

Science

Science

Earth Science

Genre	Comprehension Skill	Text Features	Science Content
Nonfiction	Draw Conclusions	<ul style="list-style-type: none">• Captions• Charts• Diagrams• Glossary	Plate Tectonics

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Plate Tectonics

by Mary Miller



Vocabulary

continental drift

core

crust

fault

lithosphere

mantle

plate boundary

plate tectonics

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Plate Tectonics

by **Mary Miller**





What are Earth's layers made of?

Earth's Variety

Victoria Falls is one of Earth's many land features. The flat, raised land around the waterfall is called a plateau. A deep crack, called a gorge, splits the plateau. Water flows over the plateau into the gorge.

In the United States a large plateau, called the Colorado Plateau, covers parts of Utah, New Mexico, Arizona, and Colorado. This landform was once flat. Over thousands of years, water washed away some of the rock, making landforms such as the Grand Canyon.

In the African desert of Namib, mountains rise high above the nearby plains. The Napa Valley region in northern California is an example of a valley. Valleys are found between mountains that are close together.



Naukluft Mountains, in
Namib Desert, Africa



Not all of Earth's features are visible. Some can be found underwater. Below the surface of the Atlantic Ocean is a long row, called a ridge, of mountains. Some of these mountains are actually volcanoes. There are also long, narrow grooves in the floor of the ocean. These grooves are called trenches.

The landforms that you see may change depending on where you live. You may live in an area that has many mountains. Maybe you live near plains. Valleys, mountains, and plains are very different from each other. But all of them were formed from processes that began deep inside Earth.



Napa Valley,
California





Earth's Layers

The surface of Earth is solid. It is made of rock and soil. There are different layers under the surface. Some of these layers are solid; some are not.

Above Earth's surface there is a thin layer of gases called the atmosphere. It contains the air we breathe. Humans could not live on Earth without the atmosphere.

The solid layer of rock that covers Earth is called the **crust**. The crust is the part of Earth that people live on. The thickness of the crust is not the same everywhere on the planet. The crust covered by ocean water is about 6–11 kilometers thick. On dry land, the crust is about 35–40 kilometers thick. Mountain ranges have the thickest crust. Yet, the crust is only a thin shell when compared with Earth's other layers.

Outer Core

Scientists think the outer core is made of iron mixed with smaller amounts of other materials.



Inner Core

The inner core is made of iron.

Atmosphere

Earth's atmosphere contains nitrogen, oxygen, carbon dioxide, and water that cycle through the environment.



The layer of Earth just below the crust is called the **mantle**. This thick layer makes up most of Earth's mass. The outer part of the mantle is solid, just as the crust is. The inner part is so hot that the rock can flow slowly over time.

The **core** is at the very center of Earth. The core is very dense. It has been compacted by the weight of all the rock above it. Scientists think that the temperature of the core is about 7,000°C. That is as hot as the surface of the Sun. There is an inner core and an outer core. The outer core is so hot that it is a liquid. The inner core is solid.

Crust

The crust is made mostly of oxygen combined with other materials—silicon, aluminum, iron, and calcium.

Mantle

This middle layer is made mostly of oxygen combined with silicon, magnesium, and iron.





Earth's Plates

Earth's crust and the outer part of the mantle form the **lithosphere**. The lithosphere is not a solid layer. It is broken into pieces called tectonic plates. The plates have different shapes and sizes. The larger ones are the size of continents, such as the South American Plate. Others, such as the Caribbean Plate, are much smaller. All the plates fit together like the pieces of a jigsaw puzzle.

The edges of the North American plate and the Eurasian plate can be seen in Iceland.

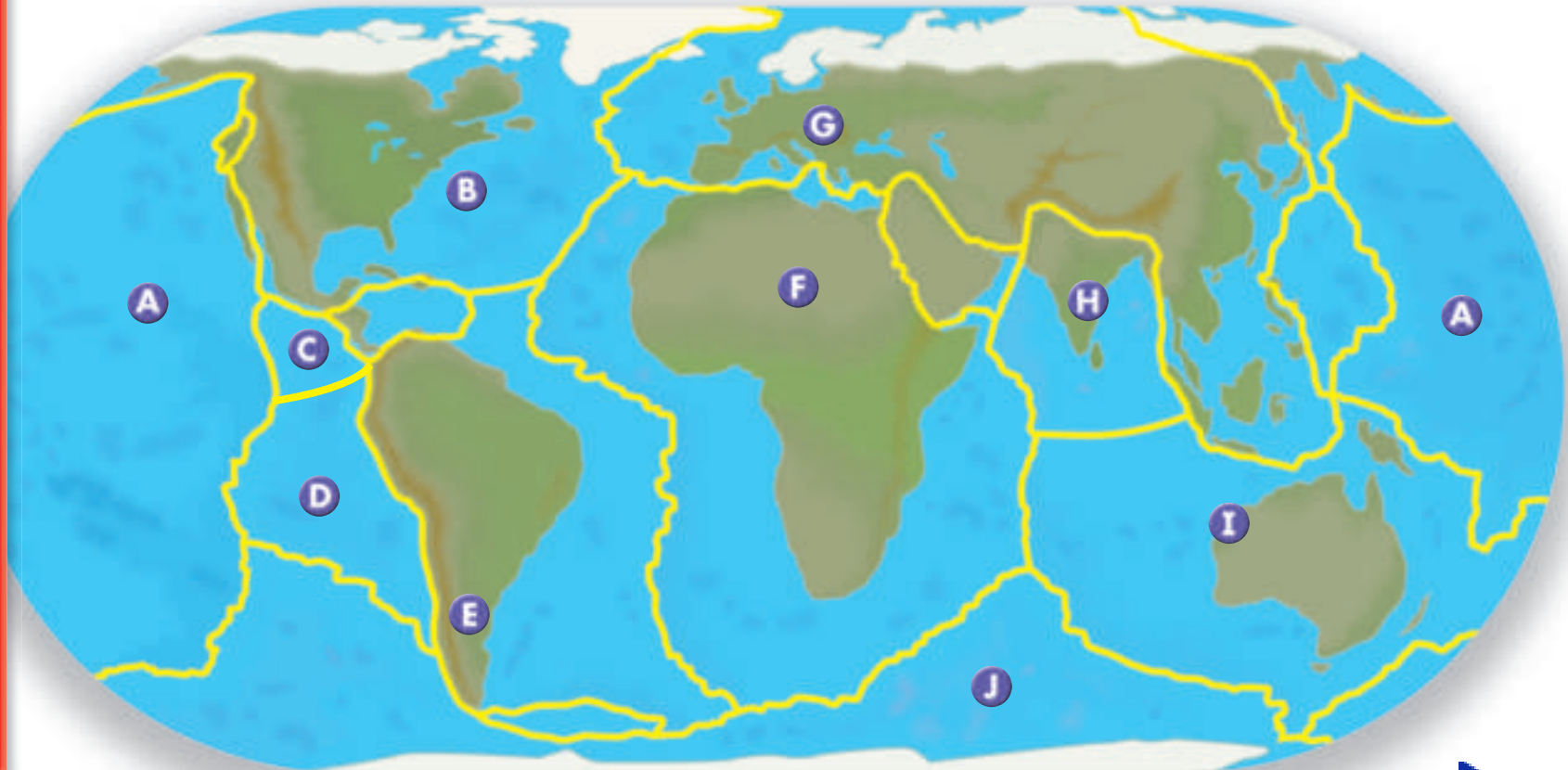


There are two kinds of crust, continental and oceanic. The continental crust makes up continents. The oceanic crust makes up the floor of the ocean. The plates do not follow the edges of the continents. Many plates are made of both continental and oceanic crust. Most of the United States is on the North American Plate. Part of the Atlantic Ocean is also on this plate. The western part of California is on the Pacific Plate. The ocean covers the rest of the Pacific Plate. Oceans and other bodies of water cover most of Earth's lithosphere.

The mantle below the lithosphere is made of molten rock. The plates float on the molten rock of the mantle.

Major Tectonic Plates

- A Pacific Plate
- B North American Plate
- C Cocos Plate
- D Nazca Plate
- E South American Plate
- F African Plate
- G Eurasian Plate
- H Indian Plate
- I Australian Plate
- J Antarctic Plate





How do Earth's plates help create landforms?

Continental Drift

Long ago, people thought that Earth's continents were always in the same place. Then, scientists noticed that the coastlines on some continents seemed to fit together like pieces of a jigsaw puzzle.

In 1912, Alfred Wegener, a German scientist, came up with an explanation for the fit of the coastlines. He suggested that about 225 million years ago all the continents had been joined together as one giant continent. Wegener called this continent Pangaea. He thought that Pangaea broke apart long ago.

Wegener introduced the idea of **continental drift**. This theory claims that as Pangaea broke apart, its pieces shifted, and they continue to do so today. These pieces form the continents.



250 million years ago



65 million years ago



Today



Similar plant and animal fossils found on different continents are evidence of Wegener's theory.



Wegener had evidence other than the shape of the continents to support his theory. Some plant and animal fossils were found on the eastern coast of South America. They were almost identical to fossils found on the western coast of Africa. Wegener did not think that these identical fossils were a coincidence. He thought that the animals had once lived together when the continents were joined as Pangaea.

Evidence to support Wegener's theory was also found in rocks. Layers of rock along the eastern coast of South America matched layers of rock along the western coast of Africa. Wegener believed this showed that the coastlines might have once been joined.

Wegener was not able to explain the forces that caused continents to move. Because of this, most scientists rejected Wegener's ideas.



The Spreading Ocean Bottom

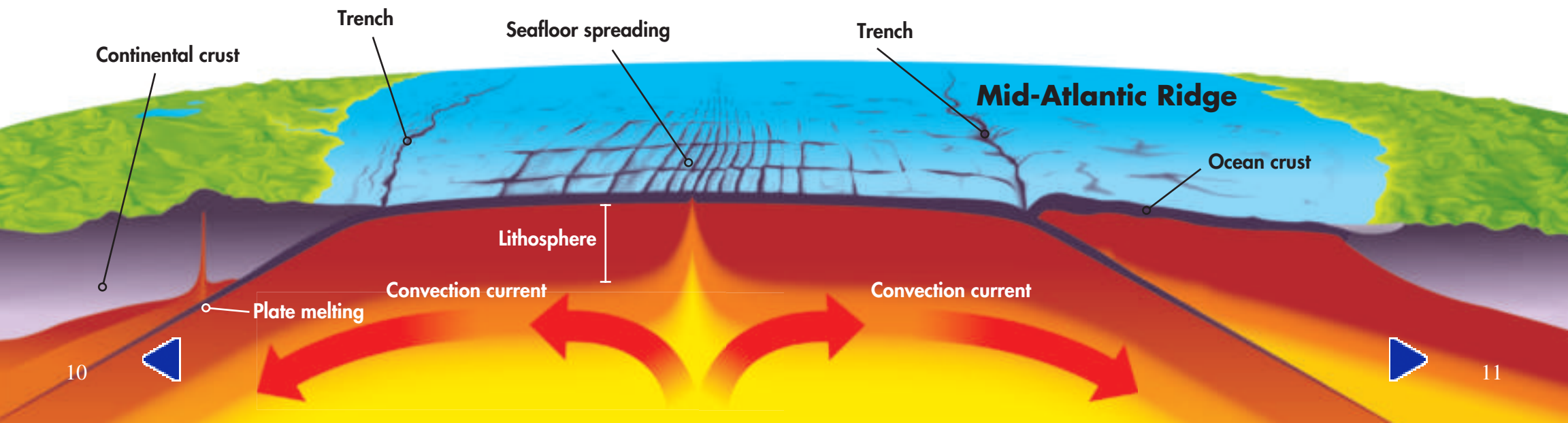
For some time there was no new evidence to support the theory of continental drift. But things changed when scientists found better ways to map the ocean's floor. Scientists found long, deep ocean trenches. They also discovered a chain of mountains along the floor of the Atlantic Ocean. These mountains are called the Mid-Atlantic Ridge.

In 1960 a scientist named Harry Hess tried to explain how the trenches and ridges came to exist. He said that new crust forms at ocean ridges. Molten rock called magma pushes up through Earth's crust. As the magma cools, it forms new crust. More magma comes up through the ocean floor. It pushes both the new crust and the old crust aside. This process is called seafloor spreading.



As Earth's plates move, the ocean floor spreads apart. Magma rises up to fill the gap in the ocean floor. Plates move because of currents caused by melted rock in the mantle.

When a liquid is heated, its particles move faster and spread apart. Because hot liquids weigh less, they can float above cooler liquids. The hot liquid rises and cools. It becomes heavier and sinks. More hot liquid can then rise above it. This process is called convection. Earth's mantle is not a liquid, but the hot rock flows slowly, resulting in currents that constantly rise, circle around, and fall. When the mantle moves, the plates floating on it also move. Convection is the force that moves Earth's plates.



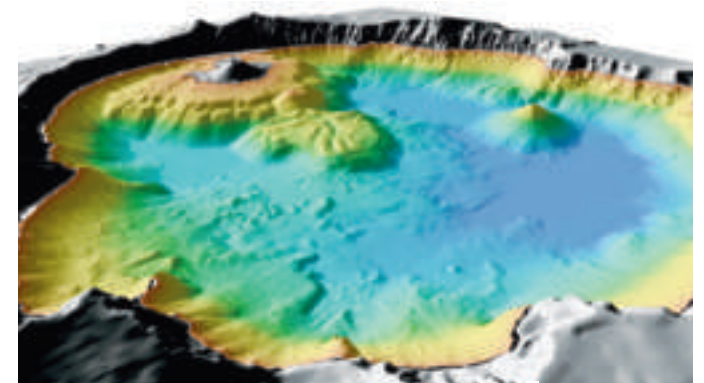


Proof of Continental Drift

Seafloor spreading helped support Wegener's ideas. Yet scientists wanted more proof for continental drift. In the early 1960s some scientists were studying the magnetism of rocks near the Mid-Ocean Ridge. They noticed a pattern. In some places, the magnetism faced north. In other places, it faced south. Scientists found alternating rows of north/south patterns. These rows spread out from the ridge.

Earth's magnetism "flips" about every half million years. If the planet's magnetism faced north, it would flip to face south. A half million years later, Earth's magnetism would flip to face north again. And so the cycle goes. As lava cools, rocks are formed. The particular magnetic pattern at that time is "frozen" into the rocks. The rows of alternating magnetic patterns are evidence that rocks slowly spread as new crust is formed.

Scientists use echoes to map surfaces of lakes and ocean floors.



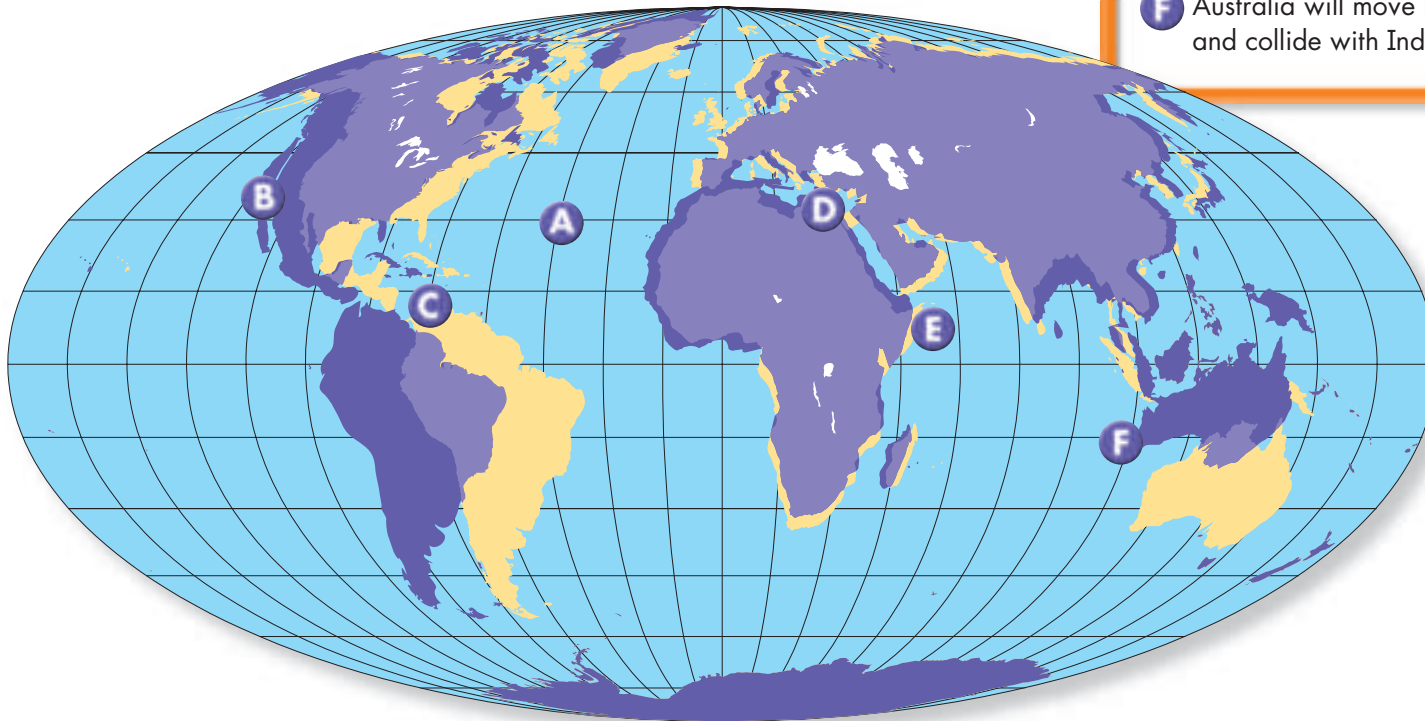


How do scientists explain Earth's features?

Theory of Plate Tectonics

Wegener's idea of continental drift suggested that continents moved. It did not explain many other parts of Earth's crust, such as mountains and volcanoes. Today, scientists use the theory of plate tectonics. **Plate tectonics** explains why Earth's features look the way they do.

This theory states that Earth's lithosphere is broken into about 20 moving plates. The continents and ocean floor make up the surfaces of these plates.



Earth in the Future

The map shows how Earth might look 50 million years from now.

- A** The Atlantic Ocean will widen.
- B** The part of California that lies on the Pacific plate will move north.
- C** North America and South America will split apart.
- D** Africa and Asia will no longer be joined.
- E** Parts of western Africa may become an island.
- F** Australia will move northward and collide with Indonesia.



Earth's plates are constantly moving, but in different directions. Some plates move toward each other, and other plates move away from each other. Other plates just slide past each other.

Scientists receive radio signals from Global Positioning System (GPS) satellites in space to figure out how the plates move. The laser beams can measure the distance between plates. Using laser beams, scientists have measured the North American plate and the Eurasian plate. They are moving away from each other about two centimeters a year. Earth's features can change over time as plates continue to move.

The theory of plate tectonics explains many of Earth's features. For example, mountain chains can form where plates move together. But if plates move apart, hot magma can rise to the surface. This is one way a volcano can form.

Scientists believe that plate movement has always taken place at about the same rate. They predict that the plates will continue to move. The continents may one day come together to form another Pangaea-like continent.





Plate Boundaries

A **plate boundary** is the edge of a plate. Plates meet at their boundaries. Plates move slowly in different directions. They can move apart, collide, or slide past each other. Different landforms are made by the changes that slowly take place at each plate boundary.

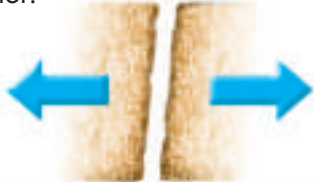
Plates move away from each other at spreading boundaries. Gaps form between the plates. Magma can bubble up from the mantle through these gaps. Huge valleys can form. This kind of plate movement causes seafloor spreading.

Plates slide past each other at fracture boundaries. Sliding boundaries often cause a break in Earth's crust called a **fault**. Strong earthquakes can occur when these plates move.



Spreading Boundary

The Mid-Atlantic Ridge cuts across Iceland at the boundary between the Eurasian plate and the North American plate. These plates are moving away from each other.

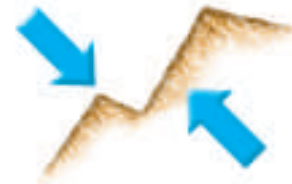


Plates push against each other at colliding boundaries. The edges of the plates can rise up to form large mountains. One plate can also slide under another plate. This action can cause deep ocean trenches. It can also cause earthquakes or volcanoes.



Colliding Boundary

The Himalaya mountains are still rising where the Eurasian plate and the Indian plate are pushing against each other.



Fracture Boundary

The San Andreas fault is a boundary between the North American plate and the Pacific plate. The two plates are sliding past each other.





What causes earthquakes and volcanoes?

Earthquakes

Plate movement is usually too slow to be seen or felt. Sometimes, jagged rock edges in the lithosphere stop a plate from moving. Over time, pressure builds at the jam site. If the pressure grows too strong, the rocks jerk forward. Earth's crust shakes. An earthquake has occurred.

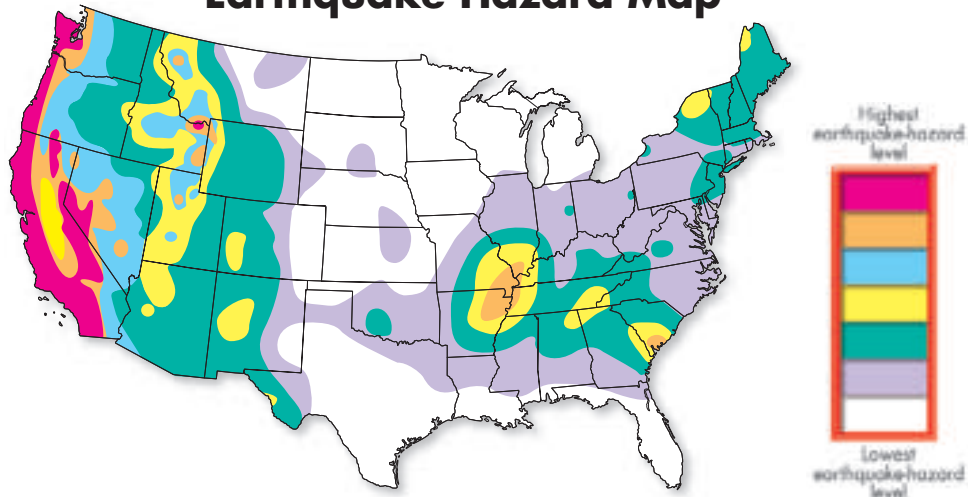
The area underground where the earthquake occurs is called the focus. The spot on Earth's surface directly over the focus is called the earthquake's epicenter.

The energy from an earthquake is carried by waves. The waves spread out from the focus and epicenter. Some waves cause the ground to move back and forth. Other waves cause the ground to move up and down or even in a circular motion.

Waves lose energy as they spread out. That is why the damage from an earthquake is greatest closest to the epicenter.

Most earthquakes take place near the edges of plates. In the United States, most earthquakes occur in California and Alaska. These states are on the boundary between two plates.

Earthquake Hazard Map



The strength of an earthquake is measured on a magnitude scale. The number tells scientists how much energy is released. For each increase of 1 on the scale, 31 times more energy is released.

The table below shows the magnitude and number of deaths caused by several earthquakes. Magnitude alone does not explain the damage or number of deaths an earthquake will cause. The number and type of buildings, kind of rock, and distance of an area from the epicenter also affect the total damage of an earthquake.



Earthquakes			
Date	Place	Magnitude	Total Deaths
1/22/2003	Mexico	7.6	29
3/29/2003	Afghanistan	5.9	1
5/27/2003	Algeria	5.8	9
9/27/2003	Russia	7.3	3
12/26/2003	Iran	6.6	30,000



Volcanoes

A volcano is an opening in Earth's surface. Red-hot magma rises out of this hole. Like earthquakes, most volcanoes occur near plate boundaries. The theory of plate tectonics explains why this occurs.

A Ash cloud

Tiny bits of rock spew into the air during an eruption, forming a thick cloud of ash.

B Crater

A crater is a steep-sided depression at the top of a volcano. Craters can form during an eruption or if the rim of the volcano collapses.

C Hot spot

Volcanoes are common in Hawaii, even though the islands are not near a plate boundary. Hawaii is on a hot spot—an area of on-going volcanic activity.



Magma forms from the melting crust of one plate that sinks underneath another. Gases in the magma can cause pressure to build up. Eventually the pressure is too great for the crust of the overlapping plate. Magma bursts through the crust as a volcano. Magma that reaches Earth's surface is called lava. Many volcanoes are found on the ocean floor. Magma flows out of the volcano. The cooled lava causes new crust to form.

D Caldera

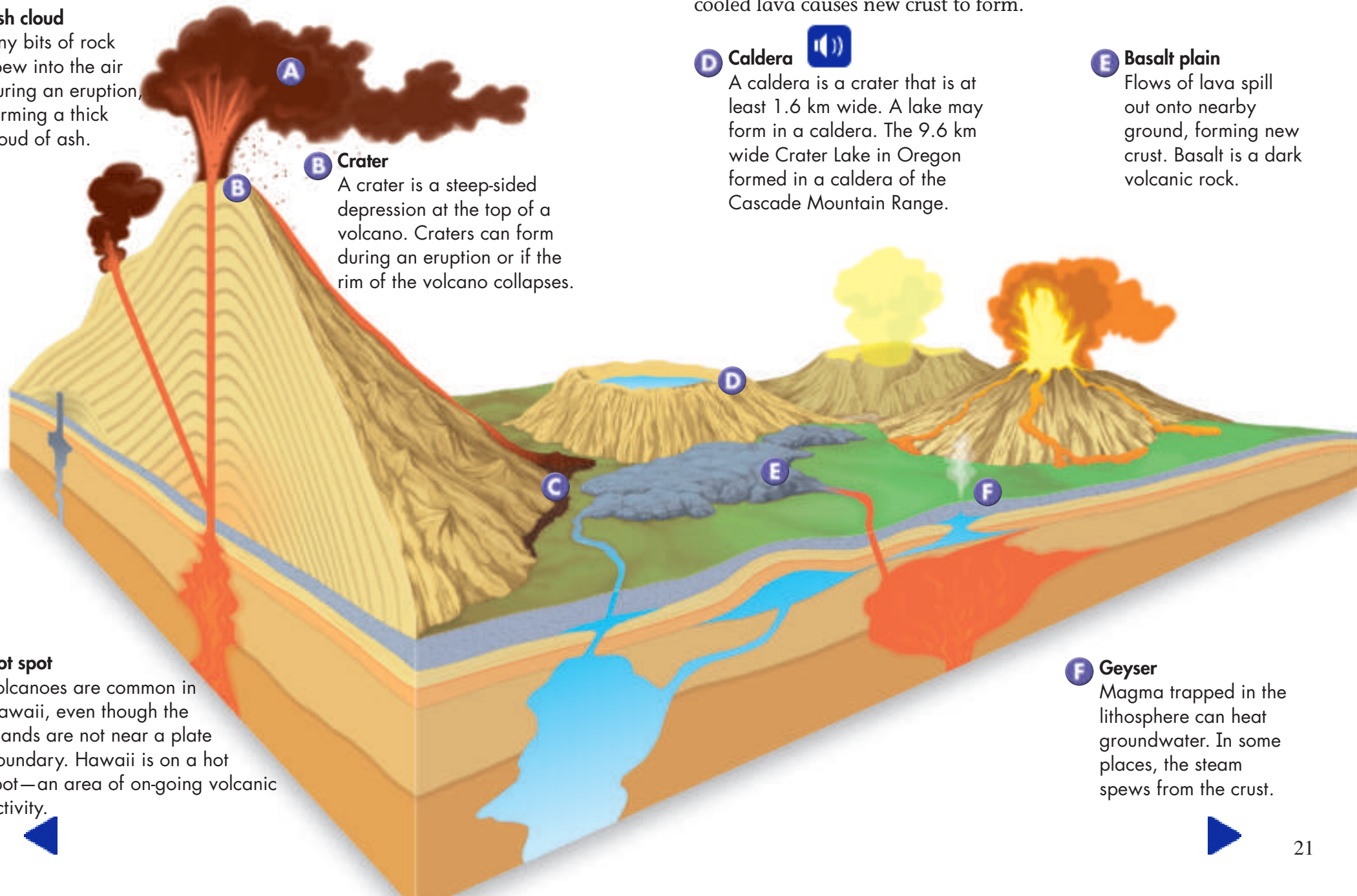
A caldera is a crater that is at least 1.6 km wide. A lake may form in a caldera. The 9.6 km wide Crater Lake in Oregon formed in a caldera of the Cascade Mountain Range.

E Basalt plain

Flows of lava spill out onto nearby ground, forming new crust. Basalt is a dark volcanic rock.

F Geyser

Magma trapped in the lithosphere can heat groundwater. In some places, the steam spews from the crust.





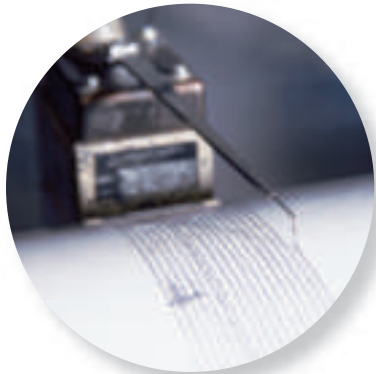
Predicting Volcanoes and Earthquakes

Scientists use many different tools to predict the threat of an earthquake or volcano. A seismometer can detect tremors, or shaking movements, in Earth's crust. Tremors are signals that magma may be rising in a volcano or that Earth's plates are shifting. Scientists use a tiltmeter to detect changes in the slope, or tilting, of the land.

Scientists can often tell where and when a volcano will erupt. Volcanoes often follow a pattern of eruption. So future activity is likely to occur at sites of past eruptions.

Earthquakes are harder to predict than volcanic eruptions. It is difficult to predict when plates will suddenly shift. So scientists listen for tremors with a seismograph. As the ground moves, the free-moving part of the seismograph moves back and forth. The movements are recorded on a sheet of paper.

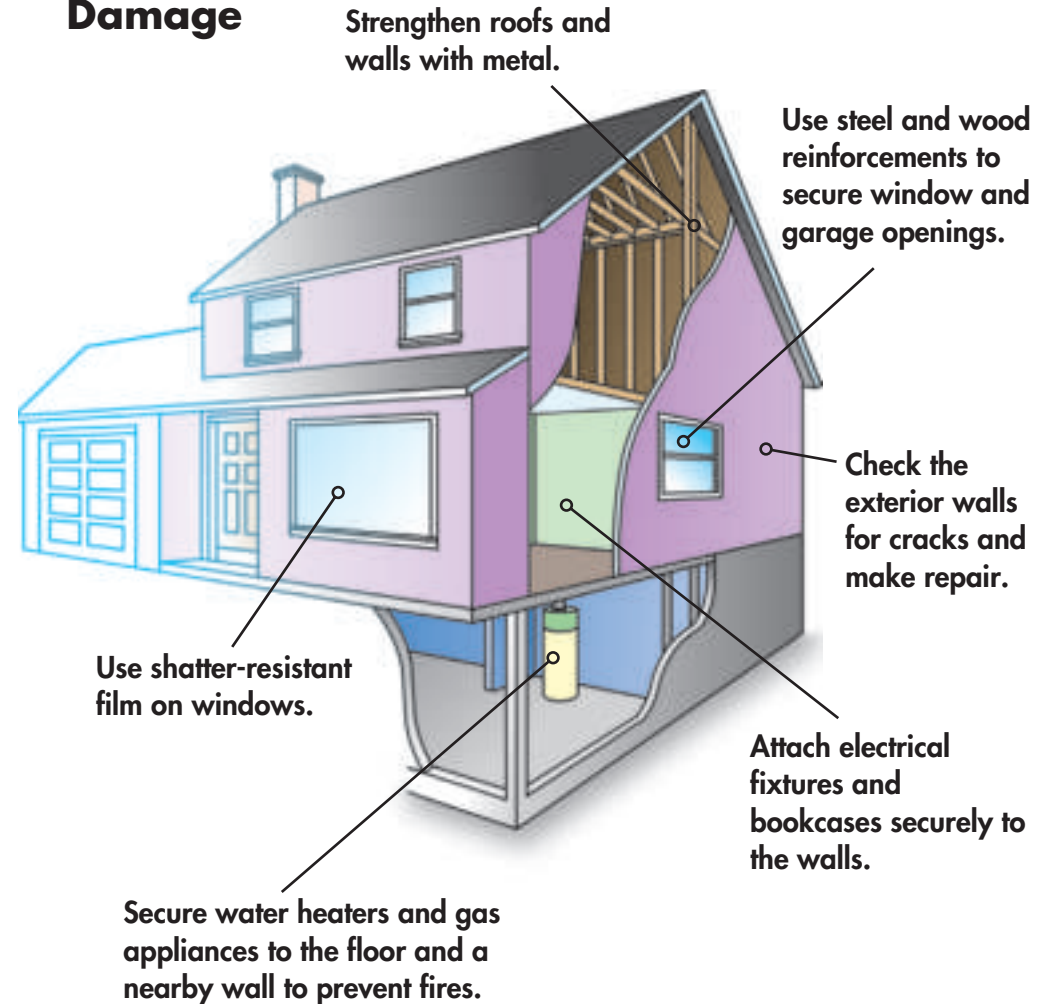
A ball would drop from a dragon's mouth to a frog's mouth if this ancient seismometer detected a tremor.



seismograph



Reducing Earthquake Damage




Preparing for Earthquakes

The best way to avoid earthquake damage is to be prepared. Many people take extra steps to protect their homes from earthquakes. The diagram above shows ways that people can do this.

Glossary

continental drift	the theory that continents drifted apart in the past and continue to do so today
core	the center part of the Earth that has a molten outer core and a solid inner core
crust	the top layer of rock that covers Earth
fault	a break in Earth's crust where plate boundaries slide past each other
lithosphere	the section that contains Earth's crust and the upper mantle
mantle	the layer of Earth between the crust and the core which includes an outer mantle of solid rock and an inner mantle of partly melted rock
plate boundary	the edge of one plate, where it meets another plate
plate tectonics	a theory that explains the origin of Earth's features because of plate movement

What did you learn?

1. How did Alfred Wegener explain the formation of continents on Earth in his theory of continental drift?
2. What is the layer called that is made of Earth's crust and upper mantle?
3. What is the place called where two plates meet?
4. **Writing in Science** According to the theory of plate tectonics, Earth has about twenty plates that are constantly moving. Write to explain the different movements that plates can make and what impact these movements have on Earth's surface. Include details from the book to support your answer.
5.  **Draw Conclusions** What might scientists conclude if an instrument detected a tremor in Earth's crust?

