Geology 15 Fall 2013 Lecture 2 Schedule:
• Hazard Update: Haida Gwaii
• Review Lecture 2
• Review Activity 1 Handout
• Cover Material/Objectives
  • Origin of the Earth
  • Earth Structure
  • Plate Tectonics
• Review Class Material
• Preview Next Class
• One minute Paper (?)
Hazard Update: Haida Gwaii

M7.7 Haida Gwaii Region, Canada Earthquake of 28 October 2012

Review Lecture 2

- **Earthquakes:** What are earthquakes? What causes them? What is the results of an earthquake?
- **Stress and Strain (Energy Transfer):** What is stress and what is strain? How do these relate to earthquakes?
- **Elastic Rebound Theory:** What is this and how does this relate to earthquakes?

Stress: Tension vs. Compression vs. Shear

Tensile stress is the stress that tends to pull something apart. It is the stress component perpendicular to a given surface, such as a fault plane, that results from forces applied perpendicular to the surface or from remote forces transmitted through the surrounding rock.

Compressional stress is stress that squeezes something. It is the stress component perpendicular to a given surface, such as a fault plane, that results from forces applied perpendicular to the surface or from remote forces transmitted through the surrounding rock.

Shear stress is the stress component parallel to a given surface, such as a fault plane, that results from forces applied parallel to the surface or from remote forces transmitted through the surrounding rock.

Image courtesy of Michael Kimberly, North Carolina State Univ.

http://earthquake.usgs.gov/learn/glossary/
What is strain?

Strain is the relative change in shape or size of an object due to externally-applied forces (e.g. stress).

Hooke’s Law: Stress is directly proportional to strain.

Zoback, 2006

1. Write a brief description of the stages of the elastic rebound model, as put forth by H. F. Reid, following the 1906 San Francisco earthquake.

2. Observe the Brick and Bungee Model. How is this similar to the elastic rebound model? In the real world, what part does friction play???
Reid, 1910, assumes that earthquakes occur when the strain accumulates to a given level and the stress drop and the magnitude of each earthquake are the same. Earthquakes with similar size occur at regular intervals.

Satake and Atwater, 2007

In time-predictable models, ruptures still occur at a given stress level, but the stress drop and the magnitudes vary. The time until the next earthquake can be predicted by the size of its predecessor.

In slip-predictable models, the time until the next earthquake is related to the amount of slip from the previous earthquake. The size of the next earthquake increases with the length of time since the preceding earthquake.
i.e. Earthquake recurrence may be neither slip nor time predictable.

Reality is more complicated, so, much like early models of plate tectonics had to be revised, so did our models of recurrence.

Weldon et al., 2004

Origin of the Earth?

http://www.baluskin.ru/products/aist

Origin of the Earth

http://lunarscience.nasa.gov/articles/nasa-scientist-jen-heldmann-describes-how-the-earths-moon-was-formed
**RELATIVE TIME**

Principle of Superposition – Sediment arranged in order

- Youngest beds "superposed" towards top
- Oldest at base
- If not disturbed
- Fossils are helpful

**ABSOLUTE TIME**

- Actual # years before present
- Radiometric age control
  
  - Radioactive elements naturally decay (change into another stable element)
  - Parent & daughter elements
  - Certain atoms decay at steady rate

Based on the Principle of Superposition, which one is oldest?

1. 1
2. 2
3. 3
4. All are the same

Rock paintings of elephant hunt, S. Africa (~40,000 yrs ago)
HALF LIFE

- Time required for ½ original “parent” element to decay into “daughter” element
  - Carbon-14 → Nitrogen-14  5730 years
  - Uranium-238 → Lead-206  4.468 billion years

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http://www.earthtime.org/trollart.html

Earth Structure?
Earth Structure

Sketch
Earth’s Cross Section

Differences in physical properties and strength.
Differences in mineral and chemical composition.

Seismology!

Refraction (Snell’s Law)

Can you think of a refraction example?

Figure 7.9  The effect of Earth’s inner and outer core on seismic waves. Reflection at the core-mantle boundary (c) and inner core (i) is shown.

Figure 7.5  Refraction of a P-wave path at a boundary. \( \theta_1 \) is the angle between wavepath and perpendicular to the boundary in the upper medium. \( V_{p1} \) is the P-wave velocity in upper medium; \( \rho_1 \) is density of upper medium.
Why are there different layers?

Refraction Example

Why is some crust above sea level?

- Isostasy is the vertical movement of the crust to attain "buoyancy" in the mantle.
- The height a block of wood floats in water depends on its density and thickness.
- The "height" of the earth's crust also depends on its density and thickness.
Plate Tectonics

- What is Plate Tectonic Theory?
- What are “Plates?”
- Where are they?
- What are in between the plates? Why?
- Do plates move? If so, why?

Where are the plates?

Bathymetry and Topography

Where (Why) Are There Earthquakes?

Earthquake epicenters (mostly along plate boundaries)
- magnitude >3 in black and >5.5 in red
1. Draw this map in your notes.
2. Label how plates interact at A and B.
3. Answer how many individual tectonic plates are in the diagram?

A and B are on the same tectonic plate.
WHY DO THE PLATES MOVE ????

Aliens?
Wind?
Emotions?

Energy! How?
Heat-flow and density changes?
Possibly due to processes involved in thermal convection
What is “thermal convection?”

Mantle convection

This idea is based on the fact that as a substance is heated its density decreases and rises to the surface until it is cooled and sinks again. This repeated heating and cooling results in a current which may be enough to cause continents to move.
Thermal Control on Crustal Depth

- Average depth ocean ridges = 2.5 km
- As plates cool, they get more dense and sink

\[
\text{Depth} = 2.5 \text{ km} + 0.33 \times (\text{sq root age in Ma})
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