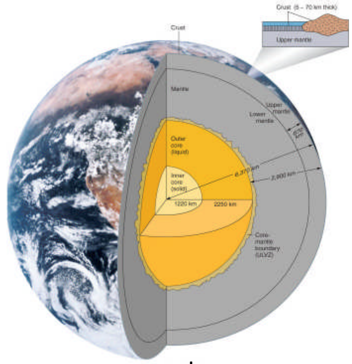
Santa Rosa 1906 earthquake damage

Chapter Outlines

NOTE: This is intended to help students 'organize' their understanding of each topic. It is not a comprehensive study guide for quizzes or midterms, i.e. study your text!

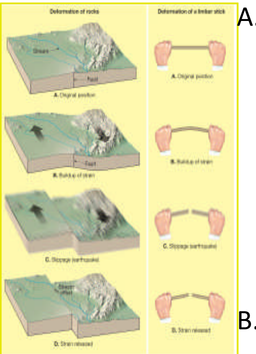


Earthquakes & Earth's Interior

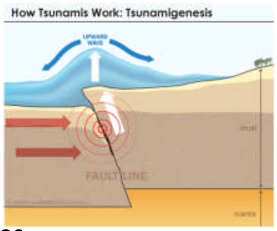
Depending on how strong they are and where they strike, earthquakes can be some of the worst natural disasters, taking thousands of lives and creating billions of dollars of damage. When occurring beneath the sea, an earthquake can result in a huge wave called a tsunami. Earthquakes are the result of the sudden movement of rock along a fault zone beneath the surface, usually centered in tectonically active areas.

Also, the rocks that can be studied on Earth's surface tell us much about Earth's uppermost crust but very little about the other 99 percent of the planet. Fortunately, the field of seismology provides compelling data that allow us to interpret how the inner earth is constructed. When integrated with other geophysical data, the data from seismic waves allow us to construct a realistic picture of how the inner earth works.

I. **Earthquakes**



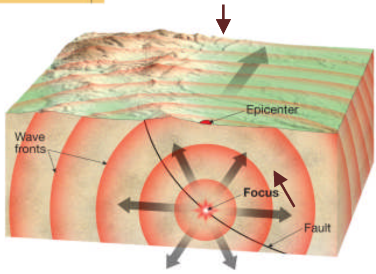
Strain, fracture, and elastic rebound



Vertical displacement of seafloor creates a tsunami

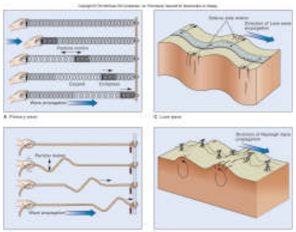
A. General features
1. Shaking of Earth produced by the rapid release of energy *(in the form of seismic waves)* when rock breaks along a fault
2. Rock slowly builds up strain *(bending under tectonic stress)*, then releases it suddenly by **fracturing**
3. Most earthquakes are associated with tectonic plate boundaries
4. Mechanism for earthquakes was first explained by H. F. Reid in the early 1900s in a phenomenon called **elastic rebound,** rocks 'spring back'

Earthquake epicenter & focus

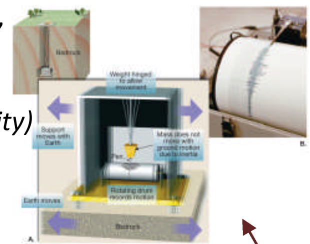


B. Earthquake waves – **seismic waves**
1. Seismic waves are released by rupturing rock, and move outward from the point of origin (**focus**)
2. The **epicenter** is the point on Earth's surface directly above the focus
3. Study of earthquake waves is called **seismology**
4. A **seismograph** records movements of the Earth. The recorded record is called a **seismogram**
5. Types of earthquake waves
   a. **Surface waves** *(**Love wave** and **Rayleigh wave**)* are complex side-to-side or up-and-down rolling motions that travel outward from an epicenter like ripples on a pond, and have the slowest velocity
   b. **Body waves** through Earth's interior
      1. **Primary (P) waves** – greatest velocity *(±7 km/sec depending on rock density)* Push-pull (compressional) motion that travels through solids and liquids
      2. **Secondary (S) waves** – slower, about half the velocity of a P wave 'Shake' *(vibrate at right angles)* motion that only travels through solids
      3. **Distance to an epicenter** can be calculated comparing arrival times of the P & S waves at a distant station, then, exact location can be found using triangulation w/other stations

P wave *Love wave*

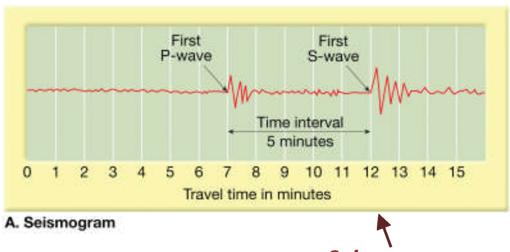


S wave *Rayleigh wave*

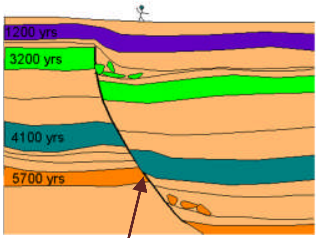


Seismometer

C. Earthquake **intensity** and **magnitude**
1. Intensity is the measure of the degree of earthquake shaking at a given locale based on the amount of damage *(**Mercalli scale**)*
2. Magnitude – often measured using the **Richter scale**… …it is based on the amplitude of the largest seismic wave
3. Moment magnitude scale - measures very large earthquakes… …it is derived from the amount of displacement *(and other variables)* that occurs along a fault zone



Seismogram



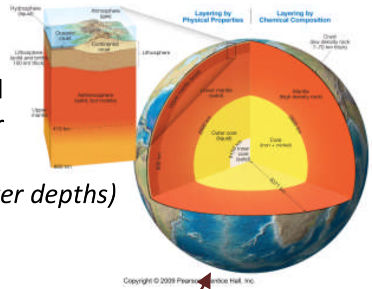
Faults can record past earthquakes

D. Earthquake destruction depends on:
  1. Intensity of the earthquake
  2. Duration of the shaking
  3. Nature of the material upon which the structure rests: bedrock, wet fill, etc.
  4. The design of the local affected buildings
  5. Generation of tsunami, landslides, ground subsidence, fire, etc.

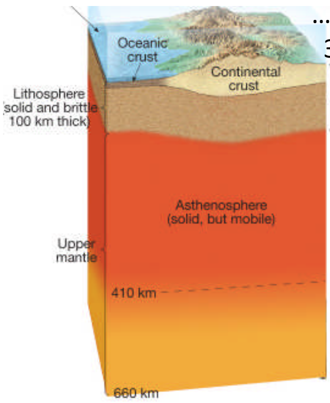
Poorly built buildings after strong earthquake

E. **Earthquake prediction**
  1. Short-range—no reliable method yet devised for short-range predictions
  2. Long-range forecasts are based on earthquake history of a particular active fault
  3. New ‘couple minutes’ warning is currently being developed

II. Earth's layered structure
 A. Most of our knowledge of Earth’s interior comes from the study of P and S earthquake waves…
  …these waves are affected by the density and state of materials through which they travel
 B. Earth layers as defined by **composition** are:
  1. **Crust**, two parts:
   a. **Continental crust** – 35-70 km thick, granitic, 2.7 g/cm^3, up to 4 b.y. old
   b. **Oceanic crust** - ±7 km thick, basaltic, ±3.0g/cm^3, 180 m.y. and younger
  2. **Mantle** - below crust to a depth of 2900 kilometers…
   …uppermost mantle is the igneous rock peridotite *(this changes at greater depths)*
  3. **Core** – below the mantle…a sphere having a radius of 3,486 km,
   iron-nickel alloy, 11 g/cm^3

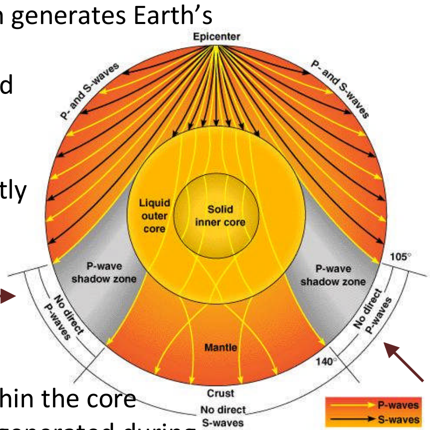


Earth’s interior



Earth’s ‘shallow’ interior

 C. Earth layers as defined by **physical properties**
  1. **Lithosphere** – cool, rigid crust and uppermost mantle ±100 km thick
  2. **Asthenosphere** – beneath the lithosphere to a depth of 660 km…
   …a soft, weak layer that is easily deformed
  3. **Lower mantle** - 660–2900 km, more rigid layer, rocks are very hot and capable of gradual flow
  4. **Outer core** - liquid layer, 2,270 km thick, convective flow within generates Earth’s magnetic field
  5. **Inner core** - sphere with a radius of 1,216 km, behaves as a solid
 D. Discovery of Earth’s major layers
  1. Discovered using changes in seismic wave velocity
  2. <u>Moho</u>rovicic discontinuity - velocity of seismic waves increases abruptly below 50 km of depth…this separates crust from underlying mantle
  3. Shadow zones
   a. **S-wave shadow zone** is evidence of a liquid outer core
   b. P waves shadow zones give evidence of the structure of the core
  4. **Inner core**
   a. Discovered in 1936 by noting a new region of seismic reflection within the core
   b. Size was calculated in the 1960’s using echoes from seismic waves generated during underground nuclear tests



Earth’s seismic shadow zones

 E. Discovery of Earth’s composition
  1. **Oceanic crust** – information came mostly from deep sea drilling beginning in the 1960’s
  2. **Mantle** - composition is more speculative…lava from the asthenosphere has a composition similar to that resulting from the partial melting of a rock called peridotite
  3. **Core** - some evidence comes from meteorites *(the remains of early solar system debris)*
   a. Composition ranges from metallic meteorites made of iron and nickel to stony varieties composed of dense rock similar to peridotite
   b. Iron, and other dense metals, sank to Earth’s interior during the planet’s early history
    i. Earth’s magnetic field supports the concept of a molten outer core
    ii. Earth’s overall density is also best explained by an iron core

Ship for seafloor drilling