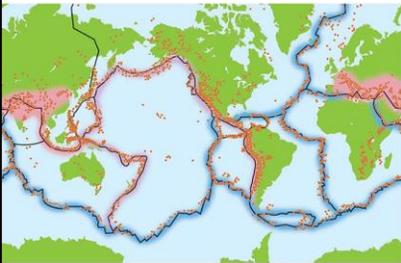


# Earthquakes

## Earthquakes

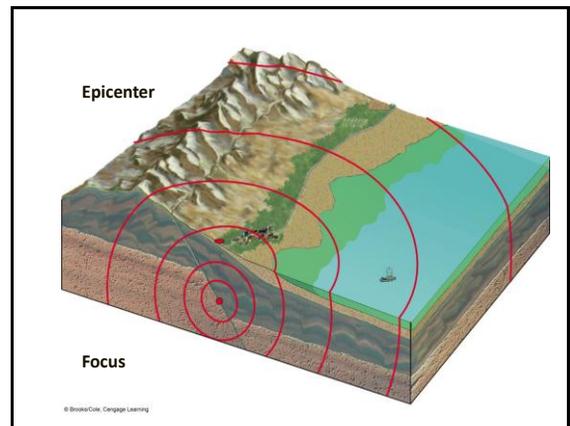
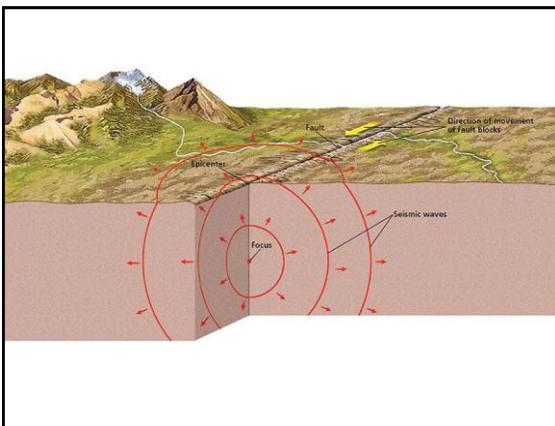
- Caused by friction and movement between Earth's tectonic plates
- A release of force
- Often caused by a "catch" between two plates
  - As plates slide by, they stick to each other
  - When the sticking is overcome, the plates tremble and quake

## Earthquakes Occur at All Boundaries



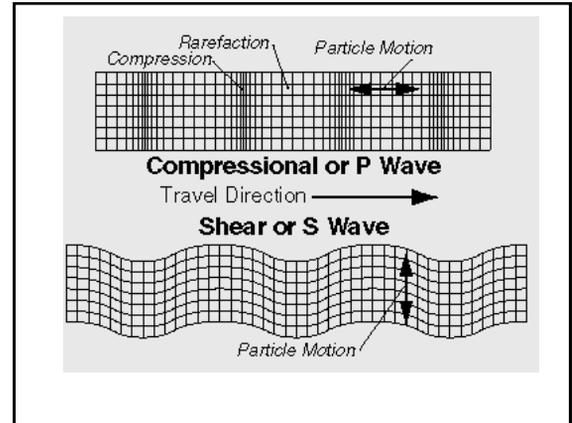
## Key Aspects of an Earthquake

- Focus: initial point of rock fracture between tectonic plates
  - "Epicenter" is the point on Earth's surface above the focus
- Direction of Waves: different earthquakes at different faults are affected by waves in different ways!
- Measured with seismometers
  - Seismographs: draw out constant record of motion



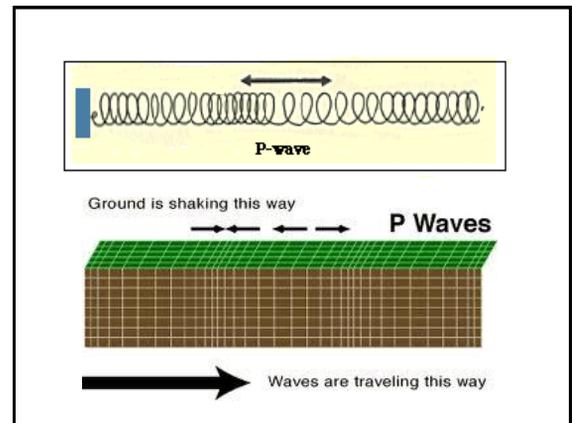
## Seismic Waves

- Waves are either **body** waves or **surface** waves
- "Shadow zones" are areas where waves cannot be detected
- Body waves bounce through the interior of the Earth
  - Behave differently depending on density, type, and temperature of material they pass through
  - Similar to light waves



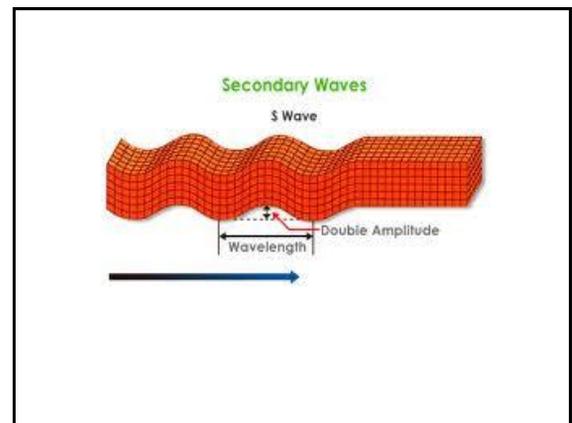
## Body Waves: Primary Waves

- AKA P-waves
- Compressed, longitudinal waves
- Wave movement parallel to direction of **propagation** (direction of energy transfer)
- Can travel through any material, solid, liquid, or gas
- Fastest body waves so they arrive at the seismograph first, hence, **PRIMARY** waves



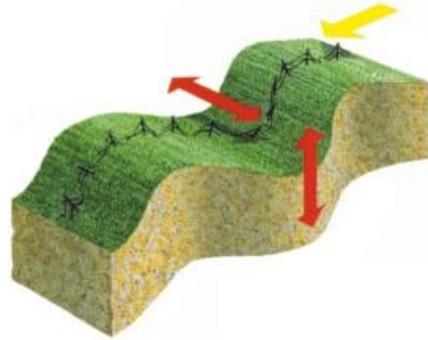
## Body Waves: Secondary Waves

- AKA S-waves
- Transverse waves
- Wave movement perpendicular to direction of propagation
- Cannot travel through liquid or gas
- Slower, thus reach the seismograph **SECOND**

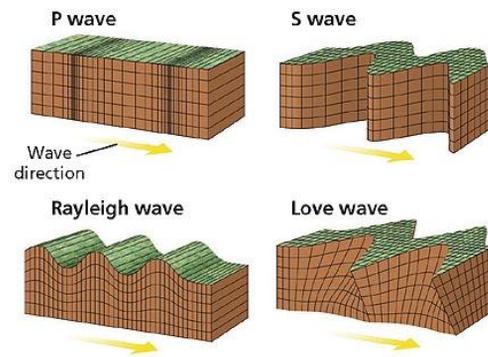


## Seismic Waves

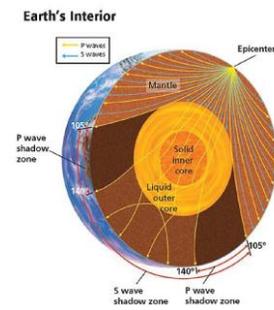
- Surface waves travel along the surface of Earth
  - AKA L-waves for "Love" waves
  - Can ripple along surface or amplify
  - Slower than body waves
  - Similar to water waves in behavior
  - Long duration and amplification can make them devastating



## Types of Seismic Waves



Different types of waves give us clues about Earth's interior



## Wave Type Demo!

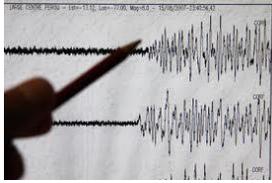
- I need five brave volunteers!
- You can picture this same general force at work in a swimming pool:
  - Make a wave pushing forward and the wave propagates forward
  - Make a wave thrashing sideways and nothing travels forward—need a solid for this!

## Earthquake scales

- Richter scale
  - Measures ground motion to determine strength (magnitude)
- Moment magnitude scale
  - Measures strength based on area size that the fault moved, average distance that fault blocks move, and rigidity of blocks in fault zone
  - The greater the number, the stronger the (E). < 2.5 not felt by people
  - 6.9 Kobe, Japan 1995
- Modified Mercalli scale
  - Based on intensity and effect felt / damage to structure (I – XII)



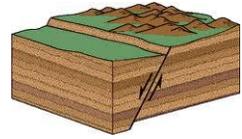
Richter Scale



Value	Potential Hazard
10	Extraordinary
9	Outstanding
8	Far-reaching
7	High
6	Noteworthy
5	Intermediate
4	Moderate
3	Minor
2	Low
1	Insignificant

Types of Faults: Normal

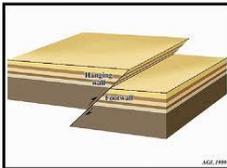
- One section of plate slips downwards alongside another
- Occurs at divergent boundaries
- Weakest Earthquake magnitudes typically at these faults



Types of Faults: Reverse

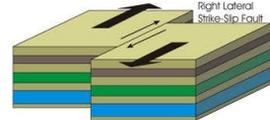
- One section of plate pushes into another and causes and upwards thrust
- AKA "thrust fault"
- Occurs at convergent boundaries
- Most violent earthquakes

Reverse Fault



Types of Faults: Strike-Slip

- Two plates sliding alongside one another slip by, causing sticking and seismic activity
- Occurs at transform boundaries



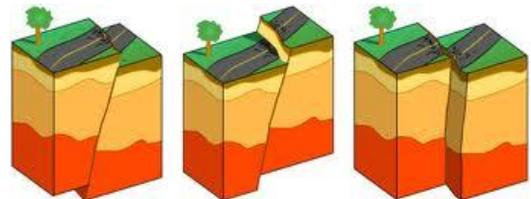
Strike-slip Faulting



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Reverse fault

Normal fault

Strike-slip fault

## Shallow and Deep Focus Earthquakes

- Shallow focus EQs occur at a depth of <70km
- Intermediate focus EQs occur at a depth of 70-300km
- Deep focus EQs occur from 300km up to 700km in depth
- **You must remember these numbers!**

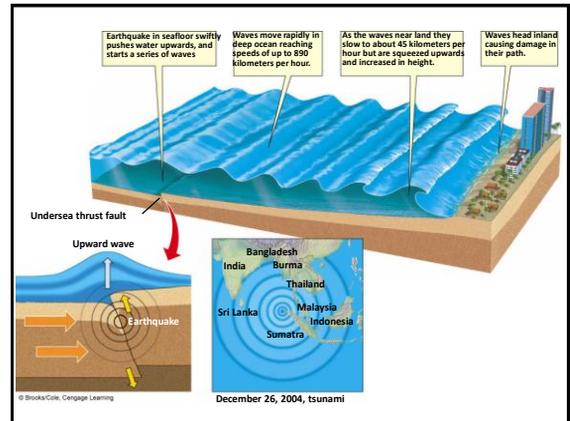
## Effects of Earthquakes



- Ground shaking can lead to:
  - Liquefaction of sediment → landslides, settling of buildings
  - Flooding of low-lying areas if near bodies of water
- In oceans can cause tsunamis
- [http://www.youtube.com/watch?v=4Y-62Ti5\\_6s](http://www.youtube.com/watch?v=4Y-62Ti5_6s)

## Tsunamis

- Caused by an epicenter located on the ocean floor
- Also caused by underwater landslide which was activated by an earthquake



Sumatran Tsunami, 2004



## Earthquake in Japan that triggered a Mega-Tsunami

<http://www.youtube.com/watch?v=1KQ2-gTqFFA>

-8.9-magnitude earthquake that struck 130 kilometres off the eastern coast - sending a reported 10-metre wall of water inland

<http://earthquake.usgs.gov/earthquakes/map/>

## Earthquakes and Volcanoes

- Because both occur at plate boundaries, EQs are a common indicator of imminent volcanic activity
- Materials used to measure:
  - Seismic detectors such as seismometers
  - Tiltmeters: measure ground depression/levelness of the Earth