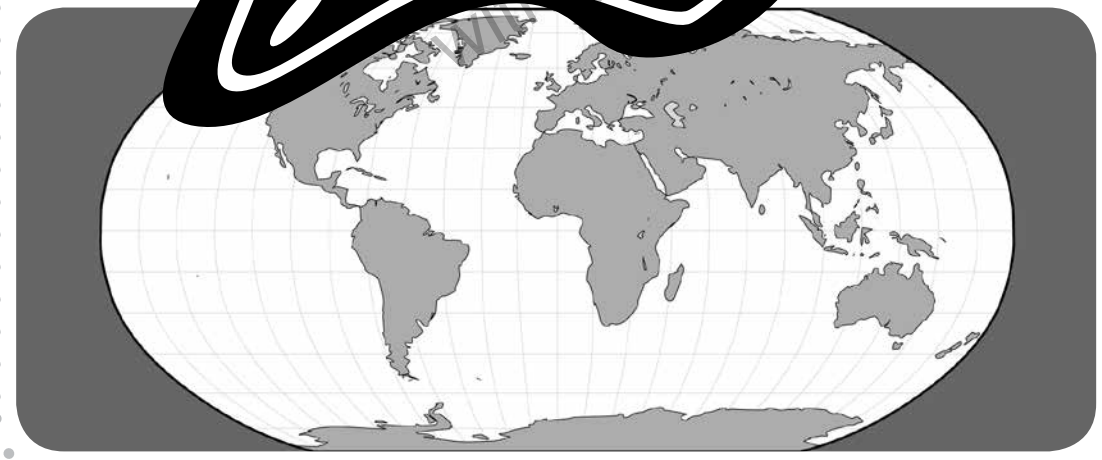
FOCUS ON SCIENCE

The Structure of Earth

Advanced Level



Earth Science
Geology

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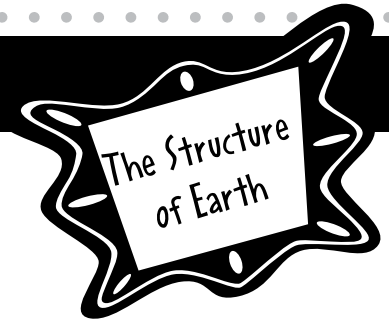


Scientific Inquiry

The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

Construct explanations independently for natural phenomena, especially by proposing preliminary visual models of phenomena.

Differentiate among observations, inferences, predictions, and explanations.

The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

Design charts, tables, graphs, and other representations of observations in conventional and creative ways to help them address their research question or hypothesis.

Organize results, using appropriate graphs, diagrams, data tables, and other models to show relationships.

Earth Science

Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

The interior of Earth is hot. Heat flow and movement of material within Earth cause sections of Earth's crust to move. This may result in earthquakes, volcanic eruption, and the creation of mountains and ocean basins.

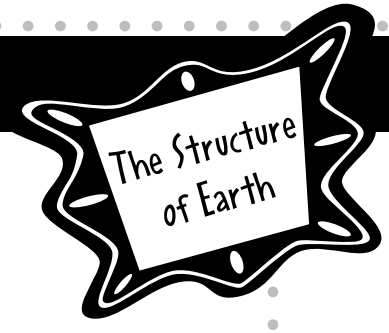
Analysis of earthquake wave data (vibrational disturbances) leads to the conclusion that there are layers within Earth. These layers—the crust, mantle, outer core, and inner core—have distinct properties.

Folded, tilted, faulted, and displaced rock layers suggest past crustal movement.

Continents fitting together like puzzle parts and fossil correlations provided initial evidence that continents were once together.

The Theory of Plate Tectonics explains how the "solid" lithosphere consists of a series of plates that "float" on the partially molten section of the mantle. Convection cells within the mantle may be the driving force for the movement of the plates.

Plates may collide, move apart, or slide past one another. Most volcanic activity and mountain building occur at the boundaries of these plates, often resulting in earthquakes.



English Language Arts

The following is a selective listing of the literacy competencies addressed in this book.

Literacy Competencies

Word Recognition

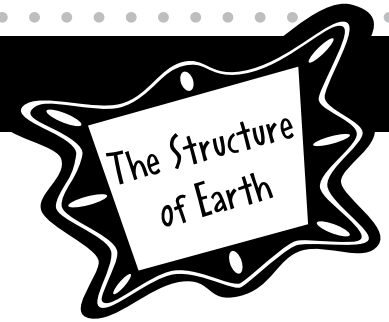
- Recognize at sight a large body of words and specialized-content vocabulary

Background Knowledge and Vocabulary

- Determine the meaning of unfamiliar vocabulary and idioms by using prior knowledge and context clues

Comprehension Strategies

- Use a variety of comprehension strategies (e.g., predicting, questioning, summarizing, visualizing, and making connections) to support understanding and response to reading



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How to Help Your Students Make the Best Use of This Book

Encourage students to develop nonfiction literacy skills by completing the Active Reader activities. Also encourage them to . . .

- Underline main ideas in paragraphs.
- Circle details that support the main ideas.
- Write down questions as they read.
- Circle key words as well as unfamiliar words.

Printing Instructions

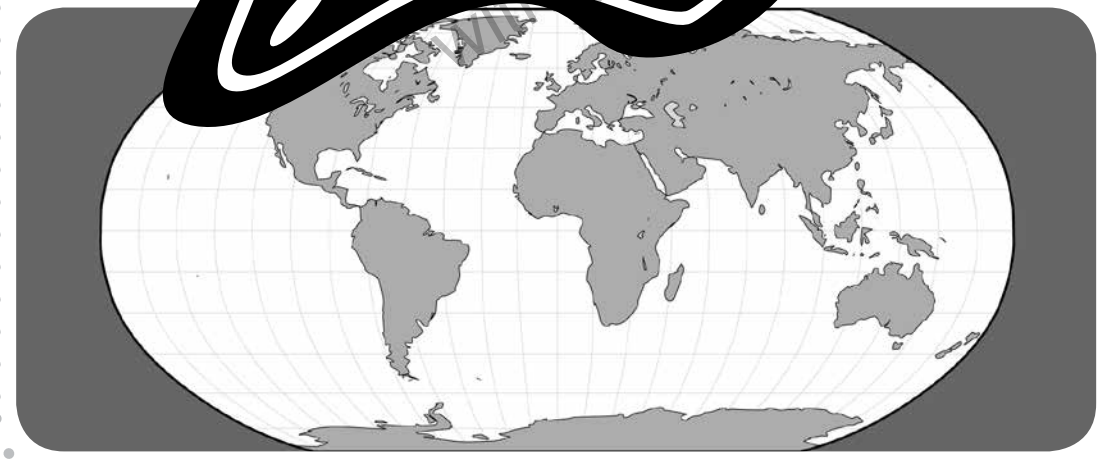
Student Book: print pages 5–30

Assessments: print pages 31–34

Answer Key: print pages 35–38

FOCUS ON SCIENCE

The Structure of Earth



How do we as scientists gather and interpret evidence that Earth is continually changing?

200–300 million years ago Earth's continents were connected in one large land mass called Pangaea. This single continent split into smaller fragments that drifted away from each other. Today the seven continents are still in motion.

How can such large land masses move so far away? What forces cause the continents to continue to move? Plate tectonics is the study of the movement of the interacting plates that make up the outer layer of Earth. Read on to learn more about the structure of Earth and how this plate tectonics cause the surface of Earth to constantly change.

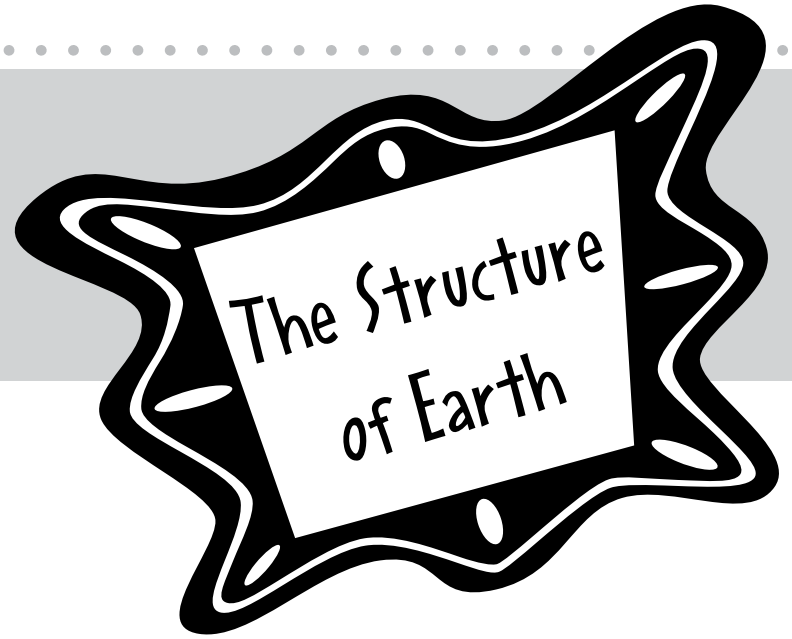


Table of Contents

Starting Points

Build Background 8
Key Vocabulary 9
Key Concepts 10
Hands On Science: Model the Rock Cycle 11

Chapter 1 Continental Drift

Earth's Interior 12
Puzzle Pieces 14
Evidence for Continental Drift 15
What Drives Continental Drift? 16
Stop and Think 17

Chapter 2 Plate Tectonics

Plate Tectonics 18
Divergent Plate Boundaries 20
Convergent Plate Boundaries 22
Transform Plate Boundaries 24
Hot Spots 25
Stop and Think 27
Hands On Science: Cotton Plates 28

Glossary 29
Assessments 31
Answer Key 35

Starting Points

Build Background

Label It

Below are blank word webs, along with a list of words about geology at left. Choose three of the words and write each in the center of a word web. Then, on the spokes coming off the web, write words and phrases that describe or relate to the word about geology.

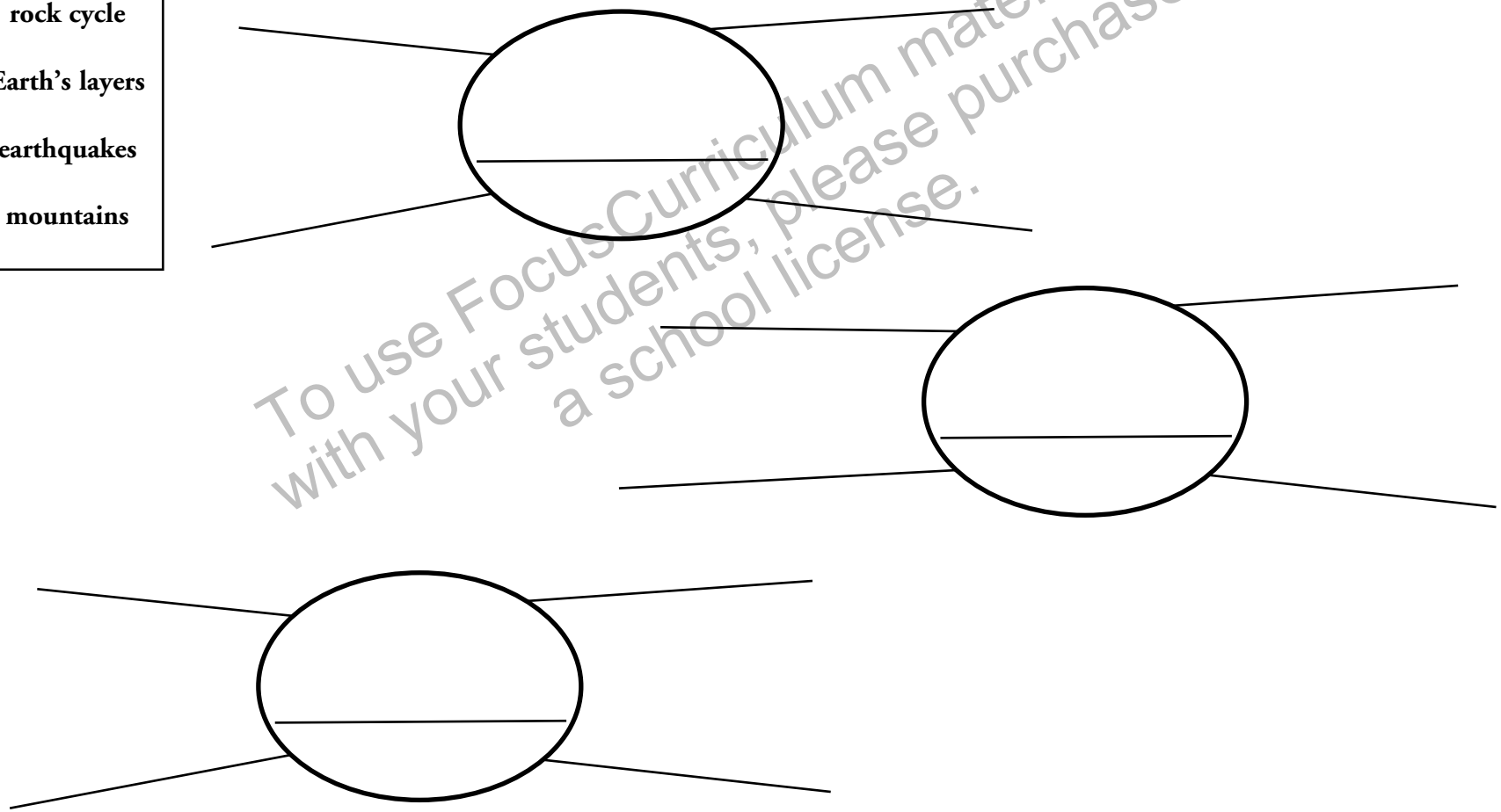
volcanos

rock cycle

Earth's layers

earthquakes

mountains



Starting Points

Key Vocabulary

Rate Your Knowledge

The words listed below have to do with the structure of Earth. Each word is important, but some may be new to you. Read each word. Rate your knowledge of each by putting a check or a few words in the appropriate column. After completing this book, come back to this page and write the definitions of words you did not know.

	I don't know it.	I've seen it, and I think it means . . .	I know it well. It means . . .
lithosphere			
asthenosphere			
convection currents			
mid-ocean ridge			
subduction			
divergent			
convergent			
rift valley			
fault			
ocean trench			
magma chamber			

Use Roots to Unlock Meaning

Knowing Greek roots can help you unlock the meanings of many science terms. Read the roots below. Write a word from the chart above that contains the root. Then use the root to figure out the meaning.

1. litho (Greek root meaning "stone") word: _____

   possible meaning: _____

2. asthenia (Greek root meaning "weakness") word: _____

   possible meaning: _____

Starting Points

Key Concepts

The Rock Cycle

Recall the three types of rock: igneous, sedimentary, and metamorphic. The rock cycle describes how rocks change due to temperature and pressure within Earth.

Igneous rocks have formed from molten material produced during volcanic activity. Those that have cooled on the surface, from lava, are called extrusive. Basalt is an example of an extrusive igneous rock. Those that have cooled underground, from magma, are called intrusive. Granite is an example of an intrusive igneous rock that has cooled underground.

Sedimentary rocks have formed from fragments of preexisting rocks. Generally, they have been subjected to various forms of weathering and erosion. The two main types of sedimentary rocks are lithogenous and biogenous. Lithogenous sedimentary rocks, such as sandstone and shale, are conglomerates of rock fragments. Biogenous sedimentary rocks, such as limestone, contain fragments of once living organisms such as shells, skeletons, oil, or carbon.

Metamorphic rocks are igneous or sedimentary rocks that have been subjected to extreme heat, pressure, or hot fluids while under the surface of Earth. This causes the rocks to change in composition. Marble is a metamorphic rock that was once sedimentary. Through heat and pressure, the chemical makeup of the rock was changed.

The Rock Cycle

ACTIVE READER

1 Monitor *Underline the three sentences that describe how each type of rock forms.*

2 Recall *What does the prefix bio- mean?*

---

3 Identify *Circle a word in paragraph 3 that is a synonym for mixtures.*

4 Visualize *In the box at left and below, draw a diagram showing how the rock cycle works. Hint: Use arrows to show progression from one stage to another.*

Good to Know

Thermal energy within Earth's mantle causes existing rock to melt and turn into molten magma. Granite is an intrusive igneous rock. It is molten magma that has cooled and crystallized under the surface of Earth.

Model the Rock Cycle

The rock cycle explains how the three rock types are related to each other. It also shows how Earth processes change a rock from one type to another throughout geologic time. Plate tectonic movement is responsible for the recycling of rock materials and is the driving force of the rock cycle. Prepare the following materials to help you learn more about how the rock cycle works.

Materials

sugar cube	**test tube clamp**	**hand lens**
candle	**foil**	**goggles**

1. **Examine the sugar cube with a hand lens. How is it like sedimentary rock?**

2. **Crush the sugar cube into a powder. What part of the rock cycle does this represent?**

3. **Make a boat with your foil. Pour the crushed sugar into the foil boat. What part of the rock cycle does this represent?**

4. **With the help of an adult, light the candle. Use the test tube clamp to hold the boat carefully over the candle flame. Observe as the sugar begins to melt. What part of the rock cycle does this represent?**

5. **Set the foil boat aside and let the sugar cool and harden. What part of the rock cycle does this represent?**

6. **Break the hardened sugar into pieces. What part of the rock cycle does this represent?**

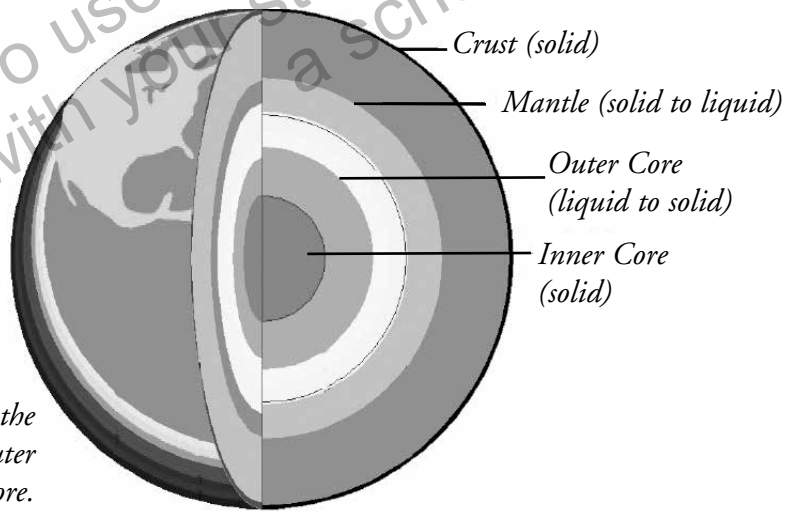
Chapter 1 Continental Drift

FOCUS The underlined sentence states an important idea about why the structure of Earth matters. As you read this section, find out about the layers of Earth.

Earth's Interior

Undoubtedly you are aware of many of the geologic features on Earth. The majestic Rocky Mountains, as well as the Hawaiian Islands are a result of geologic activity. Have you ever wondered how mountains are formed? Have you asked yourself what causes a volcano to erupt? Well, you already have some knowledge of the rock cycle. As you read further you will be introduced to the interior structure of Earth and the idea of tectonic plates. These concepts together will help you to understand why volcanoes erupt, how mountains are formed, and why earthquakes occur.

In order to understand geologic processes such as earthquakes, volcanic eruptions, hot spots, and mountain building, it is important to first understand the interior structure of Earth. Scientists have utilized many tools and methods to study the size, shape, and density of Earth. Models, topographical maps, and globes have all been used to display this research and help facilitate further examination of Earth. Using sonar-like waves beamed toward Earth's center, scientists have learned that Earth is divided into four primary layers. Each has distinct properties.



Earth has four main layers: the crust, the mantle, the outer core, and the inner core.

ACTIVE READER

1 Connect *Which word in paragraph 1 means "impressive"?*

_____

2 List *What are the three primary layers of Earth?*

a. _____

b. _____

c. _____

3 Explain *What is the difference between a map and a globe?*

_____

_____

_____

A globe would be more useful to

_____

_____

A map would be more useful to

_____

_____

Earth's Outer Layers

The outer layers are divided into crust and mantle based on rock type, and into **lithosphere** and **asthenosphere** based on rigidity. The lithosphere is the solid, rigid part of Earth comprising the crust and the upper mantle. It extends about 150 kilometers below the surface.

Tectonic plates are located within the lithosphere. A tectonic plate is a massive piece of continental or oceanic crust. Some measure hundreds of kilometers in area and can be up to 200 kilometers thick. Seven major plates cover the surface of Earth. These plates play an important role in nearly all major geologic events.

Beneath this layer of crust is the asthenosphere, which extends from the lithosphere to a depth of about 350 kilometers. The asthenosphere is plastic, or pliable, because of the higher temperatures at greater depths within the mantle. Some scientists believe that parts of the asthenosphere may be close to melting point. The rigid, less dense tectonic plates in the lithosphere float on top of the hot, dense asthenosphere within the mantle.

The Core

Nearly 2,900 kilometers below the surface of Earth lies the core. It is made up of a very dense, molten outer core and a solid inner core. The core is made up of the metals iron and nickel. Because of the high temperature within the outer core, it is in a liquid state. The inner core is even hotter, but the extreme pressure prevents melting. Thus, the inner core is in a solid state.

FOCUS QUESTIONS

1. **Explain the relationship between tectonic plates and the asthenosphere.**

2. **What is the lithosphere?**

ACTIVE READER

1 Monitor *Underline the two ways that the outer layers of Earth are divided.*

2 Analyze *Explain what "plastic" means in paragraph 3.*

3 Recall *Which two metals compose Earth's core?*

Good to Know

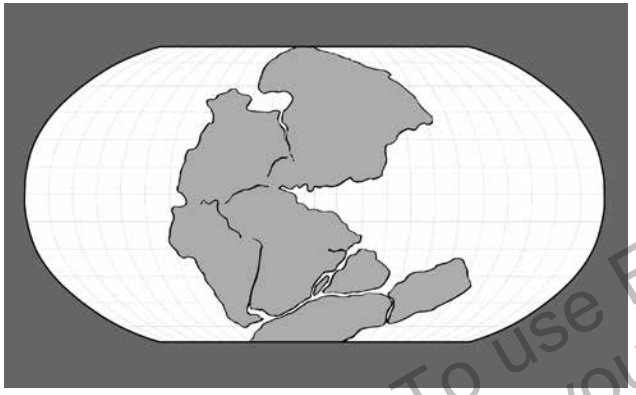
It was once believed that "drifting" tectonic plates plowed or pushed through the ocean floor. Scientists now know that the plates, located within the lithosphere, float on top of the hotter, less rigid asthenosphere.

FOCUS

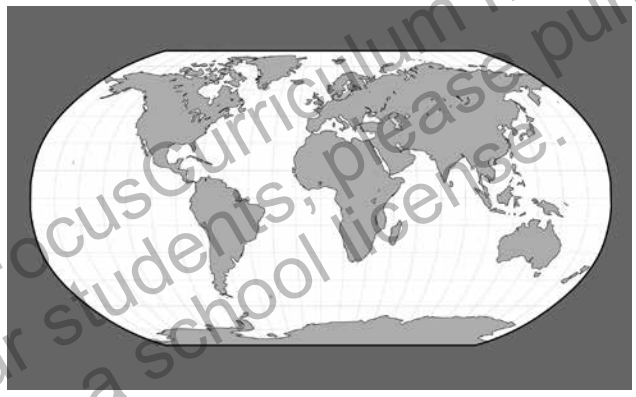
In this section you will learn about the origin of the continents. As you read, note what evidence exists for continental drift.

Puzzle Pieces

When you examine a globe or map of Earth, what do you notice about the shape of the continents? Looking at the map at the right, study the western coastline of Africa and compare it to the eastern coastline of South America. Now imagine pushing the two continents together. They seem to fit together like pieces of a puzzle, don't they?



225 million years ago



Present Day

In the 1920s, German scientist Alfred Wegener noticed the very same thing when studying the continents of Earth. Wegener produced a hypothesis called continental drift. He claimed that the continents once formed one large land mass called Pangaea. He believed that about 200 million years ago the land mass began to break into smaller fragments and drift apart.

ACTIVE READER

1 Infer *Use the map to describe the probable location of India 225 million years ago.*

_____

_____

_____

2 Identify *Who proposed the theory of continental drift?*

_____

Web Quest

Did you know that Pangaea split into two large continents before fragmenting further? Surf the Web to find information on Pangaea. Locate the names of the two continents that Pangaea split into before fragmenting into several smaller continents. How did they get these names?

Evidence for Continental Drift

Shapes of the Continents

Wegener used a variety of evidence to support his theory. He noticed that when moved around a little, the continents seem to fit together. The coastlines of Africa and South America fit nicely together. Similarly, the coastlines of North America, Asia, and Australia seem to fit together.

Glaciers

Wegener also noticed that the location of the glaciers on Earth supports the one land mass theory. Glaciers are large bodies of ice that move extremely slowly across the land, creating grooves in the landscape. The glacial grooves found in Australia, India, Africa, and South America support the idea that these areas were once one large glaciated area. Furthermore, if the continents were pushed together, the remaining glaciers would all fan out from Antarctica.

Fossils

Wegener also learned that fossils of an ancient freshwater reptile have been found in Brazil and South Africa. But this reptile would have been unable to swim across the Atlantic Ocean. Plant fossils such as glossopteris have been discovered on each continent, yet the seeds of glossopteris were heavy and did not float. It is more likely that the continents themselves drifted apart.

Glossopteris fossils are one form of evidence for continental drift.

ACTIVE READER

1 Explain *In what way do the presence of glacial grooves suggest that Pangaea existed?*

_____

_____

_____

2 Recall *On which continents are Brazil and South Africa located?*

_____

_____

Good to Know

Fossil remains of the freshwater reptile mesosaurus have been discovered in southern South America as well as in southern Africa. This fossil evidence further supports the theory of continental drift.

Rocks

The location of rocks supports the theory of continental drift. For example, identical rock types have been collected from South America and Africa. Rock structures in the Appalachian Mountains in North America are very similar to rock structures in the mountains of Europe and Greenland. The location of mountain ranges around the world also provides evidence. When the continents are pushed together the mountain belts of each continent line up. They are even similar in age, sediment, and composition.

What Drives Continental Drift?

The evidence that supports continental drift seems sufficient. But how do the continents move? Why did one large land mass break into smaller fragments that then drifted apart? Scientists of Wegener's day rejected his theory because he was never able to prove it. In the years after Wegener's death, advanced technology provided additional evidence for continental drift.

FOCUS QUESTIONS

1. **Explain how fossil evidence supports Alfred Wegener's theory of continental drift.**

2. **Explain the "puzzle pieces" evidence for continental drift.**

ACTIVE READER

1 List *The mountain belts of each continent are similar in what three ways?*

1. _____

2. _____

3. _____

2 Extend *What is the relationship between evidence and proof?*

Stop and Think

This page will help summarize what you have read so far.

1. Which statement describes the asthenosphere?

(1) molten portion of the core
(2) solid nickel and iron inner core
(3) solid, rigid crust and upper mantle
(4) pliable, hot, dense part of the mantle

Tip:
To answer question 1, scan the text for the bold-faced key word asthenosphere.

2. What was Alfred Wegener's theory of continental drift?

(1) The continents are slowly drifting toward one another.
(2) A large land mass broke into smaller fragments that then drifted apart.
(3) Plate motion is a direct result of the activity that occurs beneath Earth's surface.
(4) Rocks, plants, and animals have drifted from one continent to another over millions of years.

Base your answers to questions 3 and 4 on your knowledge of the theory of continental drift.

3. What is one example of evidence for continental drift?

_____

_____

4. Why did other scientists reject Wegener's theory about continental drift when he first proposed it?

_____

_____

Dear Ms. Understanding,

I've just learned that North America is drifting from its current location and will be located elsewhere in 50 years. If this is true, should I start preparing to live in a different climate when I'm older?

Wondering in Watertown

Dear Wondering,

The North American continent is indeed moving. But don't give away your summer clothes just yet! Currently, the continents are moving at a rate of 2-10 cm per year. You won't notice the movement of the continents, nor will you live in a different climate when you're "older."

Ms. Understanding

Chapter 2 Plate Tectonics

FOCUS

This section explains the relationship between continental drift and the rock cycle. As you read, learn about volcanic activity, earthquakes, mountains, and rift valleys.

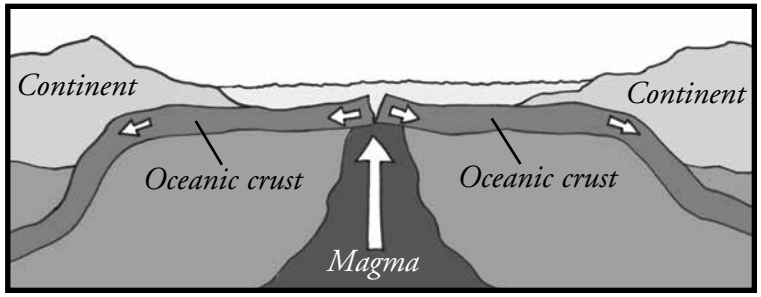
Plate Tectonics

You have learned about the interior structure of Earth and continental drift. Now, recall your knowledge of the rock cycle. Keeping these concepts in mind will aid you in learning about tectonic plates and the thermal forces within the mantle that cause them to move.

Sea Floor Spreading

In 1960 U.S. scientist Harry Hess proposed a theory—sea floor spreading—to explain continental drift. Hess believed that **convection currents** rising up from within Earth were the driving forces behind continental drift. These slow-moving currents of magma within the mantle cause the plates to move. Heated magma rises up at the **mid-ocean ridge** and cools when it meets the water, creating new sea floor. The new sea floor pushes the older sea floor away from the ridge. As the sea floor slowly moves it carries the continents with it.

Plenty of evidence exists in support of the theory of sea floor spreading. The rocks that make up the sea floor become increasingly older the further they are from the mid-ocean ridges. Additionally, the rock that makes up the oceanic crust is significantly younger than the continental crust. This supports the idea of **subduction**, or the idea that older oceanic crust has been pulled under another plate.



Rising magma creates a new sea floor which pushes away from the ridge.

ACTIVE READER

1 Define *What is sea floor spreading?*

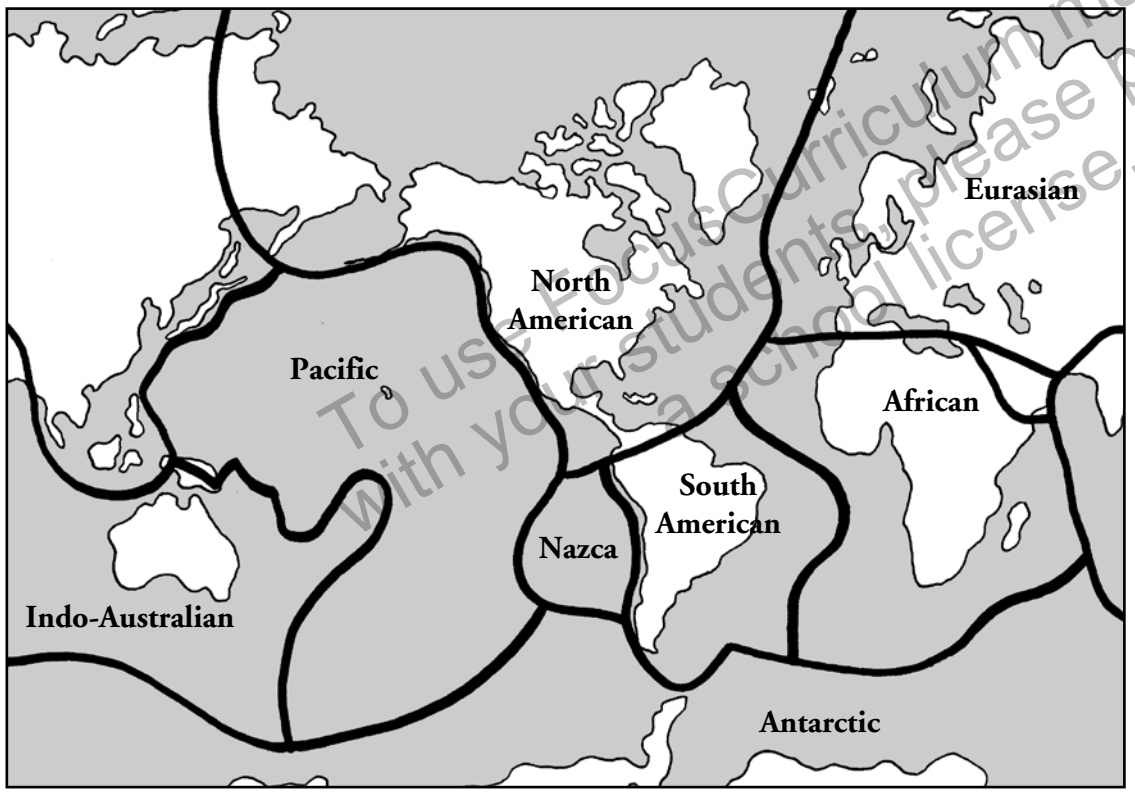
Good to Know

To better understand the convection process, imagine a pot of boiling water. As the water is heated tiny bubbles form and rise to the surface near the center of the pot. They then travel laterally to the outer edges of the pot. As the water cools slightly at the edges, it is drawn back to the bottom. Once there it is heated again, drawn to the center of the pot and pushed to the surface again. The convection process that is creating new sea floor acts in a similar fashion.

Theory of Plate Tectonics

The theory of plate tectonics was formulated in the 1960s. Scientists explained that the lithosphere was made up of seven large, and many smaller, tectonic plates. Each plate may be made up of continental crust or oceanic crust.

While drifting it is common for the plates to interact with one another. The point at which two plates meet is called a plate boundary. Plates may interact with each other at boundaries in one of three ways. They may separate at a **divergent boundary**, collide at a **convergent boundary**, or slide past one another at a **transform boundary**.



There are eight major tectonic plates on Earth.

ACTIVE READER

1 Interpret *Identify three sets of plates moving away from each other.*

a. _____

_____

b. _____

_____

c. _____

_____

2 Monitor *Circle the term that describes the point at which two plates meet.*

3 Connect *The prefix di- comes from dis-, which means "apart." The prefix con- means "together." Based on this, provide a definition for divergent and convergent.*

Divergent means _____

_____

Convergent means _____

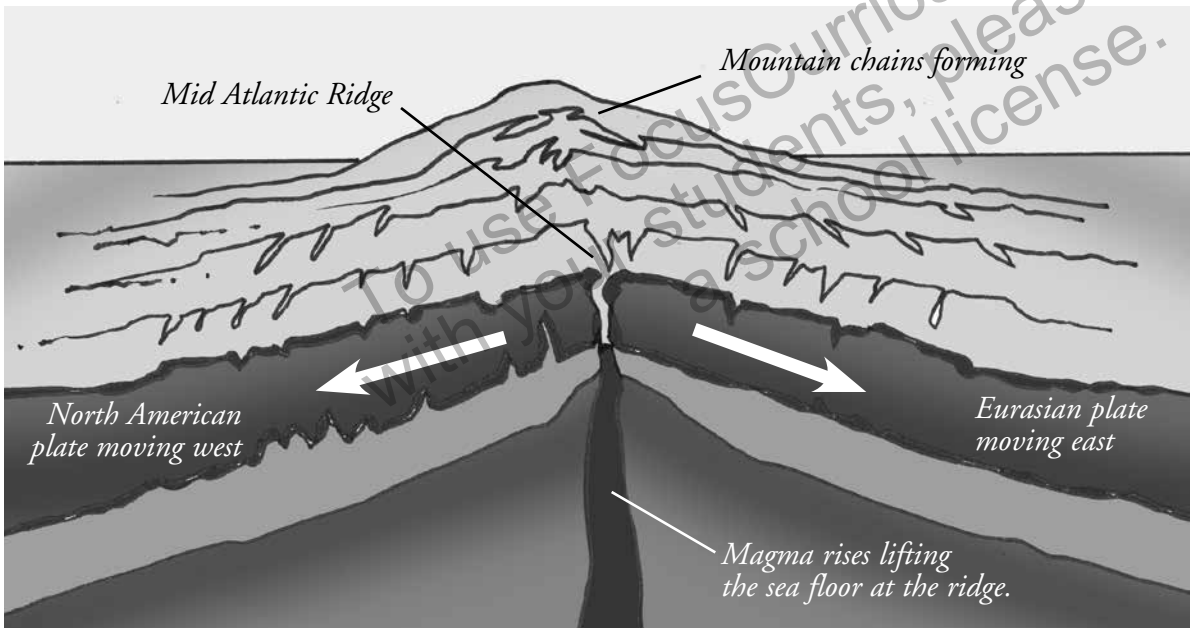
_____

Divergent Plate Boundaries

Let's utilize what you have learned while examining divergent plate boundaries. A divergent plate boundary occurs where tectonic plates pull apart from each other.

When Oceanic Plates Diverge

The Mid Atlantic Ridge is a good example of diverging oceanic plates. It lies at a divergent plate boundary along the floor of the Atlantic Ocean. The Eurasian Plate is moving in an easterly direction, while the North American Plate is moving in a westerly direction. As these oceanic plates pull away from each other, magma flows to the surface and becomes new sea floor. Because of the rising magma, the sea floor is lifted at the ridge, creating a mountain chain. This type of boundary, where oceanic plates diverge, can cause volcanic activity and earthquakes.



ACTIVE READER

1 Summarize *Which two types of geologic activity can occur when two oceanic plates diverge?*

_____

_____

2 Restate *Which type of landform is produced at the Mid Atlantic Ridge?*

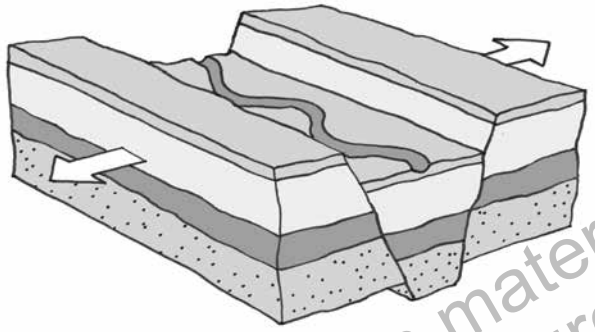
_____

Web Quest

Use the Internet to find a map of the globe that outlines the sea floor. Locate the Mid Atlantic Ridge. What country lies at the northern most point of the ridge?

When Continental Plates Diverge

A divergent boundary may also involve two continental plates. In this case a **rift valley** is formed where continental crust is stretched, becoming thinner. **Faults**, or fractures, form as the crust is stretched and pulled apart. Over time, a large valley begins to take shape. As it sinks lower, streams may flow into the valley, creating a lake. The East African Rift Valley is an example of what happens when continental plates diverge. Earthquakes often occur as a result of this fracturing.



A rift valley occurs when continental plates diverge.

ACTIVE READER

1 Connect *Circle a synonym for fractures.*

2 Summarize *What happens when continental plates diverge?*

FOCUS QUESTIONS

1. **Compare and contrast diverging oceanic plates and diverging continental plates.**

2. **Explain sea floor spreading.**

FOCUS

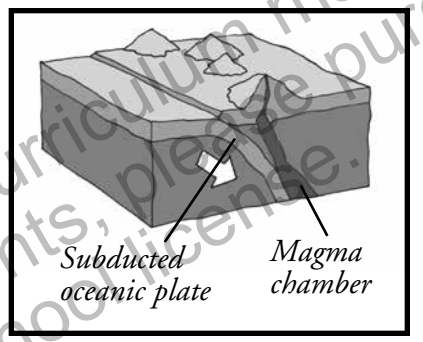
This section explains what occurs when tectonic plates collide.
As you read, find out about the three different kinds of convergent plate boundaries.

Convergent Plate Boundaries

Now, let's examine the various types of convergent plate boundaries. A convergent plate boundary occurs where two tectonic plates collide with one another.

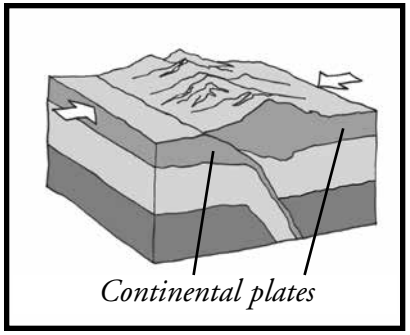
When Oceanic Plates Converge

When oceanic plates converge, the older, denser oceanic plate is subducted. The point of subduction in this case is called an **ocean trench**. The subducted plate is exposed to heat as it descends into the mantle. The molten magma then ascends through the lithosphere by way of large underground pools called **magma chambers**. The magma chambers that reach the surface can break through and form a volcanic cone on the ocean floor. Over time these cones can grow large enough to break the surface of the sea. Island chains form in the sea as a result of this process. For example, Aleutian Islands extending south of Alaska were produced by converging oceanic plates.



When Continental Plates Converge

Continental plates are less dense than the asthenosphere. Therefore, subduction rarely occurs at a boundary where continental plates converge. When continental plates converge, it generally results in faulting and folding of the lithosphere. Mountain ranges rise up as a result of this folding process. Earthquakes are also common at these boundaries. The Himalaya Mountain Range is an example of two continental plates converging. In this case, the Indian Plate is colliding with the Eurasian Plate.



ACTIVE READER

1 Connect *Circle a synonym for converge.*

2 Define *What is a magma chamber?*

_____

_____

_____

_____

_____

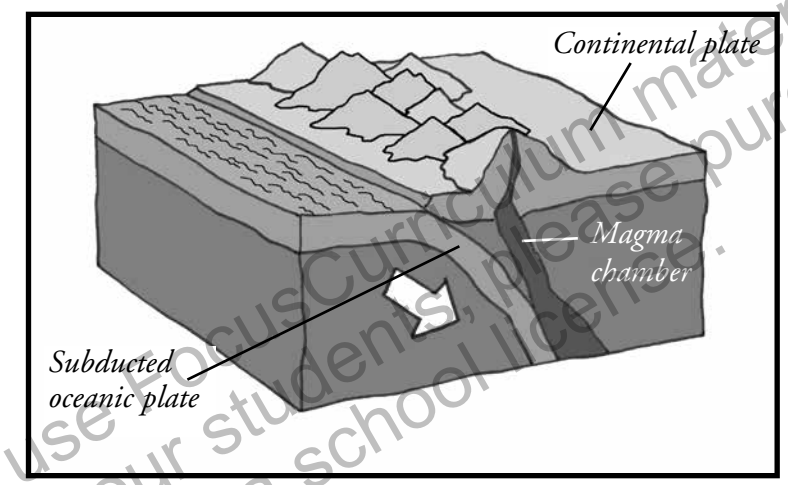
Good to Know

A rift valley can be the very beginning of a new ocean basin. As the continent rifts, the crust becomes thinner until it eventually splits apart. The two separate pieces of crust continue to pull away from each other and ocean waters fill the rift.

When Oceanic Plates Converge with Continental Plates

When oceanic plates collide with less dense continental plates, the oceanic plate is pushed under the continental plate. Because of its greater density, oceanic crust is almost always subducted when oceanic and continental plates converge. The oceanic plate is heated to melting point as it descends into the mantle. Magma chambers allow the molten material to rise up to the surface in the form of a volcano. The Andes Mountain Range is an example of a convergent boundary between the Nazca Plate and the South American Plate.

The convergence of the Nazca and South American Plates has formed the peaks of the Andes.



ACTIVE READER

1 Research *Why are oceanic plates less dense than continental plates?*

2 Infer *The Andes Mountain Range is located on which continent?*

3 Identify *Which plate is subducted when an oceanic plate converges with a continental plate?*

FOCUS QUESTIONS

1. How are volcanic cones produced?

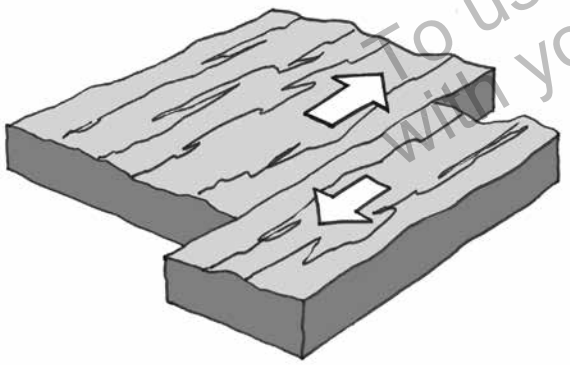
2. Describe the two situations when converging plates result in subduction.

FOCUS

The underlined sentence states an important idea about transform plate boundaries. As you read, find out about hot spots and how they are formed.

Transform Plate Boundaries

Transform plate boundaries occur when two plates slide past one another. In this case, plates can either move in opposite directions or they can move in the same direction at different speeds. As the plates move past one another, a transform fault, or crack, in the lithosphere results. Transform plate boundaries are characterized by frequent earthquakes. The San Andreas Fault in California is an example. The Pacific Plate and the North American Plate are both moving north. However, the Pacific Plate is moving much faster.



The San Andreas Fault is an example of a transform plate boundary.

ACTIVE READER

1 Recall *List the three types of plate boundaries.*

1. _____

2. _____

3. _____

2 Explain *Which two ways can a transform plate boundary occur?*

_____

_____

_____

_____

Good to Know

In 1989 a major earthquake shook the San Francisco Bay area. The San Andreas fault was the culprit. Many scientists believe that another major earthquake will occur at this transform plate boundary in the near future.

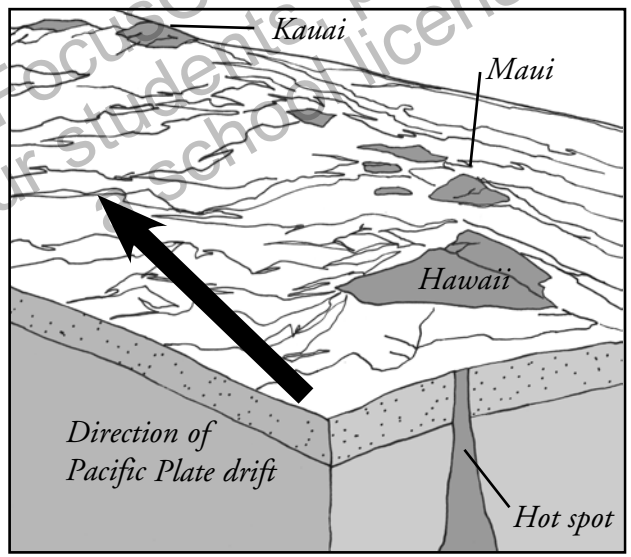
Hot Spots

As you can see, tectonic plate movement causes most of the major geological events that take place on Earth, including earthquakes, volcanoes, and mountain building. In fact, nearly all of the constructive and destructive geologic processes on Earth are a direct result of tectonic plate movement. For example, many of our landforms have been formed by plate movement.

Another geologic process caused by plate movement is a **hot spot**. A hot spot is an area of constant volcanic activity. The Hawaiian Islands were created through this process. In fact, new surface is continually being added to Hawaii as a result of this activity.

A hot spot is a small, extremely hot region located within the mantle. This source of heat melts existing rock, creating molten magma. The magma is pushed through the lithosphere, often erupting in the form of a volcano at the surface. The hot spot stays in the same place but as the less dense plate slides over it, a chain of volcanoes is produced. In the case of the Hawaiian Islands, heat and magma expelled from a hot spot have weakened the overriding Pacific Plate. When magma pushes through to the surface, it erupts and is deposited on the ocean floor. This deposition of lava builds, reaching sea level and eventually becoming an island volcano.

Examine the layout of the Hawaiian Islands. As the Pacific Plate moves, the island volcanoes on the sea floor move with it. When the island volcano drifts beyond the hot spot it is considered **dormant**. As new sea floor is slowly positioned above the hot spot, the process repeats itself. Can you guess which islands in the chain are oldest?



The Hawaiian Islands drift beyond the hot spot as the Pacific Plate moves.

ACTIVE READER

1 Infer *Is the Pacific Plate a continental plate or an oceanic plate?*

_____

2 Hypothesize *Why are some parts of the mantle hotter than others?*

_____

_____

_____

_____

Use the Internet to learn more about hot spots. Find a web page that illustrates the movement of the Hawaiian Islands. Find out which direction the islands are moving.

Positioned farthest away from the hot spot, Kauai is the oldest of the Hawaiian Islands. Its volcano is now dormant. The "Big Island," or Hawaii, is still positioned above the hot spot. Thus, new volcanic rock is continually being formed.

FOCUS QUESTIONS

1. What two ways can a transform plate boundary occur?

2. Explain how hot spots create volcanoes.

ACTIVE READER

1 Define *Based on the context, what do you think dormant means?*

2 Interpret *Which is the second oldest Hawaiian Island?*

3 Deduce *What will happen when the "Big Island," or Hawaii, drifts beyond the hot spot?*

Stop and Think

This page will help summarize what you have read so far.

1. **Along the Washington-Oregon coastline the Juan de Fuca Plate is sliding under the North American Plate. This plate movement is producing volcanoes known as the Cascade Mountain Range.**

   What type of plate boundary is this?

   (1) hot spot
   (2) divergent plate boundary
   (3) transform plate boundary
   (4) convergent plate boundary

Tip:
Remember that the type of plate boundary determines the type of geologic activity.

2. **Which statement describes how new sea floor is produced?**

   (1) Faults, or fractures, form as the crust is stretched and pulled apart.
   (2) A subducted plate is exposed to heat as it descends into the mantle.
   (3) Magma rises up at the mid-ocean ridge and cools when it meets the water.
   (4) Magma is pushed through the lithosphere, erupting in the form of a volcano at the surface.

Base your answers to questions 3 and 4 on your knowledge of science.

3. **What are the two types of divergent plate boundaries?**

   _____

   _____

4. **What geologic activity results from each type of divergent plate boundary?**

   _____

   _____

Dear Ms. Understanding,

I'm pretty sure that the Hawaiian islands are a chain of mountains that rise up from the sea floor. Each of them was created at about the same time, so they're all the same age, right?

Curious in Canarsie

Dear Curious,

Well, you're right and you're wrong. The islands are volcanic mountains that extend up from the ocean floor. But because they are a result of molten magma that has been released through a magma chamber or hot spot on the sea floor, each island was created as the sea floor drifted directly over the hot spot. The islands vary in age according to their current distance from the hot spot.

Ms. Understanding

Hands On Science

Cotton Plates

At a convergent boundary, two continental plates are colliding. The results of this type of plate collision may vary, depending on the type of plate. However, when two continental plates are colliding the result is almost always the folding of continental crust.

Procedure

To demonstrate how this folding takes place, gather two cotton towels of at least three different colors. For example, you may use two red towels, two blue towels, and two yellow towels. The colors represent the different rock layers.

Fold one red towel in half. Then fold a blue towel in half and place it on top. Fold a yellow towel in half and place it on top of the blue towel. Do the same with the second group of towels, making sure that the color order remains the same. Place the two piles side by side, about an inch apart. Each pile represents a tectonic plate.

1. **Predict what will happen if you slide the two piles together.**

_____

2. **Next, place a hand on each plate and push them together. Observe what happens when the towels converge.**

3. **Explain the behavior of each "cotton plate" when the edges met. Was your prediction accurate?**

_____

4. **What happens to the "rock layers"?**

_____

5. **Use the map on page 19 to locate two convergent continental plates. Write the names of the two plates.**

_____

6. **What type of geologic feature is located where these two plates meet? What is its proper name?**

_____

Glossary

asthenosphere – the pliable, dense, upper part of the mantle

convection currents – slow-moving currents of magma within the mantle

convergent boundary – where two plates collide

divergent boundary – where two plates move away from each other

dormant – no longer active or erupting, but capable of erupting one day

faults – fractures that form where crust is stretched apart

hot spot – a small, extremely hot region within the mantle

lithosphere – the solid, rigid part of Earth comprising the crust and the upper mantle

magma chambers – large underground pools of molten magma

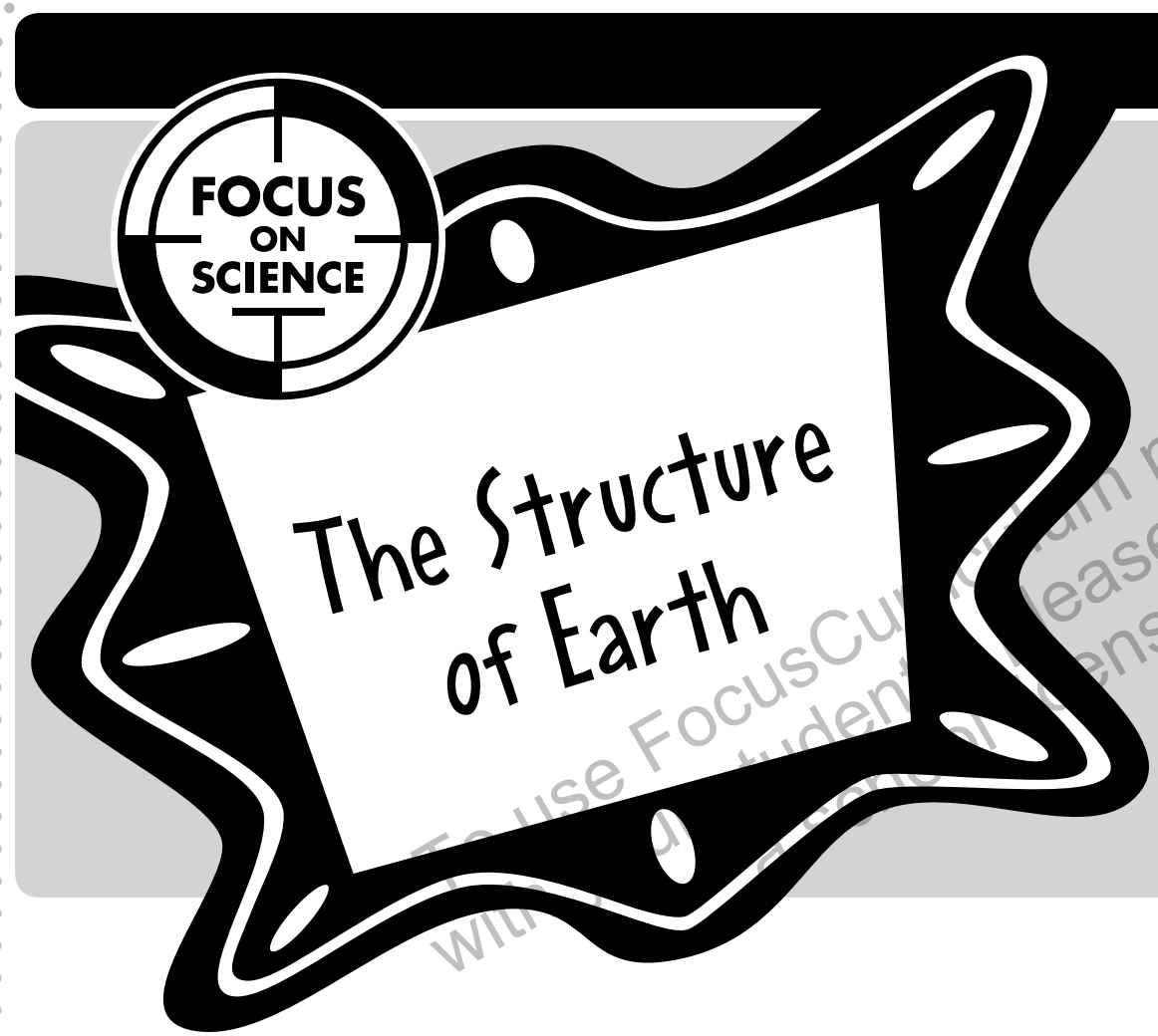
mid-ocean ridge – underwater mountain range produced by a divergent plate boundary

ocean trench – where oceanic plates converge and the older, denser oceanic plate is subducted

rift valley – a valley that forms where continental crust is stretched and becomes thin

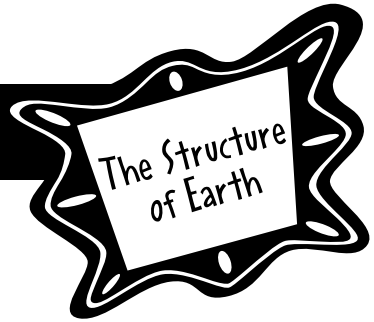
subduction – the process of an older oceanic plate being pulled under another plate

transform boundary – where two plates slide past one another



Assessments

Check Understanding



In the Answer Document on this page, mark your answer in the row of circles for each question by filling in the circle that has the same number as the answer you have chosen.

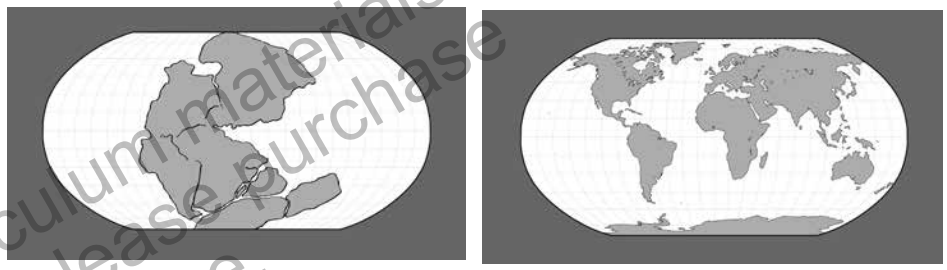
1. In what layer of Earth are tectonic plates located?

   (1) core
   (2) mantle
   (3) lithosphere
   (4) asthenosphere

2. When is a rift valley likely to form?

   (1) when oceanic plates diverge
   (2) when oceanic plates converge
   (3) when continental plates diverge
   (4) when continental plates converge

Base your answer to question 3 on the maps below and on your knowledge of science.



225 million years ago

Present Day

3. The maps above show how Earth's surface looked during two different time periods.

   Which phrase best describes the geologic activity shown in the maps?

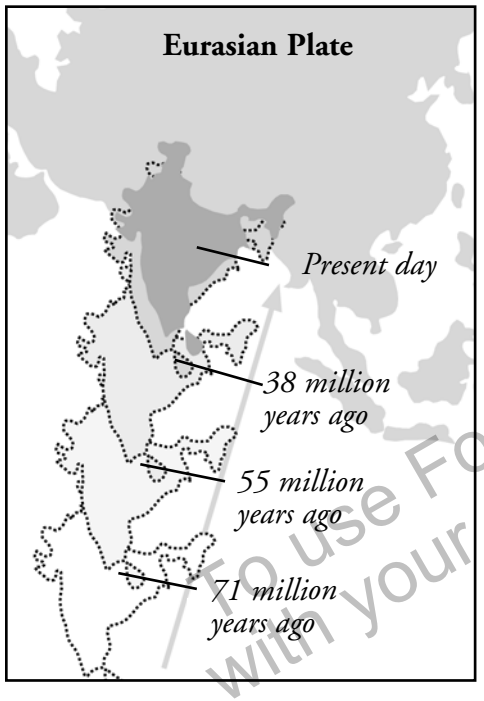
   (1) Pangaea
   (2) subduction
   (3) continental drift
   (4) Mid Atlantic Ridge

Answer Document

1.	①	②	③	④		3.	①	②	③	④
2.	①	②	③	④						

Check Understanding

Base your answer to question 4 on the diagram below. It shows the movement over time of the land mass we know as India.



4. What landform was produced by the collision of the India land mass with the Eurasian continental plate?

   (1) volcano

   (2) rift valley

   (3) earthquake

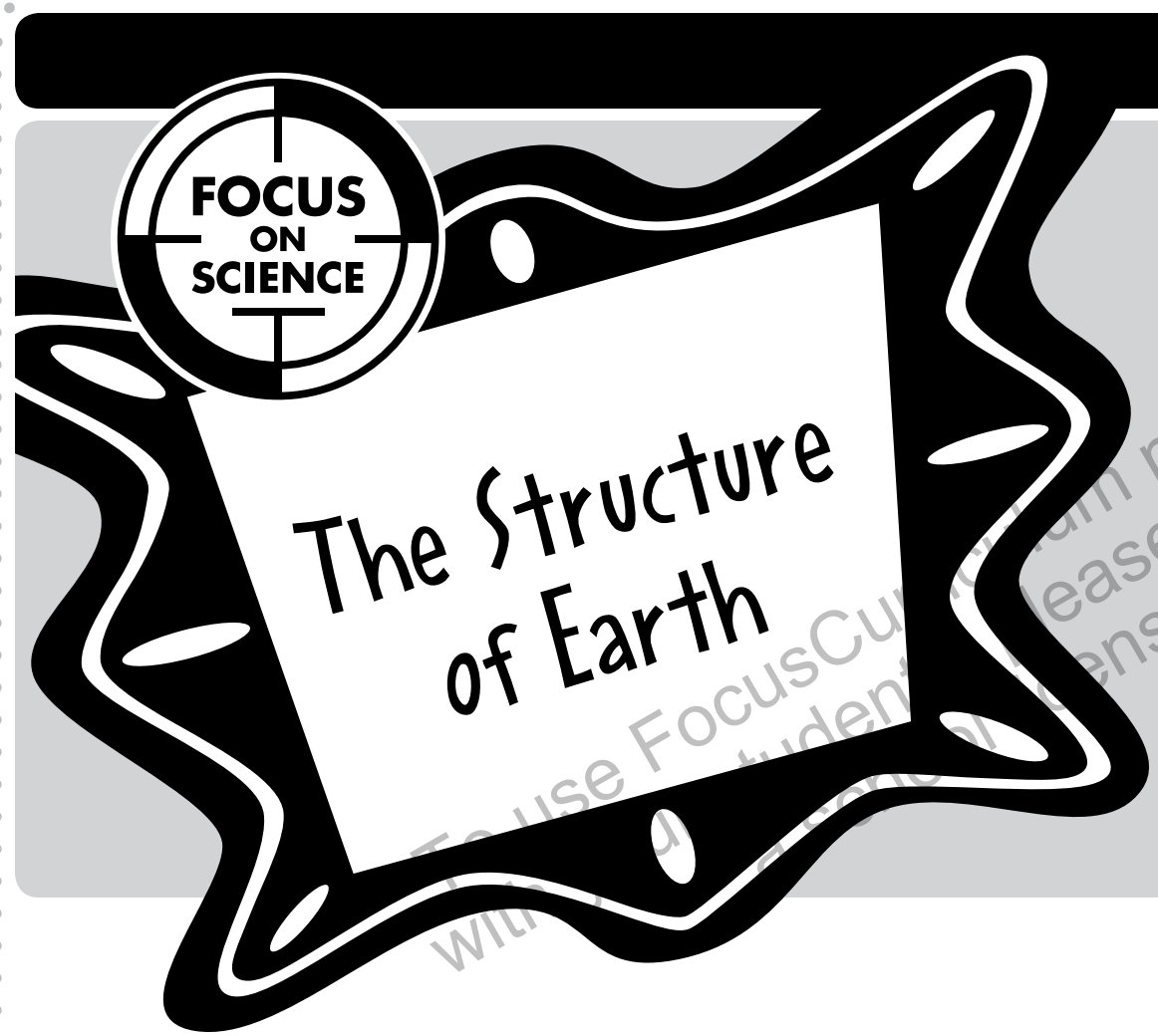
   (4) mountain range

Answer Document

4. ① ② ③ ④

5. What process, discovered in 1960, explained Alfred Wegener's theory about continental drift?

6. Describe the process.



Answer Key

Answer Key

Page 8: Starting Points
Build Background
Label It: Sample answers: Volcano: ring of fire, magma, builds islands, lava, erupts, on Earth's crust, smoke, ash; Rock Cycle: sedimentary, igneous, metamorphic, temperature, pressure, chemical change, physical change; Earth's layers: crust, core, mantle, liquid, solid, magma; Earthquake: faults, plates move, ring of fire, subduction, convergence, divergence; Mountains: uplift pressure, plates move, ring of fire, subduction, convergence

Page 9: Starting Points
Key Vocabulary
Rate Your Knowledge: Answers will vary according to the student's prior knowledge. Use Roots to Unlock Meaning: 1. lithosphere, stone, or rigid, area; 2. asthenosphere, weak, or soft, area

Page 10: Starting Points
Key Concepts
Active Reader: 1. Underline the first sentence in paragraphs 2-4. 2. Life; 3. Circle: conglomerates; 4. Diagrams will vary but should convey that the rock cycle is a cyclical process.

Page 11: Hands On Science
Model the Rock Cycle: 1. It is a conglomerate of smaller fragments. 2. Weathering and erosion; 3. Transport of sedimentary rocks; 4. Melting/metamorphic processes, heat, pressure; 5. Crystallization/cooling; 6. Weathering and erosion

Page 12: Chapter 1
Active Reader: 1. majestic; 2. crust, mantle, core; 3. A map is flat and a globe is three-dimensional, a sphere. Answers will vary.

Page 13: Chapter 1
Active Reader: 1. Underline: rock type, rigidity; 2. Plastic means that it can change shape easily. 3. iron and nickel
Focus Questions: 1. The tectonic plates in the lithosphere float on top of the asthenosphere, which is part of the mantle. 2. The lithosphere is the solid, rigid part of Earth made of the crust and the upper mantle.

Page 14: Chapter 1
Active Reader: 1. India was further south and located between Africa, Antarctica, and Australia. 2. Alfred Wegener

Page 15: Chapter 1
Active Reader: 1. The grooves are all found in those pieces of land that Wegener believed were once connected. 2. South America and Africa

Page 16: Chapter 1
Active Reader: 1. age, sediment, composition; 2. Enough evidence can prove that something is true, or provide truth.
Focus Questions: 1. Sample answer: Fossils of a reptile have been found in Brazil and South Africa. But the animal was unable to swim. This suggests the continents were once connected. 2. The present day continents look as if they could fit together well. This suggests that they were once all connected.

Page 17: Chapter 1
Stop and Think
1. (4); 2. (2); 3. Sample answer: The location of glacial grooves in Australia, India, Africa, and South American suggests that all these land masses were once connected as one.; 4. Continental drift was rejected because Wegener was unable to prove it.

Answer Key

Page 18: Chapter 2
Active Reader: 1. Sea floor spreading is when heated magma rises up at the mid-ocean ridge, cools, and creates new sea floor, pushing the older sea floor away and causing the continents to move.

Page 19: Chapter 2
Active Reader: 1. Sample answer: North American plate and African plate, South American plate and African plate, Antarctic plate and Indo-Australian plate; 2. Circle: plate boundary; 3. Divergent means to move apart; Convergent means to move together.

Page 20: Chapter 2
Active Reader: 1. volcanic activity and earthquakes; 2. mountain chain

Page 21: Chapter 2
Active Reader: 1. Circle: faults; 2. A rift valley is formed where the continental crust is stretched. Over time the valley sinks lower.
Focus Questions: 1. Both sets of plates are moving away from each other. Both can cause earthquakes. Diverging oceanic plates produce new sea floor and may cause volcanic activity. Diverging continental plates create rift valleys and earthquakes. 2. Convection currents in the mantle cause the plates to move. Heated magma rises up and cools when it meets the water. The new sea floor pushes the older floor away from the ridge, moving the continents.

Page 22: Chapter 2
Active Reader: 1. Circle: collide; 2. A magma chamber is a large underground pool of molten magma.

Page 23: Chapter 2
Active Reader: 1. They contain different minerals. 2. South America; 3. oceanic plate
Focus Questions: 1. When oceanic plates converge, magma chambers that reach the surface become volcanic cones. 2. When the oceanic plates converge the older, denser plate is subducted. When oceanic and continental plates converge, the oceanic plate is subducted.

Page 24: Chapter 2
Active Reader: 1. divergent plate boundaries, convergent plate boundaries, transform plate boundaries; 2. The plates can slide past each other when moving in opposite directions or they can slide past each other when moving in the same direction at different speeds.

Page 25: Chapter 2
Active Reader: 1. Oceanic; 2. Answers will vary.

Page 26: Chapter 2
Active Reader: 1. Sample answer: No longer erupting; 2. Oahu; 3. The process will repeat itself and a new island will form.
Focus Questions: 1. When two plates slide past each other in opposite directions or when two plates are moving in the same direction but one is moving faster than the other. 2. The heat in a hot spot melts rock, creating magma that pushes through the lithosphere in the form of a volcano.

Page 27: Chapter 2
Stop and Think
1. (4); 2. (3); 3. divergent oceanic plates and divergent continental plates; 4. In both situations, earthquakes may result. When oceanic plates diverge, volcanic activity may also result. A rift valley may form when continental plates diverge.

Page 28: Hands On Science
Cotton Plates: 1. Sample answer: One pile will fold over the other pile. 2. The edges of the towels met and began to bunch up, lift up, and/or fold. 3. They are displaced.
4. Sample answer: Indian and Eurasian
5. Folded mountains; The Himalayas

Page 33
Check Understanding
1. (3); 2. (3); 3. (3)

Page 34
Check Understanding
4. (4); 5. Sea floor spreading; 6. Magma rises up and then cools when it meets water, creating new sea floor. The new sea floor pushes older sea floor away from this ridge. As the sea floor moves, the continents do as well.