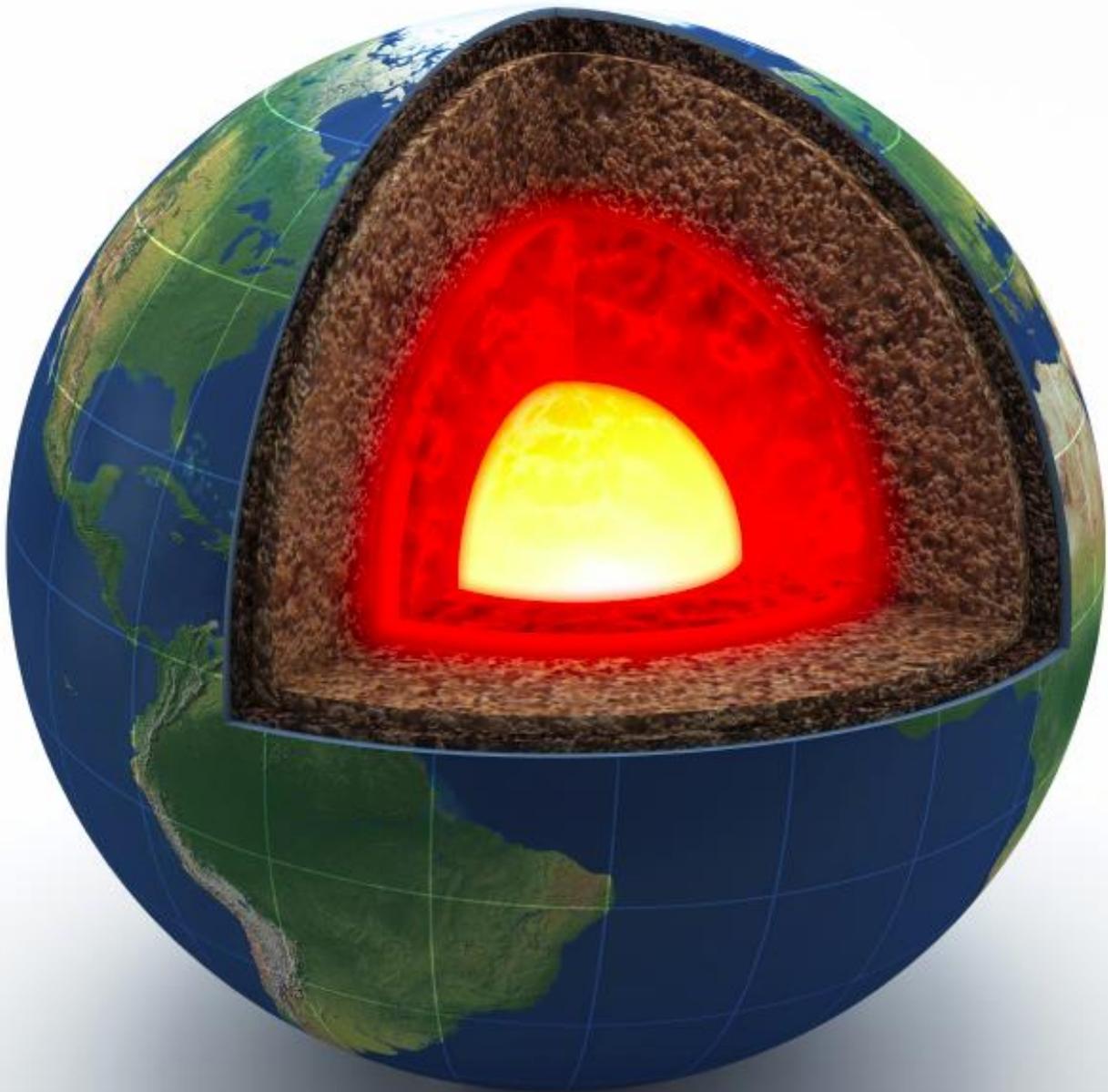
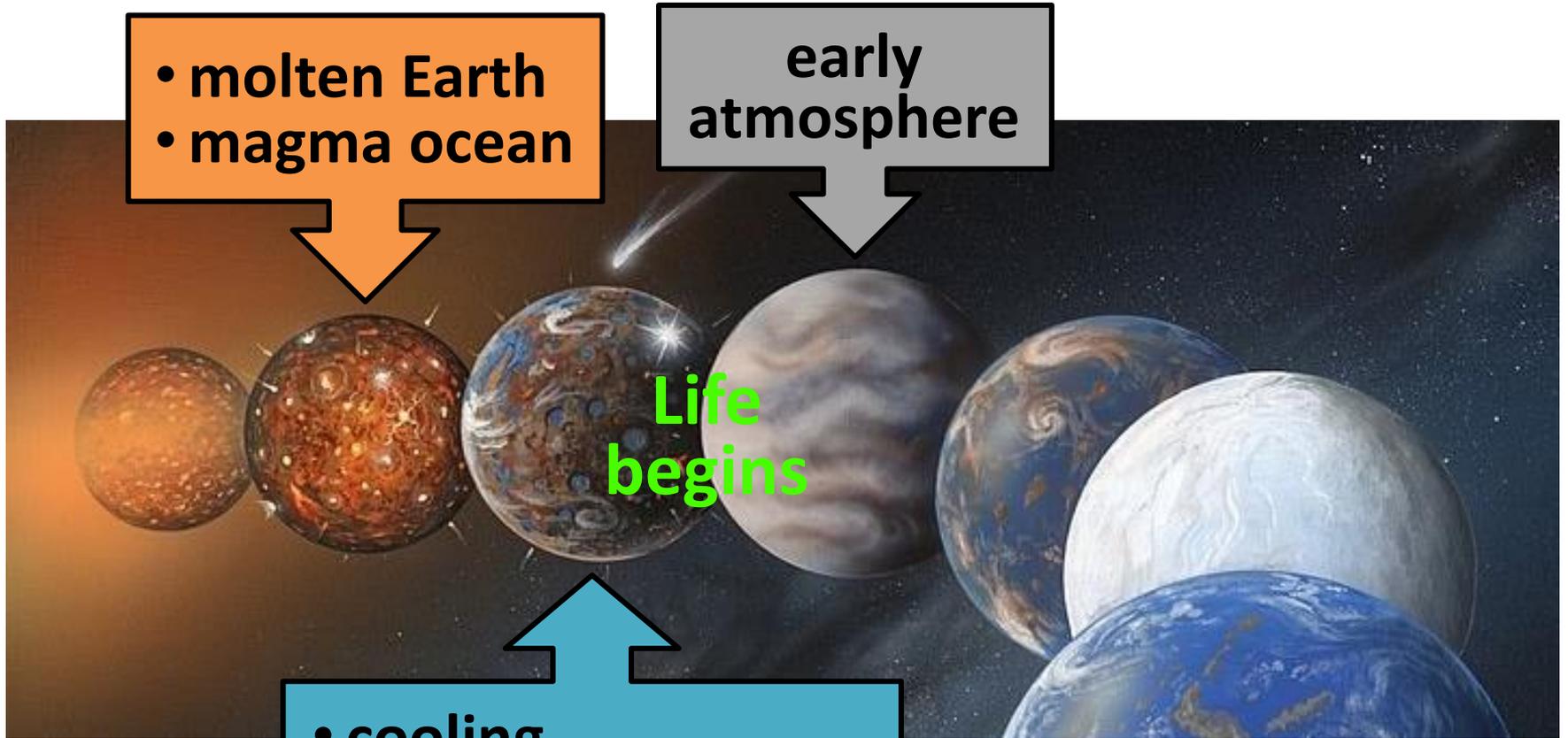


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# Earth Evolution



- molten Earth
- magma ocean

early atmosphere

Life begins

- cooling
- crust formation
- volcanic outgassing
- comet impacts

**“A planet and its life will co-evolve”**

# Earth's Layers

## ➤ Inner core

- R = 1300 km  
(0-800 mi)

## ➤ Outer core

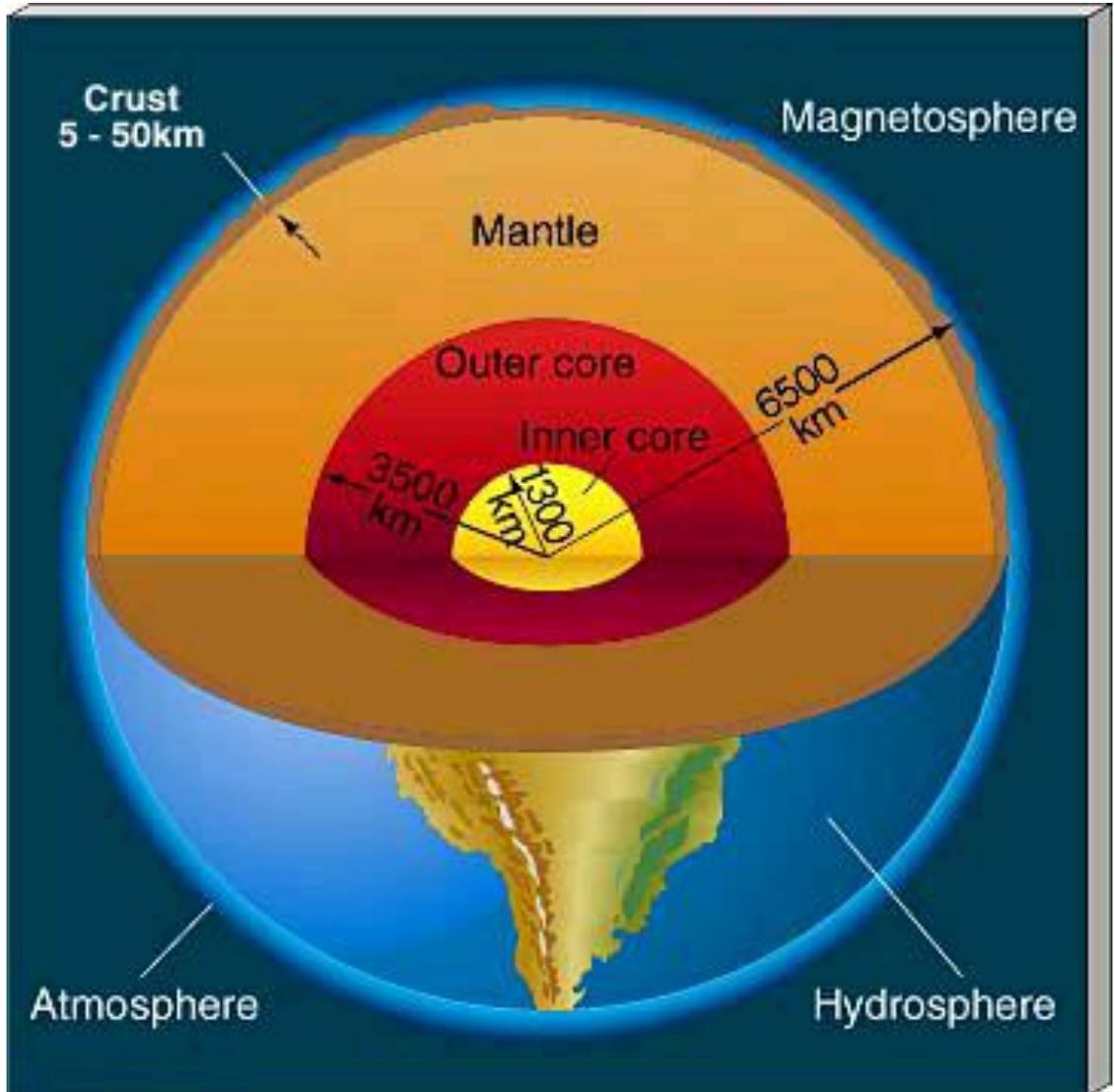
- 1300-3500 km  
(800-2200 mi)

## ➤ Mantle

- 3500-6400 km  
(2200-4000 mi)

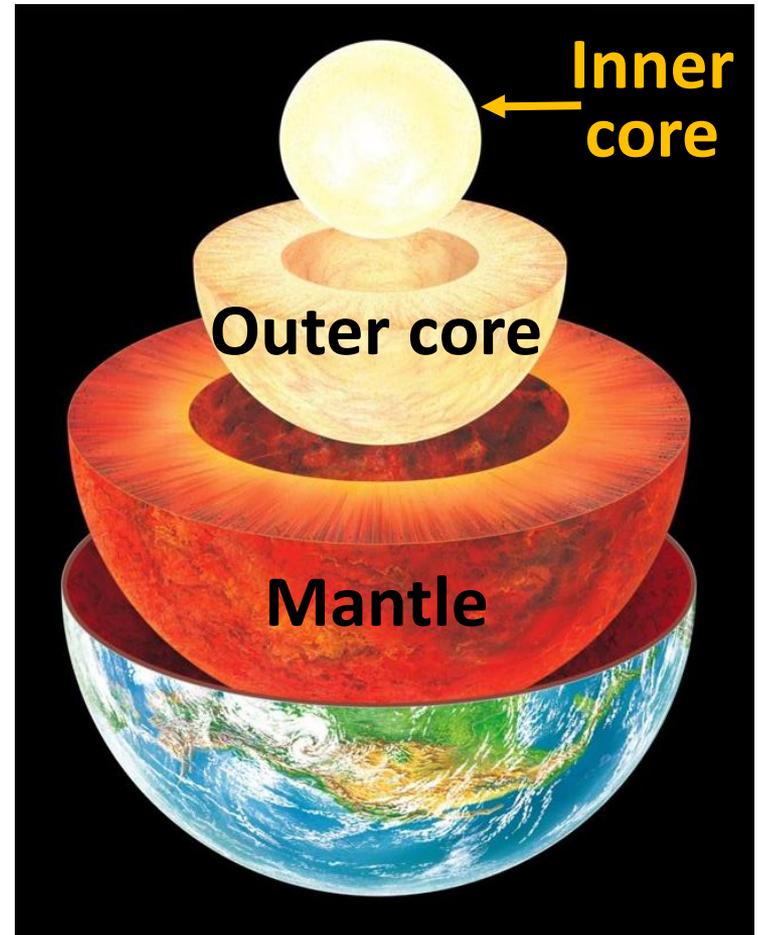
## ➤ Crust

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



# The Core

- 16% of Earth's volume
- Two sections:
  - inner core
    - total diameter ~2600 km (larger than Mercury!)
    - $T \sim 6,000\text{-}7,000\text{ K}$  ( $>10,000^\circ\text{F}$ )
    - solid, very dense
    - nickel-iron alloy
    - grows ~1 mm per year
  - outer core
    - ~2250 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

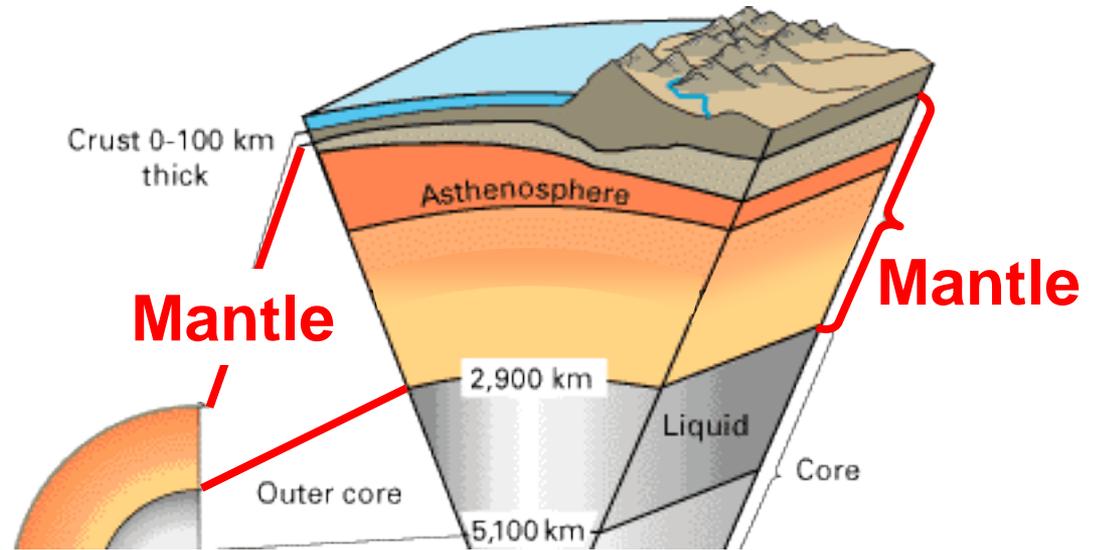
- dense, **solid** (due to *enormous pressure!*)
- temperatures between ~2000-3,500 K (~3,100-5,800°F)

- 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**).

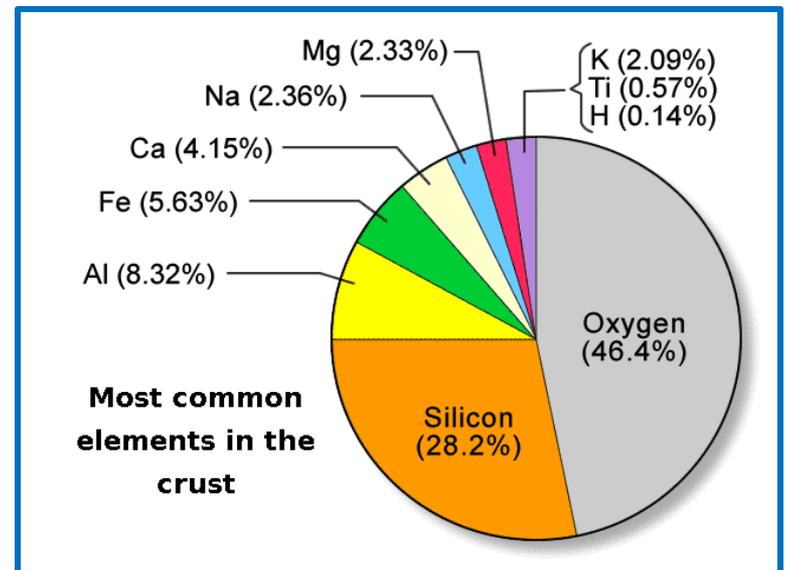
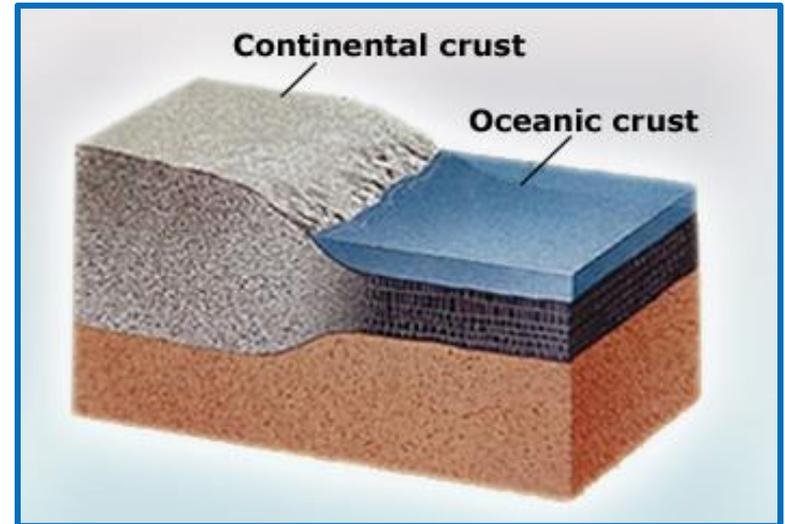
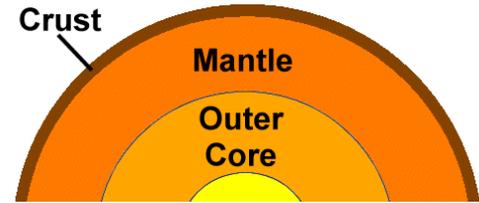
- uppermost region

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



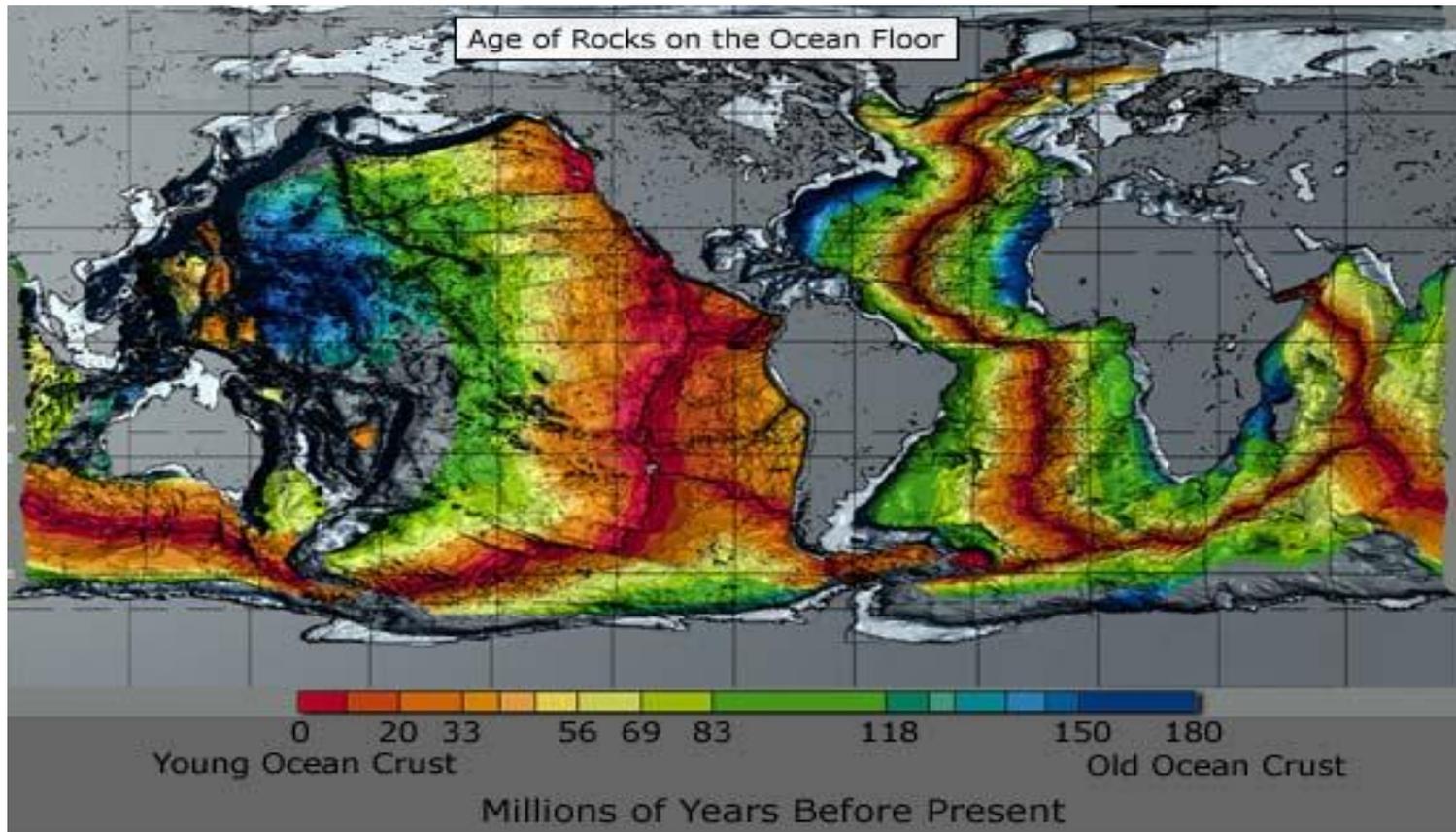
# The Crust

- <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*)



# Age of Oceanic Crust

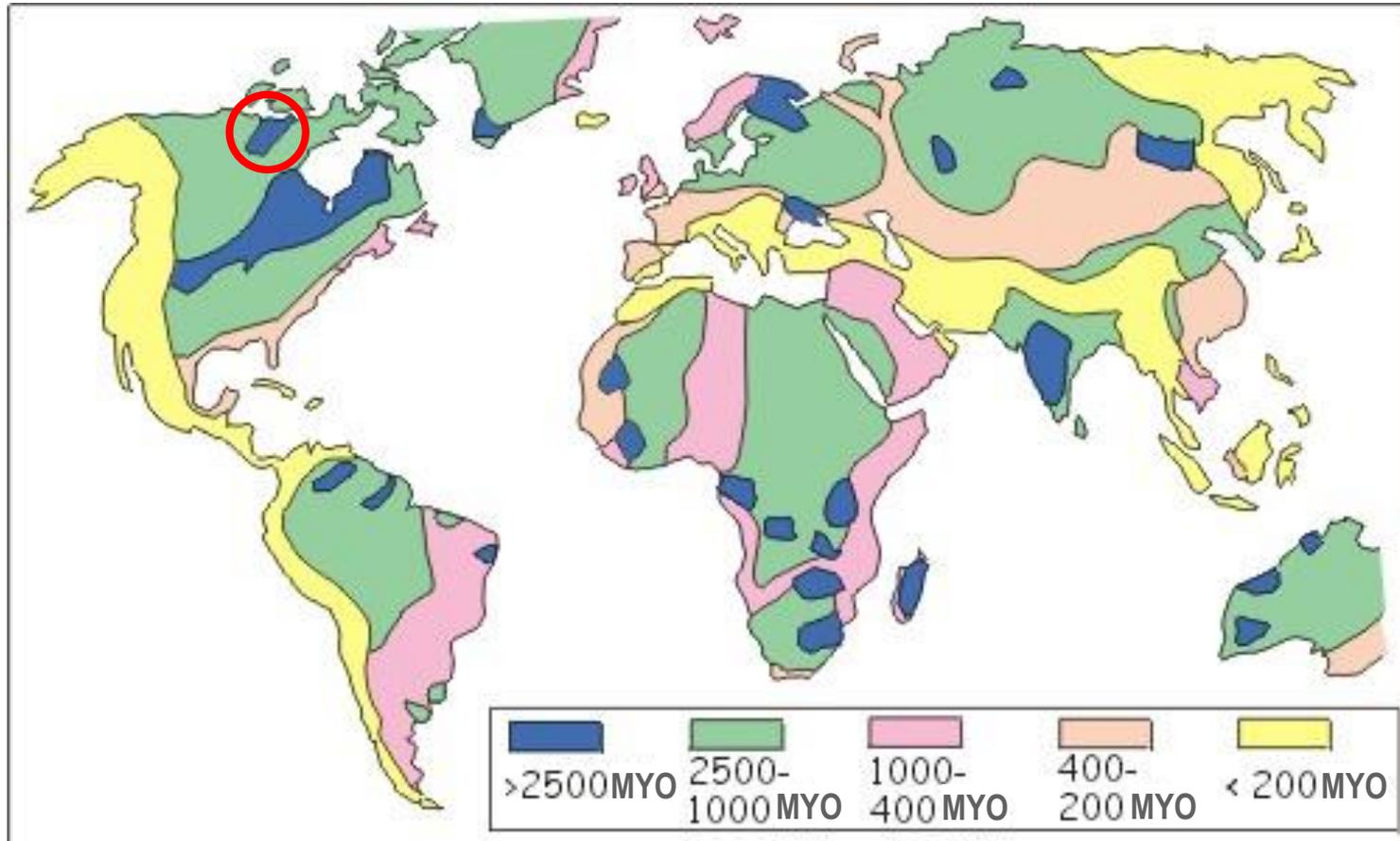
By analyzing **radioactive minerals in igneous rocks** (*those formed through the cooling and solidification of magma or lava*), scientists can tell how much time has passed since rocks solidified from lava - **the age of a rock**.



**Oceanic crust is seldom more than 200 million years old.**

# Age of Continental Crust

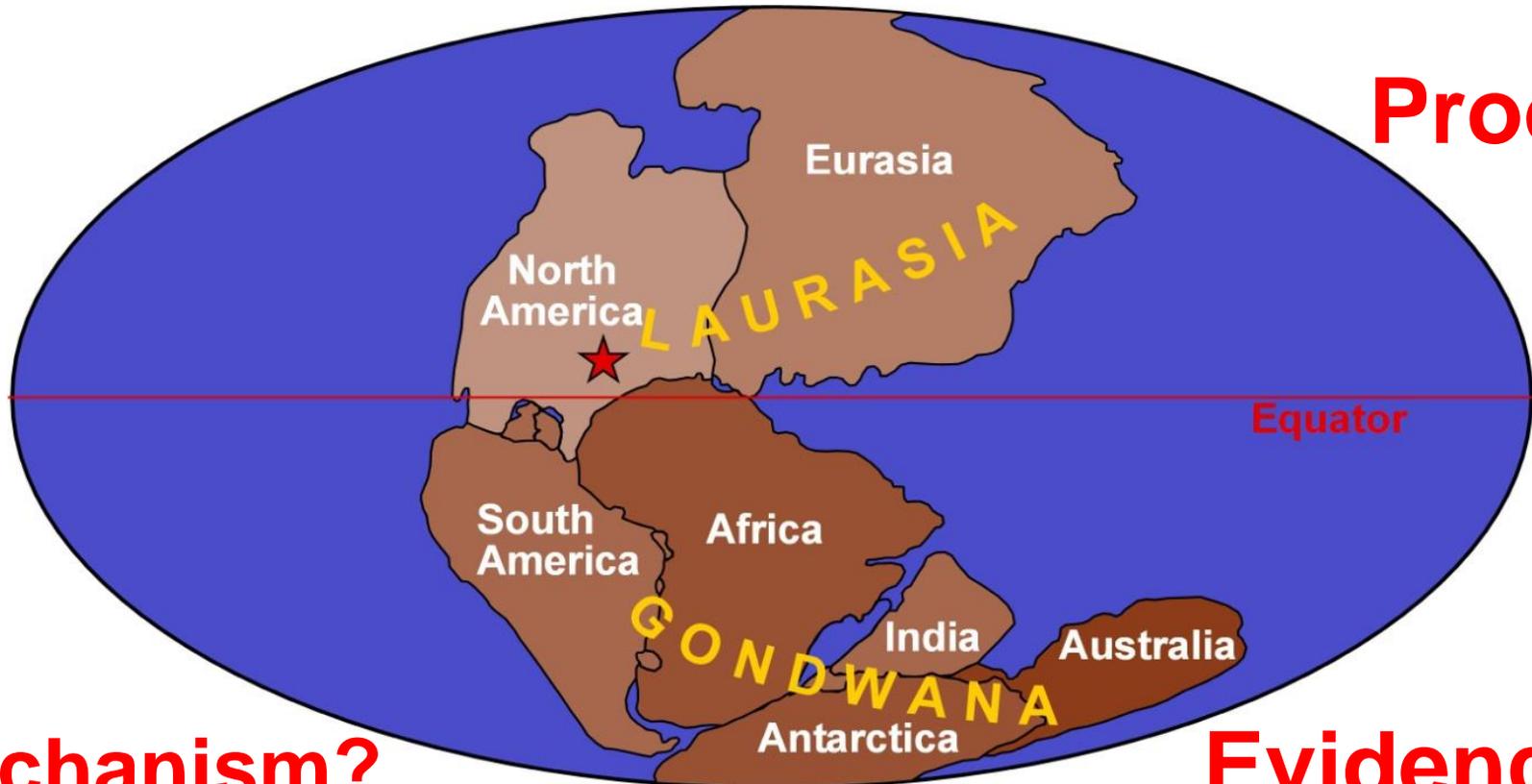
The **oldest rocks** on Earth are found **within the stable cores of the continents**. The oldest known intact crustal fragment on Earth, **Acasta Gneiss** (located in Northwest Territories, Canada), is believed to be **~4 billion years old**.



# Continental Drift

- In the late 19<sup>th</sup> and early 20<sup>th</sup> centuries, geologists assumed that the Earth's major features were fixed.
- In 1912, **Alfred Wegener** proposed that up until about 200 million years ago, all of the present continents were joined together into a single super-continent later called **Pangea**.

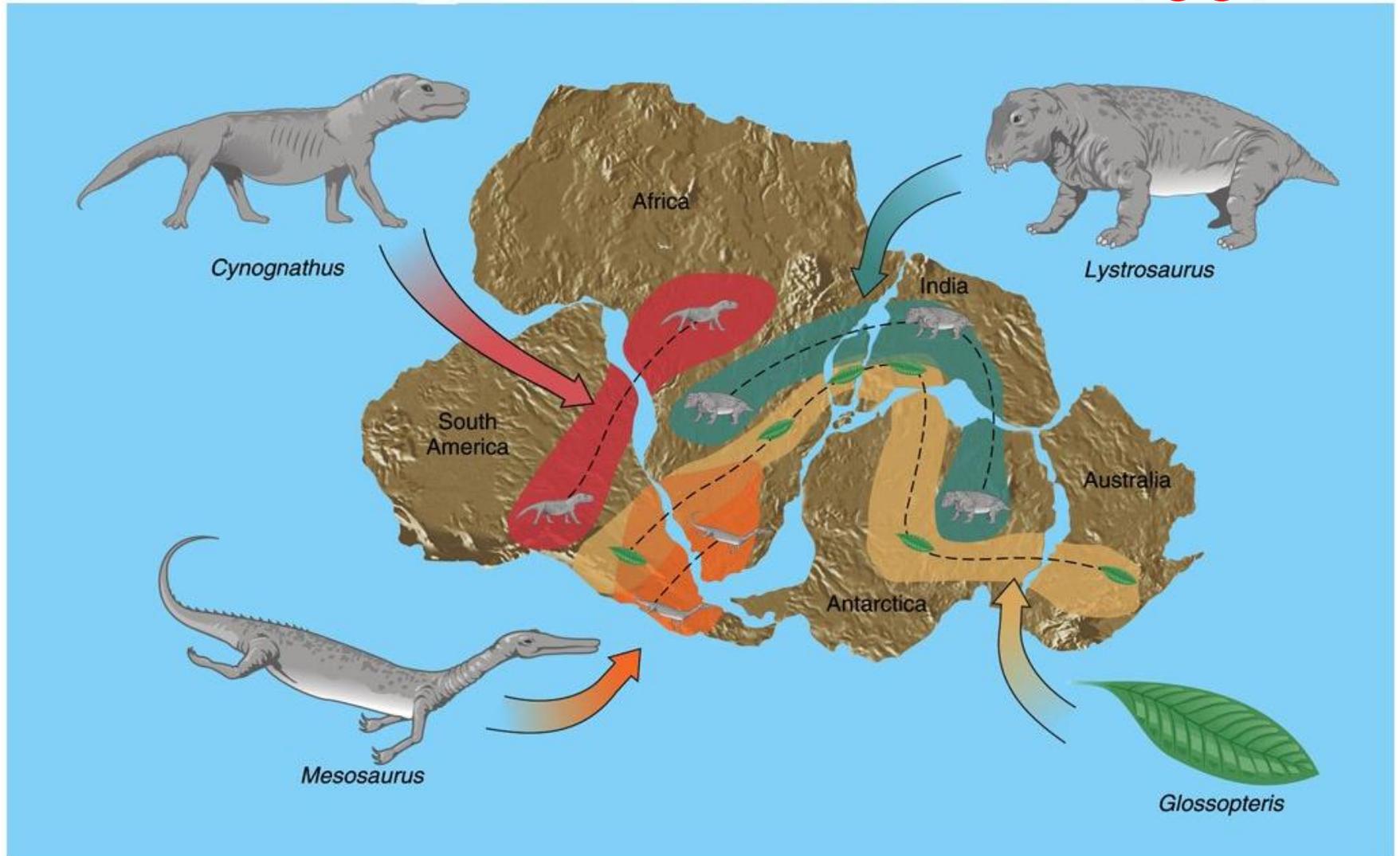
**Proof?**



**Mechanism?**

**Evidence?**

# Continental Drift: Fossil Evidence 1937



# Continental Drift: Debate

- Fifty years long lively debate started between "drifters" or "mobilists" (proponents of the theory) and "fixists" (opponents), during which the **theory of plate tectonics was born**.
- Early "weak" evidence:
  - Parts of **Scotland and Ireland** contain **rocks very similar** to those found in **Newfoundland and New Brunswick**.
  - The **Caledonian Mountains of Europe** and parts of the **Appalachian Mountains of North America** are very similar in structure and composition.
- Strong geophysical evidence:
  - **Paleomagnetism**, the rocks of different ages show a variable magnetic field direction consistent with continents movement.
  - Late 1950s and early 60s data on the **bathymetry of the deep ocean floors** and the nature of the oceanic crust; **evidence of seafloor spreading** along the *mid-oceanic ridges*.

# Continental Drift Simulation

## The Past

<https://www.youtube.com/watch?v=UwWWuttntio>

## The Future

<https://www.youtube.com/watch?v=bQywDr-btz4>