LESSON 9

INTRODUCING VOLCANOES

WHAT DO YOU THINK THIS VOLCANOLOGIST IS DOING WITH THIS SEISMOGRAPH AT LAKE BUTTE IN YELLOWSTONE NATIONAL PARK?

PHOTO: NPS photo by Jim Peaco

INTRODUCTION

Earthquakes often occur with little warning. Volcanic eruptions, by contrast, can often be forecast well before they happen. Many different signs from the earth tell scientists that a volcano may be about to erupt. Earthquakes, which normally occur before a volcanic eruption, mean that molten rock within the earth is rising and putting pressure on rock. Usually these earthquakes are weak and cannot be detected without the aid of seismographs. An increase in the number of earthquakes may indicate to scientists that a volcano is getting ready to erupt.

Other signs of possible eruption include the presence of steam and ash, which can emerge during small explosions from a volcanic vent. The amount of sulfur in the air over a volcano might also increase as gas is released from the rising molten rock. The top and sides of the volcano may begin to bulge as the molten rock approaches the surface. Volcanologists use special tools to measure the changes that occur in a volcano. By monitoring these changes, scientists can attempt to forecast when the volcano might erupt. The right forecast can save lives and protect property.

What causes volcanoes? How are volcanoes destructive? Do volcanoes have any constructive, or good, effects? In this lesson, you will investigate questions such as these and discuss the relationships among volcanoes and other plate tectonics.

READING SELECTION

EXTENDING YOUR KNOWLEDGE

VOLCANOES: HELP OR HINDRANCE?

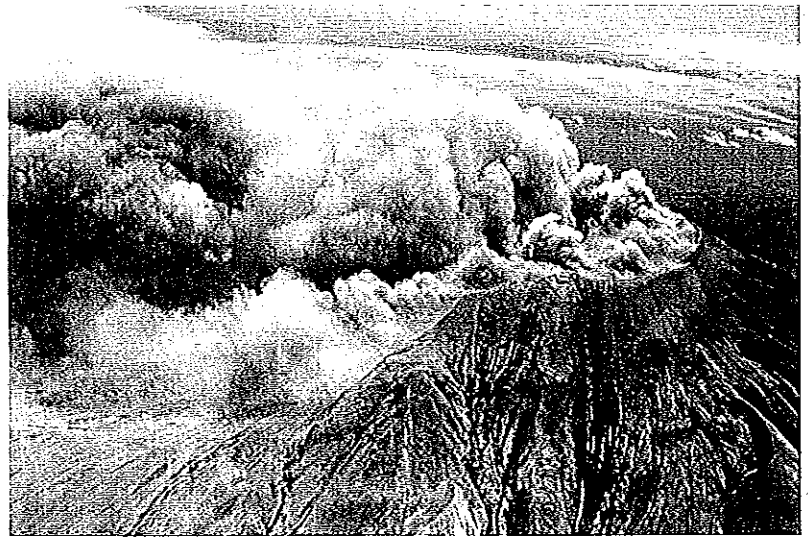
Volcanic eruptions can range from violent to mild. All kinds of eruptions have effects that can be both harmful and beneficial to people and the environment.

VOLCANOES CAN BE DESTRUCTIVE

When volcanoes erupt, they often spew molten rock and fragments of rock over the ground and into the air. Fine fragments of rock, called ash, are usually ejected during very violent eruptions. Ash can affect people hundreds of kilometers away from an eruption. In 1980, in Spokane, Washington, it was dark at noon as a result of the ash cloud from the Mt. St. Helens' eruption more than 300 kilometers (186 miles) away. Closer to the mountain, several people died from suffocation by the ash cloud from the initial blast. Volcanic ash can also contaminate water supplies, cause electrical storms, and collapse roofs.

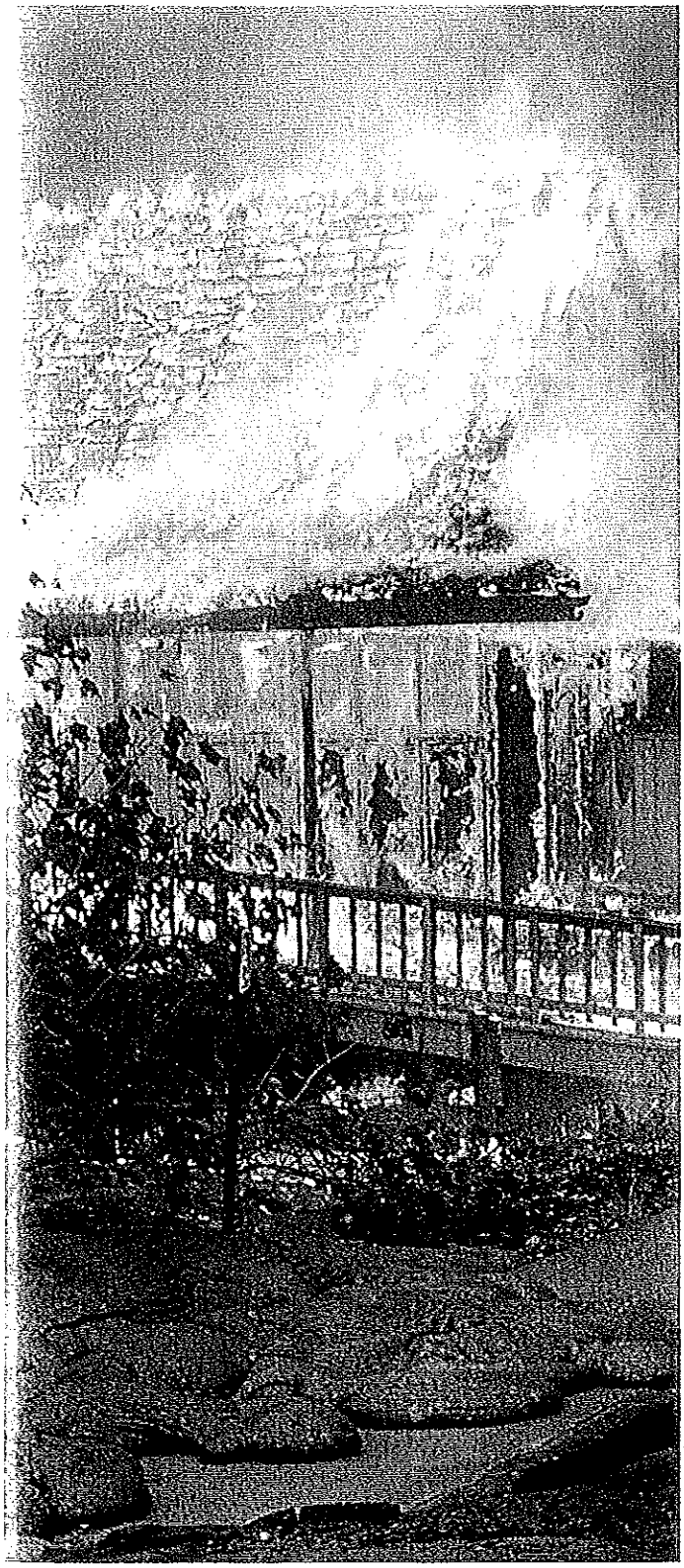
Sometimes a volcano explodes sideways, shooting out ash and large pieces of rock that travel at very high speeds for several kilometers. These explosions can cause death by suffocation and knock down entire forests within seconds. Rivers of molten rock or hot fragments of rock from such eruptions can instantly ignite fires for great distances.

An erupting volcano can also be accompanied by earthquakes, flash floods, rockfalls, and mudflows. Floods occur when rivers are dammed by trees felled during an eruption or by molten rock moving across a river. Mudflows are powerful rivers of mud that form when debris from a volcanic



FOR WEEKS, MT. ST. HELENS SPEWED VOLCANIC ASH OVER THE SURROUNDING LANDSCAPE AND FOR HUNDREDS OF KILOMETERS DOWNWIND TO THE EAST. NOTICEABLE AMOUNTS OF ASH FELL IN 11 STATES. ALTOGETHER, MT. ST. HELENS EXPELLED ENOUGH ASH TO COVER A FOOTBALL FIELD TO A DEPTH OF 240 KILOMETERS (149 MILES).

PHOTO: U.S. Geological Survey/Cascades Volcano Observatory/photo by Peter Lipman



eruption moves into a stream or river. Mudflows can move faster than people can run, and bridges in the path of these flows can be destroyed instantly. One kind of mudflow, called a lahar, happens when rain falls through clouds of ash or when rivers become choked with falling volcanic debris. During the eruption of Mt. St. Helens in 1980, lahars destroyed more than 200 homes, more than 300 kilometers (186 miles) of roads, and 220 kilometers (137 miles) of river channel.

A volcanic eruption can also cause a tsunami. A tsunami is a series of sea waves usually brought on by underwater earthquakes, but volcanoes can cause tsunamis, too. The collapse of an island during a volcanic eruption or the dumping of heavy loads of volcanic debris into the ocean can create massive waves. The 1883 eruption of Krakatoa, a volcanic island in Indonesia between Sumatra and Java, unleashed a tsunami that swept the coasts of Sumatra and Java and drowned more than 36,000 people.

Severe-weather-related events often accompany volcanic activity. These include lightning, thunderstorms, and whirlwinds (including tornadoes). In addition, the heat caused by a volcanic eruption can melt snow and glaciers, which can lead to flooding and landslides. Ash clouds from an erupting volcano can temporarily affect the weather in cities that are hundreds or even thousands of kilometers away. For example, the 1883 eruption of Krakatoa released 20 cubic kilometers (4.8 cubic miles) of volcanic dust into the air. The dust rose so high that it reached the stratosphere. Within 13 days, it had encircled the globe and blocked sunlight from entering the atmosphere. For months, sunsets were strange-colored. Average daily temperatures around the world dropped an estimated 0.5°C (33°F) during 1884. It took five years for all of the volcanic dust to settle to the ground.

IN 1989, THE WAHAULA VISITOR CENTER IN HAWAII WAS ENGULFED BY A HOT LAVA FLOW AND BURST INTO FLAMES. ALL ATTEMPTS TO SAVE THE CENTER WERE USELESS.

PHOTO: U.S. Geological Survey/photo by J.D. Griggs

READING SELECTION

EXTENDING YOUR KNOWLEDGE

AFTER THE ERUPTION OF MT. ST. HELENS, THIS HOME WAS DAMAGED BY VOLCANIC MUDFLOW ALONG THE SOUTH FORK TOUTLE RIVER IN WASHINGTON STATE.

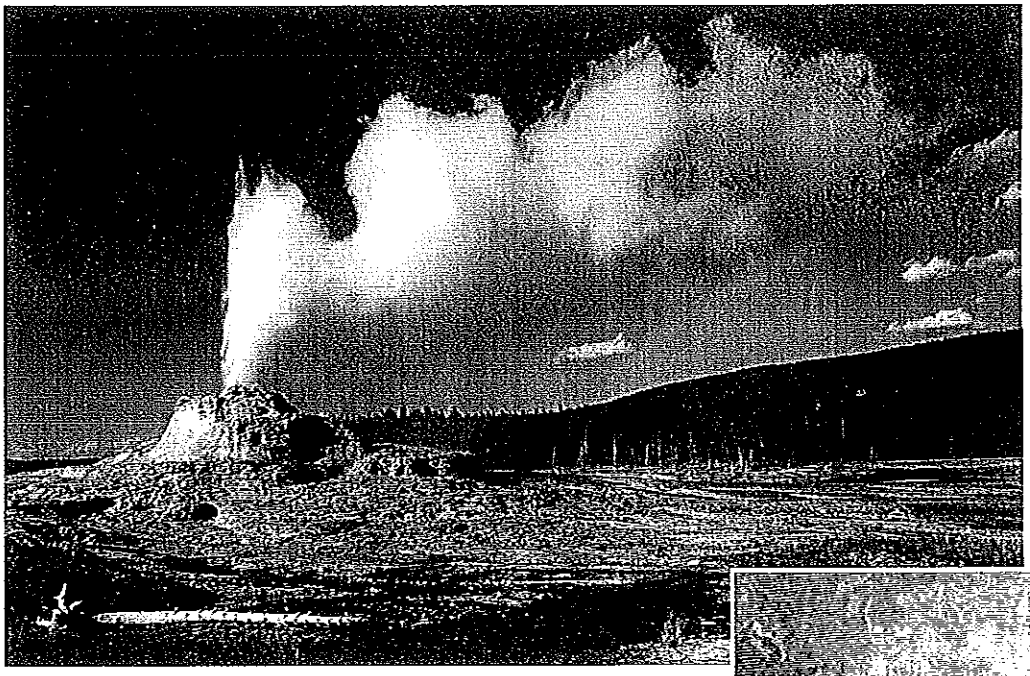
PHOTO: U.S. Geological Survey/Cascades Volcano Observatory/photo by Lyn Topinka

In 1815, a different Indonesian volcano, Tambora, erupted even more powerfully. It blasted about 150 cubic kilometers (36 cubic miles) of volcanic debris high into the atmosphere. The dust blocked so much sunlight that crops failed to grow around the world, and 1816 became known as "the year without a summer." Again, it took several years before the effects of this eruption passed.

VOLCANOES CAN BE CONSTRUCTIVE

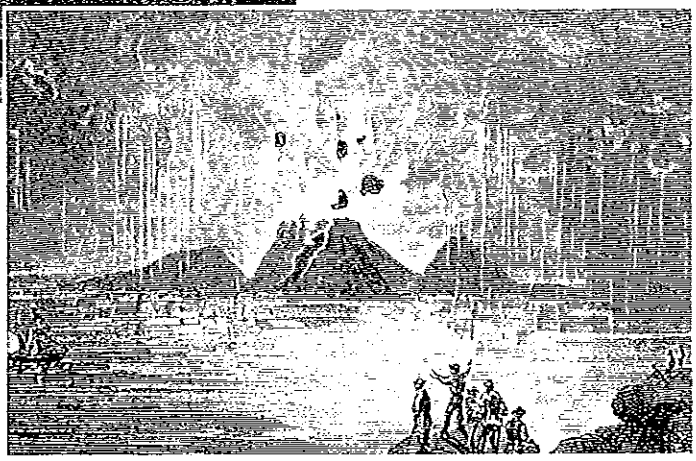
Not all the materials that come out of volcanoes are harmful. Many volcanic areas have permanent hot springs that are beautiful to look at and provide recreation for residents and tourists. In addition, people can tap the geothermal energy of hot springs to heat their homes directly or to produce electricity. Icelanders, for example, use geothermal energy to heat their homes, buildings, and swimming pools. Iceland has a very short growing season, but greenhouses heated by geothermal energy provide Icelanders with vegetables, tropical fruit, and flowers year-round. Some people living in Arctic regions also heat their homes and greenhouses with water from hot springs. The hot water flows through pipes in their houses, warming the air. Geothermal steam is used to generate electricity in places such as Italy, New Zealand, the United States, Mexico, Japan, and Russia.

Volcanoes provide a wealth of natural products. Basalt, which forms from cooled lava and makes up much of the seafloor, is a raw material for cleaning agents, and it has many chemical and industrial uses. Volcanic ash enriches the soil with mineral nutrients. Minerals in molten rock are a major world source of nickel, chromium, platinum, and several other important elements. Obsidian, or "volcanic glass," is an ideal material for fine stonework because it breaks with a typical curved fracture when struck with a sharp blow. Beautiful arrowheads of obsidian have been found in Ohio



MOST GEYSERS ARE HOT SPRINGS THAT ERUPT FOUNTAINS OF SCALDING WATER AND STEAM.

PHOTO: NPS photo by Frank Balthis



THIS OLD ENGRAVING SHOWS THE 1866 ERUPTION OF NEA KAMENI, SANTORINI, IN GREECE. A GIANT VOLCANIC EXPLOSION CAUSED THE SUDDEN SINKING OF THE ISLAND'S CENTER BENEATH.

PHOTO: P. Hedervari, National Geophysical Data Center/NOAA

from the Hopewell culture, which flourished 1500 to 2300 years ago.

Volcanoes also create beautiful landscapes. Without volcanic activity, there would be none of the spectacular fissures that dot the Hawaiian landscape or the majestic peaks of the Cascade Range, such as Mt. Rainier.

Most people think of catastrophic events as violent natural hazards that create human and environmental risks. But as we have just seen, there is another side of the story. Catastrophic events can also be constructive forces on the earth. Volcanoes affect the composition of our oceans and atmosphere. Floods create sandy beaches along riverbanks. And earthquakes, as well as volcanoes, create and shape the mountains and islands that people enjoy. ■

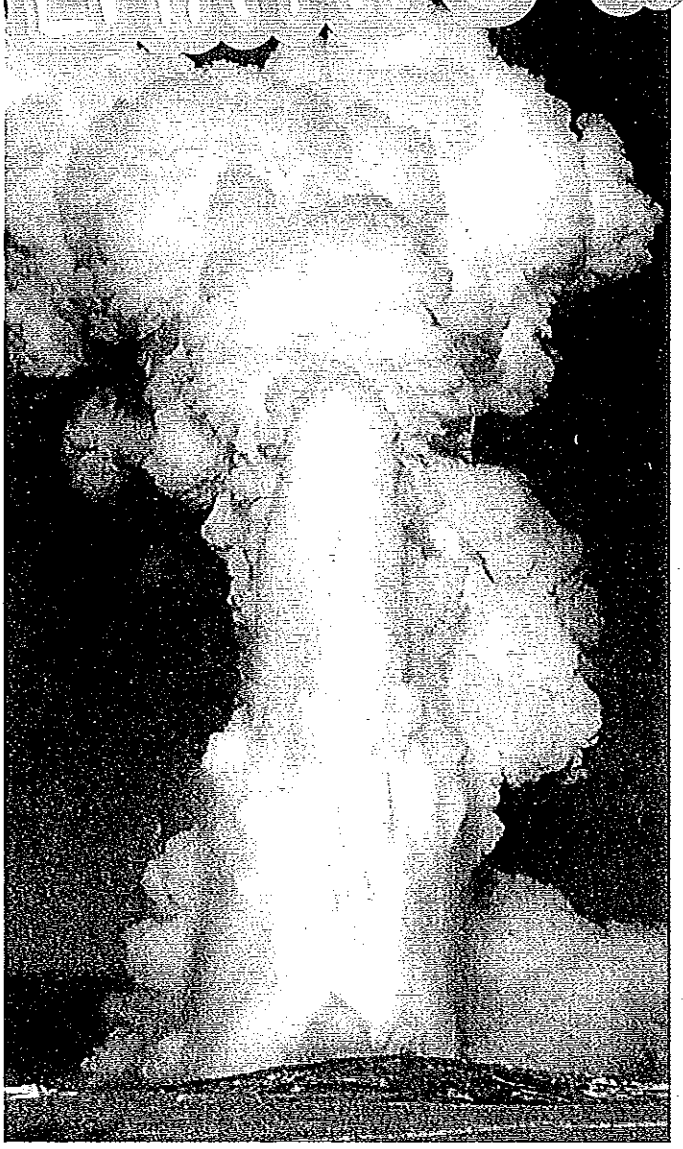
DISCUSSION QUESTIONS

1. The primary effect of a volcanic eruption is the spewing of lava, rocks, and/or ash. What are some secondary effects of a volcanic eruption?
2. What are two ways in which volcanoes are seen as beneficial?

READING SELECTION

EXTENDING YOUR KNOWLEDGE

Yellowstone Wonders



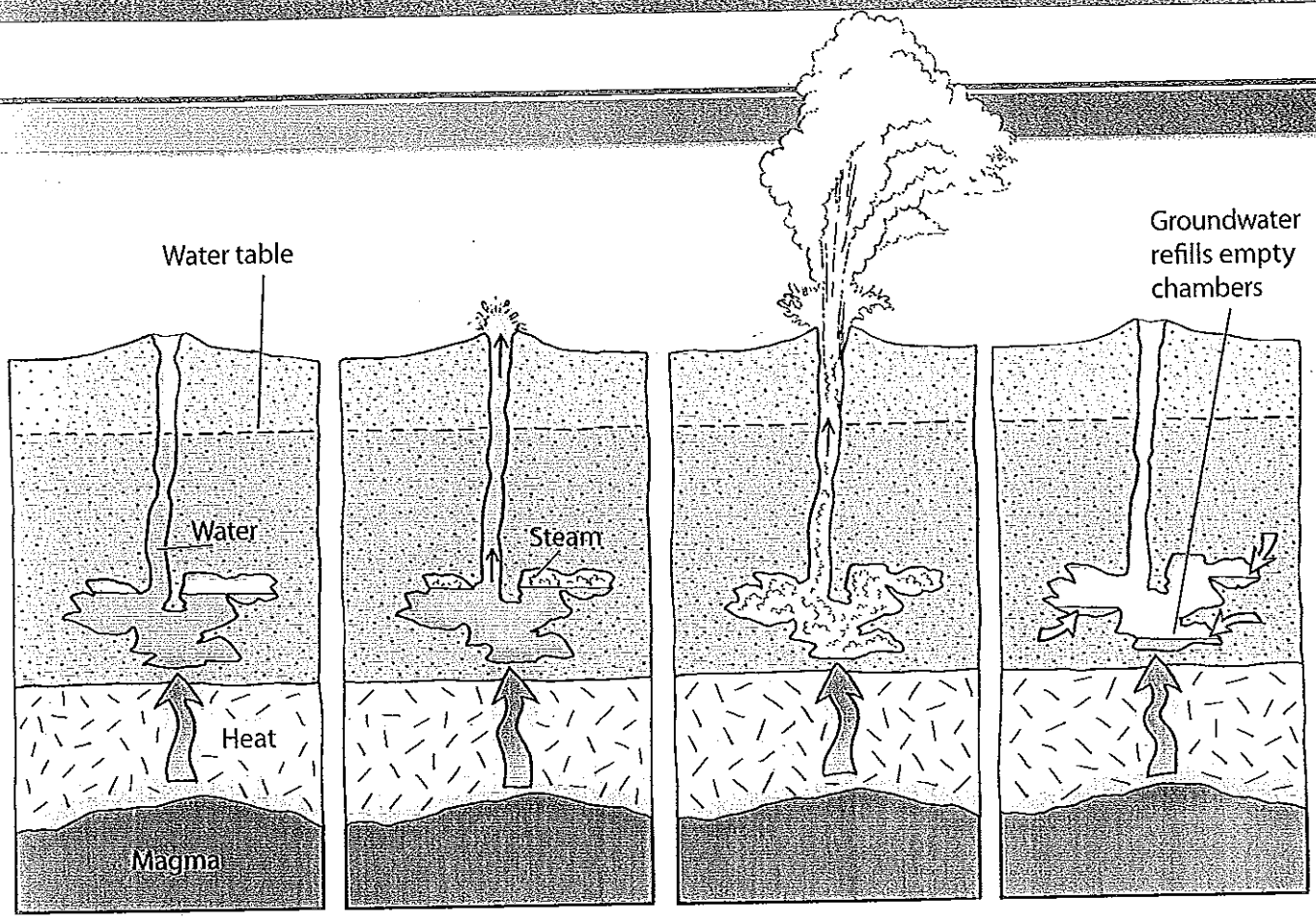
OLD FAITHFUL IS THE MOST FAMOUS GEYSER IN YELLOWSTONE NATIONAL PARK.

PHOTO: NPS Photo

In the 1800s, fur trappers who ventured into the Rocky Mountains came back and told of "the place where hell bubbles up." No one believed them. One of the trappers, a Virginian named Jim Bridger, told people about finding a column of water as thick as his body that spouted 18 meters (about 60 feet) in the air. People called him a liar. But explorers later confirmed the trappers' stories. They had found the roaring geysers (springs that spout hot water and steam) and craters of boiling mud in the area that is now Yellowstone National Park. Today, several million people every year come to view these wonders at Yellowstone.

Yellowstone Park, located in Wyoming and Montana, is the hottest, most active geyser area in the world. It contains more than 500 geysers, or nearly three-fourths of all the world's geysers. In all, Yellowstone has 10,000 geothermal features ("geo" means "earth" and "thermal" means "heat"). Besides geysers, Yellowstone's geothermal features include hot springs and bubbling mud pots.

Why does Yellowstone have so many hot springs? Most of Yellowstone sits inside an ancient caldera. The volcano's last major eruption, which created the caldera, happened 600,000 years ago. Smaller lava flows from the volcano gradually filled up most of the caldera. Rock under the earth's surface can stay hot for thousands of years. Heat from molten rock a few kilometers below the surface heats the groundwater. The groundwater is held in a porous type of rock, and the heated water travels upward until it bursts through the earth's surface like a fountain.



A GEYSER FORMS WHEN MAGMA HEATS UP GROUNDWATER THAT IS UNDER PRESSURE.

Old Faithful, Yellowstone's most famous geyser, got its name because it normally erupts on a regular basis—on average, every 79 minutes. The eruptions are so regular because the water supply and the structure of the rock remain fairly constant over time. Yet Old Faithful isn't completely predictable. The time between eruptions actually varies between 45 and 105 minutes, depending on the amount of super-hot water left in the spongy rock when the geyser runs out of steam.

Recently, scientists lowered a video camera and other instruments into the vent of Old Faithful. They found that for the first 20 or 30 seconds of each eruption (which lasts for several minutes), steam and boiling water rocket through the narrowest underground cracks at the speed of sound!

WHAT MAKES A GEYSER GO?

Rainwater trickles through cracks into porous rock, where it collects like water in a sponge. Heat from magma a few kilometers beneath the earth's surface rises and heats the water in the porous rock. The porous rock layer is like a pressure cooker: it has lots of heat from the magma and lots of pressure from the weight of water and rock above it. The water in the porous rock can reach temperatures of 310°C (590°F) without boiling because of the tremendous pressure.

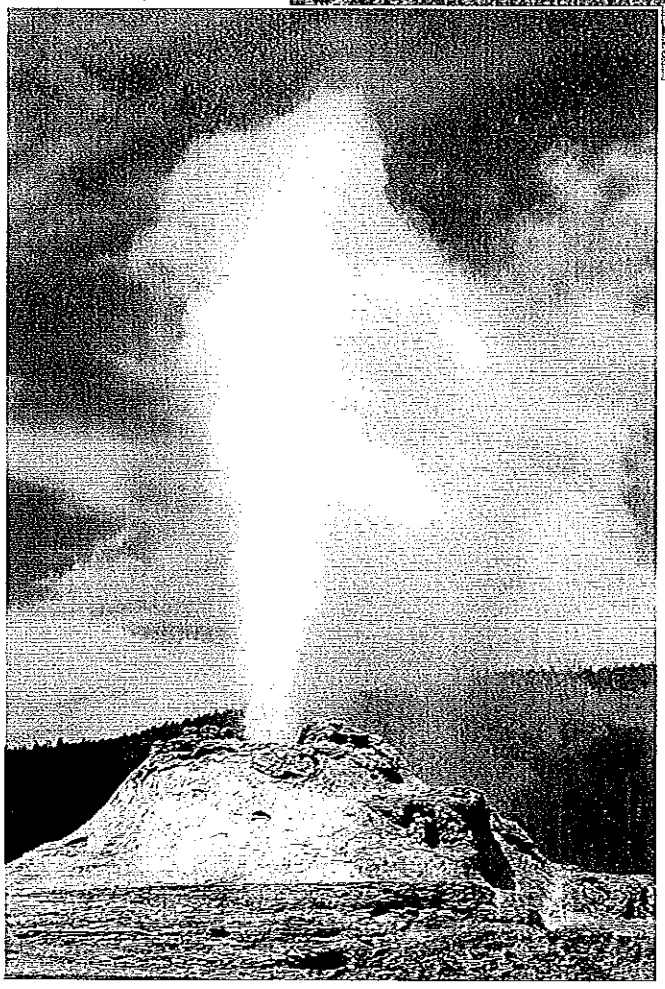
This super-hot water rises into pockets of groundwater that are also under pressure. Steam forms, more pressure builds, and bubbles rise. Steam keeps building until a spout of hot water and vapor explodes to the surface and shoots high into the air. More super-hot water then bursts into steam and blasts more groundwater out of the earth, erupting sometimes for up to several hours.

READING SELECTION

EXTENDING YOUR KNOWLEDGE

HOT SPRINGS ARE ONE OF THE GEOTHERMAL FEATURES FOUND AT YELLOWSTONE NATIONAL PARK.

PHOTO: NPS photo by J.R. Douglass



WHEN THE WATER FROM CASTLE GEYSER IN YELLOWSTONE NATIONAL PARK EVAPORATES, A MINERAL CALLED SILICA IS LEFT BEHIND. THIS MOUND OF SILICA IS CALLED A GEYSERITE.

PHOTO: NPS photo by George Marle

If the super-hot water mixes with cool groundwater that is not under pressure, it rises to the surface as a hot spring. When hot springs become choked with pieces of weathered rock (sediment) that break off from the surrounding rock, bubbling mud pots are the result.

If the super-hot water rises to the surface with no resistance, it begins to boil and erupts at the surface as steam. This thermal feature, called a fumarole, is like a geyser, except that it is mostly steam.

WHEN GEYSERS LOSE THEIR STEAM

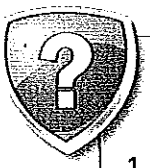
Some old geysers lose their steam. The super-hot water carries minerals that, through time, accumulate on the walls of the underground channels and cracks. Like arteries, the cracks become clogged, and the steam and water can no longer escape.

For one Yellowstone geyser, named Porkchop, the pressure was too much. It spouted water and steam for years. Then one day it blew rocks the size of TV sets into the air and stopped gushing for good. ■

EARTHQUAKE PREDICTOR?

In 1990, a scientist from the Carnegie Institution in Washington, DC, worked with a person who owned property near a geyser in California to study patterns in the geyser's eruption cycle. The geyser didn't always erupt on schedule. For 15 years, the property owner had collected data on the geyser's eruptions. The scientist compared the data with records of thousands of earthquakes in California and found that major changes in the geyser's activity coincided with three large earthquakes that occurred within 248 kilometers (154 miles) of the geyser. In all cases, changes in the geyser happened one to three days before the earthquake. The scientist hypothesized that underground movements that caused the earthquakes may also have affected the geyser's water supply.

Earthquakes often hit the Yellowstone National Park area, shaking and moving the geysers'"plumbing system" and choking off the water supply. An earthquake in 1995 moved heat and water away from Steamboat Geyser and redirected it to Monarch Geyser, which had been dormant for 81 years. Suddenly, Monarch began blowing off steam. Could a geyser be an earthquake detector? It's possible, but more study needs to be done on this subject.



DISCUSSION QUESTIONS

1. Why do geysers erupt? Why don't they remain as pools of hot underground water?
2. Imagine you are a scientist tasked with studying how geysers might serve as earthquake detectors. What sort of data could you gather?