Notes for Week 6.

We will focus discussion on three topics:

Plate tectonics and seismology, with comments on convection

Atmospheric chemistry: Contrasting Venus and Earth

Seasons and climates and ice ages on Earth

1. Plate tectonics

The book gives a good review of this topic, which is also one of the more interesting from the historical perspective - it was scoffed for a long time before the evidence finally confirmed its essential correctness.

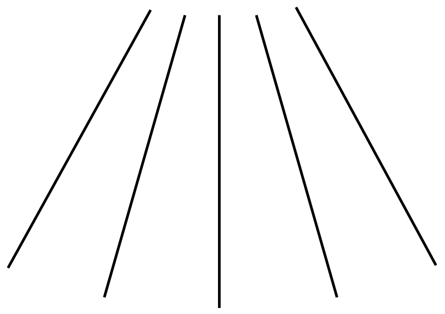
Evidence includes:
- volcanic locations and character
- mid-ocean ridges and the magnetic stripes
- direct observation of separation of the continents

Seismology:

Important concepts include P vs. S-waves and how they propagate.

P waves travel at the speed of sound, $dP/d\rho$ For a gas, this is $\gamma P/\rho$ with $\gamma=1$ for isothermal soundwaves and $\gamma = 5/3$ for adiabatic soundwaves in an ideal gas. Thus, in a gas, the sound speed depends mainly on the temperature.

P waves actually travel in curved paths, because the speed of sound is not constant inside the Earth:



Where the speed of sound is faster, the waves are farther apart.

S waves cannot propagate through liquid.

Atmospheric chemistry: Venus vs. Earth.

Where did the atmospheres of these planets come from?

What about the "greenhouse effect" and global warming?

Origin and evolution of a terrestrial planet's atmosphere:

Atmosphere now - fraction by volume:

N_2	0.78084
O_2	0.20948
Ar	0.00934
CO_2	0.000333
Ne	18.18×10^{-6}
CH_4	2×10^{-6}

Why is CO_2 so important in the "greenhouse effect", if there is so little of it? Ditto methane?

H_2O variable - around a few x 10^{-6}

Possible sources of the atmospheres of terrestrial planets:

- Release of gas from volcanic activity.
- Accreted material - comets, meteorites, asteroids.
- Accreted gas

Volcanoes:
60% water, 25% CO2 (deep-seated ones!)

Comets: (0.5 to 10 km)

H2O	83%
CH2O	6%
CO2	4%
C2H2	1%
C3H4	1%
CH4	.5%
HCN	1%
N2H4	2%
NH3	0.5
S2	0.2
H2S	0.2
CS2	0.2

Possible sinks:

- loss to space
- loss into solid or liquid

How big a comet to provide 1% boost to atmosphere? (Real comets: 10^{14} to 10^{18} gm = 10^{11} to 10^{15}kg, Halley's ~ 10^{17} gm = 10^{14}kg)

Why are little comets more useful than big ones here?

> Big ones splash atmosphere back into space; little ones vaporize and blend with the atmosphere. There's about 10^4 kg of atmosphere above each m^2 of ground, so m_{atmo} intercepted ~ $1*D^2$ while mass ~ rho * D^3 = 1000 D^3 and these are equal when D ~ 10^4/1000m = 10m.

Some interesting numbers (from Lang compendium):

Mass of Earth: 5.97e27
Escape v: 11.19 km/s
Mean density: 5.515 gm/cm^3

Mass of atmosphere: 5.1×10^{18}kg
Mass of ice: 25 to 30 x 10^{18}kg
Mass of oceans: 1.4×10^{21}kg
Mass of crust: 2.5×10^{22}kg
Mass of Mantle: 4.05×10^{24} kg
Mass of Core: 1.90×10^{24}kg

Equatorial radius 6378.14 km
Polar radius 6,356.755 km
flattening factor $(r_e - r_p)/r_e = 1.298$.

[Volume < $4/3 \pi r_e^3$ and > $4/3 \pi r_p^3$]

AU 149.6 Mkm
Perihelion 147.1
Aphelion 152.1