

Natural Disasters

Lecture 3

Ch 2 – Energy Flows in Earth History & Natural Disasters

Text Source Today:

Prologue

p. 26-36, 48, 228-233, 247-248, 406, 451

2.1: Ch. 2 – Energy Flows in Earth History and Natural Disasters

Age of Universe: 13.5 to 14 billion years

Age of Solar System: ~4.57 billion years

♦ **Age of Earth: ~4.5 billion years (radioactive isotopes)**

Moon Creation (Orpheus Impact): ~4.46 billion years ago

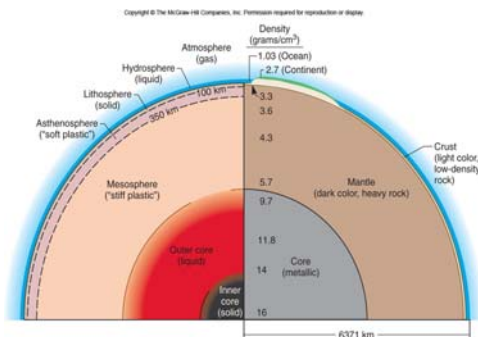
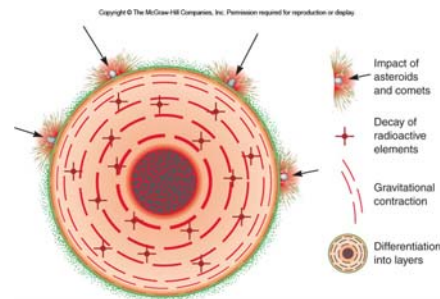
♦ **First Oceans and Small Continents: ~4.4 billion years ago**

Photosynthetic Bacteria: ~3.5 billion years ago

Large Continents: ~2.5 billion years ago

Active Plate Tectonics: ~1.5 billion years ago

- ♦ **Early Earth Formation** required tremendous quantities of heat from:
- (1) **impact energy**; (2) **decay of radioactive elements**;
 - (3) **gravitational energy**;
 - (4) **differentiation into layers** (Fig.2.2).



- ♦ **The Layered Earth** was created as the **densest material (heavy metals)** was pulled toward the center of the planet and the **lighter material (low density rocks)** “floated” toward the surface (Fig. 2.3).

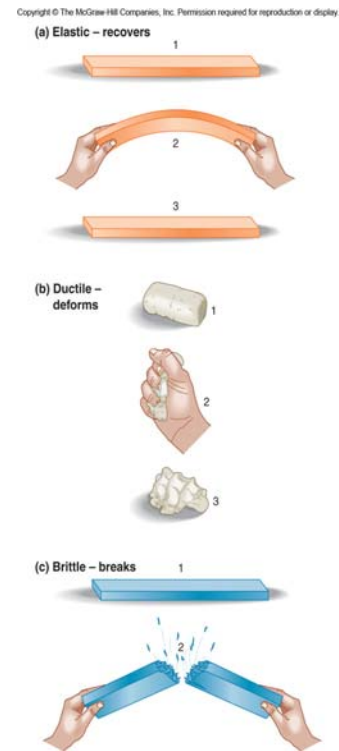
- ♦ **Isostasy:** applies a **buoyancy principle** to the low density continents and mountain ranges that literally float on the denser mantle below. (Parts of Finland and Sweden continue to experience **uplift**, due to the retreat of the continental glacier that had buried the region fewer than 20,000 years ago.)

♦ **Behavior of Materials:** when materials are subjected to sufficient **stress (or force)**, they will **deform or undergo strain** in different ways.

1) **Elastic:** a **recoverable deformation** (similar to pulling on a spring and letting it go; the spring deforms, but returns to its original shape)

2) **Ductile:** a **plastic deformation**, where the change is **permanent** (similar to a wad of chewing gum or “Silly Putty”)

3) **Brittle:** the deformation results in **fracture or a breakup into pieces** (similar to sharply bending a thin board of wood)



(Fig. 2.5)

Rocks are brittle at the low temperatures and low pressures at the Earth's surface, but **ductile** at the high temperatures and high pressures at depth inside Earth (e.g., **asthenosphere**).

♦ Energy Sources of Disasters

1) **The impact of extraterrestrial bodies**

- were **abundant and important** early in Earth history
- collisions (asteroids and comets) have become **infrequent**
- **Earth travels around the sun** in excess of 108,000 km/hr (67,000 mph), netting 2.7×10^{33} joules of kinetic energy
- **a large asteroid** moves at 65,000 km/hr (40,000 mph)
- **a comet** moves at 150,000 km/hr (93,000 mph)
- head-on collisions transfer tremendous amounts of energy, with the effects on life being **catastrophic and worldwide**

2) Gravity

- the **attractive force** between bodies
- dependent on **mass and distance between bodies**

$$\text{Gravity (g)} = \frac{G \times m_1 \times m_2}{\text{distance} \times \text{distance}}$$

G = universal constant
m₁, m₂ = body mass
distance between bodies

- causes glaciers to flow, hillsides to fall in landslides, and snowy mountain slopes to give way to avalanches
- the **tidal effect** on Earth caused by the Moon and Sun varies by the **inverse cube of the distance** between them; the Sun's tidal effect is only **~45%** of that of the Moon
- as the Moon continues to move slowly **away** from Earth about 3.8 cm (1.5 in.) per year, the **Earth's rotation is slowing** and the days are getting **longer**

3) Earth's internal heat

- **internal energy** flows unceasingly toward the surface
- over short time spans, energy is released in **volcanic eruptions and by earthquakes**
- over longer intervals of geologic time, energy has produced the **continents, oceans and atmosphere**

4) The Sun

- the most important **external energy source**
- provides the energy for the **"hydrologic cycle"** (Fig. 2.23)
- global energy transfer in **atmosphere and oceans** (Fig. 2.25 & 2.27)
- over short time spans, provides the **energy** that drives our **weather (e.g., hurricanes, thunderstorms, tornadoes)**
- over longer time spans, is a factor in **world climate**

♦ Processes of Construction versus Destruction

- **Processes of Construction:** Earth's internal heat energy-produced igneous rock formation creates and elevates **landmasses** (the “rock cycle” ; Prologue Figure, p. 5).

- **Processes of Destruction:** processes that erode the continents and ultimately dumps the debris into the oceans.

- On a long timescale, the sun and gravity power the agents of **erosion**, that wear away the continents and dump their broken pieces into the oceans.

♦♦ If the interior of Earth **cooled** and the flow of internal energy **stopped**, then mountain building and uplift **would cease** and it would take only about 45 million years for erosion to reduce all the continents to **sea level! Earth would become an ocean-covered planet!**

- **Uniformitarianism:** the concept that the same laws and processes operating on and within the Earth throughout **geologic time** are the same laws and processes operating **today**.

- **Actualism:** using the **actual processes** operating on Earth today to interpret the past; not inventing **unrecognized processes** to explain the past.

- Our view of Earth history means ignoring **our very short human lifetimes** and doing our thinking in ***geologic time***, using thousands, millions, and billions of years.