Name _____ Class _____ Date _____

CHAPTER 12 Earthquakes

SECTION 1

How and Where Earthquakes Happen

KEY IDEAS

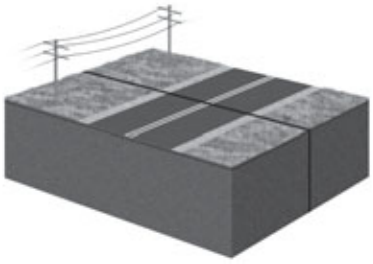
As you read this section, keep these questions in mind:

- What is elastic rebound?
- What are the similarities and differences between body waves and surface waves?
- How does the structure of Earth's interior affect seismic waves?
- Why do most earthquakes happen at plate boundaries?

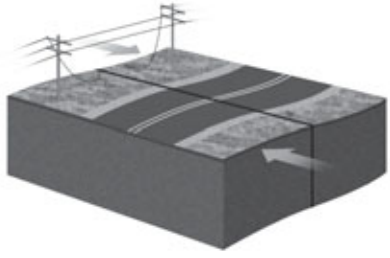
What Makes Earthquakes Happen?

Remember that a *fault* is a crack in rock. If there is pressure on the rock around a fault, the rock is under stress. Friction along the fault keeps the rock from moving. The stress can build up. Eventually, the stress becomes too high. The rock moves suddenly along the fault. It releases a great deal of energy. The energy makes the ground shake. The shaking is an **earthquake**.

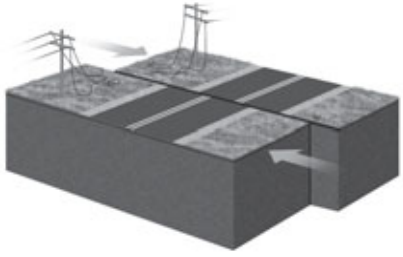
Elastic rebound is important in causing earthquakes. **Elastic rebound** happens when a rock that is deformed goes back to its original shape. The diagram below shows an example of elastic rebound.



1. Two blocks of crust are pressed together at a fault. They are under stress, but they do not move because friction holds them in place.



2. Stress builds up at the fault. Parts of the crust are stretched out of shape.



3. When the stress gets large enough, the blocks of crust slip past each other. The movement of the crust releases energy, which causes an earthquake. Each piece of crust snaps back to its original shape, but the two pieces of crust have moved past each other.

READING TOOLBOX

Organize As you read this section, create a concept map using the following terms: *P wave, surface wave, seismic wave, S wave, Love wave, body wave, Rayleigh wave, earthquake, focus, epicenter, fault,* and *movement.*

LOOKING CLOSER

1. Compare How does the road in the middle figure look different from the road in the top figure? Why is it different?

FOCUS AND EPICENTER

When rock moves along a fault, the first motion on the fault is generally underground. The **focus** (plural, *foci*) of an earthquake is the point where the first motion occurs. The energy an earthquake releases moves outward in all directions from the focus. The **epicenter** of an earthquake is the point on Earth's surface directly above the focus. ☑

Scientists group earthquakes based on how deep their foci are. A *shallow-focus earthquake* has a focus less than 70 km below Earth's surface. An *intermediate-focus earthquake* has a focus between 70 km and 300 km below Earth's surface. A *deep-focus* earthquake has a focus more than 300 km below Earth's surface.

READING CHECK

2. Describe What is the difference between the epicenter and the focus?

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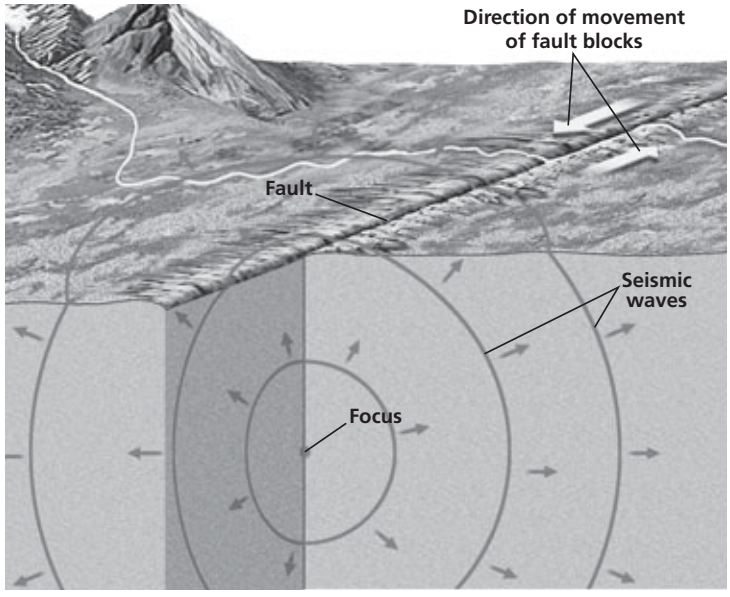
Talk About It

Visualize Use an atlas or map to find two places on Earth that are about 70 km apart and two places that are about 300 km apart. Talk with a partner about how this information can help you understand shallow-focus, intermediate-focus, and deep-focus earthquakes.

LOOKING CLOSER

3. Identify Label the epicenter on the figure.



The vibrations of an earthquake start at the focus and spread out.

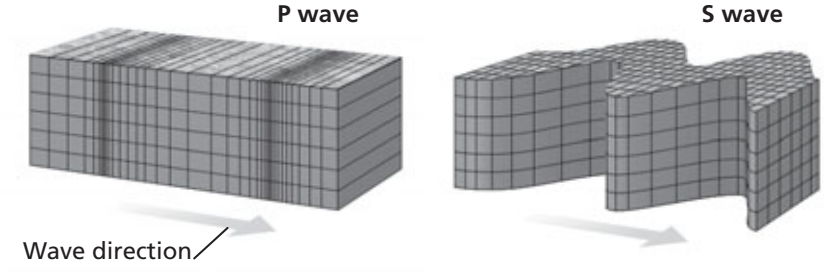
What Are Seismic Waves?

Look again at the figure above. You can see that there are seismic waves moving outward from the focus. *Seismic waves* are vibrations caused by the energy released in an earthquake. When a pebble falls into a pond, small waves ripple outward from the point the pebble hits. Similarly, seismic waves ripple outward from the focus of an earthquake. The seismic waves travel in all directions from the focus through the rock around it.

There are two main types of seismic waves: body waves and surface waves. **Body waves** travel through rock. **Surface waves** travel along the surface of Earth.

TYPES OF BODY WAVES

There are two types of body waves: P waves and S waves. **P waves** cause rocks to move back and forth, parallel to the direction that the wave is moving. **S waves** cause rocks to move side to side, perpendicular to the direction that the wave is moving. The picture and table below give more information about P waves and S waves.



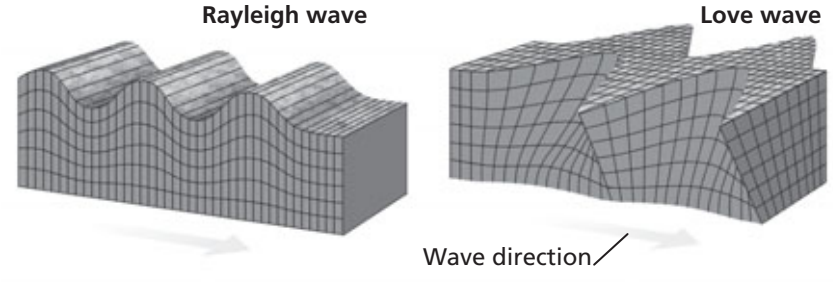
Type of Wave	Other Names	Other Facts
P wave	• primary wave • compression wave	• fastest seismic waves • can move through solids, liquids, and gases
S wave	• secondary wave • shear wave	• slower than P waves • can move only through solids

SURFACE WAVES

Surface waves move along Earth's surface. Surface waves move more slowly than body waves, but surface waves can cause more damage. Most surface waves form in one of two ways:

- movement along a fault that is close to the surface
- change in the way rock moves when a body wave reaches Earth's surface

There are two main types of surface waves: Love waves and Rayleigh waves. The diagram below shows how Love waves and Rayleigh waves move the ground.



A Rayleigh wave moves the ground in a rolling, up-and-down motion.

A Love wave moves rock back and forth. It also causes rock to twist.

LOOKING CLOSER

4. Describe Draw arrows on the pictures to show the direction the ground moves when each type of wave passes.

Critical Thinking

5. Compare How are a Love wave and an S wave the same? How are they different?

What Can Seismic Waves Tell Us About Earth's Structure?

Scientists study seismic waves to learn more about Earth's structure. Seismic waves move at different speeds in different substances. In addition, the direction in which a seismic wave travels changes when it moves from one substance to another. By studying how seismic waves change as they move through Earth, scientists can learn about the makeup of Earth's interior. ☑

READING CHECK

6. Explain Why can scientists use seismic waves to learn about Earth's interior?

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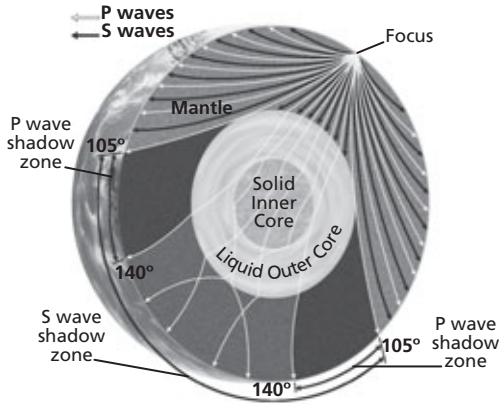
EARTH'S LAYERS

In 1909, a Croatian scientist named Andrija Mohorovičić discovered that seismic waves change speed about 30 km below the continents. The change in speed happens suddenly. The place where this change happens is where the crust and mantle meet. Today, scientists call this boundary the *Mohorovičić discontinuity*, or just the *Moho*. Below the continents, the Moho is about 30 km deep. Below the oceans, it is about 10 km deep.

Scientists have been able to use seismic waves to learn about other layers inside Earth. They now know that Earth has three main compositional zones: the crust, mantle, and core. Earth has five main structural zones: the lithosphere, asthenosphere, mesosphere, outer core, and inner core.

SHADOW ZONES

Remember that seismic waves change speed and direction as they move through Earth. Those changes can bend the waves in specific ways. The bending of the waves produces shadow zones. **Shadow zones** are areas on Earth's surface where waves from an earthquake cannot be detected.



The shadow zones for different earthquakes are different.

Critical Thinking

7. Make Connections Why do the S waves in the diagram stop when they reach the liquid outer core?

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Where Do Earthquakes Happen?

Most earthquakes happen near the boundaries between plates. The movements of the plates put stress on the rock in the plates. The stress can cause the rock to slip and cause earthquakes.

Some earthquakes happen in the oceans. Others happen on land. The table below summarizes the environments where earthquakes can happen.

Type of Environment	Description	Example
Convergent oceanic	places where an oceanic plate collides with another oceanic plate or with a continental plate	Andes Mountains, Aleutian Islands
Divergent oceanic	places where two oceanic plates move apart	Mid-Atlantic Ridge
Continental	places where two continental plates collide, move apart, or slide past each other	San Andreas Fault, Himalaya Mountains

FAULT ZONES

Most faults exist in groups. An area that contains a lot of faults that are close together is called a **fault zone**. Fault zones can exist at any kind of plate boundary. One example of a fault zone is the North Anatolian fault zone in Turkey. Movement of the crust along the faults in this fault zone produces many earthquakes in Turkey. ☑

EARTHQUAKES AWAY FROM PLATE BOUNDARIES

Most earthquakes happen at plate boundaries. However, earthquakes can also happen far from plate boundaries. For example, in 1811 and 1812, several large earthquakes happened near New Madrid, Missouri. New Madrid is far from any plate boundaries.

Scientists are not sure why these earthquakes happened. However, they have discovered a very old fault zone underneath New Madrid. The fault zone is more than 600 million years old. It is buried under many layers of rock and sediment. Scientists think the New Madrid earthquakes may have happened when rock around the fault zone moved. However, they are not sure what made the rock move, or whether it might move again in the future.

Talk About It

Review With a partner, talk about the different types of plate boundaries that you have learned about. Discuss how the information you know about plate boundaries relates to the information in this section.

READING CHECK

8. Define What is a fault zone?

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Name _____ Class _____ Date _____

Section 1 Review

SECTION VOCABULARY

body wave a seismic wave that travels through the body of a medium

earthquake a movement or trembling of the ground that is caused by a sudden release of energy when rocks along a fault move

elastic rebound the sudden return of elastically deformed rock to its undeformed shape

epicenter the point on Earth's surface directly above an earthquake's starting point, or focus

fault zone a region of numerous, closely spaced faults

focus the location within Earth along a fault at which the first motion of an earthquake occurs

P wave a primary wave, or compression wave; a seismic wave that causes particles of rock to move in a back-and-forth direction parallel to the direction in which the wave is traveling

shadow zone an area on Earth's surface where no direct seismic waves from a particular earthquake can be detected

surface wave a seismic wave that travels along the surface of a medium and that has a stronger effect near the surface of the medium than it has in the interior

S wave a secondary wave, or shear wave; a seismic wave that causes particles of rock to move in a side-to-side direction perpendicular to the direction in which the wave is traveling

1. Describe Relationships How is elastic rebound related to earthquakes?

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2. Explain Why do most earthquakes happen at plate boundaries?

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3. Compare Describe three differences between P waves and S waves.

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4. Describe What are shadow zones, and why do they exist?

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