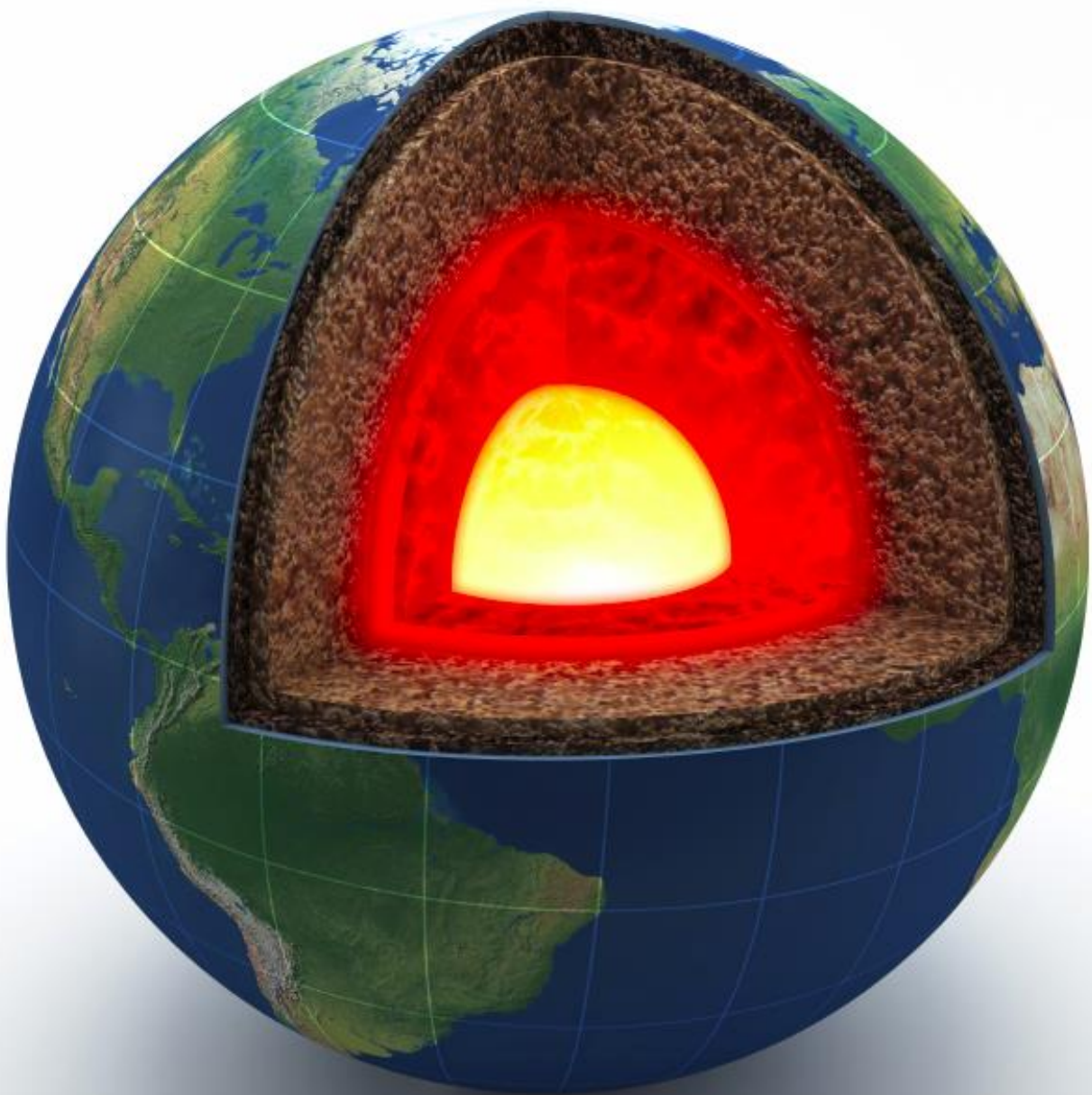


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Solid Earth Evolution

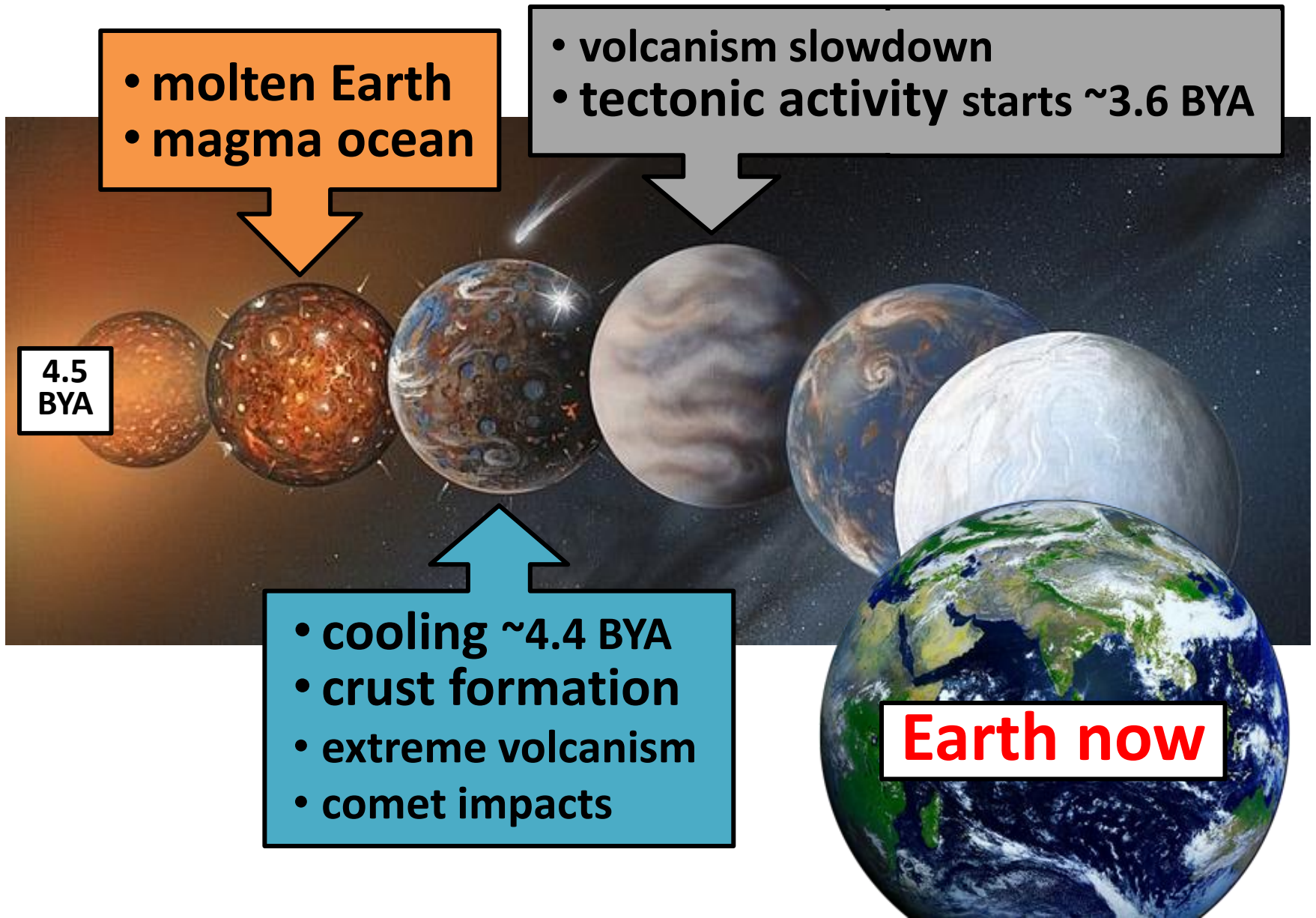
- molten Earth
- magma ocean

- volcanism slowdown
- tectonic activity starts ~3.6 BYA

4.5
BYA

- cooling ~4.4 BYA
- crust formation
- extreme volcanism
- comet impacts

Earth now



Inside Earth: Layers

➤ Inner core

- $R = 1300$ km
(0-800 mi)

➤ Outer core

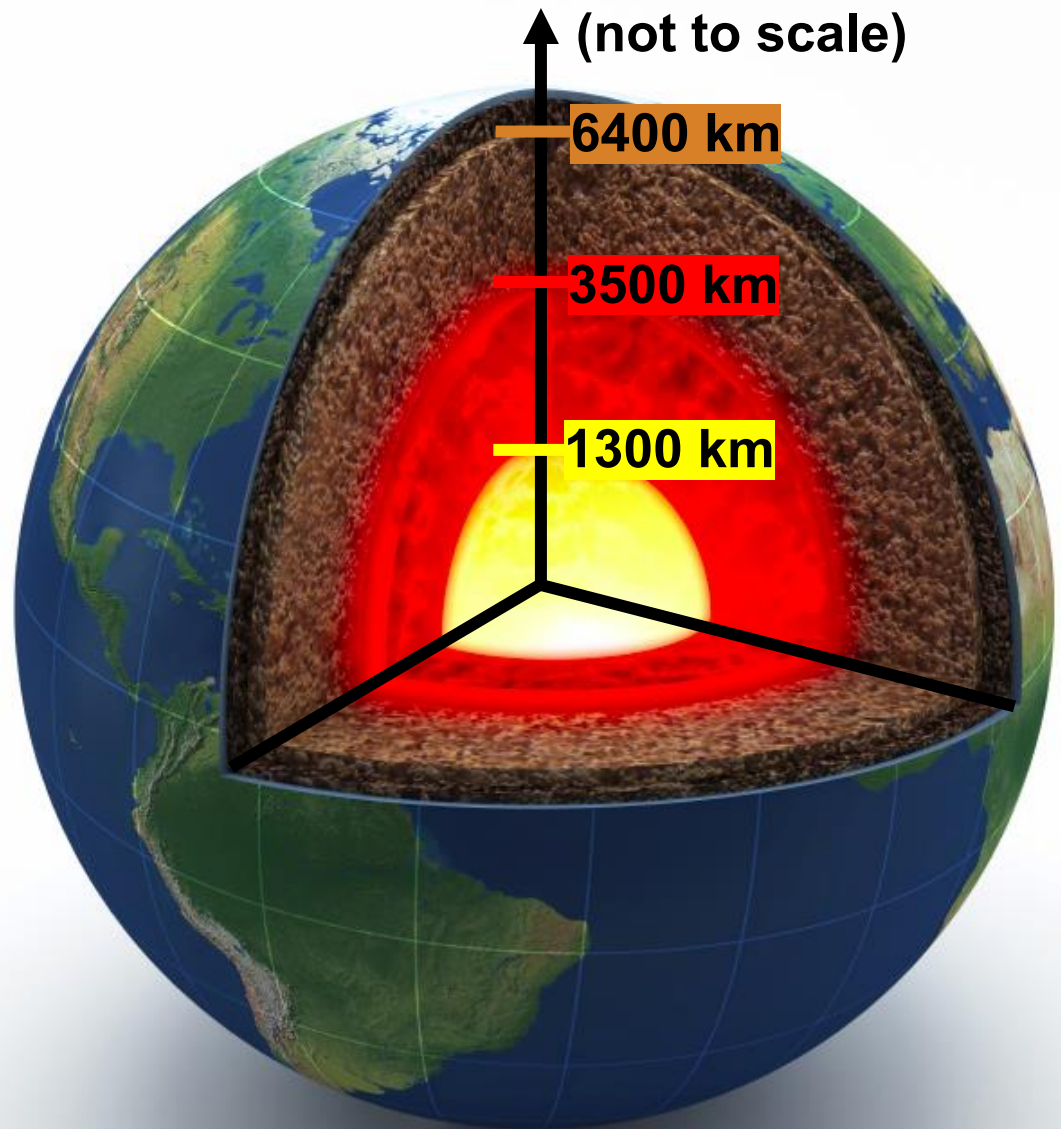
- 1300-3500 km
(800-2200 mi)

➤ Mantle

- 3500-6400 km
(2200-4000 mi)

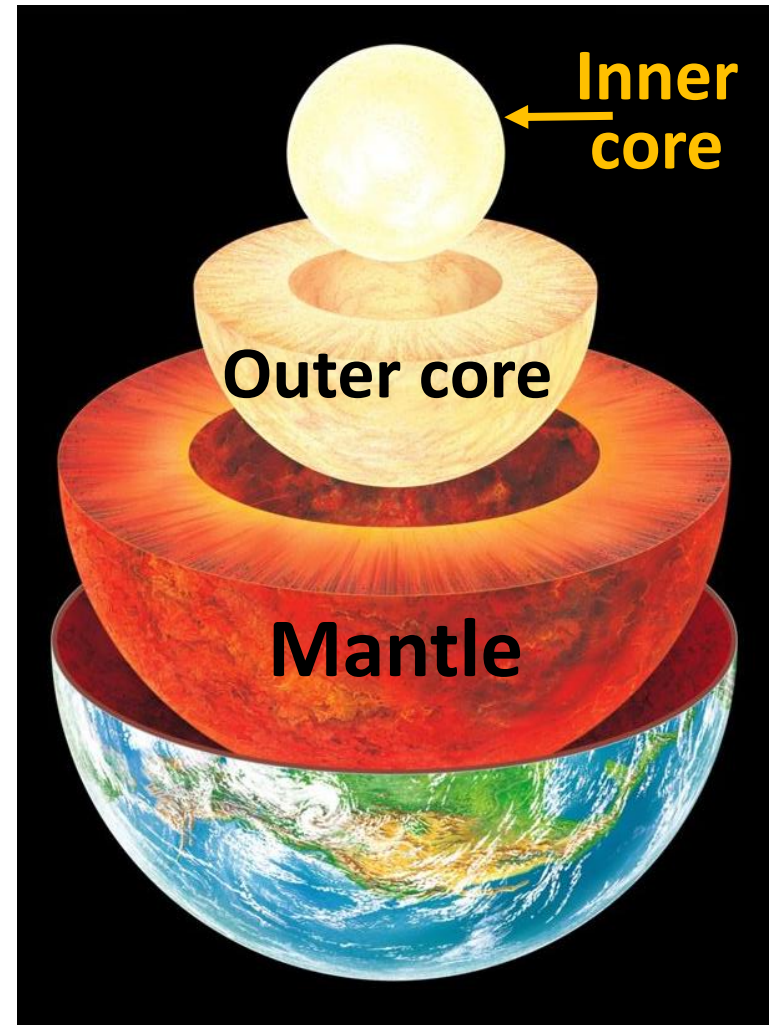
➤ Crust

- tops mantle
- 5-50 km thick
(3-25 mi)



The Core

- 16% of Earth's volume
- Two sections:
 - inner core
 - total diameter ~2600 km
 - $T \sim 6,000\text{-}7,000\text{ K}$ ($>10,000^{\circ}\text{F}$)
 - solid, extremely dense
 - nickel-iron alloy
 - grows ~1 mm per year
 - outer core
 - ~2200 km thick
 - liquid
 - $T \sim 4,000\text{-}6,000\text{ K}$ ($\sim 6,700\text{-}10,300^{\circ}\text{F}$)
 - primarily iron with some nickel and sulfur
 - convection of liquid metals creates the Earth's magnetic field



The Mantle

- 2900 km thick
- ~84% of Earth's volume

- Three regions:

- lower region

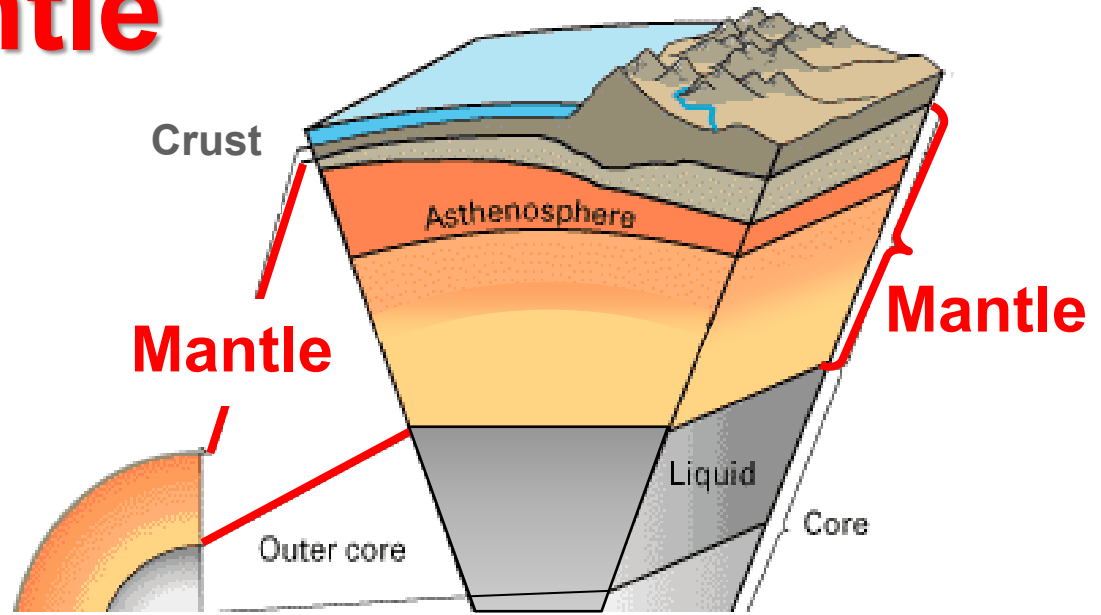
- dense, **solid** (due to *enormous pressure!*)
 - temperatures between ~2500-4,000 K (~3,400-6,700°F)

- upper region (***asthenosphere***, “weak” sphere)

- has reduced pressures and rock strength
 - ***plastic rock*** (at pressures and temperatures found in this region, mantle rock **can deform and flow slowly**).

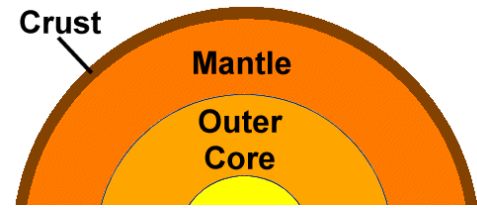
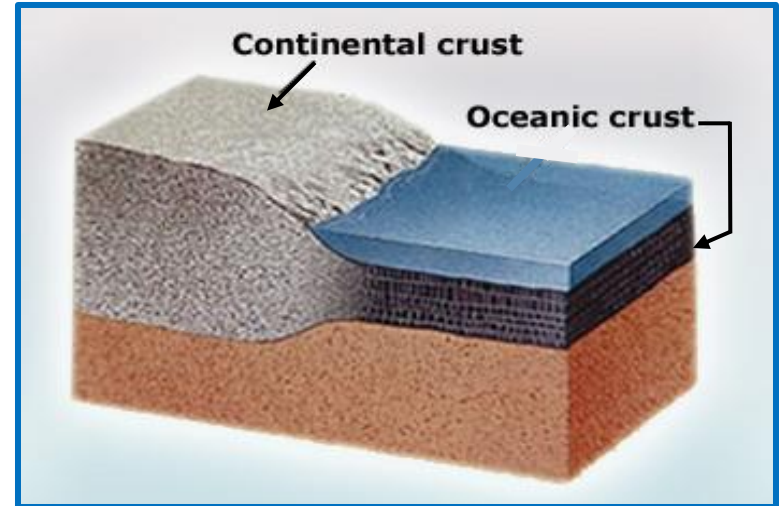
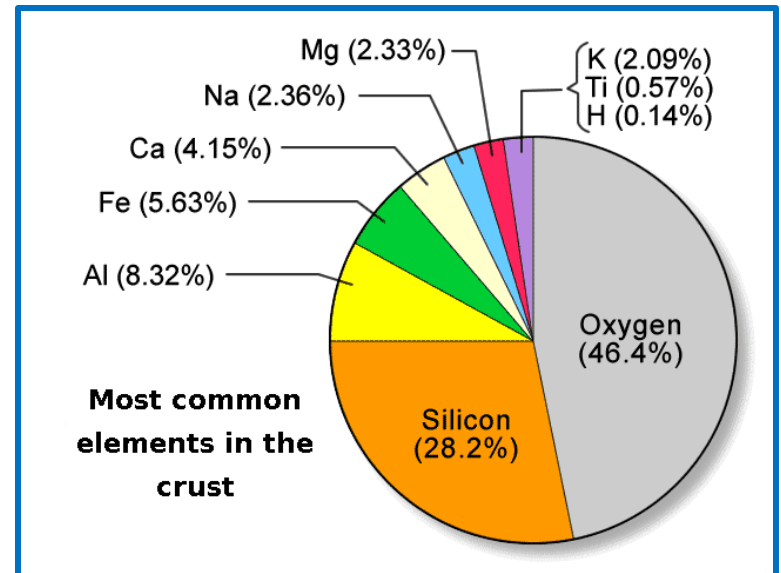
- uppermost region

- **solid**; temperatures between 750-1200 K (~900-1,700°F)

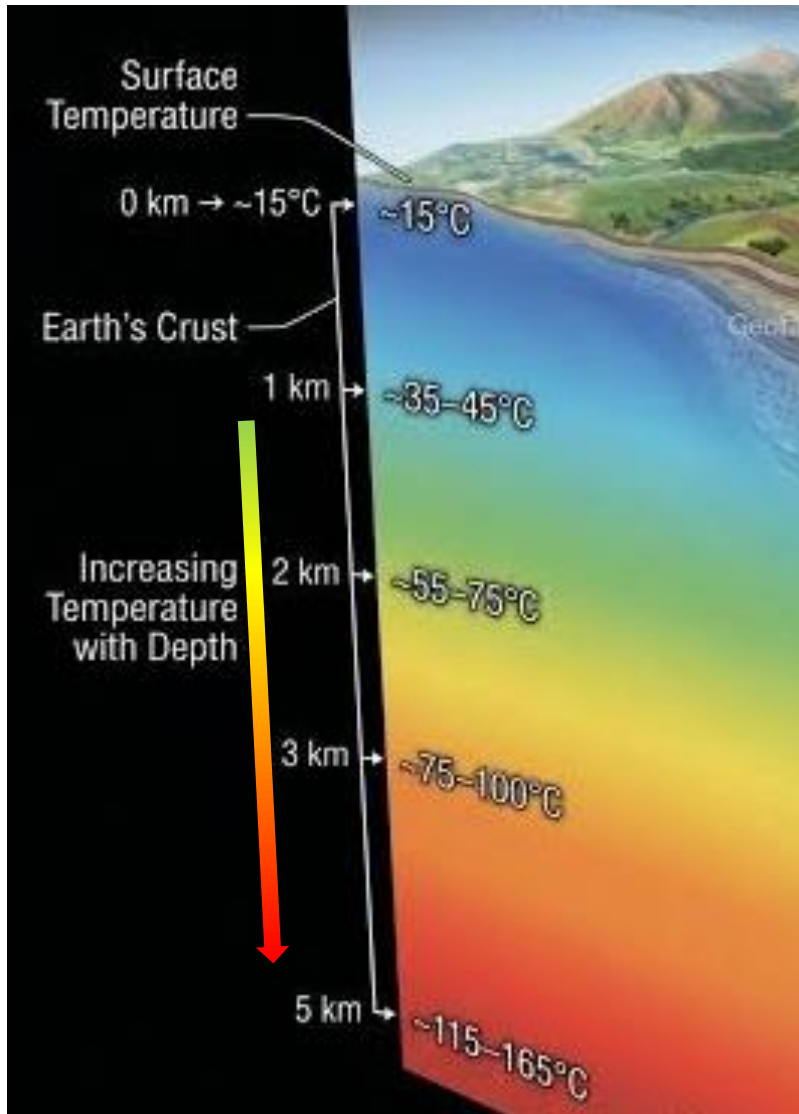


The Crust

- <1% of Earth's mass
- Solid
- Two types:
 - oceanic crust
 - 55% of the surface
 - 6 to 10 km thick
 - composed of basalts
 - relatively young (<200 MYO)
 - continental crust
 - 45% of the surface
 - 70% by volume
 - 25 to 70 km thick
 - granites (*less dense*)
 - mostly old (*up to 3.5-4 BYO*)



How HOT is it underground?



- Average **surface** temperature is about **60°F** (~15°C) on land.
- **Every 100 ft down** from the surface is **1-1.5°F hotter** on average (every 1 km down is 20 to 30°C hotter).
- At a depth of 1 mile (5280 ft) underground, the rock temperature is over ~110°F !
- The **deepest (~4 km deep) mine in the world**, located in South Africa, has **rock temperatures of ~60°C (140°F)**.