

Seismicity & Earthquakes

1. What is an Earthquake?

- a. Vibration of the Earth produced by the rapid release of energy.
- b. Energy release due to plate tectonics and failure (fault zones) of the Earth's crust
- c. Energy radiates as waves in all directions from the focus (source)
- d. Epicenter – surface expression of the focus

2. Elastic Rebound Theory

- a. Tectonic forces slowly deform the rock
- b. As the rock bends, it stores energy
- c. When the rock's resistance to the stress is overcome, the rock slips or breaks
- d. Slippage occurs at the weakest point (focus), rock "snaps" back to original position
- e. Energy released produces the vibrations we know as an earthquake

3. Earthquake Waves - Seismicity

- a. Seismic waves – elastic energy released at the focus following the rupture of rock
- b. Seismology- study of earthquake (seismic) waves
- c. Seismograph – instrument that records earthquake waves
- d. Seismogram – record of the seismic waves

4. Seismic Waves

a. P-waves – Primary Waves

- i. Body wave
- ii. Compressional wave – push and pull rock in direction of movement
- iii. Can travel through all materials (solids, liquids, and gases)
- iv. Fastest moving wave
- v. Smallest wave amplitude (lowest energy)

b. S-waves – Secondary Waves

- i. Body-wave
- ii. Shear wave - Waves shake material at right angles to their direction of movement
- iii. TRAVEL ONLY THROUGH SOLIDS
- iv. Intermediate speed – 2nd to arrive at seismic station

c. Surface waves

- i. travel along the Earth's outer layer
- ii. Move up and down, similar to ocean waves
- iii. Can also move side-to-side.
- iv. Very damaging waves
- v. Travel the slowest – last to arrive at seismic station
- vi. Greatest wave amplitude (highest energy)

- d. Different materials transmit waves at different speeds, i.e. p-waves change speed as they move from the crust to the mantle and from the mantle to outer core
- e. Velocity and Amplitude Are a Function of the Material

5. Shadow Zones
 - a. P-wave Shadow Zone
 - i. Liquid causes p-waves to bend (refract)
 - ii. Refraction of waves creates a zone where no p-waves are recorded (shadow zone)
 - iii. 103 to 143 degrees from focus
 - b. S-wave Shadow Zone
 - i. S-waves cannot pass through liquid
 - ii. Waves refract at surface of outer core, creating a zone where no s-waves are recorded (shadow zone)
 - iii. 103 to 180 degrees from focus
6. Locating Earthquakes – **Will not cover in lecture, see material in book for added explanation**
 - a. Need three seismic stations.
 - b. Use the time difference (t_H) in the arrival of the p-waves and the s-waves.
 - c. Distance (d) extrapolated from a time-distance graph.
 - d. A circle with a radius of d is drawn around the seismic station.
 - e. Earthquake occurred somewhere on the circle.
 - f. The intersection from three stations shows the epicenter location.
7. Locations of Earthquakes- **Will not cover in lecture, see material in book for added explanation**
 - a. By studying 1000s of earthquakes, geologists learned most occur along plate boundaries
8. Earthquake Intensity and Magnitude- **Will not cover in lecture, see material in book for added explanation**
 - a. Mercalli intensity scale
 - i. Assesses the damage from an earthquake at a specific location
 - ii. Based upon human observation
 - iii. Can vary from location to location
 - b. Richter Scale
 - i. Describes the earthquakes magnitude (energy released)
 - ii. Measures amplitude of largest wave, adjusted for travel time
 - iii. Is the same from location to location
 - iv. A 1 digit increase in Richter scale is a 30 fold increase in energy released
9. Earthquake Prediction
 - a. Time Interval Analysis
 - i. Statistics is used to generate a “best-fit line” which can be used to predict the time of the next earthquake
 - ii. Not reliable
 - iii. This example has not occurred
 - b. Seismic Gap
 - i. Look at the location of earthquakes
 - ii. Areas (Gaps) where no earthquake has happened is an area of accumulating strain
 - iii. Gaps represent locations of future earthquakes

10. Environmental Impacts

- a. Tsunami
 - i. Giant tidal waves created by earthquakes
 - ii. Move at speeds between 500 and 950 km/hr (300 – 600 miles/hr)
 - iii. Waves reach height of over 30 meters (100ft)
- b. Landslides and ground subsidence
 - i. Vibrations cause unstable material to slide down slopes
 - ii. Vibrations cause stable material to turn into fluid – liquefaction