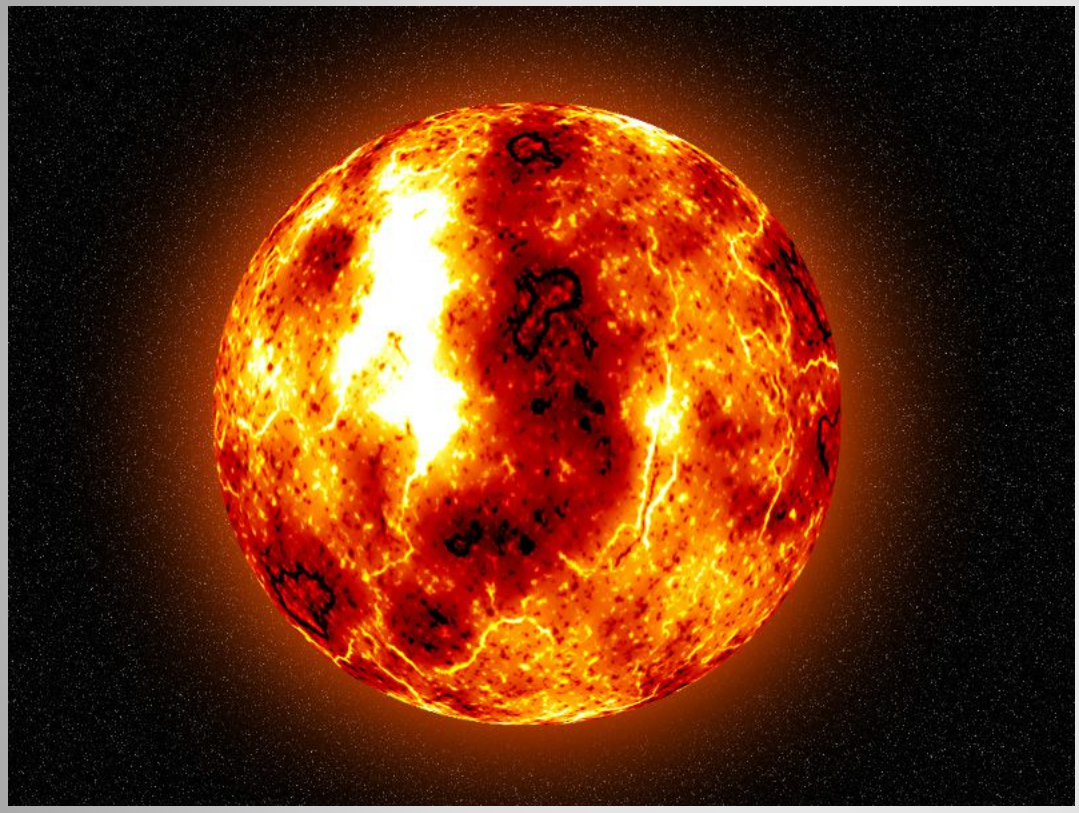
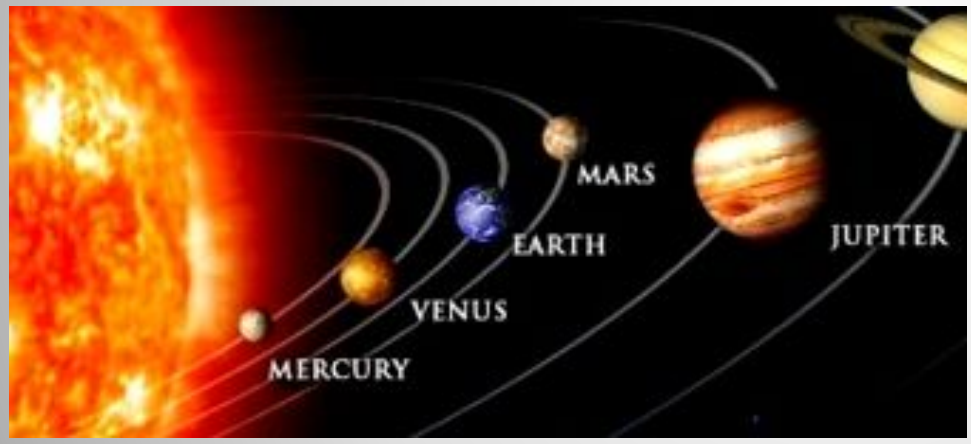


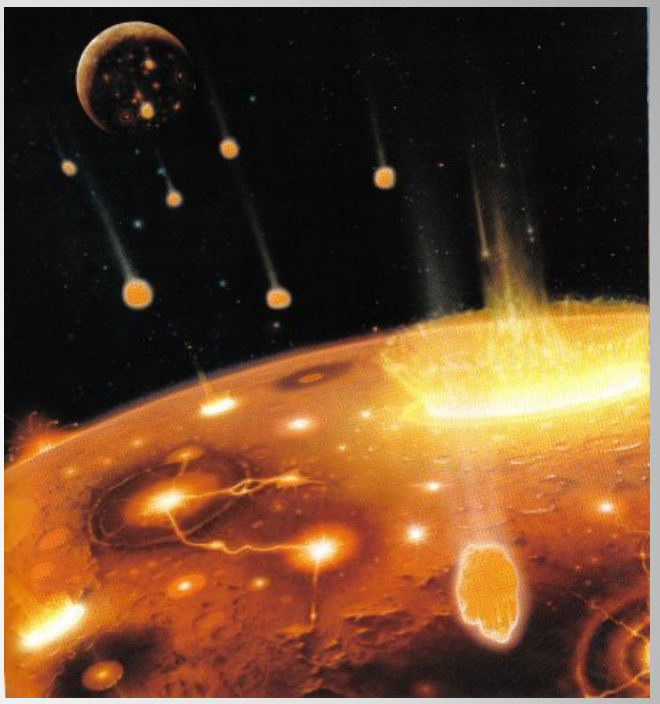
So Hot!

Why?

Early Earth 4.6bya

Proximity to sun

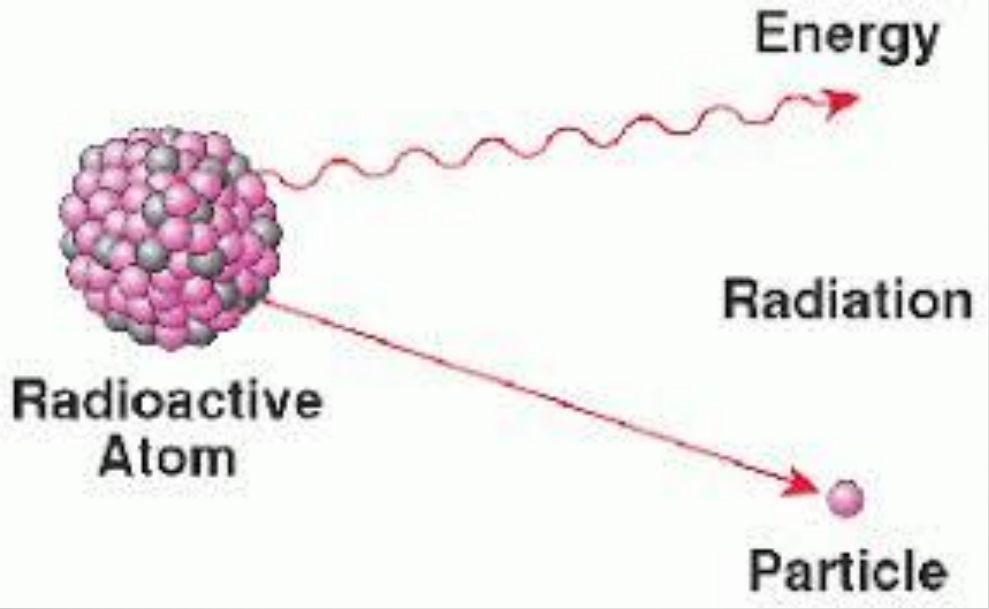


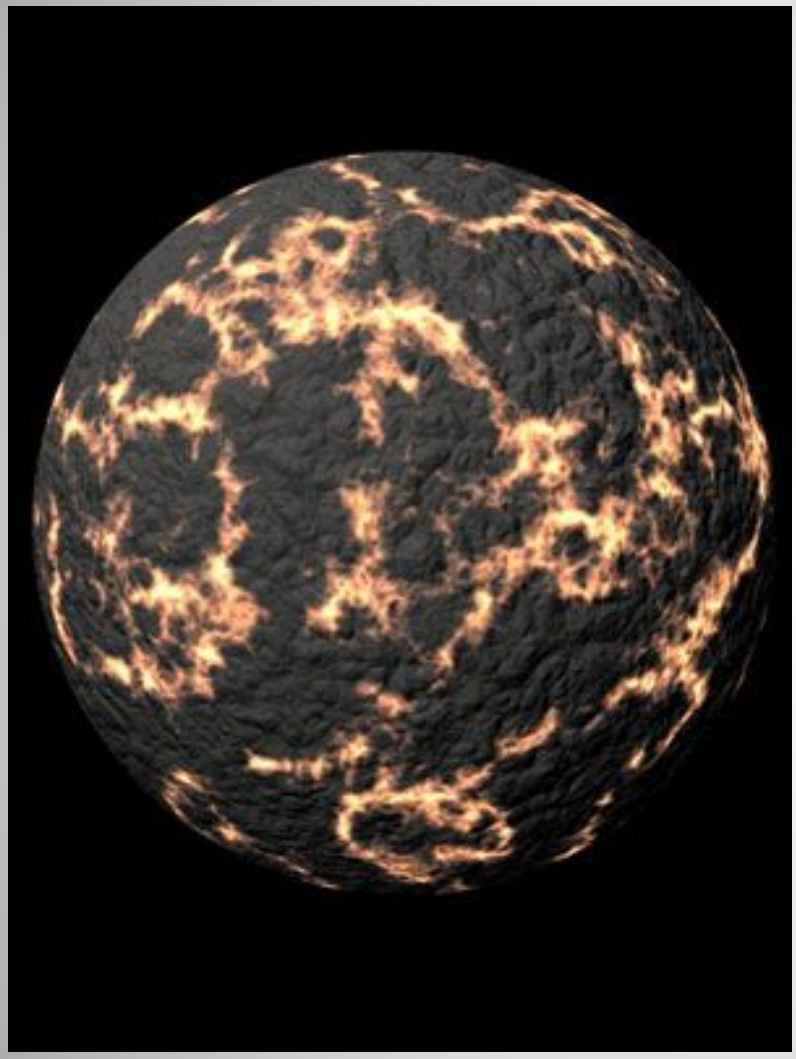


Accretion
primordial heat

Radioactive Decay

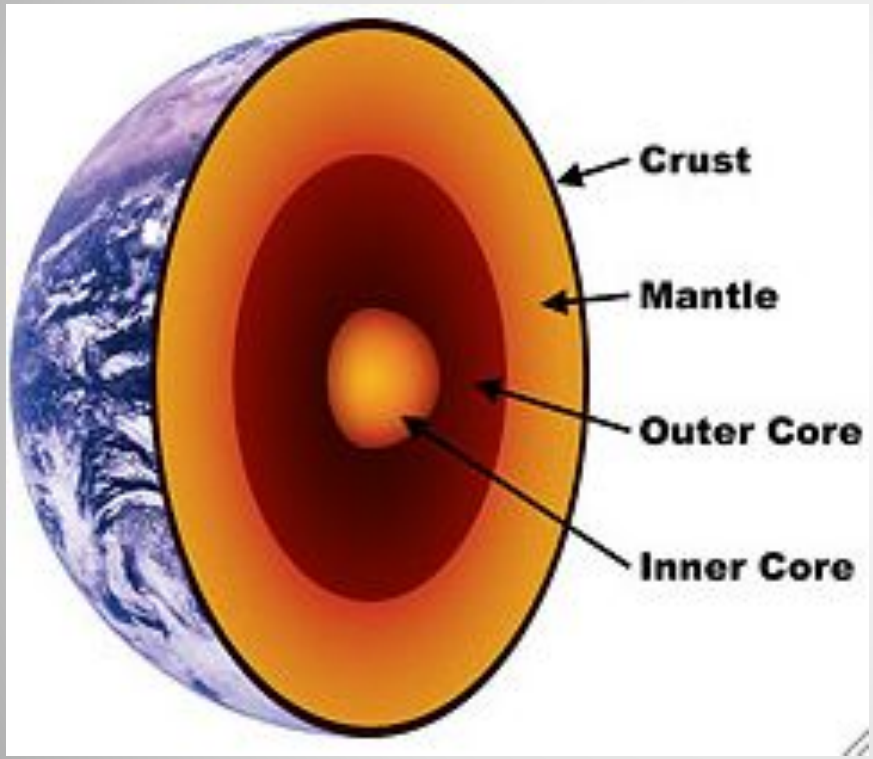
Unstable atoms in Earth's crust & mantle release high energy radiant waves in radioactive decay





- Sun’s ignition clears the solar system
- Fewer collisions
- Earth surface begins to cool
- Layers form as Earth cools

A Cooled Earth is a Layered Earth



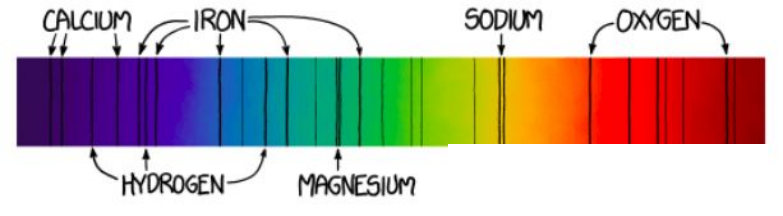
Direct evidence via physical samples from crust, mantle

Indirect evidence for the core

- density calculations
- sun composition, meteorites
- pressure models
- seismic wave behavior
- magnetic field

Evidence: *Chemical Composition*

- Solar spectra tells what elements the Sun is made up of



- Meteorite samples tell same

- If we assume a common solar system origin and we know what elements are in other SS bodies, and we know directly those in Earth's crust & mantle, the 'remainder' must be found in Earth's core

Evidence: *Differences in Density*

Layer	**Density** g/cm^3	*Data Source*
Overall	5.5	*calculated from Earth's volume and mass*
Continental crust	2.7	*direct observations ('subtract' from overall)*
Oceanic crust	3.0	
Mantle	3.9	
Core	12.0 *data*	*deduced using above*

Evidence: *Element mass*

element	*atomic mass*	*layer(s)*
O *oxygen*	16	crust & mantle
Mg *magnesium*	24	
Si *silicon*	28	
Fe *iron*	56	core
Ni *nickel*	59	

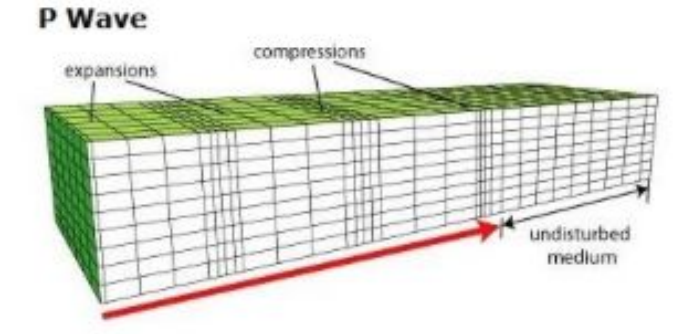
Light elements rise to surface

Heavier ones sink

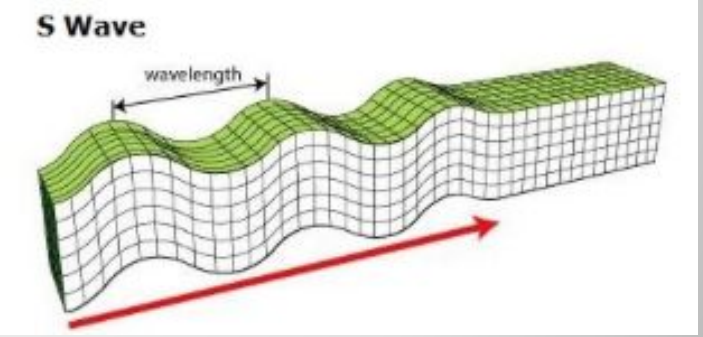
Evidence: *Seismic Wave Behavior*

- Primary (P) and secondary (S) earthquake waves pass through Earth's interior and are measured by scientists around the world

P (compression wave)

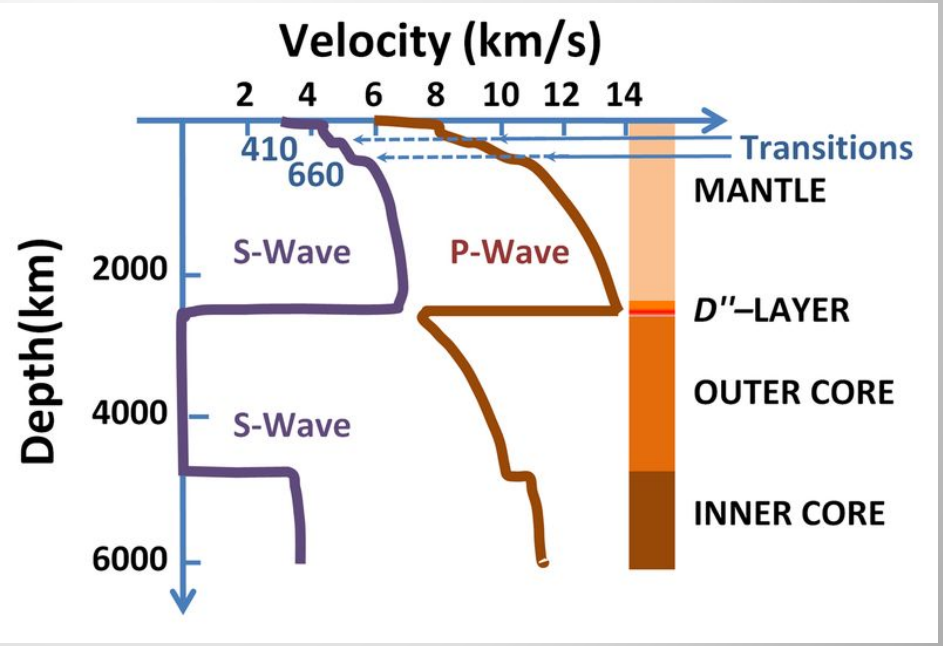


S (transverse wave)

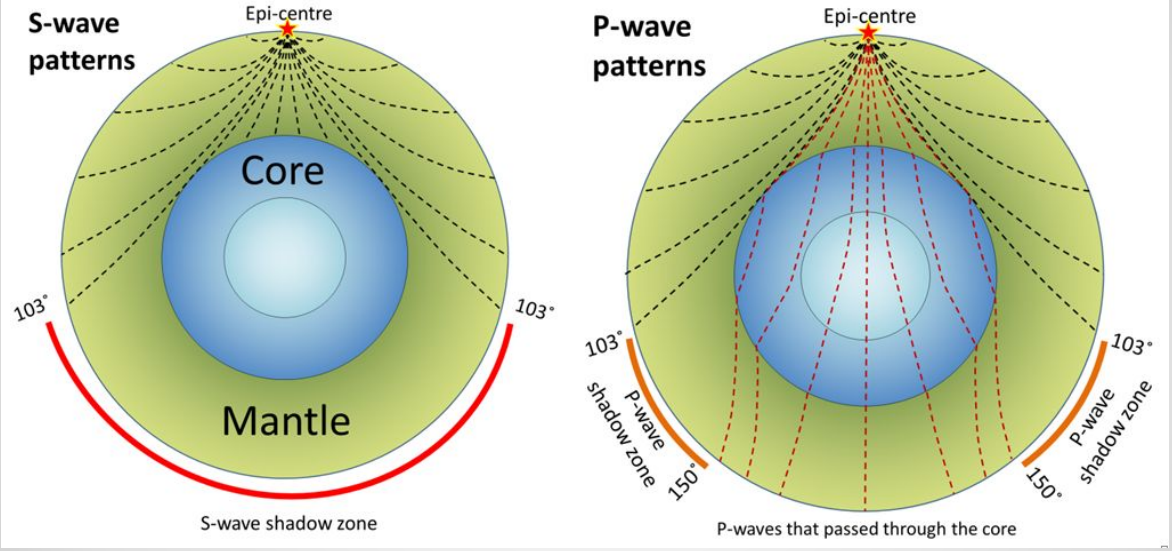


- P and S waves travel at different speeds in different materials: faster through denser rock, slower if there is any melting of the rock

- S-waves are stopped altogether by liquid rock

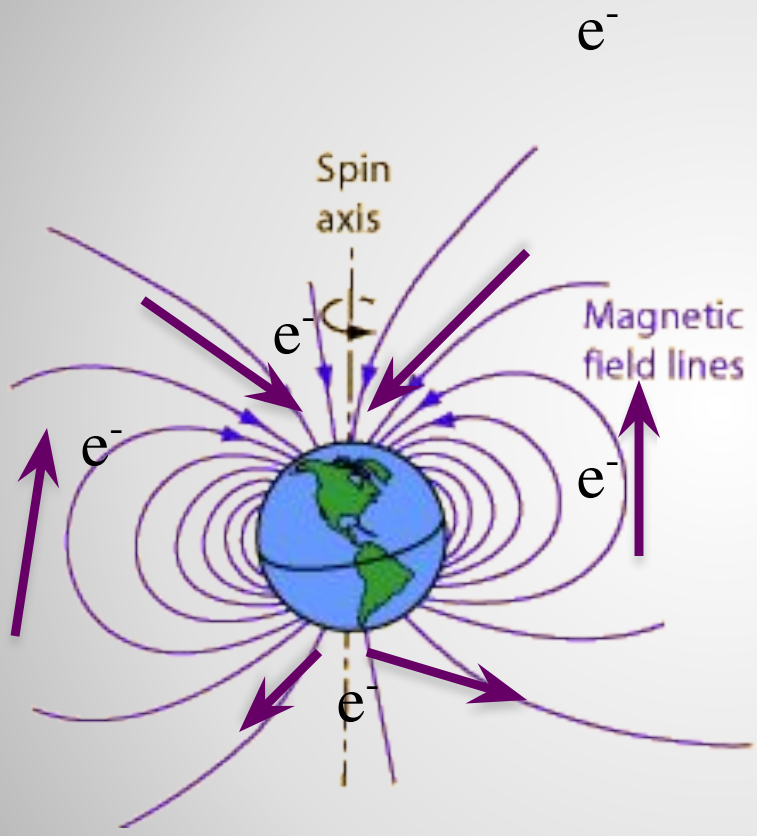


As the waves encounter different rock types, they refract (bend).

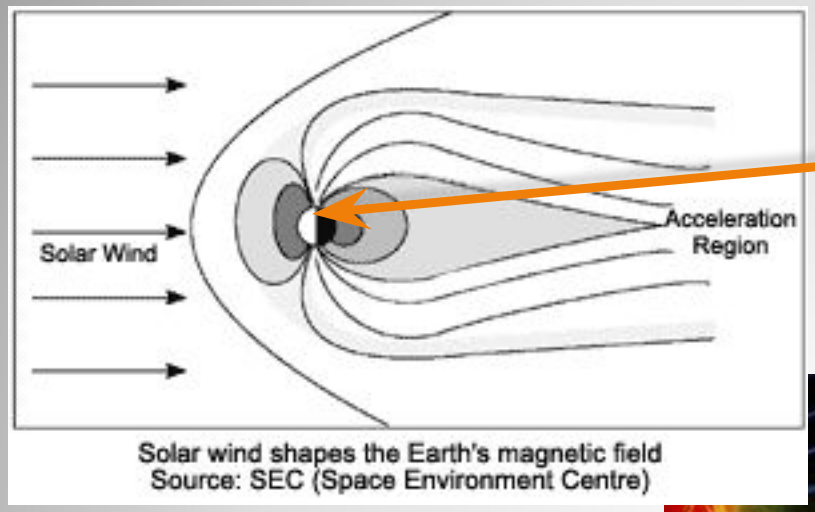


The pattern of wave arrival ('shadows') at distant stations reveals that the outer core is liquid, and the inner core is solid

Evidence: *Earth's Magnetic Field*

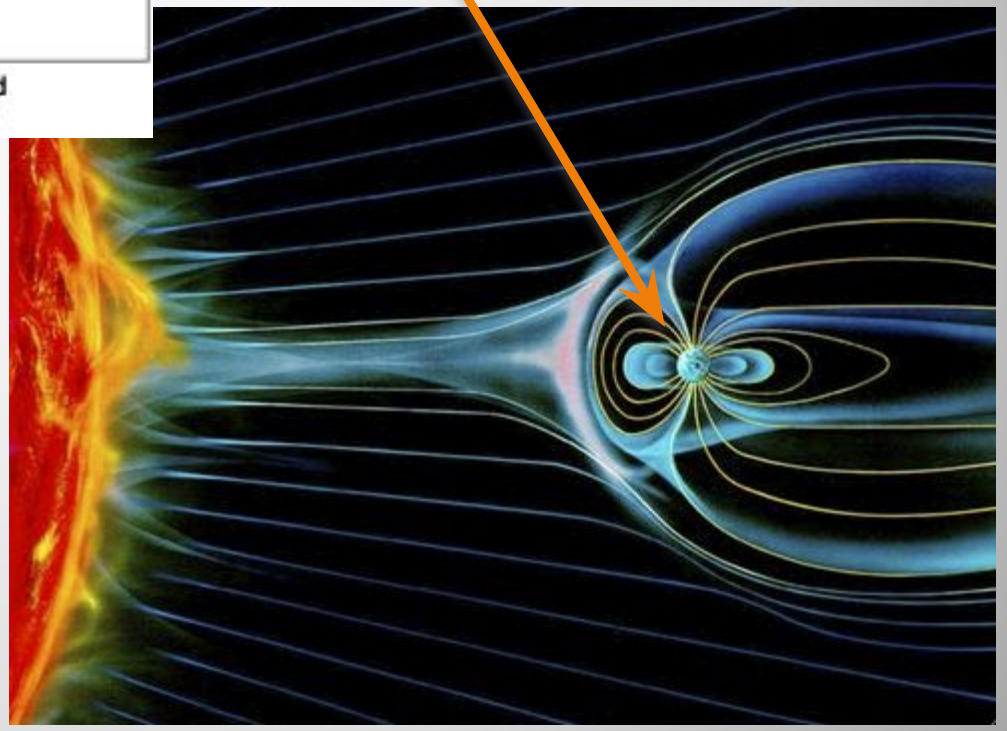


- Must be a layer that is high in metal elements
- Must be liquid metal to generate an electric current to cause magnetism

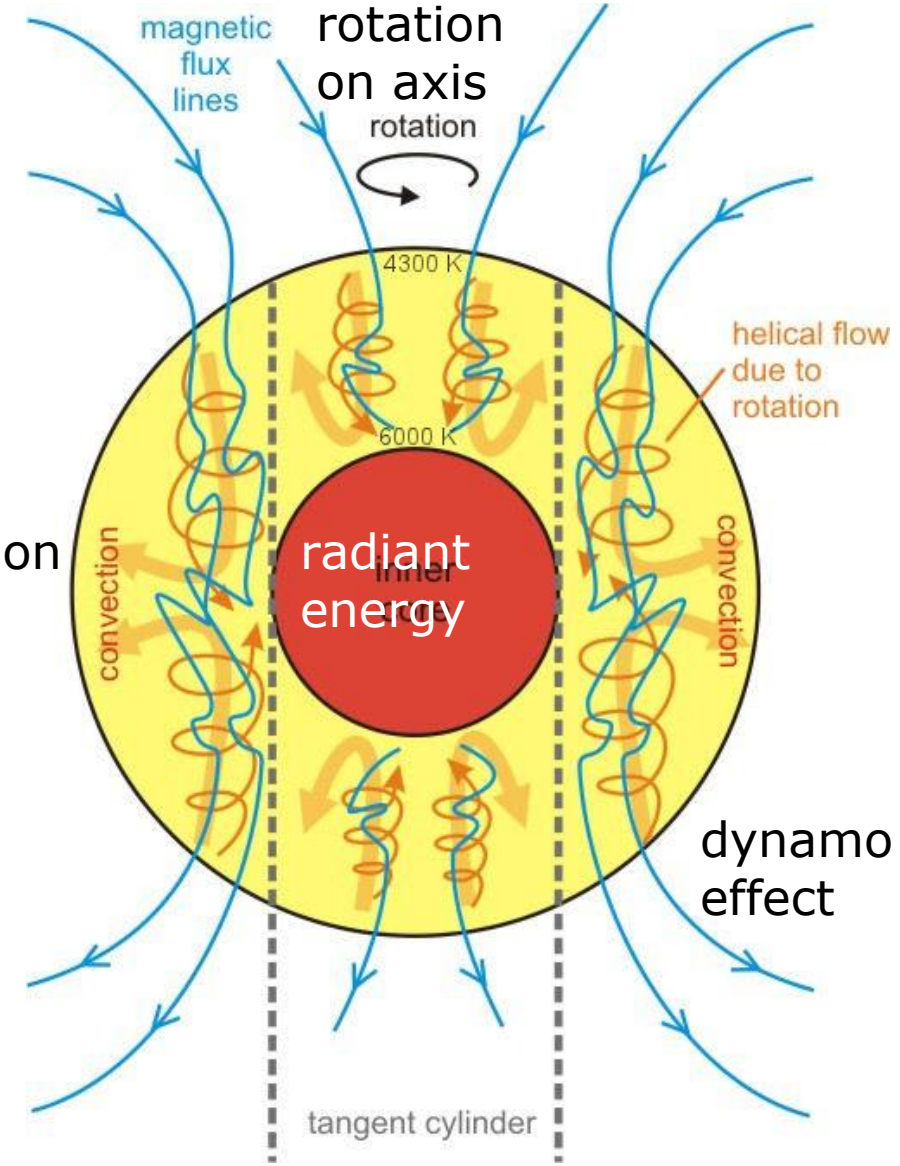


Solar wind shapes the Earth's magnetic field
Source: SEC (Space Environment Centre)

Earth



This **magnetosphere** protects the Earth from the solar wind



Infer: Unequal heating of the outer core causes circulation of the liquid

Axial spin does too

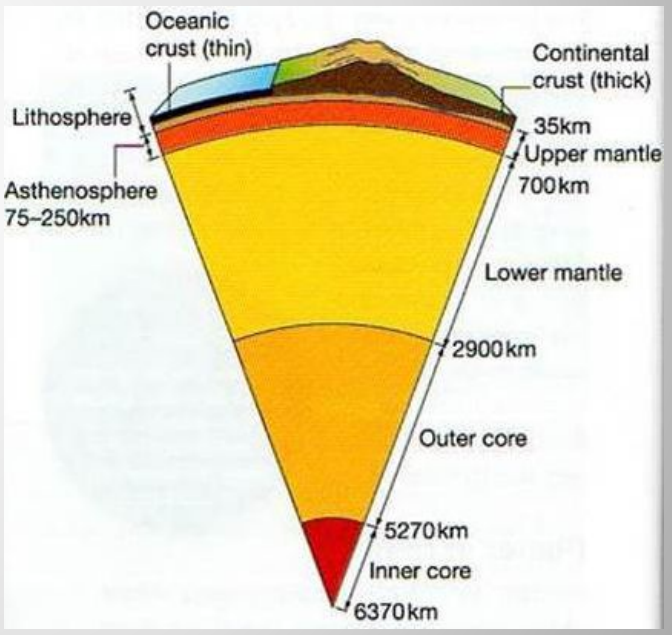
Causes magnetosphere

Core conclusions:

Both: Largely Fe, Ni metals

Inner – great density & temperature, but also pressure; therefore **solid**

Outer – great temp but less pressure, therefore **liquid;** currents created by spin on axis causes magnetosphere



SIDEBAR

Where the magnetosphere is thin, near the poles, we see the interaction of the atmosphere, charge e^- of the magnetosphere, and the solar wind, causing an **Aurora**

Mantle

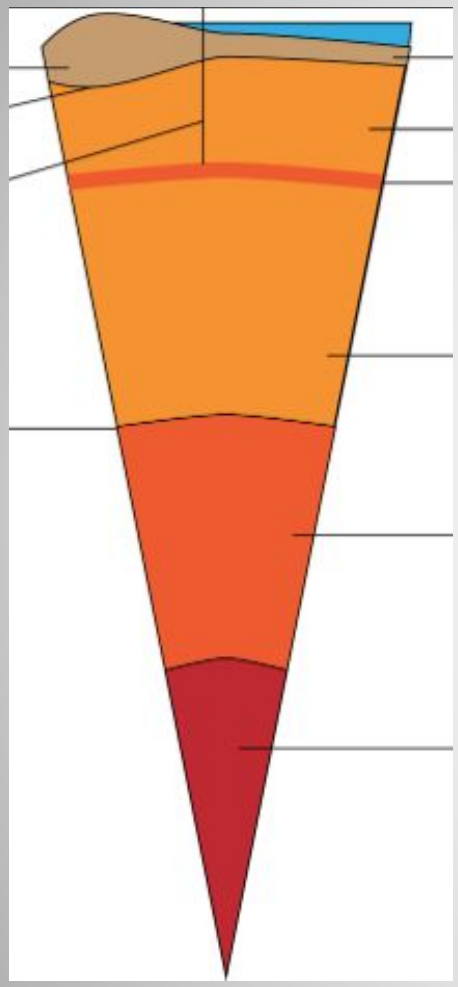
Olivine rock from the mantle

- *Thickest layer makes up most of the planet*
- A **fluid solid**

  solid – state of matter
  fluid – describes behavior

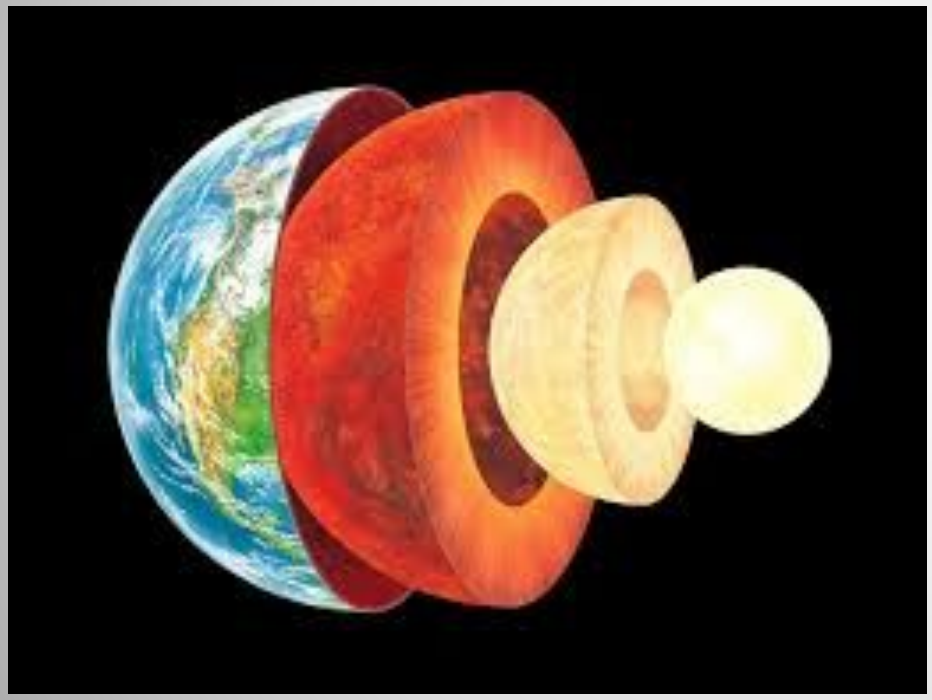
- a solid that flows
- albeit very slowly ~cm/year

Like Silly Putty!



- The mantle is heated by the core at its base
- mantle is cool near the crust

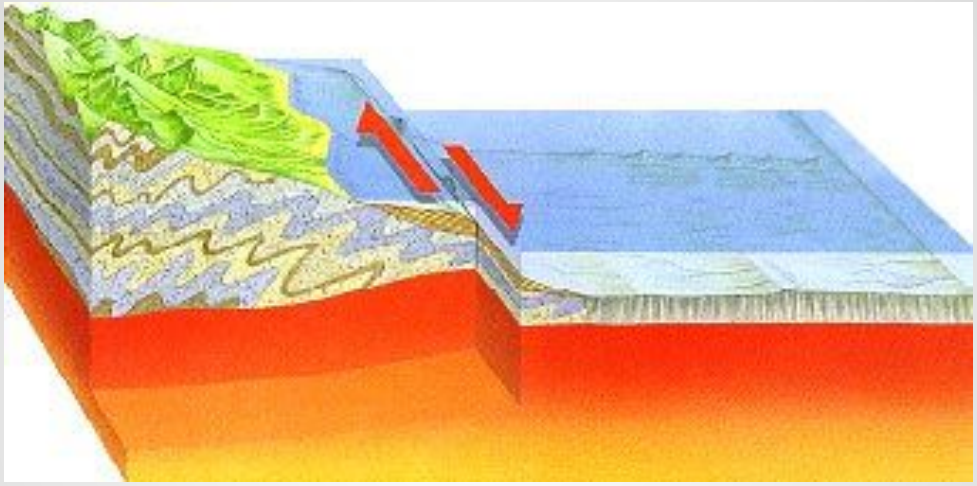
Crust



- Highest in light, less dense elements like Si, lowest in heavy, dense Fe

- Broke into pieces as the planet cooled

Two types

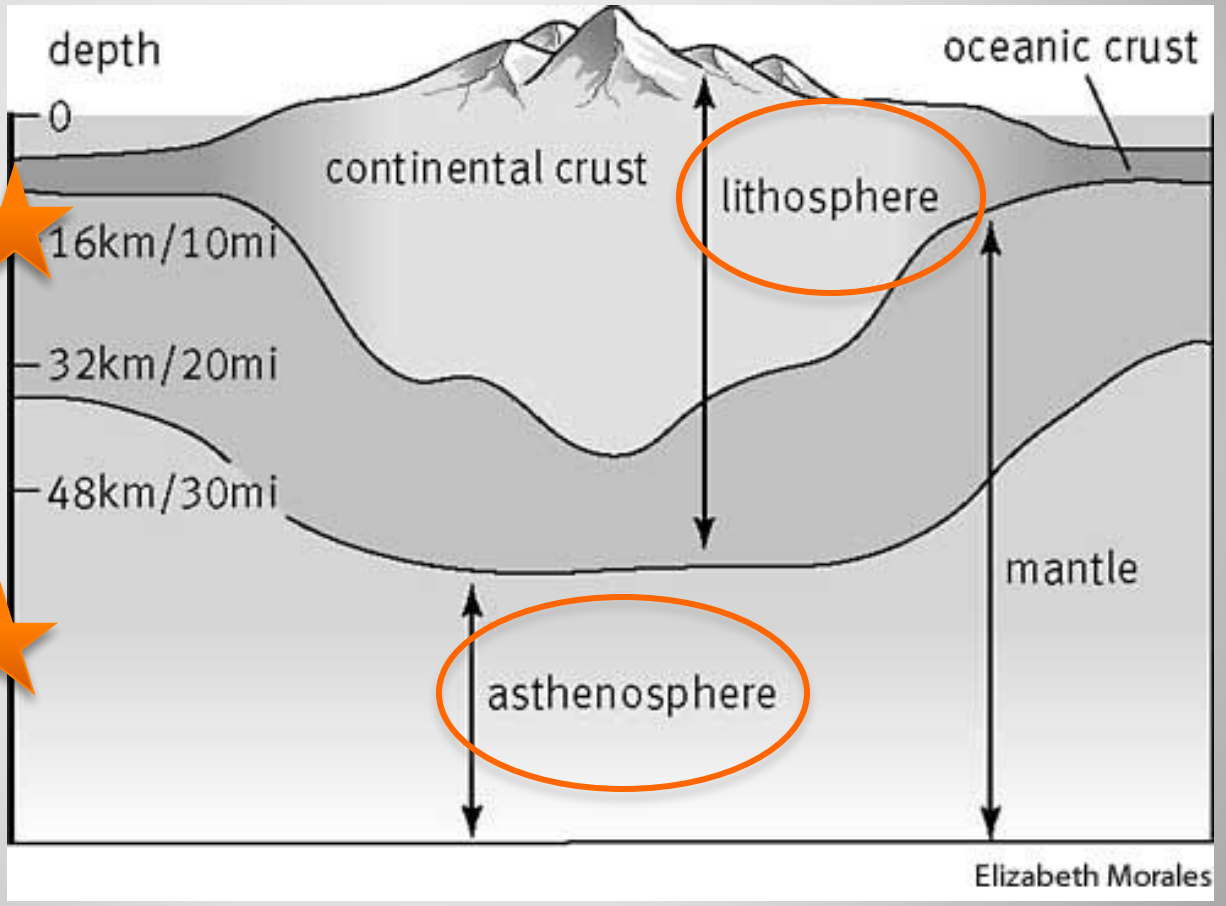


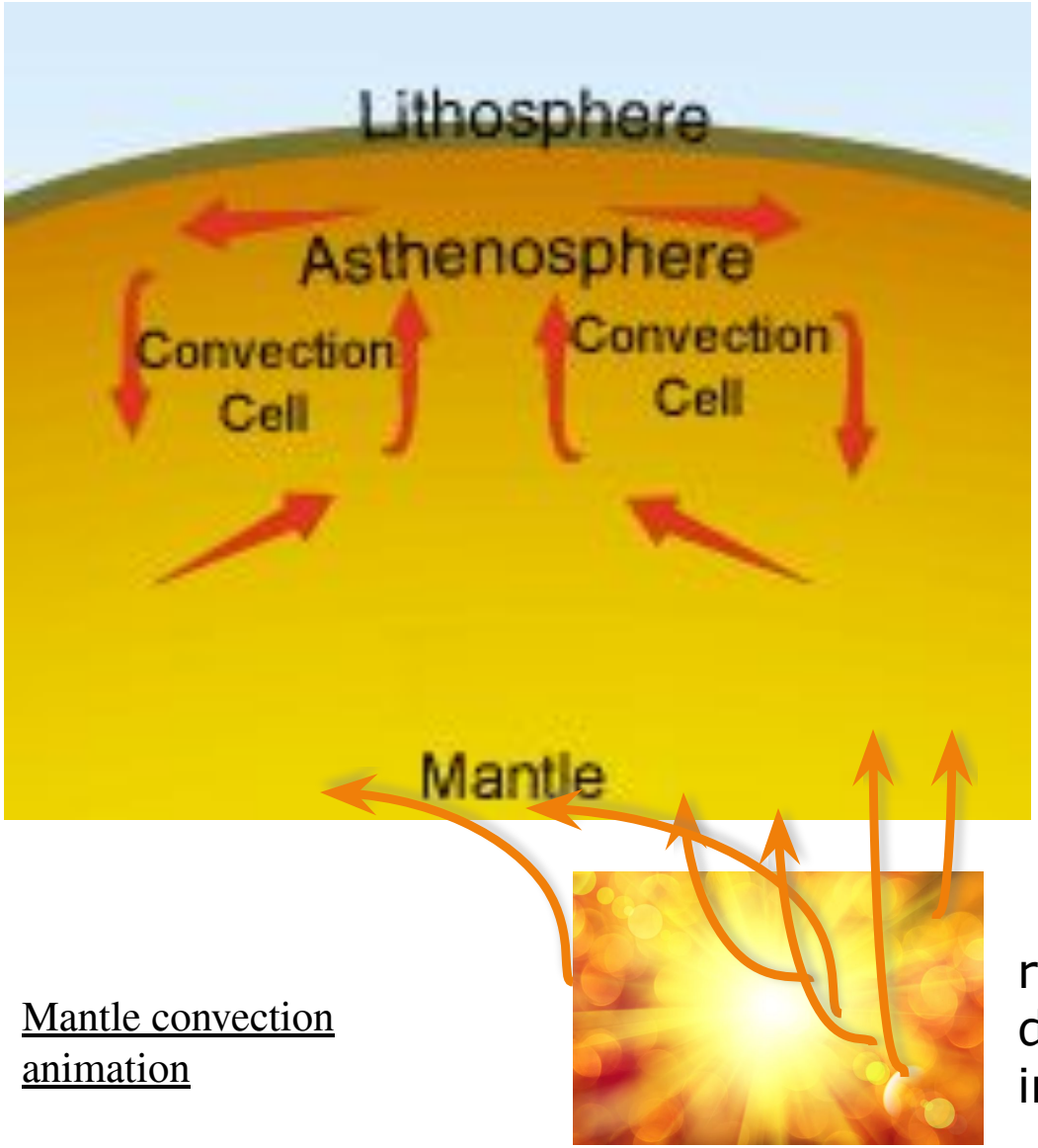
continental crust	sea floor crust:
thick	thin
less dense granitic rock	dense basalt rock

Alternate Layering Scheme

Crust, plus cooled upper mantle

Deeper, warmer, flowing mantle





Infer: Unequal heating of the mantle material causes rock to flow

Rising • cooling • sinking • in a cycle

Drives movement of the plates

Mantle convection animation

radiant energy from decay, residual heat in Earth's core