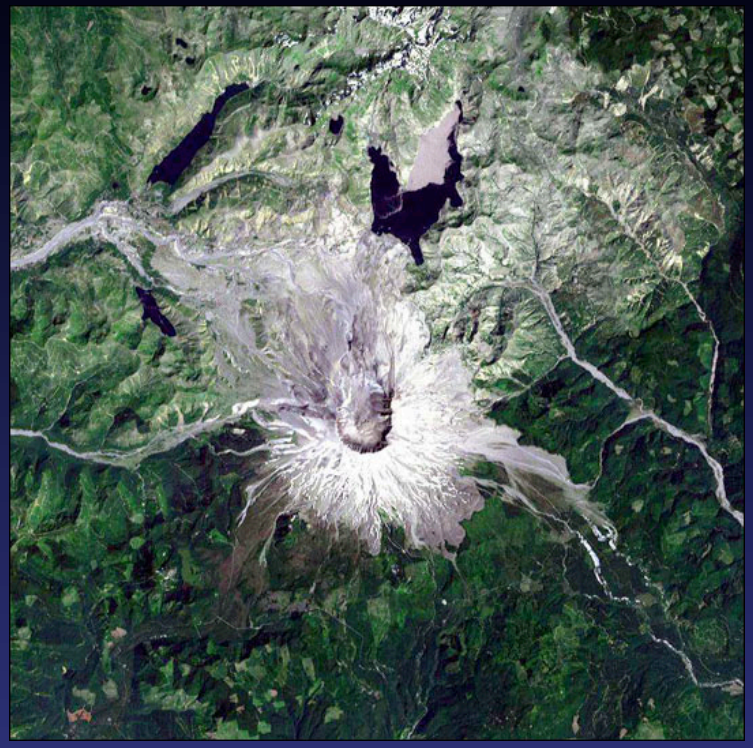
Astronomy 405
Solar System and ISM

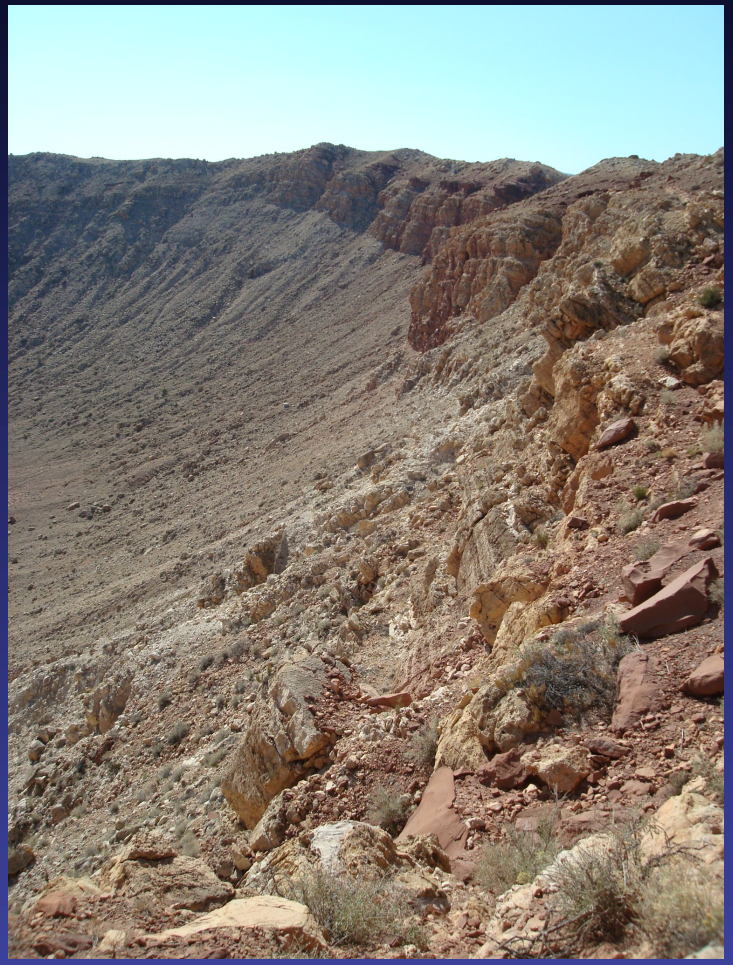
Lecture 7
The Earth

January 30, 2013

Mount St. Helens



Barringer Crater



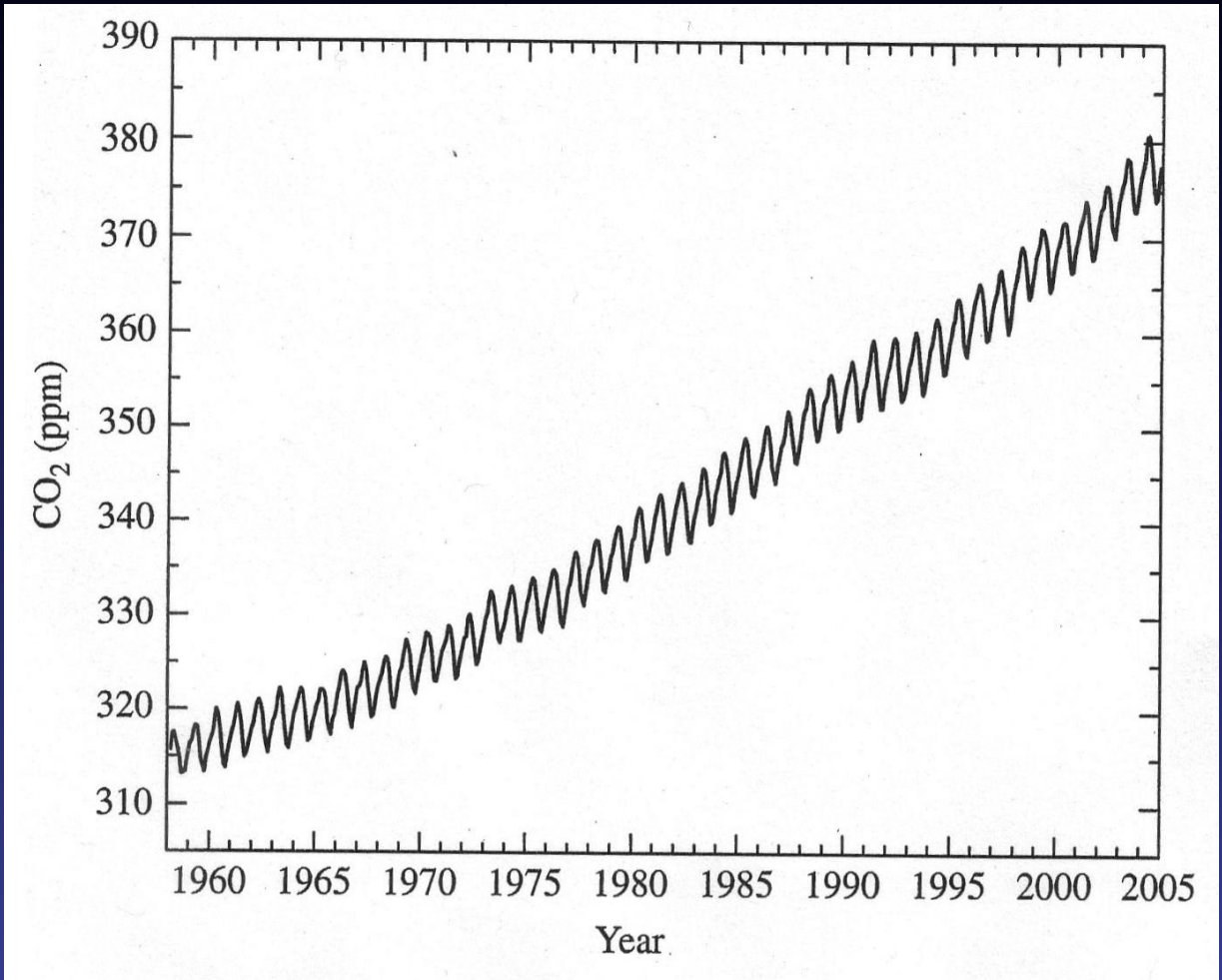
Atmosphere

Abundances in order of : H, He, O, C, N,…
Thus, there should be abundant CO_2. Venus has more CO_2 in its atmosphere than the Earth. CO_2 in the Earth's atmosphere dissolved into water and become chemically bound up in carbonate rocks such as limestones.

The Sun was less luminous, Earth should be icy 2 Gyr ago, but Earth's oceans were liquid 3.8 Gyr ago.
⇒Greenhouse effect + different compositions

Present-day composition (by number):
78% N_2, 21% O_2, 1% H_2O, traces of Ar, CO_2, etc.
(outgassing from rocks, photosynthesis, radioactive decay of potassium in crust)

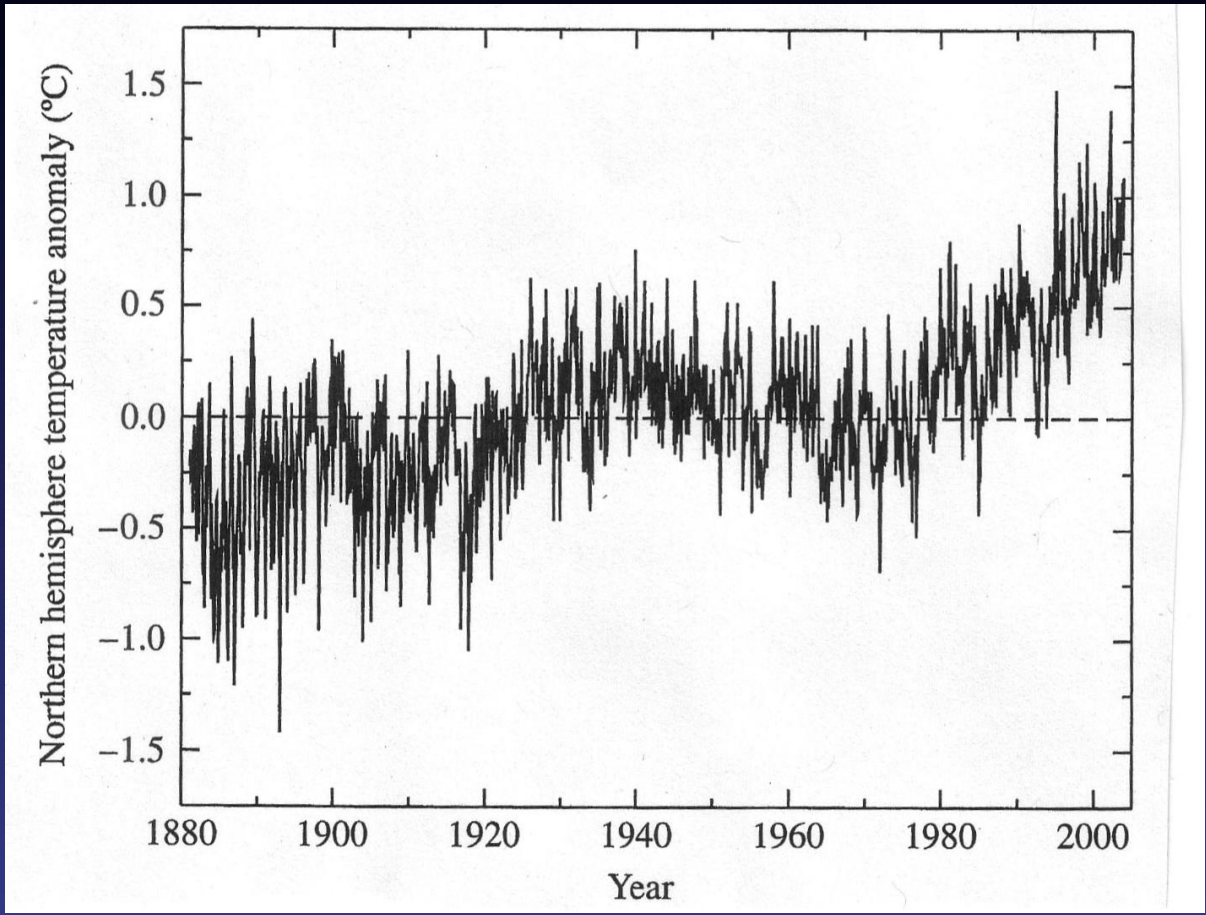
Greenhouse Effect & Global Warming



The amount of CO_2 in parts per million by volume (ppm) over Mauna Loa, Hawaii, as a function of time.

The steady increase over the years is alarming!!!

Greenhouse Effect & Global Warming



The upward trend is obvious! Glaciers are receding worldwide. The average ocean surface temperature increased by 0.5 C since the late 1960s. Depletion of ozone layer above the North and South Poles. Who's responsible? Human!!!

What have people done?

Destroy vast regions of vegetation, e.g. Amazon rain forest
$\Rightarrow$reduce the recycling of CO_2

Injecting CO_2 and other chemicals into the atmosphere

The injection of chlorofluorocarbons
$\Rightarrow$ rises and stays above the polar regions
$\Rightarrow$ removes O and O_3
$\Rightarrow$ depletion of ozone

How did O_3 get there?
$H_2O + \gamma \rightarrow$ O and H
H escapes, leaving O to form O_3

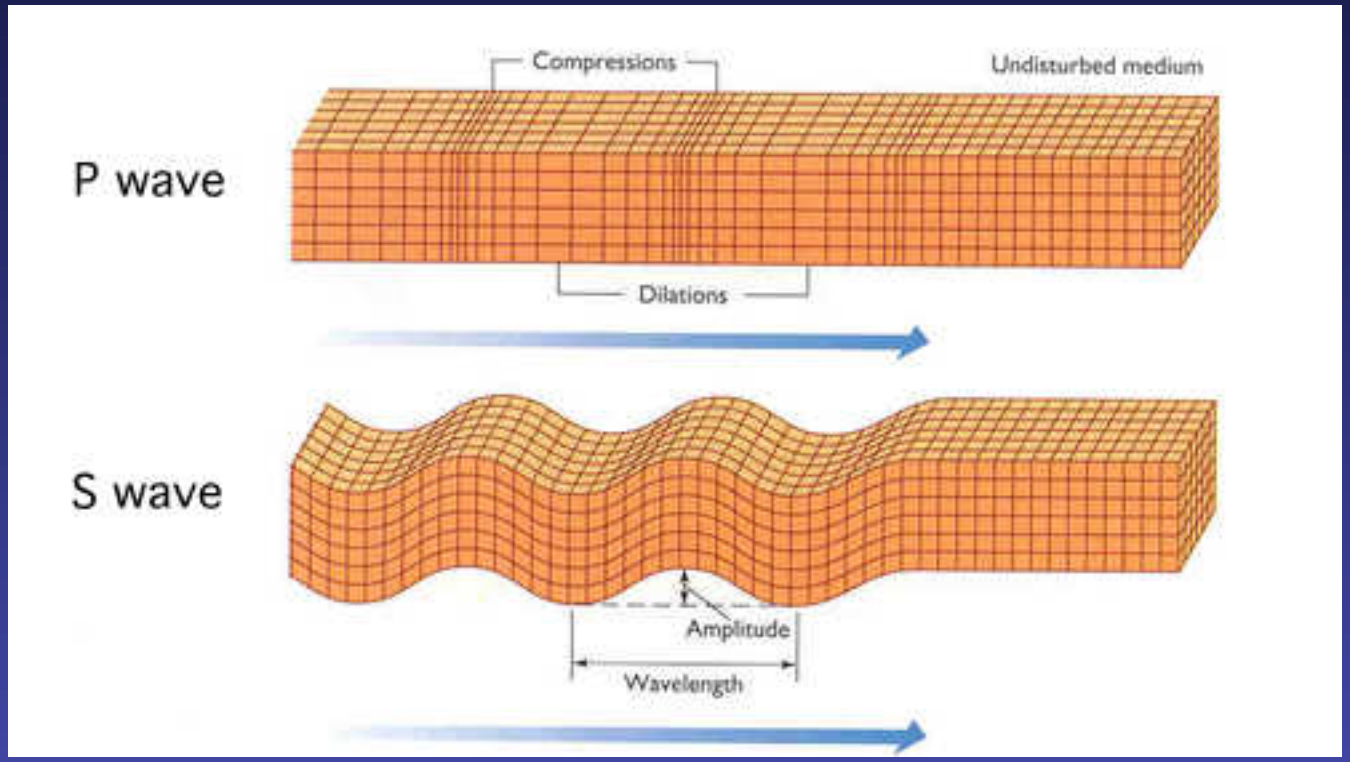
Seismology and Earth's Interior

Two types of seismic waves:

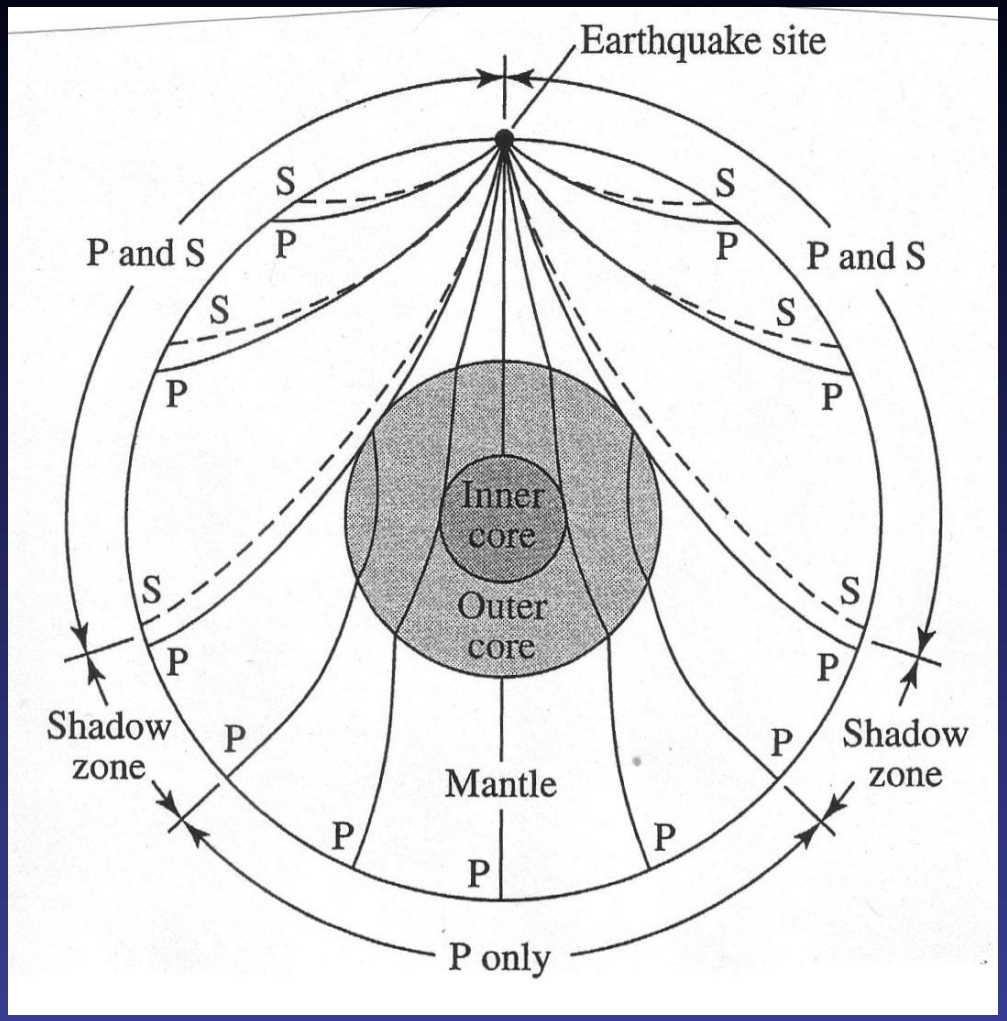
P wave -- pressure, primary, longitudinal

S wave -- shear, secondary, transverse

S wave can NOT go through liquid



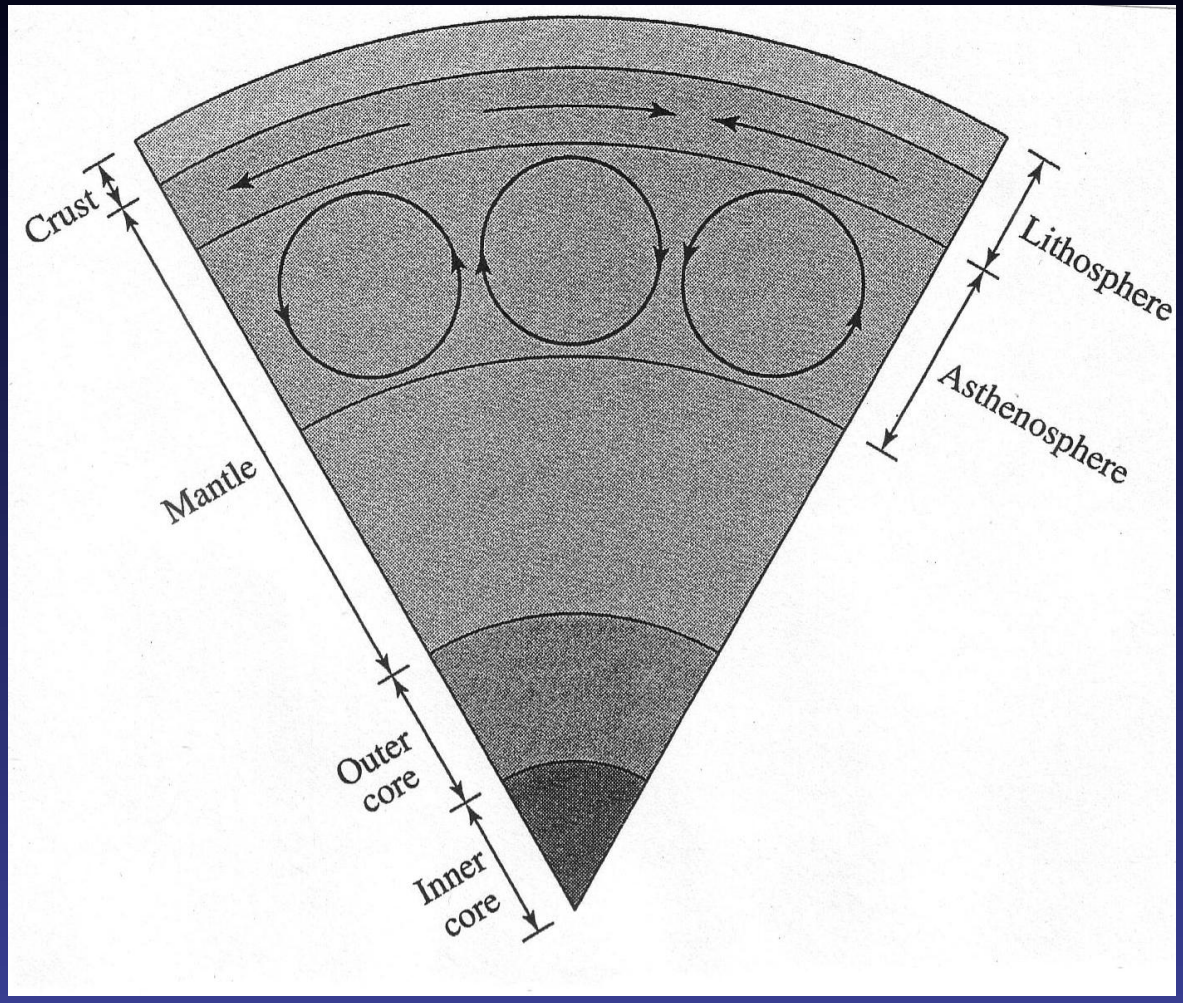
Seismology and Earth's Interior



The propagation of S and P waves depends on the density and state of the medium. The state depends on temperature and pressure.

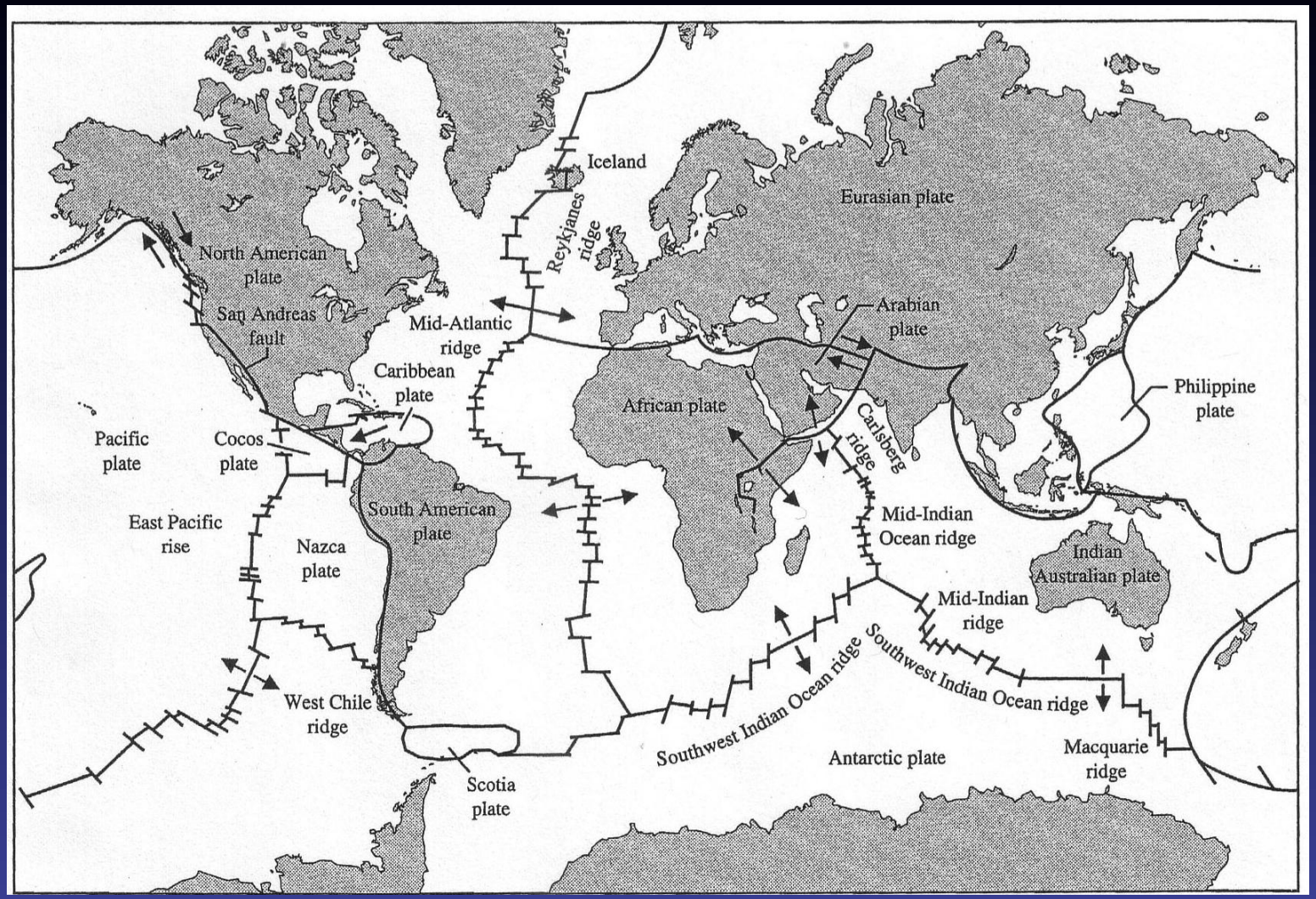
Solid inner core, molten outer core, thick mantle.

Plate Tectonics



The lithosphere is fractured into crustal plates, which ride on the convective asthenosphere.

Plate Tectonics



The Atlantic Ocean is widening at a rate of 3 cm/yr. Material from Earth's interior rises to the surface. Mid-Atlantic ridge is formed.

Plate Tectonics

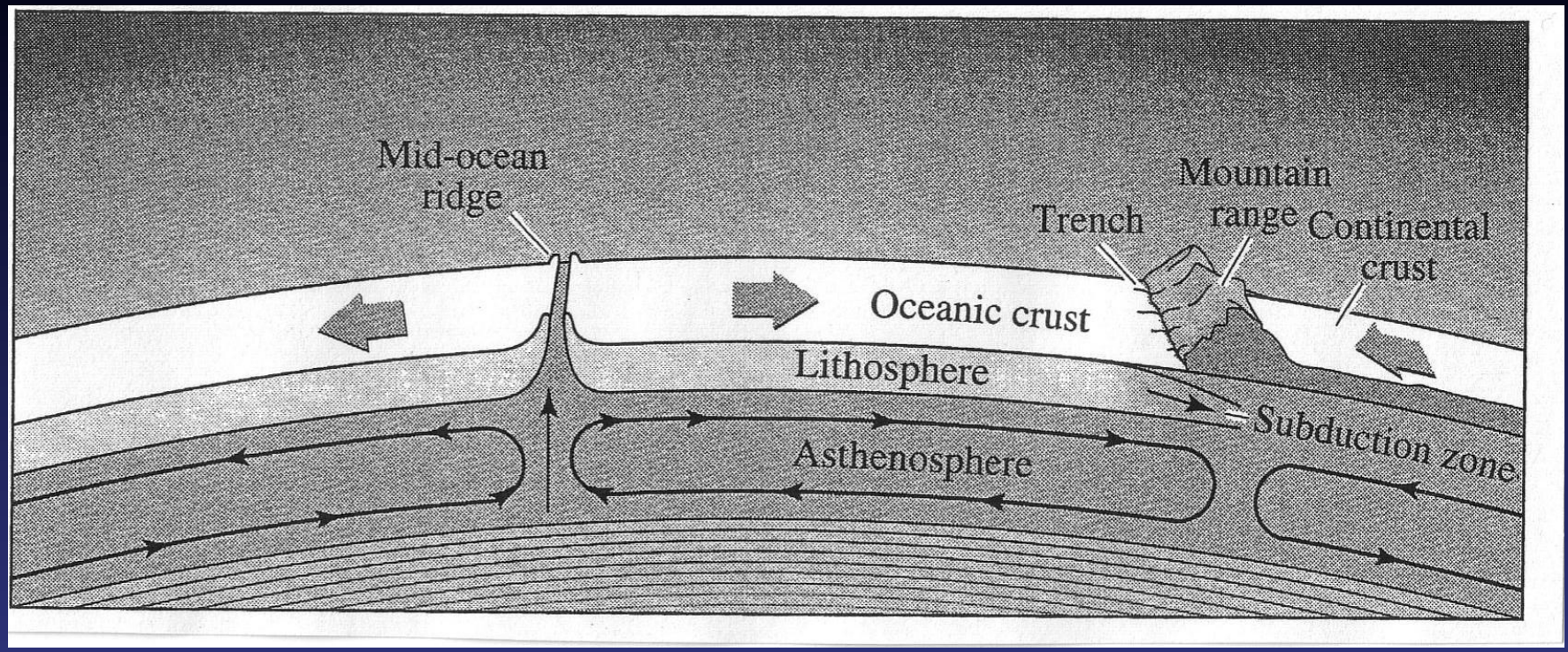


Plate boundaries are sites of active volcanism, mountain building, and earthquakes. Pacific Ring of Fire.
Ocean crust collides with continental crust => subduction
Continental crusts collide => mountains are formed

Sources of Internal Heating

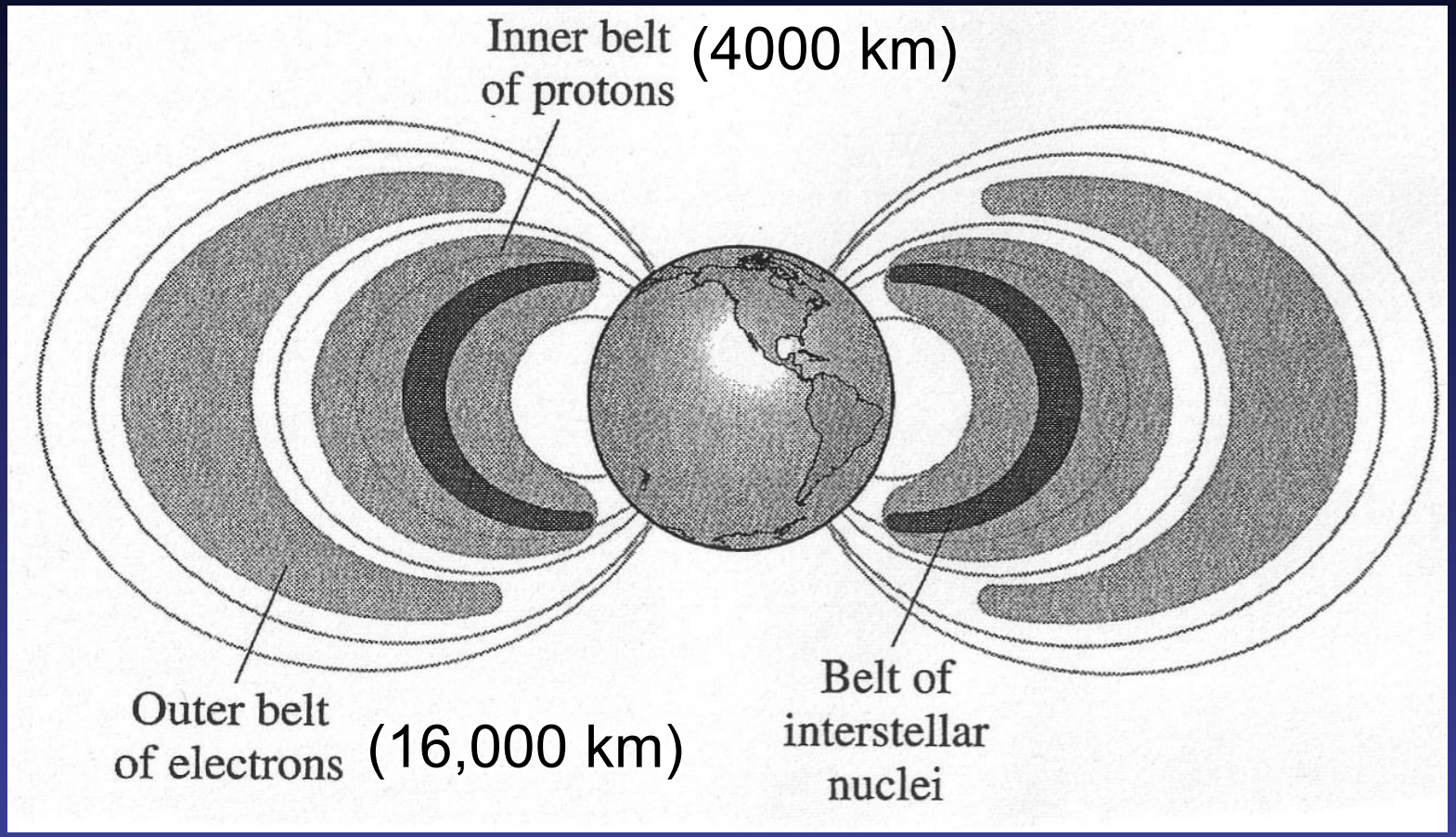
Heat escapes at a rate of 4×10^{13} W, implying an average flux of 0.078 W/m^2.

There must be heating sources to maintain the Plate tectonic activity:

- tidal dissipation of the rotational energy
- gravitational separation of material in the molten layers
- radioactive decay of unstable isotopes.

Earth's Variable Magnetic Field

The rotating molten core generates a global magnetic field.



The Van Allen radiation belts arise from charged particles trapped in the magnetic field of Earth.

Earth's Variable Magnetic Field

Earth's magnetic field weakens, reverses polarity, and reestablishes itself on an irregular time scale of some 10^5 years.

-- similar to the Sun's magnetic field flipping every 11 years.

-- Earth's magnetic field is weakening today.