Seismic Waves

Reading Preview

Key Concepts

- What are the types of seismic waves?
- How does a seismograph work?

Key Terms

- seismic wave • P wave
- S wave • surface wave
- tsunami • seismograph

Target Reading Skill

Building Vocabulary Using a word in a sentence helps you think about how to best explain the word. As you read, carefully note the definition of each Key Term. Also note other details in the paragraph that contains the definition. Use all this information to write a sentence using the Key Term.

Lab zone **Discovery Activity**

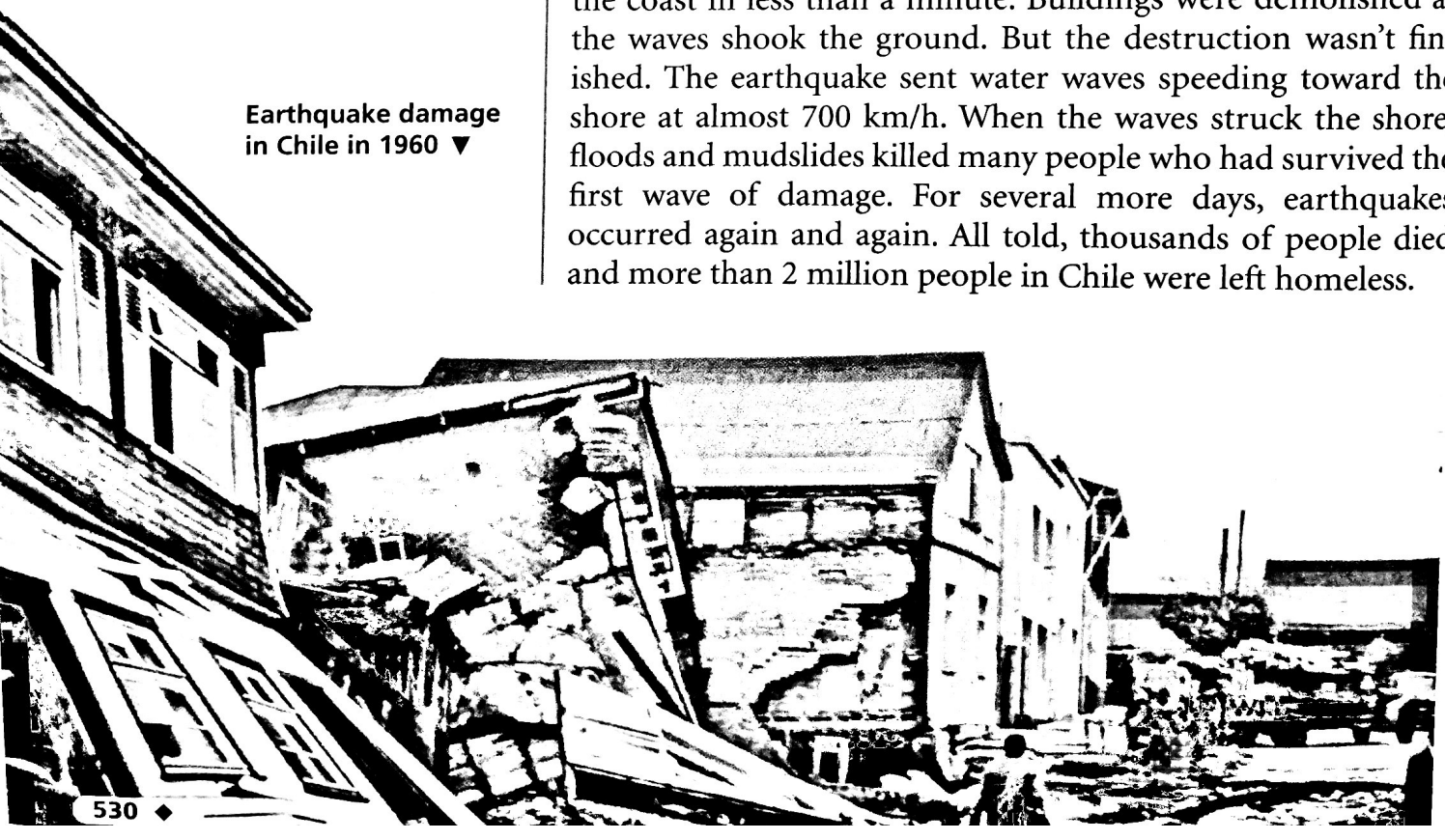
Can You Find the Sand?

1. Fill a plastic film canister with sand and replace the lid.
2. Place the canister on a table with four identical but empty canisters. Mix them around so that a classmate does not know which canister is which.
3. With your fist, pound on the table a few times. Ask your classmate which canister contains the sand.
4. Then stick each canister to the table with some modeling clay. Pound on the table again. Can your classmate tell which canister contains sand?

Think It Over

Inferring Pounding on a table makes waves. Why might the canister with sand respond differently from the empty canisters?

On May 22, 1960, a massive earthquake occurred under the Pacific Ocean about 120 km west of Chile. Traveling underground faster than the speed of sound, earthquake waves hit the coast in less than a minute. Buildings were demolished as the waves shook the ground. But the destruction wasn't finished. The earthquake sent water waves speeding toward the shore at almost 700 km/h. When the waves struck the shore, floods and mudslides killed many people who had survived the first wave of damage. For several more days, earthquakes occurred again and again. All told, thousands of people died and more than 2 million people in Chile were left homeless.



Earthquake damage in Chile in 1960 ▼

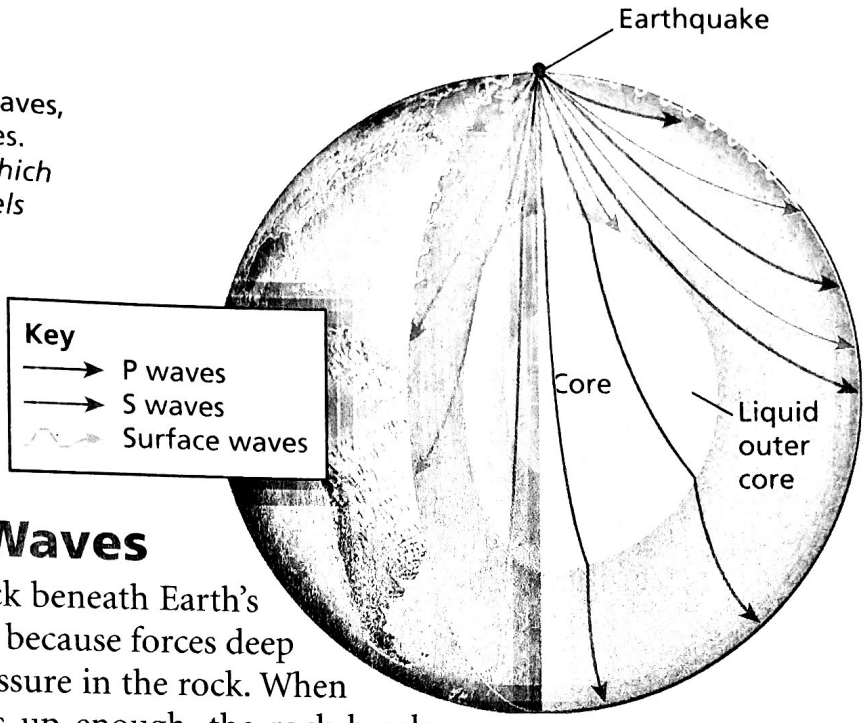


FIGURE 13
Seismic Waves
Seismic waves include P waves, S waves, and surface waves.
Interpreting Diagrams *Which kind of seismic wave travels through Earth's core?*

Types of Seismic Waves

An earthquake occurs when rock beneath Earth's surface moves. This rock moves because forces deep inside Earth create stress or pressure in the rock. When the pressure in the rock builds up enough, the rock breaks or changes shape, releasing energy in the form of waves. The waves produced by earthquakes are called **seismic waves.** (The word seismic comes from the Greek word *seismos*, which means "earthquake.")

Seismic waves ripple out in all directions from the point where the earthquake occurred. As the waves move, they carry energy through Earth. The waves can travel from one side of Earth to the other. **Seismic waves include P waves, S waves, and surface waves.** Figure 13 shows how each kind of wave travels through Earth.

P Waves Some seismic waves are longitudinal waves. Longitudinal seismic waves are known as **P waves,** or primary waves. They are called primary waves because they move faster than other seismic waves and so arrive at distant points before other seismic waves. P waves are made up of compressions and rarefactions of rock inside Earth. These waves compress and expand the ground like a spring toy as they move through it.

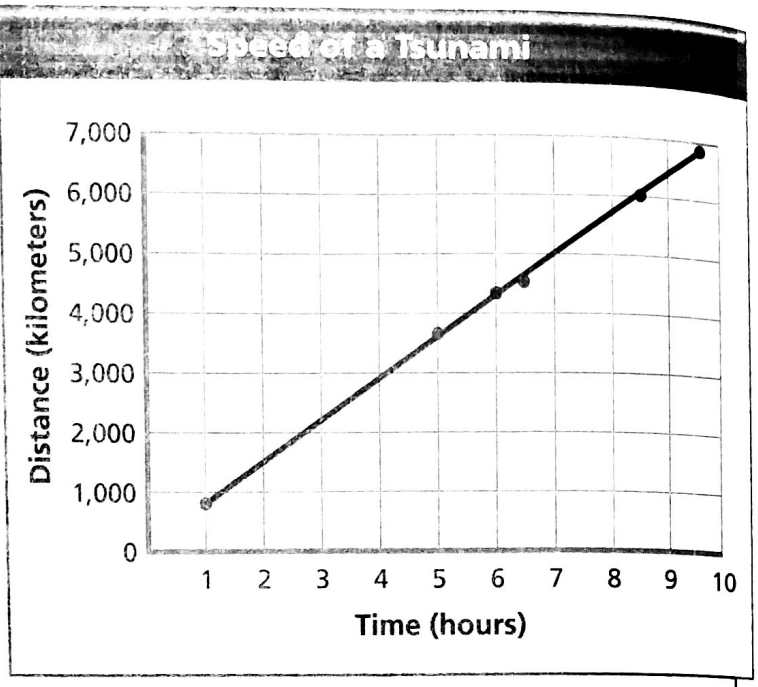
S Waves Other seismic waves are transverse waves with crests and troughs. Transverse seismic waves are known as **S waves,** or secondary waves. S waves shake the ground up and down and side to side as they move through it. They cannot travel through liquids. Because part of Earth's core is liquid, S waves do not travel directly through Earth like P waves. Therefore, S waves cannot be detected on the side of Earth opposite an earthquake. Scientists on the side of Earth opposite the earthquake detect mainly P waves.

Math Analyzing Data

Motion of a Tsunami

This graph shows the rate at which a tsunami moves across the Pacific Ocean. Use the data plotted on the graph to answer the following questions.

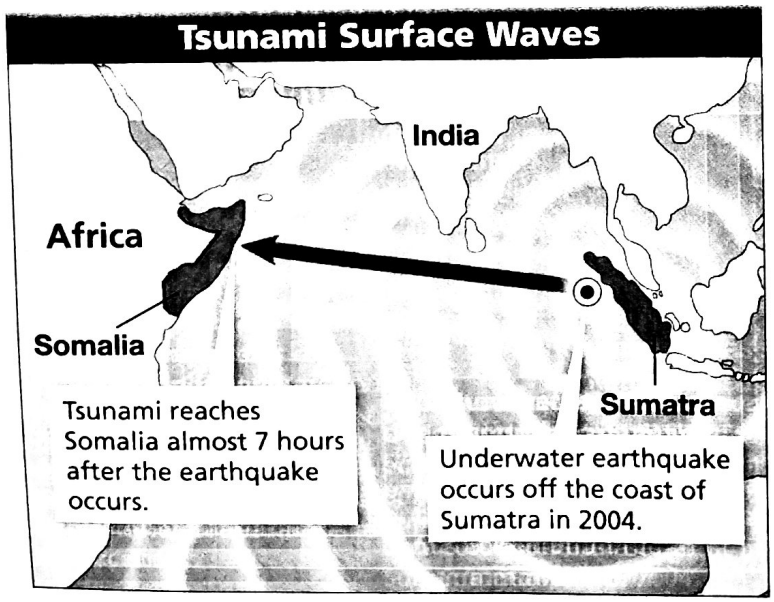
1. **Reading Graphs** What two variables are plotted on the graph?
2. **Interpreting Data** How far does the tsunami travel in two hours? In four hours?
3. **Predicting** Easter Island is 3,700 kilometers from the earthquake. How many hours would it take the tsunami to reach Easter Island?



Surface Waves When P waves and S waves reach Earth's surface, they can create surface waves. A **surface wave** is a combination of a longitudinal wave and a transverse wave that travels along the surface of a medium. Surface waves produced by earthquakes move more slowly than P waves and S waves. However, they can cause the most severe ground movements. They combine up-and-down and side-to-side motions, making the ground roll like ocean waves.

Earthquakes that occur underwater, like the one off the coast of Sumatra, Indonesia in 2004, can produce huge surface waves on the ocean called **tsunamis** (tsoo NAH meez). Tsunamis come in all sizes, from 2 centimeters to 30 meters tall. They can travel thousands of kilometers across the ocean. In the deep ocean, the larger waves are only about 1 meter high. But as they near land, tsunamis slow down in the shallow water. The waves in the back catch up with those in the front and pile on top. Tsunamis caused by the 2004 earthquake near Sumatra traveled as far as 7,000 km across the Indian Ocean to Somalia. Tragically, the tsunamis killed more than 230,000 people worldwide and caused more than $100 billion in home and property damage.

FIGURE 14
This map shows the progress of the 2004 tsunami caused by an earthquake near Indonesia. **Classifying** *What type of wave interference—constructive or destructive—causes tsunamis?*



Reading Checkpoint **How are tsunamis produced?**

Detecting Seismic Waves

To detect and measure earthquake waves, scientists use instruments called **seismographs** (SYZ muh grafs). **A seismograph records the ground movements caused by seismic waves as they move through Earth.**

The frame of the seismograph is attached to the ground, so the frame shakes when seismic waves arrive. Seismographs used to have pens attached to the frame that made wiggly lines on a roll of paper as the ground shook. Now scientists use electronic seismographs to record data about Earth's motion.

Because P waves travel through Earth faster than S waves, P waves arrive at seismographs before S waves. By measuring the time between the arrival of the P waves and the arrival of the S waves, scientists can tell how far away the earthquake was. By comparing readings from at least three seismographs located at different places on Earth, scientists can tell where the earthquake occurred.

To find oil, water, and other valuable resources, geologists set off explosives at Earth's surface. Seismic waves from the explosions reflect from structures under the ground. Geologists then use seismograph data to locate the underground resources.

FIGURE 15
Seismologist Studying Data
A scientist studies the arrival time of seismic waves on the printout from a seismograph.

Section 4 Assessment

Target Reading Skill Building Vocabulary Use your sentences about seismic waves to help you answer the questions below.

Reviewing Key Concepts

1. a. **Identifying** What are three types of seismic waves?
   b. **Classifying** Which seismic waves are transverse waves? Which are longitudinal waves?
   c. **Comparing and Contrasting** Why do seismic waves that travel along Earth's surface cause more damage than other seismic waves?
2. a. **Defining** What is a seismograph?
   b. **Explaining** How does a seismograph work?
   c. **Interpreting Data** S waves arrive in Los Angeles 3 minutes after P waves. In Dallas, S waves arrive 1 minute after P waves. Which city is closer to the earthquake? Explain your answer.

Lab zone At-Home Activity

Sounds Solid Explore how waves travel through different solids. Have a family member or friend tap one end of a table with a spoon. Now put your ear to the table and listen again. What difference do you notice? Repeat the tapping on various surfaces around your home. What observations have you made?