Earthquakes

Photo credit: USGS

Pancaked Building - 1985 Mexico City

B

Photo by M. Celebi, U.S. Geological Survey

Earthquake

An earthquake is the motion or trembling of the ground produced by sudden displacement of rock in the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, and collapse of caverns.

Structural failure #1

Northridge, California Earthquake
January 17, 1994
Magnitude 6.7

Photo Credit: J. Dewey,
U.S. Geological Survey

Structural failure #2

Loma Prieta earthquake,
October 17, 1989
Oakland, California
Magnitude: 6.9

Photo Credit: H.G. Wilshire,
U.S. Geological Survey

Structural failure #3

Santa Monica Freeway

Northridge earthquake,

January 17, 1994
Magnitude 6.7

Photo credit: M. Celebi,
U.S. Geological Survey

Structural failure #4

Armenian Earthquake December 7, 1988

Spitak, Armenia

Magnitude 6.9

Photo Credit: C.J. Langer,
U.S. Geological Survey

Structural failure #5

San Francisco, CA, October 18, 1989

Loma Prieta earthquake

Magnitude 6.9

Photo Credit: D. Perkins,
U.S. Geological Survey

Structural failure #6

Izmit (Kocaeli) earthquake, August 17, 1999
Izmit, Turkey
Magnitude 7.4

Photo Credit: National Geophysical Data Center

Landshift #8

Motagua, Guatemala

February 4, 1976

Magnitude 7.5

Photo Credit: U.S. Geological Survey

Landshift #9

Government Hill School, March 27, 1964

Anchorage, Alaska

Magnitude 9.2

Photo Credit:
NOAA/NGDC

Landslide #10

El Salvador

January 13, 2001

Magnitude 7.6

Photo Credit: USGS

Landslide #11

Puget Sound, Washington

May 2, 1996

Magnitude 5.3

Photo Credit: USGS

Landslide #12

Seattle, Washington
April 29, 1965
Magnitude 6.5

Photo Credit: University of California, Berkeley

Landslide #13

Alaska Earthquake
March 27, 1964
Magnitude 9.2

Photo Credit: U.S. Geological Survey, Menlo Park, CA

Liquefaction #14

Niigata, Japan
June 16, 1964
Magnitude 7.4

Photo Credit: National Geophysical Data Center

Resulting fires #15

Great Alaska Earthquake
March 28, 1964
Valdez, Alaska
Magnitude 8.4

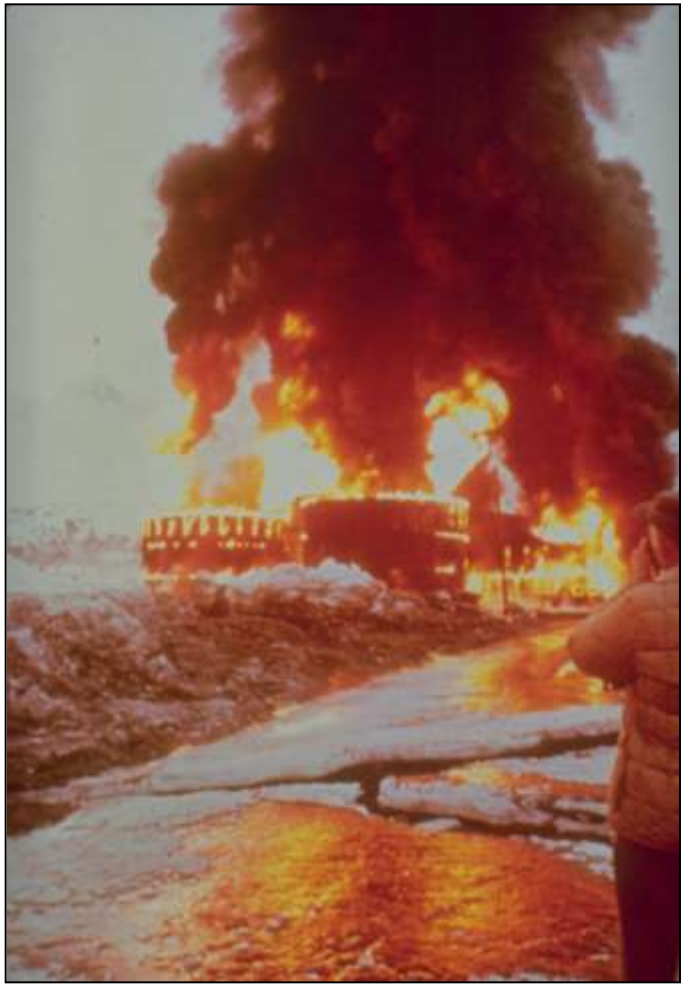


Photo Credit: EERI,
Slides on Learning from Earthquakes, Set IV

Resulting tsunami #16

Alaska Earthquake
March 28, 1964
Whittier, Alaska
Magnitude 9.2

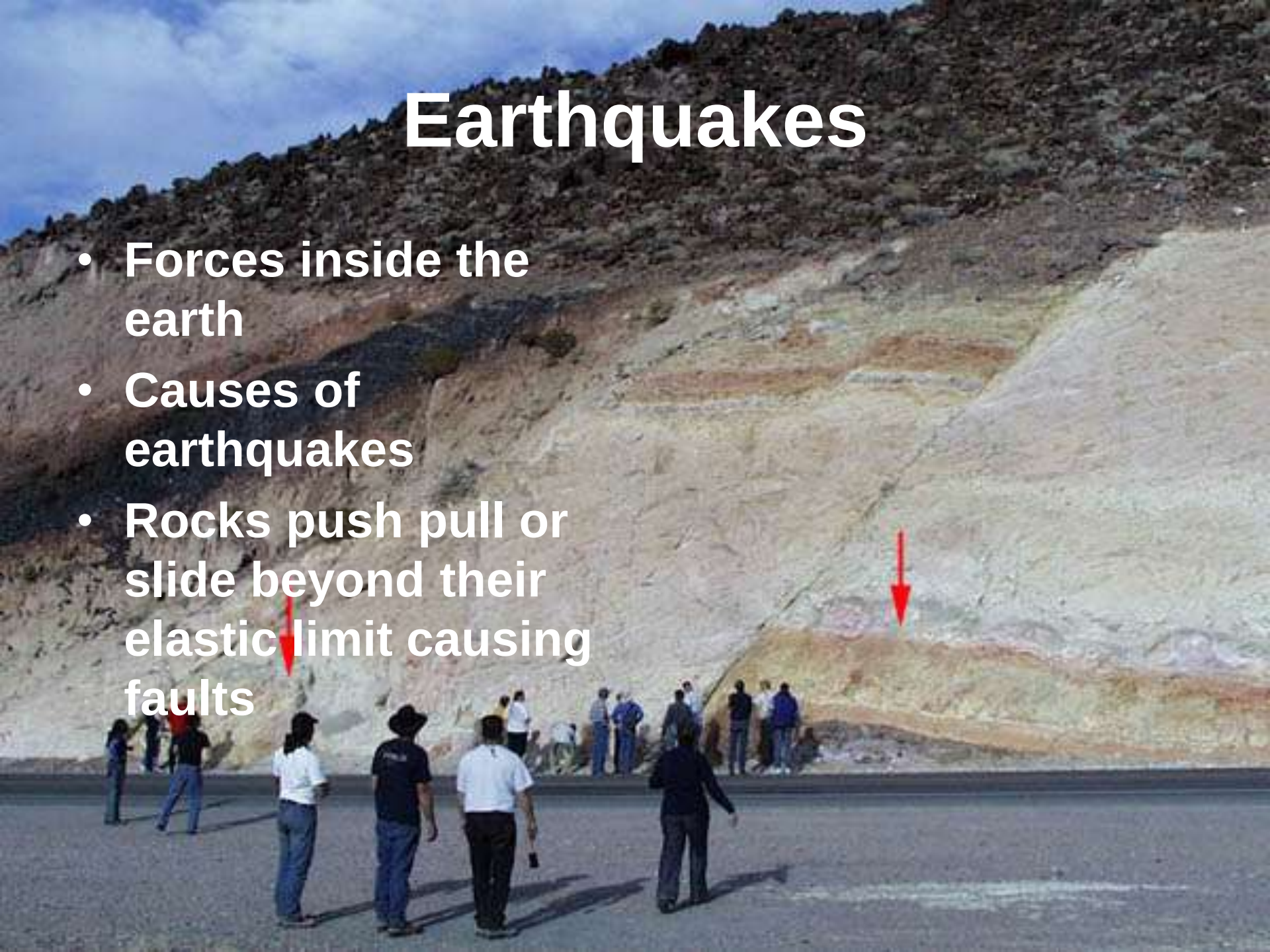
Photo credit: U.S. Geological Survey

Resulting tsunami #17

Flores Island, Indonesia
September 1, 1992
Magnitude 7.0

Photo Credit: Harry Yeh,
University of Washington

Earthquakes

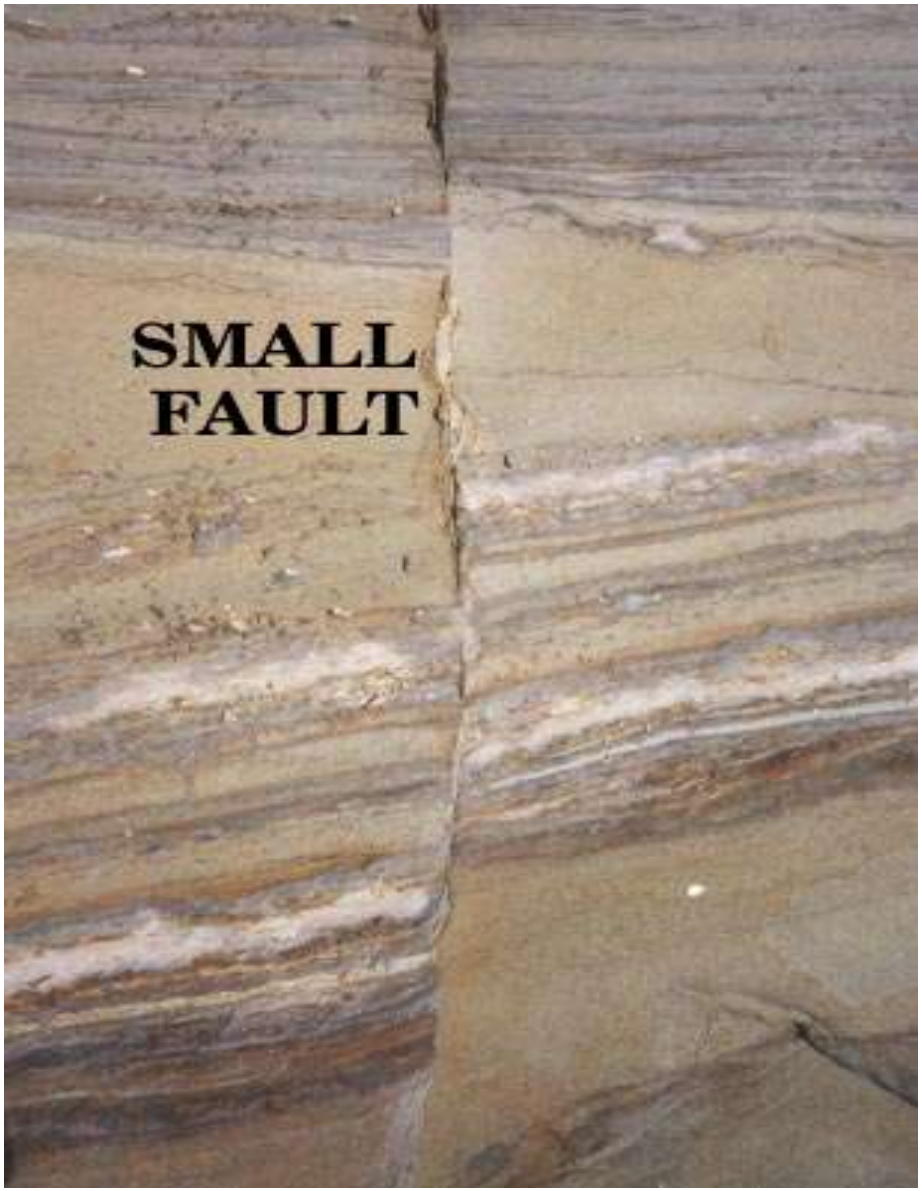


- Forces inside the earth
- Causes of earthquakes
- Rocks push pull or slide beyond their elastic limit causing faults

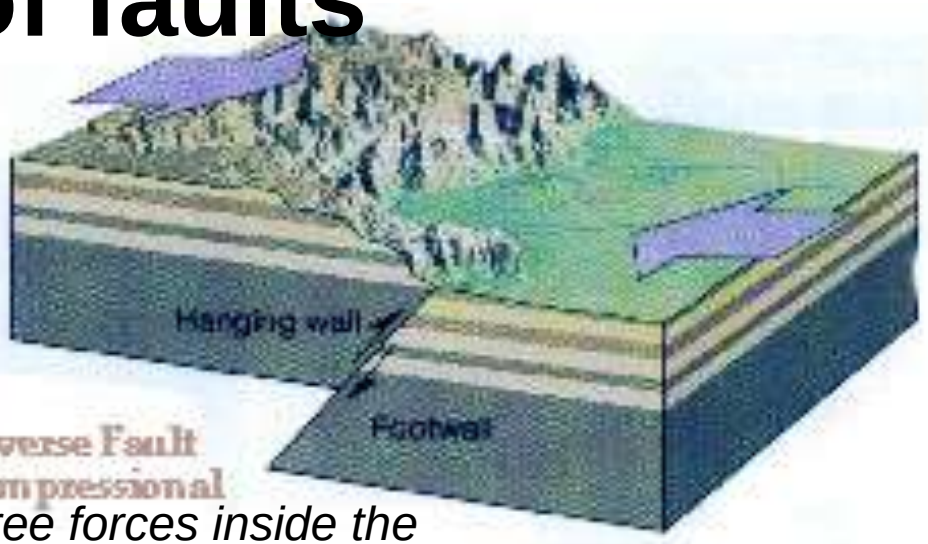
Fault is an area where rock move against each other

Earthquake

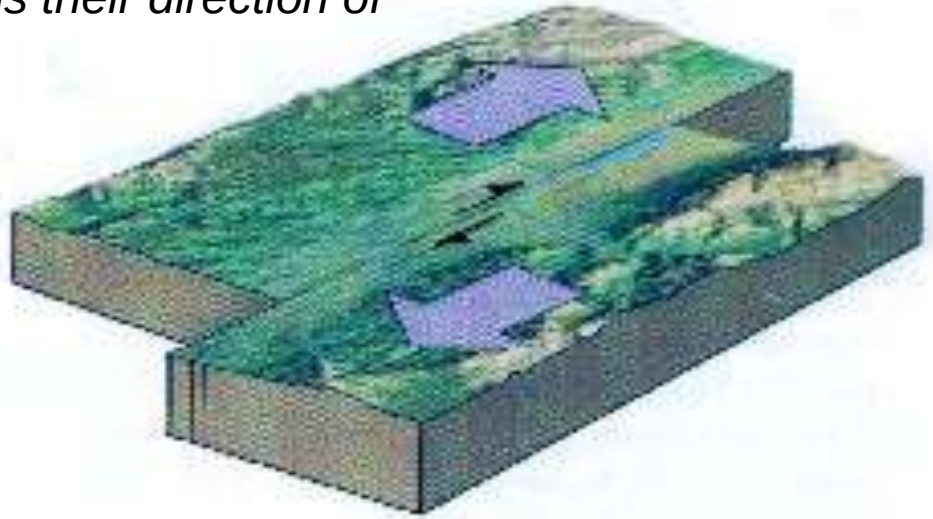
- **is an area where pressure builds then a rock breaks causing a sudden release of energy**



Types of faults



*What are the three forces inside the earth and what is their direction of movement?**

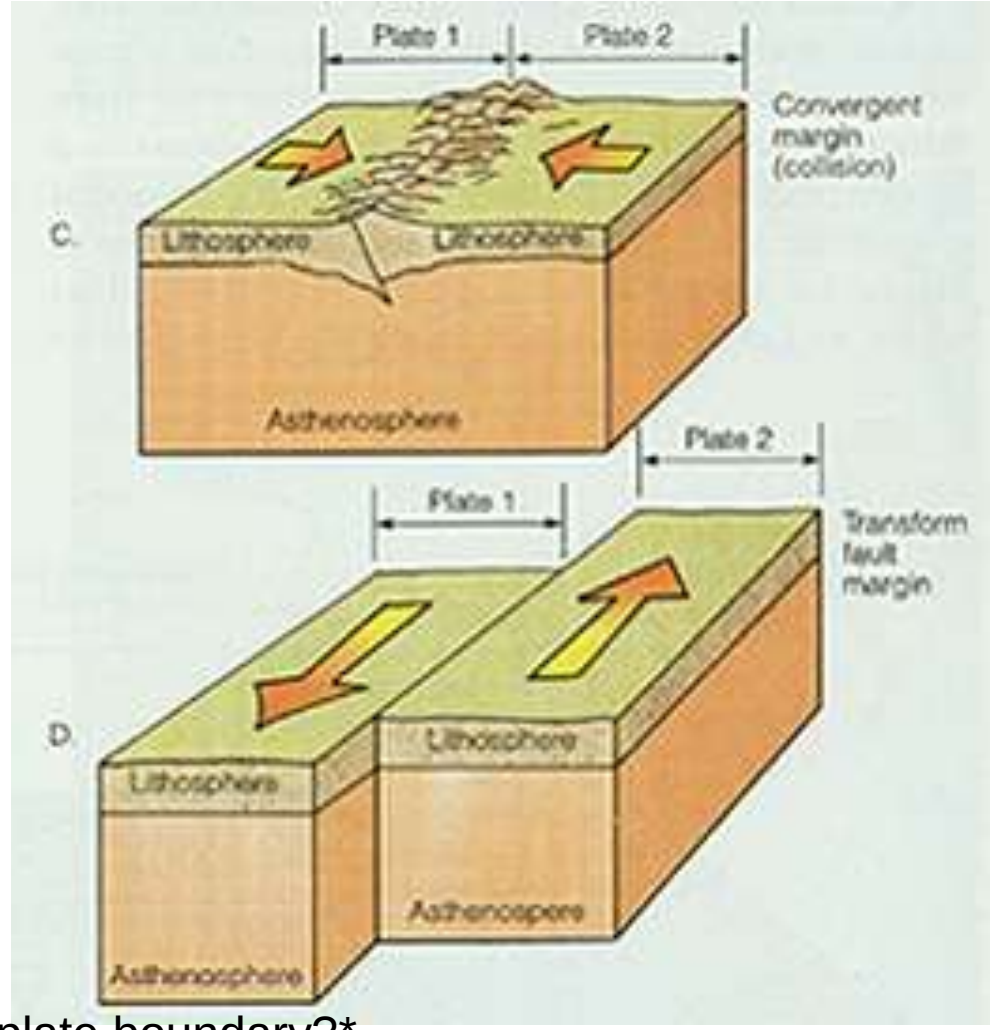


- **Normal Faults – Tension force**
- **Reverse Faults – compression force**
- **Strike slip Faults – shear forces**

*What are the three fault types and what force cause each?**

Plate Boundaries

- Plate boundary is where areas of the crust move different directions
  - Divergent
    - Where two plates move apart
    - Normal fault
  - Convergent
    - Where two plates move together
    - Reverse fault
  - Transform
    - Where two Plates slide by each other
    - Strike slip fault



What type of fault is at a convergent plate boundary?*

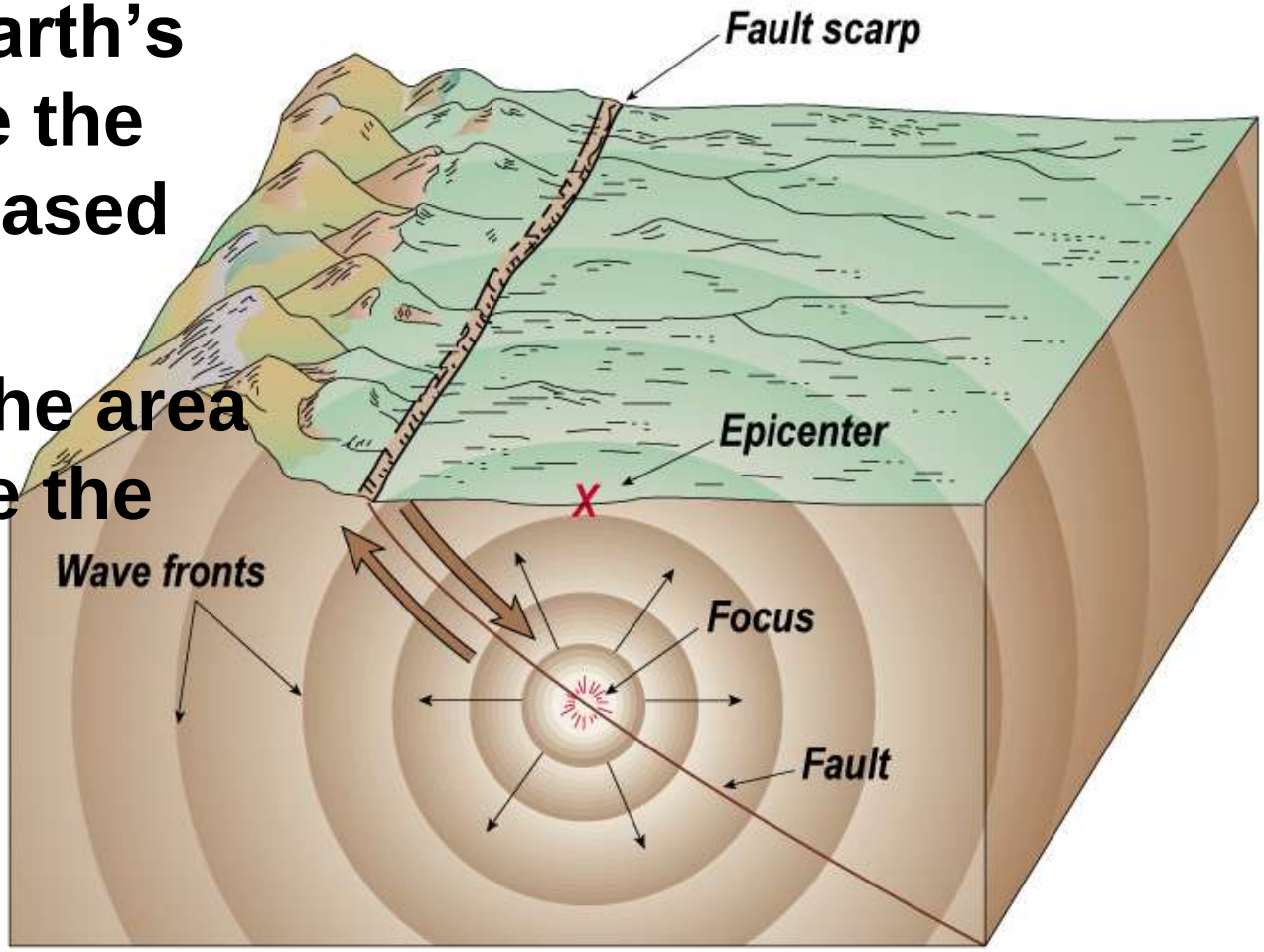
What type of fault is at a divergent plate boundaries?*

Offset Lettuce Rows - El Centro, CA

Photo by Univ. of Colorado; courtesy National Geophysical Data Center, Boulder, CO

Earthquake information

- **Earthquake focus the point in earth's interior where the energy is released along a fault**
- **Epicenter is the area directly above the fault**

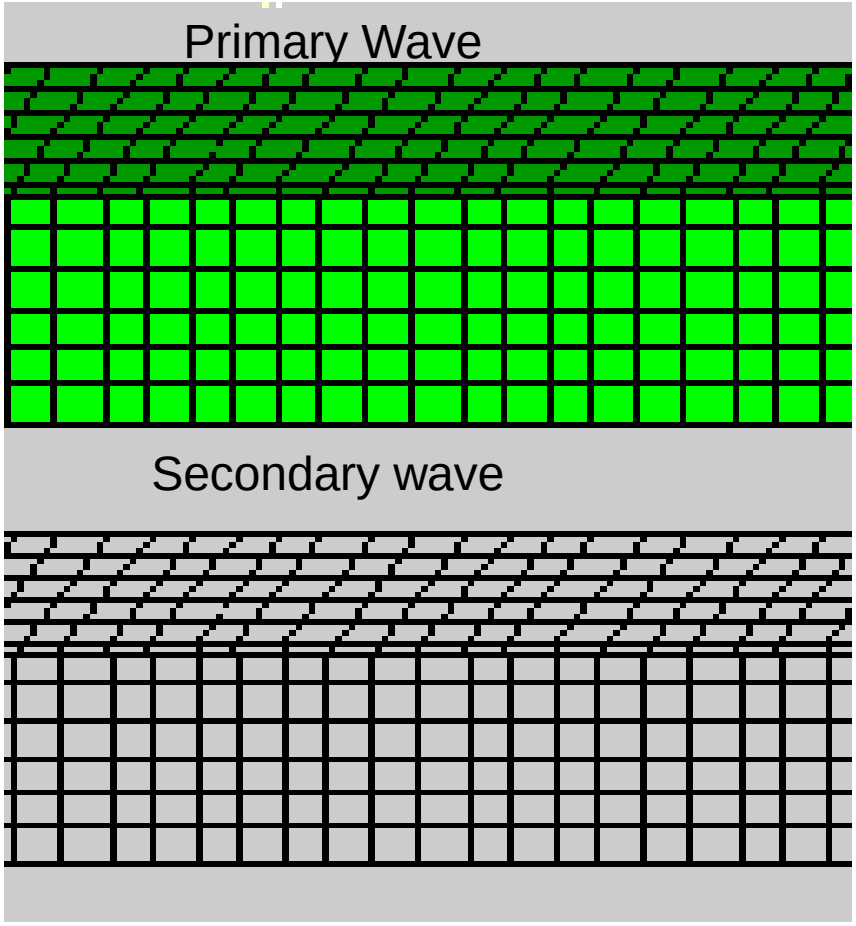


Quiz

1. What are the three types of faults and what force causes each?
2. What are the three types of plate boundaries and what type of faulting is at each type?

Seismic Waves

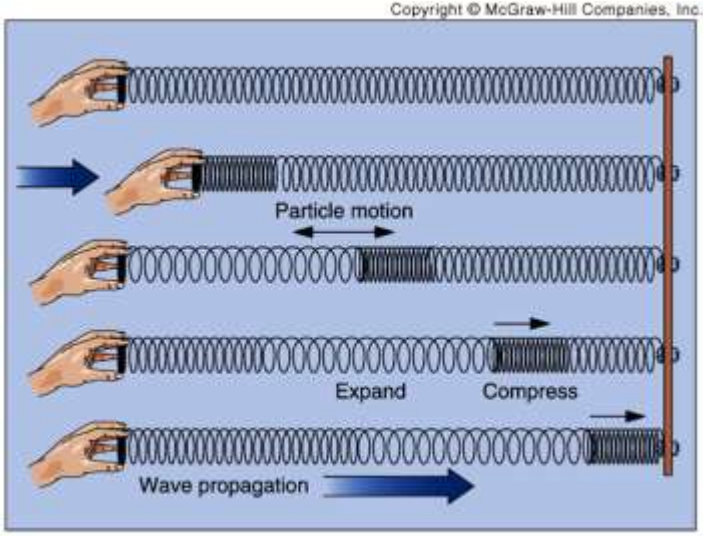
- **Primary waves – move in the same direction wave is moving (compressional wave)**
- **Secondary wave – The particles in the Earth move at right angles to the direction the wave is going (Transverse)**
- **Surface waves – travel on the surface directly outward from the epicenter**
  - **Surface waves cause the most destruction during an earthquake**



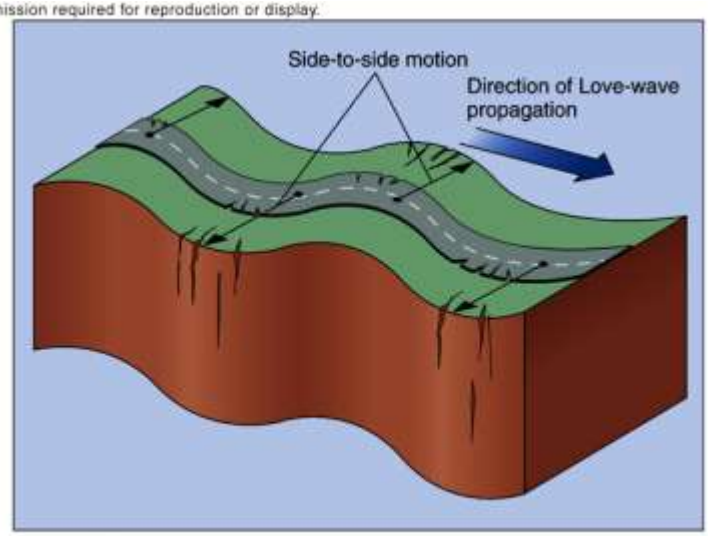
*Which seismic wave does the most property damage and why?**

*List the seismic waves in order from the fastest to the slowest.**

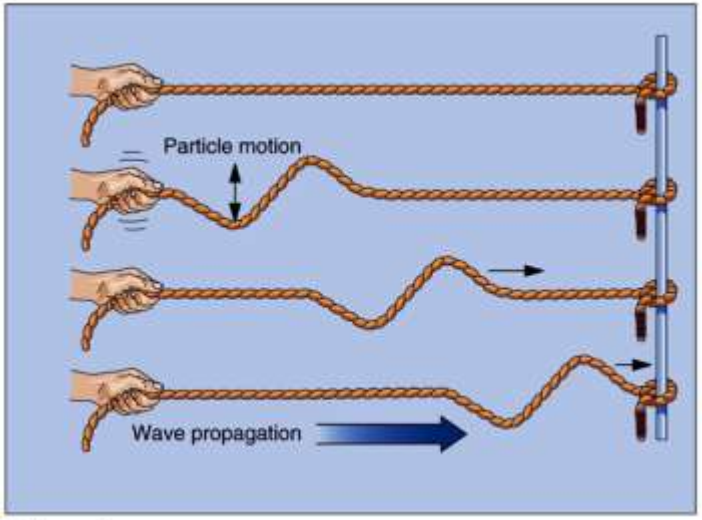
Seismic Wave Types



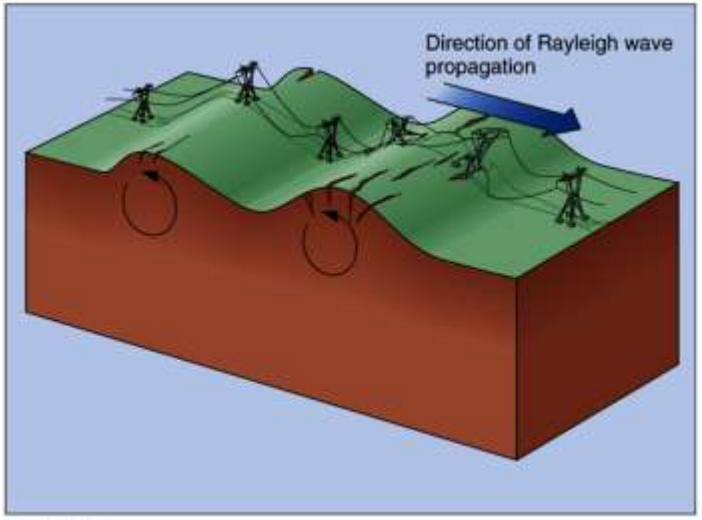
A Primary wave



C Love wave



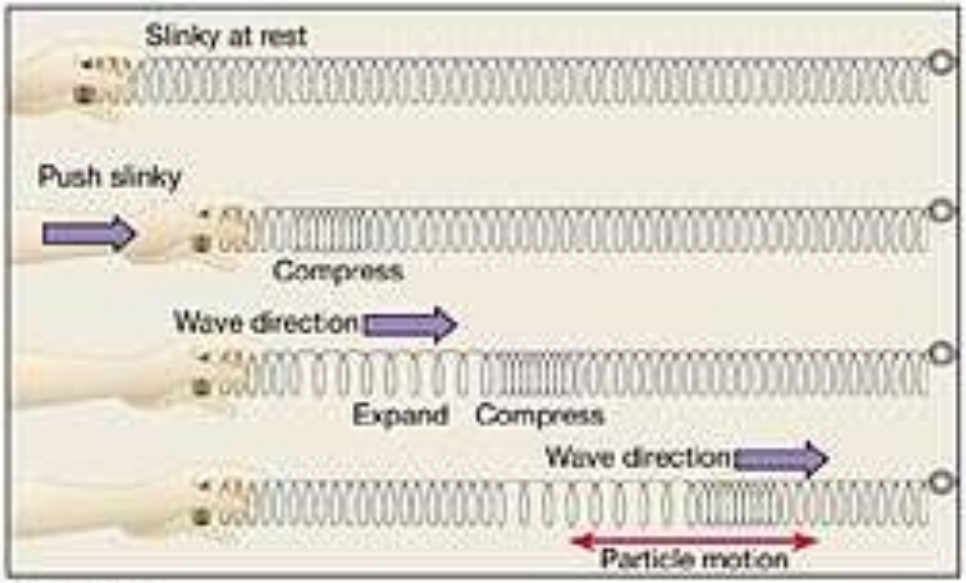
B Secondary wave



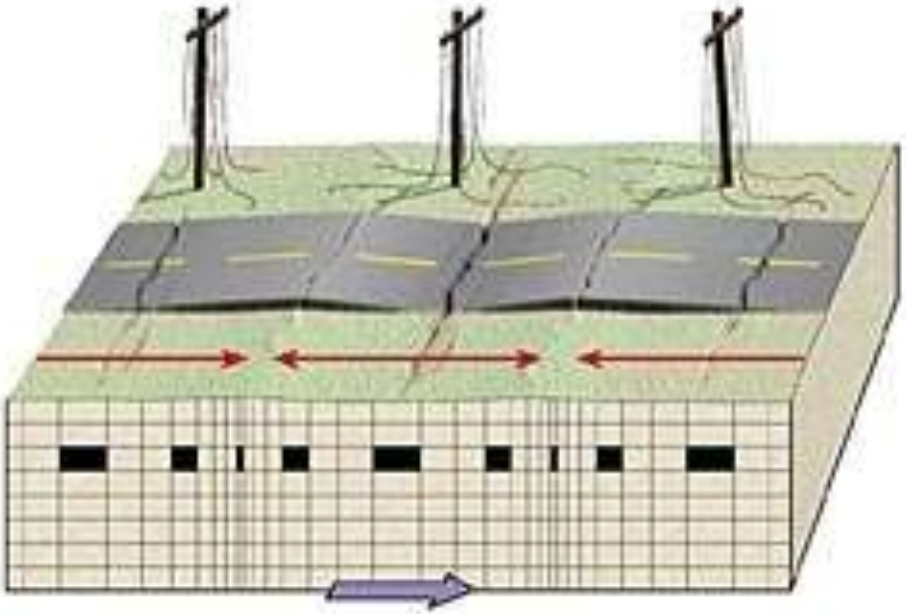
D Rayleigh wave

Body Waves

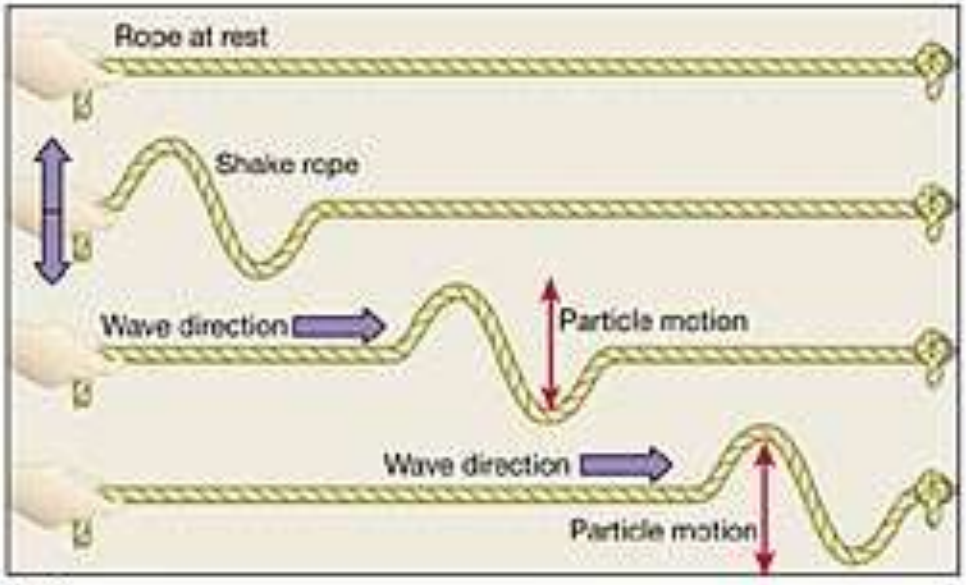
Surface Waves



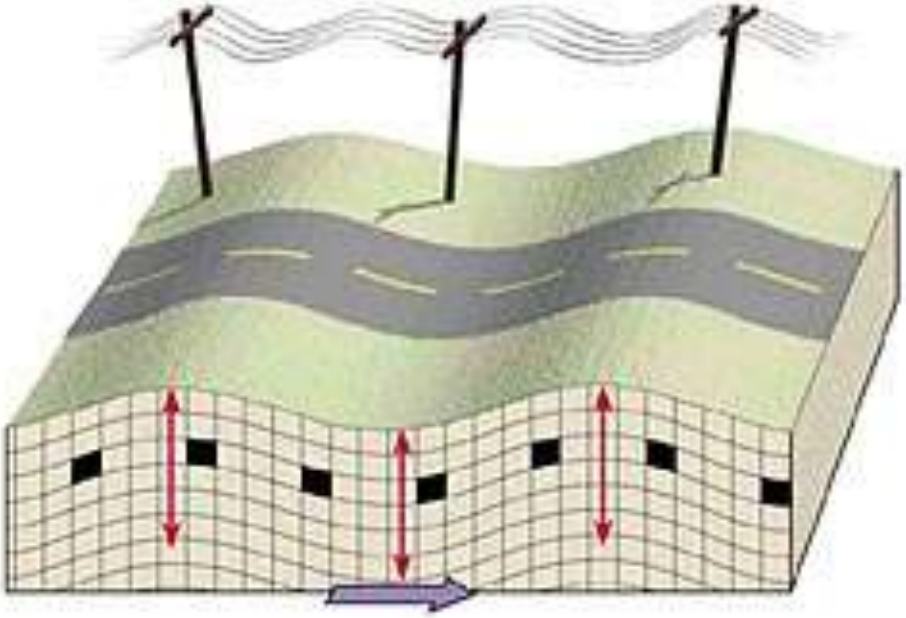
A. P wave



*Which type of waves stretch and compress rocks?**



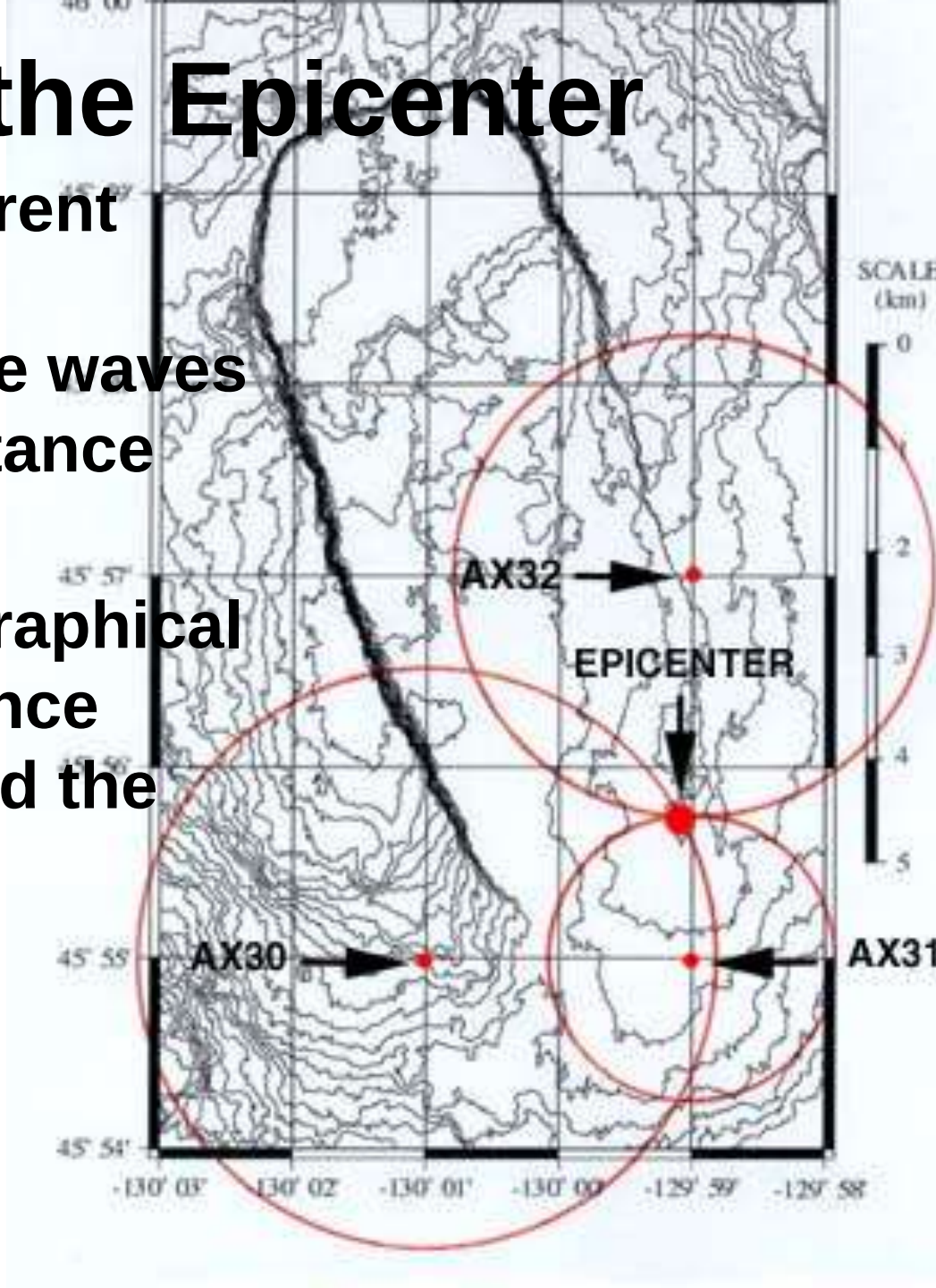
B. S wave



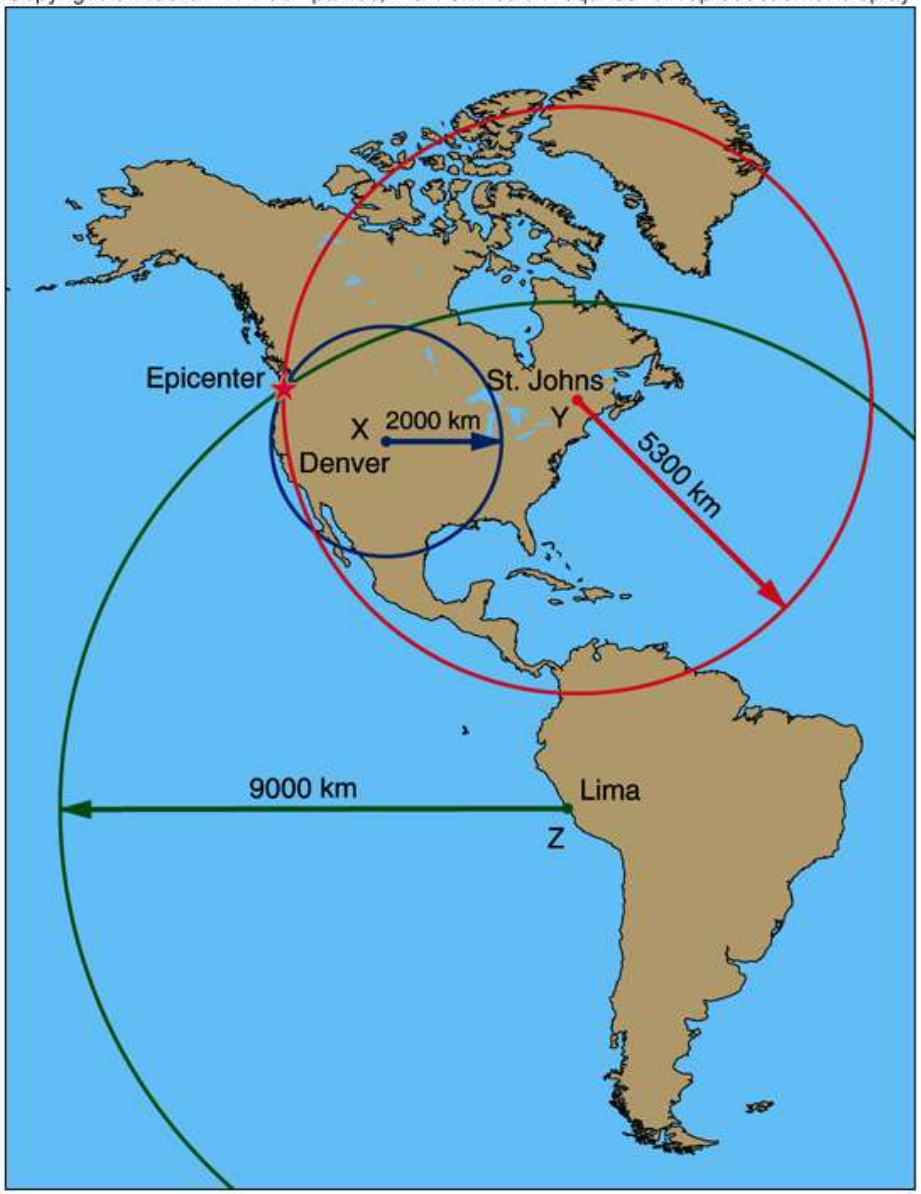
Locating the Epicenter

- **Scientist use the different speeds that primary, secondary and surface waves travel to calculate distance from epicenter**
- **If there are 3 seismographical stations making distance recording they can find the epicenter**
  Waves from

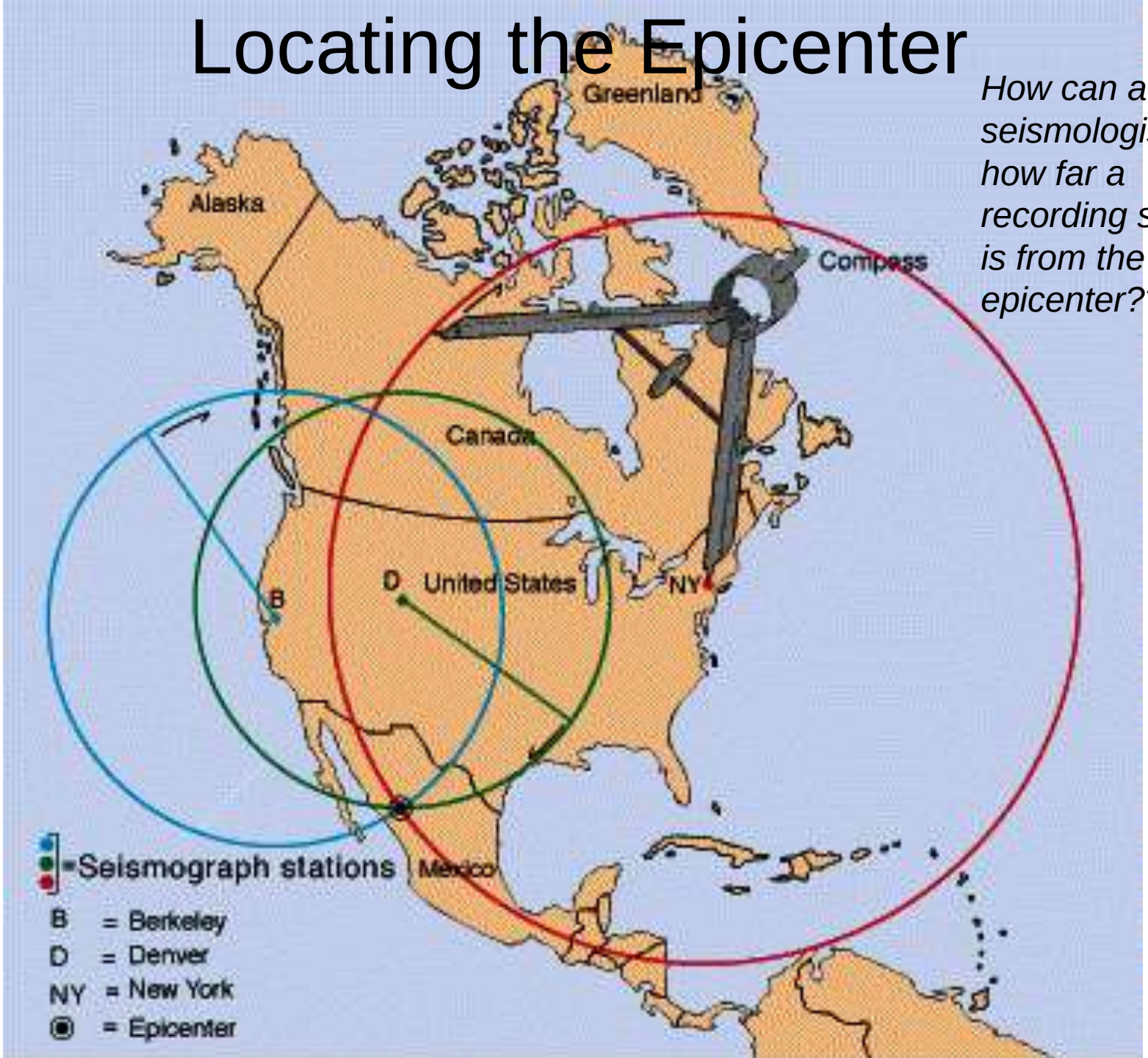
*Why is a seismic record from three location needed to determine the position of an epicenter?**



Earthquake Location by Range

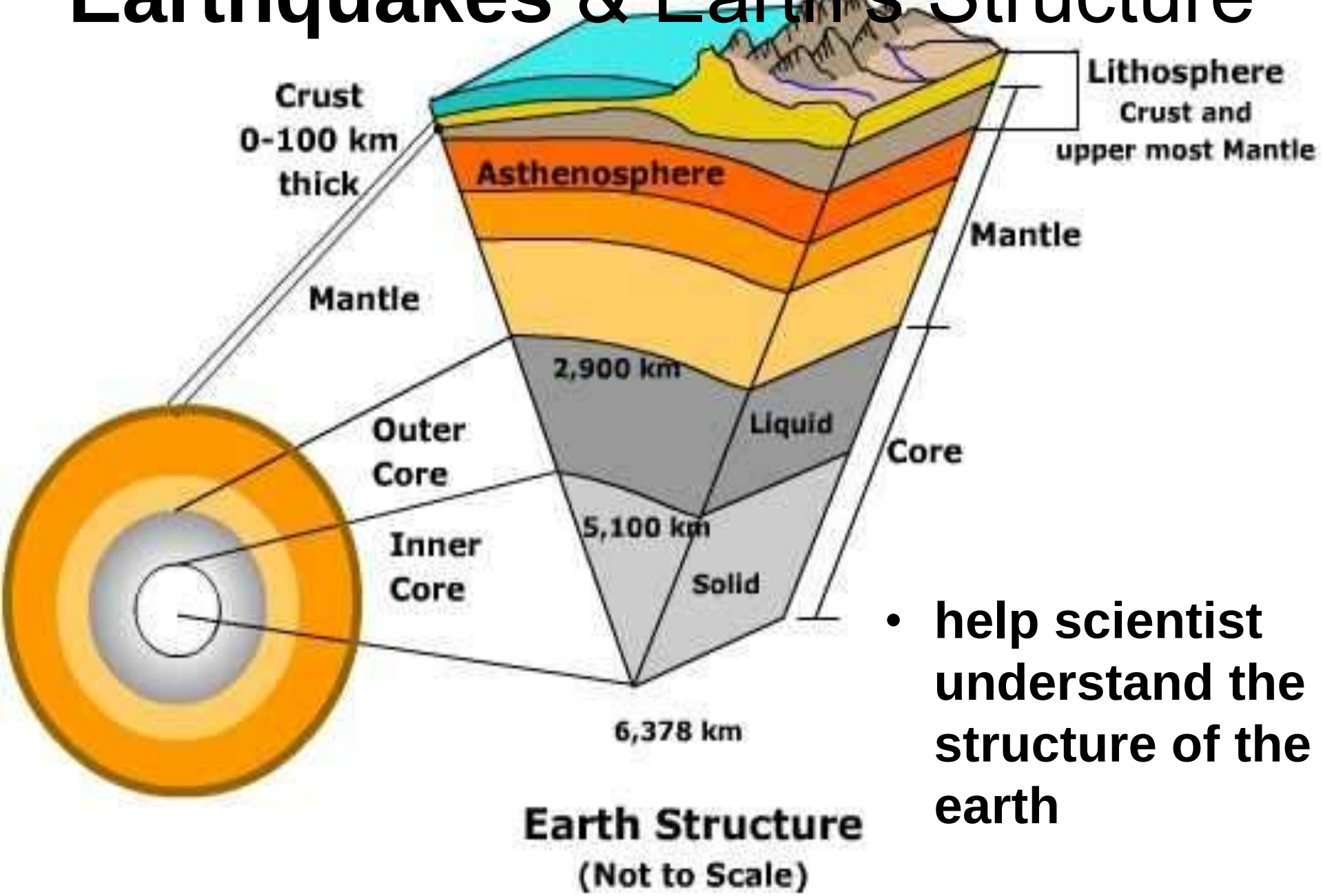


Locating the Epicenter



*How can a seismologist tell how far a recording station is from the epicenter?**

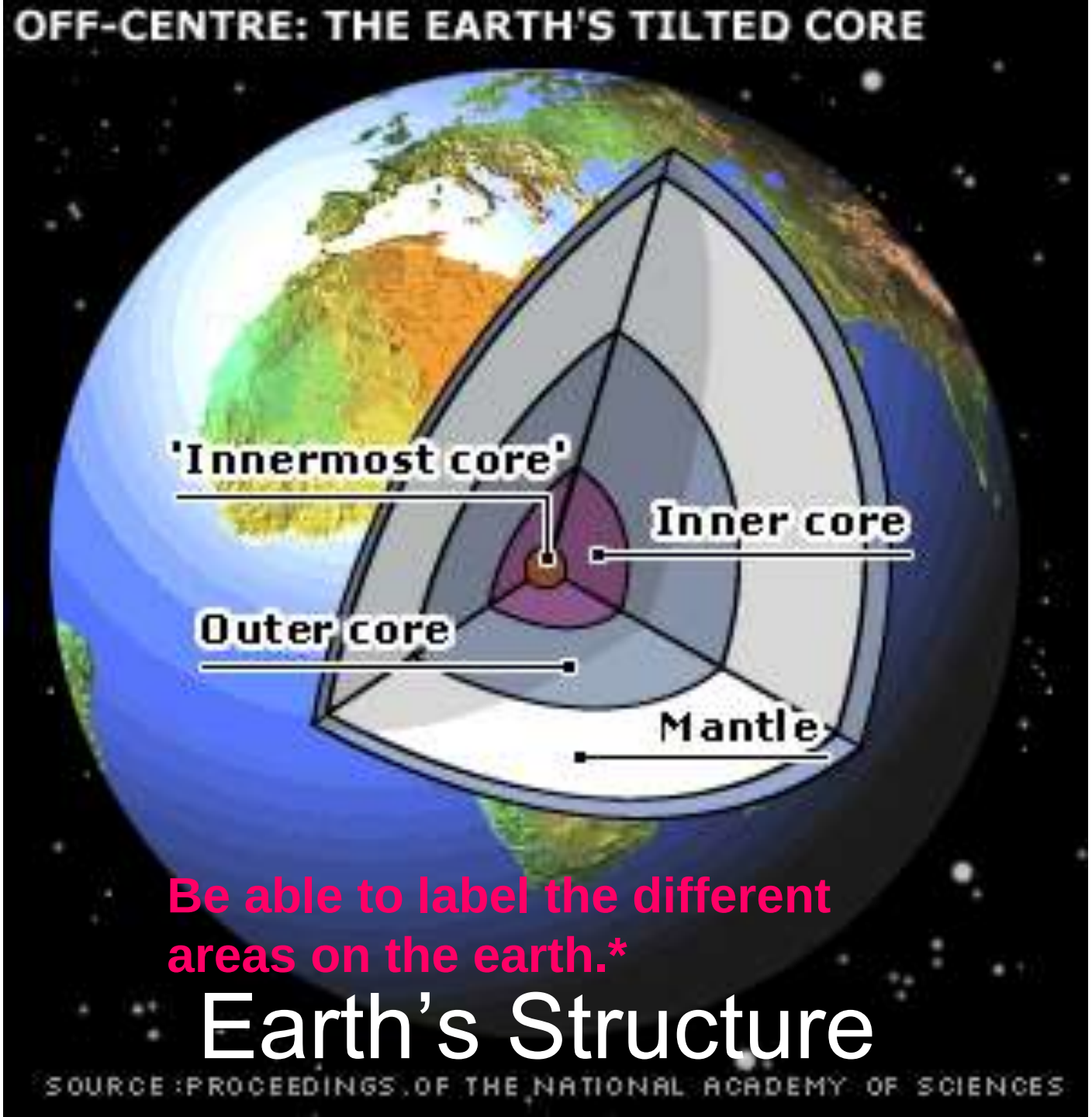
Earthquakes & Earth's Structure



- **help scientist understand the structure of the earth**

Earth's Structure

- Inner core solid dense are composed of iron and nickel
- Outer core – liquid iron & nickel
- Mantle – molten silicon, Iron, oxygen & magnesium
- Crust – outer most layer separated from the mantle by Moho discontinuity
- Lithosphere is made up of the crust and upper mantle

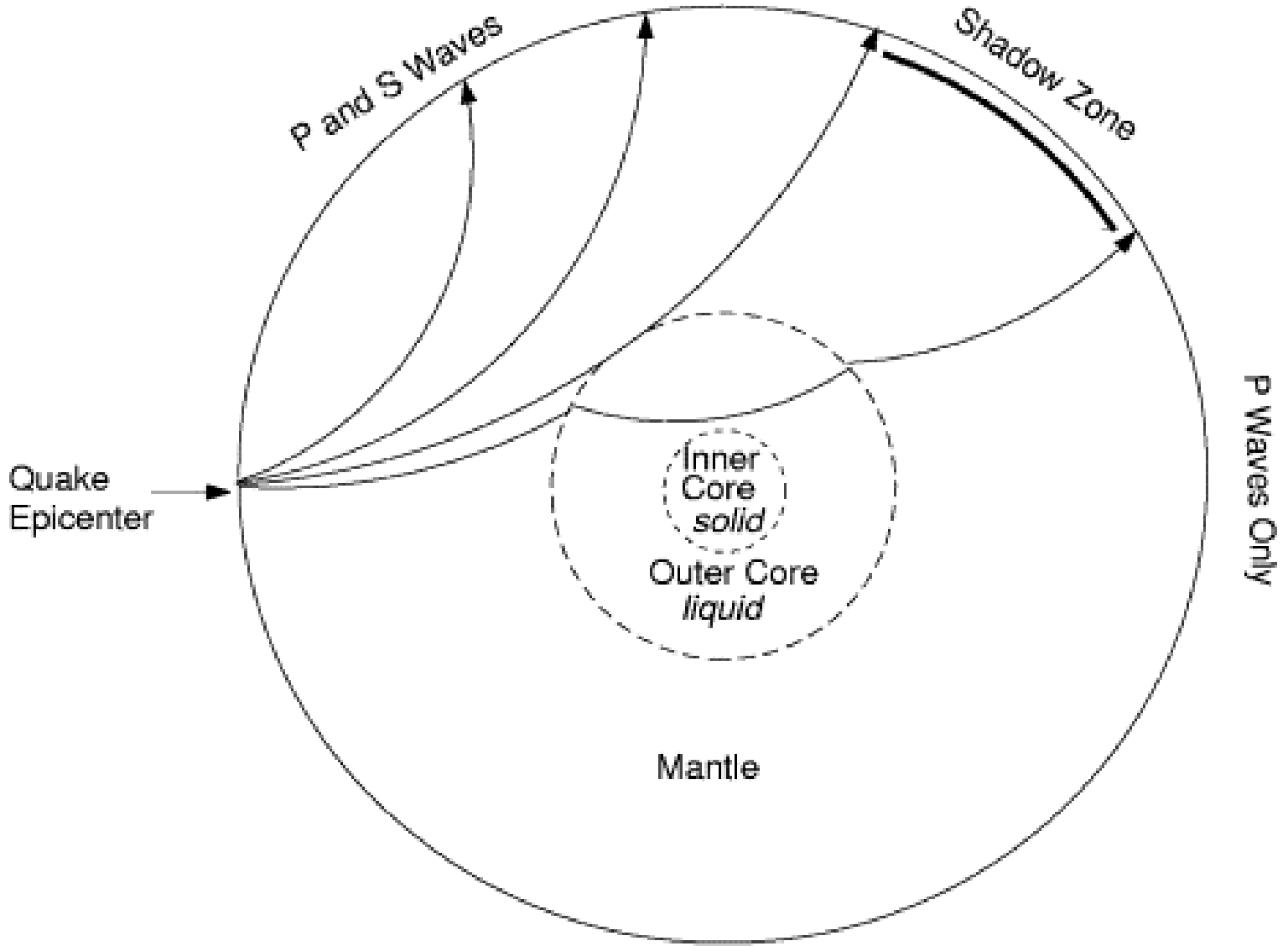


Be able to label the different areas on the earth.*

Earth's Structure

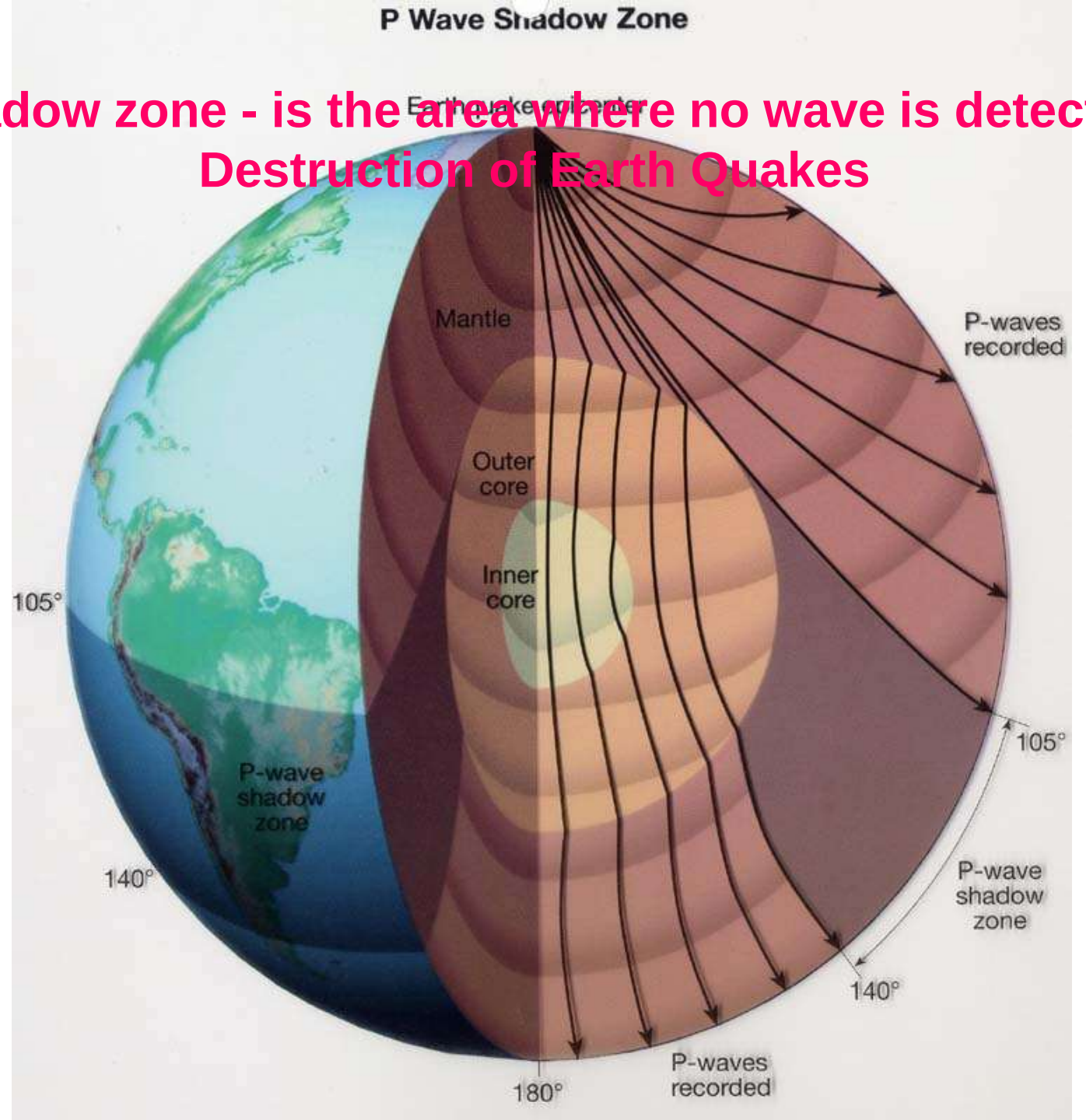
Shadow zone

- **Secondary waves are stopped completely by liquid outer core primary waves are slowed**

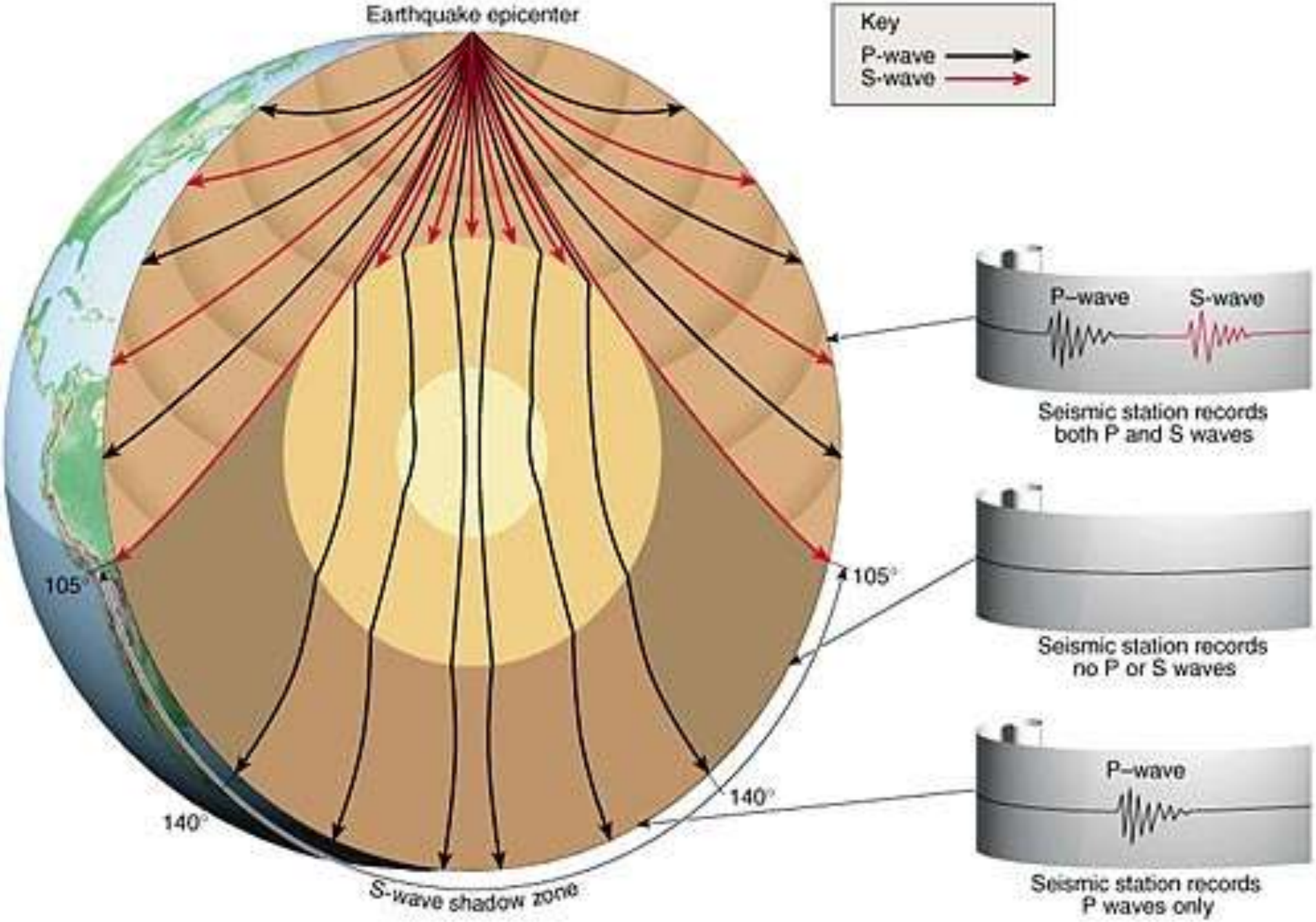


Shadow zone - is the area where no wave is detected

Destruction of Earth Quakes



Shadow Zone


Earthquake epicenter
Key
P-wave
S-wave
105°
105°
140°
140°
S-wave shadow zone
P–wave
S-wave
Seismic station records
both P and S waves
Seismic station records
no P or S waves
P–wave
Seismic station records
P waves only

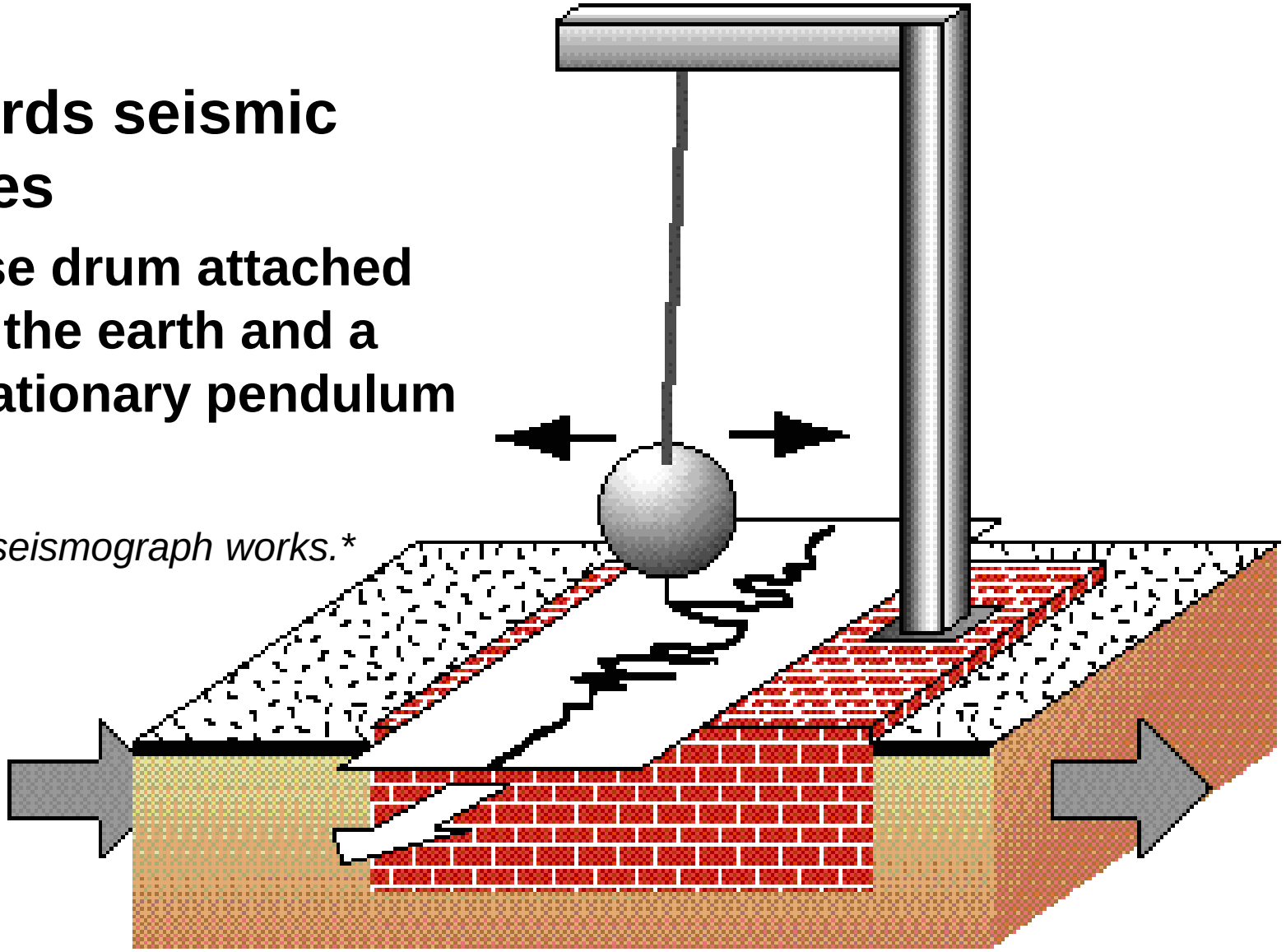
Seismology

- **Study of earth quakes**

Seismograph

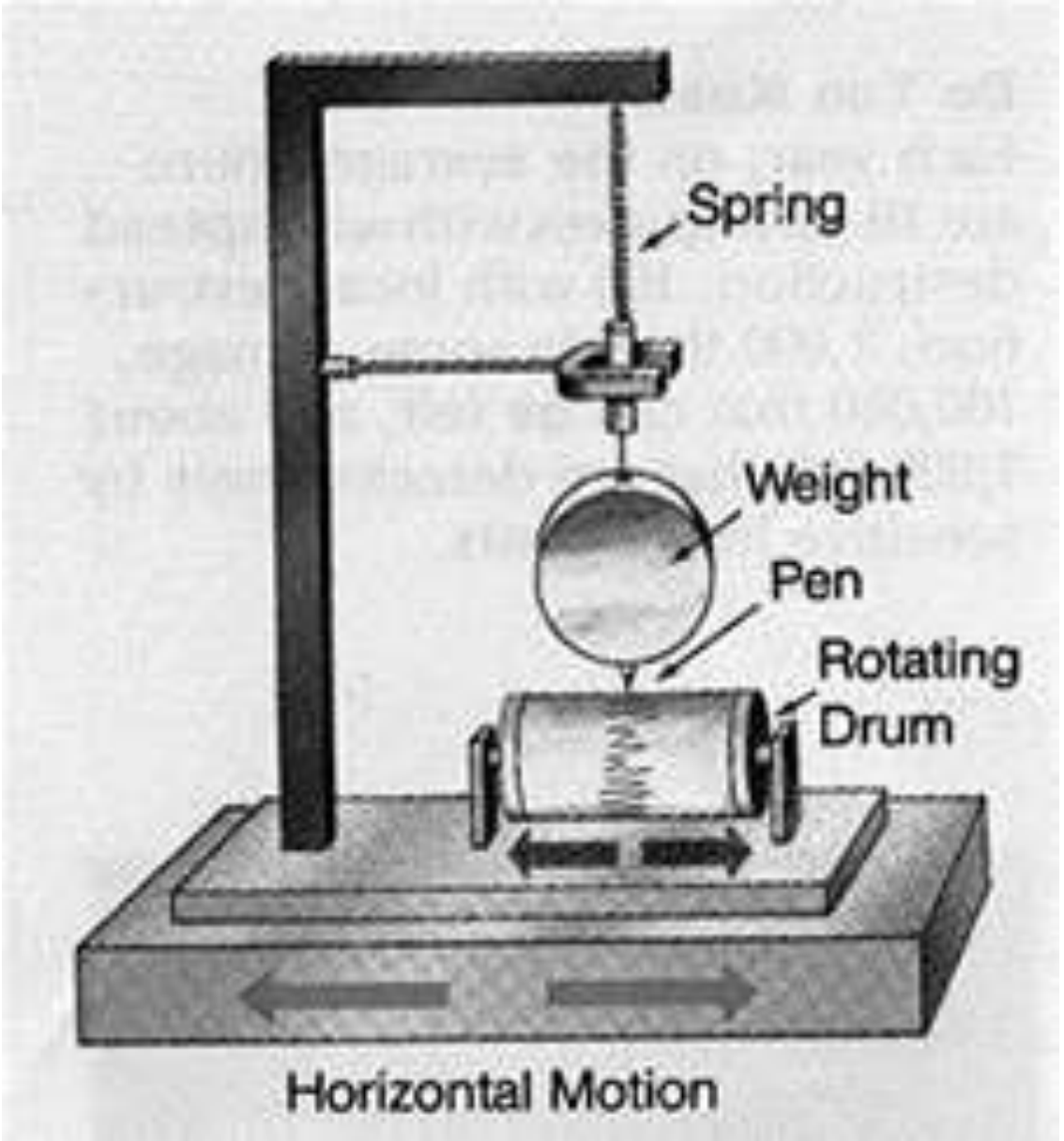
- **records seismic waves**
  - **Use drum attached to the earth and a stationary pendulum**

*Explain how a seismograph works.**

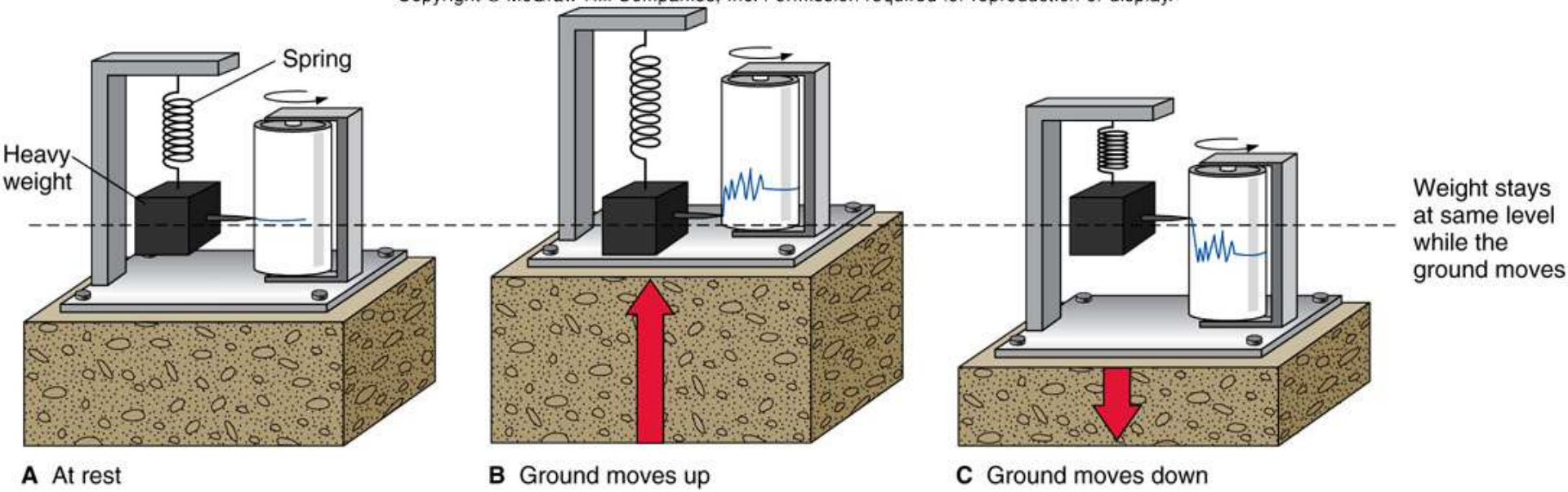


Seismograph

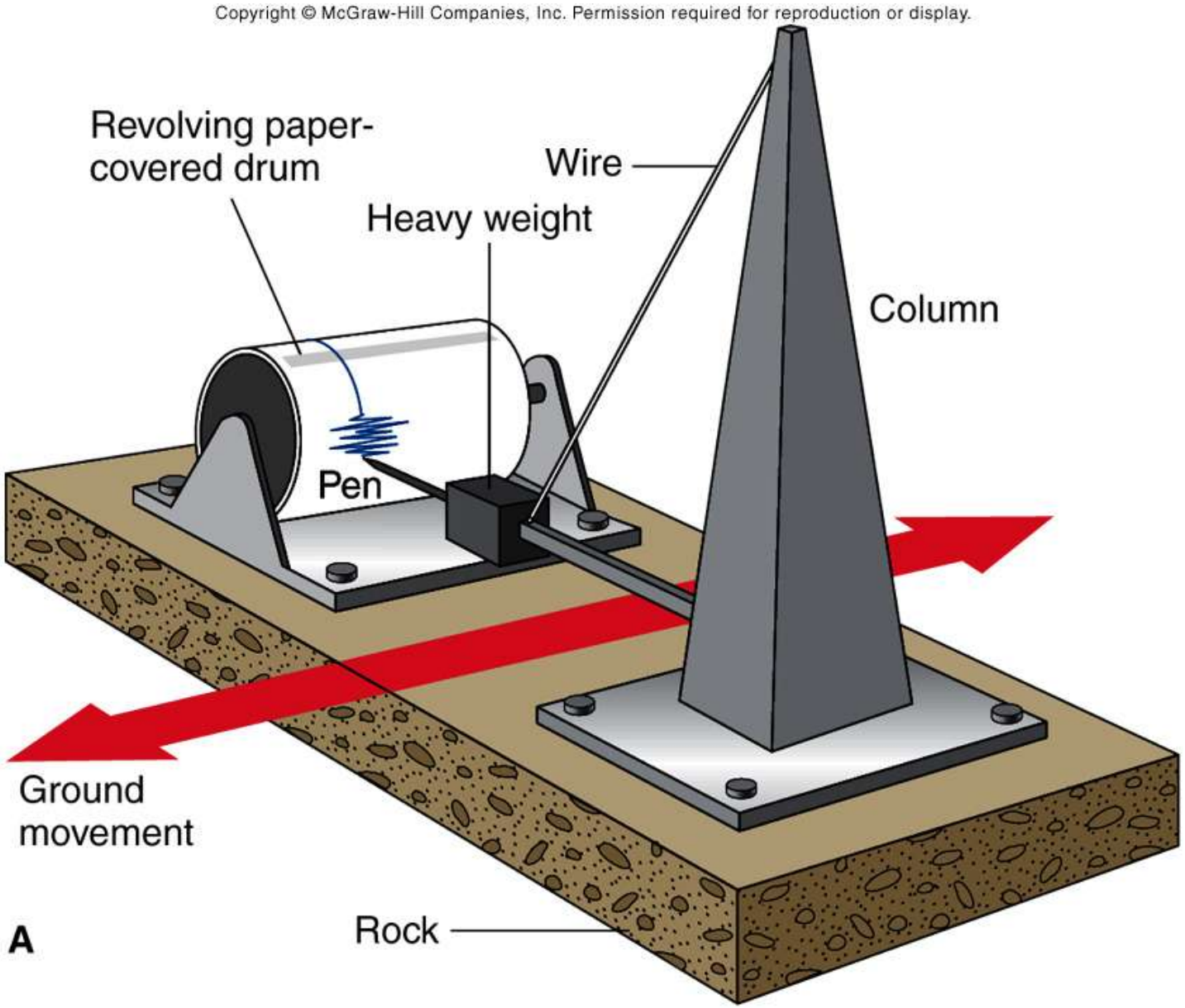
*How can a seismologist tell how far a recording station is from the epicenter?**



Vertical Component Seismometer



Horizontal Component Seismomter



Richter scale

- **the energy in the break is measured**
- **The greater the energy the greater the earthquake**
- **For each increase of one the amplitude of the largest surface wave increase by 10**
- **About 32 time as much energy is released with each increase of one on the richter scale.**

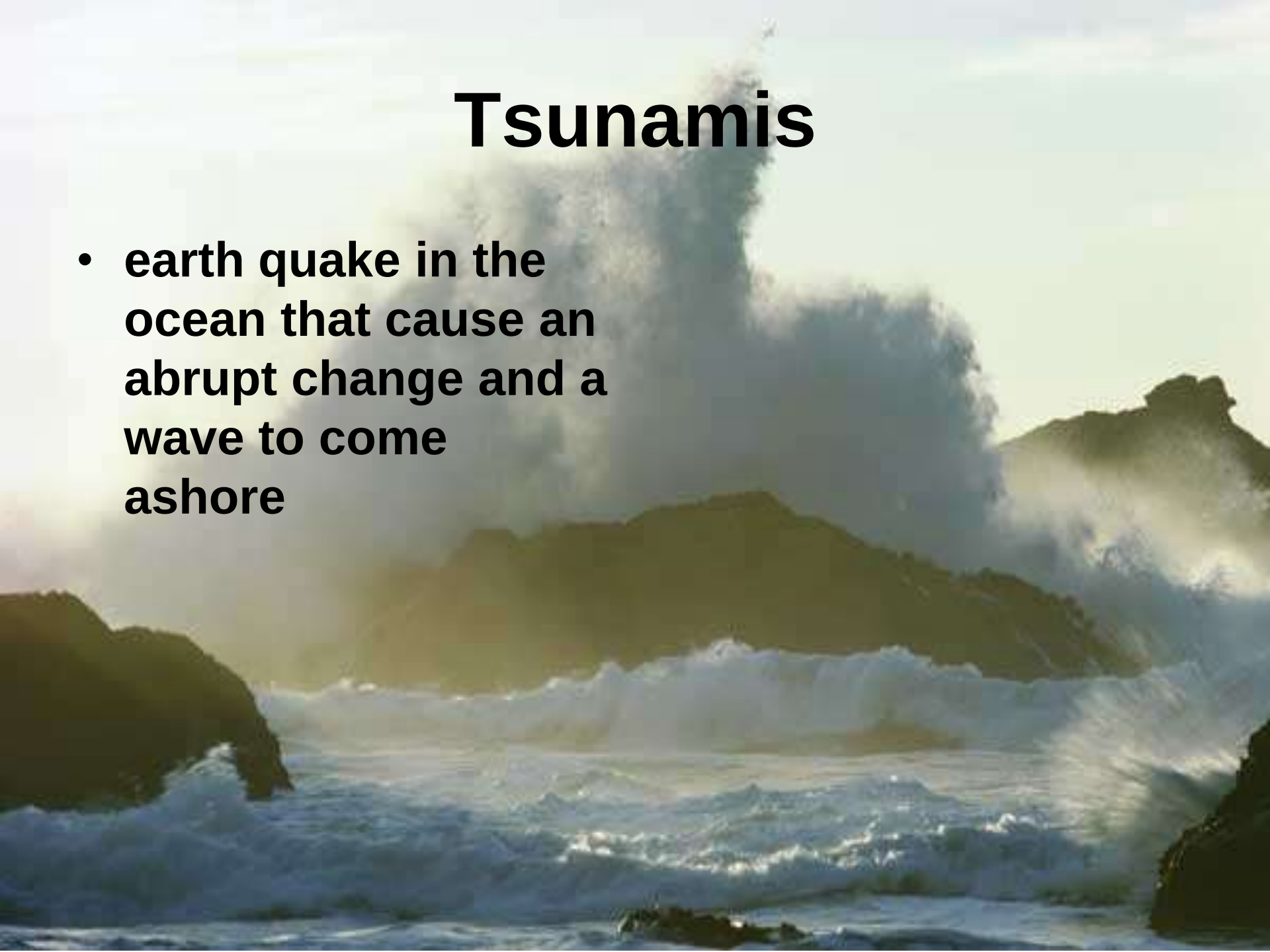
Effects of Tremor	The Richter Scale
Only detected by seismometers	2
Felt by walkers, window and doors rattle	4
Severe structural damage to houses	6
Total destruction, ground actually rises and falls	8

*What scale is used to measure the magnitude of an earth quake?**

*What conditions cause greater loss of life in different earthquakes with the same magnitude?**

Tsunamis

- **earth quake in the ocean that cause an abrupt change and a wave to come ashore**



How Tsunamis Work: Tsunamigenesis