

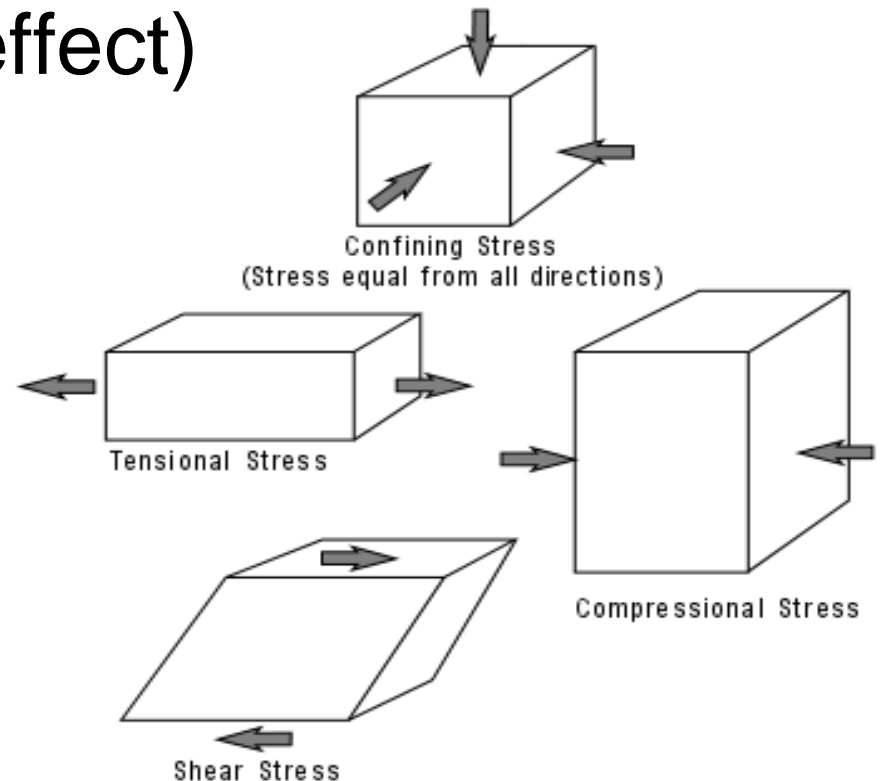
Section 19.1 - Forces Within Earth



8th Grade Earth & Space Science - Class Notes

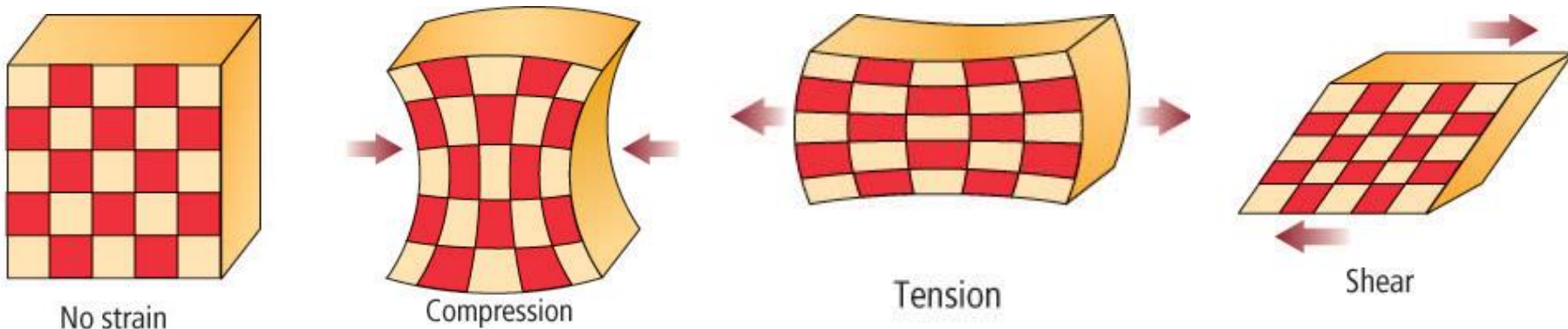
Stress and Strain

- **Stress** - is the total force acting on crustal rocks per unit of area (cause)
- **Strain** – deformation of materials in response to stress (effect)



Types of Strain

- **Compression** causes a material to shorten.
- **Tension** causes a material to lengthen.
- **Shear** causes distortion of a material.

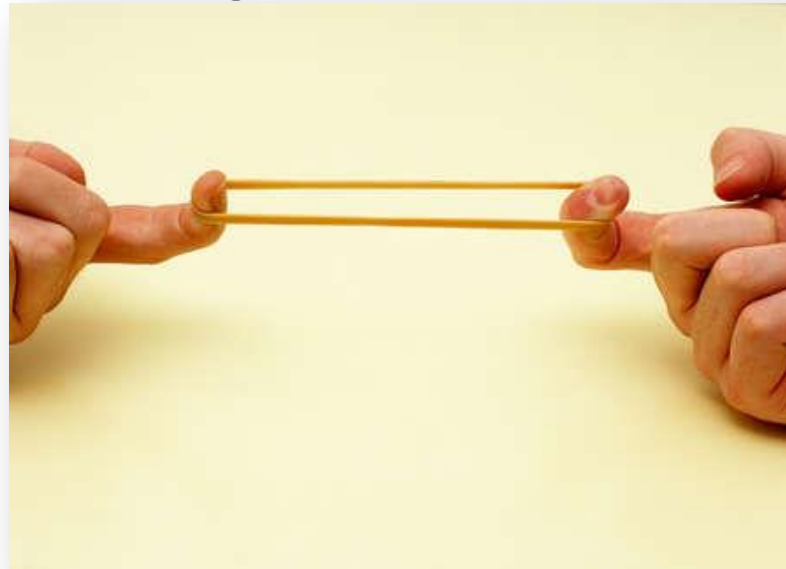


Results of Stress & Strain

- Rocks fracture when stress and strain reach a critical point.
- At these breaks rocks can move releasing the energy built up as a result of stress.
- Earthquakes are the result of this movement and release of energy.

Elastic Deformation

- **Elastic deformation** is caused under conditions of **low stress** when a material is compressed, bent, or stretched.
- When the stress is removed, material returns to its original shape.

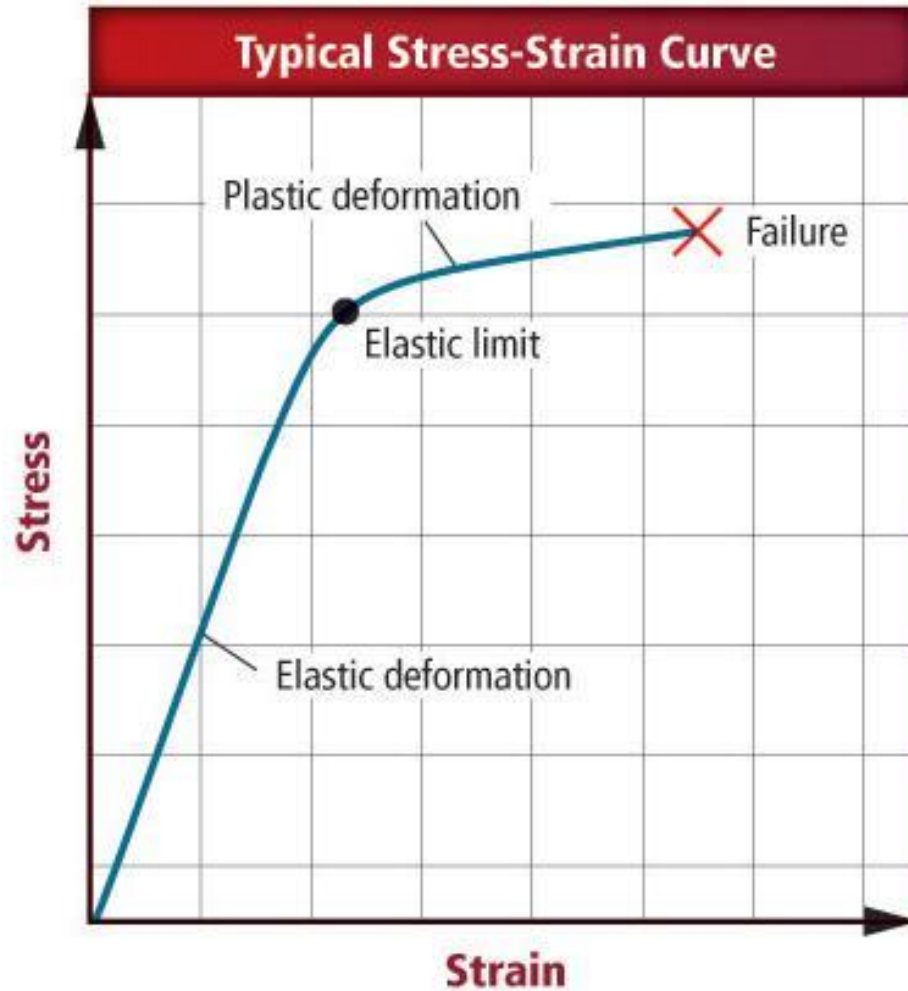


Plastic Deformation

- When stress builds up past a certain point, called the *elastic limit*, rocks undergo **plastic deformation**.
- This type of strain produces permanent deformation.



The Stress-Strain Curve

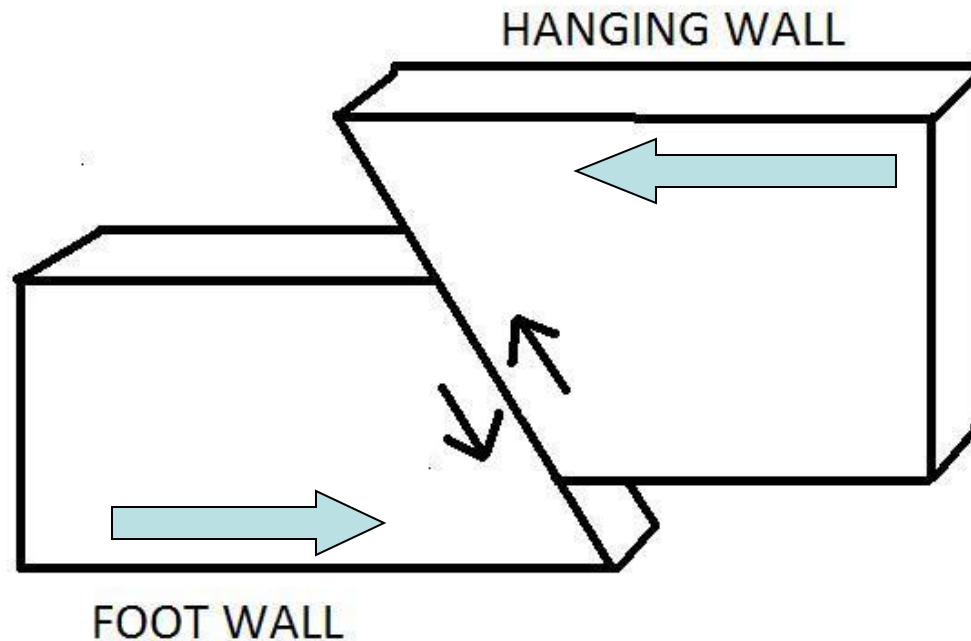


Faults

- Crustal rocks fail when stresses exceed the strength of the rocks.
- The resulting movement occurs along a weak region in the crustal rock called a fault.
- **Fault** - any fracture or system of fractures along which Earth moves

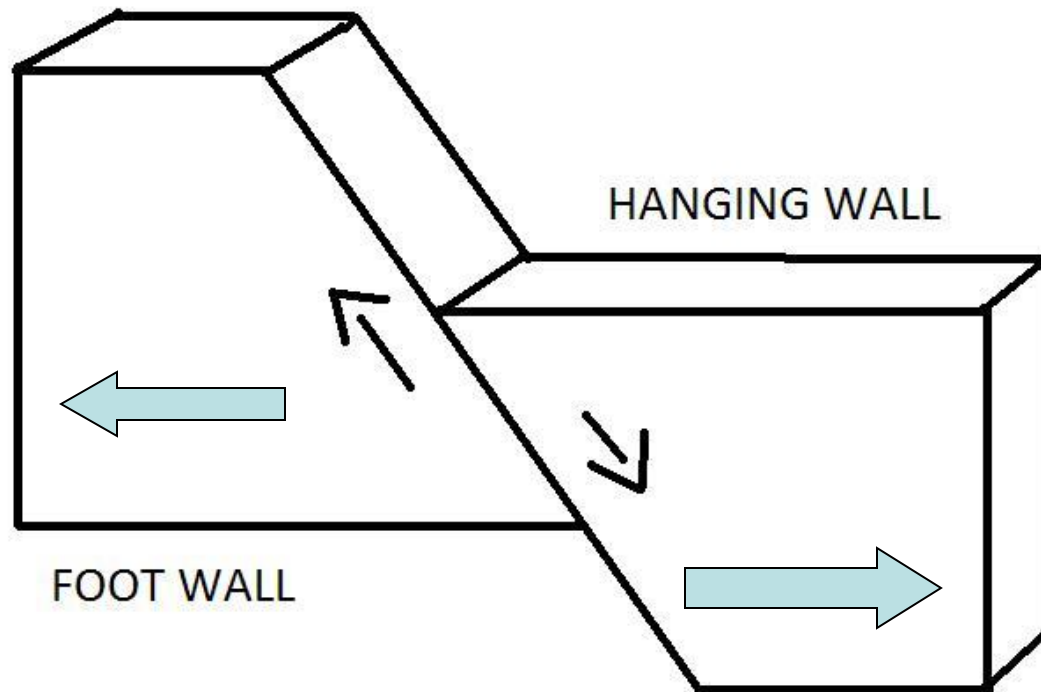
Reverse Faults

- **Reverse faults** form as a result of horizontal and vertical compression that squeezes rock and creates a shortening of the crust.



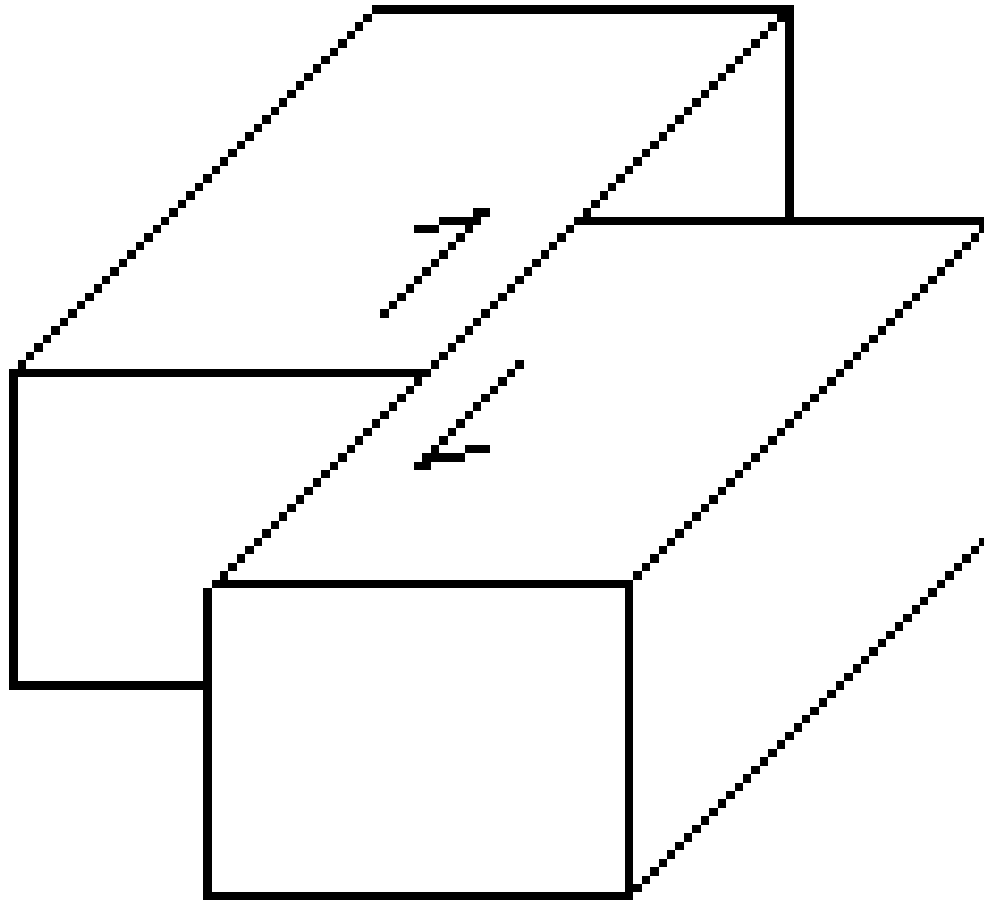
Normal Fault

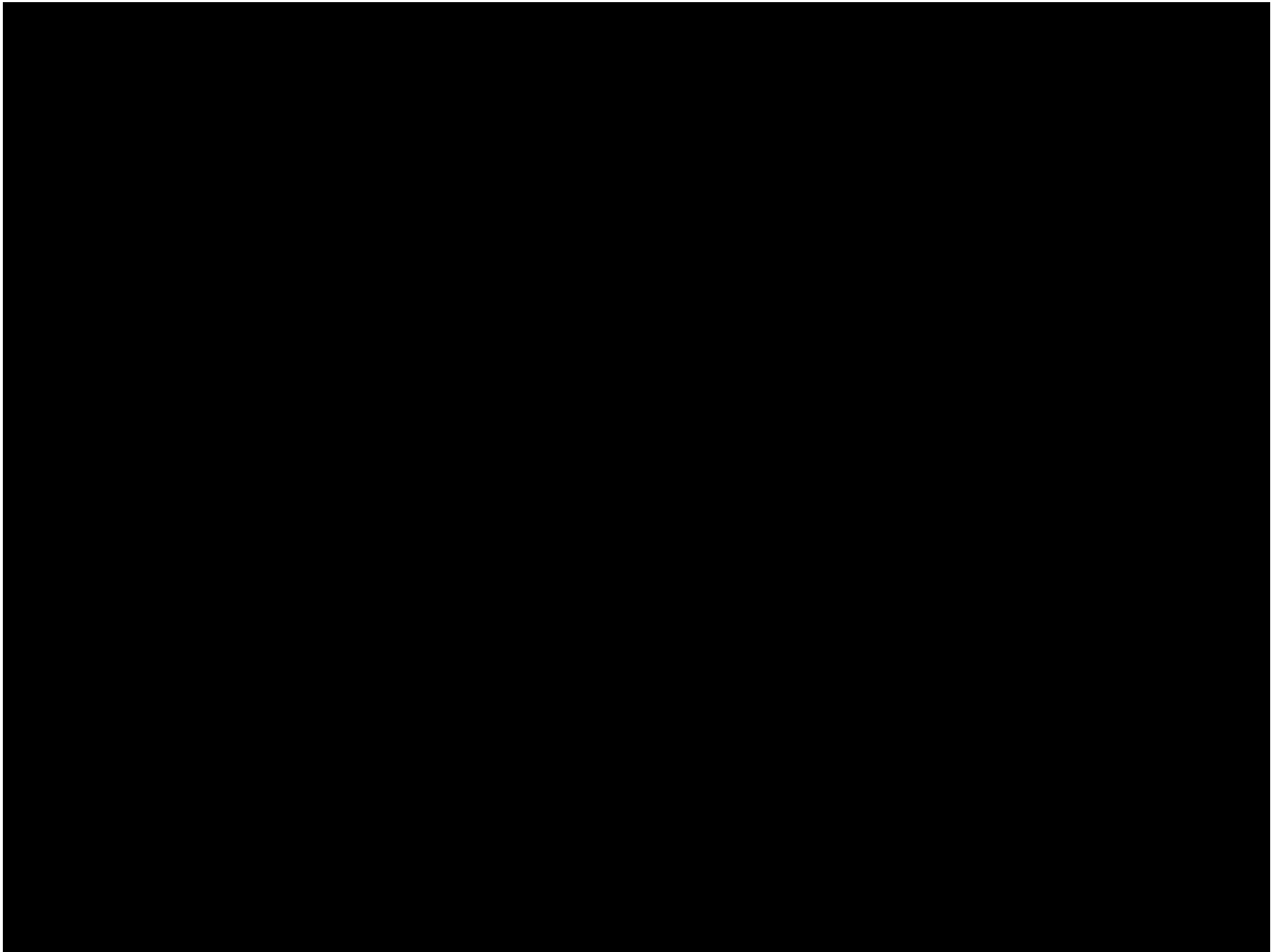
- The horizontal movement pulls rock apart (tension) and stretches the crust.



Strike-Slip Fault

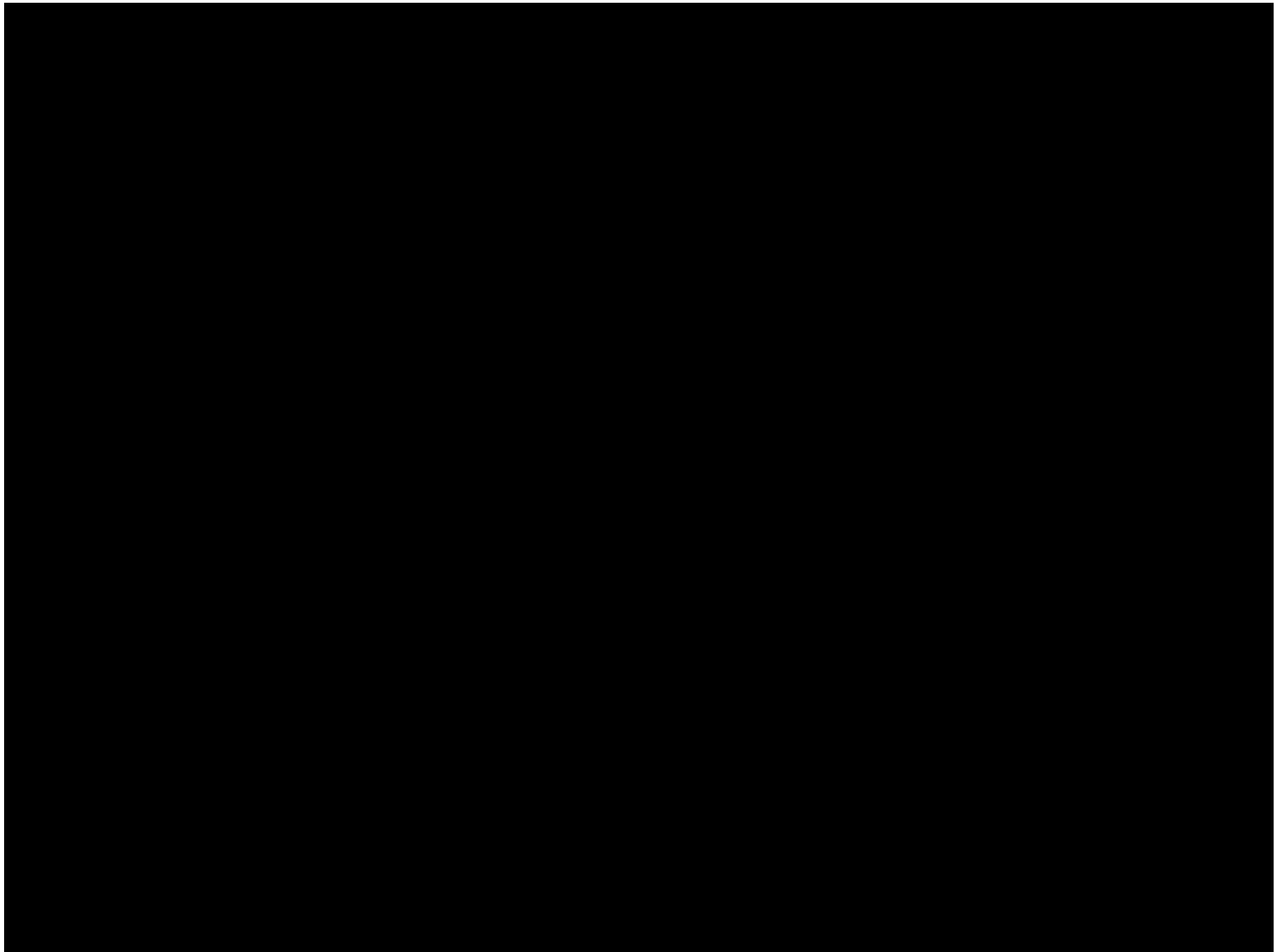
- Strike-slip faults are caused by horizontal shear.





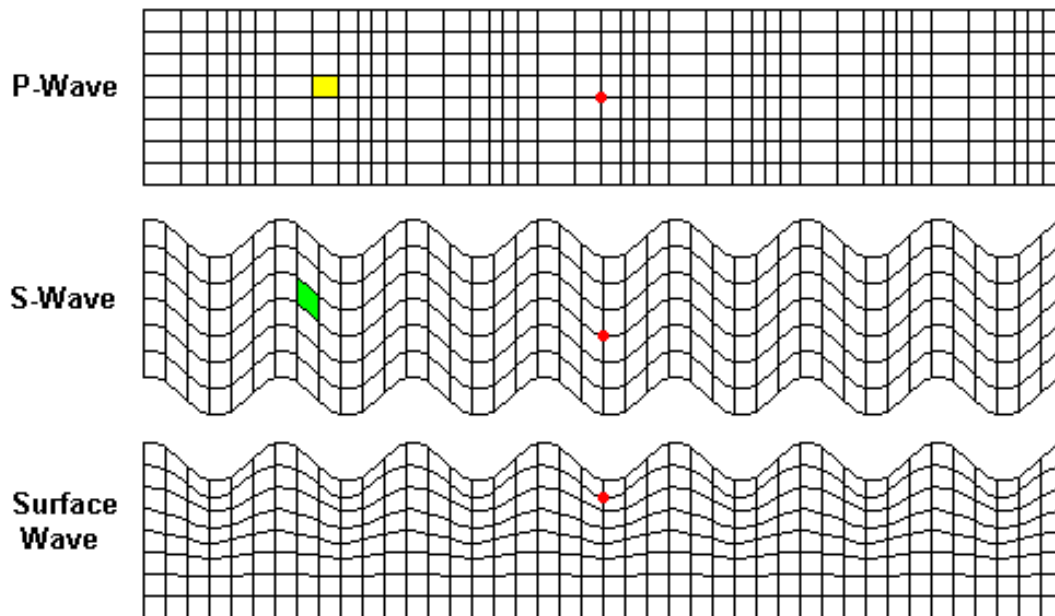
Earthquake Waves

- **Seismic waves** – vibrations of the ground produced during an earthquake
- Every earthquake has 3 types:
 - Primary (P) waves
 - Secondary (S) waves
 - Surface waves



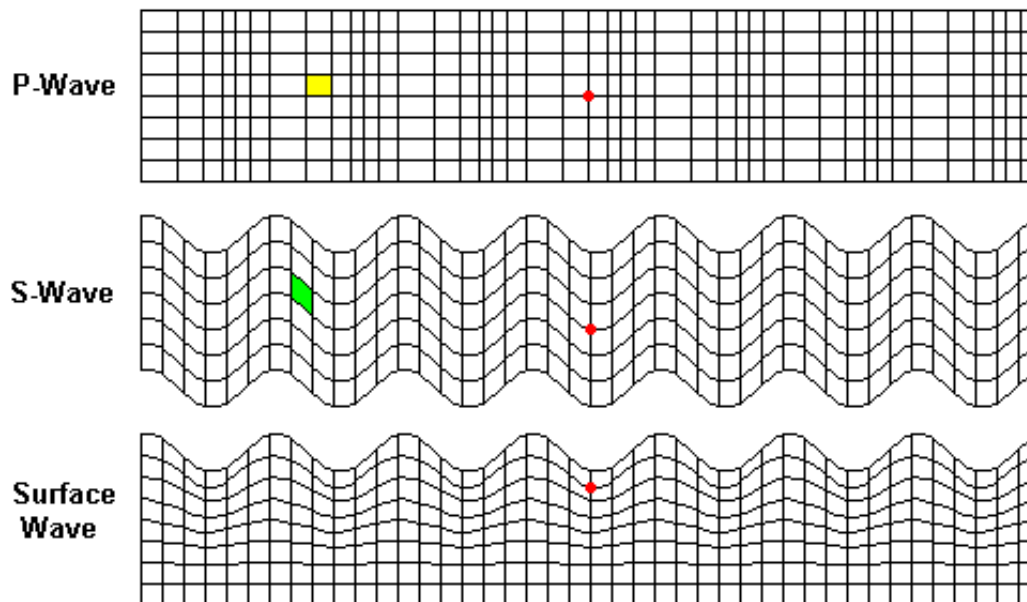
Primary (P) Waves

- First set of waves to be felt
- Squeeze and push rocks in the direction along which the waves are traveling
- Think of a coil being pushed in and out



Secondary (S) Waves

- Slower than (P) waves; second set of waves to be felt
- Their motion causes rocks to move at right angles in relation to the direction of the waves
- Comparison – jump rope

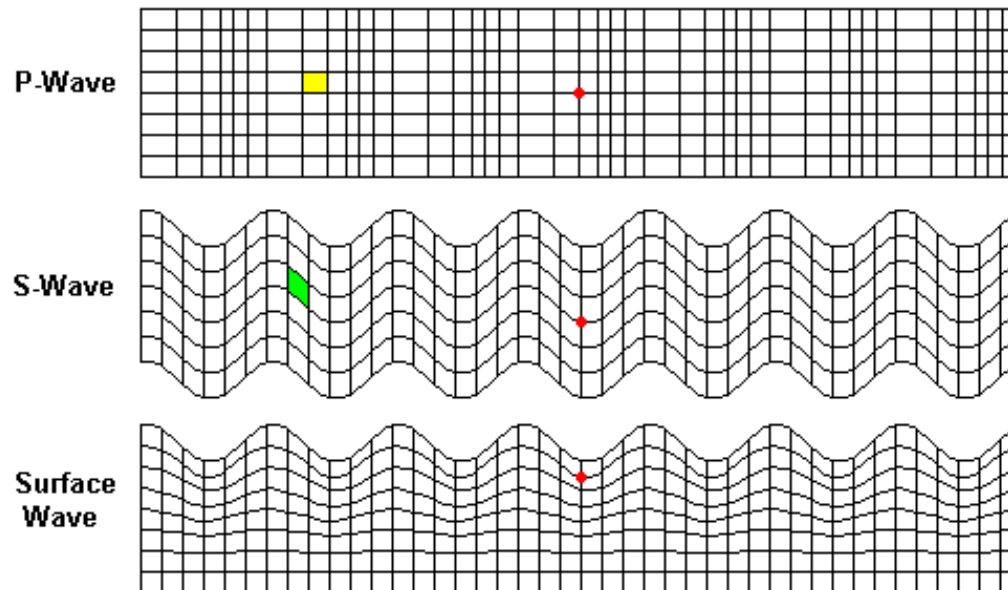


P Waves & S Waves

- Both P waves & S waves pass through Earth's interior.
- For this reason, they are also called *body waves*.
- We will discuss this further in the next section.

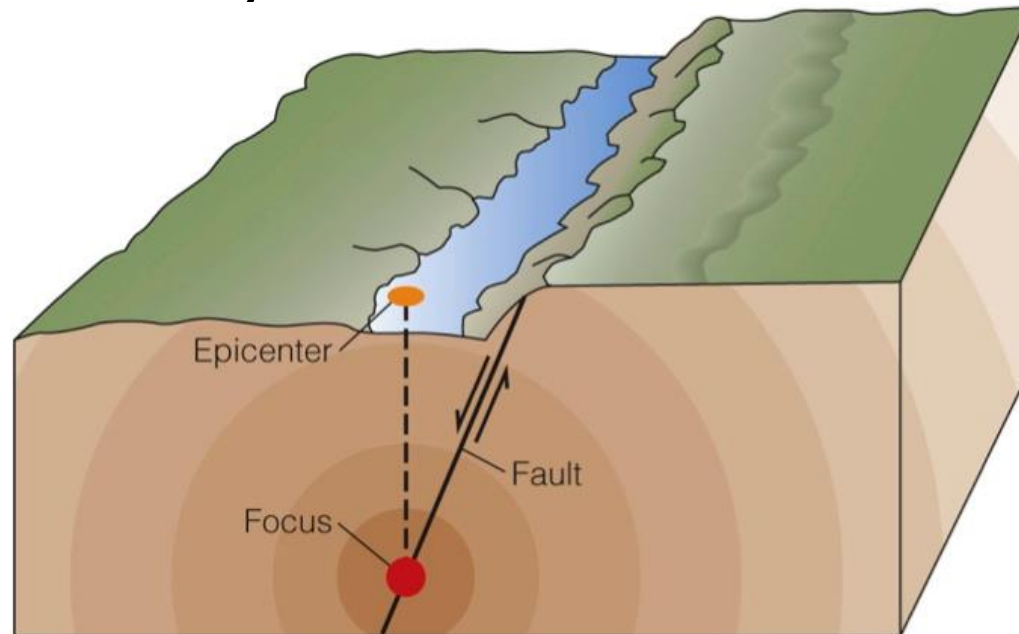
Surface Waves

- Last set of waves to be felt
- Travel along the Earth's surface
- Can cause rock particles to move both up and down and side to side
- Last the longest and cause the most destruction

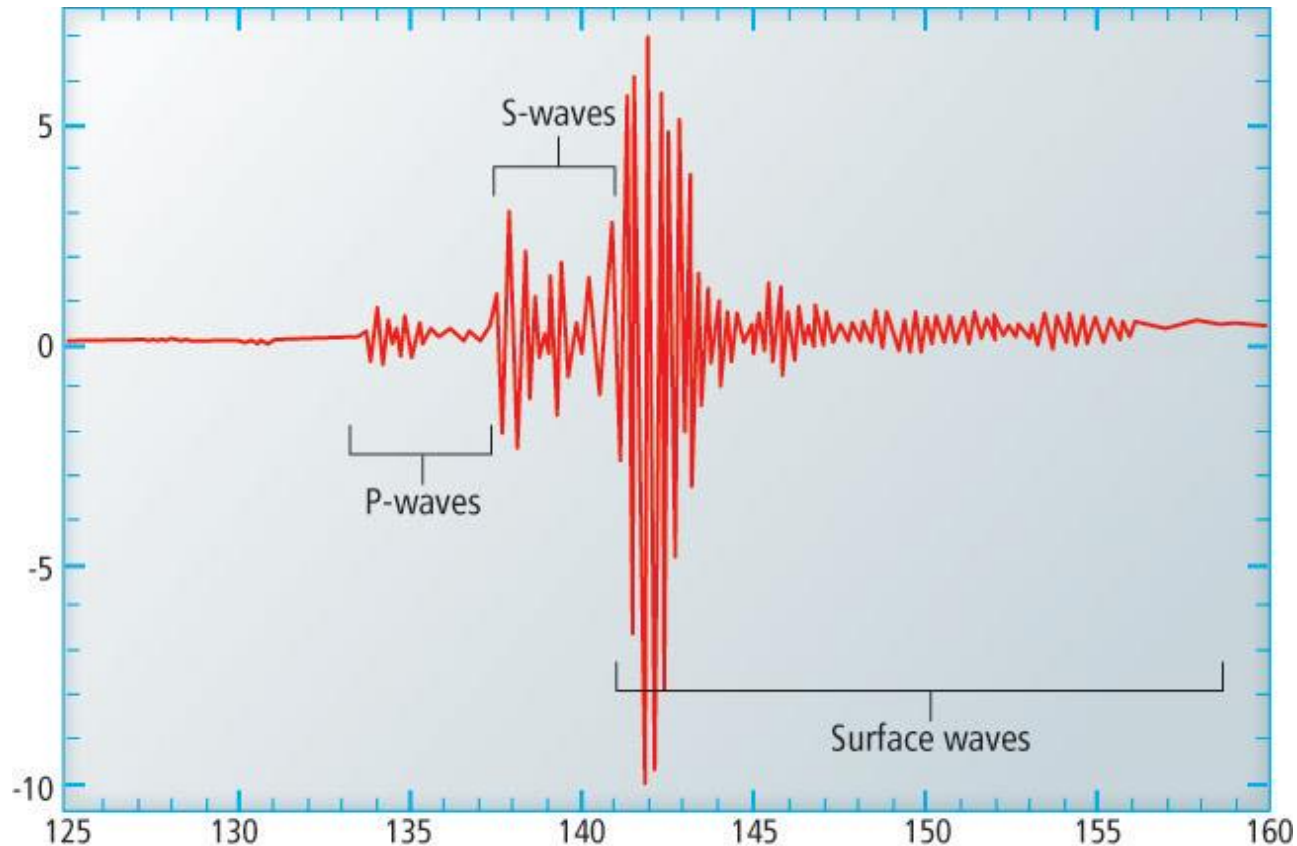


Generation of Seismic Waves

- **Focus** – point of failure where the waves originate
- **Epicenter** – the point on the Earth's surface directly above the focus



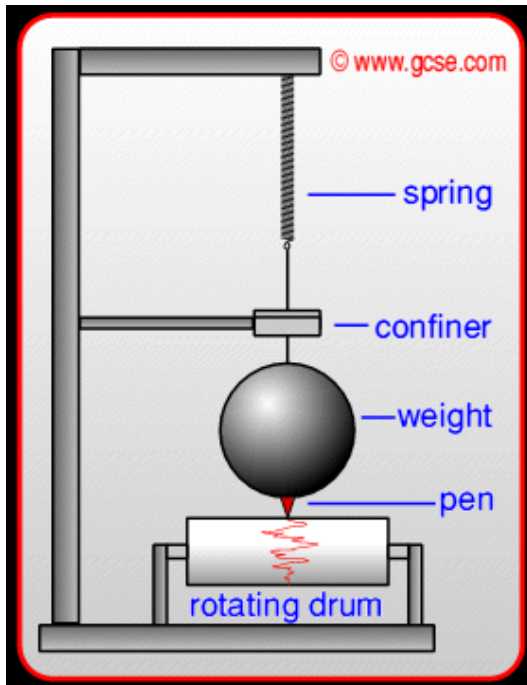
Section 19.2– Seismic Waves & the Earth's Interior



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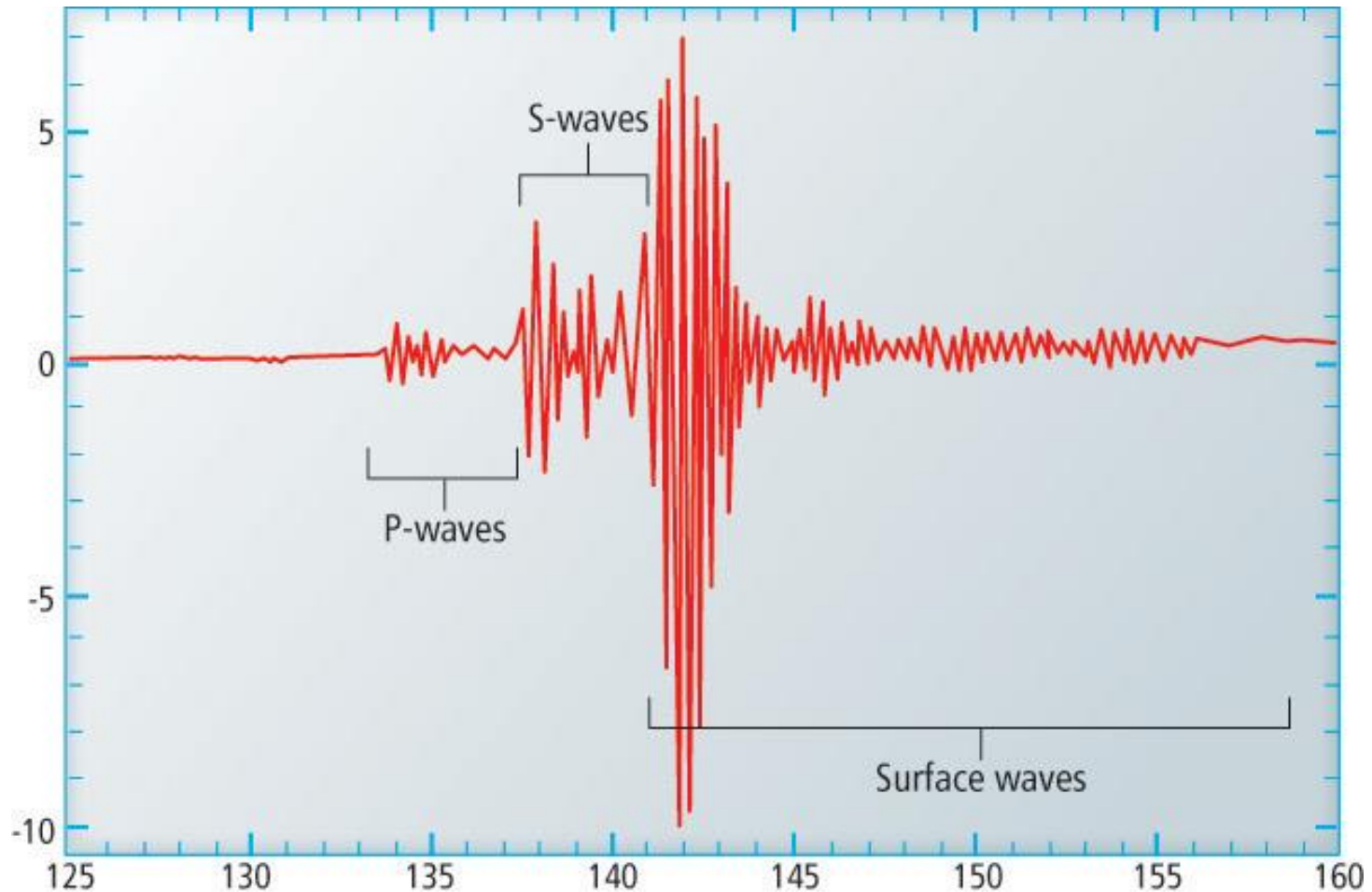
Seismometers

- **Seismometer** – instrument that detects seismic vibrations
 - Measures vertical and horizontal motion during an earthquake



Seismograms

- **Seismogram** – record produced by a seismometer

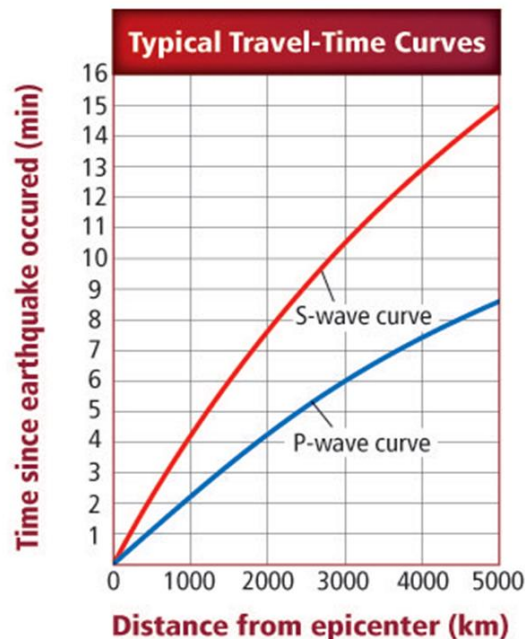


Travel Time Curves

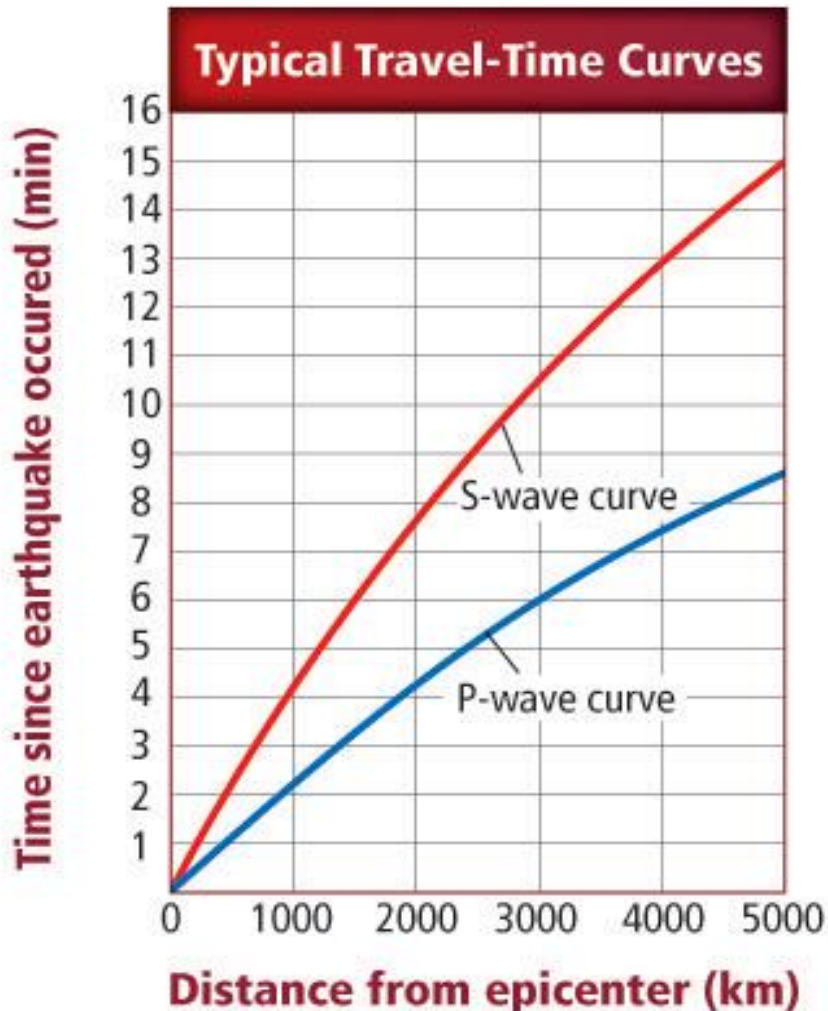
- *Travel-time curves* provide the average time it takes for P- and S-waves to reach seismic stations located at different distances from an earthquake's epicenter.
- P-waves and S-waves recorded on seismograms from more distant facilities are farther apart than waves recorded on seismograms at stations closer to the epicenter.

Travel Time Curves

- The separation of seismic waves on seismograms can be used to determine the distance from the epicenter of an earthquake to the seismic facility that recorded the seismogram.
 - The further away the epicenter the more separated the waves will be on a seismogram.



Travel Time Curves



1. How long does it take P-waves to travel to a seismometer 2000 km away?
2. How long does it take for S-waves to travel the same distance?

Locating an Earthquake

- To locate the epicenter of an earthquake –
- scientists identify the seismic stations on a map
 - draw a circle with the radius of distance to the epicenter from each station.
 - point where all the circles intersect is the epicenter.

Locating an Earthquake



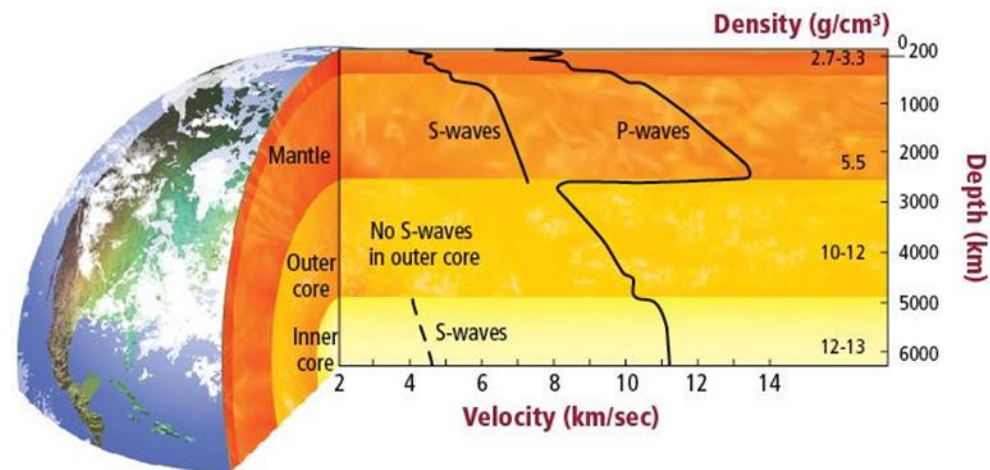
- You must have 3 stations to determine an epicenter.
- Any two stations will overlap only at two points.

The Earth's Internal Structure

- Seismic waves change speed and direction when at the boundaries between different materials.
- As P-waves and S-waves initially travel through the mantle, they follow fairly direct paths. When P-waves strike the core, they are refracted, which means they bend.

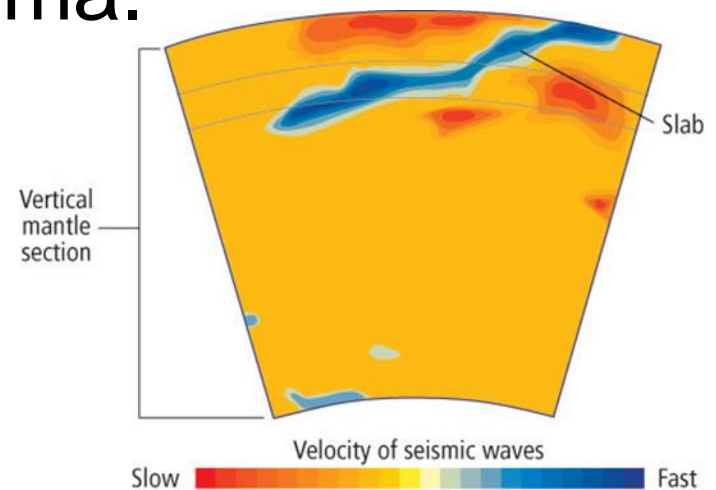
The Earth's Internal Structure

- The back-and-forth motion of S-waves does not travel through liquid.
- The data collected for the paths and travel times of the waves inside Earth led to the current understanding that Earth has an outer core that is liquid and an inner core that is solid.

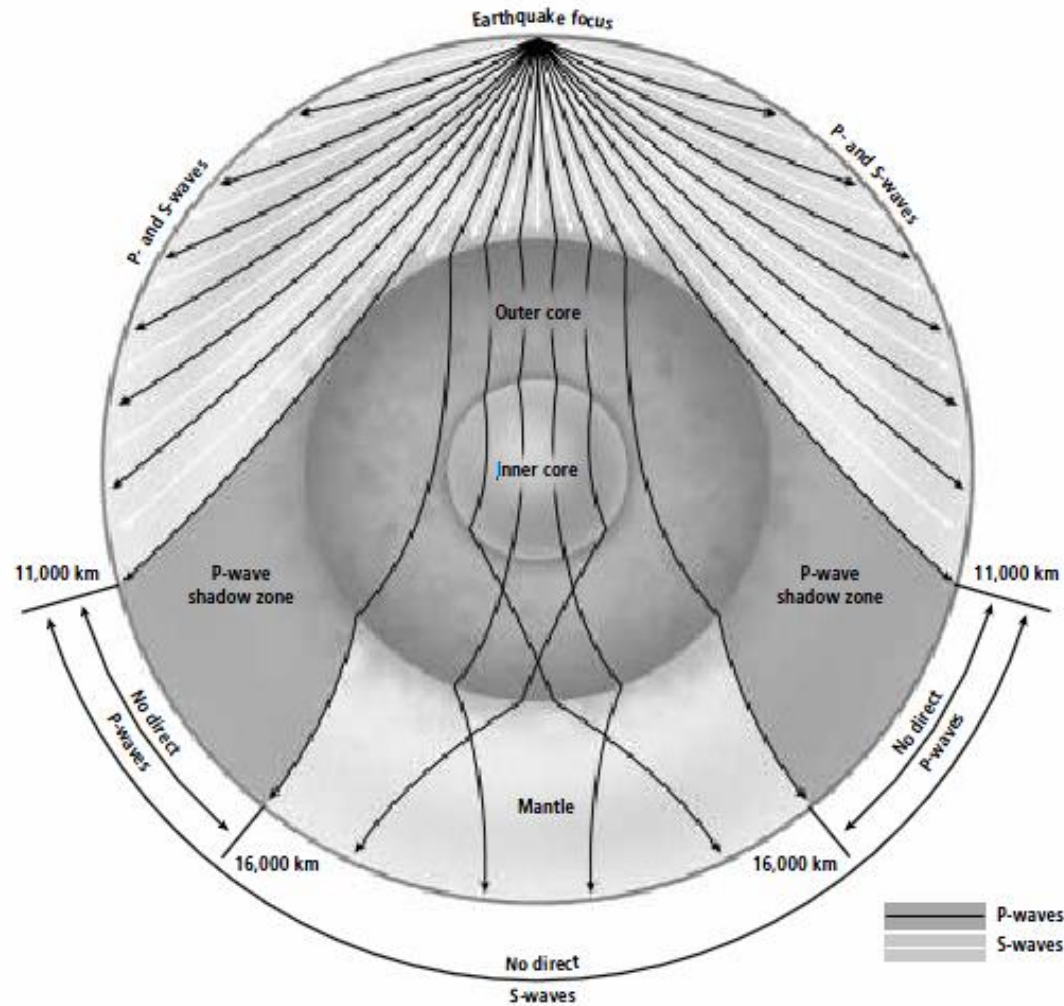


Imaging the Earth's Interior

- Speed of waves decreases as temperature increases.
 - Waves travel slower in hotter areas and faster in cooler areas.
- Seismic waves can be used to locate slabs of crust and plumes of magma.

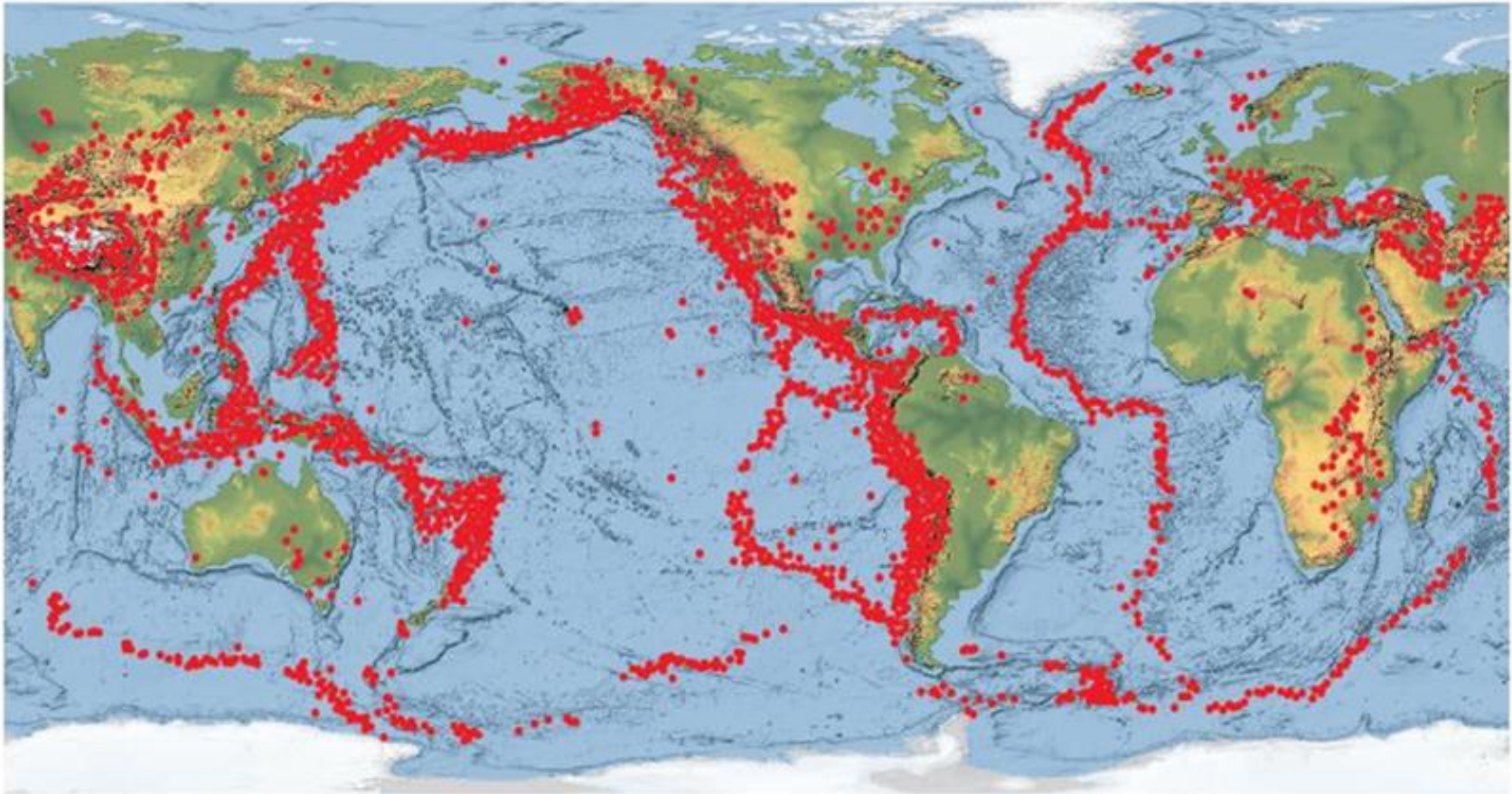


Visualizing Seismic Waves



Section 19.3 – Measuring & Locating Earthquakes

Global Earthquake Epicenter Locations



8th Grade Earth & Space Science Class
Notes

Earthquake Magnitude & Intensity

- **Richter scale** – measures the *magnitude* (energy) of an earthquake.
 - Determined by the *amplitude* (height) of the seismic wave
 - Each number on the Richter scale corresponds to an *amplitude* increase of 10x
 - i.e. – a magnitude 8 is 10X larger than a magnitude 7
 - Each increase in magnitude corresponds to a 32x increase in *energy*

Earthquake Magnitude & Intensity

- **Moment magnitude scale** – measures the energy released by an earthquake, taking into account the size of the fault rupture, the amount of movement along the fault, and the rocks' stiffness
- Used most often by seismologists
- This is what is often reported by news outlets

Earthquake Magnitude & Intensity

- **Modified Mercalli** – measures the intensity of the earthquake by the type and amount of damage it causes.

Modified Mercalli Scale

- I.** Not felt.
- II.** Felt by persons at rest, on upper floors, or favorably placed.
- III.** Felt indoors. Vibration like passing of light trucks.
- IV.** Vibration like passing of heavy trucks.
- V.** Felt outdoors. Small unstable objects displaced or upset.
- VI.** Felt by all. Furniture moved. Weak plaster/masonry cracks.
- VII.** Difficult to stand. Damage to masonry and chimneys.
- VIII.** Partial collapse of masonry. Frame houses moved.
- IX.** Masonry seriously damaged or destroyed.
- X.** Many buildings and bridges destroyed.
- XI.** Rails bent greatly. Pipelines severely damaged.
- XII.** Damage nearly total.

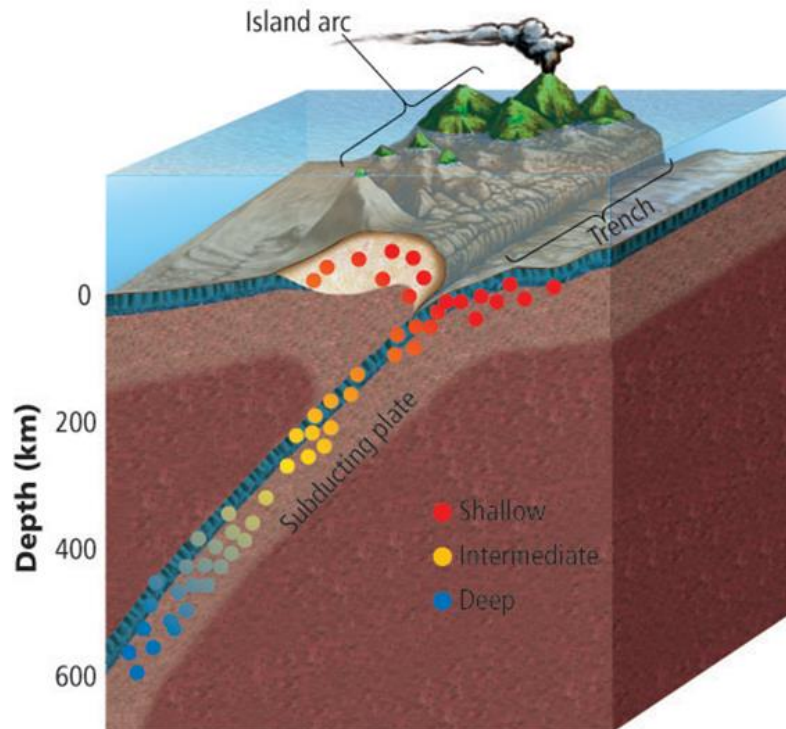
Earthquake Intensity

- The intensity of an earthquake depends primarily on the amplitude of the surface waves generated.
- Intensity is highest closest to the epicenter and decreases as you travel further from the epicenter.



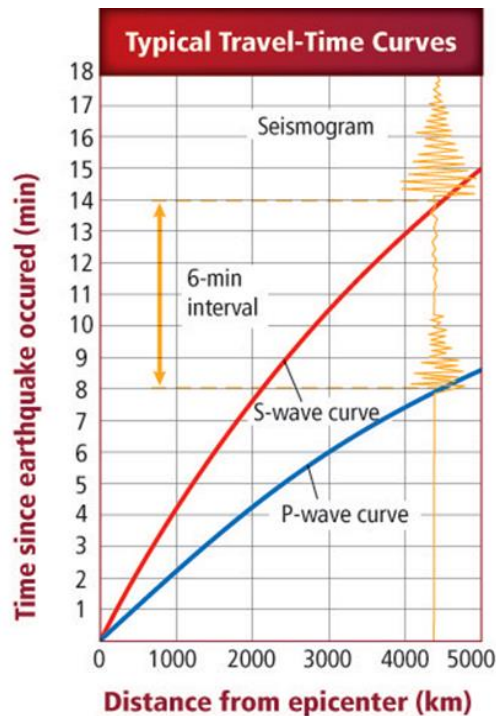
Depth of Focus

- Earthquakes are classified as shallow, intermediate, or deep, depending on the location of the focus.
- Shallow-focus earthquakes are the most damaging.



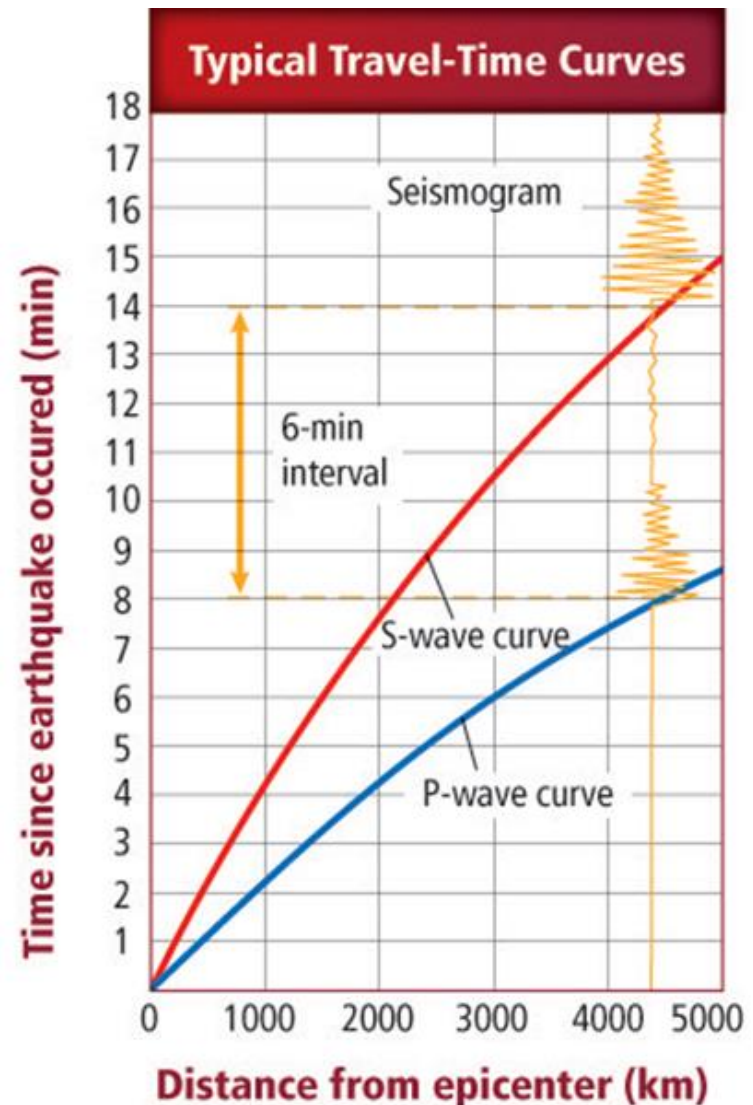
Locating an Earthquake

- An earthquake's epicenter's location, as well as the time of occurrence, can be determined using seismograms and travel-time curves.



Locating an Earthquake – Distance to an Earthquake

The distance to an earthquake's epicenter can be determined by measuring the separation on any seismogram and identifying that same separation time on the travel-time graph.



Locating an Earthquake – Distance to an Earthquake

- Scientists identify the seismic stations on a map, and draw a circle with the radius of distance to the epicenter from each station.
- The point where all the circles intersect is the epicenter.



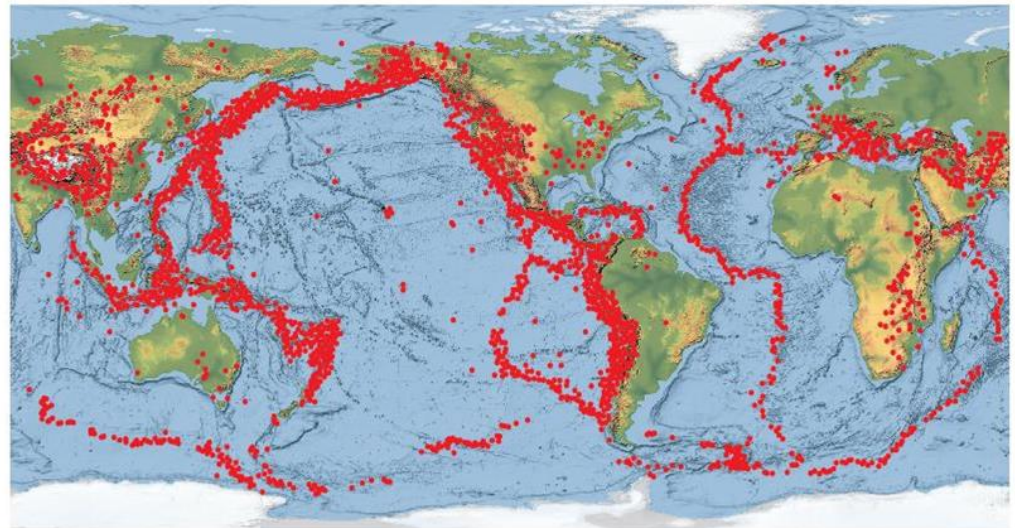
Locating an Earthquake – Time of an Earthquake

- Seismologists can use a seismogram to gain information about the exact time that an earthquake occurred at the focus.
- The time can be determined by using a table similar to a travel-time graph.

Seismic Belts

- The majority of the world's earthquakes occur along narrow seismic belts that separate large regions with little or no seismic activity.
- The locations of most earthquakes correspond closely with tectonic plate boundaries.

Global Earthquake Epicenter Locations



Section 19.4 – Earthquakes & Society



8th Grade Earth & Space Science - Class Notes

Earthquake Hazards

- *Earthquake hazards* are factors that determine the severity of damage produced by an earthquake.
- Identifying earthquake hazards in an area can sometimes help to prevent some of the damage and loss of life.

Structural Failure

- *Pancaking* - shaking causes a building's supporting walls to collapse and the upper floors to fall one on top of the other like a stack of pancakes.
- If the shaking caused by an earthquake has the same frequency of vibration as the natural sway of buildings of certain heights, those buildings will sway the most during the earthquake.
- Shorter and taller buildings are less likely to be affected.

Land & Soil Failure

- In sloping areas, earthquakes can trigger massive landslides.
- In areas with sand that is nearly saturated with water, seismic vibrations can cause the ground to behave like a liquid in a phenomenon called *soil liquefaction*.
 - can cause trees and houses to fall over or to sink into the ground and underground pipes and tanks to rise to the surface

Tsunami

- Another type of earthquake hazard is a *tsunami*—a large ocean wave generated by vertical motions of the seafloor during an earthquake.

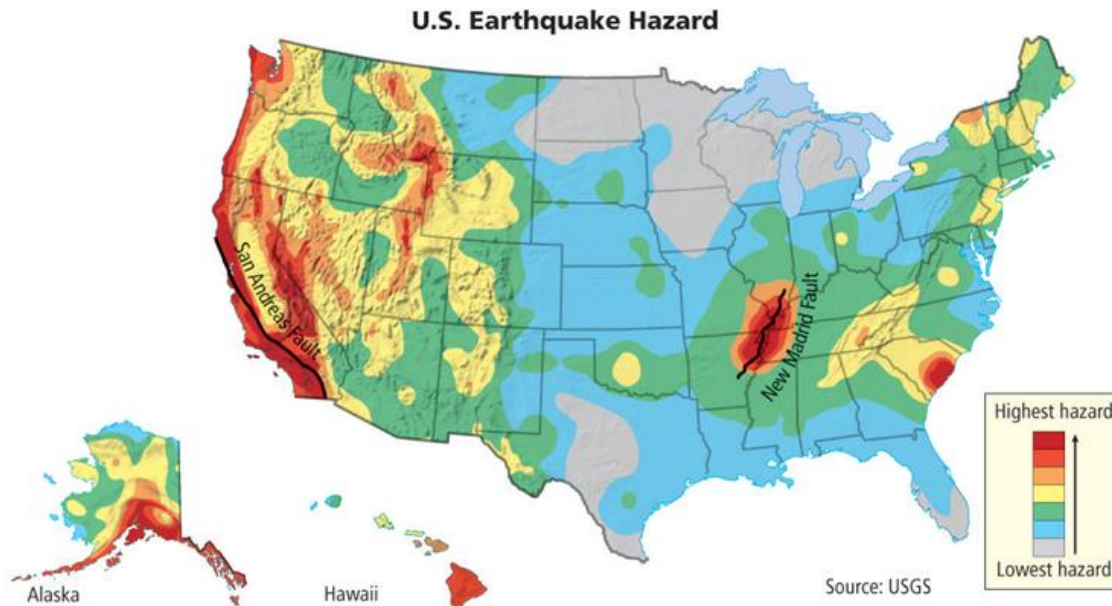


Forecasting Earthquakes

- There is currently no completely reliable way to forecast the exact time and location of the next earthquake.
- The probability of an earthquake's occurrence is based on two factors
 - the history of earthquakes in an area
 - rate at which strain builds up in the rocks

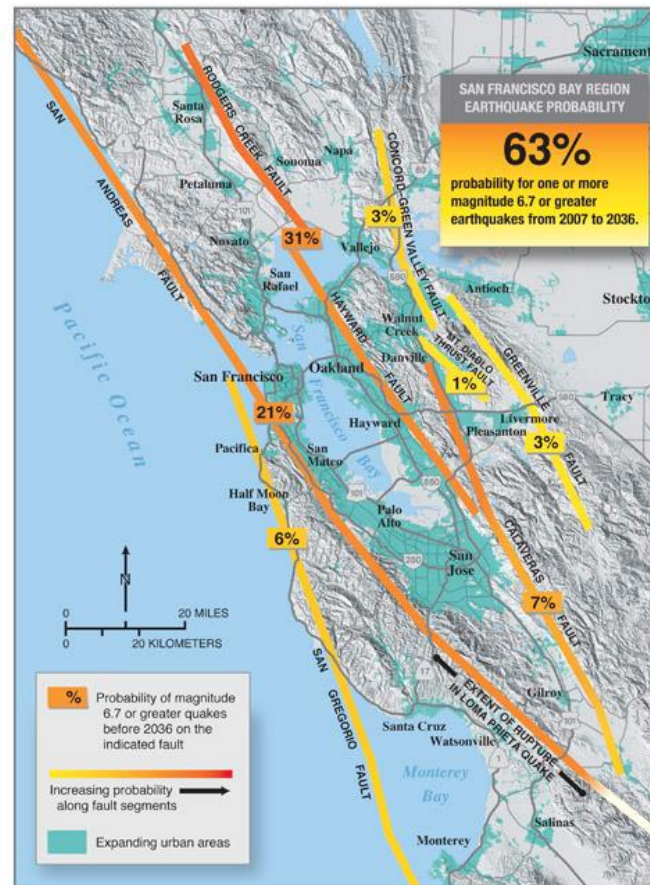
Seismic Risk

- The probability of earthquakes in seismic belts is much greater than elsewhere on Earth.
- The history of an area's seismic activity can be used to generate *seismic-risk maps*.



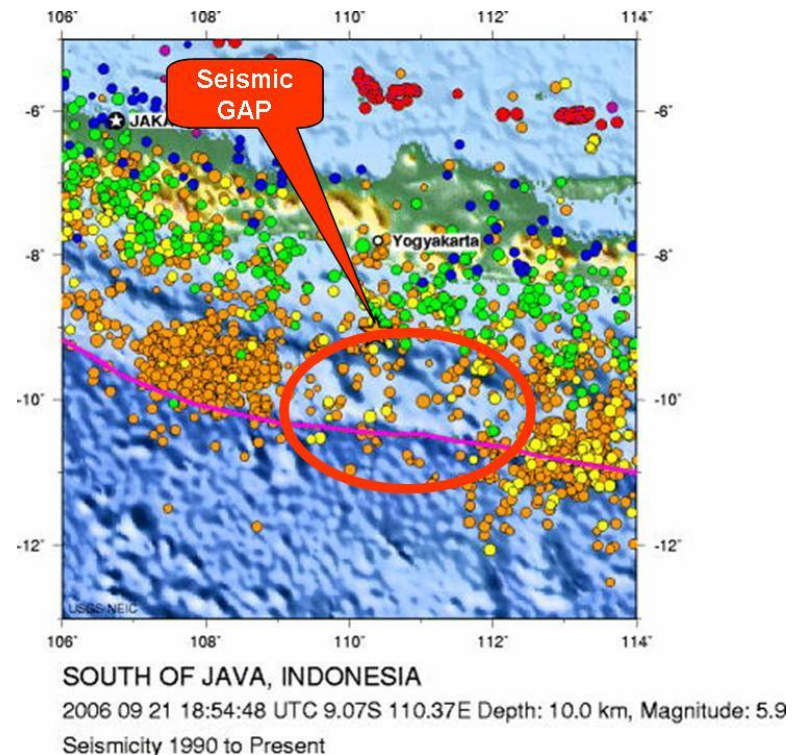
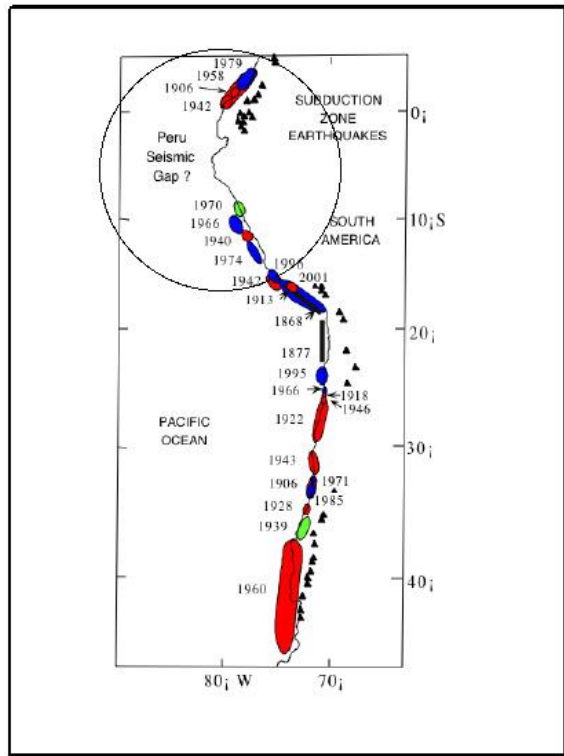
Reoccurrence Rates

- Earthquake-recurrence rates along a fault can indicate whether the fault ruptures at regular intervals to generate similar earthquakes



Seismic Gaps

- *Seismic gaps* are sections located along faults that are known to be active, but which have not experienced significant earthquakes for a long period of time.



Stress Accumulation

- The stress accumulated in a particular part of a fault, together with the amount of stress released during the last earthquake in a particular part of the fault, can be used to develop a stress-accumulation map.

