

9.3

Earthquakes

LEARNING TIP

Preview the headings on these two pages. What can you say about where earthquakes occur?

As the plates that make up Earth's crust move, the rough edges lock together. Over time, pressure builds up until one or both of the plates suddenly move, releasing the energy stored in rocks. The sudden release of energy causes vibrations of Earth's crust called **earthquakes**.

Earthquakes can occur at all three types of plate boundaries:

1. divergent
2. convergent
3. transform fault.

Earthquakes at Divergent Boundaries

Earthquakes can occur where two plates are being pushed apart. Hot magma rising below the crust pushes upward toward an opening in the crust (**Figure 1**). Pressure builds up where the plates are joined. Then suddenly, the pressure is enough to push the plates apart, and the crust shakes. This produces a small local earthquake. There are constant small earthquakes along the Mid-Atlantic Ridge.

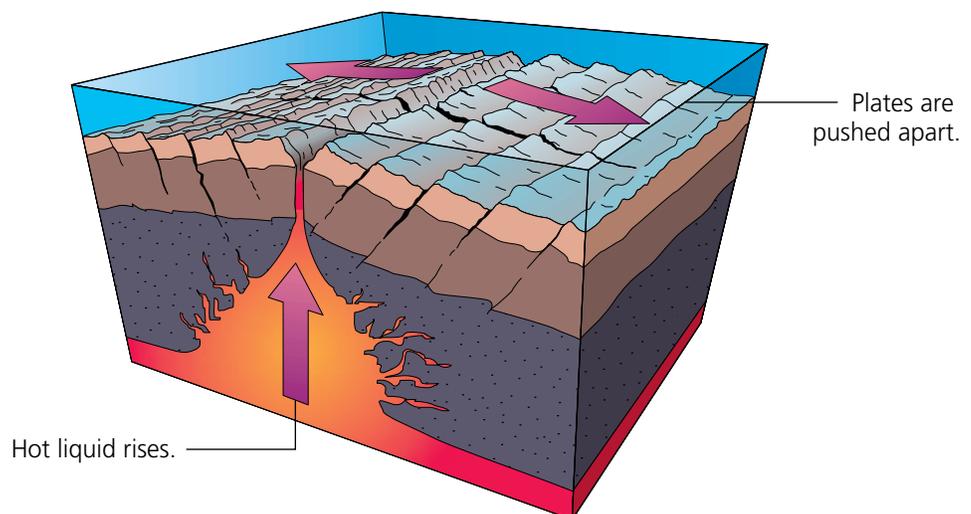


Figure 1

Some earthquakes occur as two plates are pushed apart.

Earthquakes at Convergent Boundaries

When an oceanic plate is subducted under another oceanic plate or a continental plate, it may get stuck against the top plate (Figure 2). The force builds up until the top plate suddenly moves. This sudden movement can cause a large earthquake. The longer a plate is stuck, the stronger the earthquake is when the plate breaks free. Southern British Columbia experiences almost 200 earthquakes a year as the Juan de Fuca Plate is subducted under the North American Plate.

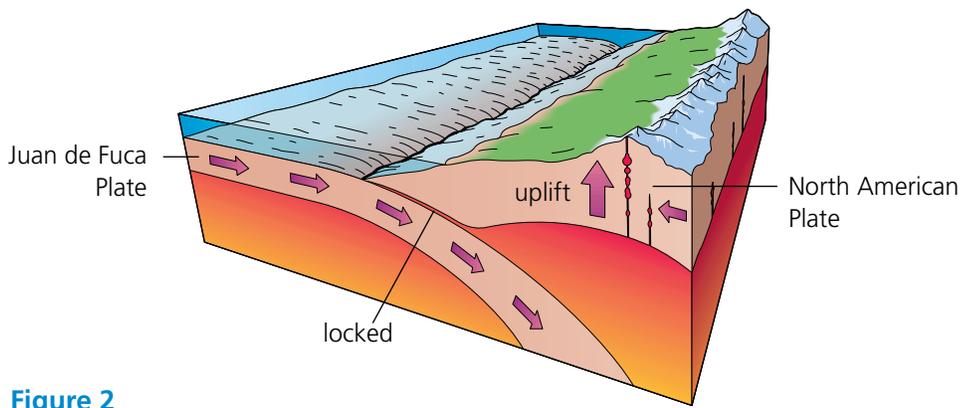


Figure 2
Some earthquakes occur in subduction zones.

Earthquakes at Transform Fault Boundaries

When two plates are moving past each other in opposite directions along a transform fault boundary, they sometimes get stuck (Figure 3). The force builds up until one plate suddenly moves, causing an earthquake. The longer the time before the plates slip, the stronger the earthquake is. There have been many powerful earthquakes of this type along the San Andreas Fault in California.

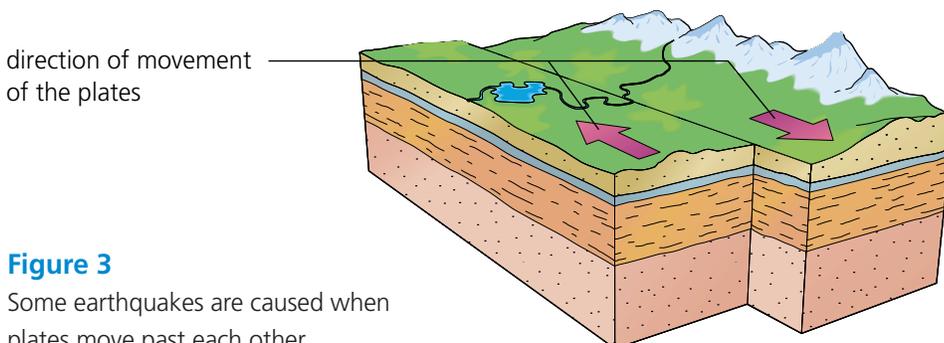


Figure 3
Some earthquakes are caused when plates move past each other.

LEARNING TIP

Check your understanding of why earthquakes occur at plate boundaries by explaining Figures 1, 2, and 3 to a partner.



The Effects of Earthquakes

News reports and newspaper articles about earthquakes usually include large, dramatic photos of the damage that earthquakes cause (Figure 4). How does this damage occur?



Figure 4

Earthquake damage in Mexico City in 1985.

The exact location within Earth at which an earthquake starts is called the focus (Figure 5). The focus is often deep within Earth's crust. The point on the surface of Earth directly above the focus is called the epicentre of the earthquake. The shock waves that are sent out when an earthquake occurs are called **seismic waves**. Smaller tremors can occur at any time for months after an earthquake as the pressure within Earth's crust is gradually released. These tremors are called **aftershocks**.

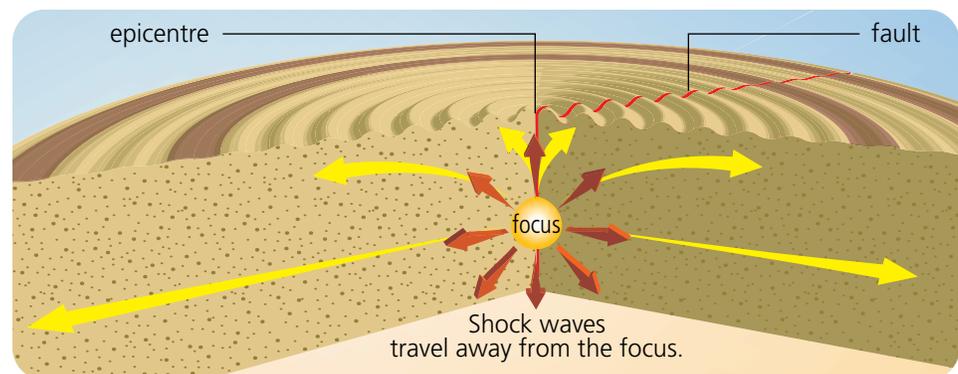


Figure 5

Comparing the focus and epicentre of an earthquake.

The energy that is released from the focus travels outward in all directions. The strength of the earthquake depends on the amount of energy that is released from the plate movement. There are two main types of seismic waves: primary (P) waves and secondary (S) waves. These waves and their effects are compared graphically in the Venn diagram in **Figure 6**.

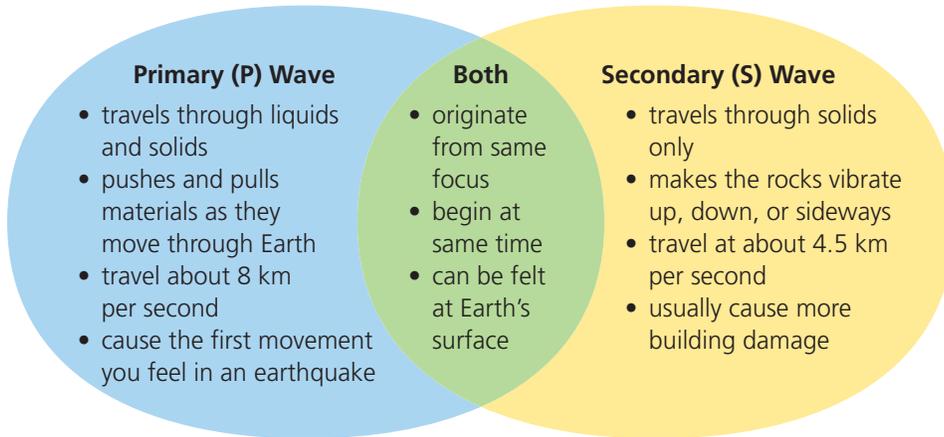


Figure 6
The two types of seismic waves that are produced by an earthquake cause different effects.

Geologists cannot observe Earth's mantle and core directly. They use indirect evidence from seismic waves to infer the characteristics of the interior of Earth (**Figure 7**).

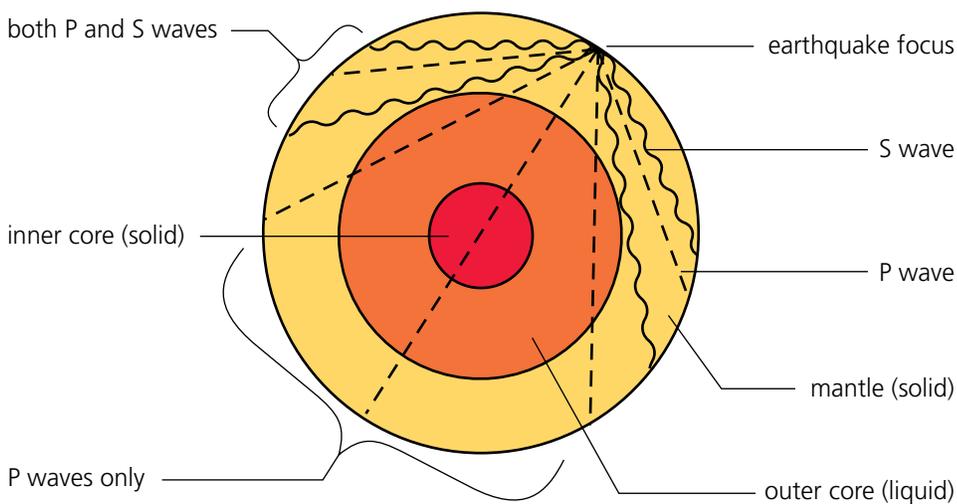


Figure 7
When an earthquake starts at the focus, the P waves can be detected anywhere. The S waves can be detected only at the locations shown. Since S waves cannot travel in liquid, scientists assume that part of Earth's interior must be liquid. This liquid part is called the outer core.

LEARNING TIP

Look at the overall diagram of earthquake waves travelling through Earth. Then look closely at each type of wave (P or S) separately and follow its path. If you are not sure why their paths are not the same, re-read the caption.



When an earthquake begins, the ground starts to shake, causing buildings to sway back and forth. If this happens in a rural area, only a few people may be in danger. If this happens in a city or town, many people may be affected. In addition to damaging buildings and roads, earthquakes can cause tunnels and overpasses to collapse. Fires can start when fuel tanks and gas lines break (**Figure 8**). Water lines can also break, leaving people without drinking water or water to fight fires.



Figure 8

In 1995, an earthquake caused massive damage when it hit the city of Kobe, Japan. Over 300 fires were started as a result.

▶ **LEARNING TIP**

The name “tsunami” comes from the Japanese words for harbour (津 or *tsu*) and wave (波 or *nami*). Why is this name a good choice?

If a large earthquake causes a section of the sea floor to move, a series of ocean waves is created. Ocean waves that are caused by an earthquake or an underwater volcano are called **tsunamis** [tsu-NAH-mees].

In the open ocean, tsunamis are small and pass almost unnoticed, except that they travel much faster than normal ocean swells. Tsunamis can travel at speeds of more than 800 km/h, as fast as a commercial jetliner, in deep water. When they approach shallower waters, their speed is reduced but they grow to surprising heights. In narrow inlets or shallow harbours, their height can increase to 30 m or more. Tsunamis can cause massive destruction and flooding in coastal areas.

Tsunamis from the Anchorage, Alaska, earthquake of 1964 hit the coast of British Columbia. The Hesquiaht [HESH-dwit] village at the head of Hot Spring Cove was completely wiped out (Figure 9). As well, there was considerable damage to Port Alberni because the narrow Alberni Inlet pushed the waves to greater heights.



Figure 9

In 1964, tsunamis moved nearly every house in this Hesquiaht village at Hot Spring Cove off its foundation, forcing the people to rebuild elsewhere.

CHECK YOUR UNDERSTANDING

1. What is the main cause of earthquakes?
2. List the three types of plate boundaries. Explain why earthquakes can occur at each type of boundary. Use sketches and diagrams in your explanation.
3. Which two types of plate movement produce the biggest earthquakes? Why do you think the other type of plate movement produces smaller earthquakes?
4. Why do seismologists (scientists who study earthquakes) worry if a plate stops moving?
5. What are aftershocks? Why do aftershocks present a special danger?
6. What are tsunamis? Describe how tsunamis are produced.