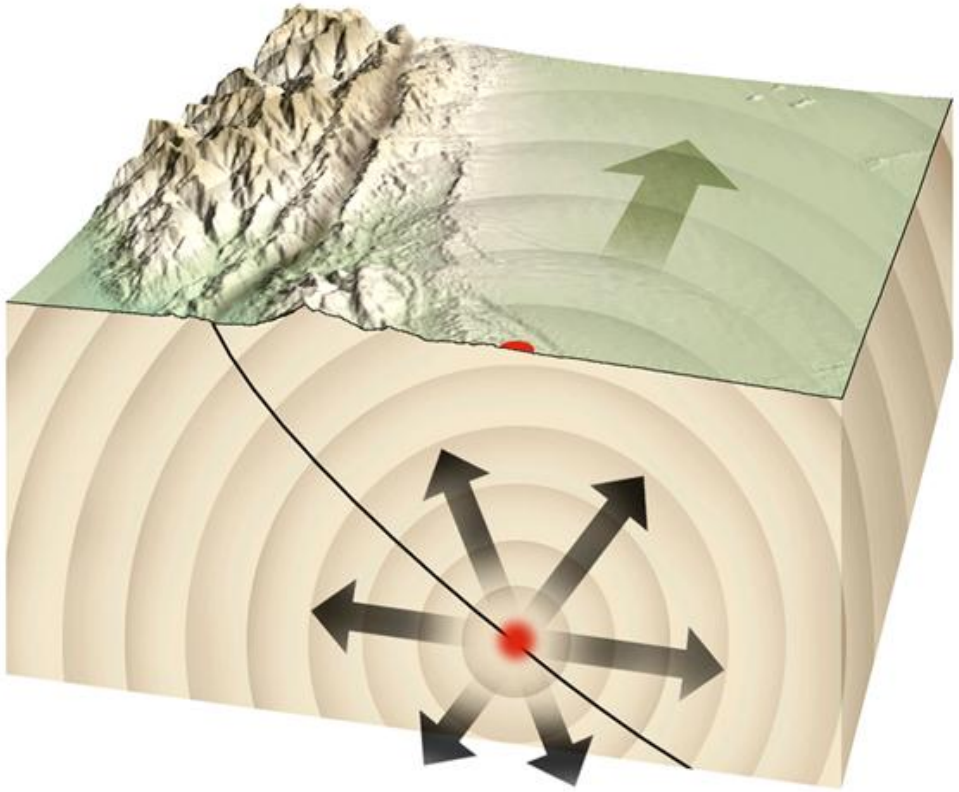
Earthquake



Guest Lecture by:

Muhammad Haroon

Assistant Professor
Head of the Department
Civil Engg. Department

Outline

- What is an Earthquake?
- Cause of Earthquake
- Measuring Earthquake
  - Earthquake's Epicenter Located?
  - Size and Strength of an Earthquake Measured?
- Destruction from Earthquake
- Earthquake Prediction
- Remedial Measures
- Case Studies

Field Tectonic Studies

- Many tectonic problems are approached by studying structures at outcrop scale, and smaller (microscopic) or larger (100's to 1000's of km) scales

- Systematically observe/record the patterns of rock structures (e.g., fault, fold, foliation, fracture). This gives the geometry of the structures.

Tectonics vs. Structural Geology

- Both are concerned with the reconstruction of the motions that shape the outer layers of earth
- Both deal with motion and deformation in the Earth's crust and upper mantle
- Tectonic events at all scales produce deformation structures
- These two disciplines are closely related and interdependent

Applications of Structural Geology

- Engineering Issues
  - Bridges
  - Dams
  - Power Plants
  - Highway Cuts
  - Large Buildings
  - Airports

Applications of Structural Geology

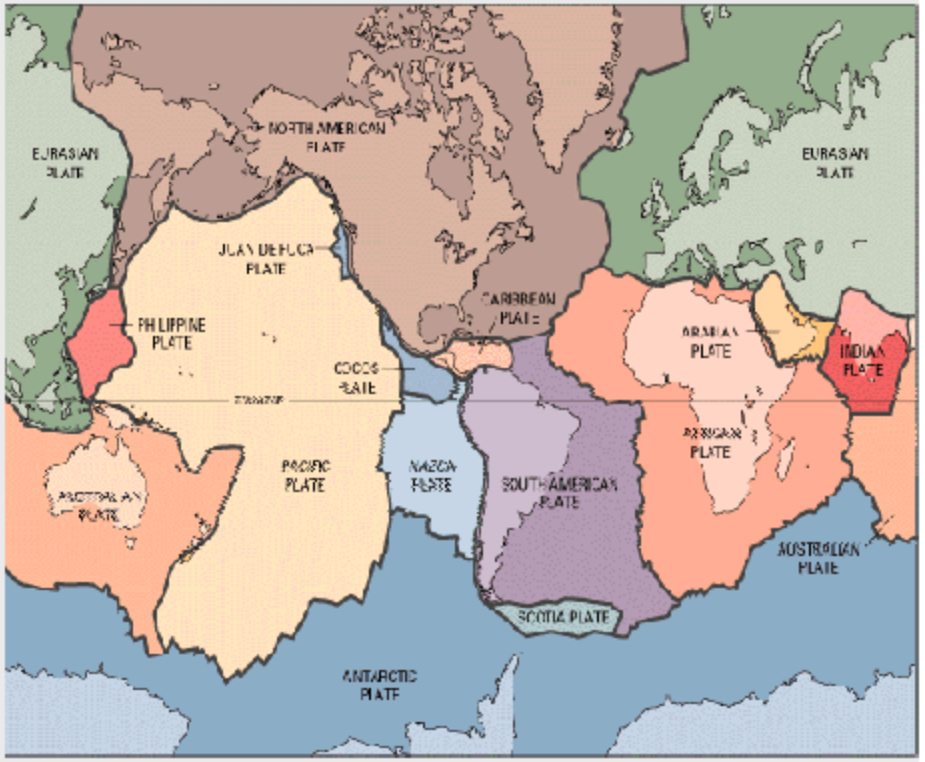
- Environmental Issues
  - Earthquake hazard
  - Location of landfill sites
  - Contamination cleanup
  - Distribution of groundwater
  - Mineral exploration

Scale in Structural Geology

- **Microscopic** – Need magnification
  - Foliation, Micro folds
- **Mesoscopic** – Hand specimens and outcrops
  - Foliation, Folds, Faults
- **Macroscopic** – Mountainside to map levels
  - Basins, domes, Metamorphic Core Complexes

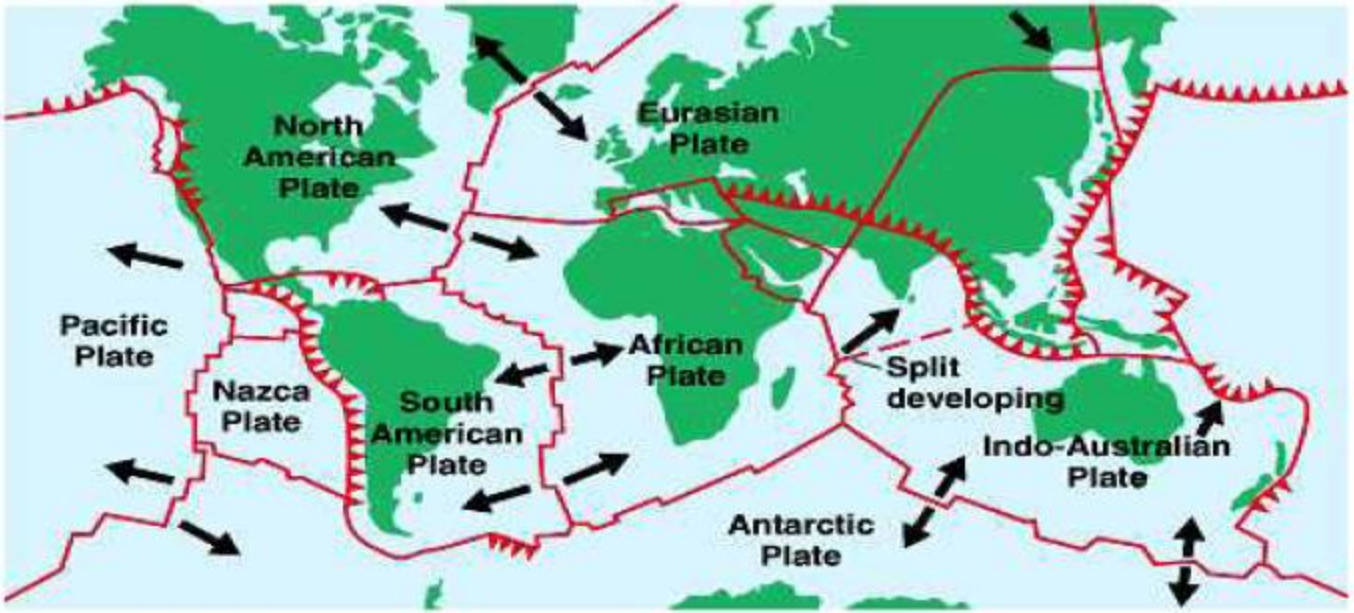
Plate Tectonics

- Theory of Plate Tectonics
  - The surface of the Earth is composed of about a dozen major rigid, moving crustal plates and several smaller plates
  - **Continental Drift** – states that the continents have drifted and still are drifting apart.

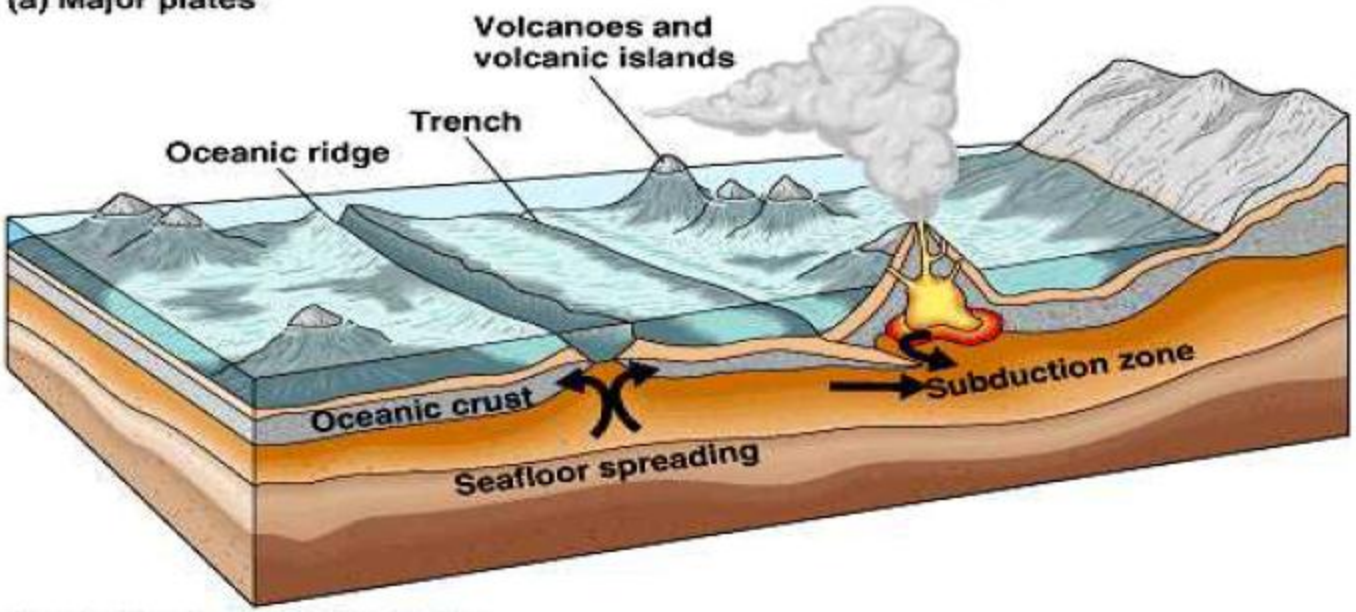


Why do the plates move?

1. Due to tremendous heat, rock in the asthenosphere is like hot taffy
2. This allows plates to ride on top of hot, flowing rock.
3. Plates move because heat is being released from deep inside the earth.
4. Convection currents causes hot material to rise and expand (plates diverge) and cooler material to sink and contract (plates converge).



(a) Major plates



(b) Events at plate boundaries

What Is an Earthquake?

Earthquakes

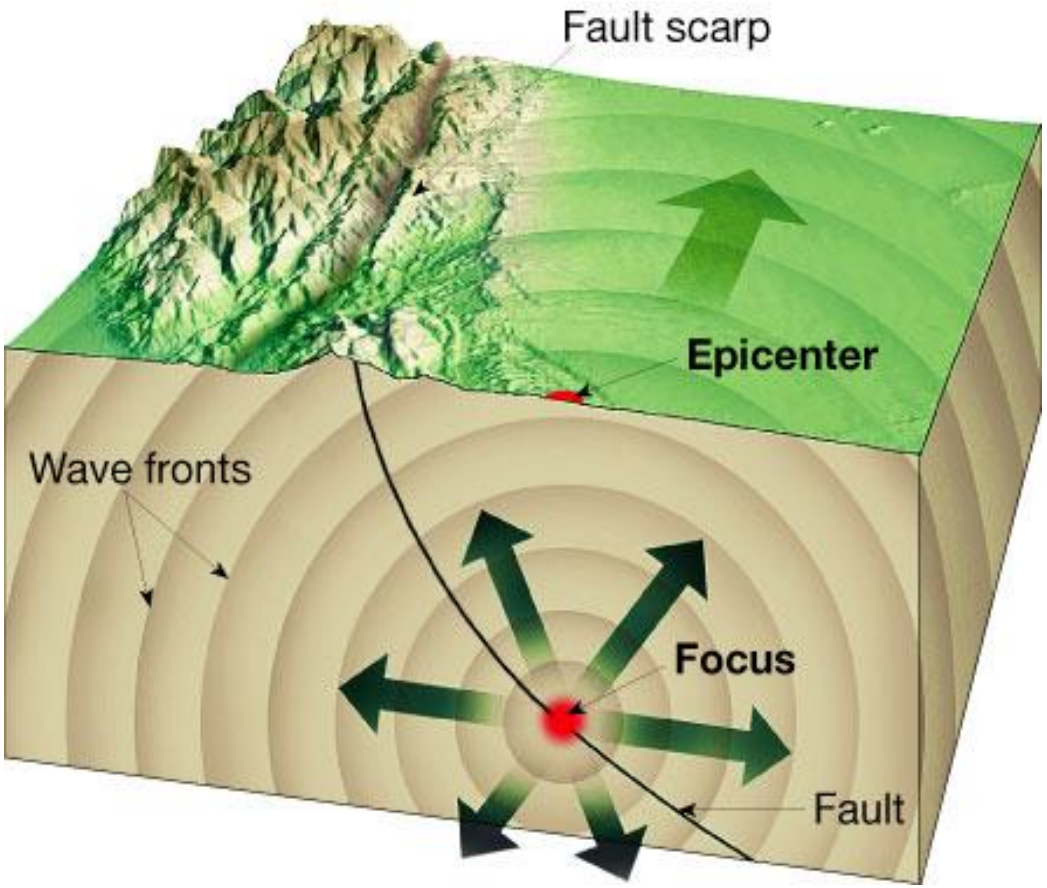
- An **earthquake** is the vibration of Earth produced by the rapid release of energy

FOCUS AND EPICENTER

Focus and Epicenter

- **Focus** or **hypocenter** is the point within Earth where the earthquake starts.
- **Epicenter** is the location on the surface directly above the focus.

Focus, Epicenter, and Fault



Cause of Earthquakes

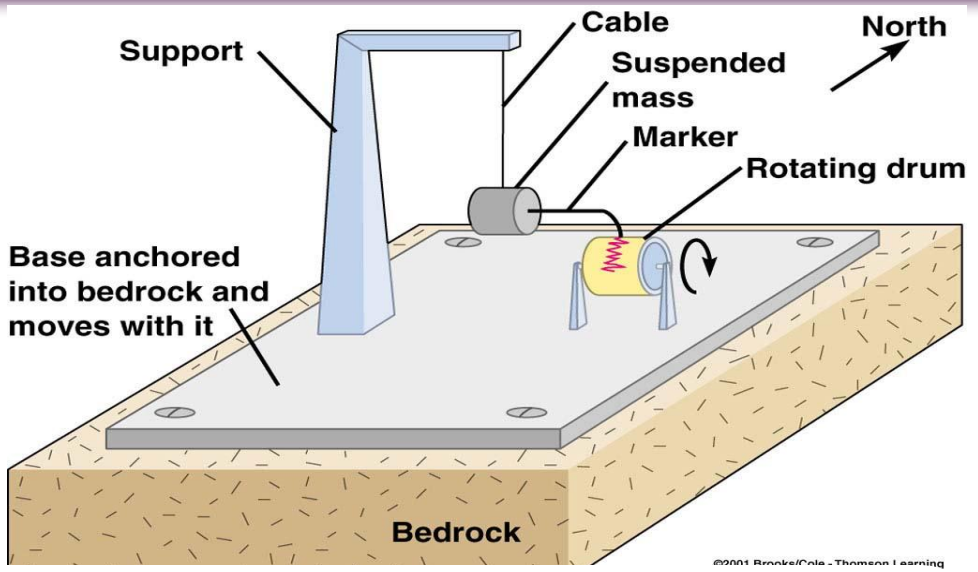
Aftershocks and Foreshocks

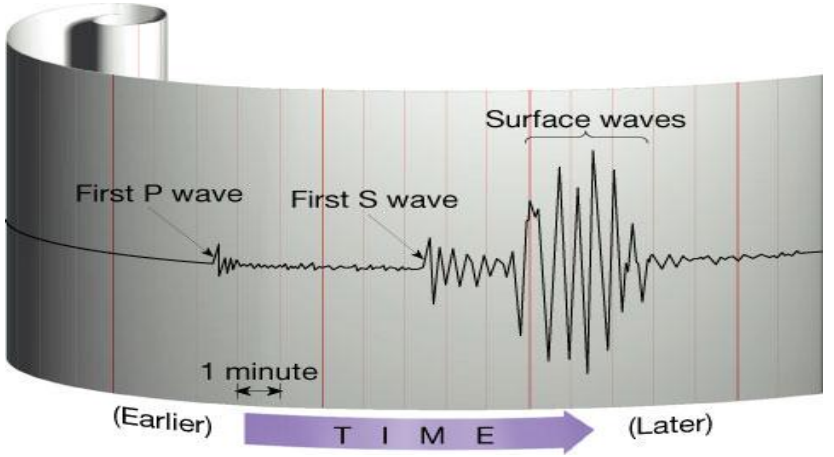
- An **aftershock** is a small earthquake that follows the main earthquake. Continuing adjustment of position results in aftershocks.
- A **foreshock** is a small earthquake that often precedes a major earthquake.

Measuring Earthquakes

Earthquake Waves

- **Seismographs** are instruments that record earthquake waves.
- **Seismograms** are traces of amplified, electronically recorded ground motion made by seismographs.





Measuring Earthquakes

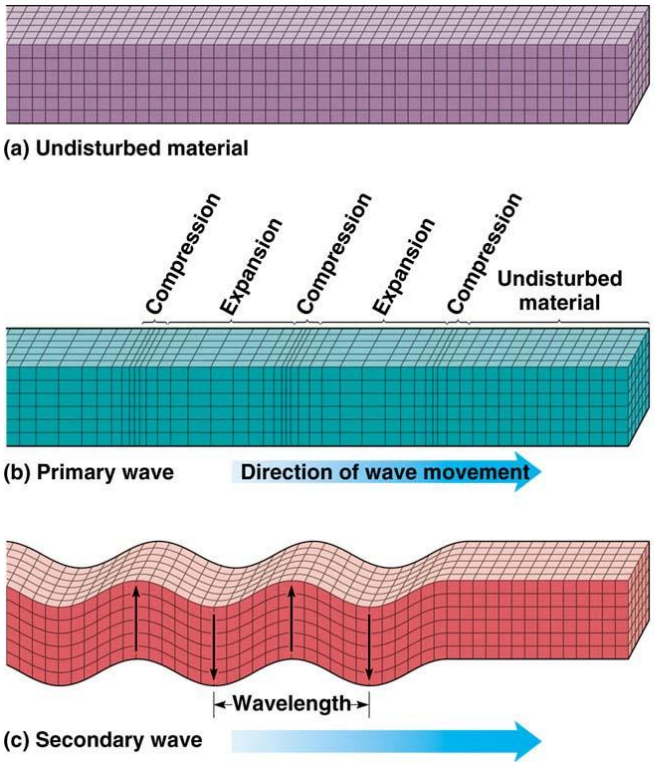
What are Seismic Waves?

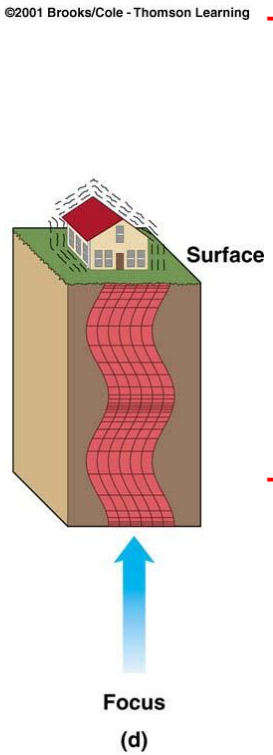
Response of material to the arrival of energy fronts released by rupture

Body Waves: P and S waves

Surface Waves: R and L waves

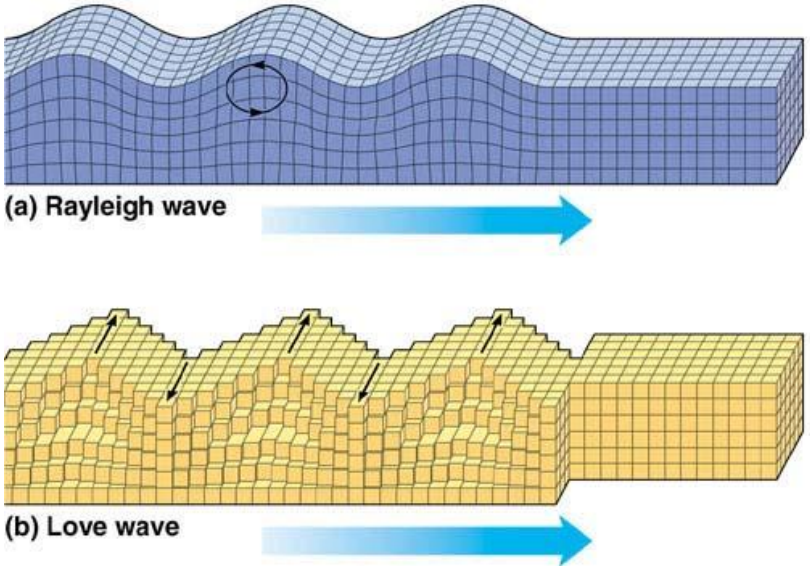
Body Waves: P and S waves

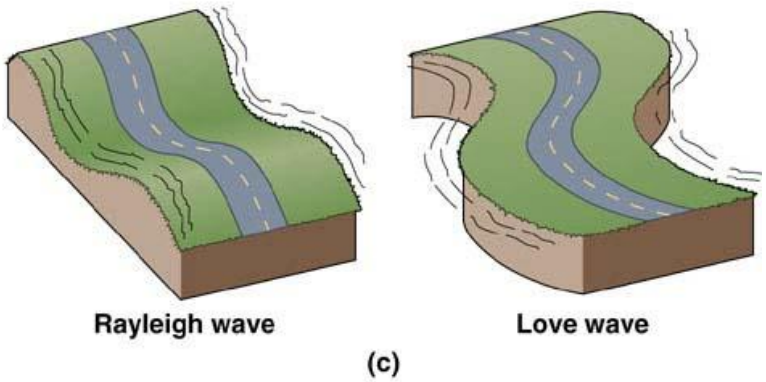




- Body waves
  - P or primary waves
    - fastest waves
    - travel through solids, liquids, or gases
    - compressional wave, material movement is in the same direction as wave movement
  - S or secondary waves
    - slower than P waves
    - travel through solids only
    - shear waves - move material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

Surface Waves: R and L waves



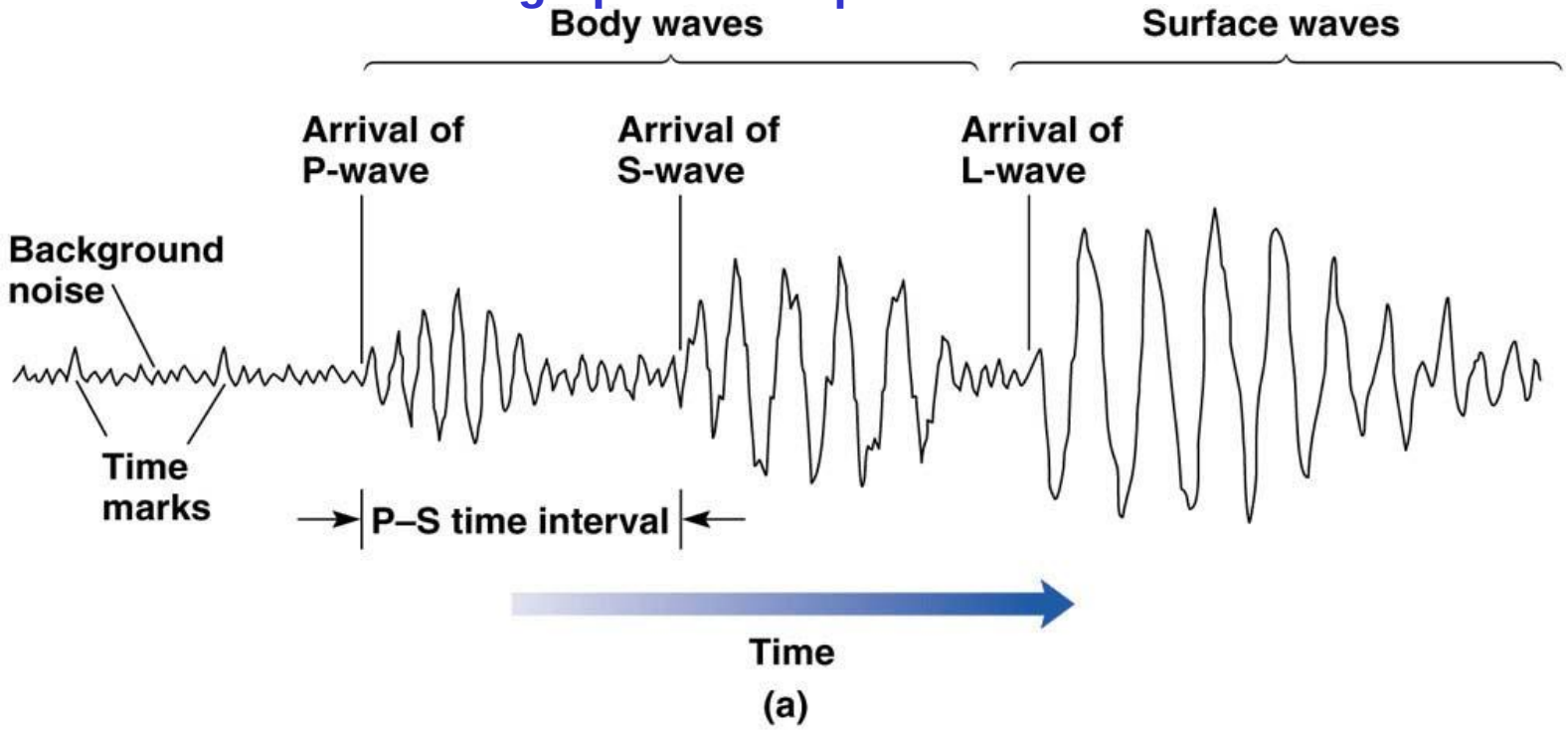


- **Surface Waves**
  - **Travel just below or along the ground's surface**
  - **Slower than body waves; rolling and side-to-side movement**
  - **Especially damaging to buildings**

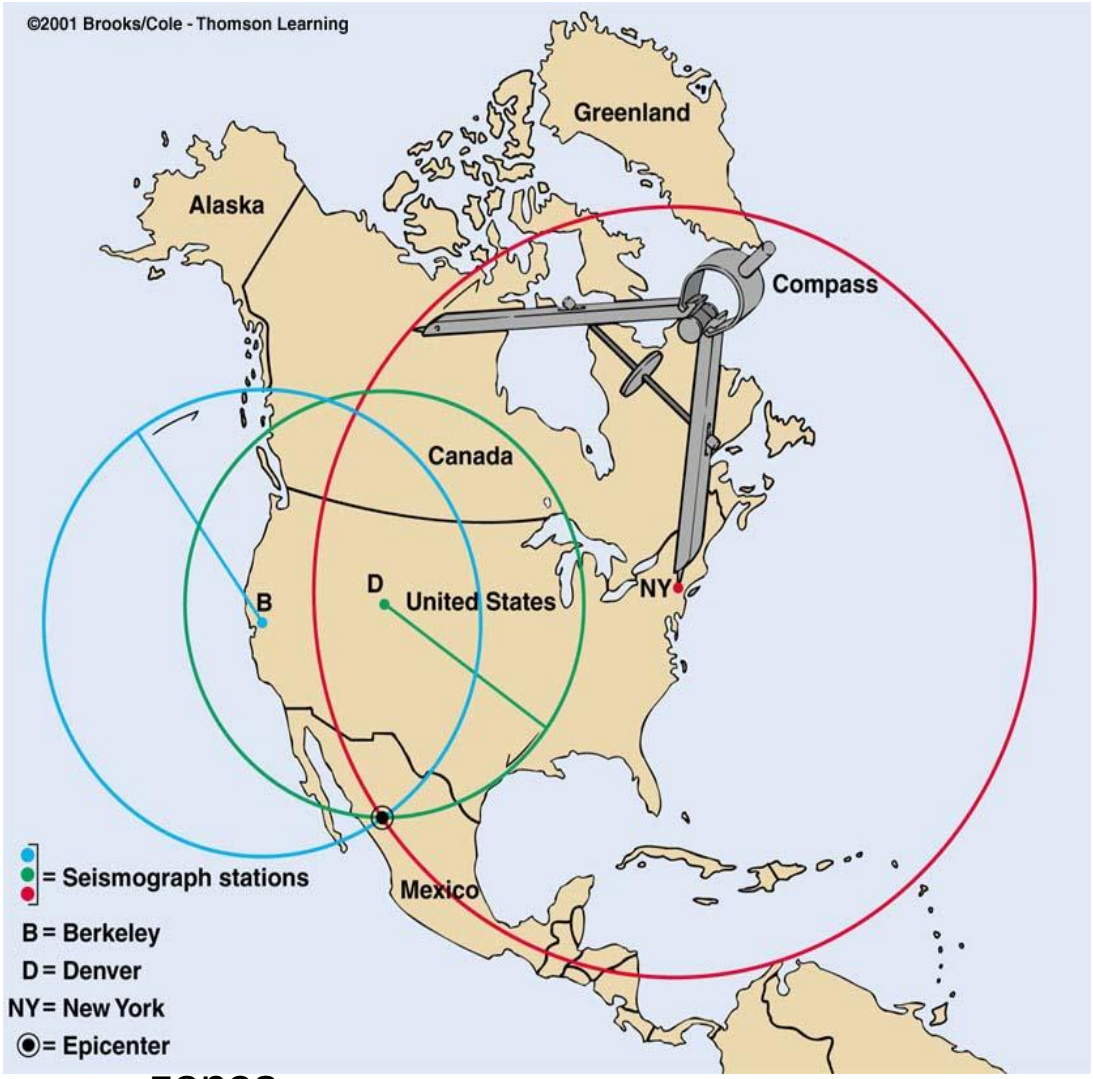
How is an Earthquake's Epicenter Located?

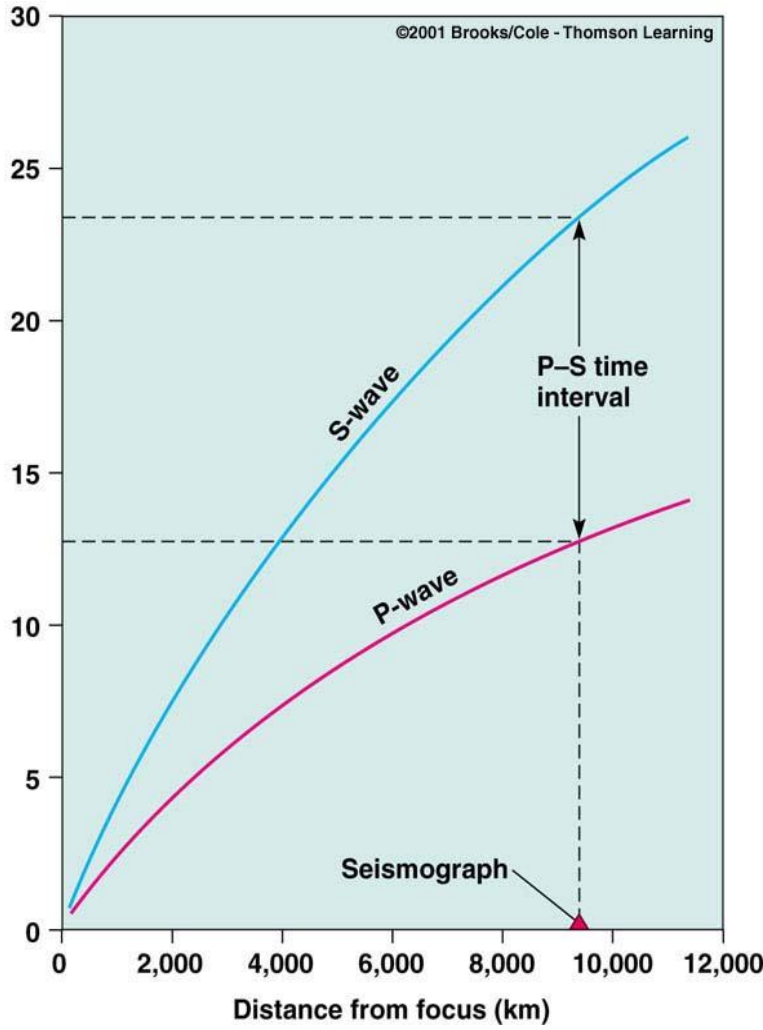
Seismic wave behavior

- **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.**



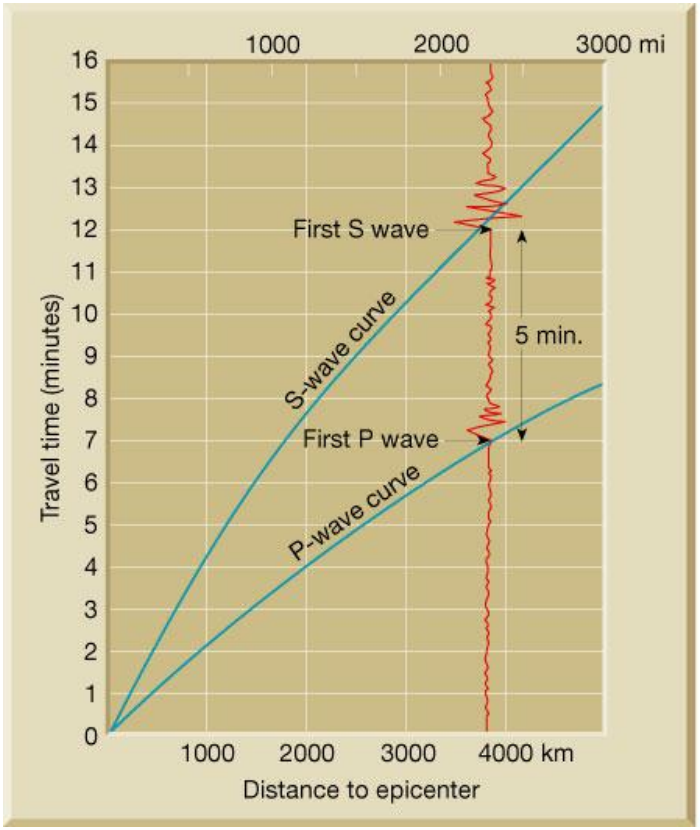
How is an Earthquake's Epicenter Located?





zones.

Locating an Earthquake

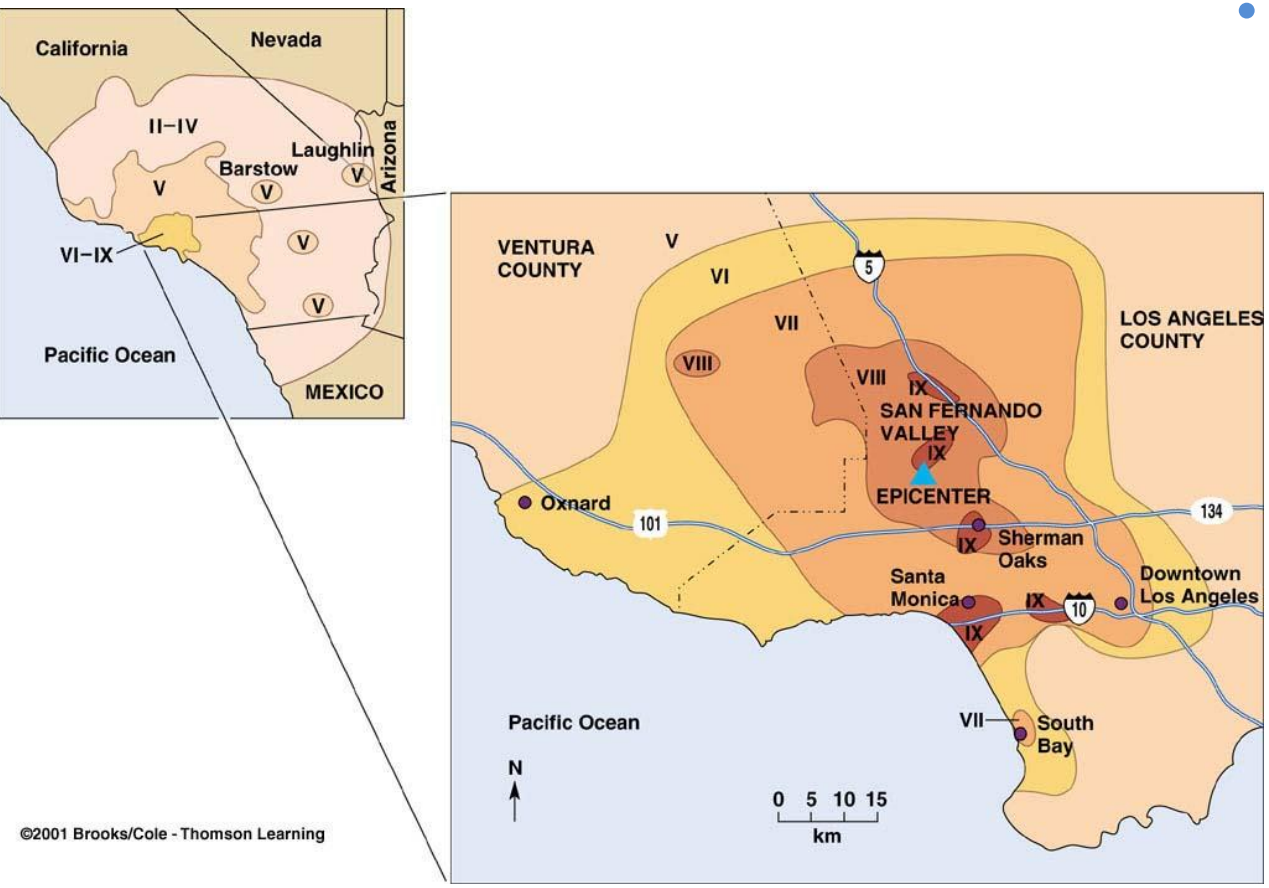


The farther away a seismograph is from the focus of an earthquake, the longer the interval between the arrivals of the P- and S- waves

Size and Strength of an Earthquake Measured?

- Historically, scientists have used two different types of measurements
  - intensity
  - magnitude

How are the Size and Strength of an Earthquake Measured?

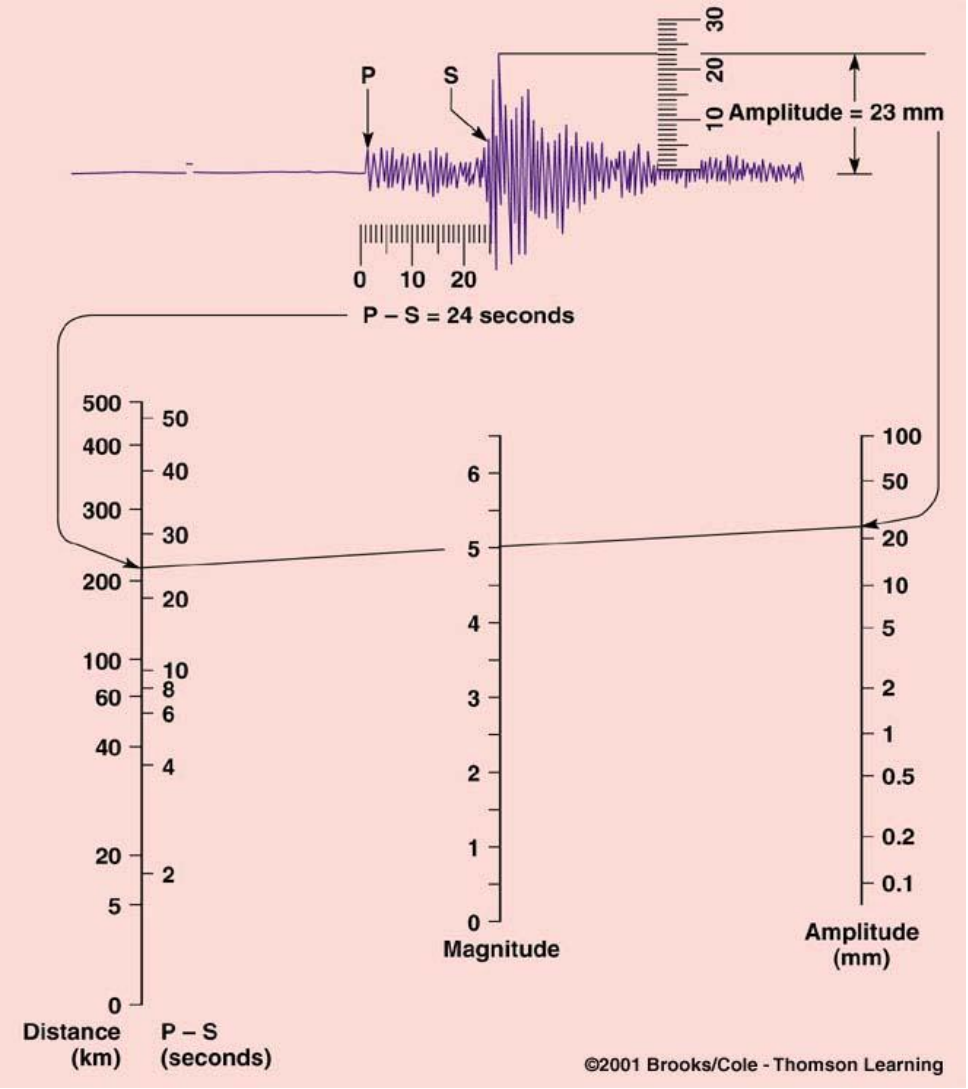


- **Intensity**
  - **subjective measure of the kind of damage done and people's reactions to it**
  - **isoseismal lines identify areas of equal intensity**

- **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**
  - **based on Amplitude of the largest wave produced by an event is corrected for distance and assigned a value on an open-ended logarithmic scale**



Each unit of Richter magnitude equates to roughly a 32-fold energy increase

Does not estimate adequately the size of very large earthquakes

Earthquake Magnitudes

Table 1 Earthquake Magnitudes and Expected World Incidence

Moment Magnitudes	Effects Near Epicenter	Estimated Number per Year
< 2.0	Generally not felt, but can be recorded	> 600,000
2.0–2.9	Potentially perceptible	> 300,000
3.0–3.9	Rarely felt	> 100,000
4.0–4.9	Can be strongly felt	13,500
5.0–5.9	Can be damaging shocks	1,400
6.0–6.9	Destructive in populous regions	110
7.0–7.9	Major earthquakes; inflict serious damage	12
8.0 and above	Great earthquakes; destroy communities near epicenter	0–1

Some Notable Earthquakes

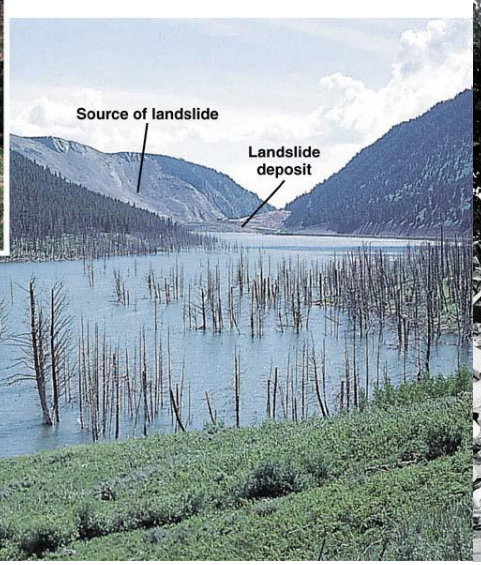
Table 2 Some Notable Earthquakes

Year	Location	Deaths (est.)	Magnitude†	Comments
*1886	Charleston, South Carolina	60		Greatest historical earthquake in the eastern United States
*1906	San Francisco, California	1500	7.8	Fires caused extensive damage.
1923	Tokyo, Japan	143,000	7.9	Fire caused extensive destruction.
1960	Southern Chile	5700	9.6	Possibly the largest-magnitude earthquake ever recorded
*1964	Alaska	131	9.2	Greatest North American earthquake
1970	Peru	66,000	7.8	Large rockslide
*1971	San Fernando, California	65	6.5	Damages exceeded $1 billion.
1985	Mexico City	9500	8.1	Major damage occurred 400 km from epicenter.
1988	Armenia	25,000	6.9	Poor construction practices caused great damage.
*1989	Loma Prieta, California	62	6.9	Damages exceeded $6 billion.
1990	Iran	50,000	7.3	Landslides and poor construction practices caused great damage.
1993	Latur, India	10,000	6.4	Located in stable continental interior
*1994	Northridge, California	57	6.7	Damages exceeded $40 billion.
1995	Kobe, Japan	5472	6.9	Damages estimated to exceed $100 billion.
1999	Izmit, Turkey	17,127	7.4	Nearly 44,000 injured and more than 250,000 displaced.
1999	Chi Chi, Taiwan	2300	7.6	Severe destruction; 8700 injuries
2001	El Salvador	1000	7.6	Triggered many landslides
2001	Bhuj, India	20,000†	7.9	1 million or more homeless

*U.S. earthquakes
†Widely differing magnitudes have been estimated for some earthquakes. When available, moment magnitudes are used.
SOURCE: U.S. Geological Survey

The Economics and Societal Impacts of EQs

- **Building collapse**
- **Ground failure / Liquefaction**
- **Tsunami**
- **Fire**



Destruction from Earthquakes

Seismic Vibrations

The damage to buildings and other structures from earthquake waves depends on several factors.

- the intensity
- duration of the vibrations
- the nature of the material on which the structure is built
- the design of the structure.

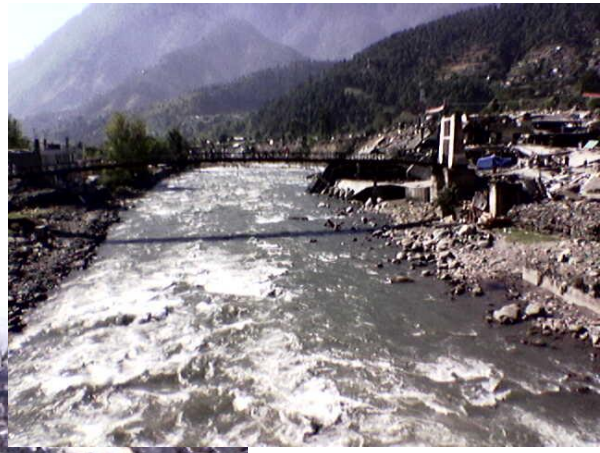
Significant Causes of Infrastructure Damage

Engineered
(Institutional Buildings)

- Quality of construction and construction materials
- Lack of seismic considerations
- Lack of monitoring
- Building codes
- Governance weakness

Non-Engineered
(Private Buildings/Homes)

- Lack of awareness about seismically resistant design
- Settling of structures
- Aspiration to modernize with insufficient knowledge of safe construction
- Cost



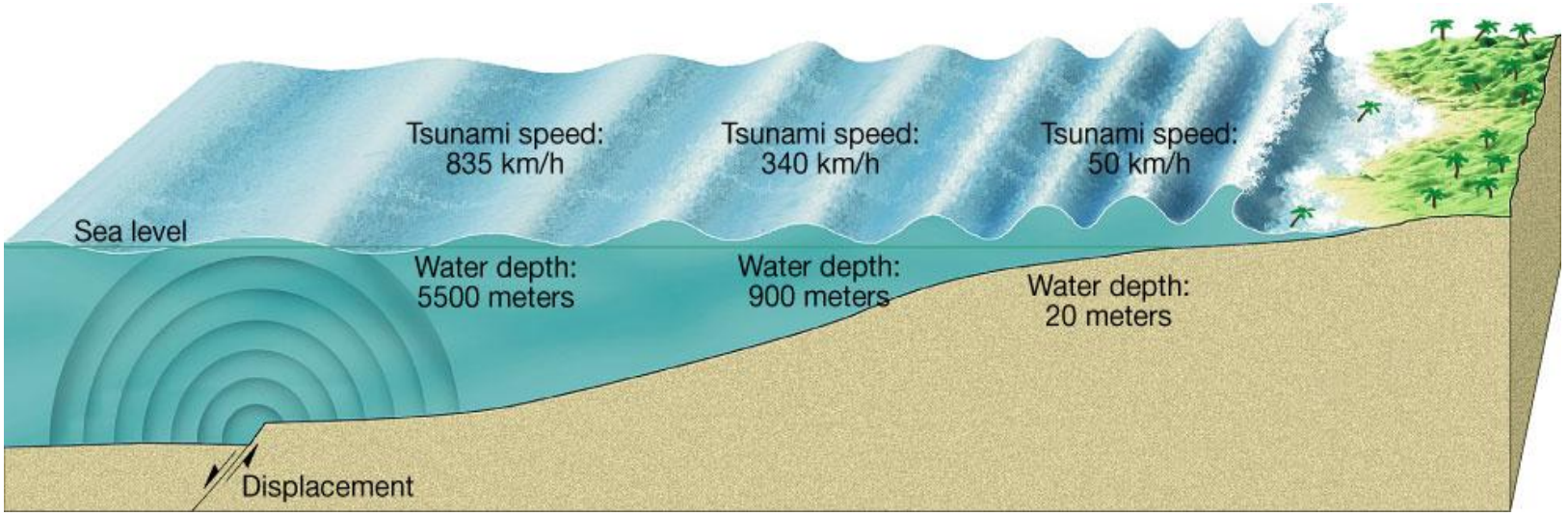
Destruction from Earthquakes

Seismic Vibrations

- **Liquefaction**
  - Saturated material turns fluid
  - Underground objects may float to surface

Destruction from Earthquakes

Tsunamis: the Japanese word for "seismic sea wave"



Although tsunamis travel quickly, there is sufficient time to evacuate all but the area closest to the epicenter.

Destruction from Earthquakes

Other Dangers

Landslides

- With many earthquakes, the greatest damage to structures is from landslides and ground subsidence, or the sinking of the ground triggered by vibrations.

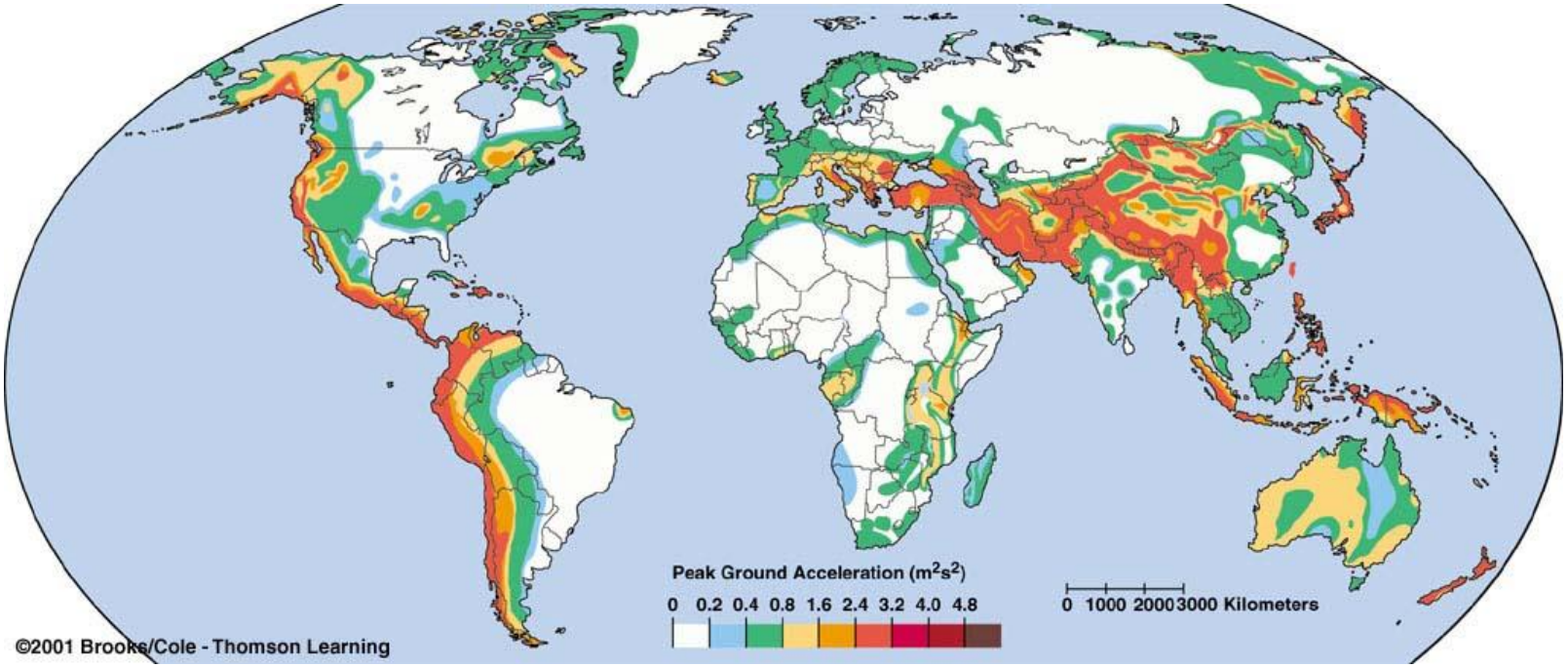
Fire

- In the San Francisco earthquake of 1906, most of the destruction was caused by fires that started when gas and electrical lines were cut.

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**



Remedial Measures

- Increase public awareness about hazard risk management.

- Build capacity of professionals and government officials.
  - Safe building practices and earthquake resistant design.

- Develop and enforce simple building codes for rural and peri-urban areas.

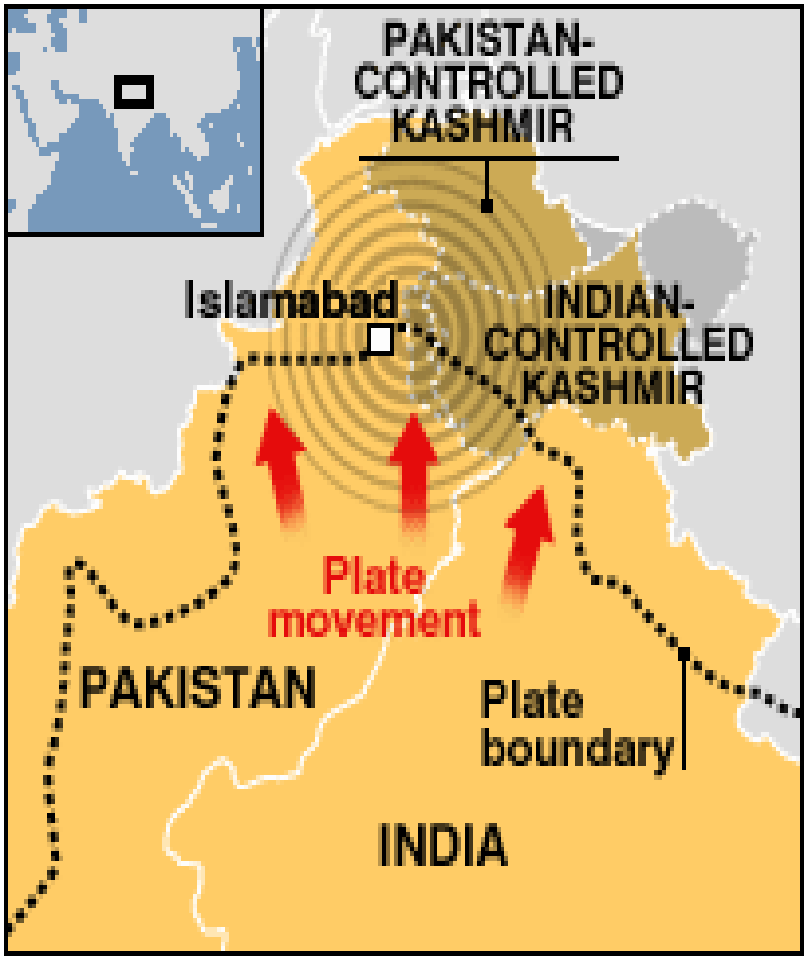
CASE STUDIES

- Kashmir Earth Quake

Kashmir Earthquake
8th October 2005

- 7.6-magnitude earthquake took place on Saturday 8th October at 0925 local time.
- The epicentre was Muzzaffarabad the capital of the Pakistan administered region of Kashmir, 80km north-east of Islamabad.
- It was followed by 20 powerful aftershocks

How did the earthquake occur



The earthquake in Pakistan is the result of India's long-term, gradual, geological movement north into Asia at a speed of five centimetres a year - a millimetre per week.

Plate Boundary ???

http://news.bbc.co.uk/1/hi/world/south_asia/4322582.stm

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Thanks