chapter 5 Earthquakes

section 2 Features of Earthquakes

Before You Read

Imagine you and a friend are holding opposite ends of a long rope. You shake one end. On the lines below, describe how you think the rope would move.

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What You'll Learn

- what seismic waves are
- how seismic waves are measured and studied
- the structure of Earth's interior

Read to Learn

Mark the Text

Main Ideas Highlight the main idea in each paragraph as you read. Use a different color to highlight the vocabulary words and their definitions.

Seismic Waves

When one end of a rope is shaken, the rope moves up and down, or side to side. Energy travels through the rope in the form of waves. **Seismic** (SIZE mihk) **waves** are generated by earthquakes. Seismic waves travel through Earth just as waves travel through rope. When an earthquake occurs, the ground moves forward and backward, up and down, or side to side. Sometimes, earthquakes cause the surface of Earth to ripple like the waves on the ocean.

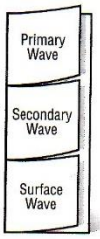
What is the origin of seismic waves?

Rocks move past each other along faults. Stress builds up along rock surfaces that catch on each other. The stress continues to build up until the rocks' elastic limit is passed. Then the built up energy is released as seismic waves. The **focus** (plural, *foci*) of an earthquake is the point where this energy is first released.

The foci of most earthquakes are within 65 km of Earth's surface. A few earthquakes have occurred as much as 700 km beneath the surface. Seismic waves are produced and travel outward from the earthquake focus.

FOLDABLES™

C Classify Make a three-tab Foldable to organize information about primary, secondary, and surface waves.



What are primary waves?

Earthquakes produce three different types of seismic waves—primary, secondary, and surface waves. All three types of seismic waves are produced at the same time. But each type of wave behaves in a different way within Earth. ☑

Primary waves (P-waves) cause particles in rock to move back and forth in the same direction that the wave is traveling. Primary waves occur when particles in rocks are compressed and then stretch apart. This motion sends primary waves traveling through the rock.

Reading Check

1. **Classify** What are the three types of seismic waves?

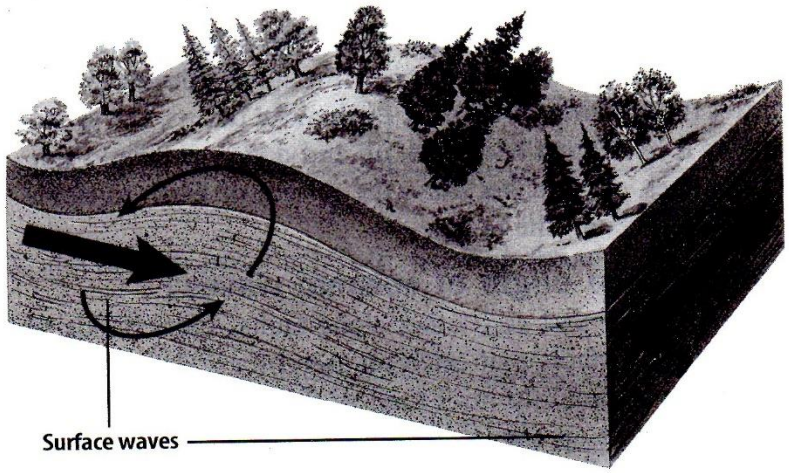
What are secondary and surface waves?

Secondary waves (S-waves) move through Earth by causing particles in rock to move at right angles to the direction in which the wave is traveling.

Surface waves move particles in rock in a backward, rolling motion and also in a side-to-side, swaying motion. The arrows in the figure below show the different directions of movement made by surface waves. Surface waves cause most of the damage from earthquakes. Many buildings are made with stiff materials that crack when surface waves shake the ground. The buildings fall apart or collapse when surface waves cause different parts of the building to move in different directions.

Picture This

2. **Explain** Why do surface waves cause much more damage than other waves?



Surface waves are produced when earthquake energy reaches Earth's surface. Surface waves travel outward from the epicenter of an earthquake. An earthquake's **epicenter** (EH pih sen tur) is the point on Earth's surface directly above the earthquake focus.

Locating an Epicenter

Different seismic waves travel through Earth at different speeds. Primary waves are the fastest; secondary waves are slower. They travel about half the speed of primary waves. Surface waves are the slowest seismic waves. ☑

Scientists have learned to use the different speeds of seismic waves to figure out the distance to an earthquake's epicenter. When an earthquake's epicenter is far from a location, the primary wave has more time to get farther ahead of the secondary and surface waves. It reaches the monitoring center first, ahead of the other seismic waves.

How are seismic waves measured?

A **seismograph** is the instrument scientists use to measure seismic waves. A seismograph registers the waves and records the time that each wave arrived.

A seismograph is made up of a rotating drum of paper and a hanging weight, or pendulum, with a pen attached to it. When seismic waves reach the seismograph, the drum vibrates, but the pendulum remains at rest. The unmoving pen traces a record of the vibrations on the moving drum of paper. The paper record of a seismic event is called a seismogram. The figure below shows two different seismographs recording two different ground movements—horizontal and vertical.

Reading Check

3. **Interpret** What are the fastest seismic waves?

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Think it Over

4. **Explain** Why are two different seismographs used to record Earth's movements?

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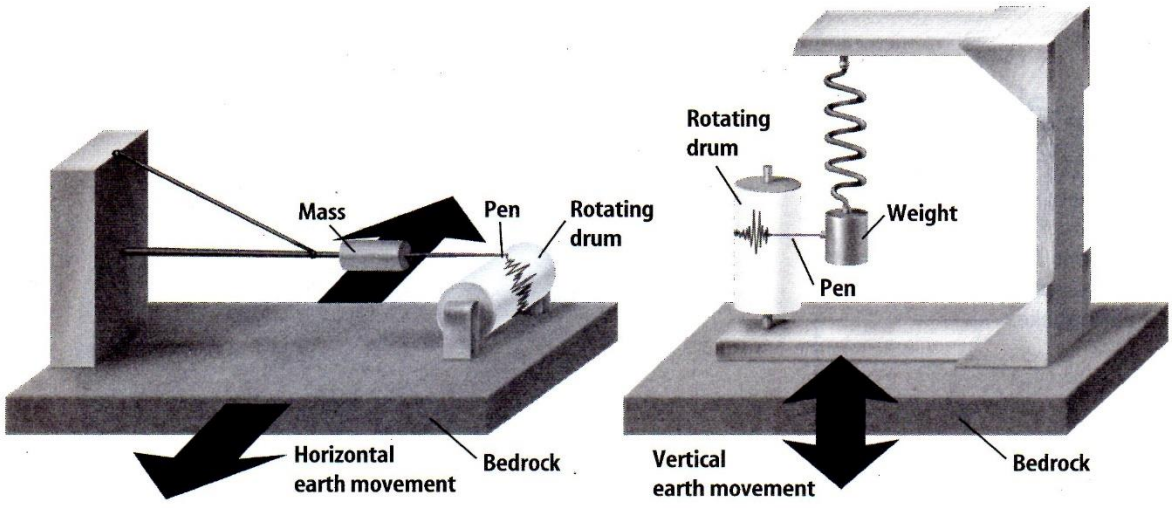


What are seismograph stations?

Seismographs are located at seismograph stations, where scientists record and monitor earthquake activity. Each type of seismic wave reaches the seismograph station at a different time, depending on its speed. Primary waves reach the seismograph station first. Secondary waves reach the station second, and the slow surface waves reach the seismograph station last. Scientists use the time difference to figure out the distance between the seismograph station and the earthquake epicenter. For example, if a seismograph station is located 4,000 km from an earthquake epicenter, primary waves will reach the station about 6 minutes before secondary waves. ☑

Reading Check

5. **Analyze** How is the speed of different seismic waves used to locate an earthquake epicenter?

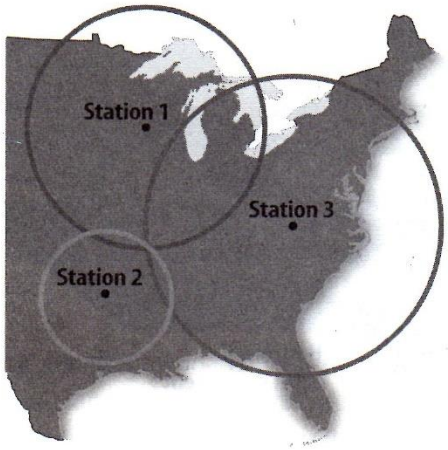
How is an epicenter located?

Seismic waves must be recorded at three or more stations to determine an earthquake's epicenter. To locate an epicenter, scientists draw a circle around each station's position on a map, as shown in the figure below. The size of each circle is based on how far each seismograph station is from the epicenter of the earthquake. The point at which the three circles meet is the location of the earthquake epicenter.

Scientists usually describe earthquakes based on their distance from the seismograph. Local earthquakes occur less than 100 km away. Regional events occur from 100 km to 1,400 km from the seismograph. Teleseismic events occur more than 1,400 km away.

Picture This

6. **Identify** Look at the figure with circles drawn around three seismograph stations. Mark the location of the epicenter of this earthquake.



Basic Structure of Earth

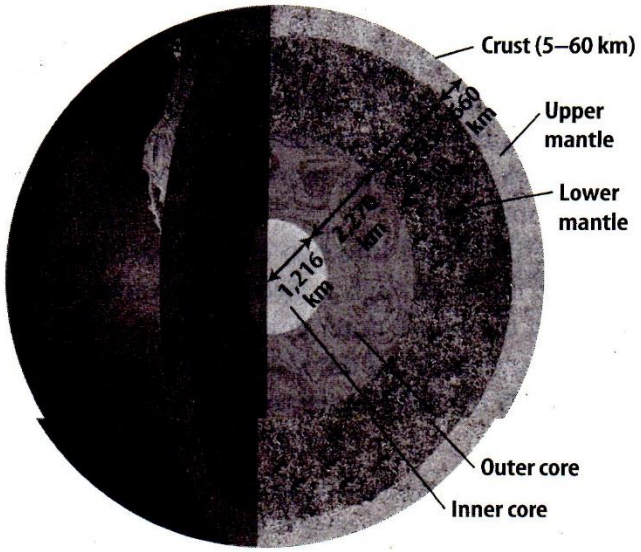
Earth's different layers are shown in the figure below. The center of Earth is a very dense, solid core made mostly of iron, with smaller amounts of nickel, oxygen, silicon, and sulfur. The core is solid and dense because of the intense pressure of all the layers above it. Above the inner core lies the liquid outer core, which also is made mostly of iron.

Earth's mantle is the largest layer. The mantle lies above the liquid outer core. The mantle is made up mainly of silicon, oxygen, magnesium, and iron. The mantle is divided into an upper mantle and a lower mantle, based on the different speeds at which seismic waves move through them. One part of the upper mantle, called the asthenosphere (as THE nuh sfihr), contains weak rock that can flow slowly, like a thick liquid.

What is Earth's crust?

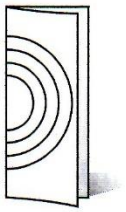
The outermost layer of Earth is called the crust. The crust contains more silicon and aluminum, but less magnesium and iron, than the mantle. The crust and the part of the mantle just beneath it make up the lithosphere (LIH thuh sfihr). The lithosphere is broken up into a number of plates. The plates move over the asthenosphere that lies just below them.

The thickness of Earth's crust varies. In some mountain regions, it is more than 60 km thick. Under some parts of the ocean, it is only 5 km thick. Earth's crust is generally less dense than the mantle beneath it.



FOLDABLES™

D Describe Make a half-book Foldable showing a cross section of Earth. Label Earth's layers. Describe each layer inside the book.



Picture This

7. Locate Use a colored pencil or marker to highlight the lithosphere in the figure.

How can scientists know about Earth's internal structure?

The speeds and paths of seismic waves change as they travel through materials with different densities. By studying seismic waves, scientists have concluded that different layers of Earth are made of different materials with different densities. In general, the deeper inside Earth a layer is, the denser it is. Studying how seismic waves travel through Earth has allowed scientists to map Earth's internal structure without being there.

Think it Over

8. **Infer** What part of Earth has the greatest density?

Do seismic waves travel through liquid?

Scientists also discovered that seismic waves do not travel through some regions of Earth. Seismic waves are not detected in the region of Earth called the shadow zone. The shadow zone occurs because secondary waves cannot travel through liquid, so they stop moving when they reach the liquid outer core. Primary waves are slowed and bent, but not stopped, by the liquid outer core. From these findings, scientists concluded that the liquid outer core and the mantle are made of different materials with different densities.

How do layer boundaries affect seismic waves?

Seismic waves change speed when they travel through different layers of Earth. Seismic waves speed up when they pass through the bottom of the crust and enter the upper mantle. Seismic waves change speed at this boundary because the crust and the upper mantle have different densities. This boundary is called the Mohorovicic discontinuity (moh huh ROH vee chihch • dis kahn tuh NEW uh tee), or Moho. ☑

Reading Check

9. **Identify** What causes seismic waves to change speeds as they move through Earth's layers?

Seismic waves also change speed as they travel through different parts of the mantle. For example, waves slow down when they reach the asthenosphere. They speed up again when they move through the more solid part of the mantle below the atmosphere.

Earth's core is divided into two regions based on how seismic waves travel through it. Secondary waves cannot travel through the liquid outer core. Primary waves slow down when they reach the outer core, but speed up again when they reach the solid inner core.

After You Read

Mini Glossary

epicenter: point on Earth's surface directly above the earthquake focus

focus: point below Earth's surface where energy is first released in the form of seismic waves

primary wave: seismic wave that causes rock particles to move back and forth in the same direction that the wave is traveling

secondary wave: seismic wave that moves rock particles at right angles to the direction of the wave

seismic wave: wave generated by an earthquake

seismograph: instrument used to register seismic waves and record the time that each arrived

surface wave: seismic wave that moves rock particles in a backward, rolling motion and also in a side-to-side, swaying motion

1. Review the terms and their definitions in the Mini Glossary. Then write two sentences about primary, secondary, and surface waves. Explain how they are alike and how they are different.

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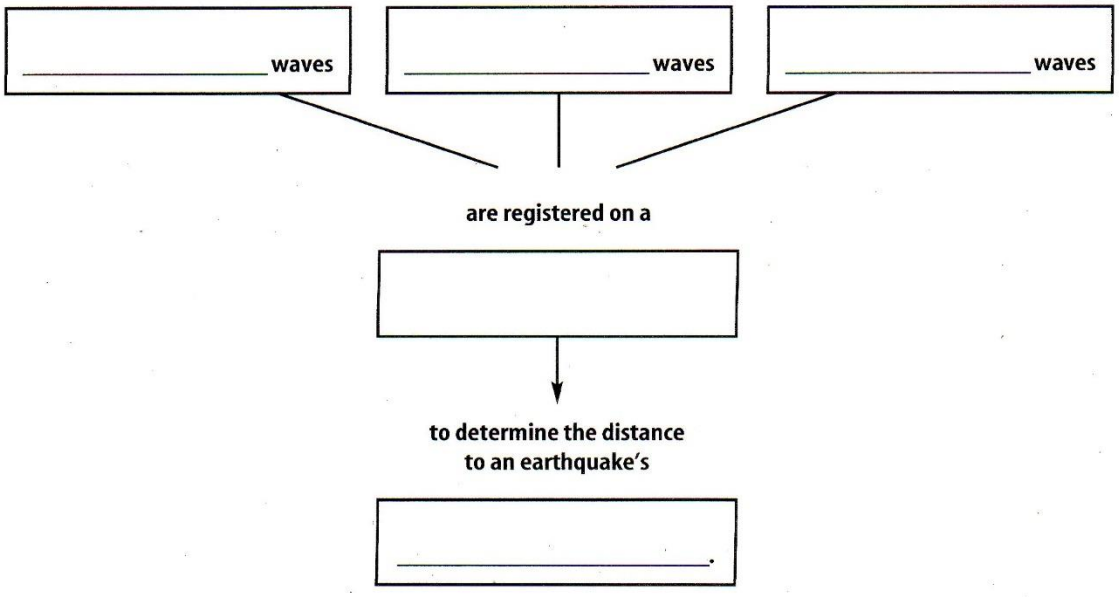
2. Fill in the blank boxes below to explain how seismic waves are used.



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End of Section