Science

Genre	Comprehension Skill	Text Features	Science Content
Nonfiction	Draw Conclusions	• Captions • Charts • Diagrams • Glossary	Plate Tectonics

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Science

Earth Science

Earth's LAYERS

by Emily Gray

Vocabulary

continental drift
core
crust
fault
lithosphere
mantle
plate boundary
plate tectonics

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Earth's LAYERS

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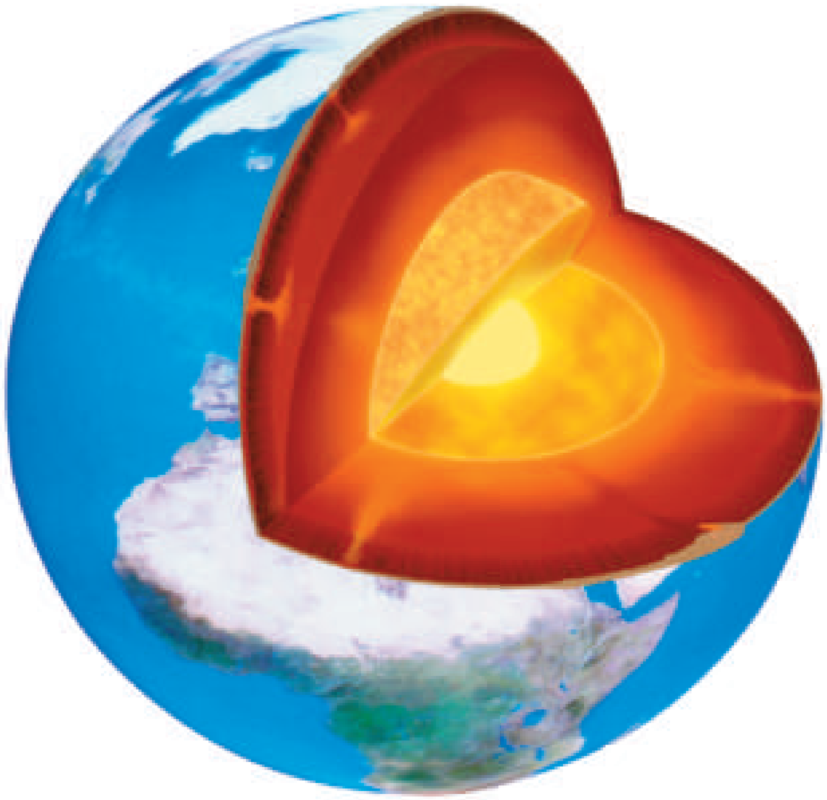

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What are Earth's layers made of?

Earth has many dramatic physical features. Landforms such as plateaus, mountains, plains, and valleys are all over the world, but these features did not develop immediately. Small changes over millions of years have eventually produced landscapes, such as the Grand Canyon, the Himalaya Mountains, and the Hawaiian Islands as we know them.

Earth also has important features under its oceans. Mountain ridges, deep trenches, and even volcanoes can be found under the sea.

In order to fully understand how all of these geographic features developed we need to understand the structure of Earth and the natural processes that are constantly occurring around us.

Earth's Layers

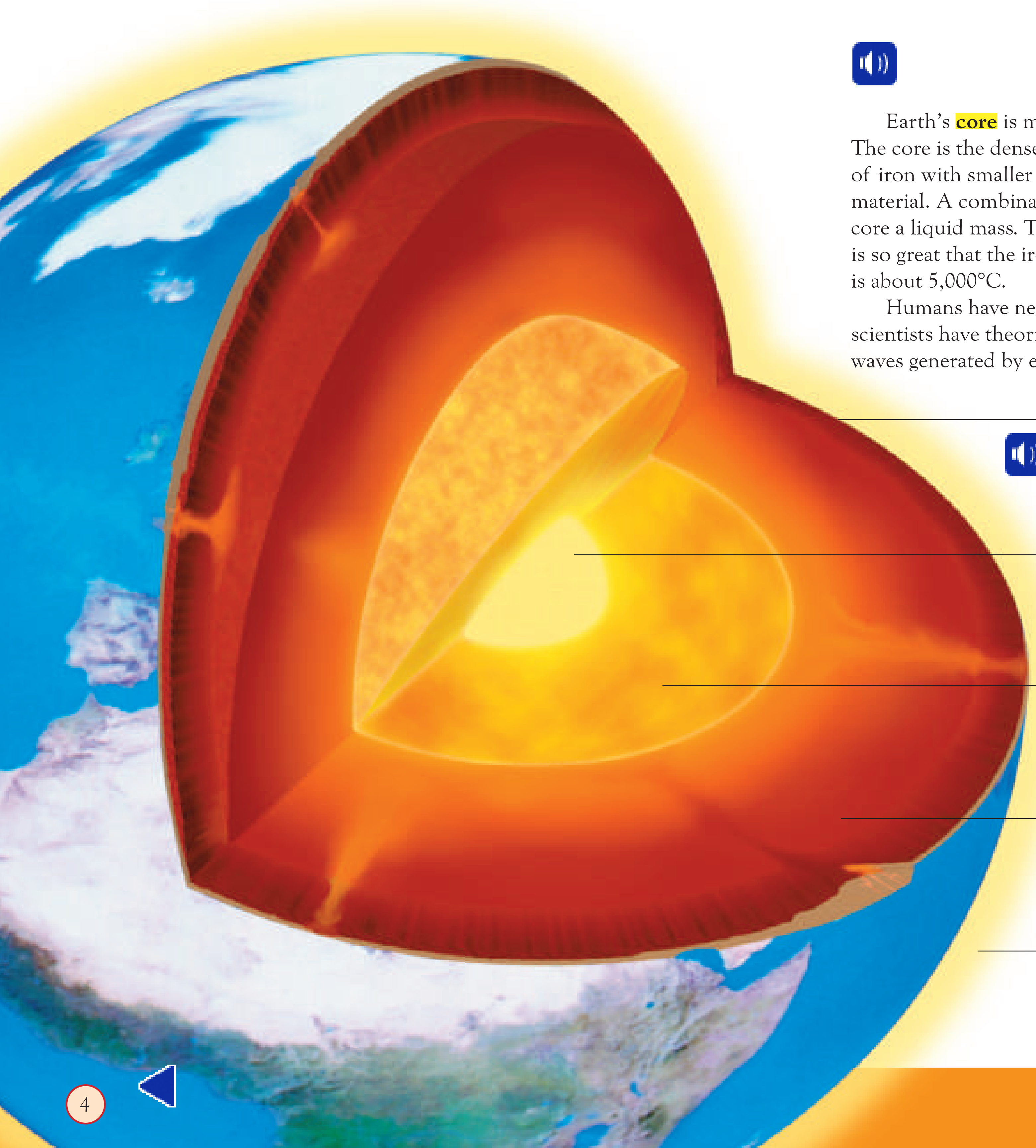
Earth is composed of several layers. Not all of these layers are solid. The atmosphere is above the surface of Earth and is a thin gaseous layer that permits the existence of living things.

The layer of Earth that we live on is the **crust.** This is the outermost solid layer of Earth. The crust is about five kilometers thick in places covered by the ocean, and about thirty kilometers thick in places that are land. Although the crust seems thick to us, it is only a thin shell covering Earth.

The layer below the crust is the **mantle,** and this layer is much thicker than the crust. The mantle is composed of several solid and liquid parts, and makes up more than 80 percent of Earth's mass. The mantle extends to a depth of about 2,900 kilometers below the crust.

Earth's core is made up of the inner core and the outer core. The core is the densest layer of Earth and is mainly composed of iron with smaller amounts of nickel, sulfur, and radioactive material. A combination of heat and pressure make the outer core a liquid mass. The inner core is a solid because the pressure is so great that the iron cannot melt. The temperature of the core is about 5,000°C.

Humans have never seen Earth below the crust layer, and scientists have theorized about Earth's composition by studying waves generated by earthquakes.



Earth's Plates

The crust and the outermost solid part of the mantle are called the **lithosphere.**

Earth's lithosphere layer is broken up into pieces known as tectonic plates. Tectonic comes from the Greek word *tektonikos*, which means "builder." Earth has about twelve large plates and many smaller plates of different shapes and sizes. Most of Earth's plates are covered by water and are not visible when viewed from outer space.

Tectonic plates fit together like jigsaw puzzle pieces, and move around on Earth's surface over long periods of time. Plates can move in three ways: they can move away from each other, they can move toward each other, or they can slide past each other.

Some plates are made up of continental crust, which is the land that makes up the continents. This accounts for about 40 percent of Earth's surface. Continental crust is older, thicker, and less dense than oceanic crust.

Oceanic crust covers about 60 percent of Earth's surface. This type of crust makes up the floor of the ocean and is thinner and denser than continental crust. Oceanic crust is constantly produced in some places on the ocean floor. Magma rises through cracks and cools, forming new crust.

Earth's lithosphere is broken up into pieces like a jigsaw puzzle.

Earth's Landforms

Continents drift apart continuously, in slow motion. One of its effects may be the creation of landforms.

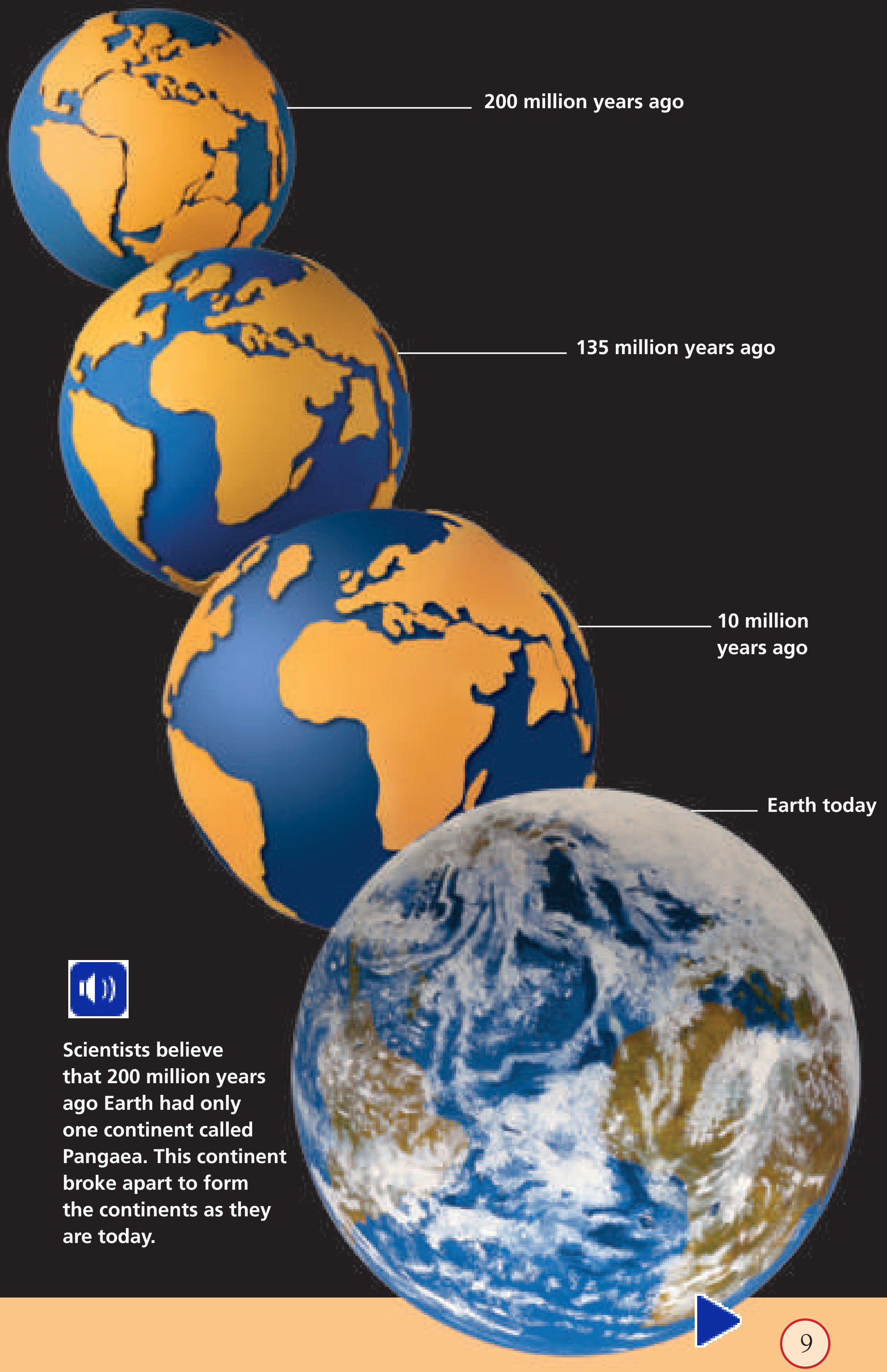
Continental Drift

In the past, most people thought that Earth's continents remained in the same place and did not move, but in the early 1500s explorers started to notice that the continents of Africa and South America looked like they might fit together. It wasn't until the 1900s that a comprehensive explanation was developed.

In 1912, a German scientist named Alfred Wegener proposed that about 200 million to 225 million years ago the continents were joined together as one continent he named Pangaea. Wegener theorized that Pangaea broke apart and shifted to form the continents as we know them today. This theory is known as **continental drift.**

Wegener did not have any firm proof that continental drift had occurred, but several other pieces of evidence supported his theory. Rocks of the same age and type were found on the coastlines of South America and Africa. Fossils of similar animals and plants were also found along those areas.

Ultimately, Wegener could not explain what kind of forces could move such large land masses across Earth, and many scientists rejected the theory of continental drift.



Scientists believe that 200 million years ago Earth had only one continent called Pangaea. This continent broke apart to form the continents as they are today.

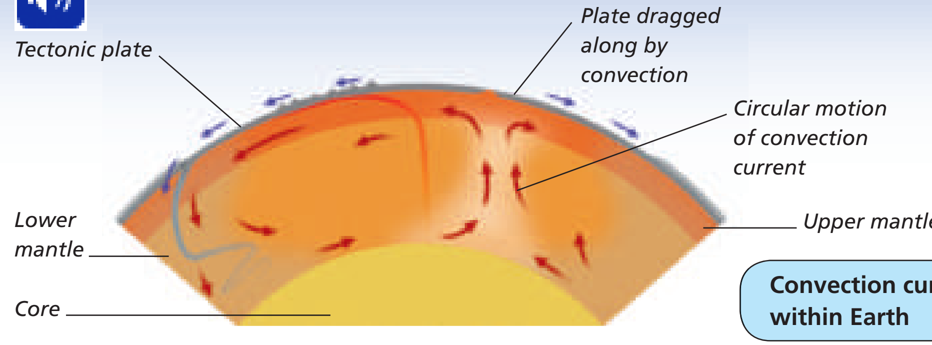
The Spreading Ocean Bottom

In the 1950s technology was developed that allowed scientists to map the ocean's floor. Long, deep trenches and mid-ocean ridges, or mountains, were discovered. These discoveries supported Wegener's theory of continental drift.

American geologist Harry Hess proposed that these ridges form when magma, or molten rock, pushes up through Earth's crust. The magma cools and forms a new crust that creates a ridge. Another scientist, Robert Dietz, named this process seafloor spreading. Hess also proposed that since the size of Earth remains the same, the crust must be recycled under mountains and along trenches on the ocean floor.

Proof of Continental Drift

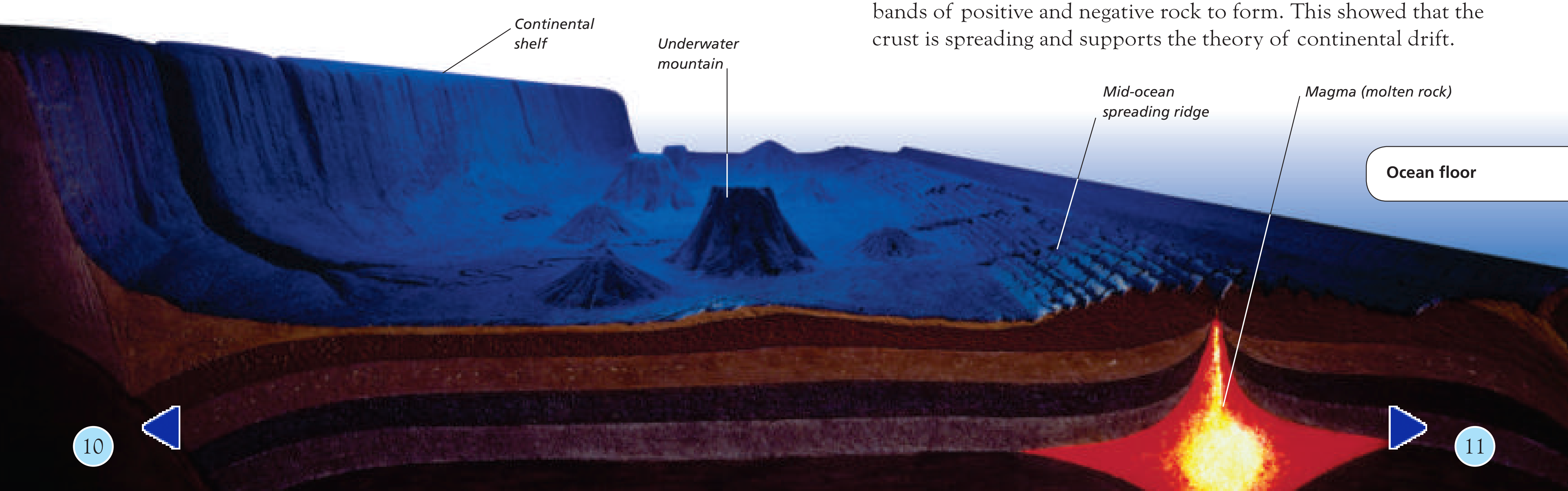
As Earth's plates move, magma rises to fill the space. When a liquid is heated, particles that make up the liquid move faster and spread apart. Hot liquids are less dense than cooler liquids and float to the top. As the liquid cools, however, it becomes denser and sinks, moving in a circular pattern. The process responsible for this is known as convection.



Convection currents within Earth

Convection is only one of the processes involved in plate movement. Scientists also believe that gravity plays a major role in the movement of tectonic plates. Since the plates are slightly cooler and denser than the layer of the mantle below them, they tend to slide down toward trenches and penetrate the mantle.

In the 1960s scientists found more evidence to support the concept of seafloor spreading. Scientists studying the rocks near the Mid-Atlantic Ridge noticed a strange pattern. In some areas the magnetism of the rocks pointed north. In other areas the magnetism pointed south. These areas form patterns that run parallel to the mid-ocean ridge and are the same on both sides of it. Earth's magnetism flips about once every half-million years. When magma cools to form new crust it keeps the magnetic pattern of the time it was formed. This caused the alternating bands of positive and negative rock to form. This showed that the crust is spreading and supports the theory of continental drift.



Ocean floor

How do scientists explain Earth's features?

The theory of continental drift was integral to understanding how and why the ocean floor spreads, but it cannot explain other features of Earth's crust.

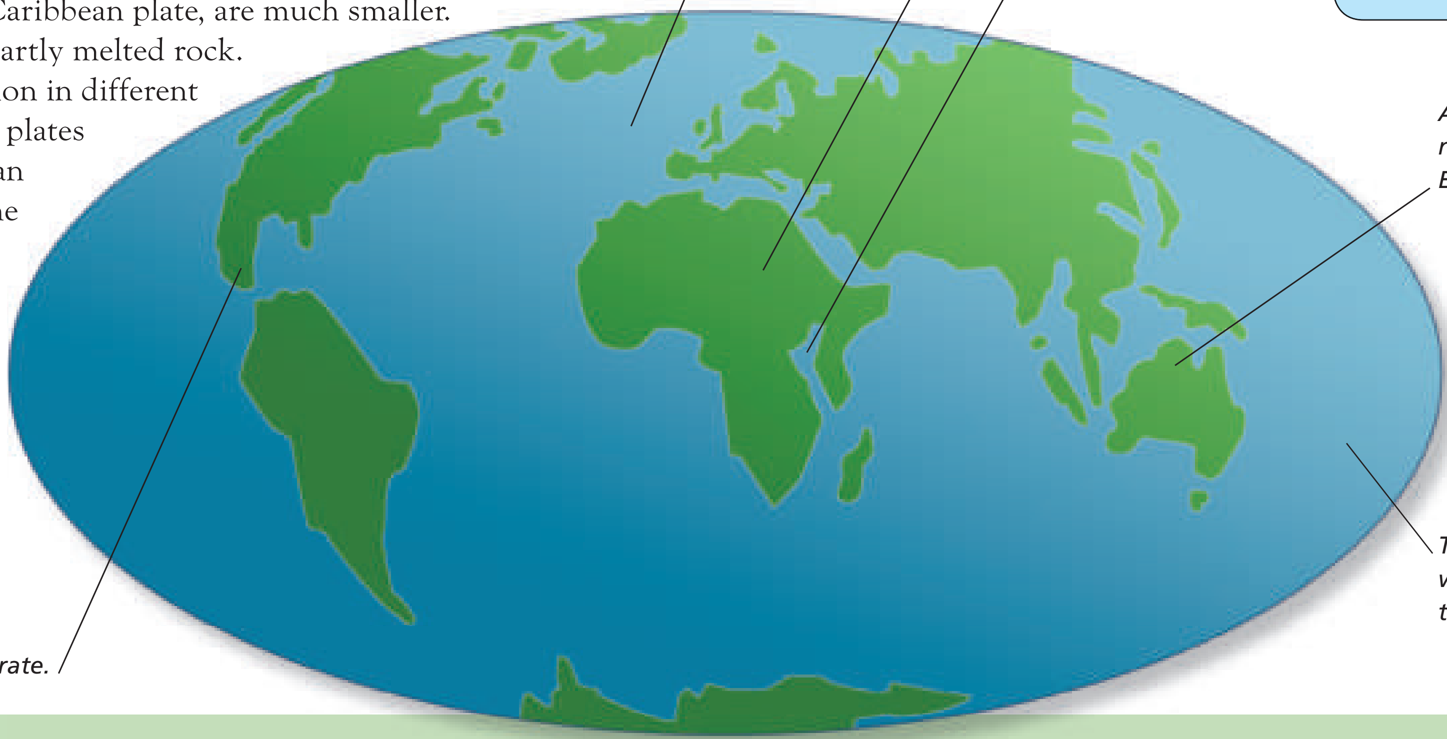
Plate Tectonics Explanation

Scientists use the theory of **plate tectonics** to explain why the features of Earth look the way they do and why certain geological events happen.

Earth's lithosphere is made up of about twenty moving plates. Some, such as the North American plate, are the size of continents. Others, such as the Caribbean plate, are much smaller. These plates float on a layer of partly melted rock. They move in a continuous motion in different directions. The surfaces of these plates form the continents and the ocean floor. Scientists can determine the direction plates move and how far they move by transmitting lasers from satellites in space down to Earth. For example, data indicates that the North American plate and the Eurasian plate are moving about 2.5 centimeters apart each year.

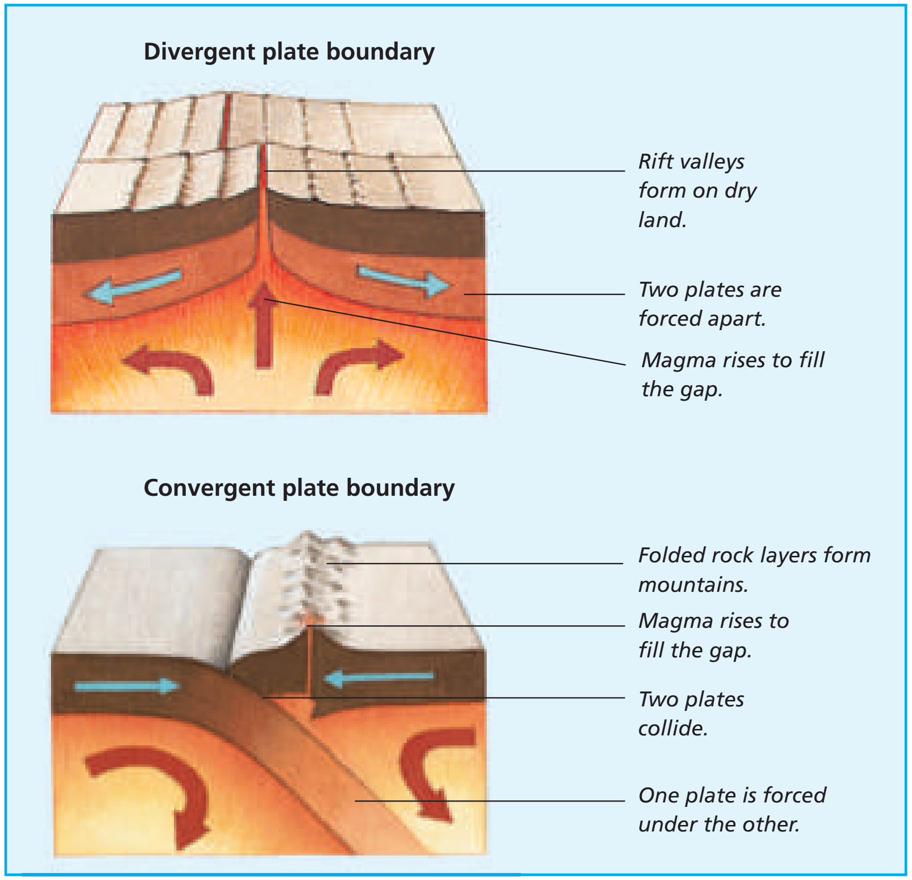
As the plates shift, continents may separate or move closer to one another, depending on the direction of movement. When magma rises to the surface through gaps in the plates, volcanoes may form. Mountain chains can also develop when the plates move together on dry land or when they move together in the ocean.

Scientists are able to predict what Earth may look like millions of years into the future. There is evidence that continental drift takes place at the same rate, and scientists predict that the plates will continue to move at that rate. Currently, plate movement is making the Atlantic Ocean larger, the Pacific Ocean smaller, and the Himalaya Mountains higher.



How Earth may look 50 million years from now

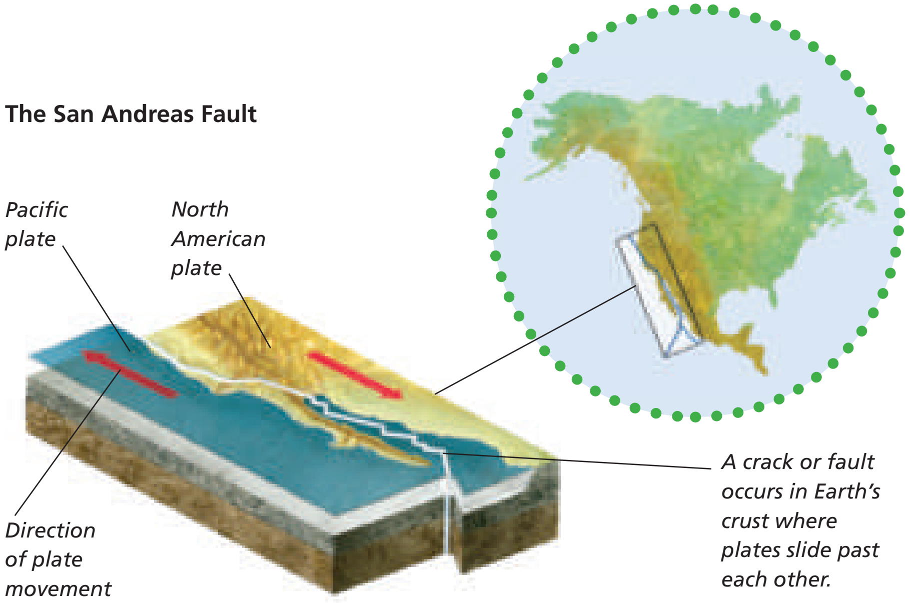
Plate Boundaries



A **plate boundary** is the area where two plates meet. As you previously learned, the theory of plate tectonics states that plates can move in three ways: they can move away from each other, they can move toward each other, or they can slide past each other.

Divergent plate boundaries occur when plates move away from each other. When this occurs, magma rises to the surface, forming rift valleys on dry land and seafloor spreading in the ocean's crust. The Mid-Atlantic Ridge, found near the middle of the Atlantic Ocean, was created at a divergent plate boundary and is still spreading. The Great Rift Valley, found in the Middle East and Africa, was created after land shifted upward.

Convergent plate boundaries occur when plates are recycled back into Earth's mantle. Rock layers in these areas can fold, and volcanoes and earthquakes may occur. Convergent plate boundaries can also double the normal thickness of the continental crust, creating mountain ranges and plateaus. The Himalaya and Andes mountain ranges were both formed when plates converged. A **fault** is a crack in Earth's crust where there has been rock movement on either side.



Transform plate boundaries, or transform fault systems, occur when two plates slide past one another. Transform faults may divide the centers of ocean ridges that are spreading or may create steep cliffs on mountains under the sea. The San Andreas Fault in California is another example of a transform fault system.

All three types of plate movements may cause earthquakes, although the frequency and magnitude are not the same in all areas. Volcanic activity usually occurs along convergent or divergent plate boundaries.

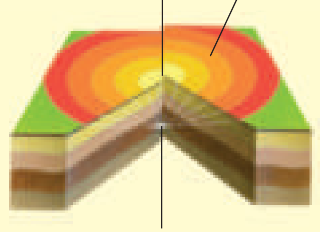
The Causes Of Earthquakes And Volcanoes

Earthquakes

Tectonic plates move so slowly that you cannot feel or see the movement. Some plates may also stop moving if the edges of the lithosphere get caught against each other. An earthquake happens when this energy and pressure build up and eventually release suddenly, shaking Earth.

During an earthquake, the rapid movement of the rocks transmits energy through Earth's crust in the form of waves. There are several types of waves that travel above and below the surface of Earth. Primary, or P waves, and secondary, or S waves, are body waves that travel below Earth's surface.

Major earthquake zones around the world



How an earthquake happens

P waves move the ground back and forth and are the fastest type of wave. S waves may move the ground up and down, or in a circular motion.

Waves lose energy as they spread out from the epicenter, so the damage caused by earthquakes is greatest at their point of origin. Aftershocks, or smaller earthquakes that happen after the initial earthquake, are caused by strain on the rocks after the original earthquake.

The focus of the earthquake is the point within Earth along the fault where the earthquake originates. The epicenter is the point on Earth's surface right above the focus.

The study of earthquakes is known as seismology, from the Greek word *seismos*, "to shake." About one thousand instruments known as seismographs are used around the world to detect earthquakes. About one million mild earthquakes are recorded each year. About twenty moderate earthquakes occur each year. Major earthquakes happen once every few years.

Seismologists compare measurements taken at several different locations to determine an earthquake's epicenter and magnitude. The strength of an earthquake is measured using the Richter scale, which measures the height of seismic surface waves. It uses a series of numbers from zero to nine, and each whole number on the scale represents a tenfold increase in strength.

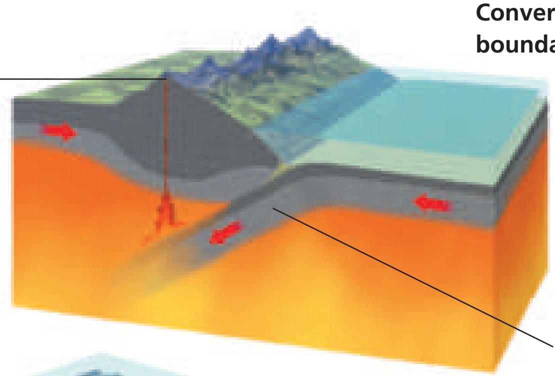
Volcanoes

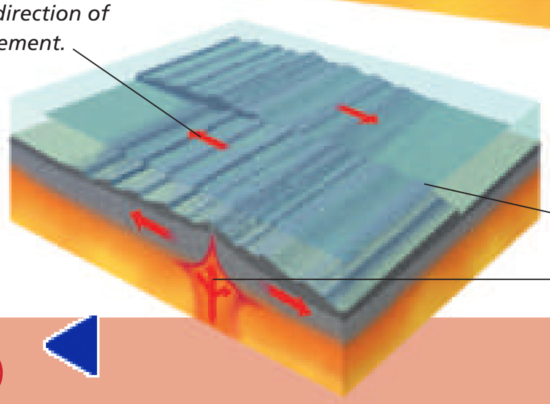
Volcanoes form deep within Earth, usually in the upper part of the mantle. Magma, or molten rock, accumulates under high temperatures and pressures, and eventually rises to the surface of Earth. The theory of plate tectonics can help explain why most volcanoes occur near plate boundaries.

At locations where there are convergent plates boundaries, one plate may sink beneath another. This crust may eventually sink far enough to melt and become magma. Gases trapped in the magma cause pressure to build up, and the pressure can increase to such an extent that the crust cannot hold it. This pushes magma toward the surface through volcanoes. Magma that reaches the surface is known as lava.

Magma can erupt from a single vent known as a volcanic vent, from a cluster of vents, or along one long crack, or fissure, in Earth's crust. Most volcanoes are found on divergent plate boundaries under the ocean and have grown to form mid-ocean ridges. As plates move away from each other, magma rises to the surface and cools. The lava forms new crust and the ridges become larger.

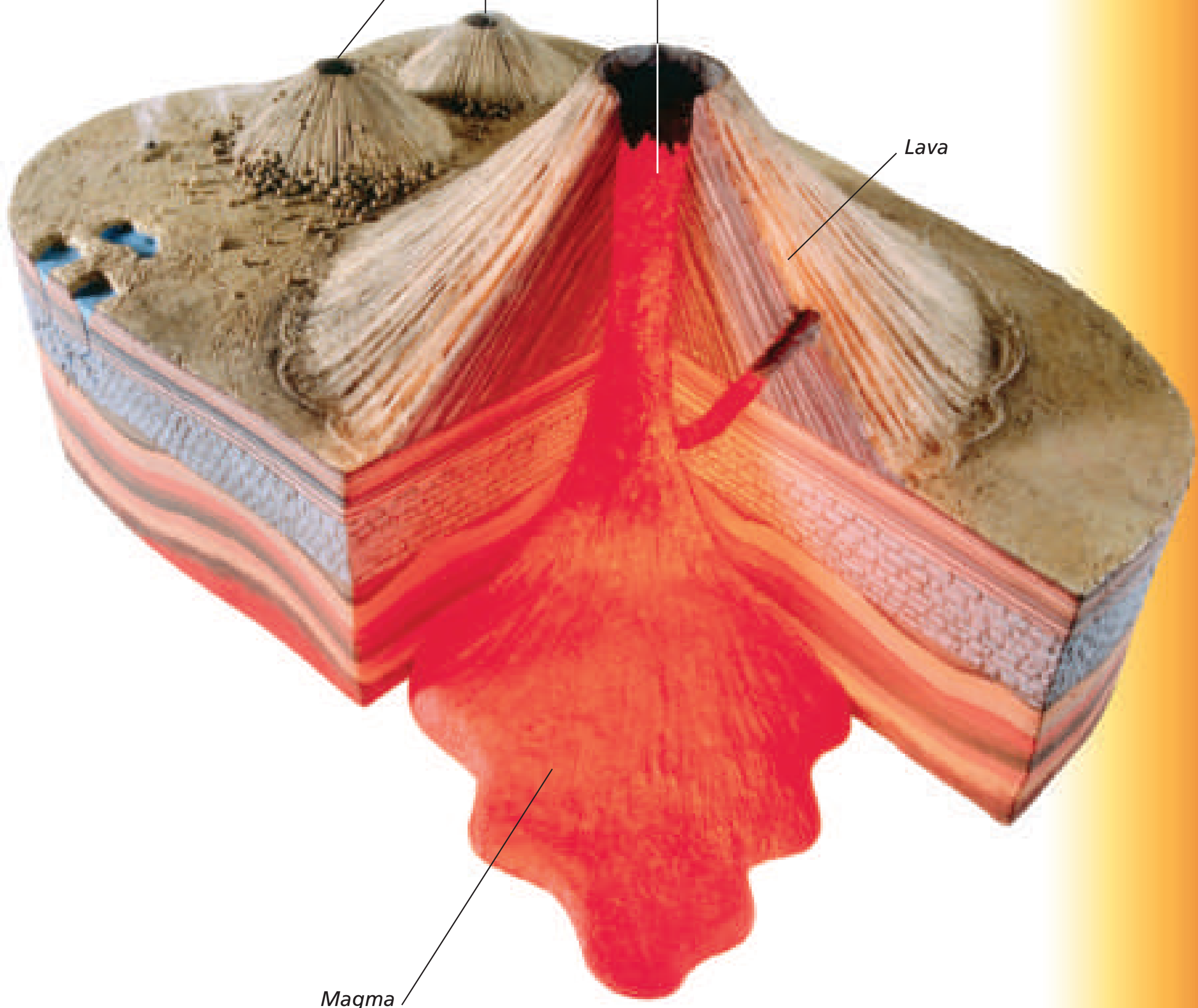
Convergent plate boundary volcano





Divergent plate boundary volcano

Structure of a volcano



Types of Volcanoes

When we think of volcanoes, most of us have a picture in our mind of a cone-shaped mountain that spews lava. However, volcanoes that have formed on land have many different shapes and sizes. This is mainly based on the way the volcano erupts, the frequency of the eruptions, and the makeup of the magma.

Composite volcanoes, such as Mount Fuji in Japan, shown below, repeatedly erupt from the same vent over long periods of time. Cinder cone volcanoes usually only erupt once. Shield volcanoes have gently sloping sides because they do not erupt with force. Lava flows out of shield volcanoes slowly and across large areas. Two examples of this type of volcano are the Hawaiian volcanoes Mauna Loa and Haleakala.

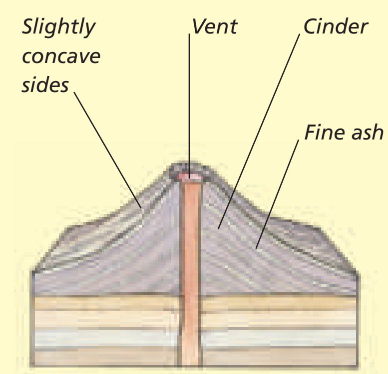
A caldera is a crater that forms after the ground collapses because of explosive eruptions. To be considered a caldera, the volcanic crater must be at least a kilometer wide, but some are over thirty-kilometers wide. Yellowstone National Park in Wyoming has several examples of calderas.

Volcanic plateaus may also form on land where lava flows out of a fissure vent. These plateaus can cover thousands of square kilometers.

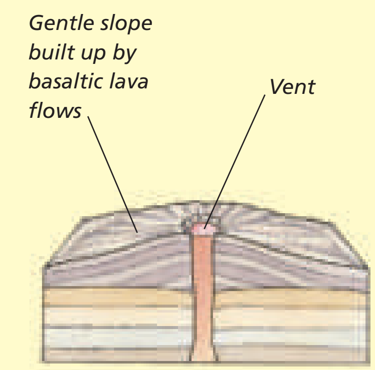
Mount Fuji, Japan

Haleakala crater, Hawaii

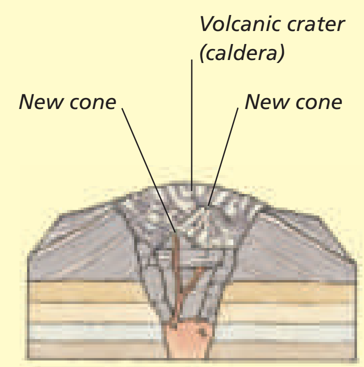
Ash cinder volcano



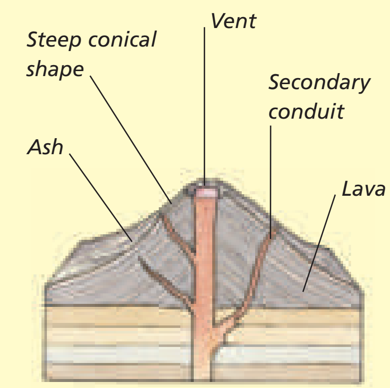
Shield volcano



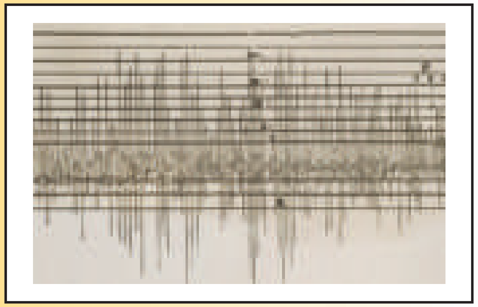
Caldera volcano



Composite volcano



Predicting Earthquakes And Volcano's Eruptions



This seismograph recording of a 1923 earthquake in Japan shows P and S waves.

A modern seismograph

Small shifts in ground level would cause a ball in a dragon's mouth to fall into a frog's mouth. The frog that contained the ball would indicate the direction from which the earthquake occurred.

The first instrument used to predict earthquakes was invented in China in A.D. 132.

Many people live in areas that are threatened by earthquakes, volcanoes, or their side effects. Scientists use several methods to help them make predictions about when or where future earthquakes or volcanoes may occur.

Seismometers are used to detect tremors in Earth's crust that may indicate that there is volcanic or earthquake activity. A tiltmeter is an instrument that scientists use to detect changes in the angle of the land. These changes may indicate that magma is rising within a volcano, preceding an eruption.

The shaking of an earthquake and eruptions of magma from a volcano may cause immediate damage, but other damaging effects can follow. Mudslides can occur after earthquakes, and tsunamis, or giant waves, can develop after an undersea earthquake or volcanic eruption. Damage from these events can be minimized if proper precautions are taken.

Glossary

continental drift	movement of continents as described by the theory of plate tectonics
core	innermost layer of Earth, composed of the inner core (solid) and outer core (liquid)
crust	outermost solid layer of Earth; the outermost part of the lithosphere
fault	a crack in Earth's crust where there has been rock movement on either side
lithosphere	Earth's crust and the outermost solid layer of the mantle
mantle	layer below the crust that consists of solid and liquid layers of matter
plate boundary	area where two plates meet
plate tectonics	theory that explains geographic features and events based on the movement of Earth's plates

What did you learn?

1. What layer of Earth do we live on?
2. Describe the makeup of Earth's core.
3. Where are most volcanoes found, and at what type of plate boundary?
4. **Writing** in Science Provide the names of the two types of waves that occur during an earthquake and describe how they are different.
5. **Draw Conclusions** List three pieces of evidence to support new findings of seafloor spreading and continental drift. Give details from the book to support your answer.