

## Seismicity and the Earth's Interior



### Chapter 18

## Earthquakes

- Earthquakes = sudden release of energy
  - energy released = magnitude of earthquake

- Seismic waves carry energy from origin

## Elastic Rebound Theory

- Rocks can deform elastically
  - Elastic energy stored if crustal blocks are "locked," elastic energy is stored

## Elastic Rebound Theory

- Elastic limits
  - Locked faults eventually reach the limit and "snap"

- Movement occurs, elastic energy released

## Seismic Waves

QuickTime™ and a PDF (LZW) decompressor are needed to see this picture.



- Propagation of elastic energy
- 2 types of waves: P- and S-waves

- P-waves = Primary waves, arrive first

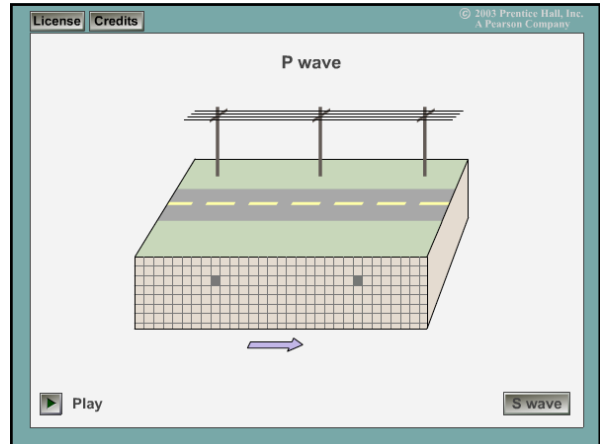
QuickTime™ and a PDF (LZW) decompressor are needed to see this picture.

- pulses of compression & expansion
- Propagate through all states of matter
- changes in volume & density of matter

- S-waves = Secondary waves, arrive 2nd

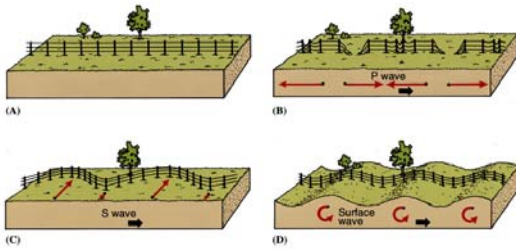
QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.

- S waves cause a shearing effect
- Travel perpendicular to direction movement
- Elastic shearing of solids, not liquids and gases



### Seismic Waves

- Surface waves
  - Travel along Earth's surface
  - Slower than P, S waves
  - Orbital motion, similar to tidal waves



Earthquakes associated with plate boundaries

Most foci within 100km of surface  
- Rocks more brittle here

### Earthquake Locations

- Grouped in 3 categories
  - (1) Shallow focus - surface to 70 km deep

QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.

- (2) Intermediate focus - 70 to 300 km deep

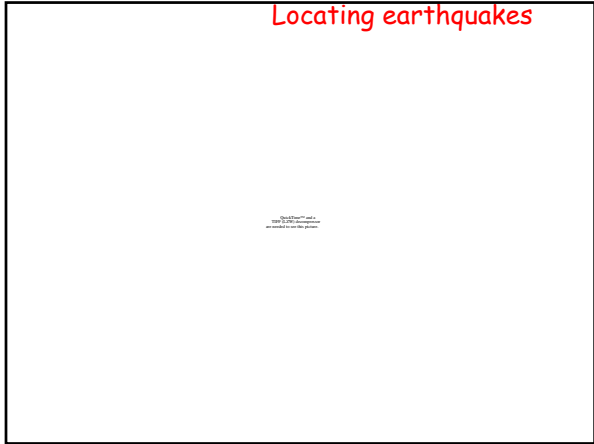
### Earthquake Locations

- Grouped in 3 categories
  - (3) Deep focus - 300 to 700 km deep

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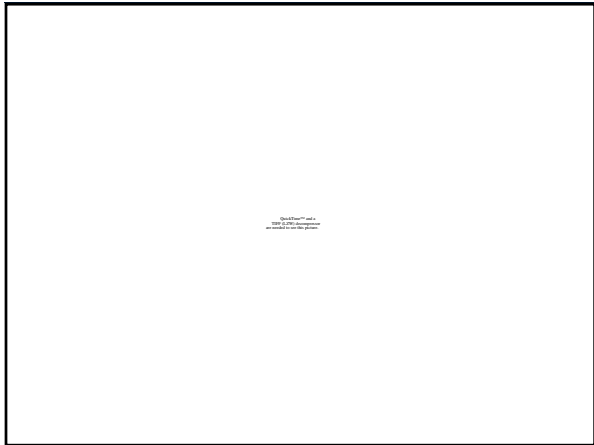
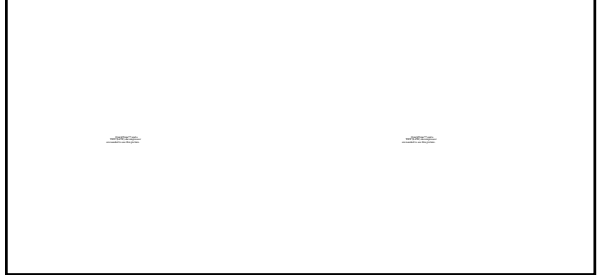
- Earthquakes are not likely to occur deeper than 700 km

## Locating earthquakes



## Earthquake Locations

- Locating earthquakes
  - Difference of arrival time of P and S waves
  - 3 seismograph stations needed to determine epicenter

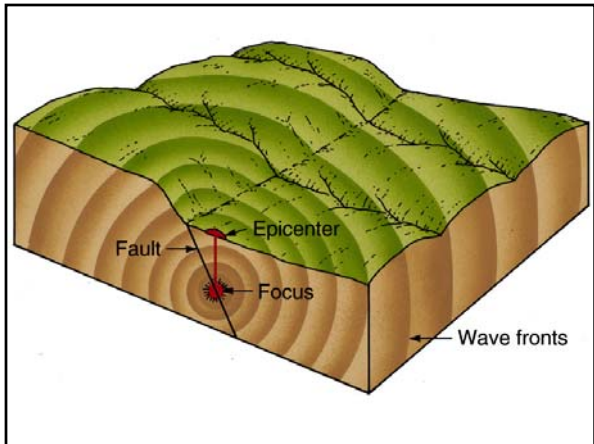



## Earthquake Locations

- The arrival time method determines the location on the map below which the earthquake occurred
  - Epicenter
- The exact point is at some depth below the surface
  - Focus

## Earthquake Intensity

- Evaluates severity of ground motion
  - Based on:
    - Total energy released
    - Distance from epicenter
    - Rock type



## Earthquake Magnitude

- measure of energy released
  - Magnitude measurements based on:
    - seismic waves (Richter Scale)
    - Moment Magnitude
    - Damage caused (Mercali Scale)

## Richter Scale

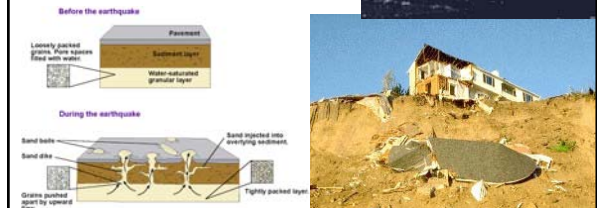
- Measures amplitude of seismic waves
  - logarithmic - Each unit on the scale means amplitude is 10 times greater.
  - Amplitude provides indication of the energy in the Earthquake

## Modified Mercali Scale

- Relates what people feel and damage done by earthquakes
  - Less precise than Richter, but correlative with Richter magnitudes

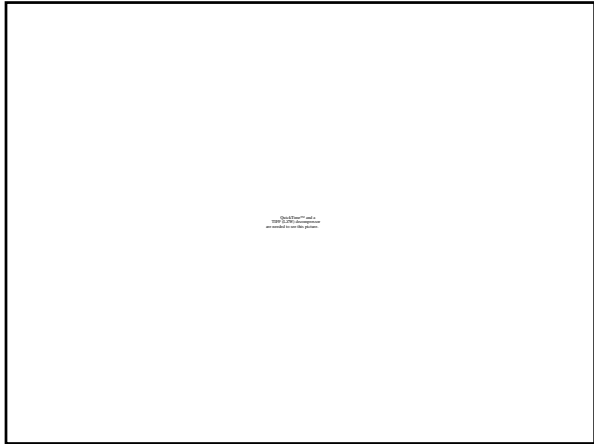
## Earthquake Hazards

- kill thousands each year
  - Primary effect is ground motion
  - indirect damage by
    - Liquefaction of soil
    - Landslides
    - Fires from broken gas pipes



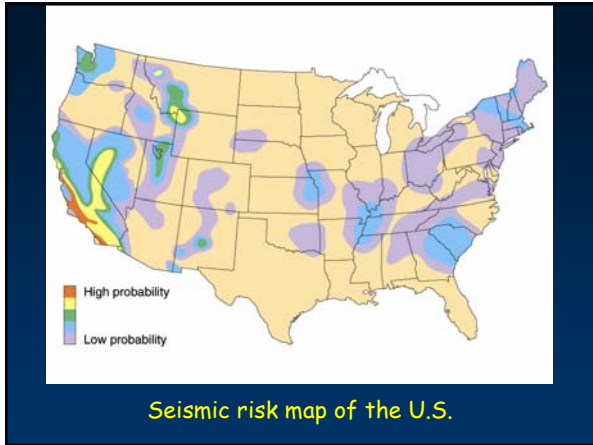
## Earthquake Prediction

- Mostly inaccurate
  - Based on several methods
    - Behavior of animals
    - "seismic gaps"
    - Measurement of small scale movement



### Earthquake Prediction

- Seismic Risk Assessment
  - Historic data, occurrence, intensity
  - Related risk factors, e.g. landslides
  - Risk maps developed regional planning and building codes



### Earthquakes & Tectonics

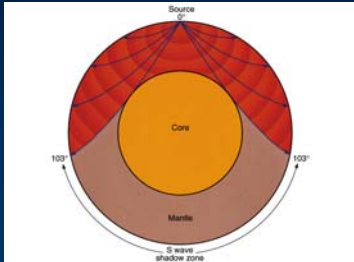
- Frequency correlates with plate boundaries
  - (1) Divergent boundaries
  - (2) Convergent boundaries
    - Subduction zones
    - Collision zones

### Earthquakes & Tectonics

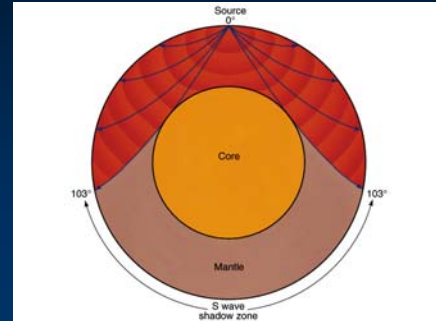
- (3) Transform boundaries
- (4) Intraplate

## The Earth's Interior

- Seismic waves pass through Earth
  - Waves are reflected and refracted
  - The structure of the core has been determined using seismic waves

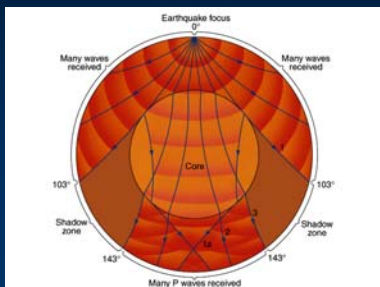


- The S wave shadow is caused by the liquid core
- S waves cannot pass through liquid
- The radius of the outer core has been determined by the size of the S wave shadow



## The Earth's Interior

- P waves are strongly reflected and refracted by the liquid outer core
  - P wave velocities give us good estimates of the density of the crust and mantle

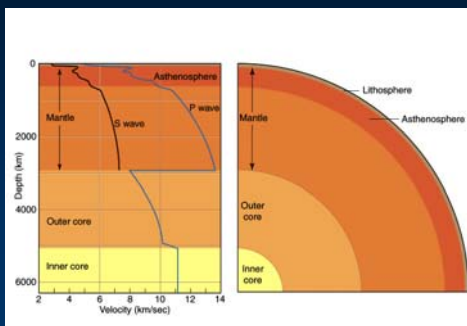


## Seismic Structure of the Earth

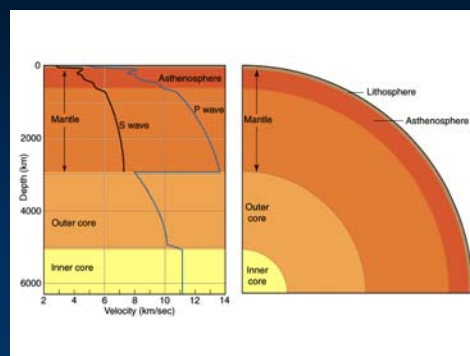
- Seismic wave velocities
  - Irregular variation with depth
  - Represent compositional changes

## Mohorovicic Discontinuity (Moho), 5 and 70 km

- base of the crust
- feldspar to olivine causes seismic velocity change

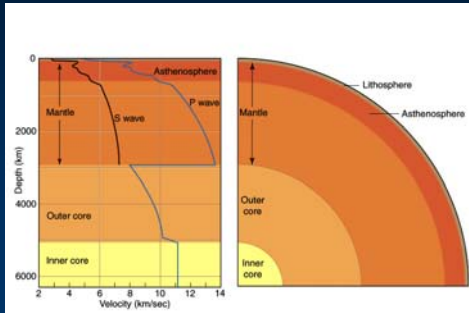


- Low-velocity zone ~100 to 250 km deep
  - partially molten mantle that slows seismic waves



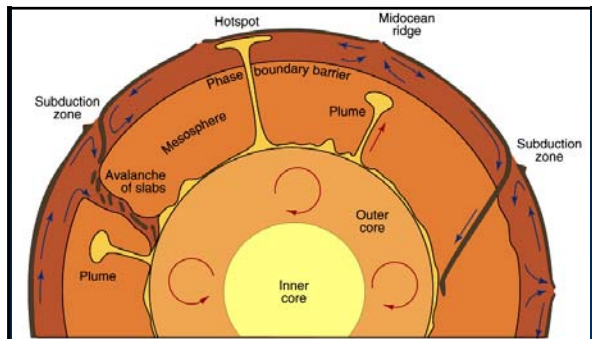
## sharp rise in velocity occurs at ~400 km

- Likely transition of olivine to magnesium spinel
- higher density = higher seismic velocities



## Convection in the Earth

- In the core
  - Seismic waves show composition & structure of core
  - 3-D models show flowing molten iron
- In the mantle
  - complex convection system



Convection in the Earth