles per hour when it hit the ground. Wieczorek is a geological engineer. He was on the team of scientists who went to the park to document what happened, before wind and weather could erase the evidence. Most geologists look at how rocks formed, what minerals they contain, and where particular rocks exist. In contrast, a geological engineer is an expert in the mechanics of rocks. Wieczorek explains, “In this case, what was it about the rocks that made them slide? What qualities [of the rocks] contributed to the dynamics of the situation?” Other members of the investigating team included scientists who study aspects of volcanic eruptions, such as dust clouds and air blasts.

Jim Snyder, now the park historian for Yosemite, contributed another expertise. Snyder worked for many years in the park’s back country and often encountered the debris and damage from rockfalls on park trails and roads. As a result, he became interested in rockfalls and researched both historic and prehistoric slides at Yosemite. His study revealed that rockfalls are common in Yosemite, but a slide accompanied by a massive air blast had happened only once before, in 1872.

As Snyder wrote in *Yosemite* magazine, rockfalls are a natural part of Yosemite. There is no way to prevent rockfalls in Yosemite’s mountainous terrain or to forecast precisely when they might occur. But understanding the history and mechanics of the rockfalls at Happy Isles can help identify where a rockfall might happen elsewhere in the park.

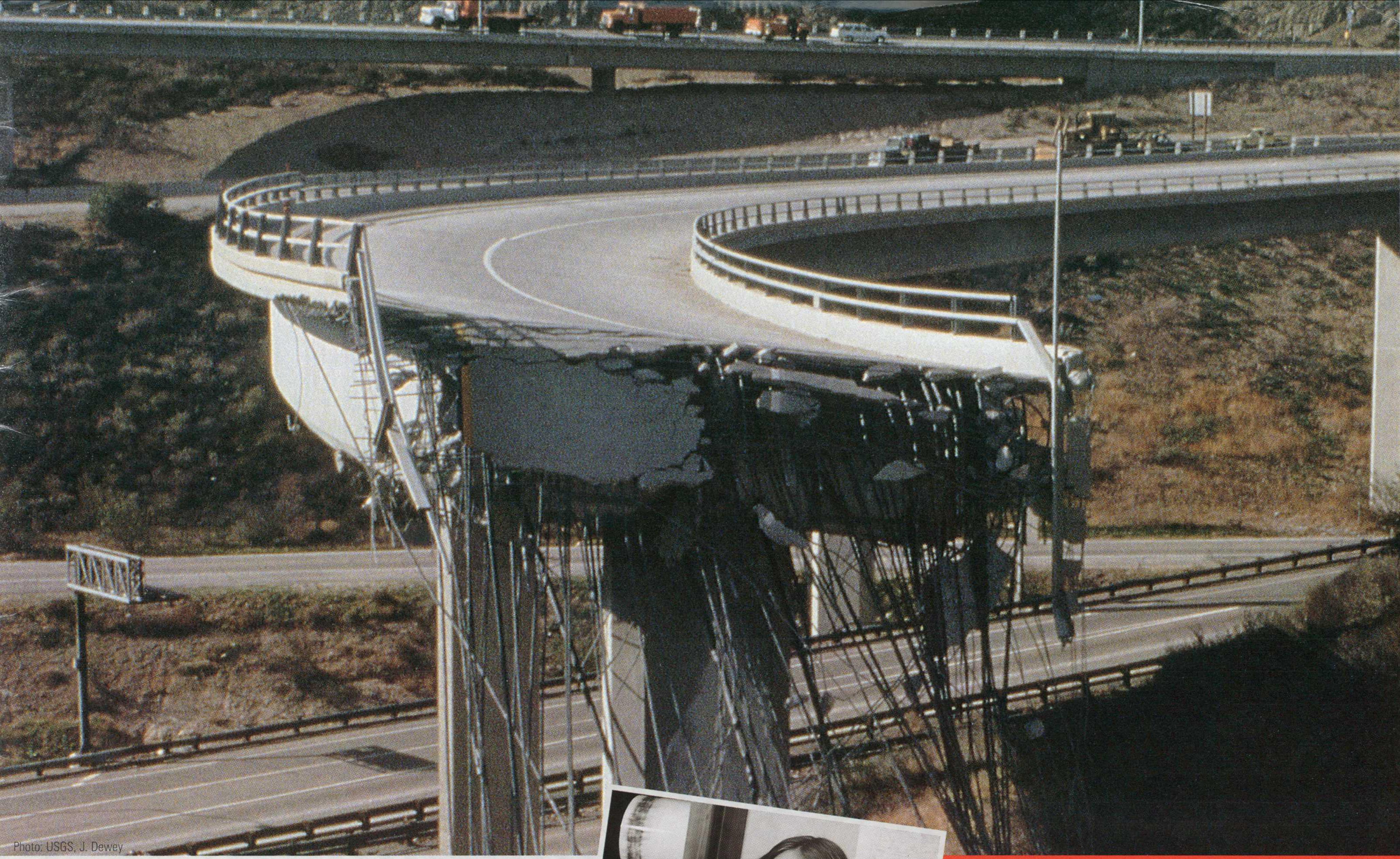


Photo: USGS, J. Dewey

Above: Collapsed freeways symbolized the Northridge earthquake more than any other type of damage.

Inset: Seismologist Lucy Jones fields questions from the press about an earthquake that struck Landers, Calif., in 1992.

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Earthquake
Northridge, California
January 17, 1994

At 4:31 a.m. on January 17, 1994, some 10 million people were shaken awake by an earthquake. The Northridge earthquake collapsed buildings, ruptured gas lines, and toppled freeways. The 6.7 magnitude quake killed 57 people, injured more than 9,000, and displaced more than 20,000 people from their homes.

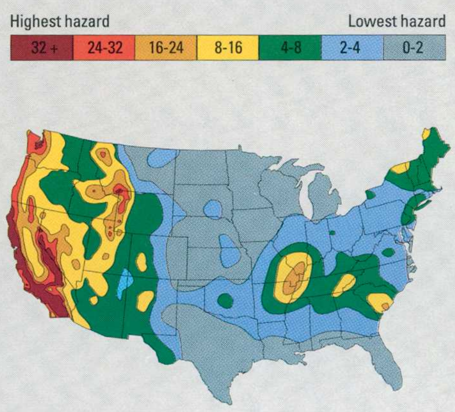
Within minutes of the main shock, earthquake scientists were analyzing data and dispatching information about the quake to emergency response agencies. "When I felt the earthquake, I jumped out of bed, threw on clothes, and came in. When you feel an earthquake, you run in," recalls Lucy Jones, a seismologist at the U.S. Geological Survey (USGS). Jones is Chief of the USGS field office in Pasadena, Calif., the office that operates the network of seismic instruments that monitors earthquakes in southern California. Seismic instruments detect, measure, and record the vibrations that travel through the Earth and over its surface when an earthquake happens.

"I spent the whole day in what we call the operations center dealing with a variety of tasks," Jones explains. "One was talking to the media. And one was tracking aftershocks." Smaller earthquakes called aftershocks, which also can cause damage, especially to buildings and other structures weakened by the initial shock, usually follow a major earthquake. Jones, an expert in earthquake statistics, estimated the probability of damaging aftershocks and where they would most likely occur. This information was of vital importance to emergency service agencies that were coordinating and dispatching response teams.

Many other scientists quickly began collecting and analyzing data to learn how to reduce hazards from future earthquakes. It is unfortunately true that the best laboratory for studying earthquakes is an actual earthquake.

Daniel Ponti is a USGS geologist who studies the surface effects of earthquakes. On the day after the earthquake, Ponti recalls, "I spent most of the day in a helicopter doing reconnaissance work from the air." He was looking for where, or if, the fault — the fracture in the Earth's crust that caused the earthquake — had ruptured the surface. When a large fault ruptures and produces an earthquake, it usually causes ground cracks that displace the foundations of buildings, fracture swimming pools, and rupture water and gas pipelines. Knowing where the greatest damage was concentrated could help Ponti and his team of geologists locate the fault.

Ultimately, Ponti and other scientists determined that the earthquake was caused by a hidden fault, called a blind thrust fault, which did not rupture the surface. The minor ground cracks were caused by shaking produced by the earthquake. Ponti and his team also dug trenches in the areas where the greatest damage occurred and looked for evidence of past earthquakes. Their investigation uncovered cracks left by two earthquakes that occurred during the past 1,300 years. Because these cracks were remarkably similar to the surface cracks caused by the Northridge earthquake, the geologists concluded that the two older earthquakes most likely occurred on blind faults as well. This information is helping geologists locate other blind faults as they study the region's earthquake history, which will improve their ability to forecast where future earthquakes might strike.



As this map shows, California is not the only place at risk from earthquake damage. Architects, engineers, and land use planners throughout the country use these maps to assess earthquake risks when planning buildings and other structures.

Floods
California
Winter 1998

The first 2 months of 1998 were the wettest on record for the continental United States. California was particularly hard hit. As heavy rains pounded the northern and central parts of the State, U.S. Geological Survey (USGS) technicians hurried to swollen streams to measure streamflows and to determine how much more water streams can handle. Collecting measurements can be risky as technicians lean precariously over bridges or hang from small cable cars suspended above swollen streams. According to USGS hydrologic technician William Boults, "You are about 15 feet above the raging waters in a cable car with a 100-pound weight, your feet dangle over the water . . . it can get scary."

When a flood threatens, field technicians are the critical link in getting accurate information to flood forecasters so that they can estimate the timing and size of the flood. To make their calculations, flood forecasters need to know two things about a river: the river stage (the height of the water) and the river discharge (the volume of the flow of water as it moves past a fixed point in a given time period). The stage is measured continuously at a stream-gaging station located on the river. More than half of the Nation's gaging stations are equipped with satellite radios that transmit river stage data every 4 hours to the USGS, the National Weather Service, and other agencies. Extremely high water triggers instantaneous emergency transmissions.

River discharge is more difficult to measure than river stage. To determine discharge, hydrologists, scientists who study the Earth's water systems, need to know how much water the stream's channel can carry. The capacity of the stream channel can change, so streams must be measured often, especially during high flow periods when the channel is most apt to change. During periods of high flow, field crews must go to stream-gaging stations to measure the river discharge.

Although Boults and other hydrologic technicians spend a great deal of time in the field, they probably spend more time in their offices compiling and summarizing data, which are interpreted by hydrologists. To do their work, hydrologic technicians use computers and sophisticated electronics, including data logging and recording systems, satellite radios, and global positioning systems (GPS). A college degree is not required to become a hydrologic technician, although many technicians have at least a 2-year technical degree.

How Often Does a 100-Year Flood Happen?

Unfortunately, the term "100-year flood" is misleading because it leads people to believe that the flood happens only once every 100 years. The term "100-year flood" is a statistical designation, and there is a 1-in-100 chance that a flood this size will happen during any year. Sometimes we get big floods in successive or nearly successive years.

Scientists R

Inset: A hydrologic technician hangs from a cableway to make stream measurements.

Below: Every year, rivers flood in many different parts of the country.

Photo: Randy Hayes, Idaho Falls, Idaho

Photo: Ed Wolfe, USGS/CVO

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Photo: J.N. Marso, USGS/CVO

Above: Mount Pinatubo after its major eruption on June 15, 1991.

Inset: Plume from a smaller eruption, July 1991.

Volcanic Eruption
Mount Pinatubo
June 15, 1991

The eruption of Mount Pinatubo in the Philippines on June 15, 1991, was one of the largest volcanic eruptions in this century. It could have killed or injured tens of thousands of people, but fortunately the eruption injured fewer than 500. About 1 million people, including some 20,000 American military personnel and their families at two U.S. military bases, lived near the volcano. Because volcanologists with the Philippine Institute of Volcanology and Seismology and the U.S. Geological Survey (USGS) forecasted the eruption, civil and military leaders were able to evacuate people in time, saving thousands of lives.

John Ewert was among the 23 USGS scientists and electronics and computer specialists on the joint Philippine-American team. One of Ewert's responsibilities was to install telemetered tiltmeters on the volcano. These instruments transmitted data to the scientists headquartered at Clark Air Force Base so that they could monitor changes in the volcano's shape. Ewert explained that as magma rises in a volcano, it changes, or deforms, the volcano's shape.

When asked what type of scientist he is, Ewert responded, "I guess I am a geologist. No, I guess I am a volcanologist." He further explained that volcanology is "highly interdisciplinary." It includes geochemistry, stratigraphy (layers of rocks), geophysics, and the subdisciplines of geophysics such as seismology (movements in the Earth's crust). "And there are lots of things we do that require a facility with electronics — from knowing how to solder two wires together to troubleshooting circuitry."

Ewert has an undergraduate degree in geology and has completed 2 years of graduate study. "Experience," he explains, "is kind of how I got into what I am doing. I finished my undergraduate degree in 1980 when Mount St. Helens erupted, and I was hired several months later. Over a period of 4 years I did everything from airborne gas monitoring, to deformation studies of the volcano's crater, to hydrologic monitoring of the streams around the volcano. There is really no substitute for that kind of experience. You don't go to a university and major in erupting volcanoes."

Rick Hoblitt, another member of the team, was an organic chemist before he earned a doctorate in geology. As part of the team at Mount Pinatubo, Hoblitt examined and mapped deposits left by past eruptions to anticipate what types of eruptions were likely to happen and the areas that were likely to be affected. "Really what I see as my chief role in these crises is data synthesis, interpretation, and then communication of that synthesis."

With the information they collected, Rick Hoblitt, John Ewert, and the other scientists were responsible for predicting if a catastrophic eruption would occur and when an evacuation should be ordered. The stress was intense. More than 10 days before the major eruption, Hoblitt wrote in his diary, "Activity at vent is up. More ash is coming up, some puffs to 1,000 feet above the summit. Dave, Andy, John, and I discuss the situation after breakfast. We're not sleeping well because of nerves. Is it possible that a catastrophic eruption could occur with no warning? I think that this is possible. Depressing subject." Hoblitt was afraid that they wouldn't be able to forecast an eruption in time to save lives. Fortunately their timing was correct.

More information on natural hazards is on the USGS Web site at www.usgs.gov/themes/hazards.

Former Spy Plane to the Rescue

The U-2, a plane that used to fly reconnaissance missions over the former Soviet Union, has been modified by NASA to gather data to help forecast brush fires and spot toxic wastes. Renamed the ER-2, the plane is equipped with an imaging spectrometer, an instrument that measures the wavelengths, or spectrum, of light that a material absorbs or reflects. Every material from gold to tree bark absorbs or reflects light differently, so it has a unique spectral signature — just as every human being has a unique fingerprint.

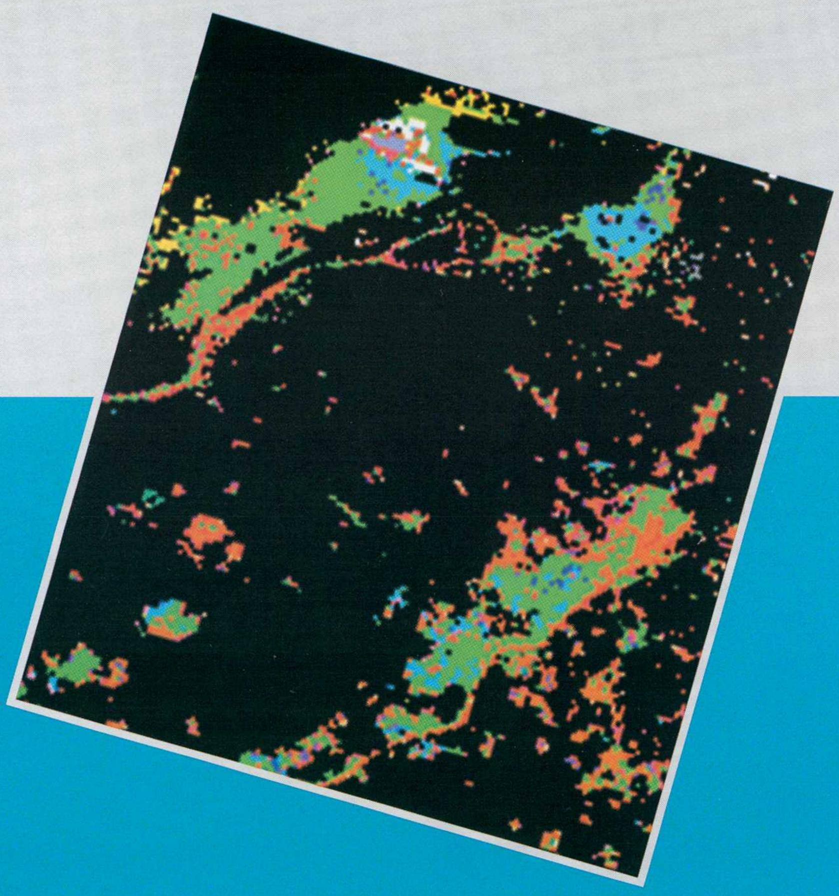
"Your eye is a crude spectrometer," explains Roger Clark, a scientist at the U.S. Geological Survey (USGS) Spectroscopy Lab. "The colors that our eyes sense are due to the absorption bands in materials." For example, a leaf looks green because it contains chlorophyll, which absorbs a particular band of light that we see as green. Our eyes, however, cannot see all wavelengths of light. The imaging spectrometer expands the capability of our eyes.

The measurements made by the spectrometer can be used to locate any natural or manmade material, ranging from minerals at old mine sites to microorganisms in hot springs to moisture in plants. The data are then used to produce maps like the one on this page. Each color on the map represents a specific mineral. These minerals came from waste materials that were left behind from mining operations in the area around Leadville, Colo. Some of the waste materials are rich in minerals that can be a source of contamination to rivers and streams. Because the map pinpoints the exact location of the minerals that can cause problems, cleanup efforts can be carried out more efficiently and cost effectively.

This new mapping technique is also helping scientists to forecast brush fires in the Santa Monica Mountains. Fires that start in these mountains can spread to nearby communities. "In the case of the Santa Monica Mountains, we are measuring the presence of molecules such as chlorophyll, leaf water, and cellulose. By measuring these molecules, we can map different vegetation patterns, all of which play a role in predicting wildfire hazards," says Robert Green, a scientist at NASA's Jet Propulsion Laboratory (JPL) where the airborne spectrometer was developed. The computer software used to analyze the data and produce maps was created by Roger Clark at the USGS.

An imaging spectrometer is also helping to map our solar system. Clark, who is a planetary scientist and an expert in mineral and vegetation mapping, is a team member on several spacecraft missions. The spacecrafts orbiting Mars and the satellites of Jupiter as well as the space probe on its way to Saturn are each equipped with an imaging spectrometer.

You can find out more about the USGS Spectroscopy Lab and see examples of the maps they produce at the Web site speclab.cr.usgs.gov. More information about how the imaging spectrometer works can be found at the NASA Web site, ophelia.jpl.nasa.gov.



Inset: Mineral map of waste rock from mining operations near Leadville, Colo. The map identifies those minerals that can contribute to water contamination. Blue, purple, and yellow colors show minerals that are of most concern. Areas in green are of less concern. Other colors represent minerals that do not contribute to water contamination.

Photo: NASA, Tony Landis

This ER-2 airplane is equipped with an imaging spectrometer that can take some 7,000 measurements per second while flying 20 kilometers (12 miles) above sea level and at a speed of 730 kilometers per hour (450 miles per hour).

Students Spark Frog Alert

Photo: USGS

This is a real frog. Its extra leg is one kind of malformation that the North American Reporting Center for Amphibian Malformations keeps track of.

Picture a sunny August day in the woods in Minnesota. It's not a day when you'd expect something unusual to happen. That's what a group of middle school students from the Minnesota New Country School who were on a nature-study field trip thought too. But what they discovered at a pond in the woods has alarmed environmentalists across the United States.

While they were walking to the pond, the kids caught some of the frogs that were hopping about. At first the class thought that someone had broken the legs on many of the frogs, because the legs weren't bending the way frogs' legs should. Then the students realized that half of all the frogs they had caught were malformed in some way. Instead of four legs, some frogs had three or five. Some had too many feet.

Back at school, the students posted their experience on the Internet and also contacted Judy Helgen, a research scientist at the Minnesota Pollution Control Agency. Helgen wanted to understand what was causing the frogs to be born with deformities, especially if the cause could be harmful to people too. Like the ripples on a pond when you throw in a rock, the story of malformed frogs got bigger and bigger. When an article about the students and Helgen was published in a local newspaper, people across Minnesota began calling her to report finding malformed frogs. Helgen realized that the problem was much more serious than a few frogs in a little pond in the woods.

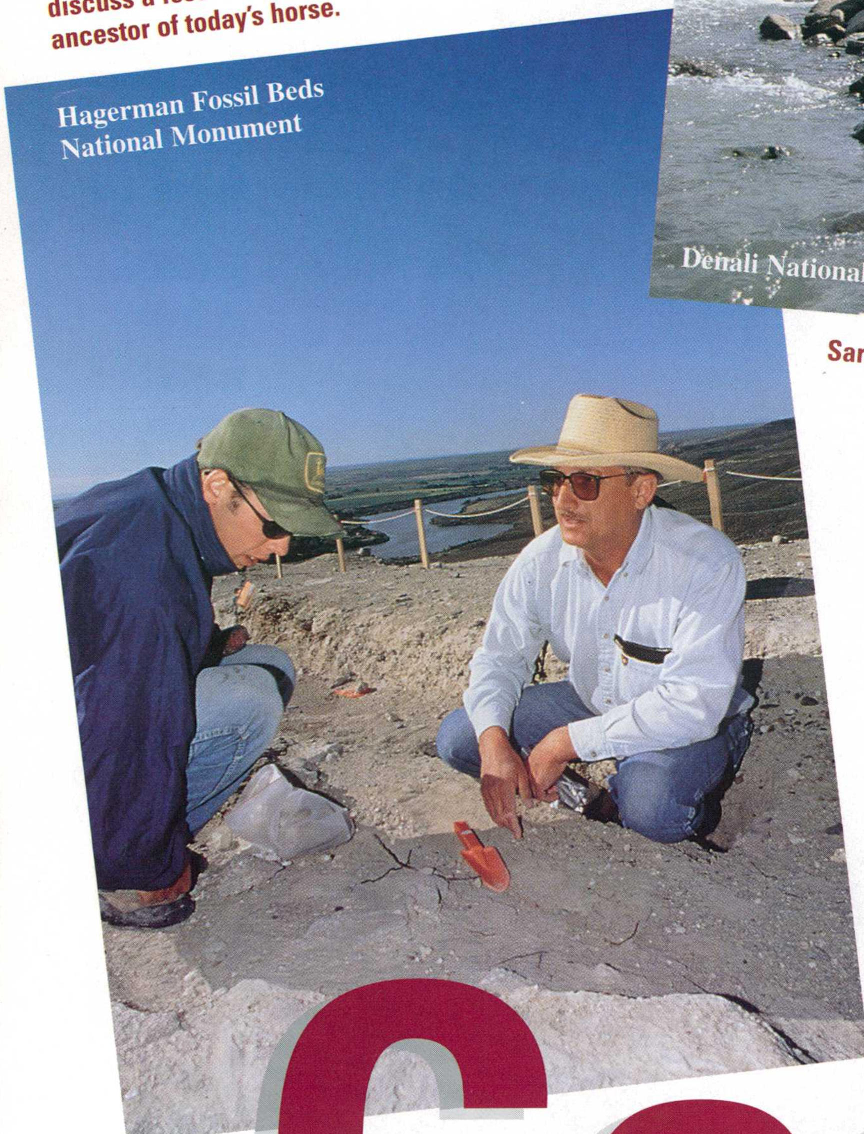
Other people realized that too. Scientific meetings were held to discuss the frogs. Then the U.S. Geological Survey (USGS) Northern Prairie Wildlife Research Center in North Dakota set up the North American Reporting Center for Amphibian Malformations (NARCAM) to receive reports of frog malformations from anywhere in the United States and Canada. People who found malformed frogs or other amphibians, such as salamanders, could report them to a Web site (www.npwrc.usgs.gov/narcam) or could call 1-800-238-9801. Suzanne Fowle, a biological technician, was a coordinator for NARCAM and one of the first people to take reports by phone. She said that a certain number of frogs in the wild are always deformed in some way, but the proportion of deformed frogs that the Minnesota students found was much too high. She explained that if a report of deformed frogs was serious enough, the USGS would send out herpetologists (reptile specialists), toxicologists (specialists in poisonous chemicals), and parasitologists (specialists in organisms like bacteria or insects that live off of other animals) to investigate. Since the USGS asked people to look for deformed frogs in 1997, reports have come from 42 States and 2 Canadian Provinces.

No one has yet explained what's causing the frogs to be malformed, or why, as scientists have recently suspected, many populations of frogs around the world are decreasing. It's not even certain that the two problems are related. Although there could be several explanations for the frog malformations, the most likely causes, according to Judy Helgen, are chemicals in the water where the frogs live and increased levels of ultraviolet radiation, or even a combination of the two. Other possibilities are rising temperatures or harmful organisms, such as viruses, parasites, or bacteria. What worries everyone who deals with the frog problem, however, is what worried Judy Helgen. Could whatever is damaging amphibians harm people too?

You can be a part of the search for malformed frogs. If you see any malformed frogs or other amphibians, visit the Web site to use the online reporting forms. If you do not have access to the Internet, call Jeff Jundt, the new coordinator at NARCAM, at the toll-free number listed above. Jundt also invites you to ask him questions about amphibians or reptiles and to visit the new and expanding online amphibian identification guide at the NARCAM site.

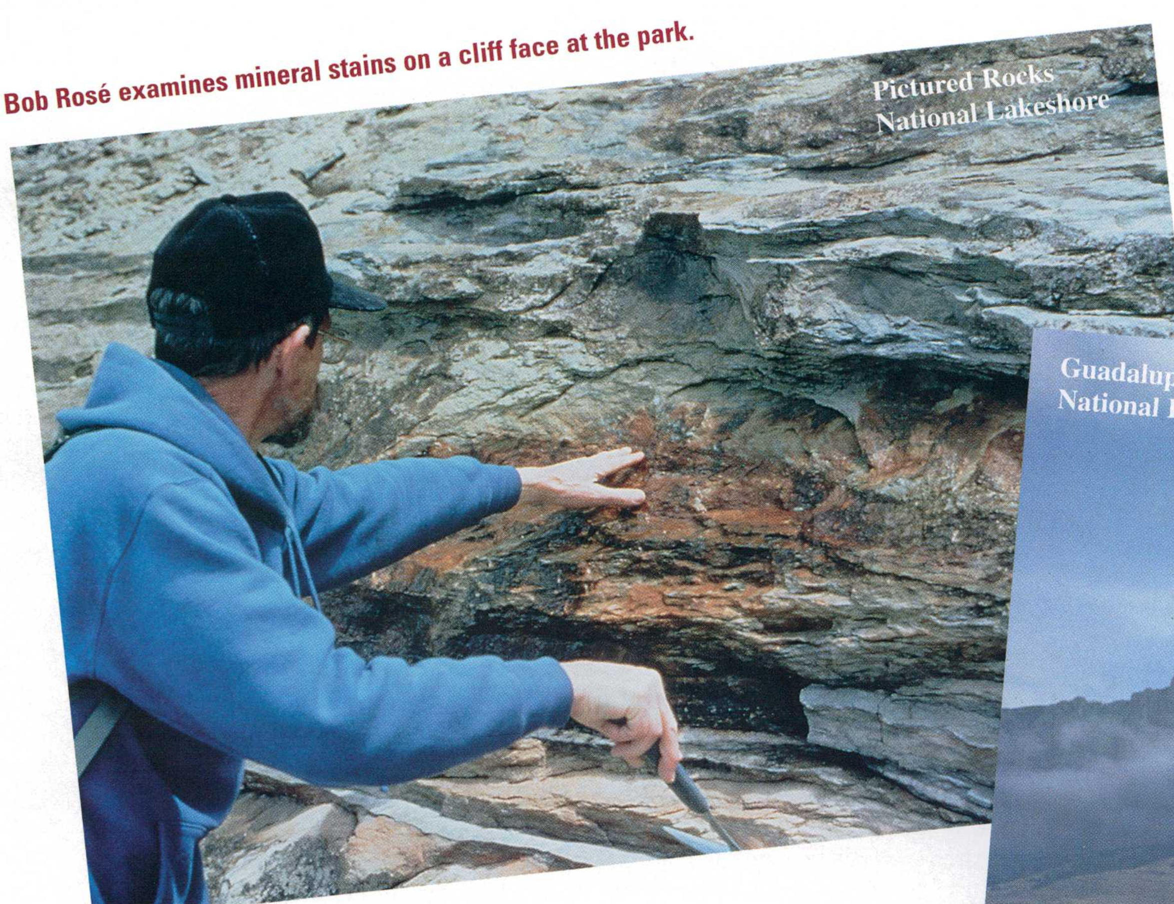
Geologis in th

Many of our natural parks are defined by their spectacular geology, such as the landforms of the Grand Canyon and the magnificent fossils in Dinosaur National Monument. Some show just how dynamic geology is, like the geysers in Yellowstone National Park. To help park staff understand and manage these resources, the National Park Service invites people to work for several months as geologists in the parks. Some positions are paid, and others are volunteer.

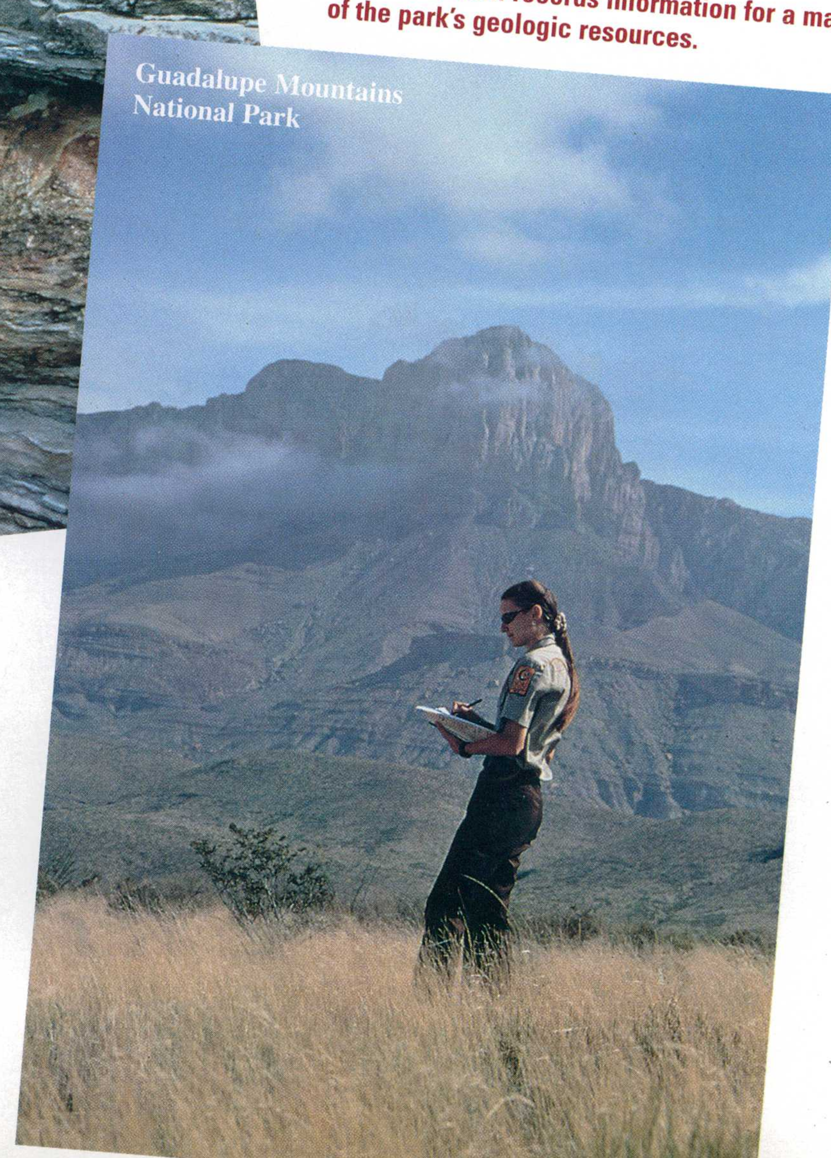


Bob Lorkowski (right) and another park geologist discuss a fossil of the Hagerman Horse, a zebra-like ancestor of today's horse.

Sara Schlichtholz collects a water sample at one of the park's streams.



Bob Rosé examines mineral stains on a cliff face at the park.



Jessica Cundiff records information for a map of the park's geologic resources.

Photos: National Park Service

Being a geologist in the parks is a great way for new earth scientists, like many of the people featured here, to get hands-on experience.

Jessica Cundiff, while an undergraduate geology major at Southwest Missouri State University, earned college credits for her work at **Guadalupe Mountains National Park** in Texas. The park contains parts of one of the Earth's largest fossil reefs. The reef formed approximately 250 million years ago when a tropical ocean covered parts of what is now Texas and New Mexico. Cundiff researched and wrote two pamphlets about the geology of the park. She also helped gather information for a road guide to the park's geology.

Catherine Impasto used her earth science degree from Dartmouth College to create exhibits and teaching materials about the geology of **Haleakala National Park**. Located on the Hawaiian island of Maui, the park is famous for its volcanic landscape filled with lava flows and cinder cones. Haleakala last erupted in 1790, but as Impasto explains, "Most people think that Haleakala is dormant and probably won't erupt anytime soon. But they're probably wrong." One of the displays that Impasto produced shows visitors what past eruptions of Haleakala looked like and what geologists believe future eruptions might look like.

Bob Lorkowski is usually teaching high school physics, chemistry, and earth science, but has recently spent several summers doing field work at **Hagerman Fossil Beds National Monument** in Idaho. The park is most famous for its fossils buried in cliffs that rise 600 feet above the Snake River. Lorkowski, who has a master's degree in geology, has been studying and making maps of six of the cliff's rock layers. Lorkowski does his field work in the park over a month-long period. He then returns to his home in California to analyze rock samples under the microscope and to write his reports. He anticipates that his research will require a total of six summers before he completes it.

Johanna Lombard was a volunteer at **Sunset Crater Volcano National Monument** near Flagstaff, Ariz. While a volunteer, she designed a previsit information packet for teachers. The packet covers seismology (the study of earthquakes), volcanology (the study of volcanoes), and plate tectonics — topics teachers will use to explain how the park's volcano, Sunset Crater, formed.

Bob Rosé, a retired petroleum geologist, brought a great deal of experience to **Pictured Rocks National Lakeshore**, located on the shore of Lake Superior. The park gets its name from a wall of rock that has been sculpted into caves and from arches that look like castles and fortresses. From looking at the park's geology and reading about it in the scientific literature, Rosé sketched what the park would have looked like 500 million years ago. His findings were so intriguing that the park asked Rosé to help design major changes to the displays in the visitors center. Rosé says, "The time I spent in the park was one of the best experiences of my life!"

Sara Schlichtholz, a recent geology graduate from the University of Montana, created a database of the fossils in Alaska's **Denali National Park**. Schlichtholz explains, "Basically, I sorted through close to 40 years of documents to squeeze out information on what fossils occur in the park and where they occur." She organized more than 800 records and plotted more than 200 localities on a park map. Now researchers needing information on the park's fossils can find it quickly.

Schlichtholz, however, did not spend all her time at the computer. "You can only spend so much time behind a computer when one is in Denali! I jumped onto whatever project had room for me. I helped gather hydrologic data from streams and installed survey markers around a glacier," she remarks.

You can reach the Geologist in the Parks Program at www.nature.nps.gov/grd/geojob.htm.

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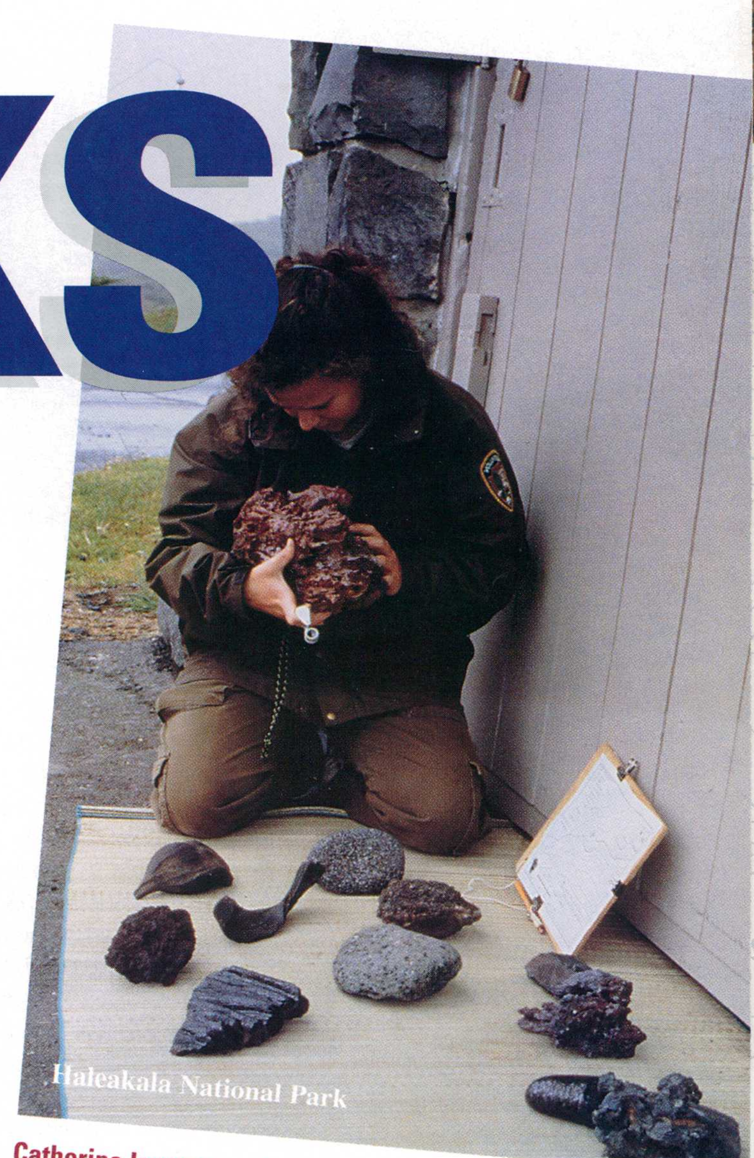
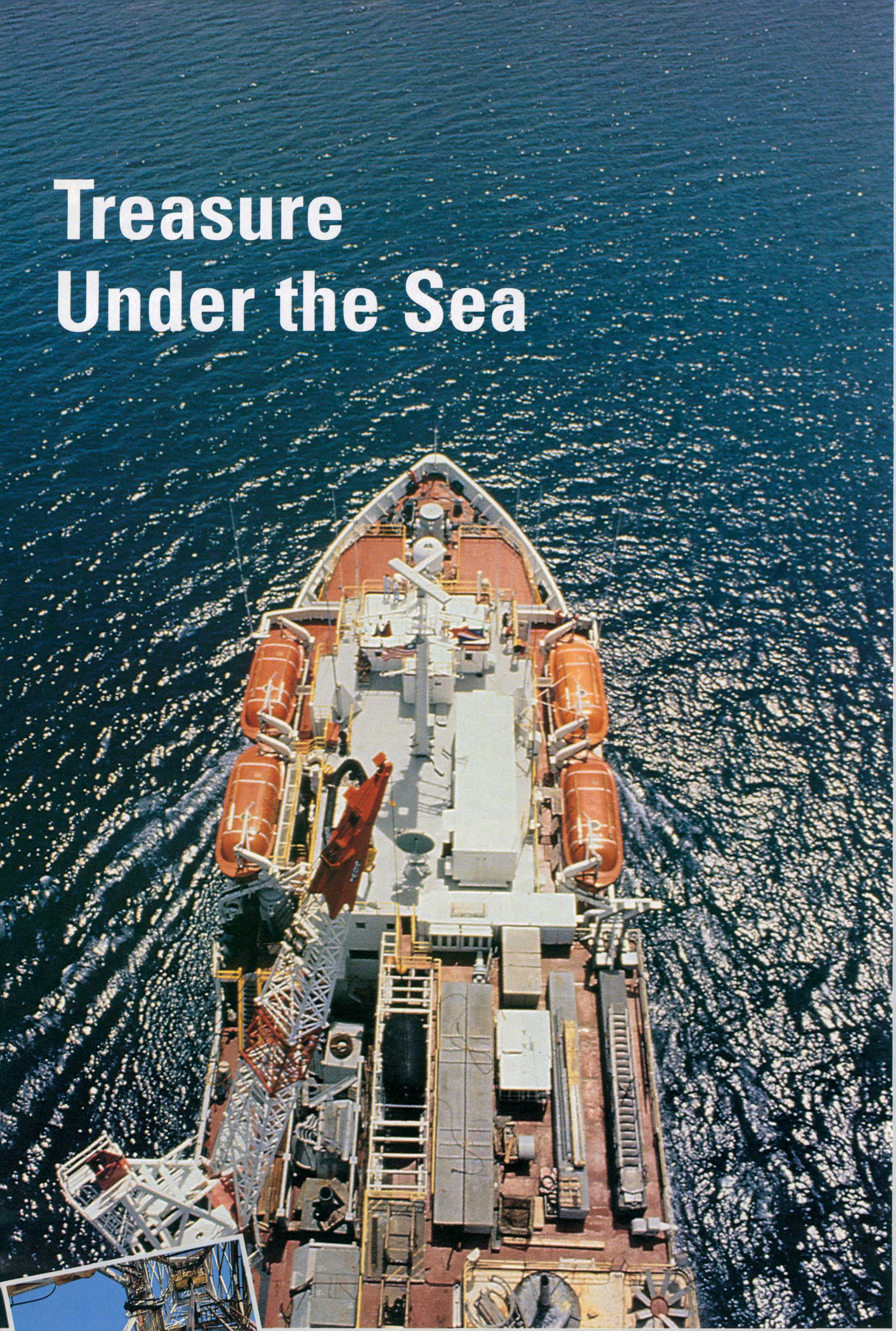


Catherine Impasto sorts volcanic rocks for a "Rock Box" she designed for local teachers to show to students before they visit the park.

Johanna Lombard helps out in the visitors center.

Treasure Under the Sea



The *JOIDES Resolution* was converted in Pascagoula, Miss., in the fall of 1984. She was built in Halifax, Nova Scotia, in 1978 and had previously sailed the world as a top-class oil-exploration vessel.

Photos: ODP/TAMU Photography Department

The ship can deploy up to 30,000 feet of drill string.

Sometimes in order to understand what's happening on the Earth, you have to go to the bottom of the ocean. By drilling a core — a column of rock and sediment — out of the ocean floor, you can learn about the Earth's past and present. If you look in the right place, you may even be able to understand what wiped out the dinosaurs 65 million years ago. That's what the drilling ship *JOIDES Resolution (JR)* did in 1997.

Brian Huber, a micropaleontologist, was on board the *JR* off the coast of Mexico the day the dinosaur-age core was brought up from 420 feet below the ocean floor. He and other scientists on the ship were looking for evidence that a giant asteroid hit the Earth just before the start of the "Great Extinction," when dinosaurs and many other species vanished from the Earth.

The Great Extinction marks the end of the Cretaceous and the beginning of the Tertiary periods of geologic time, known as the K-T boundary, Huber explains. If an asteroid hit the Earth at that time, it would have thrown great clouds of rock and ash into the air. The clouds would have chilled the Earth for so long — a phenomenon similar to nuclear winter — that many plants and the animals that depended on them for food would have died. The rock and ash would have rained down on the Earth and filtered down to the bottom of the ocean for a long time afterwards. If this scenario is correct, then an ocean core that dates from the time of the K-T boundary should have a telltale layer of material thrown up from the site of the impact.

Because Huber studies microscopic fossils to learn about the Earth's history, he was looking for something additional in the K-T boundary — foraminifera. Forams, as they're nicknamed, are single-celled organisms with distinctive shells. Billions and billions of forams have lived in the ocean for 550 million years. Tertiary forams look very different from Cretaceous forams, most of which died in the Great Extinction.

Huber describes the recovery of the K-T core: "We had gathered on the deck when we thought the next core to come up would contain the K-T boundary. When the core was pulled out, a cheer went up because we could immediately see the dramatic change from white Cretaceous chalk to dark gray pebbles from the asteroid impact to light gray Tertiary chalk."

Under a microscope, the forams in different parts of the core were different too. "Based on the age of the core and the age of the dinosaur extinction," Huber adds, "we know that the impact and extinction occurred at the same time. We call the impact 'one bad day' because so much destruction happened so fast. The asteroid was probably going about 35,000 miles an hour when it hit the ocean near what is now the Yucatan peninsula in Mexico."

To become a micropaleontologist, Huber studied geology along with chemistry, physics, and paleontology. He first studied microfossils in Antarctica where, in the ice and cold, he found the remains of a climate that had been warm enough for forests and dinosaurs. His work on the K-T boundary got him the berth on the *JR* cruise.

The *JR* makes six 2-month research trips around the world each year for the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES), sponsored by 22 countries including the United States. Each trip addresses a different set of scientific issues, such as plate tectonics, global climate change, and sea level change. The ship is staffed by 25 scientists, 20 engineers and technicians, and 65 crew members and drillers. Everybody on board works 12-hour shifts.

Directing the Ocean Drilling Program, which sponsors the *JR*, is Kate Moran. She studied civil engineering and then ocean and geological engineering and did research on the geology of the ocean floor. Now she "makes sure" the *JR* fulfills its scientific missions and continues to teach us about the Earth's history.

You can read more about the recovery of the core that showed the K-T boundary at the "Blast from the Past" Web site from the Smithsonian Museum of Natural History, www.nmnh.si.edu/paleo/blast. You can follow *JR's* world travels at the JOIDES Web site, www.joi-odp.org.

Mapping the Grand Canyon

Answer true or false: To draw a map of an area, you have to visit it first. If you are John Wesley Powell mapping the route of the Colorado River through the Grand Canyon in 1869, the correct answer is "true." You will need to convince a group of nine others to risk their lives with you on the first trip ever taken through the canyon. You won't know how far you're going, how long your trip will be, or what dangers lie around the next curve of the river.

Today, however, thanks to computers and airplane and satellite photography, the correct answer is "false." To make a map of an area, you never need to leave your office. The tens of thousands of maps that the U.S. Geological Survey (USGS) produces are made on computers by teams of specialists in the earth sciences, such as cartographers and geographers, and computer experts who often have no formal training in the natural sciences.

Because of computerization, maps can be devised to give enormous amounts of precise and specialized information. Collections of computer hardware and software known as geographic information systems (GIS) can be used to produce complex maps that combine layers of data. Uses of GIS's range from protecting wetlands from pollution to forecasting a city's evacuation time in an emergency. Say there's a pond at the end of the street where you live. If you want to build a boat dock on the pond, you might want to know how big the pond becomes when it fills with rain in the spring and how small it becomes during summer dry spells. GIS experts can get this information for you by combining topographic and other maps with data that were collected during the past 35 years and were digitized to be usable in computers. The data come from photographs taken from airplanes and from other kinds of remote sensing, not from people going to the pond and measuring it.

Topographic maps are the most widely used maps the USGS produces and some of the first maps the agency produced more than 100 years ago when people like Powell had to visit an area to map it. Topographic maps show the shape and elevation of the terrain along with natural features like rivers and lakes. They put a three-dimensional picture on a two-dimensional surface. Engineers use topographic maps to plan highways and dams. Architects use them to design buildings that will complement a chosen site. Hikers and campers use them to plan their outings. Ecologists use them to protect fragile areas.

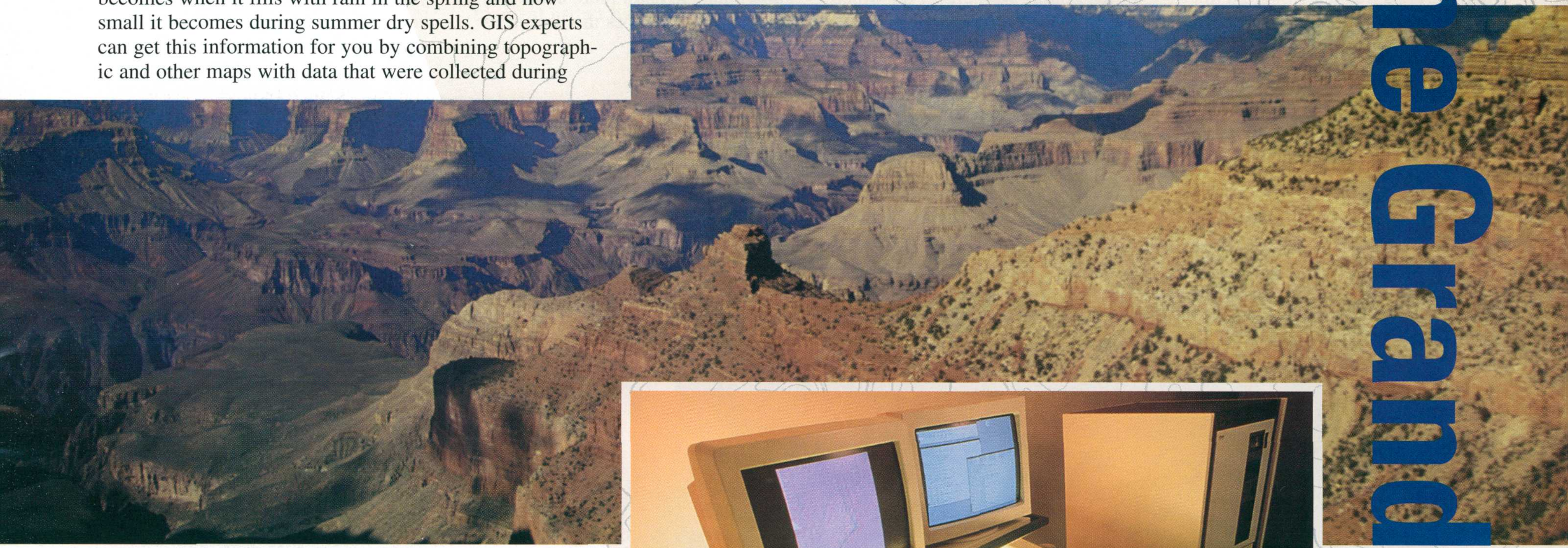
Most of the topographic maps that the USGS produces are on a scale of 1:24,000, which means that an inch on the map represents 2,000 feet — or slightly more than one-third of a mile — on the ground. At that scale, a map the width of this page represents about 4 miles on the ground. Each map covers 7.5 minutes of latitude and of longitude and covers 50 to 55 square miles. These maps are called 7.5-minute quadrangle maps. In order to be used in GIS's, existing topographic maps were scanned so computers could interpret the information. It used to take 4 to 5 years to produce a topographic map. Computers shorten that time enormously.

Maps and computers played an important part in a recent attempt to restore the appearance of the Colorado River through the Grand Canyon to something that John Wesley Powell might have recognized. Until the Glen Canyon Dam was built in 1963, the Colorado River periodically flooded. When it flooded, the river deposited tons of sand that maintained the beaches along its banks. Once the dam stopped the river from flooding, the beaches began to disappear from the lack of new deposits of sand. Hydrologists thought that a large release of water could help restore the beaches. Before they released the water, however, they made computer models to map the sand and water flow down the river. The torrents of water released down the river restored the stream banks almost exactly as the models had predicted. Success!

Get a Bird's-Eye View of Your Backyard

In June 1998, the USGS and Microsoft opened the "world's largest online database," called TerraServer. You can find an aerial photograph of almost any spot in the United States and zoom in on it until you can see individual houses. You can reach TerraServer at www.terraserver.microsoft.com

The photographs and drawings from John Wesley Powell's trip to the Grand Canyon were the first images of the Canyon's spectacular layers of rock, like the ones shown here. Powell's geologic maps helped the settlement of the American West and are still referred to today.



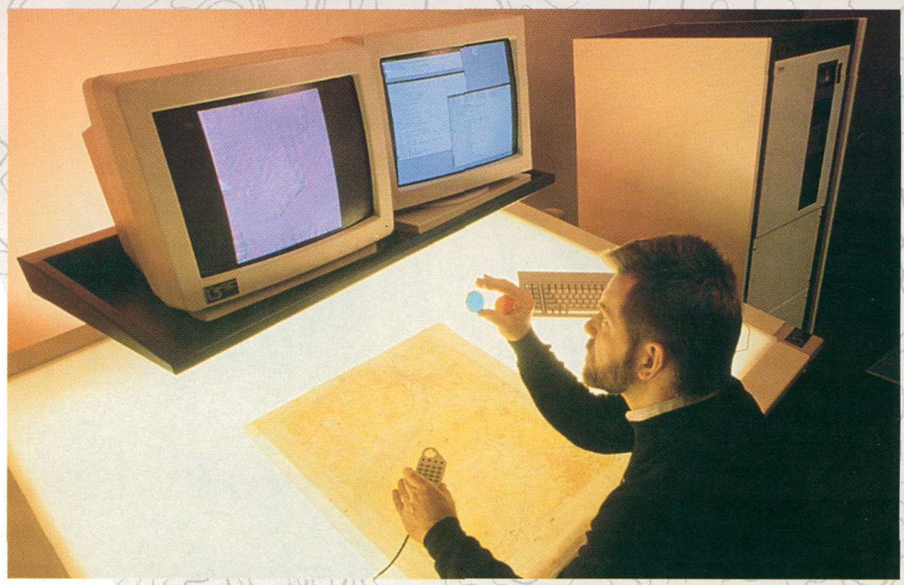


Photo: USGS

Powell's trip, made when the only way to map a place was to go there, was known as a survey. Today the USGS produces its popular topographic maps by using remote photography and computers.

The first white men to visit Yellowstone thought they had made a wrong turn into Hell. The air smelled like sulfur. Jets of boiling water shot into the sky, and everywhere on the ground were pools of steaming water and bubbling mud surrounded by splashes of red, yellow, and orange.

Fascinated by stories of Yellowstone, Ferdinand Hayden, a doctor and geologist who was partly responsible for the formation of the U.S. Geological Survey, set out in 1871 to see the area for himself. Hayden took with him a photographer and an artist so other people could see what he saw. For nearly 3 months on horseback and on foot, Hayden's expedition studied the Yellowstone region's spectacular variety of landscapes in Wyoming and Montana — the high falls on the Yellowstone River, the deep blue Yellowstone Lake, and the geysers and hot springs. On his return home, Hayden urged Congress to safeguard Yellowstone for everyone who wanted to visit it instead of letting it be owned by just a few people. As part of his argument, Hayden said that the mountains and valleys of Yellowstone probably didn't contain any valuable natural resources, and even if they did, Yellowstone was too hard to reach for anyone to get the resources out. Hayden was right about many things, but not about that. More than 100 years after it became America's — and the world's — first national park, Yellowstone is still the center of debates about how to use its natural resources.

Here is one of the debates. It's a big debate about something too small to see — the unusual microorganisms that live in the intense temperatures of the boiling hot springs for which Yellowstone is famous. Read the "pro" and "con" arguments about what Yellowstone is doing to manage research involving these special biological resources, decide which side you support, and then read what actually happened.

Pro:

The pools of steaming water and bubbling mud in the geyser section of Yellowstone are home to colorful colonies of microscopic organisms that thrive in temperatures close to 100° C. These microorganisms, called thermophiles ("heat-lovers"), make enzymes — proteins that speed up biological processes. Scientists are discovering that these enzymes can do remarkable things, such as help make beer, perfume, and paper, as well as make it easier to study the genetic material DNA. You want to conduct research in Yellowstone to see if you can discover anything new and valuable to society that some microbes might do. Your chances of discovering something useful are good because less than 1 percent of the microbes living in the hot springs have even been identified. The park also wants to learn more about the mysterious microbes that live in its 10,000 hot springs and suggests that you work out a cooperative research project with the park to study the microbes, where they live, and what they do. But such valuable research costs money. It also costs money to help preserve Yellowstone's hot springs and the still undiscovered life in them. You know that in the past some scientists were allowed to take some microbes from Yellowstone without contributing anything to the park. You also know that some of these scientists later made millions of dollars from the enzymes they discovered, but the park received nothing. You agree to contribute $100,000 to Yellowstone to help support the park's conservation work, and you'll also contribute a percentage of any profits you make from any research you conduct on the microorganisms you find. You promise to collect only very tiny samples while a park ranger watches what you do, and you'll share with park scientists what your company's microbiologists learn about the microbes.

Competing Treasures

Yellowstone Falls

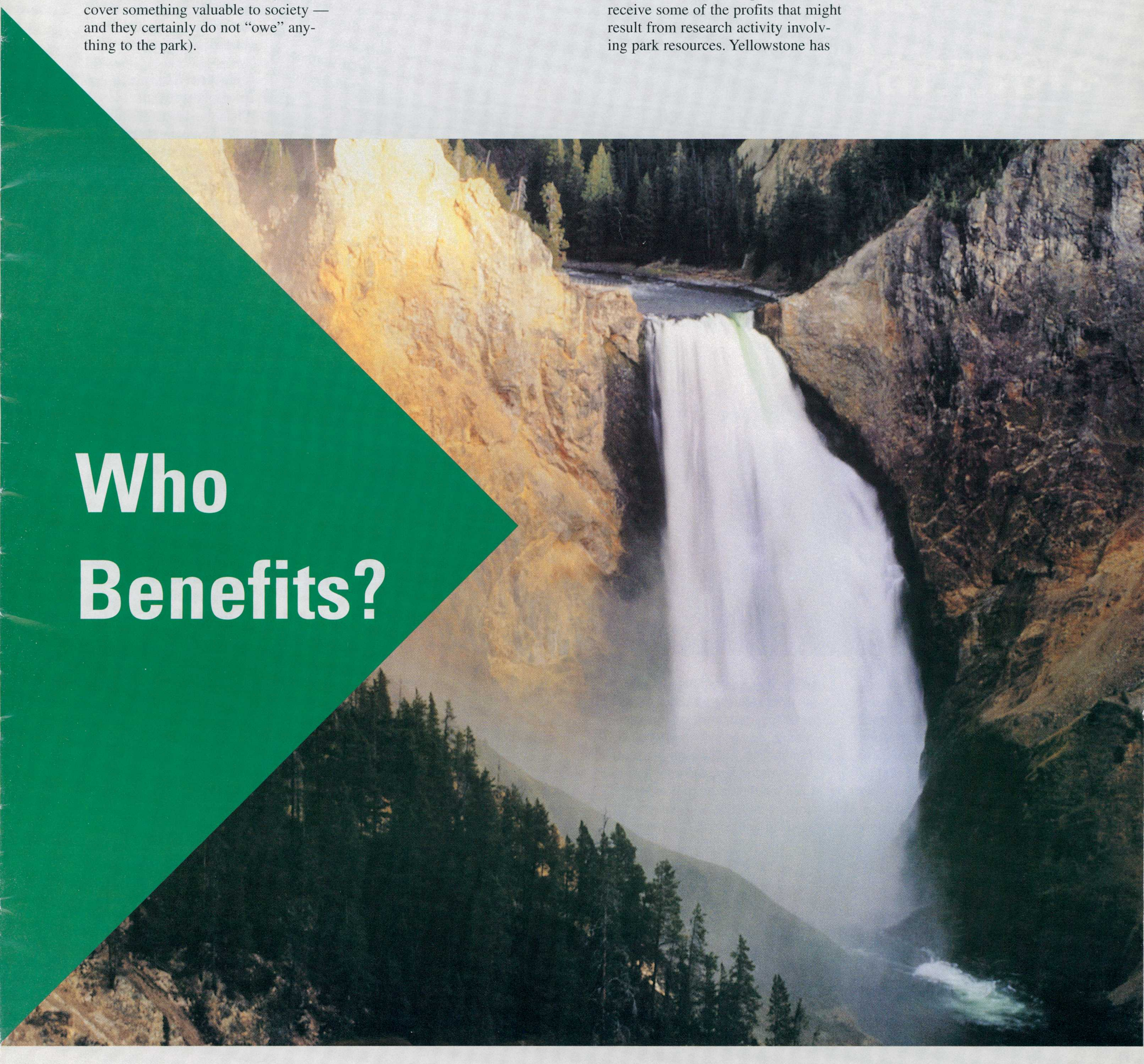
Con:

Yellowstone's designation as a national park means that no one should remove any of its resources for any reason — not minerals, plants, or animals, not even a single flower. Yellowstone should be left alone — even if someone might find a cure for a disease or something else valuable to society from research involving the microbes that live in the hot springs. Besides, if scientists are allowed to collect microorganisms from the park, who knows what resources will be allowed to be collected next? Suppose the sampling wiped out all the microorganisms forever? No one has done a study to see if that might happen. What if some of the organisms collected from the park were dangerous or unpredictable? If a company makes money from the thermophiles, what share of the money does the park deserve to receive? But if the park really needs more money to take care of its resources, let the taxpayers pay for it (scientists should not earn money from their research even if they discover something valuable to society — and they certainly do not "owe" anything to the park).

Outcome:

The National Park Service has signed a 5-year agreement with a company that wants to look for useful microorganisms at Yellowstone. The company has agreed to pay $100,000 to support Yellowstone's conservation work and up to 10 percent of the money it makes from any research involving microorganisms sampled from the park. The agreement does not affect other researchers' ability to collect and study microorganisms at Yellowstone, and the park still retains ownership of any microorganisms collected. While most conservation groups and park observers have applauded the agreement (noting that scientists who benefit from Yellowstone's conservation should contribute something), some others have said that the terms of the agreement were not completely open to the public and the effect on the environment hadn't been studied enough.

Yellowstone has explained that the first research permit for the collection of microbes at the park was issued more than 100 years ago and that Federal regulations for a long time have permitted scientists to collect samples of park resources for research as long as the resources were not harmed. In fact, most of what the park learns about the microorganisms and their hot spring environments comes from these types of authorized research projects (there are more than 100 research projects involving microbes at Yellowstone right now, and there is no way to learn about the microbes without collecting samples for study). The park also has pointed out that anything that could be "dangerous" resulting from research must be approved by the EPA or other regulatory agencies before it can be marketed. This is the first time that Yellowstone — or any park — has successfully negotiated a "benefit-sharing" arrangement with researchers so that the park will receive some of the profits that might result from research activity involving park resources. Yellowstone has released the full text of the agreement, including the range of royalty rates, but it has not released certain financial information that the researchers have claimed is protected under Federal law. U.S. Government scientists will closely monitor the project and evaluate data to determine future agreements. The agreement also is being studied by managers of other conservation areas around the world that protect valuable rainforests and other biological resources that are of interest to biotechnology and pharmaceutical researchers.



From Artist to Dinosaur Hunter

What creature sees like an artist, understands bones like a doctor, uses blow torches and plastics like an engineer, and spends summers in the Gobi Desert? A preparator. One like Amy Davidson. She is a preparator in the American Museum of Natural History's Department of Vertebrate Paleontology in New York City.

In the Paleontology Lab

"Today I'm working on a troodontid braincase." Davidson explains. "This troodontid is a small dinosaur about the size of a cat." She points to a small red rock with some bone showing. The bone is a skull fragment. Fiber-optic lights shine a ring on the small broken skull. "I'm using a hard carbide needle to remove the rock from inside the skull. That will expose the imprint of the brain." Opening a small drawer, she shows off a variety of needle points.

For larger fossils in harder rock, Davidson uses an air scribe — a minijackhammer that pecks away at the rock. Using a floor pedal, she applies a gentle stream of air to the tiny fossil, clearing away the fine dust and tiny pieces of rock.

An Aspiring Artist

As a youngster, Davidson did not dream of one day working with dinosaurs. She did, however, love the outdoors, and she loved to make sculptures. In college she studied art. Her first job was with the exhibition department of the Smithsonian Institution in Washington, D.C. There she built dioramas for the new Hall of Plant Evolution.

Amy Davidson left the Smithsonian to pursue sculpting. She worked at several jobs. She was an apprentice at a bronze foundry, where she learned to cast bronze sculptures. Later she worked for Harvard University's Department of Mammalogy, dissecting and preserving animals that had died. She also took classes in vertebrate paleontology and human anatomy.

A Fascination for Fossils

Davidson's love of both art and science led her to a career turning point. A fossil preparator at Harvard invited her to work in his lab. Her first complete preparation revealed under the microscope a perfect little creature curled up as if in sleep — a sleep of 200 million years. She was hooked.

Dinosaur Hunting in the Gobi

Davidson's most exciting adventure began later, when she came to work at the American Museum of Natural History. Ten days after starting as a preparator, she was on a plane with paleontologists Michael Novacek and Mark Norrell heading halfway around the world to Ulan Bator, Mongolia, on an expedition to the Gobi Desert.

The highlight of this 1993 expedition was the discovery of *Oviraptor* fossils. One *Oviraptor* was found protecting a nest of 22 eggs, possibly from a smothering dust storm that swept the Gobi about 80 million years ago. An expedition in 1995 turned up two more *Oviraptor* skeletons found quite close together.

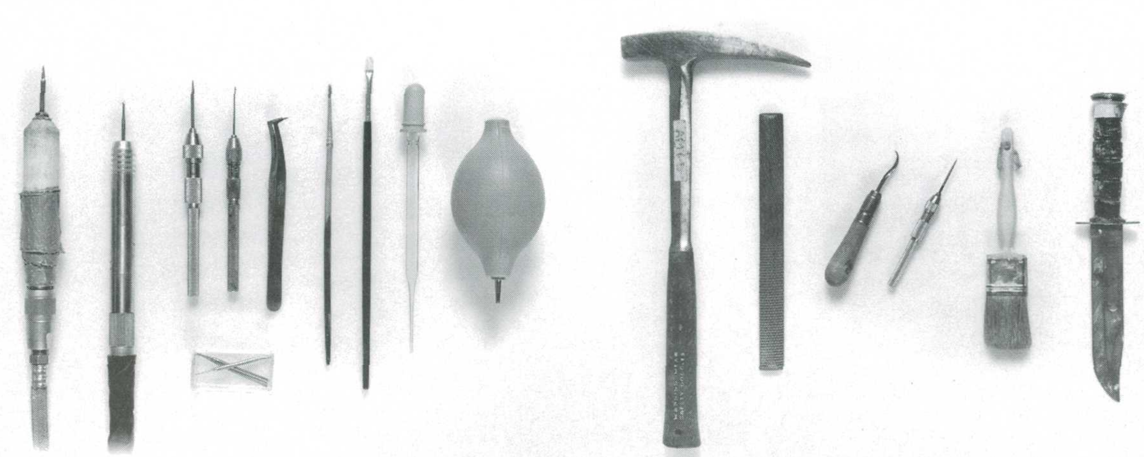
Photo: Courtesy Department of Library Services, American Museum Of Natural History

Amy Davidson in her workshop with a rare fossil — a dinosaur sitting on a nest of eggs.

A Natural Sculpture Takes Form

When the 1995 fossils arrived back in New York, Davidson went to work carefully cleaning and restoring one of the specimens. When she finished, the specimen was the most nearly perfect *Oviraptor* skeleton ever found. "Working on a new fossil is like a window into the past," she says. "It's hard to go home at night. I want to stay and continue working, chipping away at the rock that encases the fossil. As I work, a natural sculpture, a skeleton, begins to emerge from the rock. So beautiful." So speaks an artist and a scientist.

Excerpted from an article by Karen Kane, which appeared in the Spring 1997 issue of The Fossil Times, *a publication of the American Museum of Natural History, Department of Education.*



Photos: Craig Chesek

Amy Davidson's workshop tools include drill bits, brushes, an eyedropper to apply adhesive resin, and a small rubber bulb to blow away dust and rock particles.

Visiting the Museum

The American Museum of Natural History has one of the world's leading collections of dinosaur fossils. The Museum is located in New York City at Central Park West at West 79th Street. You can also visit the Museum 24-hours-a-day on its Web site, www.amnh.org.

Bringing Back the Florida Panthers

Darrell Land's appreciation for nature started early. He grew up playing in the woods and watching birds and went on to study wildlife biology in college and graduate school. Today he heads up the field staff of the Florida Panther Recovery Project. He may spend as many as 6 days a week tracking panthers through the Florida Everglades as part of an effort to keep the Florida panther from becoming extinct.

The story of the Everglades is a good example of what can happen when people change the environment without understanding what all the consequences might be. For the past century or so, people have been building on the edges of the Everglades, which is a giant wilderness of grass, trees, and shallow water. They've also constructed canals and dams throughout the Everglades in order to divert water to adjacent cities and farms. So much water used to flow into the Everglades that people thought that what they changed wouldn't make a difference. About 15 years ago, they began to realize how wrong they had been.

Pollutants washing into the Everglades from farms and cities have killed native plants, and lack of water has killed fish and birds. In particular, pollutants and lack of habitat have been killing the Florida panther, a beautiful, tawny cat about 7 feet long from nose to tail, which has been on the endangered species list since 1967. Panthers used to live all over the Eastern United States, but today the 40 or 50 Florida panthers left in and around the Everglades aren't enough to continue to thrive unless they get help.

At last, help for the Everglades and for the panthers is on the way. Geologists and geochemists from the U.S. Geological Survey (USGS) are studying soil cores taken from the Everglades to understand what the water, plants, and animals there were like during the past 100 years. Computer and mapping experts are creating maps that show what vegetation, soil, and water levels are like today. Hydrologists (people who study water) are creating computer models to understand how water would flow through the Everglades in the future if there were no canals or dams.

Hope for the panthers is coming from a closely related animal, the Texas cougar. The Panther Recovery Project with the Florida Game and Fresh Water Fish Commission has imported eight female cougars into the Everglades to mate with male panthers in the hope that these matings will create a more genetically diverse and healthier panther population than the panthers can achieve on their own. The cougars wear collars with radio transmitters that enable the biologists to follow their movements, and Darrell Land and his staff track the animals several days a week. In 3 years, the cougars have given birth to 12 half-cougar/half-panther kittens, which is better than anyone had hoped. To be a wildlife biologist, Land says, you need to have a good education, love your work, and be willing to work in remote and rough places.

Above: The Florida Everglades is a unique, fragile environment of water, tall grasses, and trees.

Inset: So few Florida panthers are left in the Everglades that the animal would probably become extinct without help from wildlife biologists.

Photo: Alan & Sandy Carey

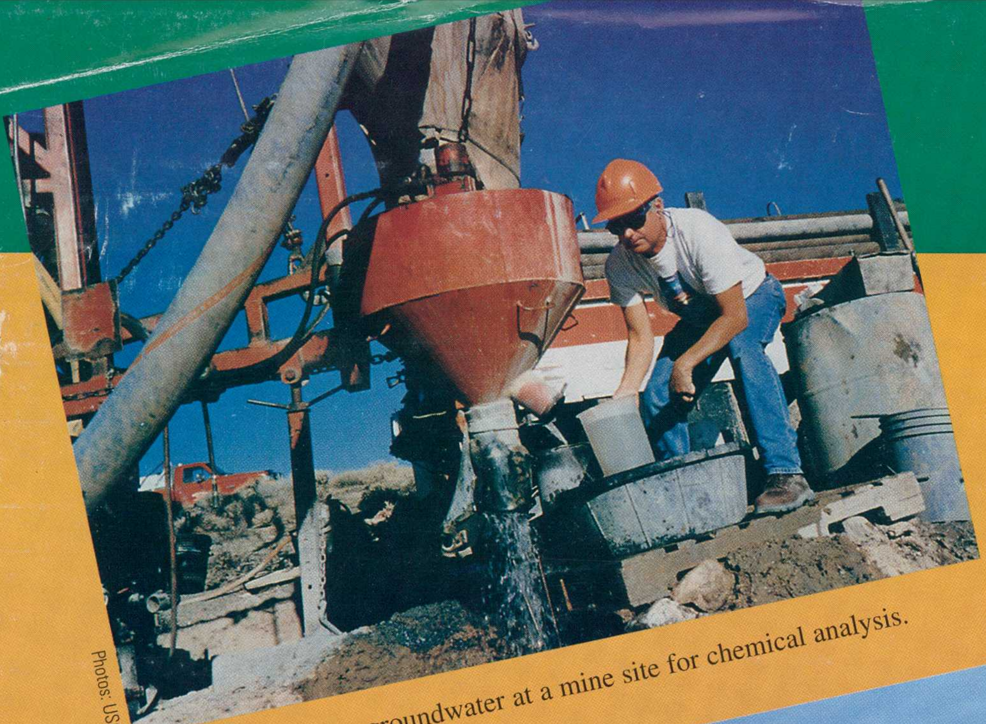
Marjory Stoneman Douglas

Photo: The Miami Herald

Without Marjory Stoneman Douglas, there would be no problem with the Everglades because there probably wouldn't *be* any Everglades. When Douglas died in 1998 at the age of 108, she had been fighting for the Everglades for almost half her life. In 1947, when she was 57 and a journalist and children's book author in Florida, she wrote a book called *The Everglades: River of Grass*. At the time, most people considered the Everglades to be an evil swamp that should be drained of its water. Douglas's book told how beautiful, fragile, and environmentally important the Everglades was. She explained that the Everglades was really a stream of shallow water moving slowly through sturdy saw grass and was home to an enormous variety of animals from fish to panthers. Later in the year that her book was published, President Harry Truman created Everglades National Park at the southwestern end of Florida. Although the Everglades is still in danger from pollution and lack of water, thanks in large part to Marjorie Stoneman Douglas it remains an ecosystem that exists nowhere else on Earth.

On the Job

Whether you're interested in rocks or animals, computers or microscopes, working indoors or out, careers in the natural sciences can take you anywhere on Earth.

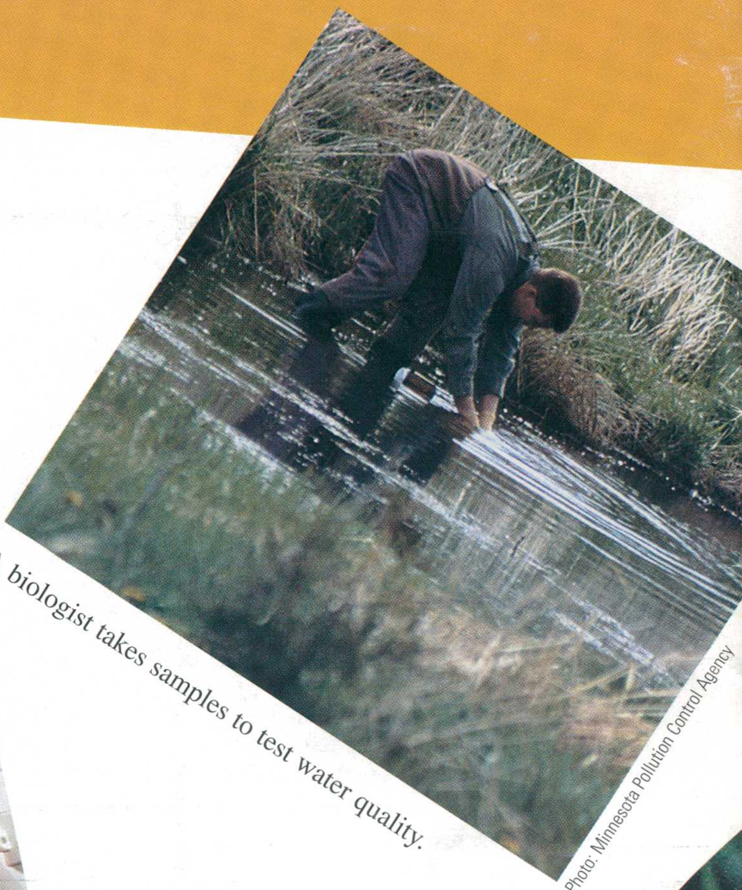


Photos: USGS

A scientist samples groundwater at a mine site for chemical analysis.

Photo: Carlos Macellari

A paleobiologist participates in the first geologic mapping of Seymour Island in Antarctica to learn about ancient climates.



A biologist takes samples to test water quality.

Photo: Minnesota Pollution Control Agency

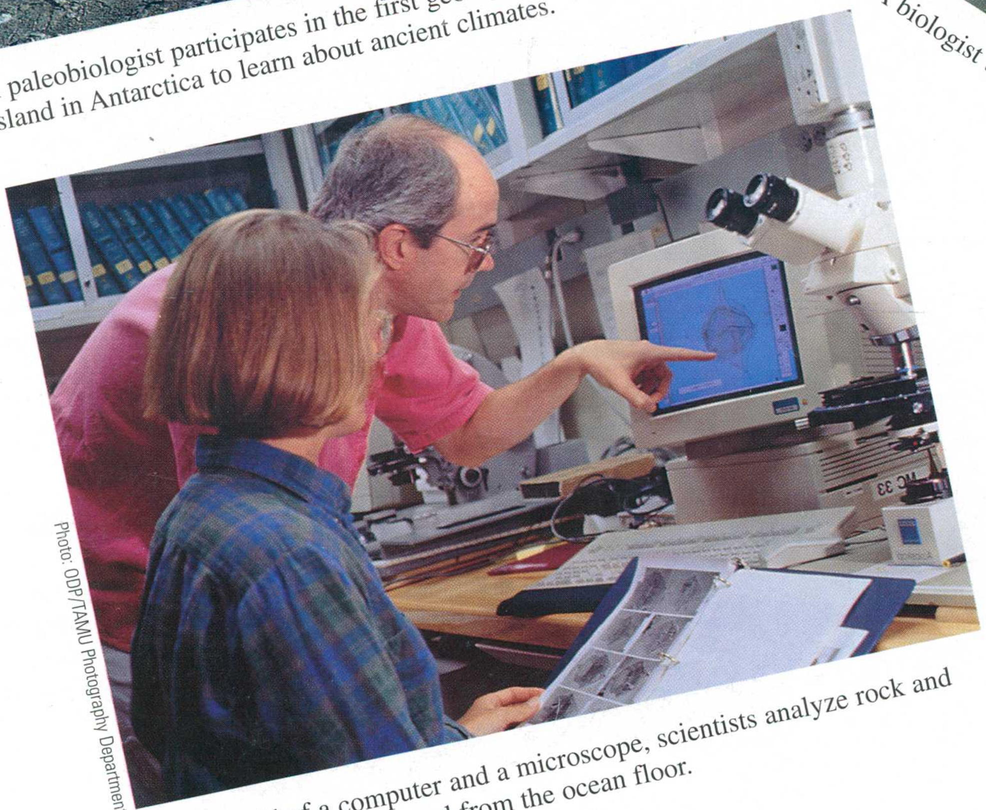
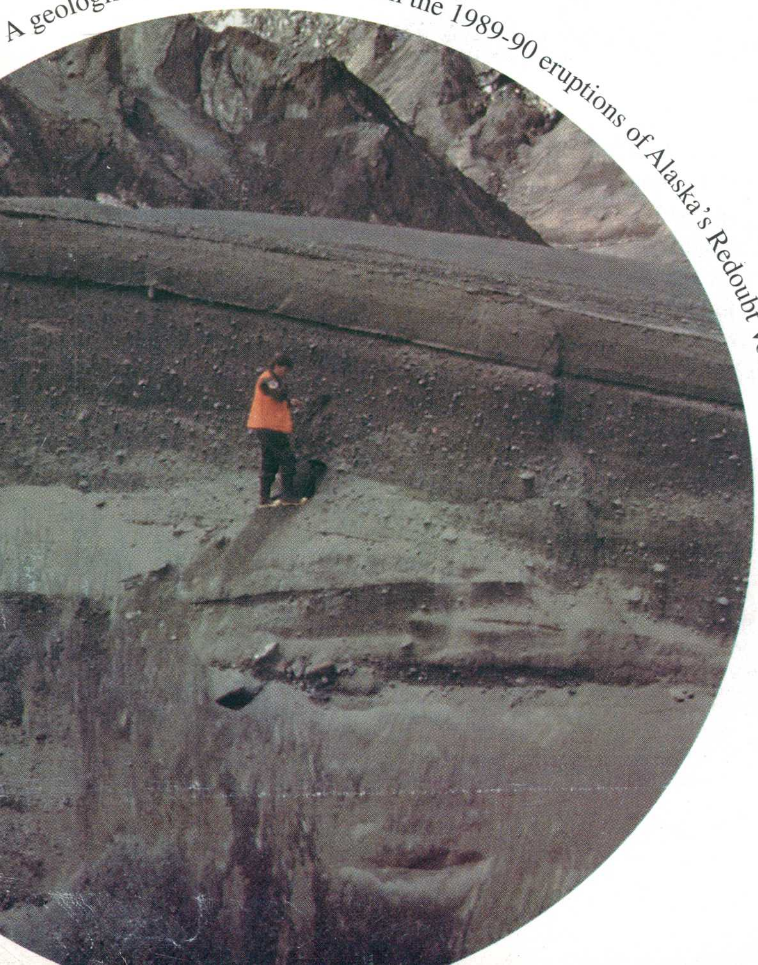


Photo: ODP/TAMU Photography Department

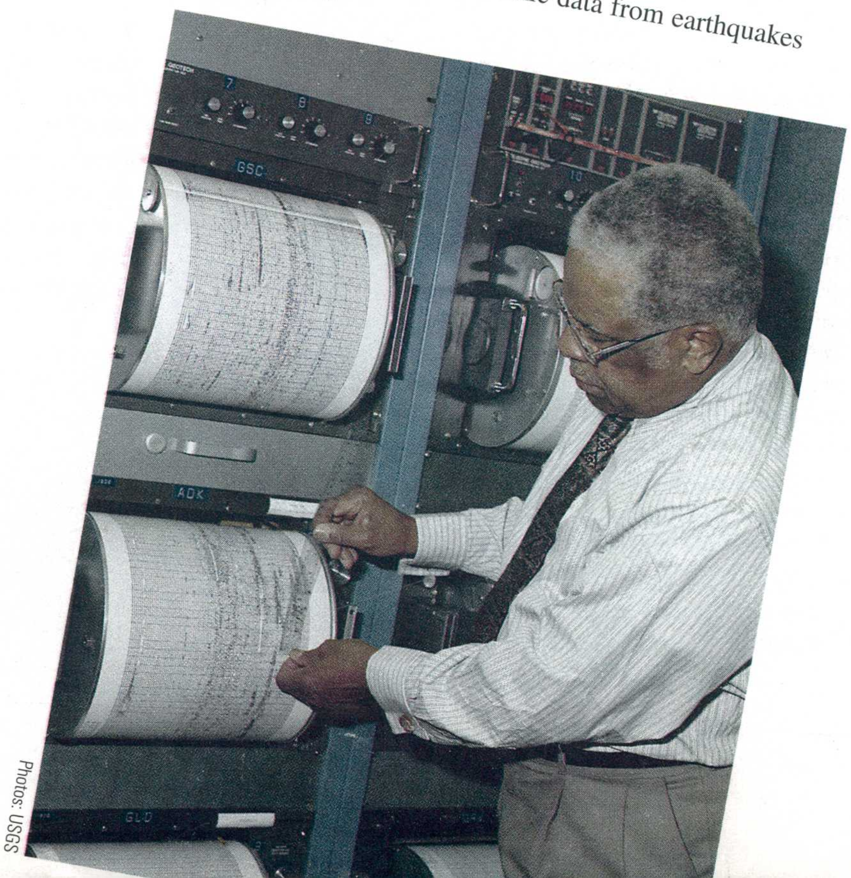
With the aid of a computer and a microscope, scientists analyze rock and sediment samples collected from the ocean floor.



A geologist examines deposits from the 1989-90 eruptions of Alaska's Redoubt Volcano.

Photo: USGS, C. Gardner

A seismologist analyzes seismic data from earthquakes as they occur.



Photos: USGS