# EARTHQUAKE

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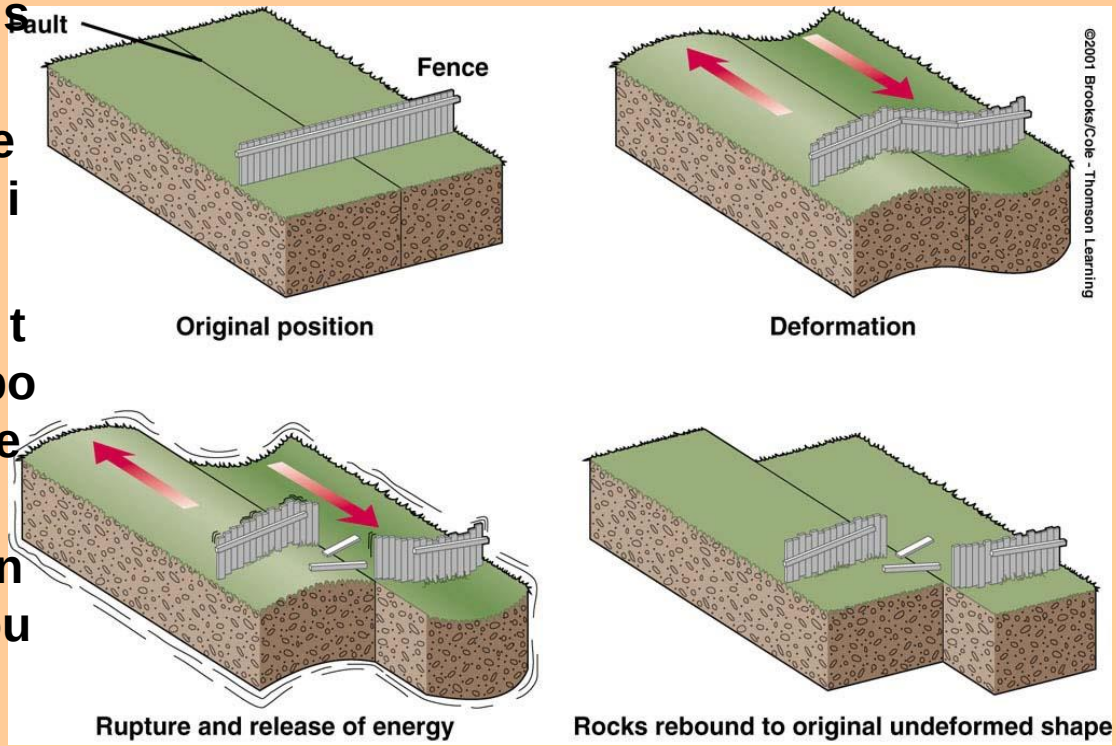
# What are Earthquakes?

- ***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***

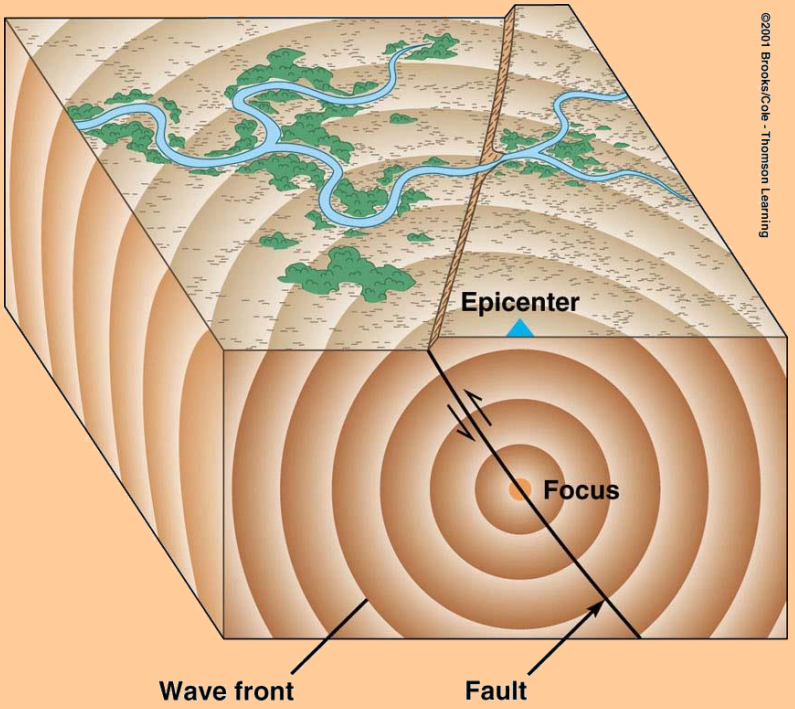
# What is the Elastic Rebound Theory?

- Explains how energy is s tored in rocks
  - Rocks bend until the strength of the rock i s exceeded
  - Rupture occurs and t he rocks quickly rebo und to an undeforme d shape
  - Energy is released in waves that radiate ou tward from the fault

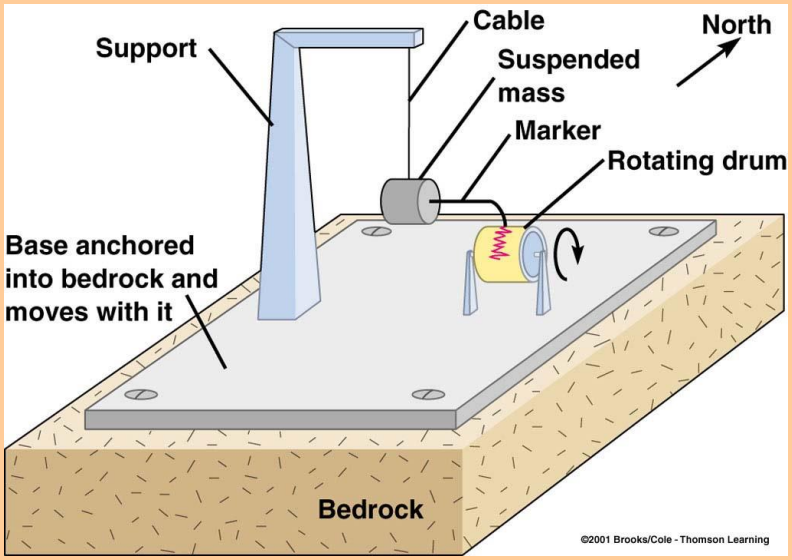


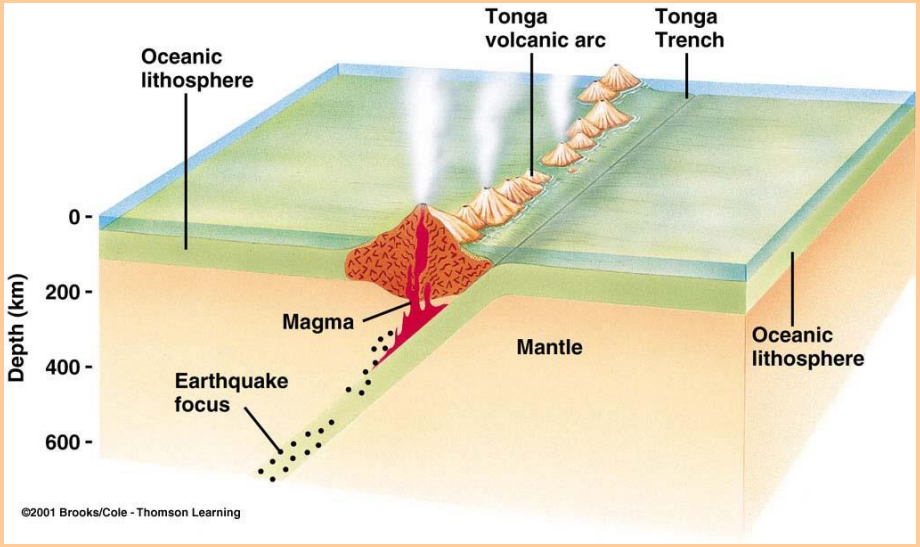
# The Focus and Epicenter of an Earthquake

- The point within Earth w here faulting begins is t he focus,
- The point directly above the focus on the surface is the epicenter



**Seismographs record earthqu ake events**



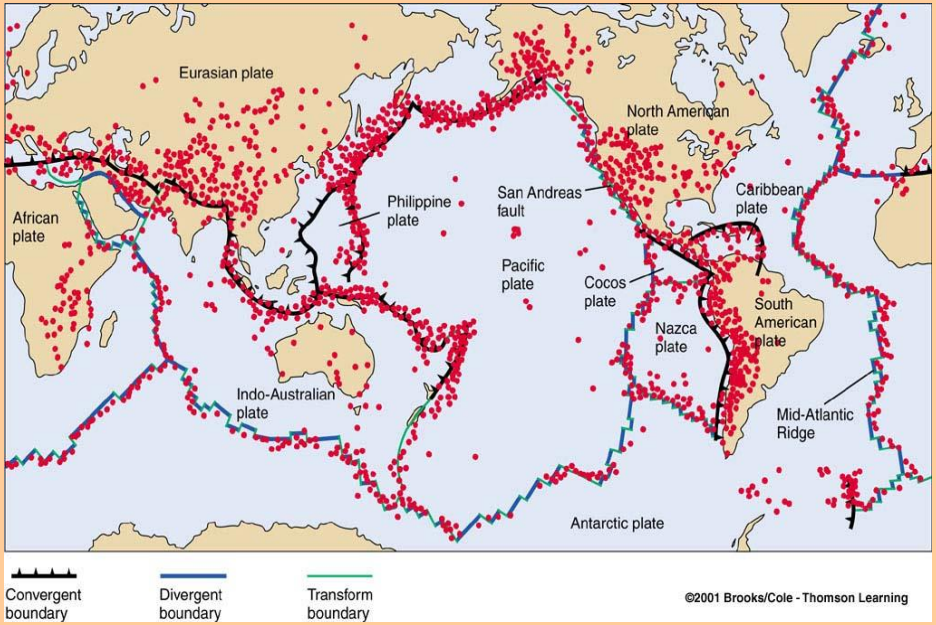




**At convergent boundaries, focal d epth increases along a dipping seismic zone called a Benioff z one**

# Where Do Earthquakes Occur and How Often?

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

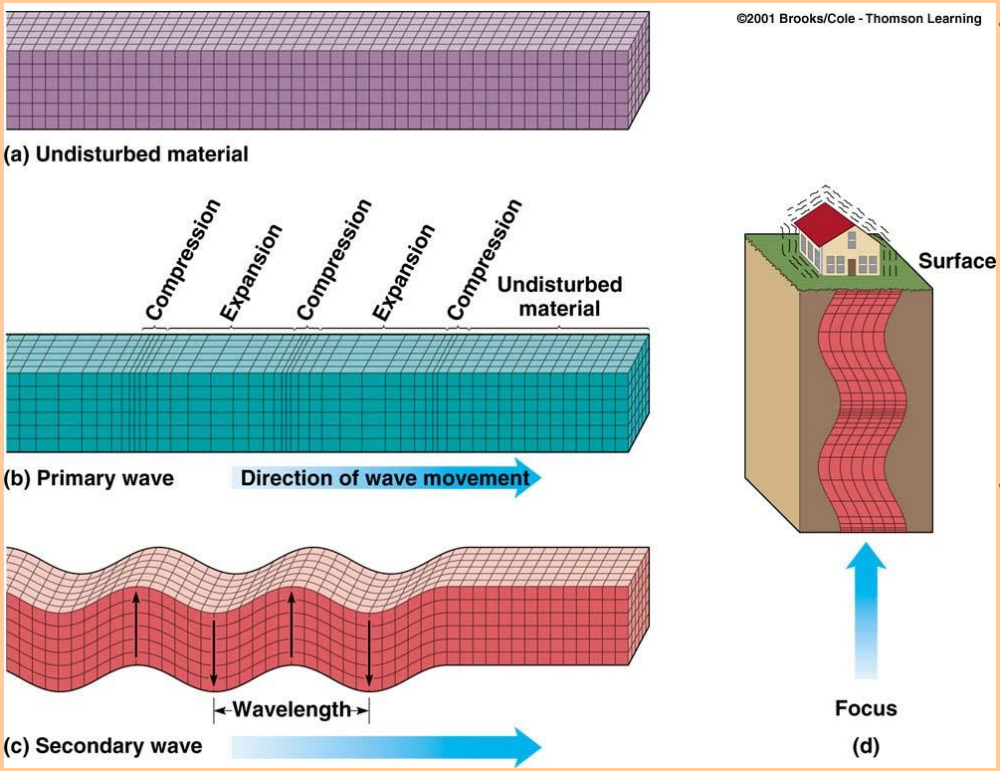
- **most of these result from convergent margin activity**
- **~15% occur in the Mediterranean-Asiatic belt**
- **remaining 5% occur in the interiors of plates and on spreadin g ridge centers**
- **more than 150,000 quakes strong enough to be felt are recor ded each year**



# *What are Seismic Waves ?*

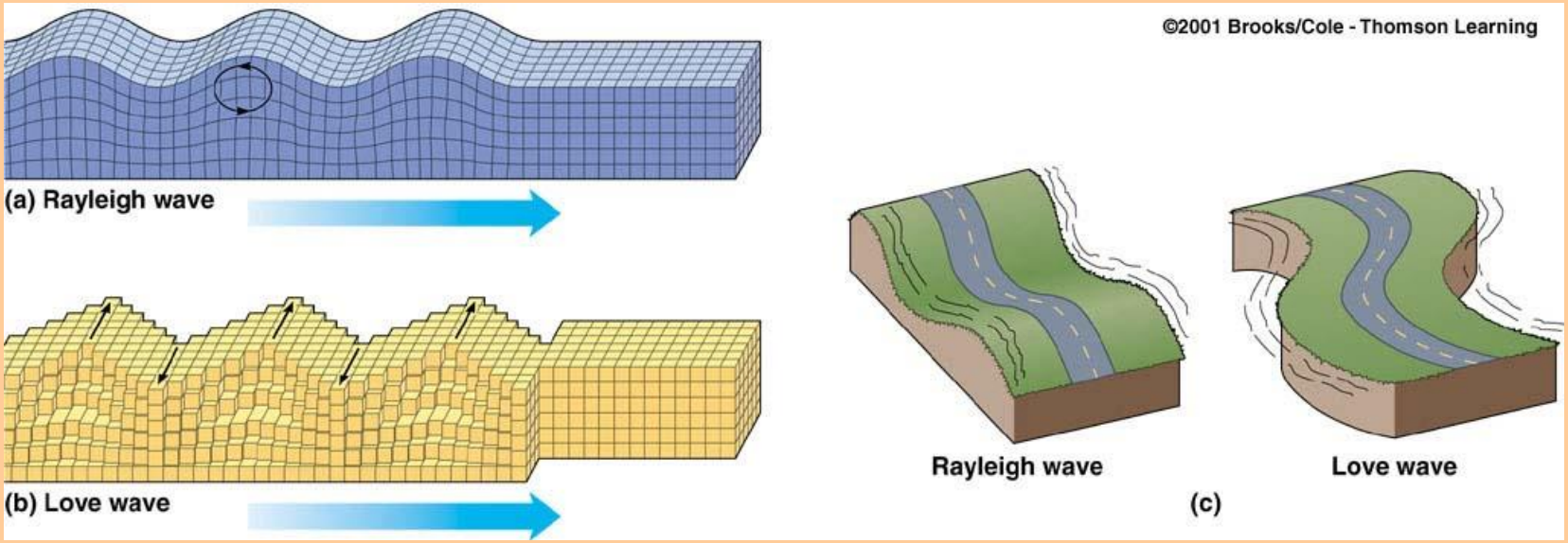
- Response of material to the arri val of energy fronts released by rupture
- Two types:
  - Body waves
    - P and S
  - Surface waves
    - R and L

# 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

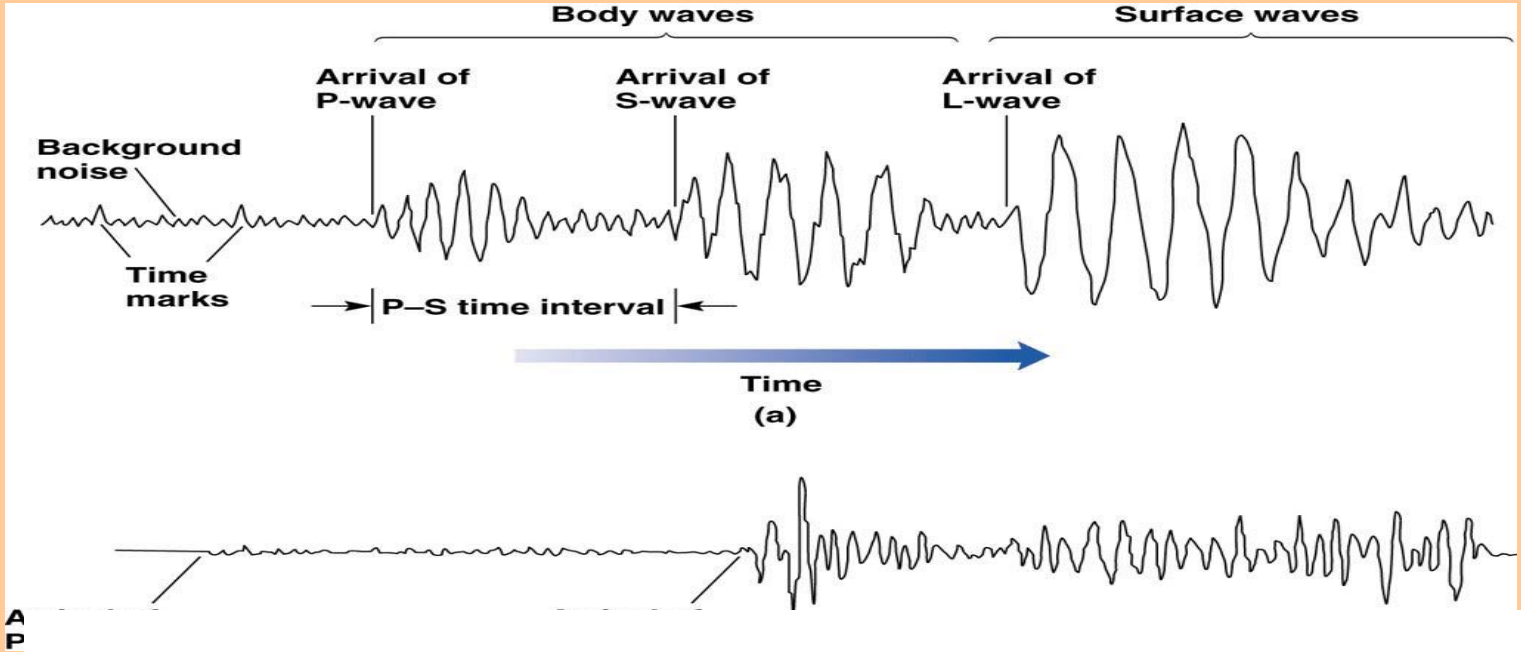



- **Surface Waves**
  - **Travel just below or along the ground's surface**
  - **Slower than body waves; rolling and side-to-side movement**
  - **Especially damaging to buildings**

# How is an Earthquake's Epicenter Located?

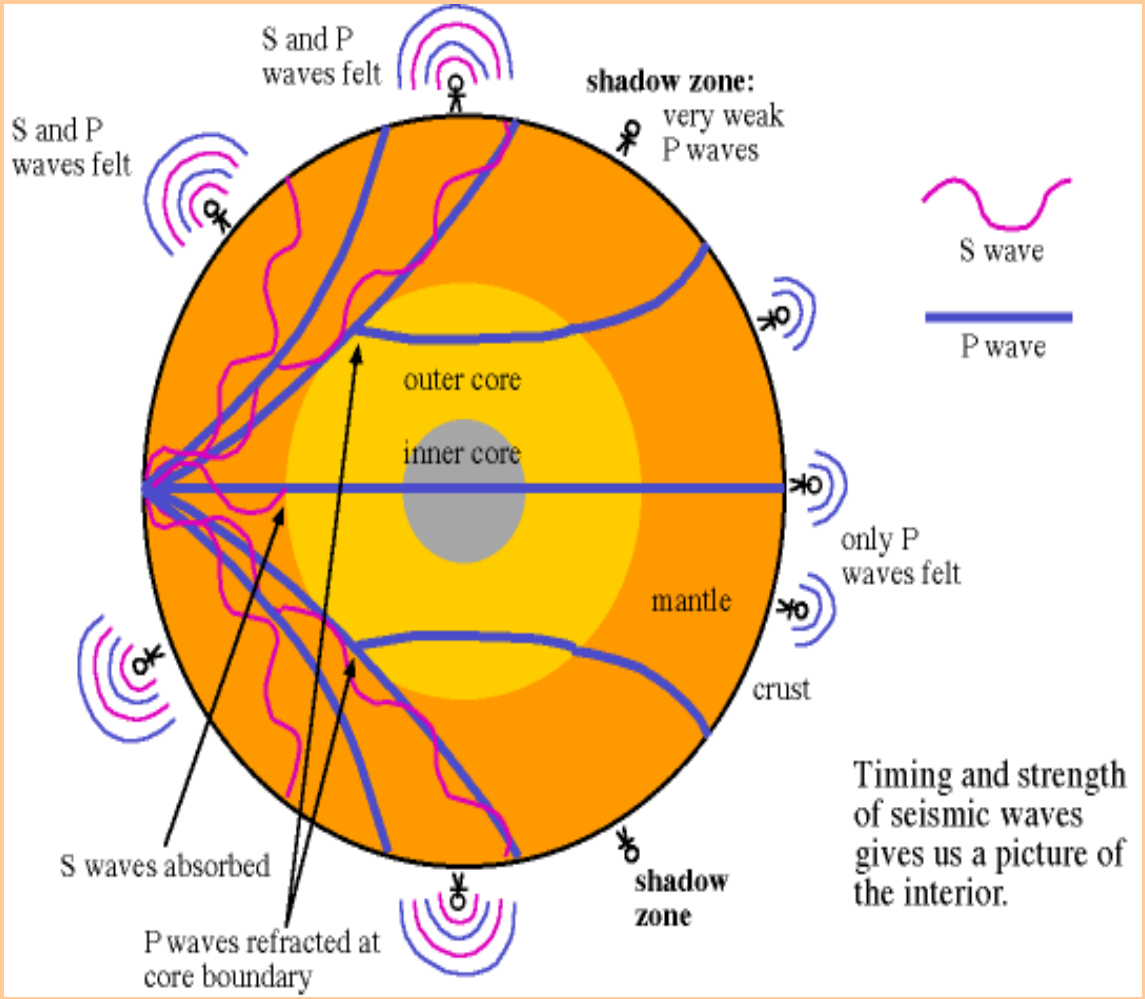
**Seismic wave behavior**

- **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 seis mograph station can be used to calculate the distance from the seismograph to the epicenter.**



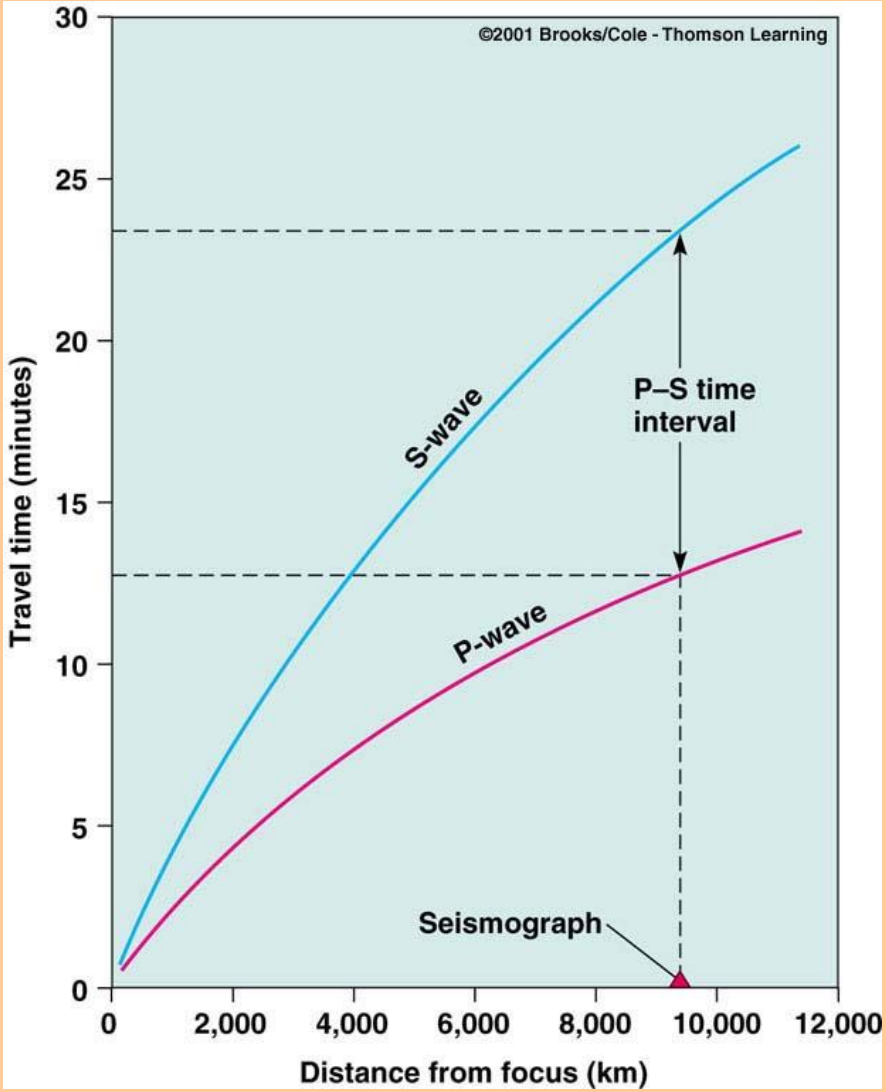
# Shadow Zones

- The shadow zone is the area of the earth from angular distances of 104 to 140
- The shadow zone results from S waves being stopped entirely by the liquid core and P waves being bent (refracted) by the liquid core.
- From the lack of S waves and a great slowing of the P wave velocity (by about 40%) it was deduced that the outer core is made of



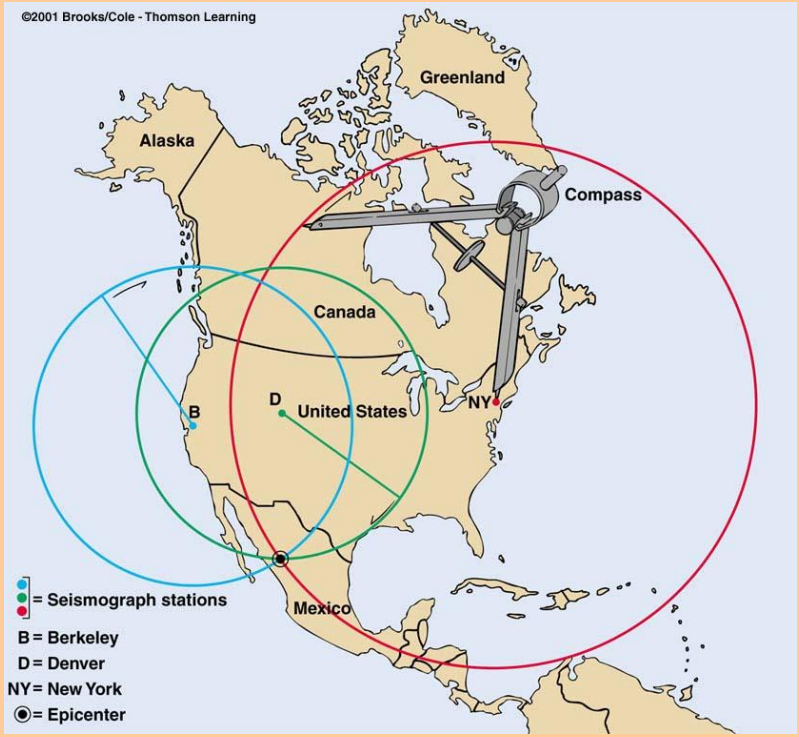
# How is an Earthquake's Epicenter Located?

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

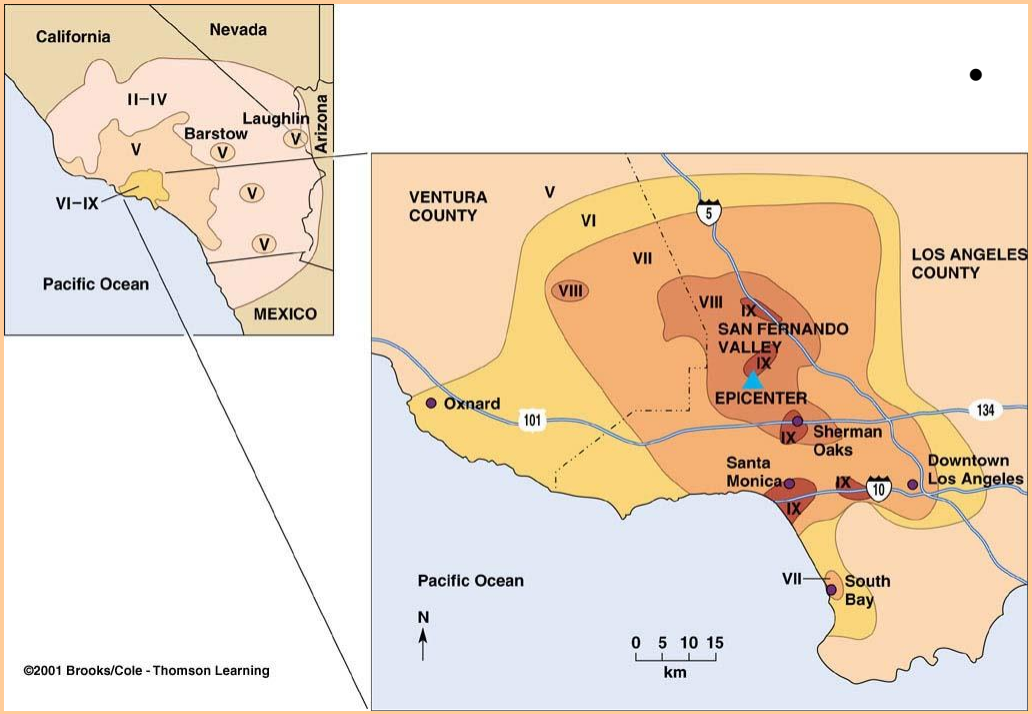


# How is an Earthquake's Epicenter Located?

- **Three seismograph stations are needed to locate the epi center of an earthquake**
- **A circle where the radius eq uals the distance to the epi center is drawn**
- **The intersection of the circl es locates the epicenter**



# How are the Size and Strength of an Earthquake Measured?

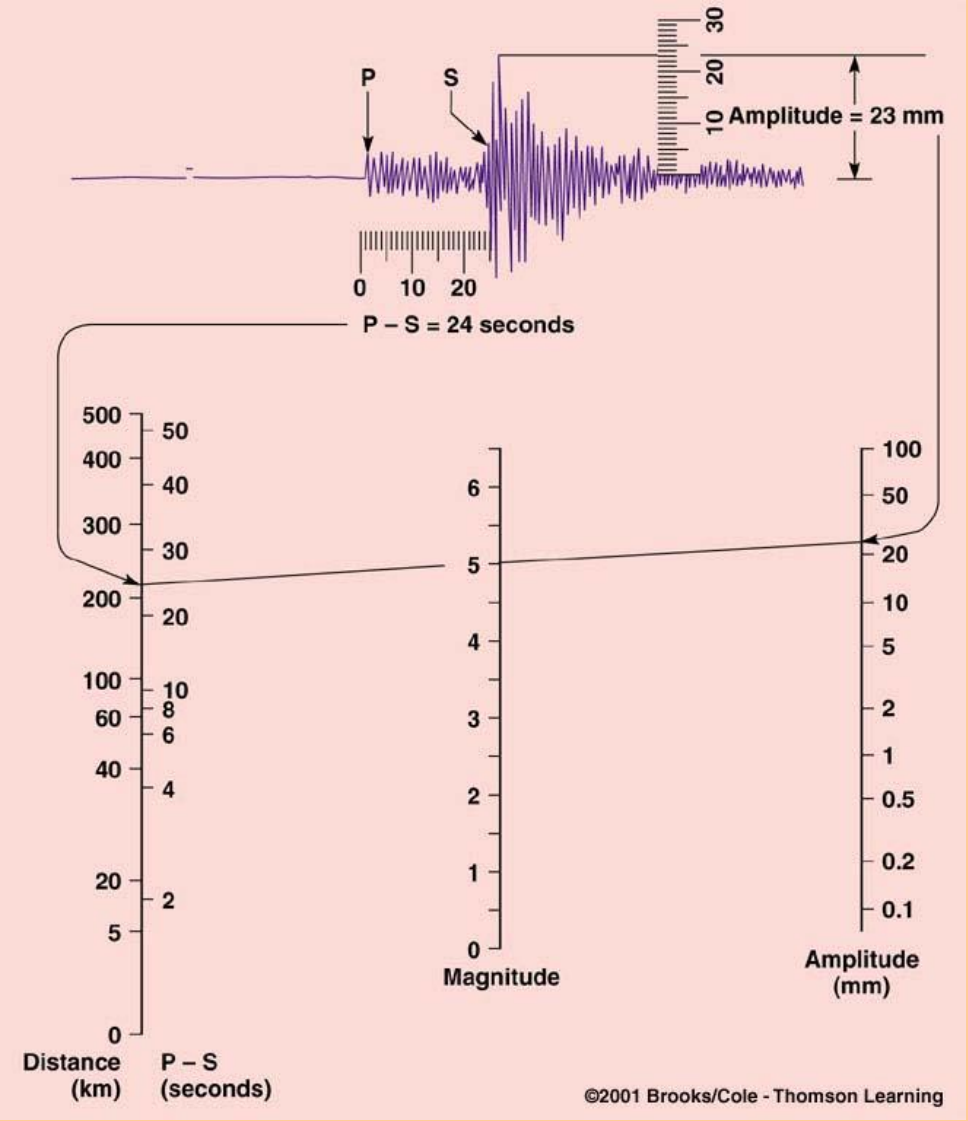



- **Intensity**
  - **subjective measure of the kind of damage done and people's reactions to it**
  - **isoseismal lines identify areas of equal intensity**

- **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**



# Richter vs Mercalli

## 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.

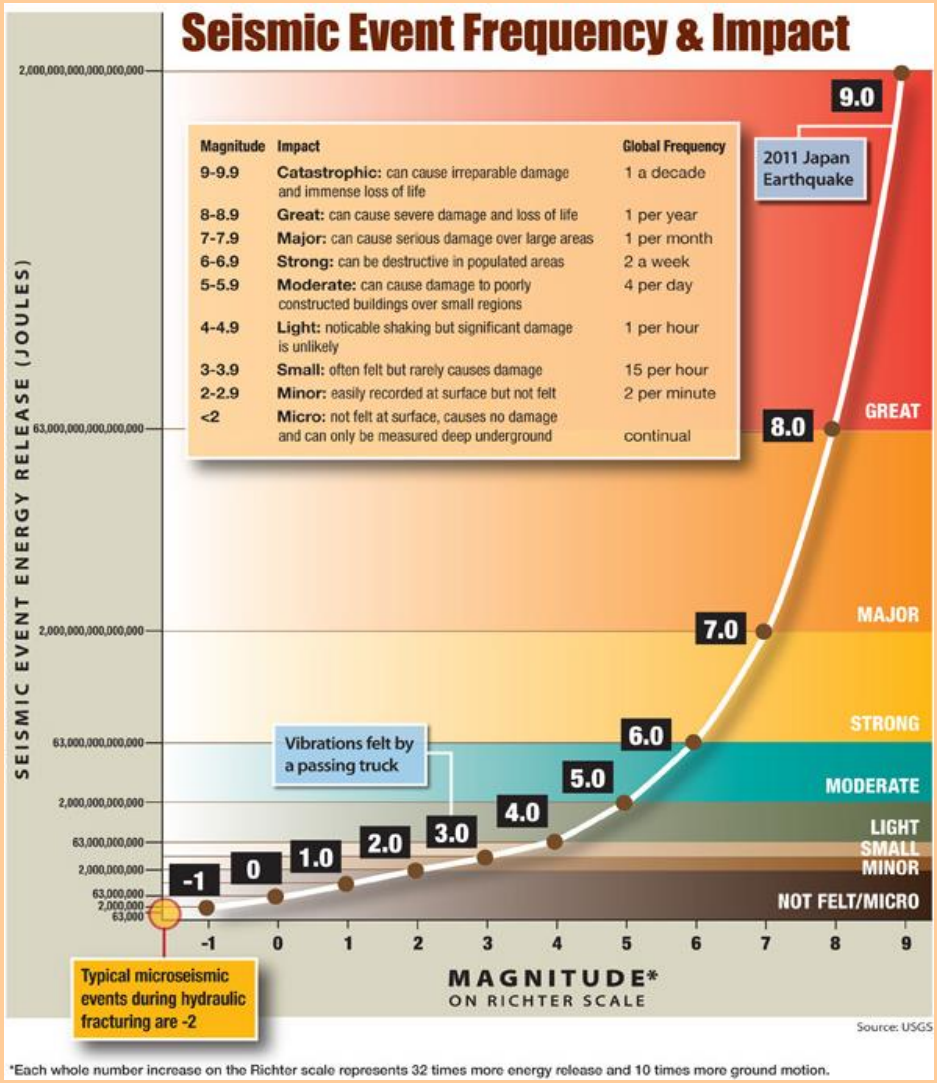
VIII. Partial collapse of masonry. Frame houses moved.

IX. Masonry seriously damaged or destroyed.

X. Many buildings and bridges destroyed.

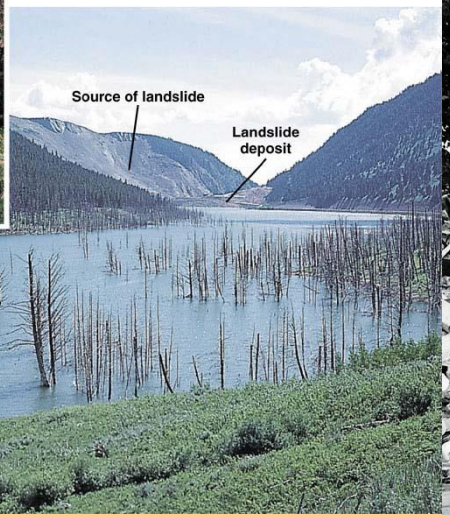
XI. Rails bent greatly. Pipelines severely damaged.

XII. Damage nearly total.



# The Economics and Societal Impacts of EQs

- Building collapse
- Fire
- Tsunami
- Ground failure

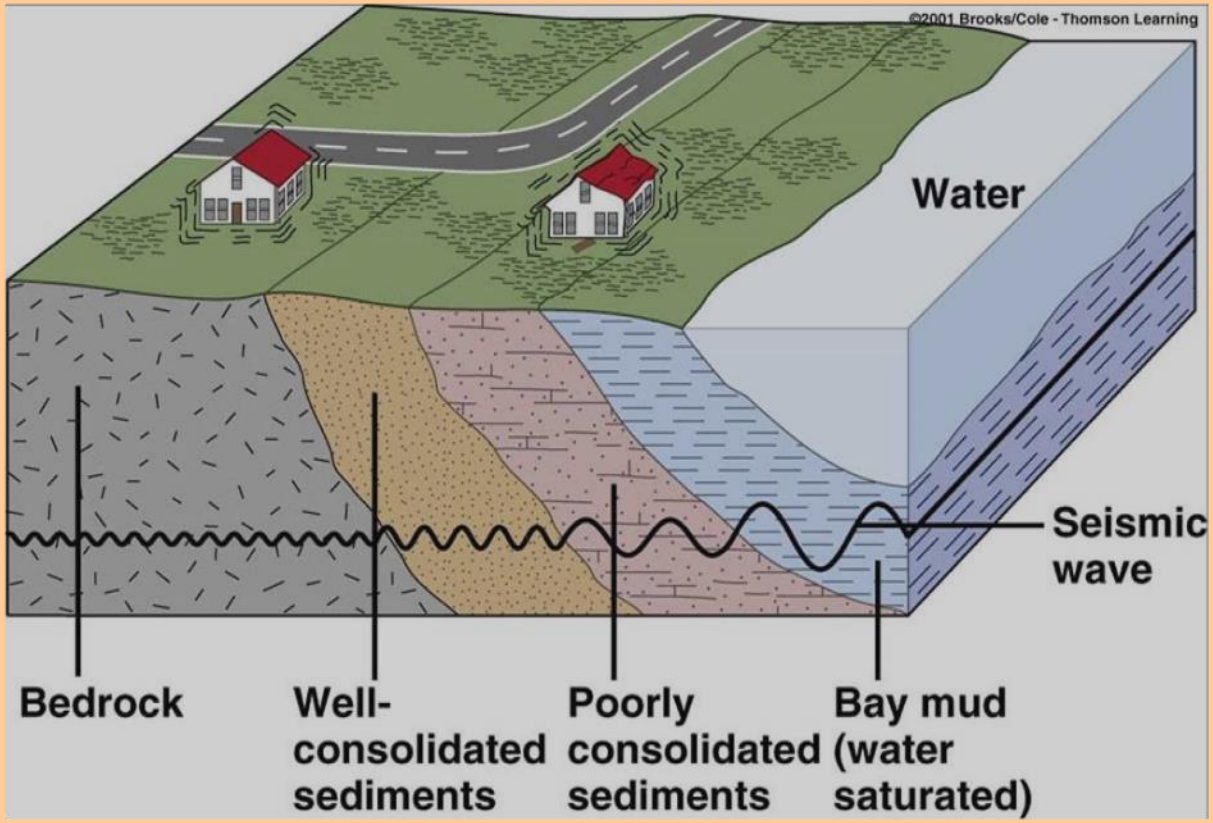








# What are the Destructive Effects of Earthquakes?

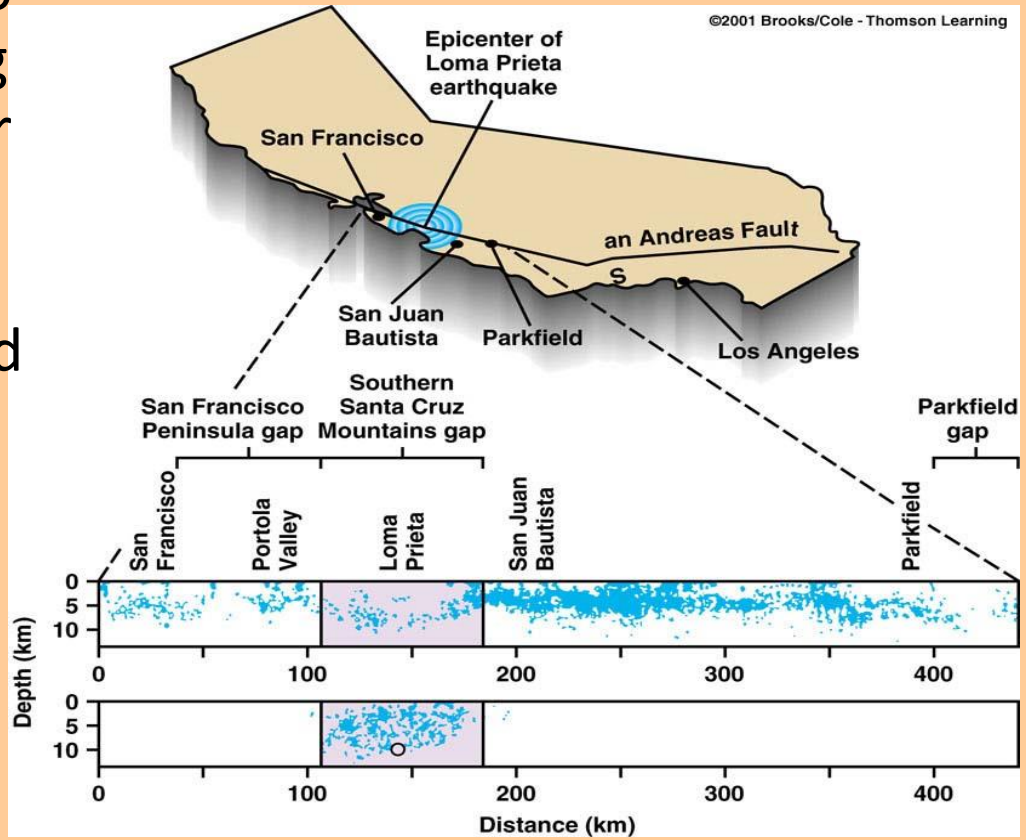
- **Ground Shaking**
  - **amplitude, duration, and damage increases in poorly con solidated rocks**



# Can Earthquakes be Predicted?

Earthquake Precursors

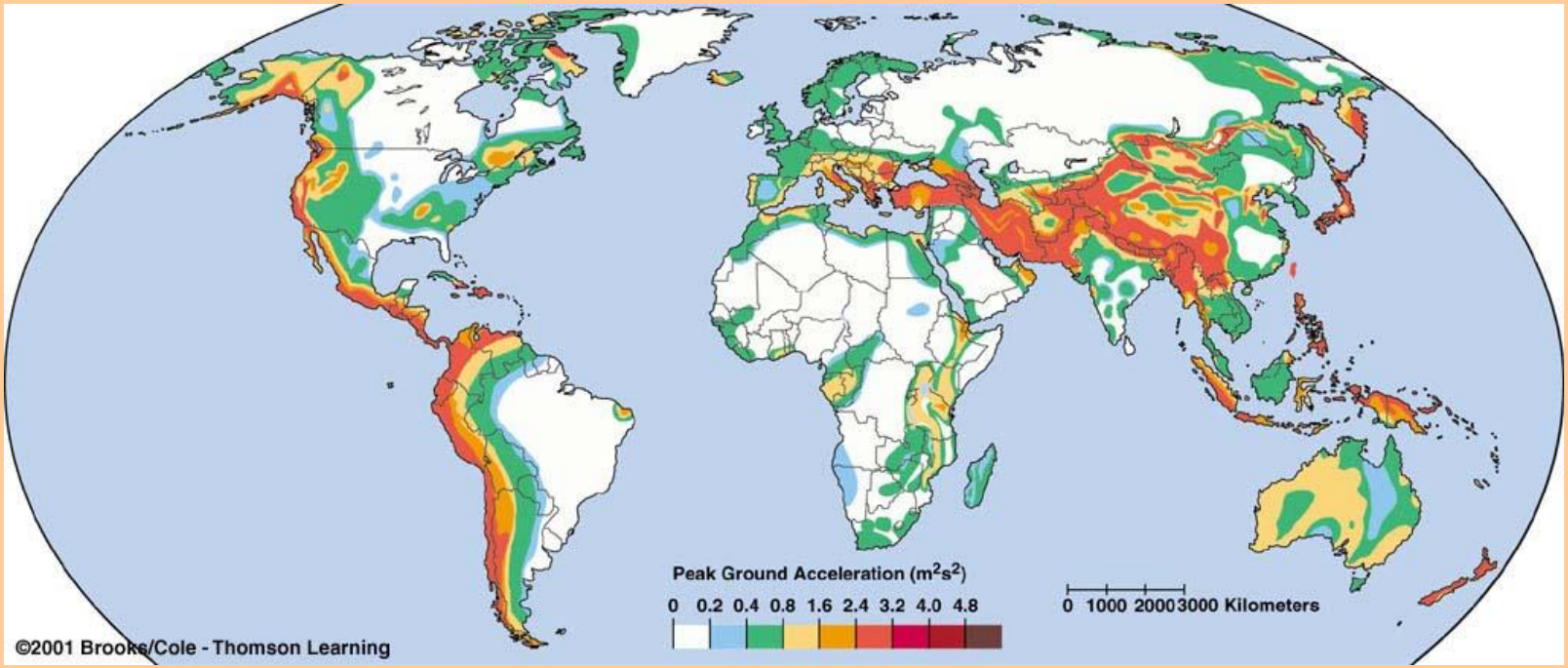
- changes in elevation or tilting of land surface, fluctuations in groundwater levels, magnetic field, electrical resistance of the ground
- seismic dilatancy model
- seismic gaps



# Can Earthquakes be Predicted?

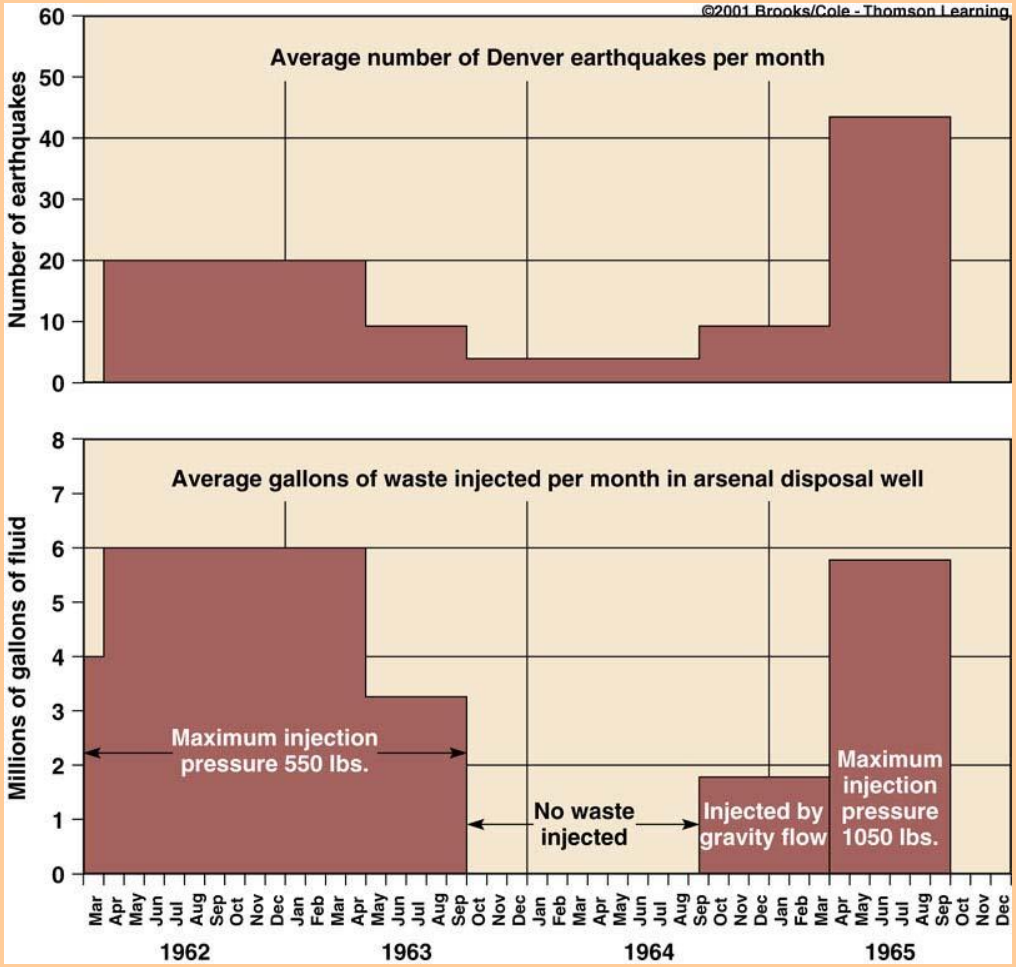
**Earthquake Prediction Programs**

- **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




Thank You!