

Earth Science

Chapter 12 - Earthquakes

Section 1 – How and Where Earthquakes Happen

E.Q.: *Explain how Earth's structure affects seismic waves?*

STANDARDS:

SES2. Students will understand how plate tectonics creates certain geologic features, materials, and hazards.

- a. Distinguish among types of plate tectonic settings produced by plates diverging, converging, and sliding past each other.**
- b. Relate modern and ancient geologic features to each kind of plate tectonic setting.**
- c. Relate certain geologic hazards to specific plate tectonic settings.**

Objectives:

- Describe elastic rebound.**
- Compare body waves and surface waves.**
- Explain how the structure of Earth's interior affects seismic waves.**
- Explain why earthquakes generally occur at plate boundaries.**

How and Where Earthquakes Happen

earthquake a movement or trembling of the ground that is caused by a sudden release of energy when rocks along a fault move

elastic rebound the sudden return of elastically deformed rock to its undeformed shape

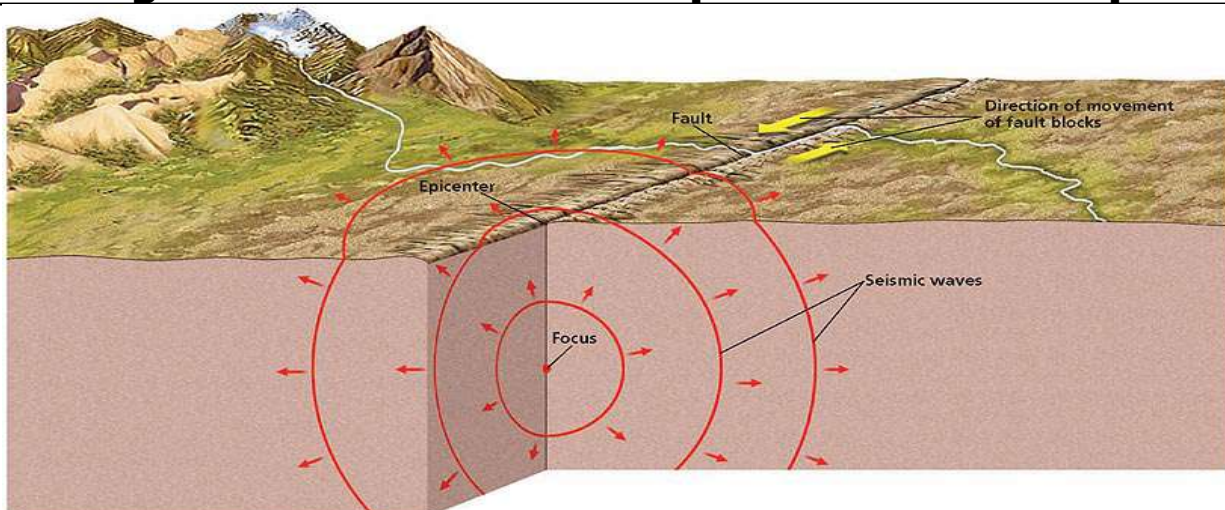
- Earthquakes occur when rocks under stress suddenly shift along a fault.**
- A *fault* is a break in a body of rock along which one block moves relative to another.**

Why Earthquakes Happen

Elastic Rebound

- Geologists think that earthquakes are the result of elastic rebound.
- In this process, the rocks on each side of a fault are moving slowly. If the fault is locked, the rock deforms, and stress in the rocks increases.
- When rocks are stressed past the point at which they can maintain their integrity, they fracture.
- The rocks then separate at their weakest point along the fault and *rebound*, or spring back to their original shape.
- **Anatomy of an Earthquake**
- **focus** the location within Earth along a fault at which the first motion of an earthquake occurs
- **epicenter** the point on Earth's surface above an earthquake's starting point, or focus
- Although the focus depths of earthquakes vary, 90% of continental earthquakes have a shallow focus.
- Earthquakes that have deep foci usually occur in subduction zones.
- Earthquakes that cause the most damage usually have shallow foci.

The diagram below shows the parts of an earthquake.



Seismic Waves

body wave - a seismic wave that travels through the body of a medium

surface wave - a seismic wave that travels along the surface of a medium and that has a stronger effect near the surface of the medium than it has in the interior

- As rocks along a fault slip into new positions, the rocks release energy in the form of vibrations called seismic waves.
- Seismic waves travel outward in all directions from the focus through the surrounding rock.
- Each type of wave travels at a different speed and causes different movements in Earth's crust.

Body Waves

- P waves and S waves are two types of body waves.
- P wave a primary wave, or compression wave; a seismic wave that causes particles of rock to move in a back-and-forth direction parallel to the direction in which the wave is traveling
- P waves are the fastest seismic waves and can travel through solids, liquids, and gases.
- The more rigid the material is, the faster the P wave travels through it.

S wave - a secondary wave, or shear wave; a seismic wave that causes particles of rock to move in a side-to-side direction perpendicular to the direction in which the wave is traveling

- S waves are the second-fastest seismic waves and can only travel through solids.

Surface Waves

- Surface waves form from motion along a shallow fault or from the conversion of energy when P waves or S waves reach Earth's surface.

- Although surface waves are the slowest-moving seismic waves, they can cause the greatest damage during an earthquake.
- *Love waves* are surface waves that cause rock to move side-to-side and perpendicular to the direction of the wave.
- *Rayleigh waves* are surface waves cause the ground to move with an elliptical, rolling motion.

Reading Check

Describe the two types of surface waves.

Rayleigh waves cause the ground to move in an elliptical, rolling motion. Love waves cause rock to move side-to-side and perpendicular to the direction the waves are traveling.

Seismic Waves and Earth's Interior

By studying the speed and direction of seismic waves, scientists can learn more about the makeup and structure of Earth's interior.

Earth's Internal Layers

- In 1909, Andrija Mohorovičić discovered that the speed of seismic waves increases abruptly at about 30 km beneath the surface of continents, where the crust and mantle meet.
- By studying seismic waves, scientists have discovered Earth's three composition layers (the *crust*, the *mantle*, and the *core*) and Earth's five structural layers (the *lithosphere*, the *asthenosphere*, the *mesosphere*, the *outer core*, and the *inner core*).

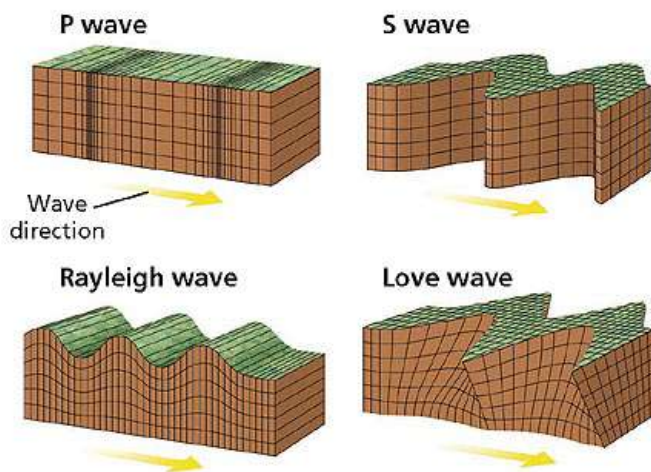
Shadow Zones

shadow zone - an area on Earth's surface where no direct seismic waves from a particular earthquake can be detected

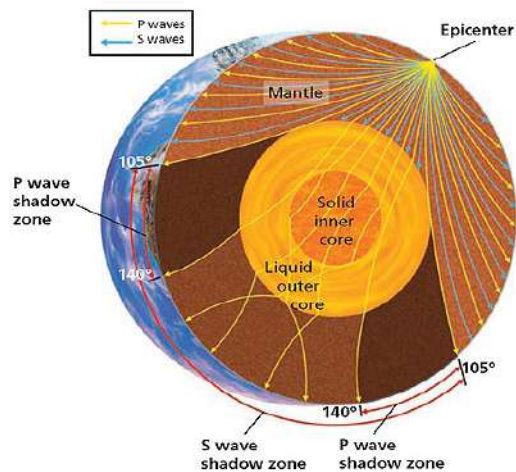
- **Shadow zones exist because the materials that make up Earth's interior are not uniform in rigidity.**
- **When seismic waves travel through materials of different rigidity, they change in both speed and direction.**
- **S waves do not reach the S wave shadow zone because they cannot pass through the liquid outer core.**
- **P waves do not reach the P wave shadow zone because of the way the P waves bend and they travel through Earth's interior.**

The diagram below shows how seismic waves interact with Earth's interior.

Types of Seismic Waves



Earth's Interior



Reading Check

What causes the speed of a seismic wave to change?

The speed of seismic waves changes as they pass through different layers of Earth.

Earthquakes and Plate Tectonics

- **Earthquakes are the result of stresses in Earth's lithosphere.**
- **Most earthquakes occur at or near tectonic plate boundaries, where stress on the rock is greatest.**

- The three main types of tectonic settings are convergent oceanic environments, divergent oceanic environments, and continental environments.

Convergent Oceanic Environments

- At convergent plate boundaries, plates move toward each other and collide.
- The denser plate moves down, or *subducts*, into the asthenosphere under the other plate, causing earthquakes.
- Convergent oceanic boundaries can occur between two oceanic plate or between one oceanic plate and one continental plate.

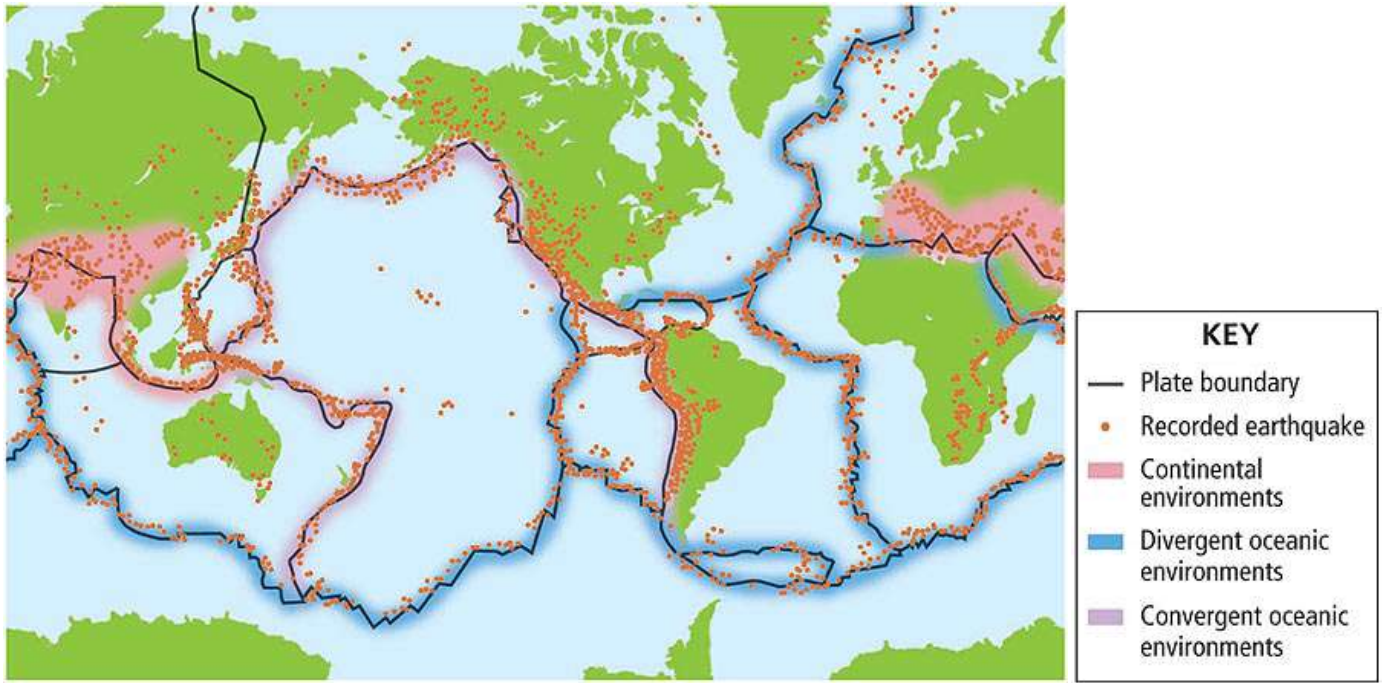
Divergent Oceanic Environments

- At the divergent plate boundaries that make up the mid-ocean ridges, plates are moving away from each other.
- Earthquakes occur along mid-ocean ridges because oceanic lithosphere is pulling away from both sides of the ridge.

Continental Environments

- Earthquakes also occur at locations where two continental plates converge, diverge, or move horizontally in opposite directions.
- As the continental plates interact, the rock surrounding the boundary experiences stress, which causes earthquakes.

The diagram below shows the different tectonic boundaries where earthquakes occur.



Fault Zones

fault zone - a region of numerous, closely spaced faults

- **Fault zones form at plate boundaries because of the intense stress that results when plates separate, collide, subduct, or slide past each other.**
- **When enough stress builds up, movement occurs along one or more of the individual faults in the fault zone and sometimes causes major earthquakes.**

Earthquakes Away from Plate Boundaries

- **Not all earthquakes result from movement along plate boundaries.**
- **In 1811 and 1812 the most widely felt series of earthquakes in United States history occurred in the middle of the continent near New Madrid, Missouri.**
- **In the late 1970s scientists discovered an ancient fault zone deep within the crust of the Mississippi River region.**