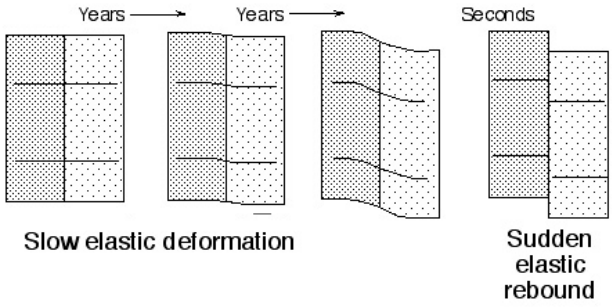
Earthquakes

Elastic Rebound Theory (foam model)

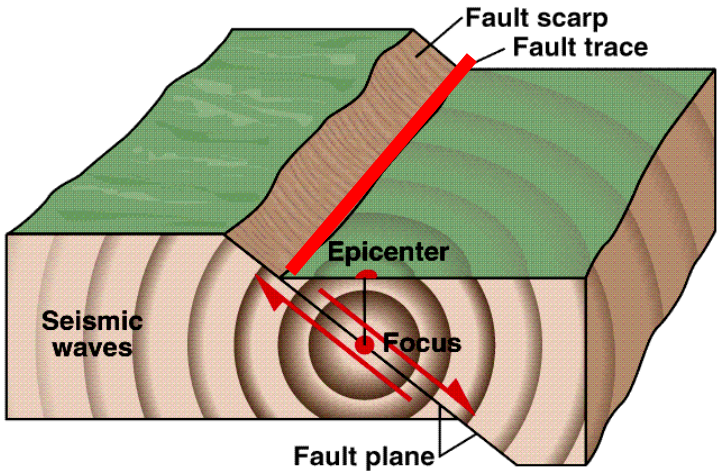
- **1906 San Francisco EQ**
  - **H.F. Reid & G.K. Gilbert**
- **Rocks are elastic**
  - **store energy over year**
  - **release it in seconds**
  - **slip on a fault**
  - **"Stick-slip"**



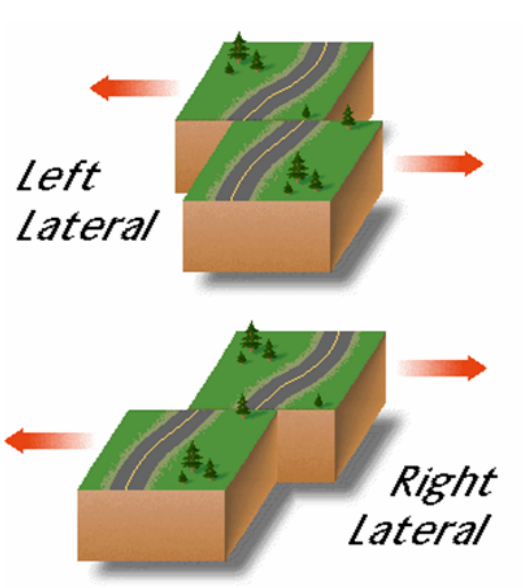
Anatomy of a fault

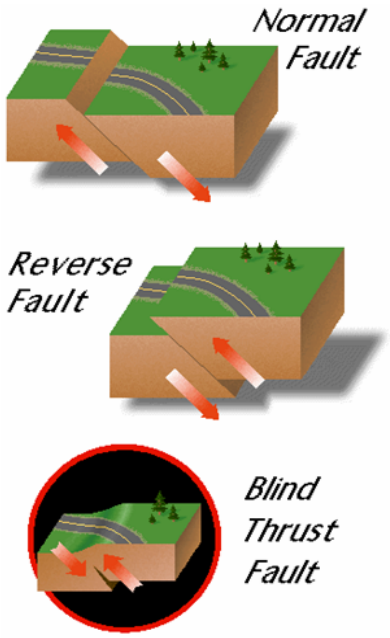
Vocabulary:

- **Epicenter**
- **Focus (hypocenter)**
- **Fault trace**
- **Fault zone**
- **Fault plane**
- **Scarp**
- **Strike**
- **Dip**

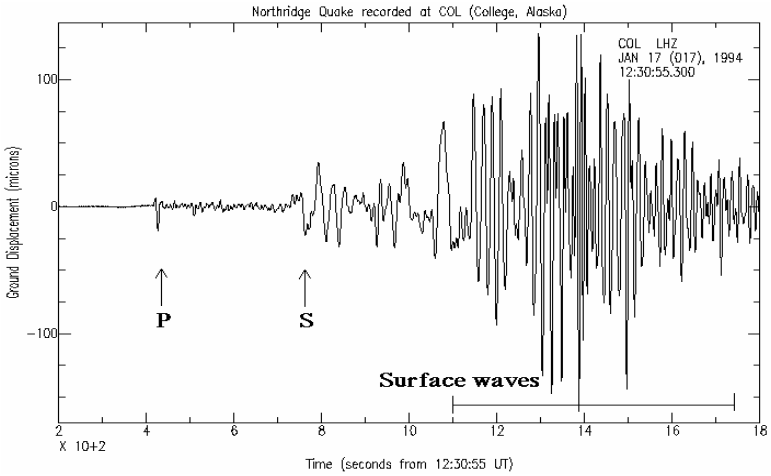


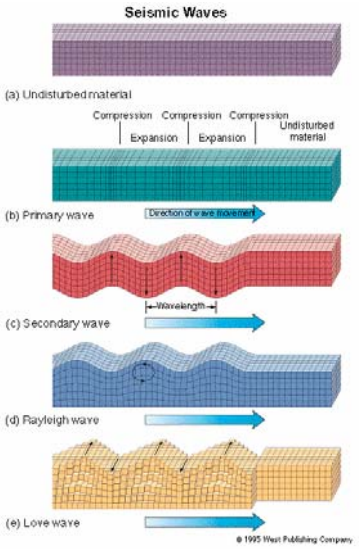
Types of fault motion:



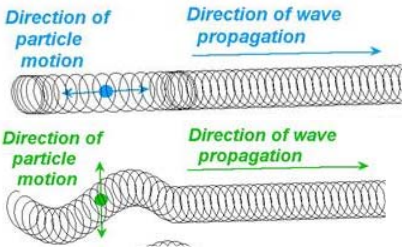


Seismic Waves



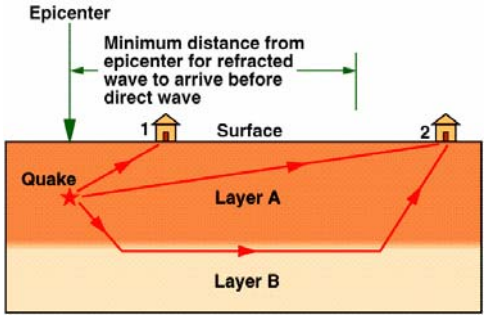


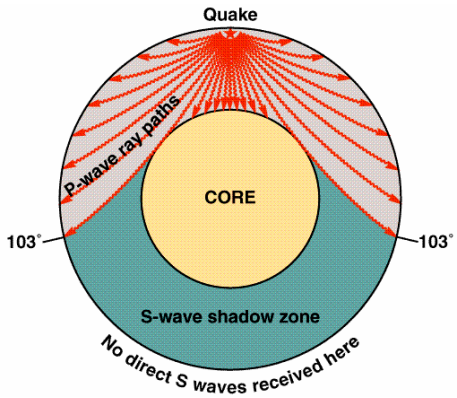
P-Wave	S-Wave	Surface Wave
Interior	Interior	Surface only
compression "**P**ush"	Shear "**S**hake"	shimmy & roll
particle parallel	Particle **S**ideways	complex
"**P**hast"	**S**low	Slowest
small amp	large amp	large amp
Pass thru liquids	**S**top in liquids	Don't pass

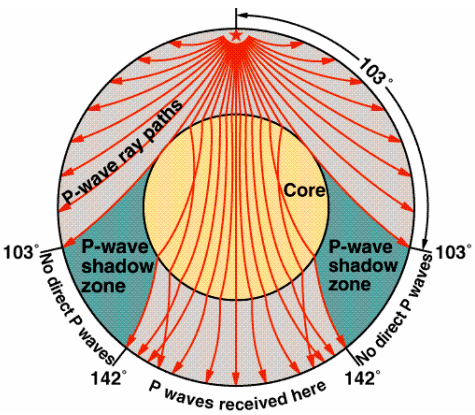


Used to image earth's interior

- **Wave speed generally increases with depth**
- **:. Fastest path is a curve**







Magnitude & Intensity

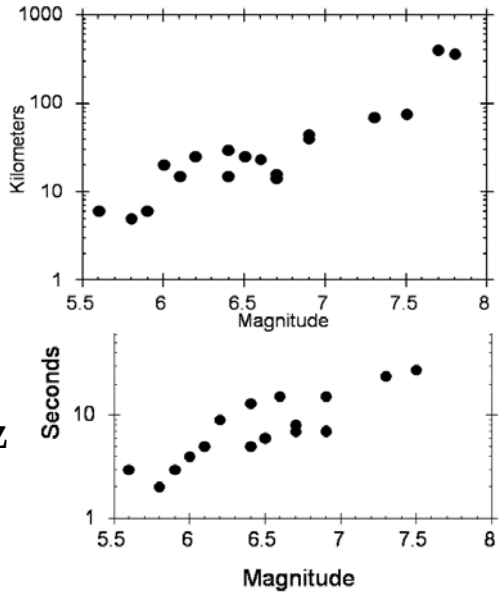
Magnitude, Amp and Energy

Magnitude Change	Amp. Change	Energy Change
1.0	10.0 times	~32 times
0.5	3.2 times	~ 5.5 times
0.3	2.0 times	~ 3 times
0.1	1.3 times	~ 1.4 times

- **Magnitude scales (Richter 1935)**
  - **Not 0-10, logarithmic**
  - **M_L = log(amp) * dist. correction**
  - **Moment (energy in dyne – cm) = shear mod * fault area * disp.**
  - **Mw = Mo calibrated to M_L**

- **Modified Mercalli Intensity Scale**
  - **Shaking intensity: magnitude + distance + local site magnification**

- **As the Magnitude increases so does the :**
  - **Fault length (area)**
  - **Slip (displacement, offset)**
  - **Event duration**



Example:

Chile 1960, May 22, 19:11:14 z

Largest quake ever
Largest quake possible?

- Mw = 9.5
- Mo = 2.5 X 10^{30} dyn·cm
- Duration = 7 min.
- Slip = ~25m
- Fault length = 1,600km (1,000mi)
- 2,000 killed, 3,000 injured, 2,000,000 homeless
- $550 million damage in southern Chile
- Tsunami caused
  - 61 deaths, $75 million damage in Hawaii
  - 138 deaths and $50 million damage in Japan
  - 32 dead and missing in the Philippines
- $500,000 damage to the west coast of the United States.

Earthquake effects

~1,300,000 fatalities in past 100 yrs

- Fault rupture (Alquist-Priolo Special Study Zones)
- Shaking – structures kill people
  - Construction matters!
  - Unreinforced masonry the worst (URMs)
  - 3rd world construction: Bam, Kobe
- Fires – San Francisco
- Landslides
- Floods – Van Norman (almost)
- Liquefaction – saturated, fine sands
- Tsunamis

Earthquake Myths

- California will fall into the ocean
- Earthquake weather
- Predictions: animals, psychics, scientists
- Number of earthquakes worldwide is increasing
- They always happen in the morning
- Faults swallow things
- My building is on rollers...
- There are “jolting” earthquakes and “rolling” earthquakes
- Aftershocks are different from mainshocks
- Small quakes “relieve the stress”, make big one less likely
  - Scale is logarithmic (x10)
  - 8 = 32x7 = 1000x6 = 32,000x5 = 10^6x4 = 32x10^6 x 3
- Get in a doorway

Global Earthquakes

Frequency of Occurrence of Earthquakes (10x 13's)

Descriptor	Magnitude	Average Annually
Great	8 and higher	1 [1]
Major	7 - 7.9	17 [2]
Strong	6 - 6.9	134 [2]
Moderate	5 - 5.9	1319 [2]
Light	4 - 4.9	13,000 (estimated)
Minor	3 - 3.9	130,000 (estimated)
Very Minor	2 - 2.9	1,300,000 (estimated)