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GEOL 117 Class #3: Origin, Age, and Evolution of the Earth

About 5 B.Y. ago: Formation of solar system: Gravitational collapse, rotating disk...
dust and gas (mostly H and He)

Then... accretion of material to form planets.

- Earth, other planets, meteorites at ~ 4600 m.y.

Early, partially molten(?) stage of Earth (first ~200 m.y.):

- silicate mantle and metallic iron core formed

Layering of the Earth Based on Chemical Composition:

Layer	Depth (km)	State	Composition	Density (g/cm ³)	T (°C)
Crust -- Continental	55 (25-90)	solid (rigid)	"granite" (less dense)	2.7	up to 1000
Crust - Oceanic	10 (5-10)	solid (rigid)	basalt (denser)	3.0	up to 1500
Mantle	to 2900	solid (ductile)	Mg, Fe silicates	4.5	1000-3000
Core- Outer	2900-5300	liquid	Fe, Ni metal	11.5	4000
Core- Inner	5300-6370	solid	Fe, Ni metal	13.0	5000

Important: Difference between Continental and Oceanic Crust- density.

Evidence : How do we know this?

- Earthquake waves pass through the earth- study carefully:

Shear (S) waves cannot pass through liquid, compressional (P) waves can

If you want to know more, see:

<http://www.eas.purdue.edu/~braile/edumod/waves/Pwave.htm>

<http://www.eas.purdue.edu/~braile/edumod/waves/Swave.htm>

Waves refracted (bent) at boundaries- shadow zones result.

Travel time tells us about materials inside (different wave speeds)

- Meteorites- Many are fragment of planets that were broken apart billions of years ago
...some are iron metal, some are Mg, Fe silicates like the mantle

Layering of the Earth based on rigidity:

Layer	Depth (km)	Rigidity
Lithosphere (Crust + some mantle)	150 beneath continents, 70 beneath oceans	Rigid (elastic)
Asthenosphere	Bottom of Lithosphere to about 250 km	Ductile (plastic; weaker)
Rest of mantle	Remainder of mantle	Ductile (stronger)

Origin of Earth's Atmosphere

Early H₂ and He (light gases)-- "blown away"

Release of gases from interior

N₂, CO₂, CH₄, NH₃, H₂S, HCl, H₂O vapor.

This atmosphere would be toxic to us

Evolution of atmosphere:

- loss/neutralization of reactive gases;
- development of life -- CO₂ removed and O₂ accumulated.

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Formation of the Oceans

- Cooling of earth ==> condensation of water vapor
 - Acid rain: from acid gases in atmosphere
 - Reaction with surface rocks to form dissolved products and sediments
- Changes in oceans through time (speculative):
 - Salinity and area remained roughly constant
 - Depth and volume increased a little

Geologic Time Scale- Based on record found in rocks -"events" in earth history

- Fossil evolution
 - Mountain building
- Gives sequence of events in earth history
More detail known about recent times

Radiometric age determinations gave ages in years

Radioactive elements: Decay produces "daughter" products

Some natural radioactive elements have very long half-lives (e.g., Uranium)

Buildup of daughter products can be used to determine ages of rocks and meteorites

Important events

- Origin of Earth: 4,600 m.y. (million years ago)
- Appearance of "oceans": ~4,400 m.y.
- Oldest preserved rock on continents: 4,200 m.y.
- First bacteria: $\geq 3,800$ m.y.
- Photosynthesizing algae appear: ~3,000 m.y.
- O₂ in the atm.: ~2,000 m.y.
- Multicellular organisms: ~600 m.y.
- First "hominids": ~4 m.y.

Oxygen in the atmosphere

- O₂ NOT present from the start- where did it come from?
Photosynthesis: Generate O₂ as follows:
 - Need carbon to make living matter- use CO₂ from atmos.
 - Need to strip off the Oxygens
- Build living tissues with C-rich organic matter
- Waste Product: O₂
 - O₂ builds up in the atmosphere if organic mater is made and not recombined with O₂
 - this happens when organic matter is buried in ocean sediments
- O₂ probably toxic to early life
- Eventual adaptation to high O₂ levels- led to development of higher organisms