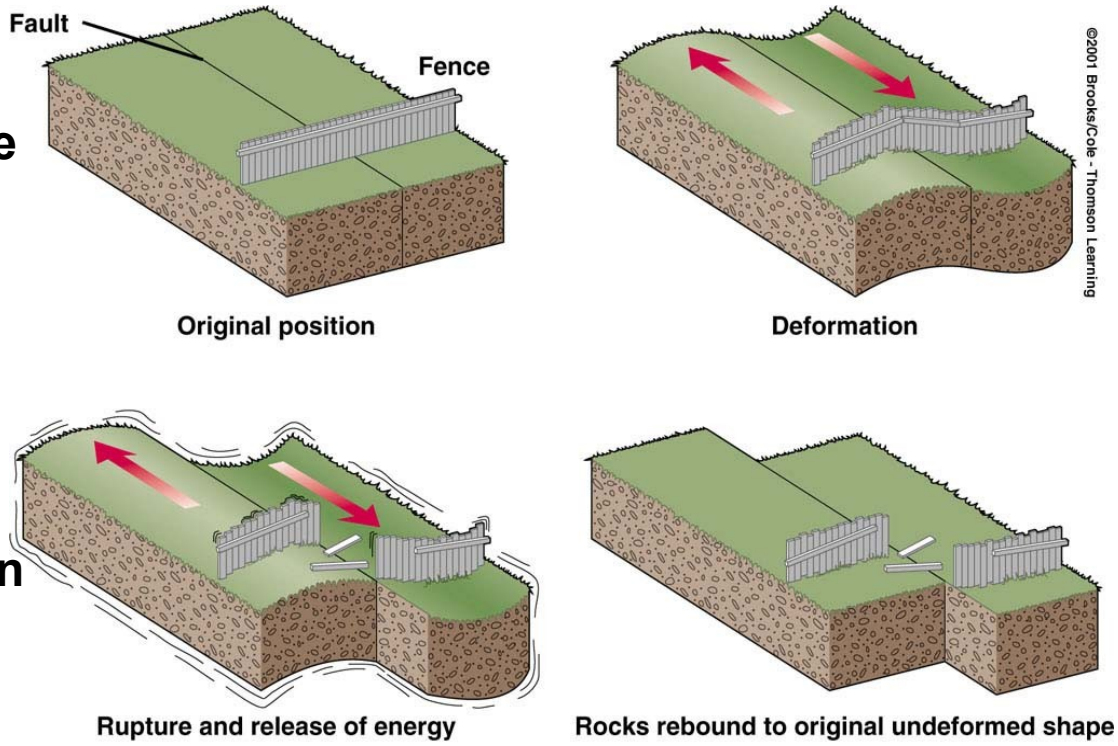
What are Earthquakes?

- The shaking or trembling caused by the sudden release of energy
- Usually associated with faulting or breaking of rocks
- Continuing adjustment of position results in aftershocks

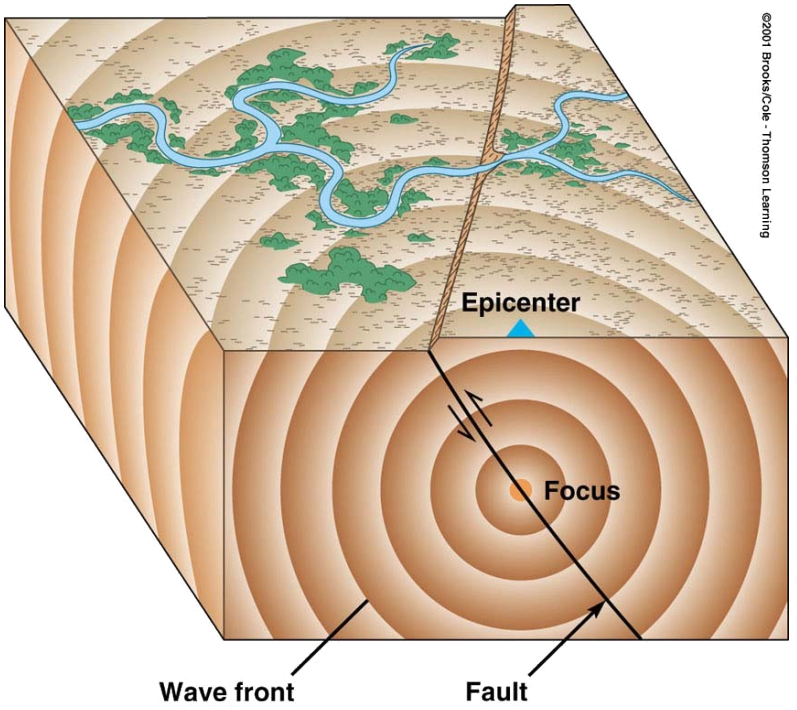
What is the Elastic Rebound Theory?

- **Explains how energy is stored in rocks**
  - **Rocks bend until the strength of the rock is exceeded**
  - **Rupture occurs and the rocks quickly rebound to an undeformed shape**
  - **Energy is released in waves that radiate outward from the fault**

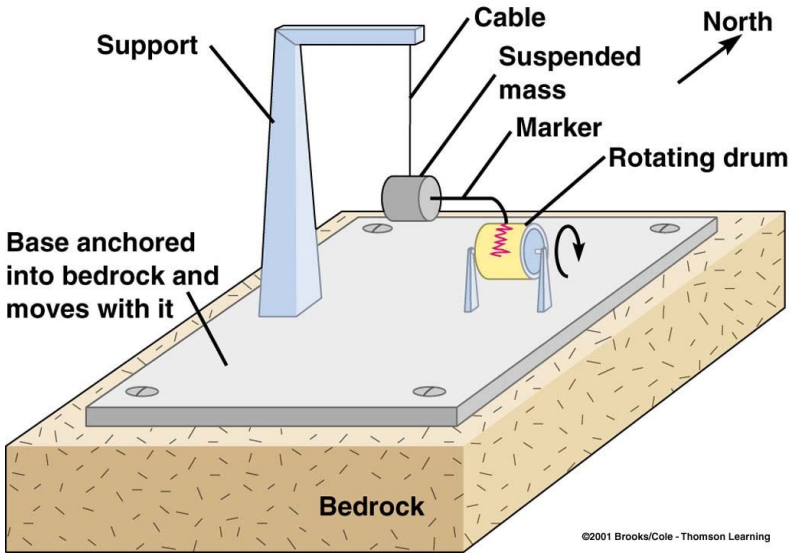


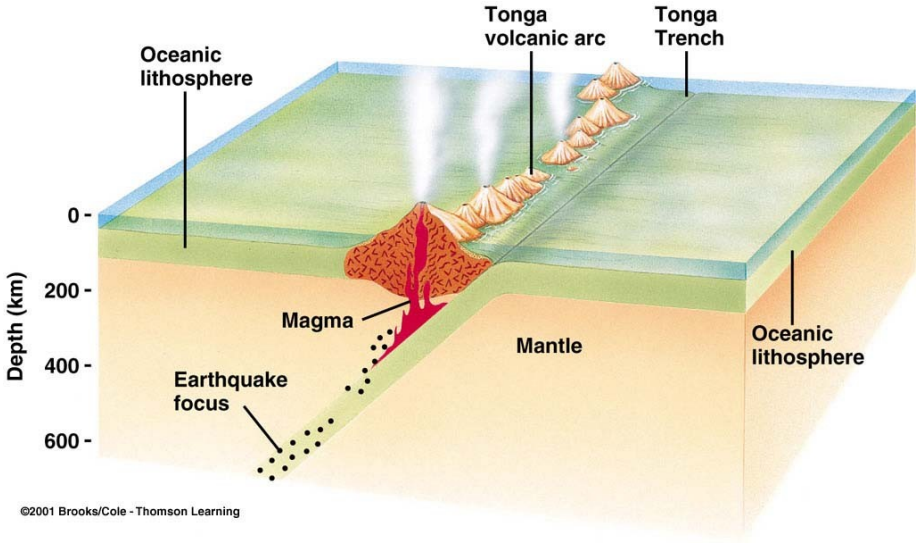
The Focus and Epicenter of an Earthquake

- The point within Earth where faulting begins is the focus, or hypocenter
- The point directly above the focus on the surface is the epicenter



Seismographs record earthquake events



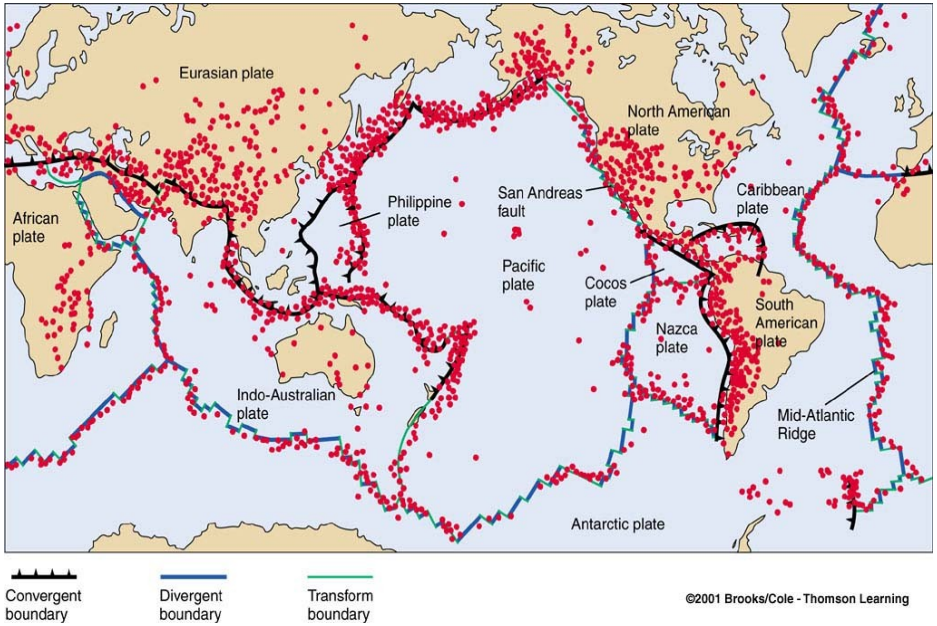


At convergent boundaries, **focal depth** increases along a dipping seismic zone called a **Benioff zone**

Where Do Earthquakes Occur and How Often?

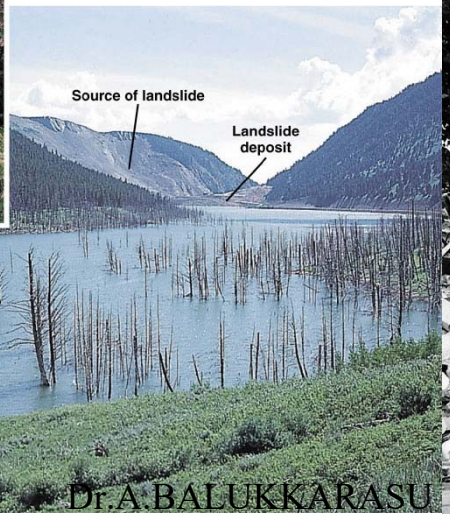
~80% of all earthquakes occur in the circum-Pacific belt

- **most of these result from convergent margin activity**
- **~15% occur in the Mediterranean-Asiatic belt**
- **remaining 5% occur in the interiors of plates and on spreading ridge centers**
- **more than 150,000 quakes strong enough to be felt are recorded each year**



The Economics and Societal Impacts of EQs

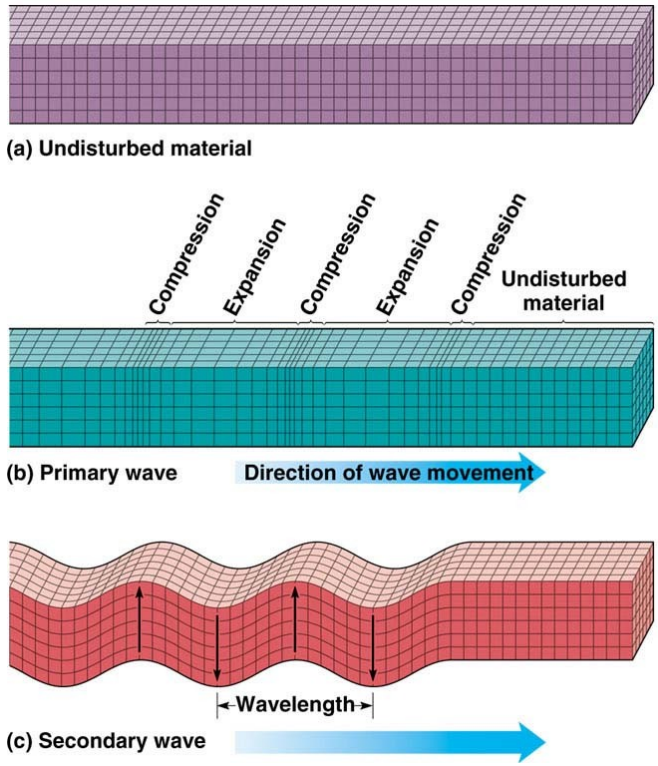
- Building collapse
- Fire
- Tsunami
- Ground failure

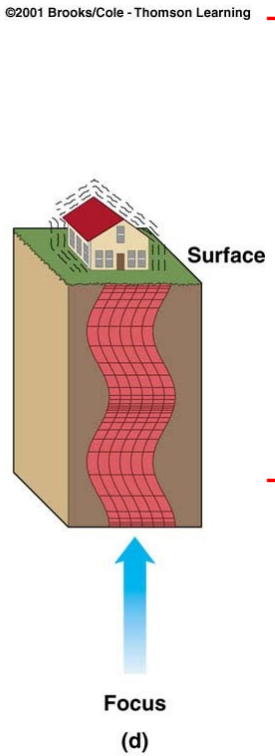


What are Seismic Waves?

- Response of material to the arrival of energy fronts released by rupture
- Two types:
  - Body waves
    - P and S
  - Surface waves
    - R and L

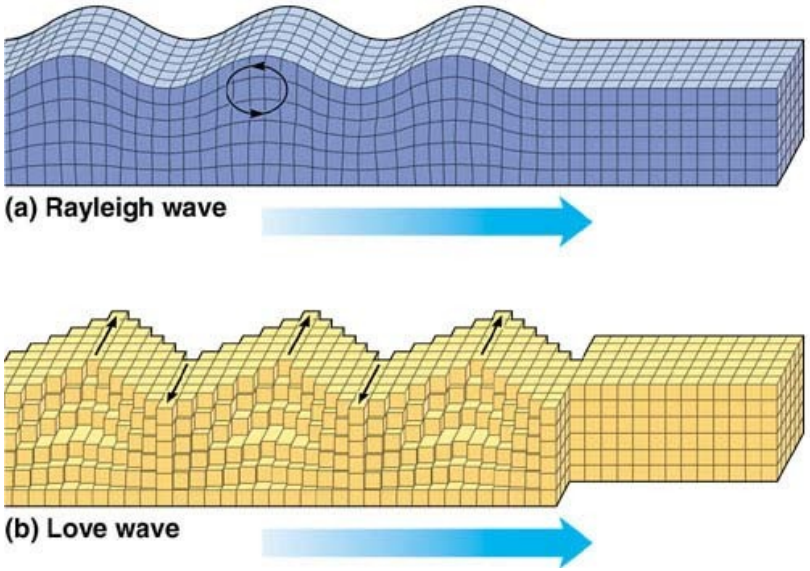
Body Waves: P and S waves

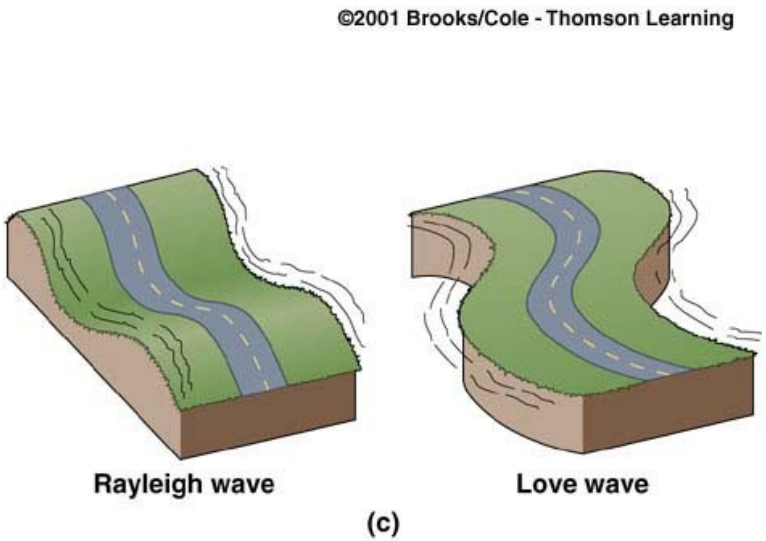




- Body waves
  - P or primary waves
    - fastest waves
    - travel through solids, liquids, or gases
    - compressional wave, material movement is in the same direction as wave movement
  - S or secondary waves
    - slower than P waves
    - travel through solids only
    - shear waves - move material perpendicular to wave movement

Surface Waves: R and L waves



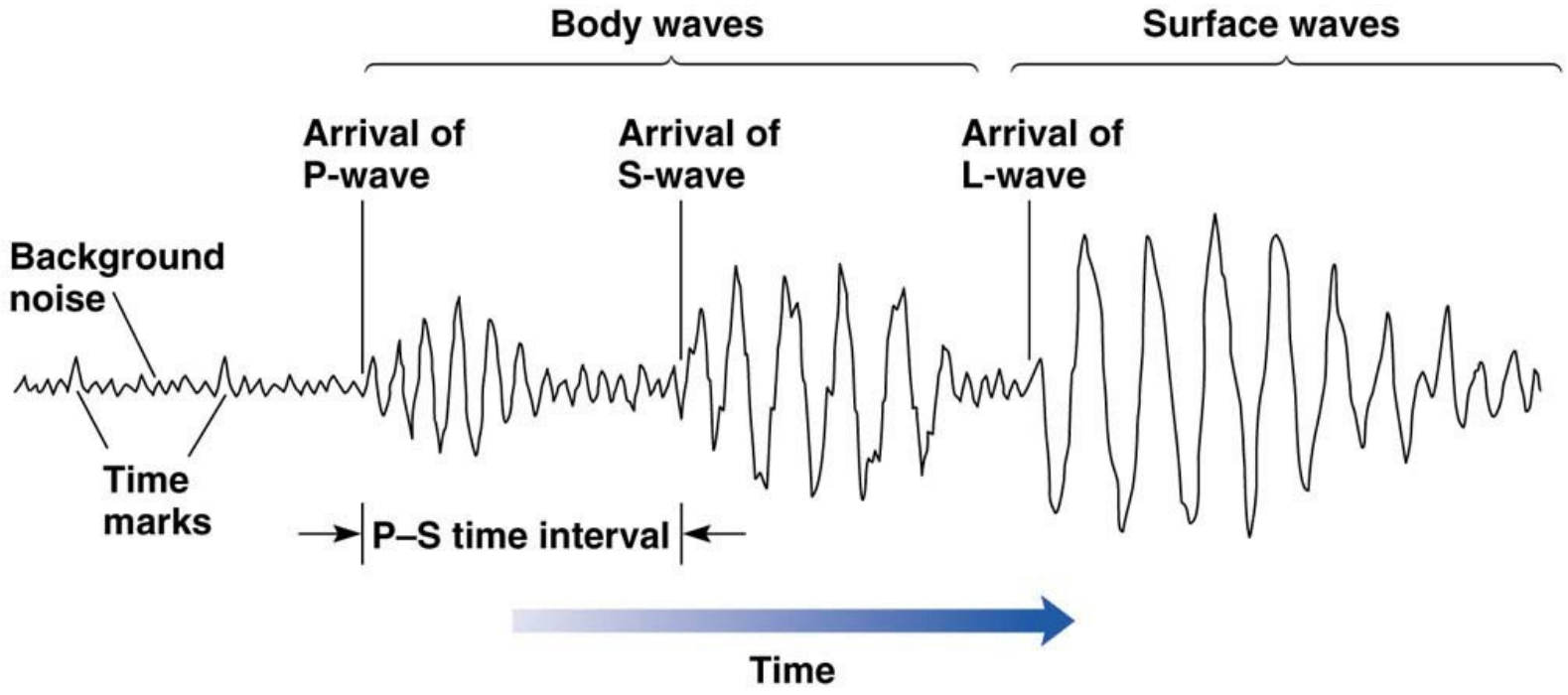


- **Surface Waves**
  - **Travel just below or along the ground's surface**
  - **Slower than body waves; rolling and side-to-side movement**
  - **Especially damaging to buildings**

How is an Earthquake's Epicenter Located?

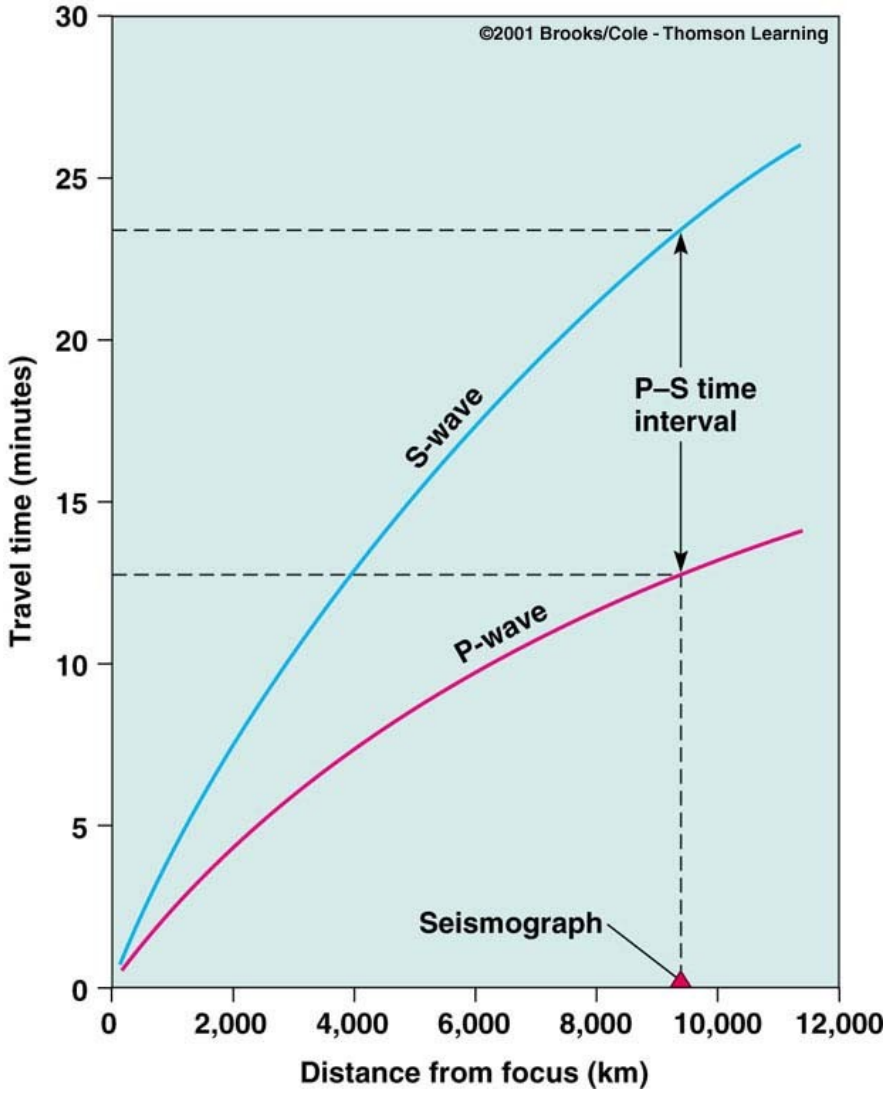
Seismic wave behavior

- **P waves arrive first, then S waves, then L and R**
- **Average speeds for all these waves is known**
- **After an earthquake, the difference in arrival times at a seismograph station can be used to calculate the distance from the seismograph to the epicenter.**



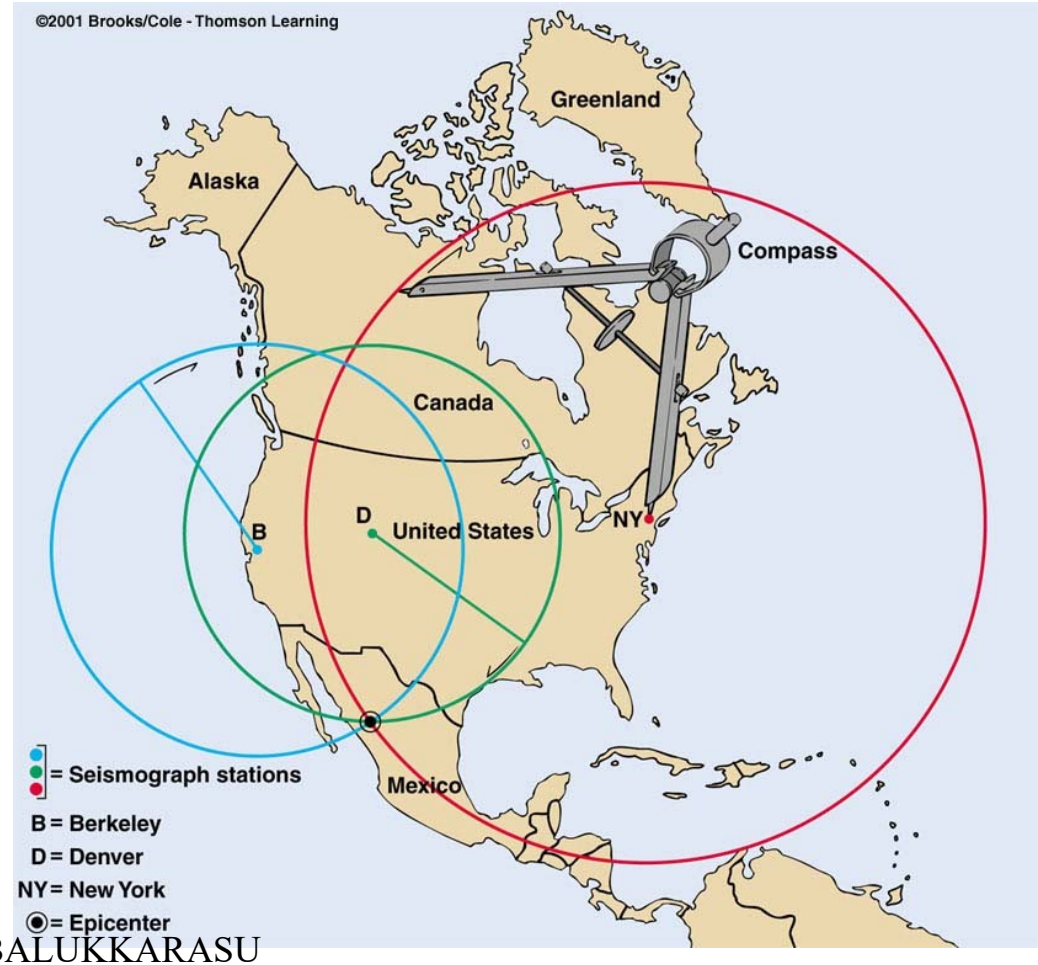
How is an Earthquake's Epicenter Located?

Time-distance graph showing the average travel times for P- and S-waves. The farther away a seismograph is from the focus of an earthquake, the longer the interval between the arrivals of the P- and S- waves

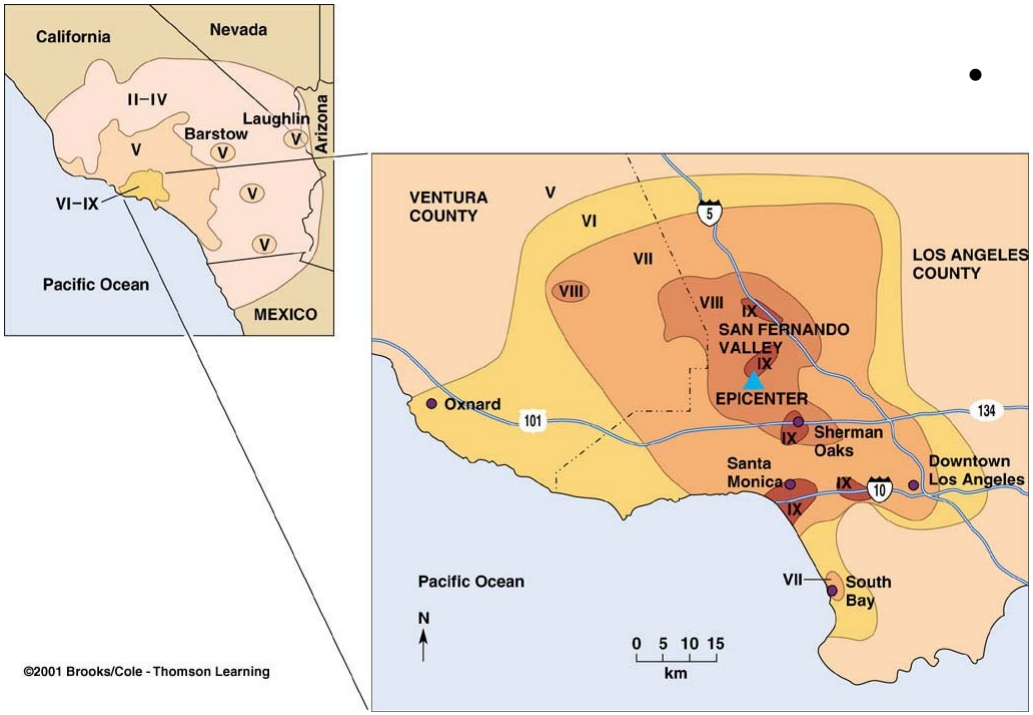


How is an Earthquake's Epicenter Located?

- Three seismograph stations are needed to locate the epicenter of an earthquake
- A circle where the radius equals the distance to the epicenter is drawn
- The intersection of the circles locates the epicenter



How are the Size and Strength of an Earthquake Measured?

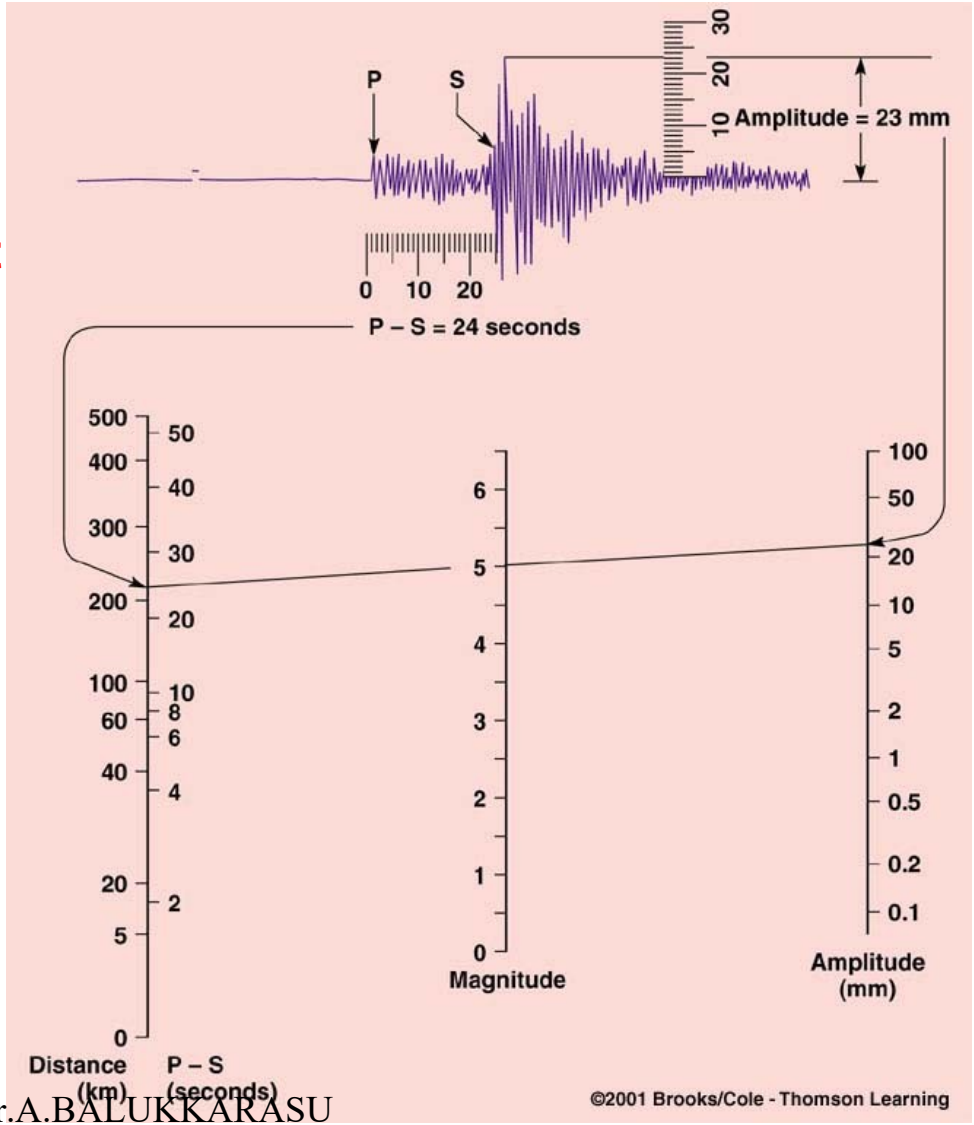


- **Intensity**
  - **subjective measure of the kind of damage done and people's reactions to it**
  - **isoseismal lines identify areas of equal intensity**

- **Modified Mercalli Intensity Map**
  - **1994 Northridge, CA earthquake, magnitude 6.7**

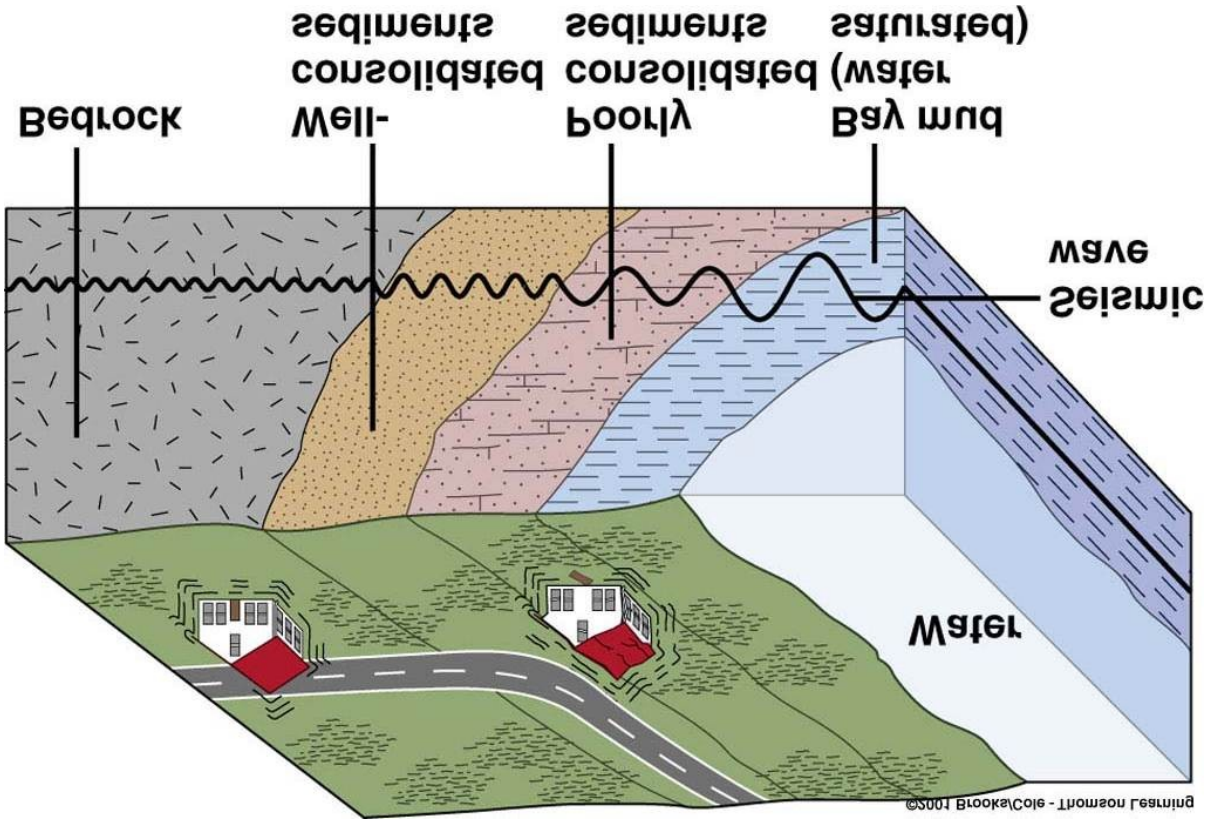
How are the Size and Strength of an Earthquake Measured?

- **Magnitude**
  - **Richter scale measures total amount of energy released by an earthquake; independent of intensity**
  - **Amplitude of the largest wave produced by an event is corrected for distance and assigned a value on an open-ended logarithmic scale**



What are the Destructive Effects of Earthquakes?

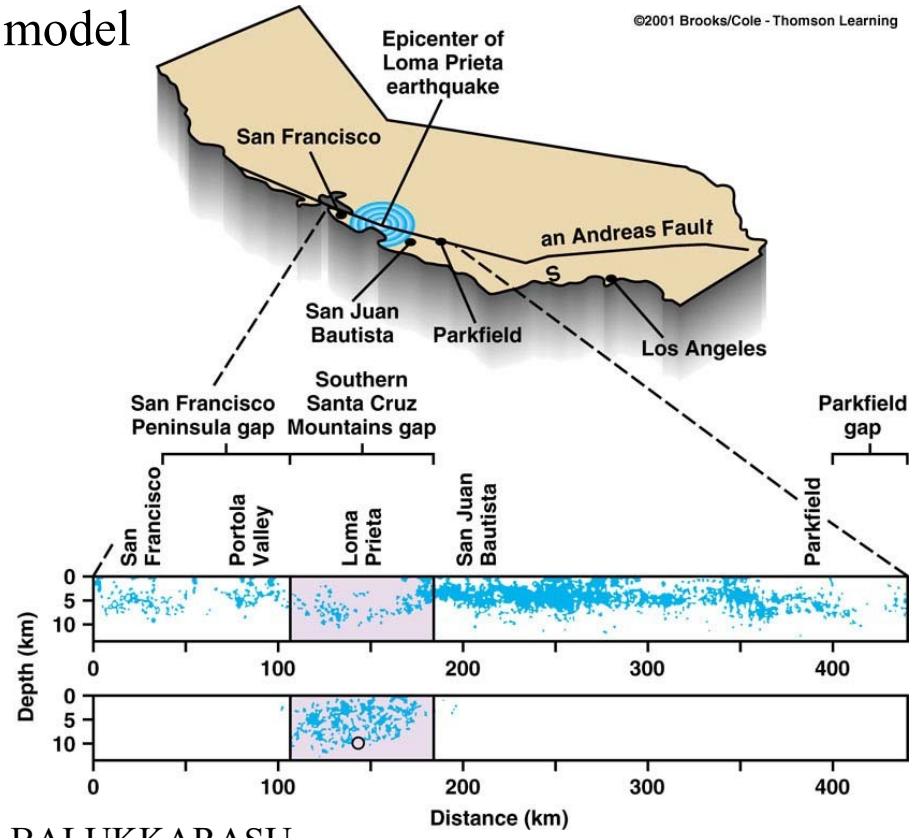
- **Ground Shaking**
  - **amplitude, duration, and damage increases in poorly consolidated rocks**



Can Earthquakes be Predicted?

Earthquake Precursors

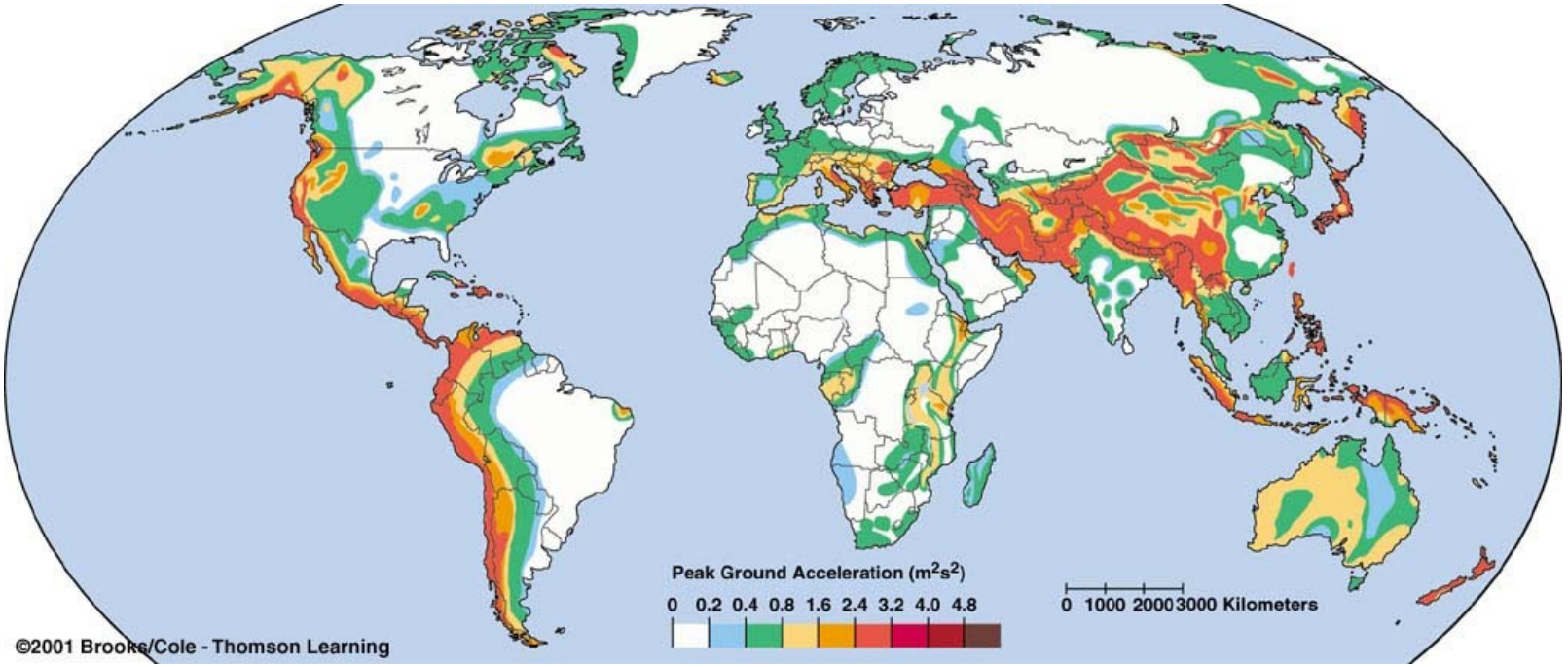
- changes in elevation or tilting of land surface, fluctuations in groundwater levels, magnetic field, electrical resistance of the ground
- seismic dilatancy model
- seismic gaps



Can Earthquakes be Predicted?

Earthquake Prediction Programs

- include laboratory and field studies of rocks before, during, and after earthquakes
- monitor activity along major faults
- produce risk assessments



Can Earthquakes be Controlled?

- Graph showing the relationship between the amount of waste injected into wells per month and the average number of Denver earthquakes per month
- Some have suggested that pumping fluids into seismic gaps will cause small earthquakes while preventing large ones