

Table of Contents

**Chapter: Earthquakes and Volcanoes**

Section 1: Earthquakes

Section 2: Volcanoes

Section 3: Earthquakes, Volcanoes, and Plate Tectonics

Earthquakes

1 **What causes earthquakes?—Elastic Rebound**

- If enough force is applied, rocks become strained, which means they change shape.
- They may even break, and the ends of the broken pieces may snap back. This snapping back is called elastic rebound.

Earthquakes

1 **What causes earthquakes?—Elastic Rebound**

- Energy is released suddenly by the action of rocks breaking and moving.
- Such breaking, and the movement that follows, causes vibrations that move through rock or other earth materials. If they are large enough, these vibrations are felt as **earthquakes**.

Earthquakes

1 **Types of Faults**

- The surface along which rocks move is called a **fault**.
- Several types of faults exist. The type that forms depends on how forces were applied to the rocks.

The diagram shows a cross-section of the Earth's crust with a fault line. Red arrows indicate the direction of stress being applied to the rock blocks on either side of the fault.

Earthquakes

1 **Types of Faults**

- When rocks are compressed, a reverse fault may form.
- When rocks are sheared, a strike-slip fault may form.

The first diagram shows a reverse fault where the top block is being pushed up relative to the bottom block due to compression. The second diagram shows a strike-slip fault where the blocks are sliding past each other horizontally due to shearing forces.

Earthquakes

1 **Making Waves**

- Earthquakes release waves.
- Earthquake waves are transmitted through materials in Earth and along Earth's surface.
- Earthquake waves are called **seismic waves**.



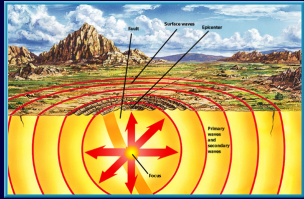
Click image to view movie.

CHAPTER RESOURCES    ?    END

Earthquakes

1 **Earthquake Focus and Epicenter**

- The point inside Earth where movement first occurs and energy is released is called the **focus** of an earthquake.

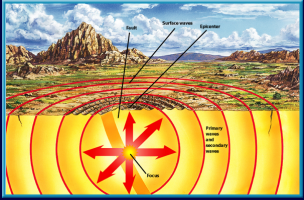


CHAPTER RESOURCES    ?    END

Earthquakes

1 **Earthquake Focus and Epicenter**

- The point on Earth's surface located directly above the earthquake focus is called the **epicenter** of the earthquake.

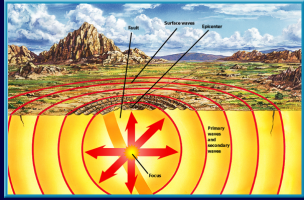


CHAPTER RESOURCES    ?    END

Earthquakes

1 **Seismic Waves**

- After they are produced at the focus, seismic waves travel away from the focus in all directions.

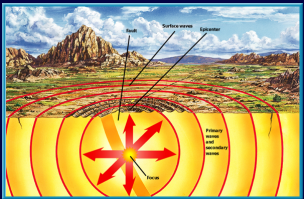


CHAPTER RESOURCES    ?    END

Earthquakes

1 **Seismic Waves**

- Some seismic waves travel throughout Earth's interior, and others travel along Earth's surface.



CHAPTER RESOURCES    ?    END

Earthquakes

1 **Seismic Waves**

- The surface waves cause the most damage during an earthquake event.
- Primary waves, also known as P-waves, travel the fastest through rock material by causing particles in the rock to move back and forth, or vibrate, in the same direction as the waves are moving.

CHAPTER RESOURCES    ?    END

Earthquakes

1 **Seismic Waves**


- Secondary waves, known as S-waves, move through rock material by causing particles in the rock to vibrate at right angles to the direction in which the waves are moving.
- Surface waves are the slowest and largest of the seismic waves, and they cause most of the destruction during an earthquake.

END

Earthquakes

1 **Learning from Earthquakes— Earthquake Measurements**

- Seismologists are scientists who study earthquakes and seismic waves.
- The instrument they use to obtain a record of seismic waves from all over the world is called a **seismograph**.




END

Earthquakes

1 **Learning from Earthquakes— Earthquake Measurements**

- The height of the lines traced on the paper is a measure of the energy released by the earthquake, also known as its **magnitude**.

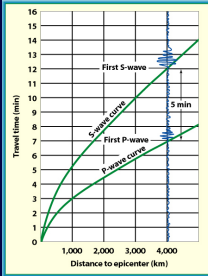


END

Earthquakes

1 **Epicenter Location**

- The farther apart the arrival times for the different waves are, the farther away the earthquake epicenter is.

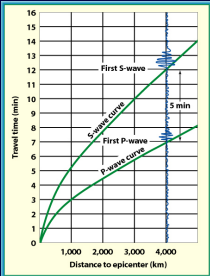


END

Earthquakes

1 **Epicenter Location**

- Using this information, scientists draw a circle with a radius equal to the distance from the earthquake for each of at least three seismograph stations.

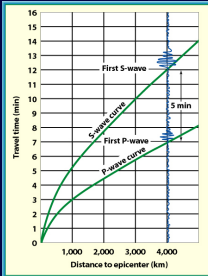


END

Earthquakes

1 **Epicenter Location**

- The point where the three circles meet is the location of the earthquake epicenter.



END

Earthquakes

1 **How strong are earthquakes?**

- Major earthquakes cause much loss of life.
- Sometimes earthquakes are felt and can cause destruction in areas hundreds of kilometers away from their epicenters.

Strong Earthquakes			
Year	Location	Magnitude	Deaths
1989	Loma Prieta, CA	7.1	62
1990	Iran	7.7	50,000
1993	Guam	8.1	none
1993	Maharashtra, India	6.4	30,000
1994	Northridge, CA	6.7	61
1995	Kobe, Japan	6.8	5,378
1999	Taiwan	7.7	2,400
2000	Indonesia	7.9	103
2001	India	7.7	20,000
2003	Iran	6.6	30,000

CHAPTER RESOURCES    ?    END

Earthquakes

1 **The Richter Scale**

- Richter (RIHK tur) magnitude is based on measurements of amplitudes, or heights, of seismic waves as recorded on seismographs.
- For each increase of 1.0 on the Richter scale, the amplitude of the highest recorded seismic wave increases by 10. However, about 32 times more energy is released for every increase of 1.0 on the scale.

CHAPTER RESOURCES    ?    END

Earthquakes

1 **Earthquake Damage**


- The modified Mercalli intensity scale measures the intensity of an earthquake.
- Intensity is a measure of the amount of structural and geologic damage done by an earthquake in a specific location.
- The range of intensities spans Roman numerals I through XII.

CHAPTER RESOURCES    ?    END

Earthquakes

1 **Earthquake Damage**

- An intensity-I earthquake would be felt only by a few people under ideal conditions.
- An intensity-VI earthquake would be felt by everyone.
- An intensity-XII earthquake would cause major destruction to human-built structures and Earth's surface.



CHAPTER RESOURCES    ?    END

Earthquakes

1 **Tsunamis**

- When an earthquake occurs on the ocean floor, the sudden movement pushes against the water and powerful water waves are produced.
- When these seismic sea waves, or **tsunamis**, are far from shore, their energy is spread out over large distances and great water depths.
- When tsunamis approach land, the waves slow down and their wave heights increase as they encounter the bottom of the seafloor.

CHAPTER RESOURCES    ?    END

Earthquakes

1 **Earthquake Safety—  
Is your home seismic safe?**

- It's a good idea to move all heavy objects to lower shelves so they can't fall on you.
- Make sure your gas hot-water heater and appliances are well secured.

CHAPTER RESOURCES    ?    END

Earthquakes

1 **Earthquake Safety—  
Is your home seismic safe?**

- In the event of an earthquake, keep away from all windows and avoid anything that might fall on you.
- Watch for fallen power lines and possible fire hazards.

CHAPTER RESOURCES

END

Earthquakes

1 **Seismic-Safe Structures**

- If a building is considered **seismic safe**, it will be able to stand up against the vibrations caused by most earthquakes.
- Many high-rise office buildings now stand on huge steel-and-rubber supports that could enable them to ride out the vibrations of an earthquake.

CHAPTER RESOURCES

END

Earthquakes

1 **Seismic-Safe Structures**

- Underground water and gas pipes are replaced with pipes that will bend during an earthquake.
- Seismic-safe highways have cement pillars with spiral reinforcing rods placed within them.

CHAPTER RESOURCES

END

Earthquakes

1 **Predicting Earthquakes**

- Researchers try to predict earthquakes by notifying changes that precede them. That way, if such changes are observed again, an earthquake warning may be issued.
- Long-range forecasts predict whether an earthquake of a certain magnitude is likely to occur in a given area within 30 to 100 years.
- Forecasts of this nature are used to update building codes to make a given area more seismic safe.

CHAPTER RESOURCES

END

Section Check

1 **Question 1**

Which of the following is NOT a type of stress in rock?

A. compression  
B. epicenter  
C. shearing  
D. tension

CHAPTER RESOURCES

SPI 0707.7.3

END

Section Check

1 **Answer**

The answer is B. The epicenter is the point on Earth's surface located directly above the earthquake's center.

CHAPTER RESOURCES

SPI 0707.7.3

END

Section Check

1

### Question 2

Where do P- and S-waves occur in relation to surface waves?

CHAPTER RESOURCES

SPI 0707.7.3, GLE 0707.7.2  
GLE 0707.7.4, SPI 0707.7.5  
SPI 0707.7.6

END

Section Check

1

### Answer

Seismic waves travel away from the epicenter in all directions. P-waves travel the fastest through rock material. S-waves move through the rock and cause particles to vibrate. Both P- and S-waves travel through the Earth's interior while surface waves move along Earth's surface.

CHAPTER RESOURCES

SPI 0707.7.3, GLE 0707.7.2  
GLE 0707.7.4, SPI 0707.7.5  
SPI 0707.7.6

END

Section Check

1

### Question 3

Why is it difficult to predict earthquakes?

CHAPTER RESOURCES

GLE 0707.7.4  
SPI 0707.7.6  
GLE 0707.7.5

END

Section Check

1

### Answer

Geologists can monitor changes in Earth that are associated with earthquakes. Measuring devices have been developed to assess changes in groundwater level and rock layers; however, no single change in Earth occurs for all earthquakes.

CHAPTER RESOURCES

GLE 0707.7.4  
SPI 0707.7.5  
GLE 0707.7.5

END

Volcanoes

2

### How do volcanoes form?

- Rising magma eventually can lead to an eruption, where magma, solids, and gas are spewed out to form cone-shaped mountains called **volcanoes**.
- As magma flows onto Earth's surface through a vent, or opening, it is called **lava**.
- Lava and other volcanic materials can be expelled through a volcano's crater.

CHAPTER RESOURCES

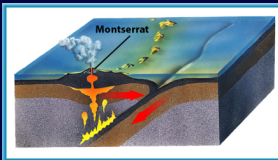
END

Volcanoes

2

### Where Plates Collide

- Some volcanoes form because of collision of large plates of Earth's crust and upper mantle.
- When one plate sinks under another plate, rock in and above the sinking plate melts, forming chambers of magma.



CHAPTER RESOURCES

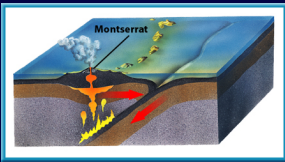
END



Volcanoes

**2** **Where Plates Collide**

- This magma is the source for volcanic eruptions that have formed the Caribbean Islands.




CHAPTER RESOURCES    END

Volcanoes

**2** **Eruptions on a Caribbean Island**

- Soufrière (soo free UR) Hills volcano on the island of Montserrat was considered dormant until recently.
- However, in 1995, Soufrière Hills volcano surprised its inhabitants with explosive activity.



CHAPTER RESOURCES    END

Volcanoes

**2** **Eruptions on a Caribbean Island**

- Plumes of ash soared to heights of more than 10,000 m.
- This ash settled over the entire island and was followed by mudflows brought on by heavy rains.

CHAPTER RESOURCES    END

Volcanoes

**2** **Eruptions on a Caribbean Island**

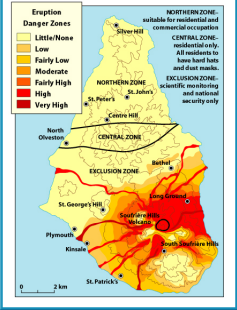
- Pyroclastic flows are another hazard for inhabitants of Montserrat.
- Pyroclastic flows are massive avalanches of hot, glowing rock flowing on a cushion of intensely hot gases.
- Speeds at which these flows travel can reach 200 km/h.

CHAPTER RESOURCES    END

Volcanoes

**2** **Volcanic Risks**

- A volcanic risk map for Montserrat was prepared to warn inhabitants and visitors about unsafe areas on the island.




CHAPTER RESOURCES    END

Volcanoes

**2** **Forms of Volcanoes**

- Volcanoes add new rock to Earth's crust with each eruption.
- The way volcanoes add this new material to Earth's surface varies greatly.
- Different types of eruptions produce different types of volcanoes.



CHAPTER RESOURCES    END

Volcanoes

2 **What determines how a volcano erupts?**

- The composition of the magma plays a big part in determining the manner in which energy is released during a volcanic eruption.
- Lava that contains more silica tends to be thicker and is more resistant to flow.

CHAPTER RESOURCES    ?    END

Volcanoes

2 **What determines how a volcano erupts?**

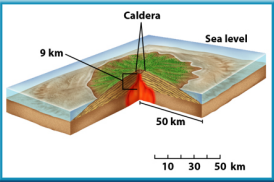
- Lava containing more iron and magnesium and less silica tends to flow easily.
- The amount of water vapor and other gases trapped in the lava also influences how lava erupts.

CHAPTER RESOURCES    ?    END

Volcanoes

2 **Shield Volcanoes**

- Basaltic lava, which is high in iron and magnesium and low in silica, flows in broad, flat layers.
- The buildup of basaltic layers forms a broad volcano with gently sloping sides called a **shield volcano**.

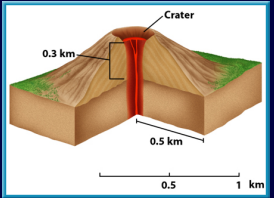


CHAPTER RESOURCES    ?    END

Volcanoes

2 **Cinder Cone Volcanoes**

- Moderate to violent eruptions throw volcanic ash, cinders, and lava high into the air.
- This tephra forms a relatively small cone of volcanic material called a **cinder cone volcano**.

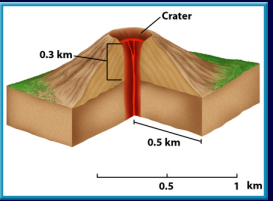


CHAPTER RESOURCES    ?    END

Volcanoes

2 **Cinder Cone Volcanoes**

- Because the eruption is powered by the high gas content, it usually doesn't last long.

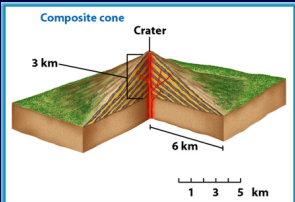


CHAPTER RESOURCES    ?    END

Volcanoes

2 **Composite Volcanoes**

- Steep-sided mountains composed of alternating layers of lava and tephra are **composite volcanoes**.



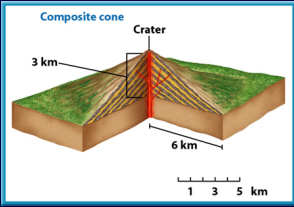
CHAPTER RESOURCES    ?    END



Volcanoes

**2 Composite Volcanoes**

- They sometimes erupt violently, releasing large quantities of ash and gas.
- Composite volcanoes form where one plate sinks beneath another.



Composite cone  
Crater  
3 km  
6 km  
1 3 5 km

CHAPTER RESOURCES

END

Volcanoes

**2 Fissure Eruptions**

- Magma that is highly fluid can ooze from cracks or fissures in Earth's surface.
- This is the type of magma that usually is associated with fissure eruptions.

CHAPTER RESOURCES

END

Volcanoes

**2 Fissure Eruptions**

- Flood basalts that have been exposed to erosion for millions of years can become large, relatively flat landforms known as lava plateaus.


CHAPTER RESOURCES

END

Volcanoes

**2 Fissure Eruptions**

- The Columbia River Plateau in the northwestern United States was formed about 15 million years ago when several fissures erupted and the flows built up layer upon layer.



CHAPTER RESOURCES

END

Section Check

**2 Question 1**

Where do most volcanoes occur?

**Answer**

Most volcanoes occur at plate boundaries where huge pieces of the crust pull apart or push together. As a result, the crust often fractures, allowing magma to reach the surface.

CHAPTER RESOURCES

GLE 0707.7.4  
SPI 0707.7.6

END

Section Check

**2 Question 2**

What type of volcano is formed by an explosive eruption followed by a quiet eruption?

- A. cinder cone volcano
- B. composite volcano
- C. fissure eruption
- D. shield volcano

CHAPTER RESOURCES

SPI 0707.7.3

END

Section Check

2

### Answer

The correct answer is B. Composite volcanoes erupt explosively releasing large quantities of gas and ash. They are followed by quieter eruptions that form a lava layer over the ash.

CHAPTER RESOURCES

GLE 0707.7.3

END

Section Check

2

### Question 3

What is a pyroclastic flow and why are they so dangerous to people who may live near volcanoes?

CHAPTER RESOURCES

GLE 0707.7.2  
SPI 0707.7.3

END

Section Check

2

### Answer

Pyroclastic flows consist of hot, glowing rock that flows with intensely hot gases. The speed of a pyroclastic flow can reach 200 km/h, which does not allow time for someone living nearby to escape.

CHAPTER RESOURCES

GLE 0707.7.2  
SPI 0707.7.3

END

Earthquakes, Volcanoes, and Plate Tectonics

3

### Earth's Moving Plates

- Earth's lithosphere is broken into separate sections, or plates.
- When these plates move around, they collide, move apart, or slide past each other.
- The movement of these plates can cause vibrations known as earthquakes and can create conditions that cause volcanoes to form.

CHAPTER RESOURCES

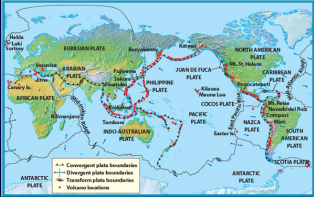
END

Earthquakes, Volcanoes, and Plate Tectonics

3

### Where Volcanoes Form

- A plot of the location of plate boundaries and volcanoes on Earth shows that most volcanoes form along plate boundaries.



CHAPTER RESOURCES

END

Earthquakes, Volcanoes, and Plate Tectonics

3

### Divergent Plate Boundaries

- Tectonic plates move apart at divergent plate boundaries.
- As the plates separate, long cracks called **rifts** form between them.
- Rift zones account for most of the places where lava flows onto Earth's surface.

CHAPTER RESOURCES

END

Earthquakes, Volcanoes, and Plate Tectonics

3 **Convergent Plate Boundaries**

- A common location for volcanoes to form is along convergent plate boundaries.
- More dense oceanic plates sink beneath less dense plates that they collide with. This sets up conditions that form volcanoes.

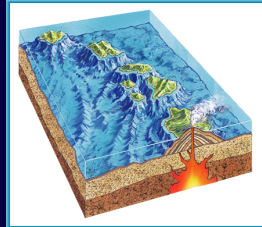
CHAPTER RESOURCES

END

Earthquakes, Volcanoes, and Plate Tectonics

3 **Hot Spots**

- The Hawaiian Islands are volcanic islands that have not formed along a plate boundary.
- Large bodies of magma, called **hot spots**, are forced upward through Earth's mantle and crust.



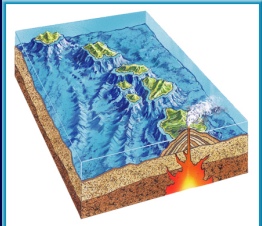
CHAPTER RESOURCES

END

Earthquakes, Volcanoes, and Plate Tectonics

3 **Hot Spots**

- Scientists suggest that this is what is occurring at a hot spot that exists under the present location of Hawaii.



CHAPTER RESOURCES

END

Earthquakes, Volcanoes, and Plate Tectonics

3 **Hot Spots**

- Volcanoes on Earth usually form along rift zones, subduction zones (where one plate sinks beneath another), or over hot spots.
- At each of these locations lava breaks through and flows out, where it piles up into layers or forms a volcanic cone.

CHAPTER RESOURCES

END

Earthquakes, Volcanoes, and Plate Tectonics

3 **Moving Plates Cause Earthquakes**

- Forces generated by locked-up plates cause strain to build up.
- Plates begin to deform until the elastic limit is passed. The breaking and elastic rebound of the deformed material produces vibrations felt as earthquakes.

CHAPTER RESOURCES

END

Earthquakes, Volcanoes, and Plate Tectonics

3 **Moving Plates Cause Earthquakes**

- Earthquakes often occur where tectonic plates come together at a convergent boundary, where tectonic plates move apart at a divergent boundary, and where tectonic plates grind past each other, called a transform boundary.

CHAPTER RESOURCES

END

Earthquakes, Volcanoes, and Plate Tectonics

**3 Earthquake Locations**

- About 80 percent of all earthquakes occur in the Pacific Ring of Fire—the same belt in which many of Earth’s volcanoes occur.



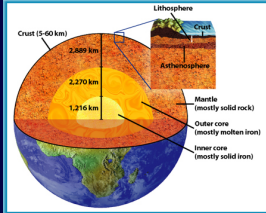
CHAPTER RESOURCES

END

Earthquakes, Volcanoes, and Plate Tectonics

**3 Earth’s Plates and Interior**

- Seismic wave speeds, and how they travel through different levels in the interior, have allowed scientists to map out the major layers of Earth.



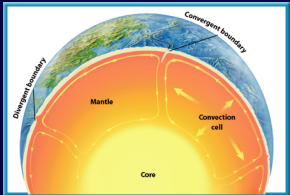
CHAPTER RESOURCES

END

Earthquakes, Volcanoes, and Plate Tectonics

**3 What is driving Earth’s plates?**

- There are several hypotheses about where all the energy comes from to power the movement of Earth’s plates.



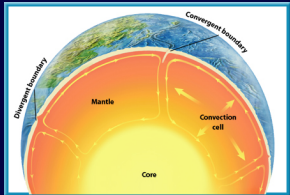
CHAPTER RESOURCES

END

Earthquakes, Volcanoes, and Plate Tectonics

**3 What is driving Earth’s plates?**

- One hypothesis suggests that convection currents inside Earth provide the mechanism for plate motion, which then produces the conditions that cause volcanoes and earthquakes.



CHAPTER RESOURCES

END

Section Check

**3 Question 1**

How does a hot spot volcano form?

**Answer**

A volcano forms above a hot spot when magma erupts through the crust and reaches the surface. Hot spot volcanoes may lie in the middle of plates far from any plate boundaries or near or on plate boundaries.

CHAPTER RESOURCES

GLE 0707.7.3

END

Section Check

**3 Question 2**

What type of eruption occurs along a diverging plate boundary?

**Answer**

Fissure eruptions often occur along a divergent plate boundary. Divergent plate boundaries create rifts or cracks between boundaries allowing magma to flow onto Earth’s surface.

CHAPTER RESOURCES

GLE 0707.7.3  
GLE 0707.7.4  
SPI 0707.7.6

END

