Earthquakes ▪ *Guided Reading and Study*

Earthquakes and Seismic Waves

This section explains how energy from an earthquake travels through Earth, how it can be detected, and how the size of an earthquake can be measured.

Use Target Reading Skills

As you read about seismic waves, complete the graphic organizer by filling in the details.

Main Idea

Seismic waves carry the energy of an earthquake.

Detail | **Detail** | **Detail**

a.	b.	c.

Introduction

1. The point at which a rock under stress breaks and triggers an earthquake

is called the _____.

2. The point on the surface directly above the focus is the

_____.

Types of Seismic Waves

3. What are seismic waves? _____

_____

_____

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Earthquakes ▪ *Guided Reading and Study*
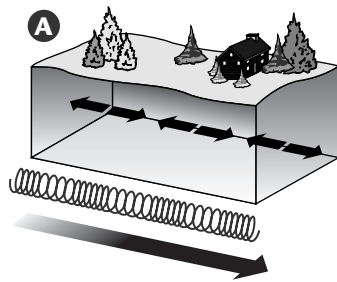
Earthquakes and Seismic Waves *(continued)*

4. Is the following sentence true or false? Seismic waves carry the energy of an earthquake away from the focus in all directions. _____.
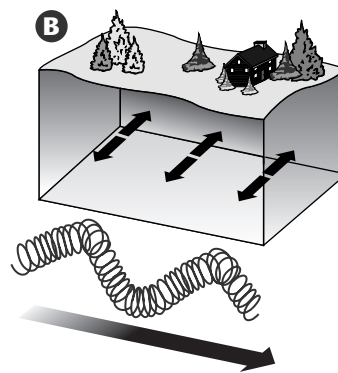
5. Circle the letter of each term that is a category of seismic wave.

   a. P wave

   b. S wave

   c. surface wave

   d. underground wave

6. Label each drawing as *S Waves* or *P Waves*.

_____   _____

7. Is the following sentence true or false? Surface waves move more quickly than P waves and S waves. _____

Type of Wave	Effect
____ **8.** P wave	**a.** shakes buildings from side to side
____ **9.** S wave	**b.** shakes buildings violently
____ **10.** Surface wave	**c.** causes buildings to contract and expand

11. A device that records the ground movements caused by seismic waves is a(n) _____.

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Measuring Earthquakes

12. List the three scales that are used for measuring earthquakes.

    a. _____

    b. _____

    c. _____

13. In your own words, write a definition of each earthquake scale.

    a. _____

    _____

    b. _____

    _____

    c. _____

Locating the Epicenter

14. Is the following sentence true or false? The closer an earthquake, the greater the time between the arrival of P waves and the arrival

of S waves. _____

15. Geologists use circles to find the epicenter of an earthquake.

    a. What does the center of each circle represent? _____

    _____

    b. What does the radius of each circle represent? _____

    _____

Earthquakes ▪ *Section Summary*

Earthquakes and Seismic Waves
Key Concepts

■ How does the energy of an earthquake travel through Earth?

■ What are the scales used to measure the strength of an earthquake?

■ How do scientists locate the epicenter of an earthquake?

An **earthquake** is the shaking and trembling that results from the movement of rock beneath Earth's surface. The point beneath Earth's surface where rock under stress breaks to cause an earthquake is called the **focus.** The point on the surface directly above the focus is called the **epicenter.** During an earthquake, vibrations called seismic waves move out from the focus in all directions. **Seismic waves carry the energy of an earthquake away from the focus, through Earth's interior, and across the surface.**

There are three categories of seismic waves: P waves, S waves, and surface waves. **P waves** compress and expand the ground like an accordion. **S waves** vibrate from side to side and up and down. When P waves and S waves reach the surface, some become surface waves. **Surface waves** move more slowly than P waves and S waves.

Three commonly used methods of measuring earthquakes are the Mercalli scale, the Richter scale, and the moment magnitude scale. The **Mercalli scale** was developed to rate earthquakes according to the level of damage at a given place. An earthquake's **magnitude** is a number that geologists assign to an earthquake based on the earthquake's strength. The **Richter scale** is a rating of an earthquake's magnitude based on the size of the earthquake's seismic waves. The seismic waves are measured by a **seismograph.** A seismograph is an instrument that records and measures seismic waves. Geologists today often use the **moment magnitude scale,** a rating system that estimates the total energy released by an earthquake. An earthquake's magnitude tells geologists how much energy was released by the earthquake. The effects of an earthquake increase with magnitude.

Geologists use seismic waves to locate an earthquake's epicenter. When an earthquake strikes, P waves arrive at a seismograph first and S waves next. The farther away the epicenter is, the greater the difference between the two arrival times. This time difference tells scientists how far from the seismograph the epicenter is. The scientists then use the information from three different seismograph stations to plot circles on a map. Each circle shows the distance from one seismograph station to all the points where the epicenter could be located. The single point where the three circles intersect is the location of the earthquake's epicenter.

Earthquakes and Seismic Waves

Understanding Main Ideas

Answer the following questions in the spaces provided.

1. What are seismic waves?

_____

_____

2. In what order do the three types of seismic waves arrive at a seismograph?

_____

_____

3. Which type of seismic wave produces the most severe ground movements?

_____

4. Describe the moment magnitude scale, and explain why it is useful in measuring earthquakes.

_____

_____

_____

5. How do geologists locate the epicenter of an earthquake?

_____

_____

_____

Building Vocabulary

Match each term with its definition by writing the letter of the correct definition in the right column on the line beside the term in the left column.

_____ **6.** focus

_____ **7.** epicenter

_____ **8.** surface waves

_____ **9.** seismograph

_____ **10.** magnitude

a. records ground movements caused by seismic waves as they move through the Earth

b. slowest seismic waves that produce the most severe ground movements

c. the point beneath Earth's surface at which rock under stress breaks and triggers an earthquake

d. a measurement of earthquake strength

e. the point on the surface directly above the point at which an earthquake occurs

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Comparing the Richter and Moment Magnitude Scales

The Richter scale rates earthquakes based on the size of their seismic waves, as measured by seismographs. The moment magnitude scale rates earthquakes based on the total amount of energy they release. To determine the moment magnitude rating, seismologists measure the surface area of the ruptured fault and how far the land moved along the fault. An earthquake's Richter rating and moment magnitude rating are not always the same. The table below shows the ratings on both scales for some famous earthquakes.

| Date | Location | Magnitude | |
		Richter scale	Moment magnitude scale
1811–1812	New Madrid, midwestern US	8.7	8.1
1906	San Francisco, California	8.3	7.7
1960	Arauco, Chile	8.3	9.5
1964	Anchorage, Alaska	8.4	9.2
1971	San Fernando, California	6.4	6.7
1985	Mexico City, Mexico	8.1	8.1
1989	San Francisco, California	7.1	7.2
1994	Northridge, California	6.4	6.7
1995	Kobe, Japan	6.8	6.9

Answer the following questions on a separate sheet of paper.

1. Which earthquake was strongest according to the Richter scale? Which was strongest according to the moment magnitude scale?

2. Which earthquakes had the same or close to the same ratings on both scales?

3. Which earthquakes were rated more than 0.5 points stronger on the moment magnitude scale than they were rated on the Richter scale?

4. Which earthquakes were rated more than 0.5 points stronger on the Richter scale than they were rated on the moment magnitude scale?

5. Why can the same earthquake have different ratings on the two scales?

Earthquakes · *Skills Lab*

Finding the Epicenter

Problem

How can you locate an earthquake's epicenter?

Skills Focus

interpreting data, drawing conclusions

Materials

drawing compass with pencil
outline map of the United States

Procedure ✂ *Review the safety guidelines in Appendix A.*

1. Review the data table showing differences in earthquake arrival times.

2. The graph shows how the difference in arrival times between P waves and S waves depends on the distance from the epicenter of the earthquake. Find the difference in arrival time for Denver on the *y*-axis of the graph. Follow this line across to the point at which it crosses the curve. To find the distance to the epicenter, read down from this point to the *x*-axis of the graph. Enter this distance in the data table.

3. Repeat Step 2 for Houston and Chicago.

4. Set your compass at a radius equal to the distance from Denver to the earthquake epicenter that you recorded in your data table.

5. Draw a circle with the radius determined in Step 4, using Denver as the center. Draw the circle on the map. (*Hints:* Draw your circles carefully. You may need to draw some parts of the circles off the map.)

6. Repeat Steps 4 and 5 for Houston and Chicago.

Earthquakes · *Skills Lab*
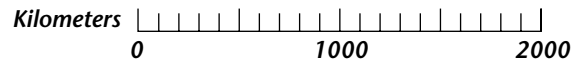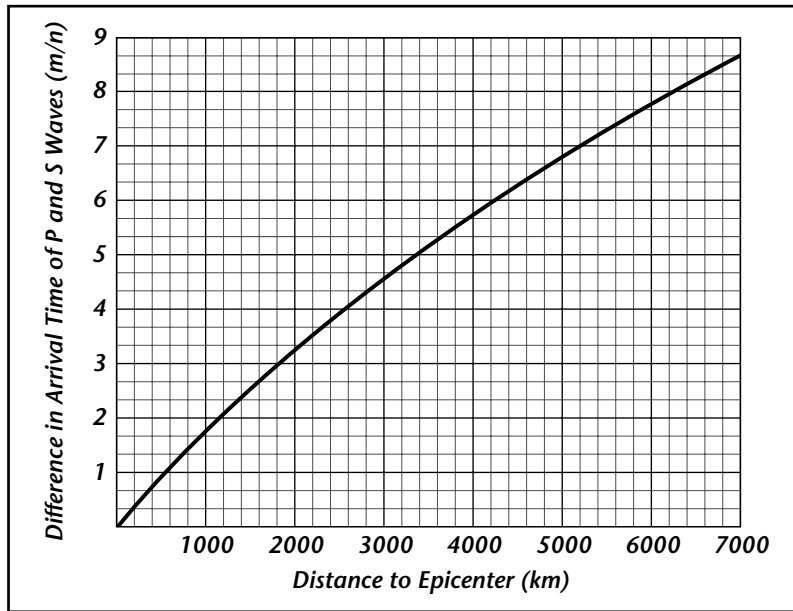
Earthquakes ▪ *Skills Lab*

Finding the Epicenter (continued)

DATA TABLE

City	Difference in P and S Wave Arrival Times	Distance to Epicenter
Denver, Colorado	2 min 10 s	1200 km
Houston, Texas	3 min 55 s	2500 km
Miami, Florida	5 min 40 s	4000 km

Analyze and Conclude

Answer the following questions on a separate sheet of paper.

1. Observe the three circles you have drawn. Where is the earthquake's epicenter?

2. Which city on the map is closest to the earthquake epicenter? How far, in kilometers, is this city from the epicenter?

3. In which of the three cities listed in the data table would seismographs detect the earthquake first? Last?

4. About how far from San Francisco is the epicenter that you found? What would the difference in arrival times of the P waves and S waves be for a recording station in San Francisco?

5. What happens to the difference in arrival times between P waves and S waves as the distance from the earthquake increases?

6. Review the procedure you followed in this lab and then answer the following question. When you are trying to locate an epicenter, why is it necessary to know the distance from the epicent for at least three recording stations?

More to Explore

You have just located an earthquake's epicenter. Find this earthquake's location on the map of Earthquake Risk in the United States in your textbook. What is the risk of earthquakes in the area of this quake?

   Now look at the map of Earth's Lithospheric Plates in your textbook. What conclusions can you draw from this map about the cause of earthquakes in this area?