Unit 4: Formation of the Earth

Objectives:

E2.2A - Describe the Earth's principal sources of internal and external energy (e.g.,radioactive decay, gravity, solar energy).

E3.2A - Describe the interior of the Earth (in terms of crust, mantle, and inner and outer cores) and where the magnetic field of the Earth is generated.

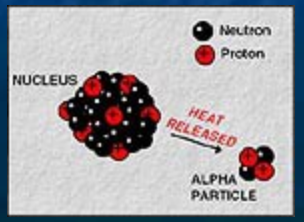
Sources of Energy*

Heat within the Earth comes from two major sources: **radioactive decay** and **residual heat**.

Radioactive decay – is the result of a process that involves the loss of particles from the nucleus of an isotope (called the parent) to form the isotope of a new element (called the daughter). The radioactive decay of naturally occurring chemical elements (usually uranium, thorium, and potassium), releases energy in the form of heat, which slowly migrates toward the Earth's surface.

Residual heat – is the gravitational energy left over from the formation of the Earth, by the "falling together" and compression of cosmic debris (much like a bicycle pump that heats up due to the compression of air inside it).

All radioactive decay processes release heat as a by-product.



Sources of Energy*

The major source of external energy to our Earth is, of course, our Sun.

Insolation – is the incoming radiation from the Sun that is received by the Earth's atmosphere and surface. It is the driving force that moves the atmosphere and creates weather on Earth in addition to providing the energy required by plants to perform photosynthesis.

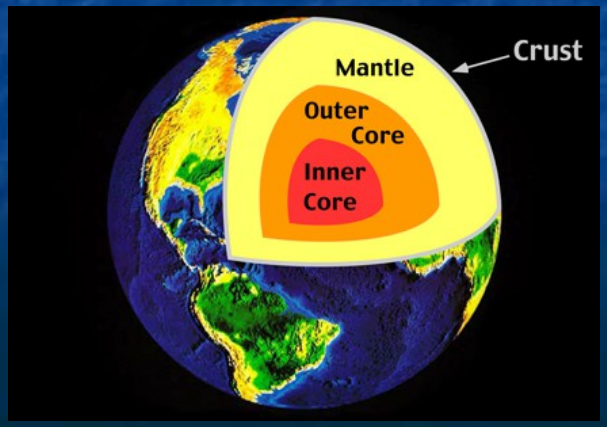
Most of the Sun's radiation received by the Earth is in the form of short-wave radiation. This high-energy radiation makes up approximately 88% of the radiation that is received on Earth. This includes ultraviolet, visible light, and the near-infrared radiation. The remaining 12% of the radiation received on Earth is low-energy long-wave radiation. This includes far-infrared and microwave radiation.

Earth's Interior

The original surface of the Earth probably looked much as the Moon's surface does today. The Earth was probably composed of the same material from its surface all the way to its center.

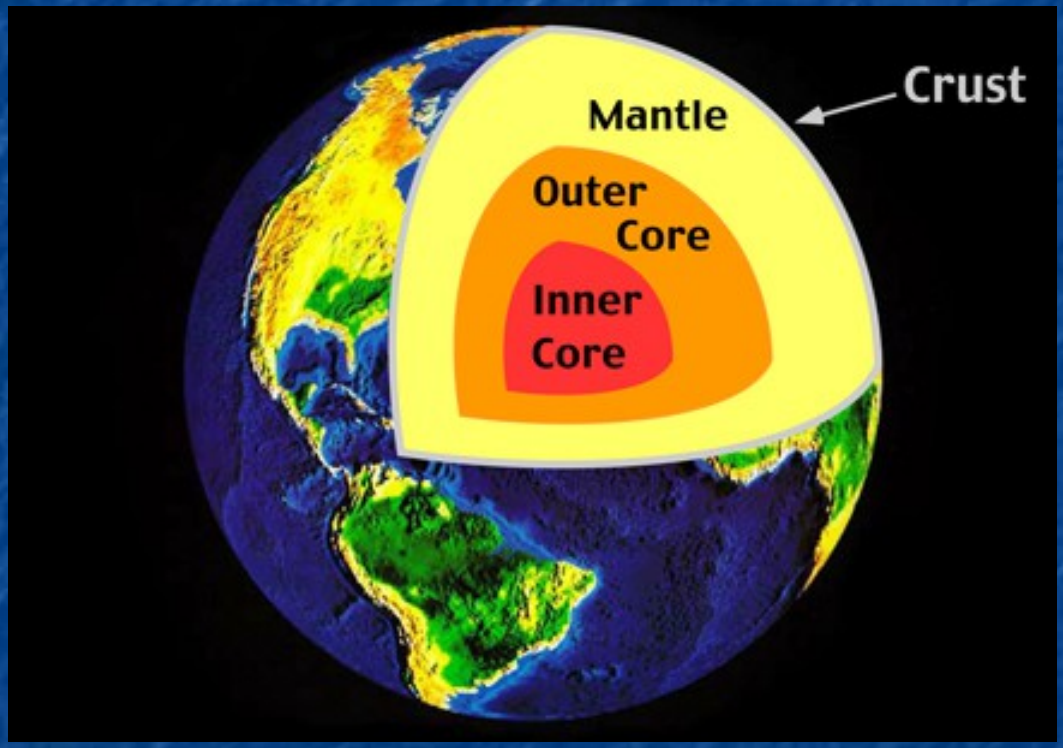
Objects colliding with Earth helped to cause Earth to grow hot enough that heavy elements such as iron and nickel melted.

The material composing Earth gradually separated into several layers, with the denser material being located near the center.

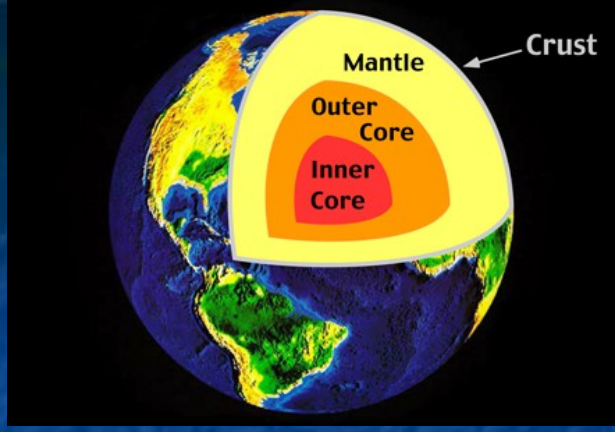


Earth's Interior

- Crust
- Mantle
- Outer core
- Inner core



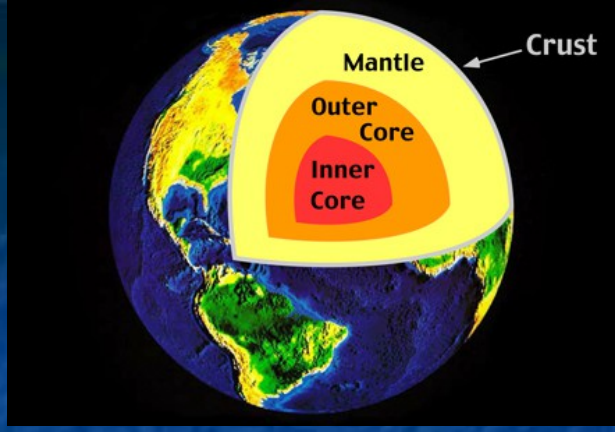
Crust*



- Solid
- A thin, rigid layer of lighter rocks
- Extends to a depth of 65 km
- Temperature is less than 1000 K, however it increases by 10-30 K for every kilometer of depth
- The part of the geosphere that humans have direct contact with, and the only place where life has been found

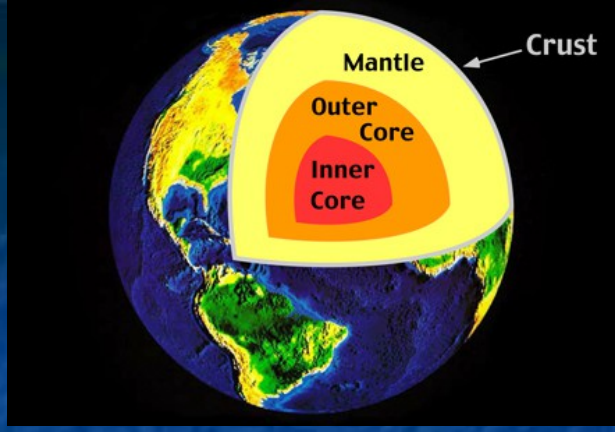
Note K = Kelvin (degrees) K = °C + 273

Mantle*



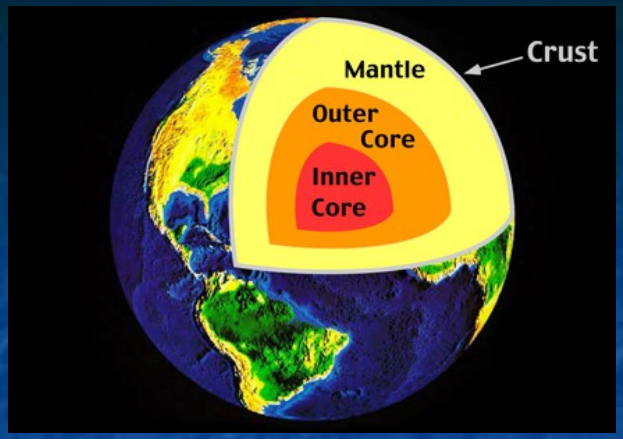
- Solid with liquid properties
- Thickest of Earth's layers
- Composed mostly of compounds rich in iron, silicon, and magnesium
- High temperatures and pressures cause it to behave as a liquid in some ways
- Extends to a depth of 2890 km (from the surface)
- Temperature is between 1500-3200 K, and increases with depth

Outer Core*



- Liquid
- Composed of iron and nickel
- Extends to a depth of 5150 km (from the surface)
- Temperature is between 3700-5500 K, and increases with depth

Inner Core*



- Solid
- Composed of iron and nickel
- Extends to a depth of 6371 km (from the surface)
- Temperature is approximately 6000 K

Drilling into the Earth

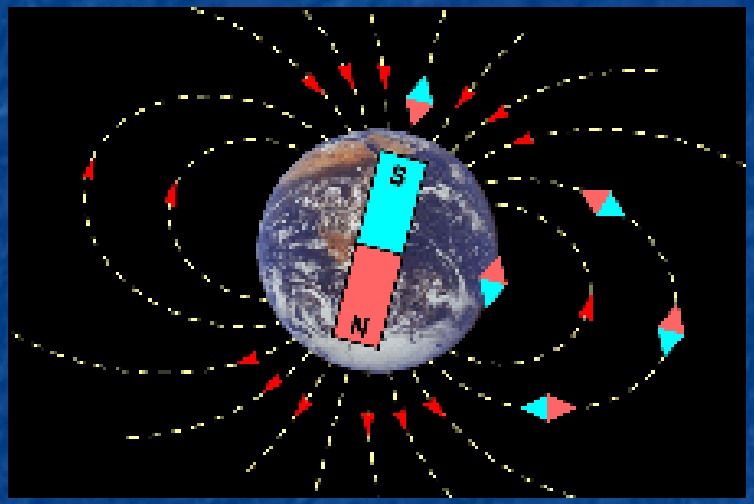
How far have humans been able to drill down into the Earth?

Humans have only been able to drill down about 12 km (approximately 7.6 miles) into the Earth's crust. We have never drilled into the mantle, outer core, or inner core.

Earth's Magnetic Field*

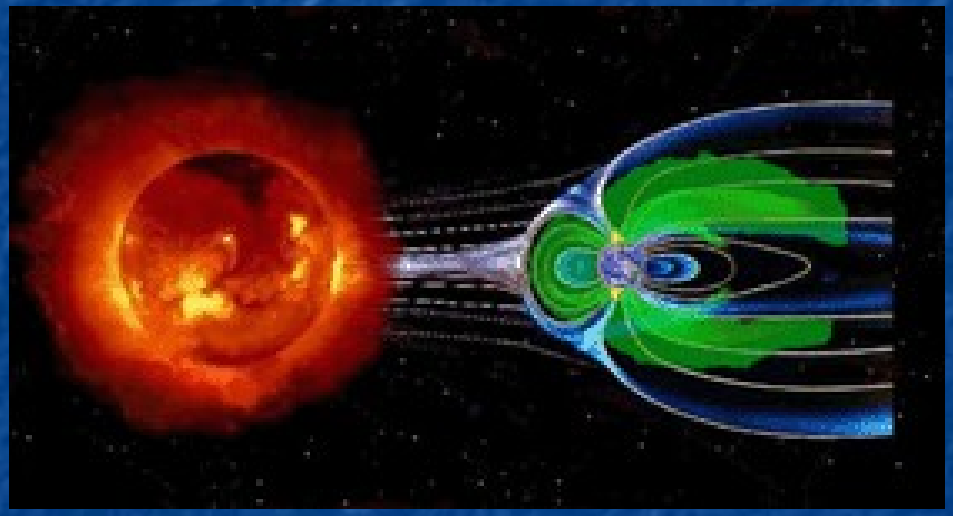
Although scientists do not fully understand the origin of Earth's magnetic field, many support a hypothesis first developed in the 1900s.

The hypothesis suggests that the movement of the liquid interior of the Earth generate a strong magnetic field that surrounds the planet. This causes the Earth to act much like a large magnet, with the poles of the magnet located near the poles of the Earth.



Earth's Magnetic Field

Our magnetic field stretches out through the atmosphere and acts as a protective barrier to deadly, high-energy solar radiation. This portion of the Earth is called the **magnetosphere**.



Earth's Magnetic Field

The Earth's magnetic field allows us to use compasses to locate direction on the planet. A small magnetic needle that is allowed to spin freely aligns itself with the Earth's magnetic field and points to the magnetic North Pole.

Earth's Magnetic Field

Because the geographic poles do not exactly match up with the magnetic poles, you need to be aware of "magnetic declination" when you use a compass.

Magnetic declination is the number of degrees and direction between true north (geographic) and magnetic north.

As you can see, Ann Arbor is about 7° west of true north.