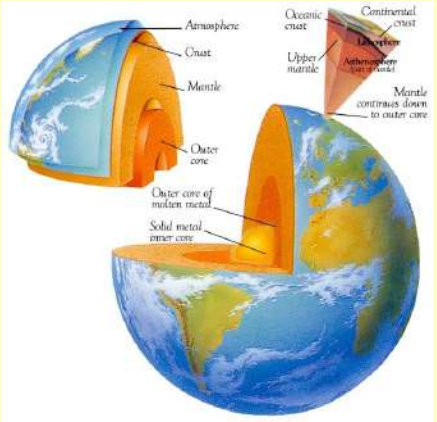
Boston College Educational Seismology

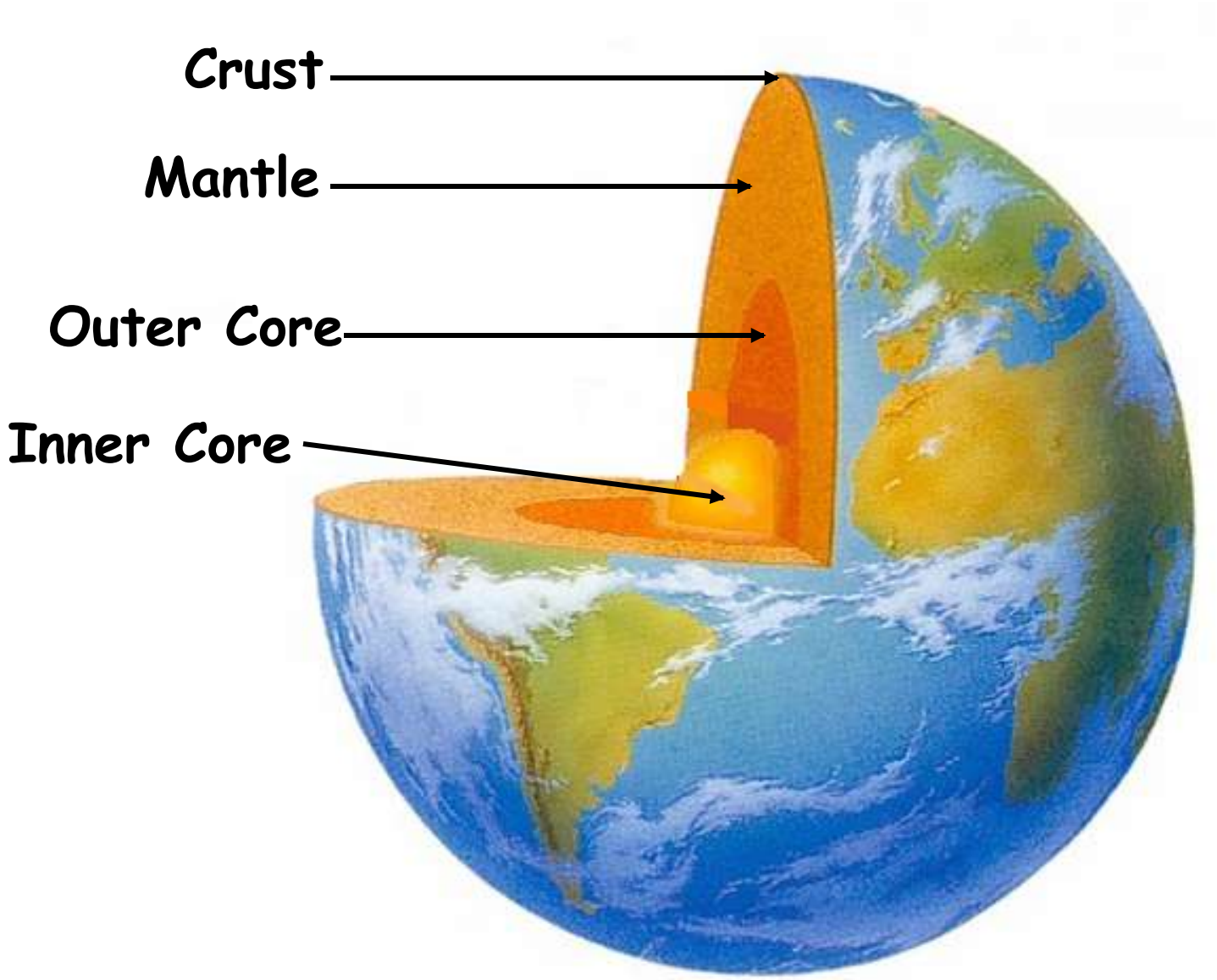


"The Earth's Interior"

Training a new generation of scientists.

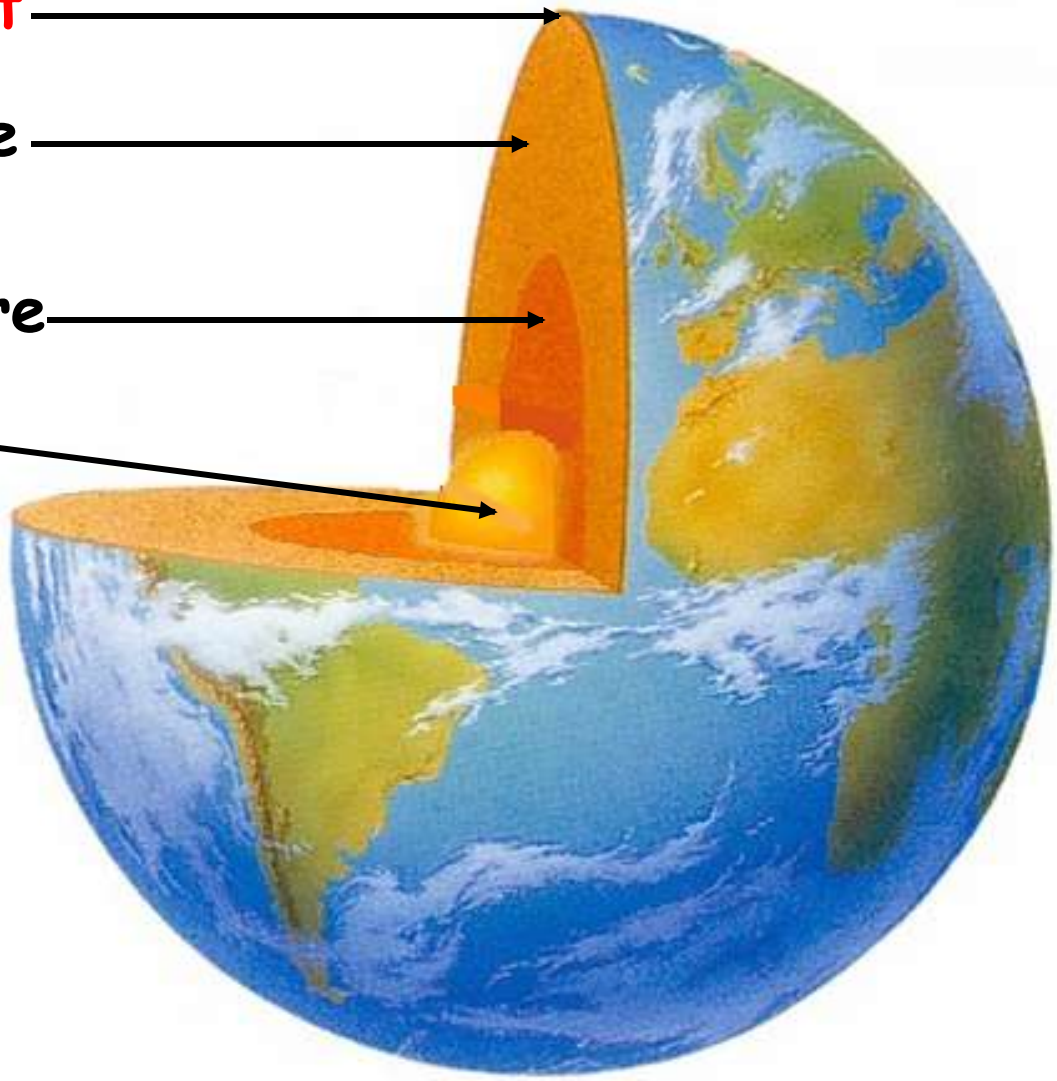
Planet Earth

The Earth's Interior



Layer	Actual Thickness (km)	Composition What is it made of?	Temperature C°	Phase of Matter (solid, liquid, gas)	**Scale Thickness**	
					mm	**cm**
Continental Crust						
Oceanic Crust						
Mantle						
Lithosphere *"Rock Sphere"*						
Asthenosphere *"Weak or Soft"*						
Mesosphere *"Middle"*						
Outer Core						
Inner Core						
Mount Everest						
Ocean Trench						

INSIDE THE EARTH



When you think of the word crust, what comes to your mind?

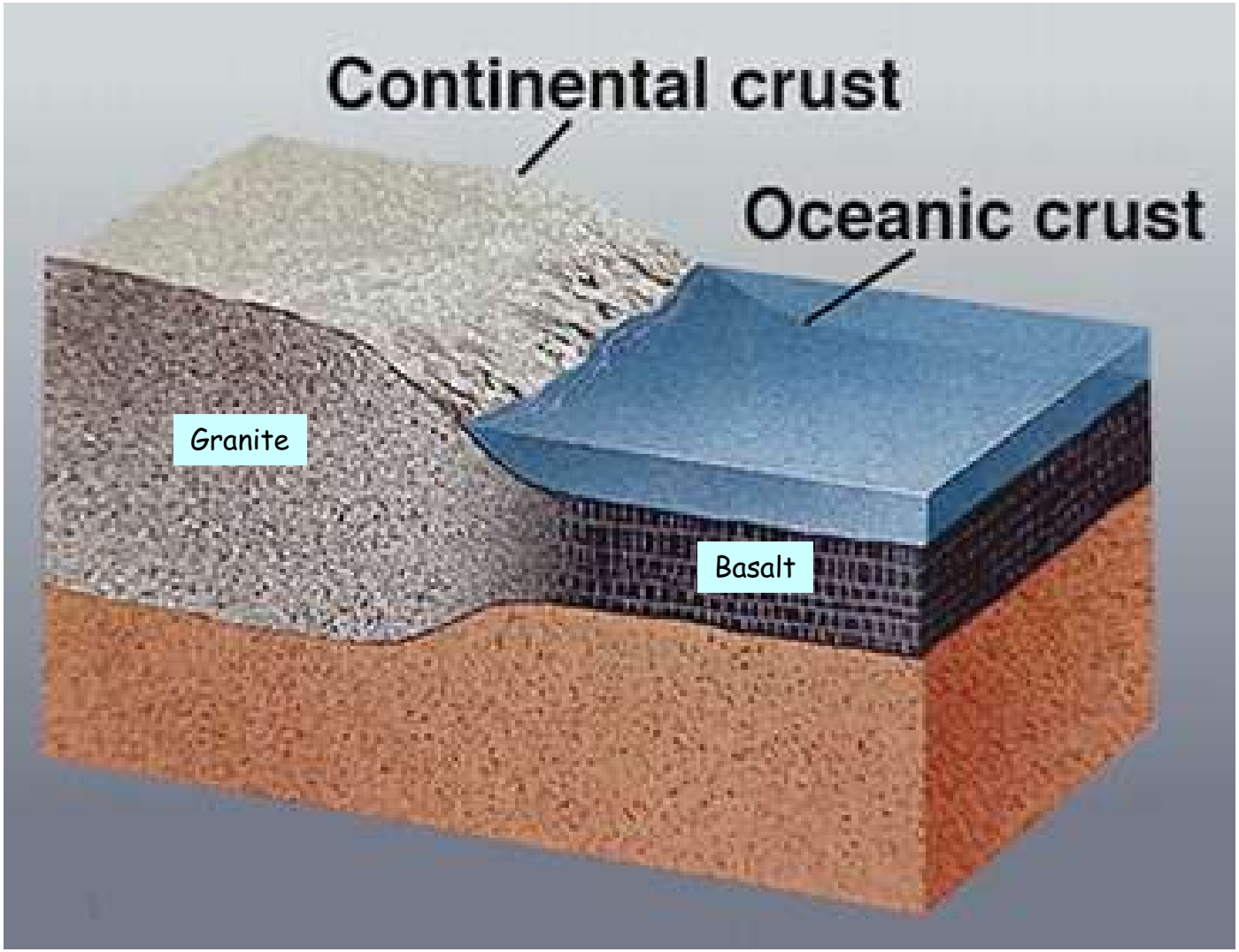
Crust

Continents

Oceans

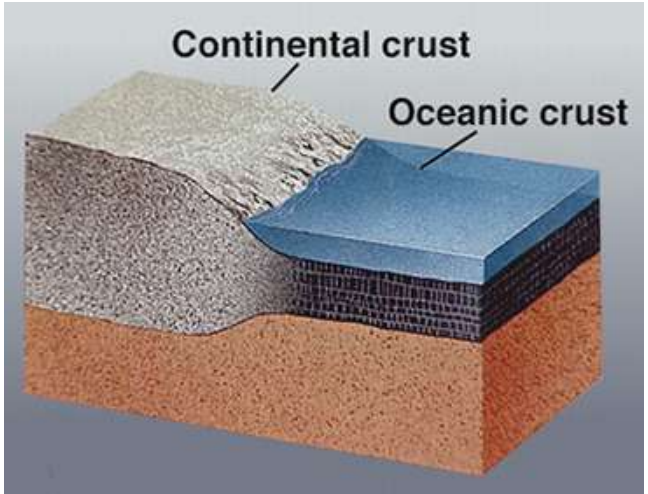
What is underneath all the water in the Oceans?

Crust



Continental vs. Oceanic

- Continental Crust
  - The rock that forms the continents or landmasses
  - Less Dense
    - particles of rock are NOT tightly packed together
  - Thicker



- Oceanic Crust
  - The rock that is beneath the ocean basins
  - More Dense

Density = mass/volume

    - particles of rock are VERY tightly packed together
  - Thinner

Continental Crust

- Consists mainly of:
  - Granite (rock)
- Mineral Composition
  - Quartz, Feldspar, Mica
- Physical State or Phase
  - Solid
- Thickness
  40 to 70 km
  400 football fields

Temperature = relatively cool

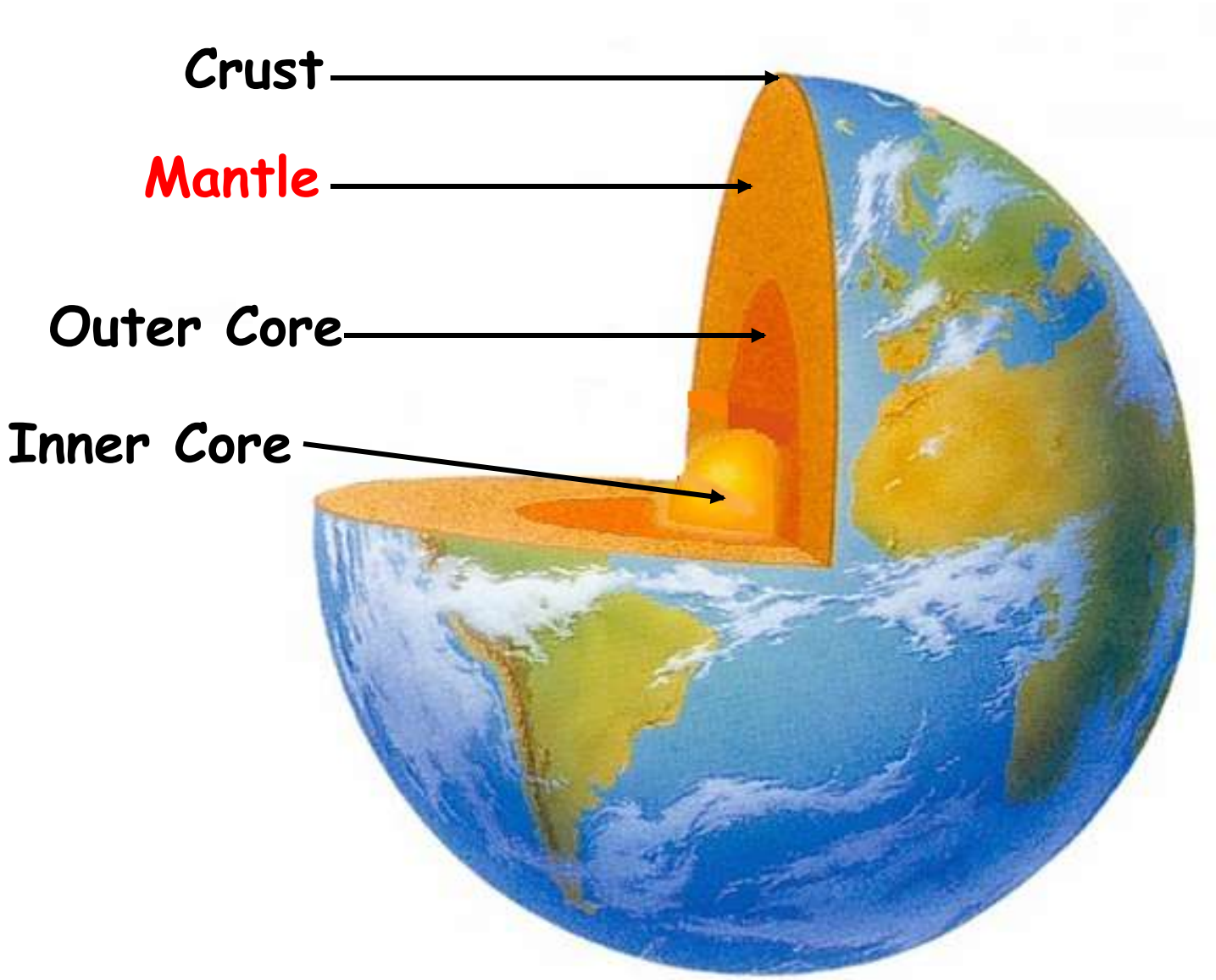
- Contains Quartz Crystals

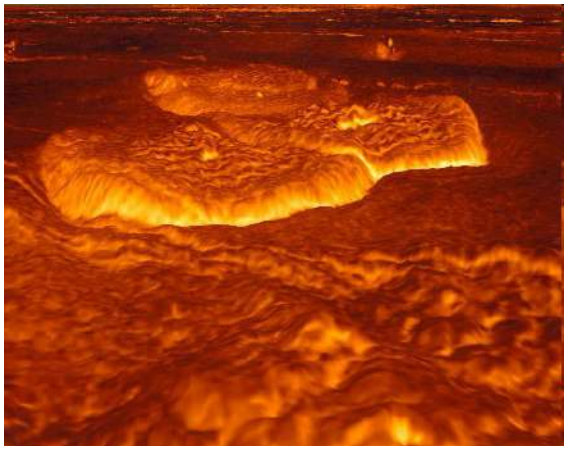
Oceanic Crust

- Consists mainly of:
  - Basalt (rock)
- Mineral Composition:
  - Iron (Fe), Magnesium (Mg)
- Physical State
  - Solid
- Thickness
  5 to 10 km
  45 football fields

  Temperature = cool

INSIDE THE EARTH





Mantle

- Upper Mantle consists mainly of:
  - Olivine and Pyroxene (rocks)

  The rest of the Mantle is magma, molten rock.

- Mineral Composition:
  - Iron, Magnesium, Silicon and Aluminum

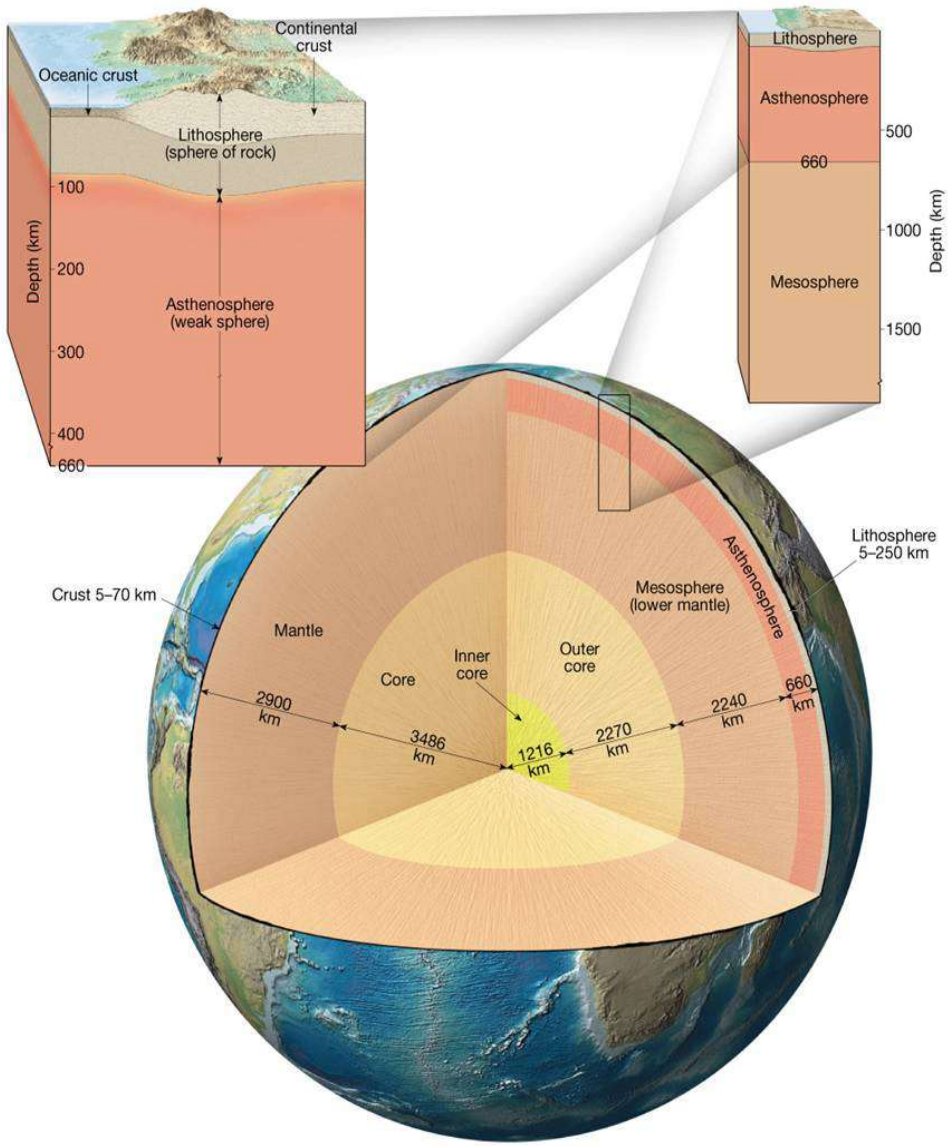
- Physical State
  - Molten rock that can flow

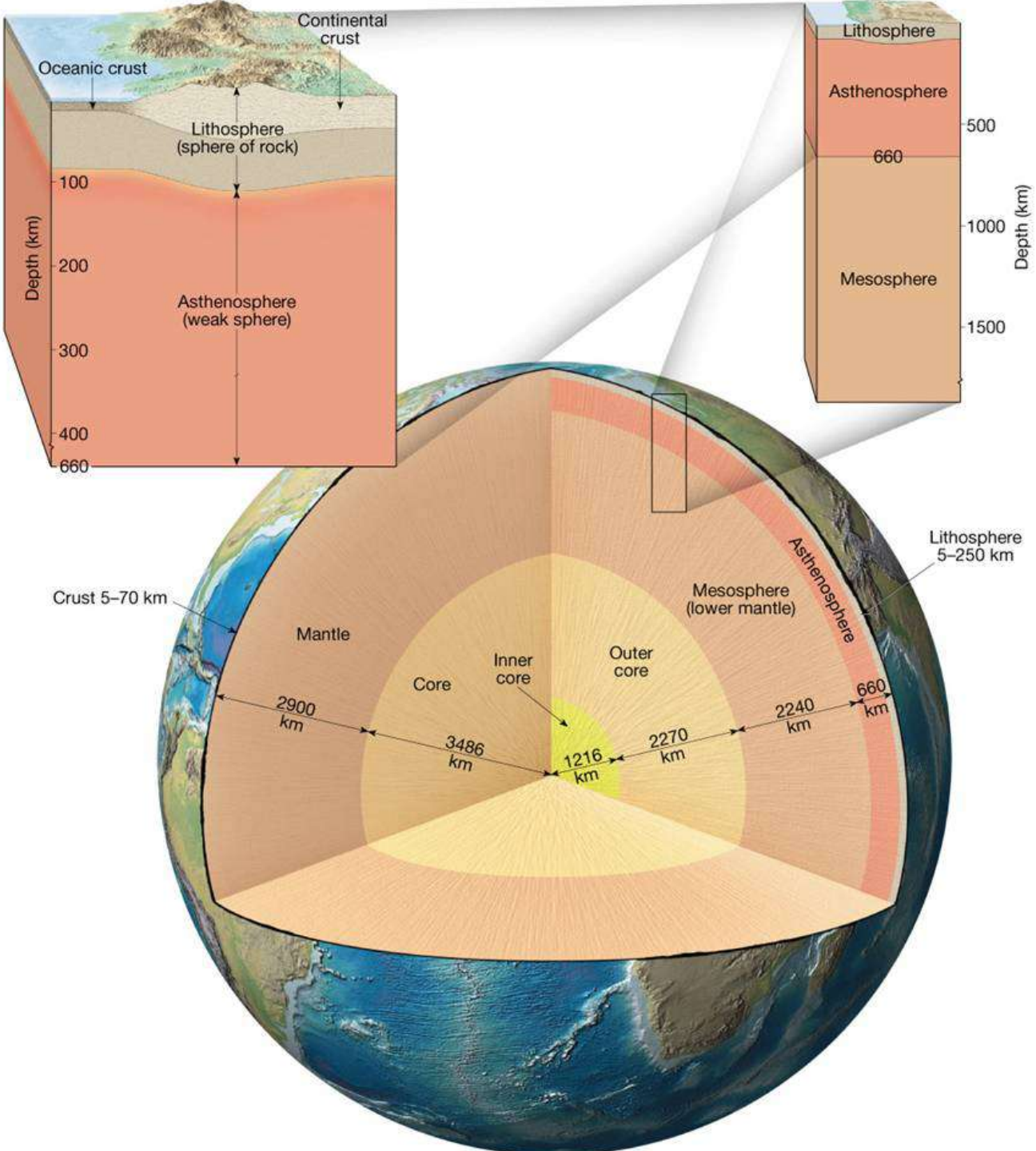
- Thickness
  2,900km
  26,364 football fields

- Temperature very hot!
  1000°C to 3600°C

Earth's Crust is broken into giant pieces called Tectonic Plates that float above the Mantle

Mantle


Continental crust
Oceanic crust
Lithosphere (sphere of rock)
Asthenosphere (weak sphere)
Depth (km)
100
200
300
400
660
Lithosphere
Asthenosphere
Mesosphere
500
660
1000
1500
Depth (km)
Crust 5–70 km
Mantle
Core
Inner core
Outer core
Mesosphere (lower mantle)
Asthenosphere
Lithosphere 5–250 km
2900 km
3486 km
1216 km
2270 km
2240 km
660 km


Continental crust
Oceanic crust
Lithosphere (sphere of rock)
Depth (km)
100
200
300
400
660
Asthenosphere (weak sphere)
Lithosphere
Asthenosphere
660
Mesosphere
500
1000
1500
Depth (km)
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2900 km
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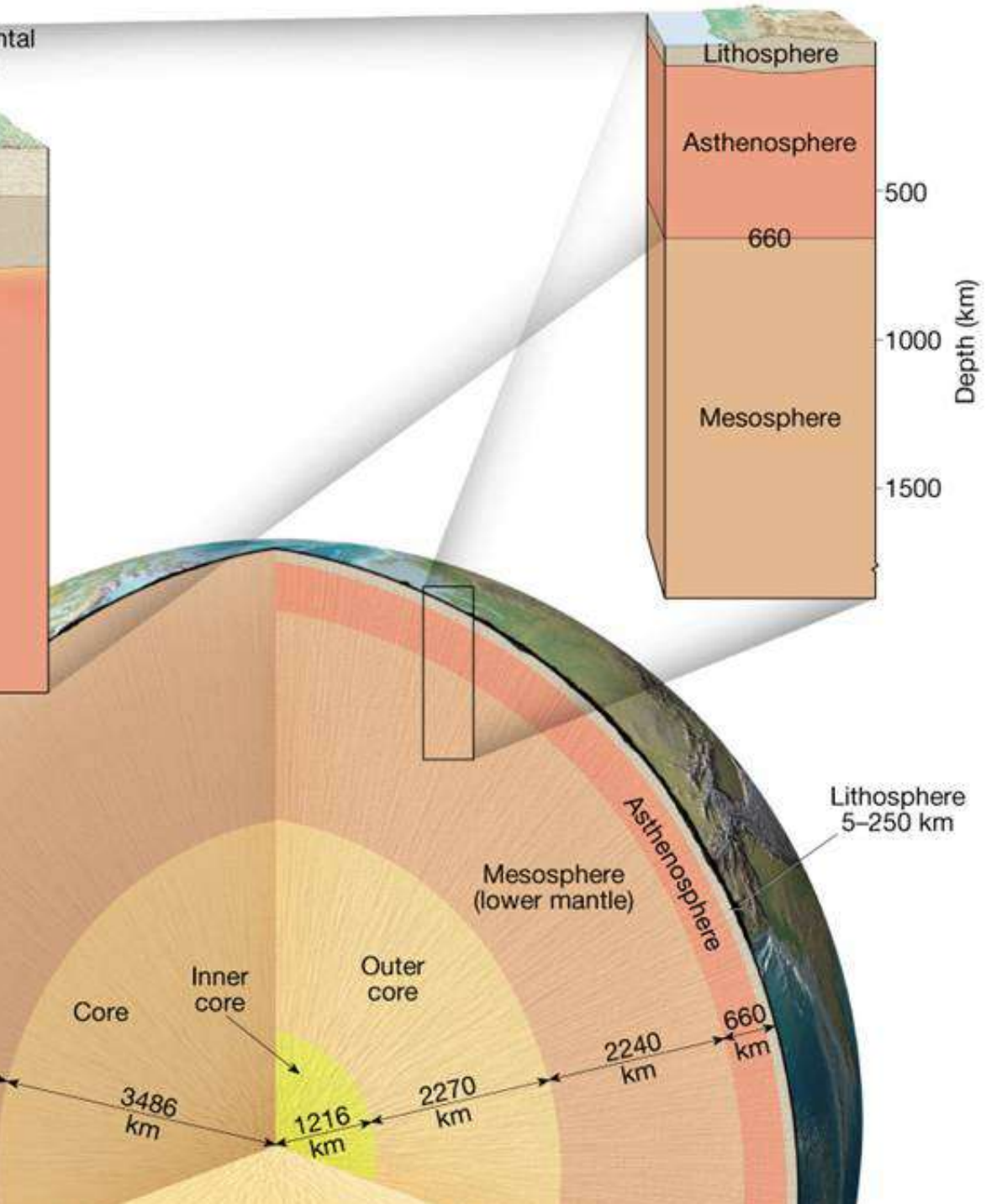
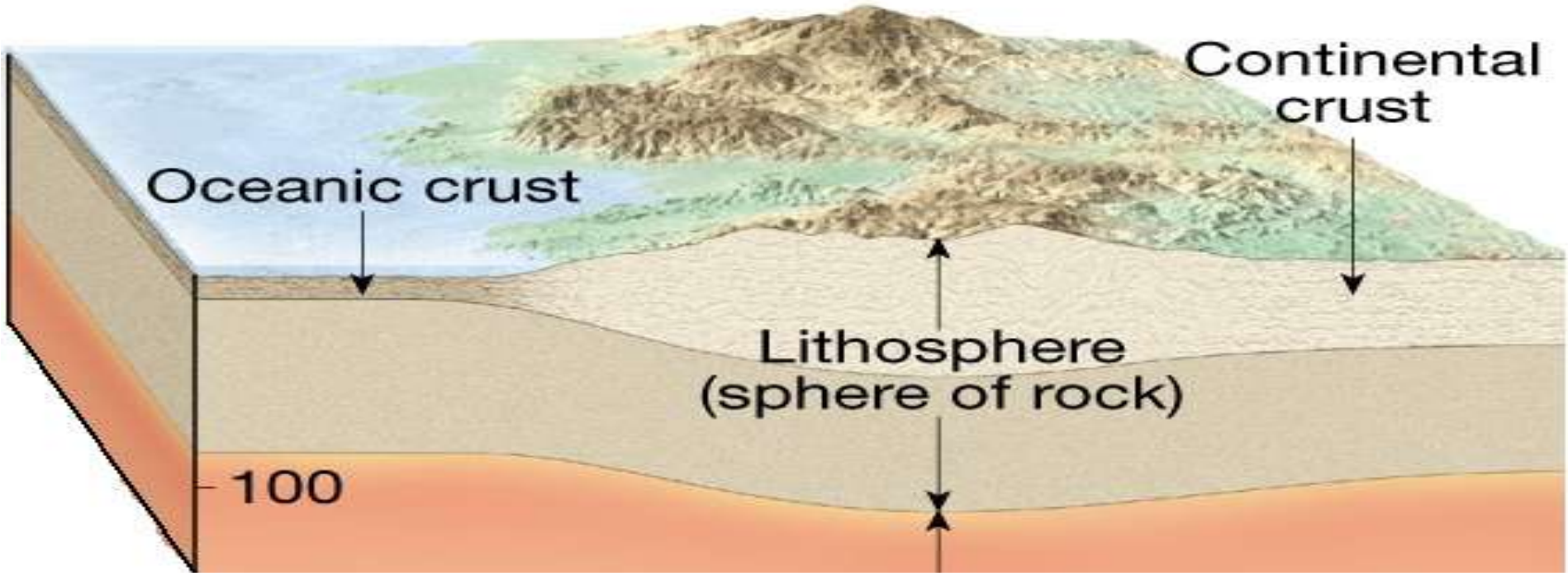
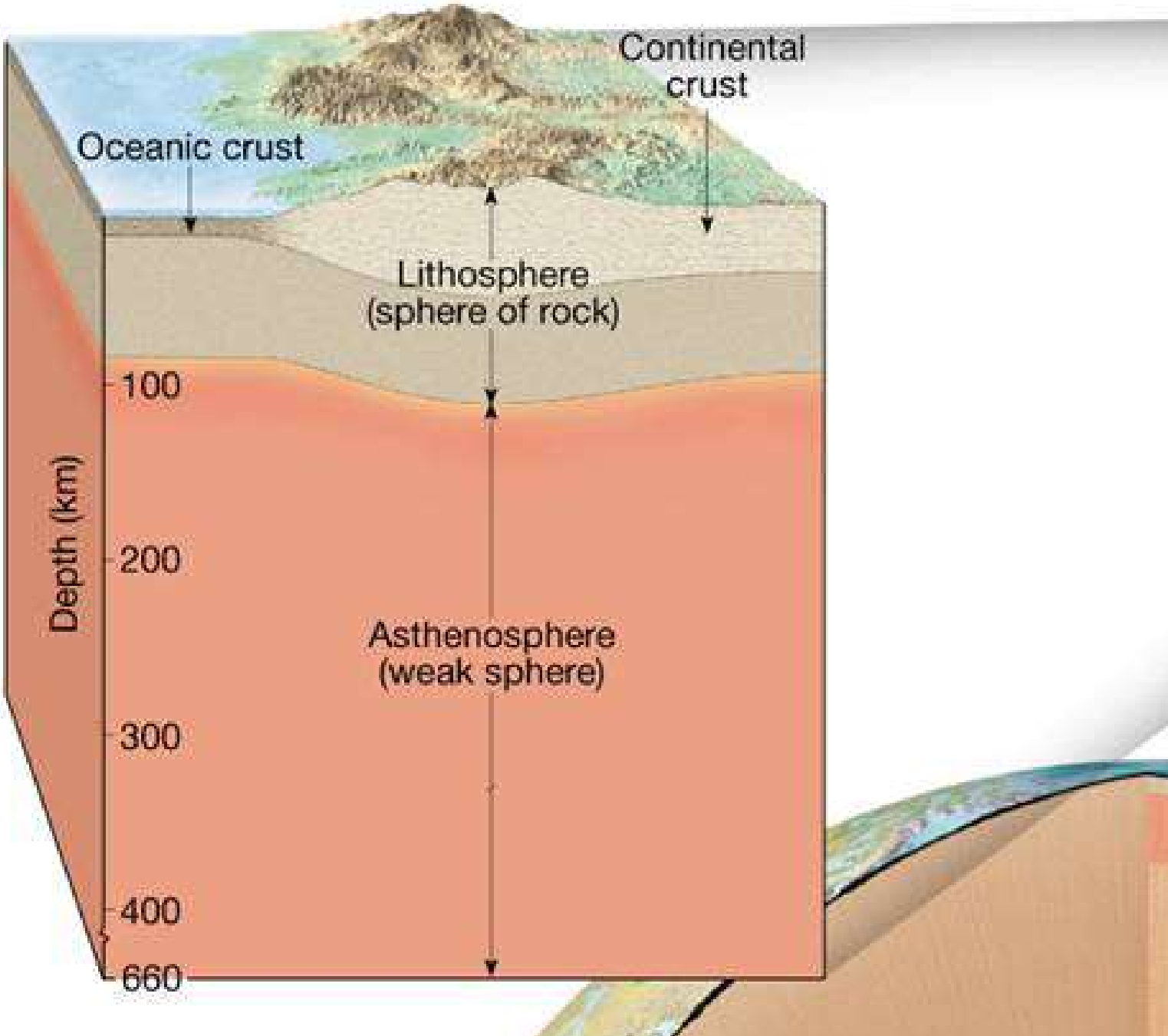
660 km


ntal
Lithosphere
Asthenosphere
500
660
1000
Depth (km)
Mesosphere
1500
Lithosphere
5–250 km
Asthenosphere
Mesosphere
(lower mantle)
Outer
core
Inner
core
Core
660
km
2240
km
2270
km
1216
km
3486
km

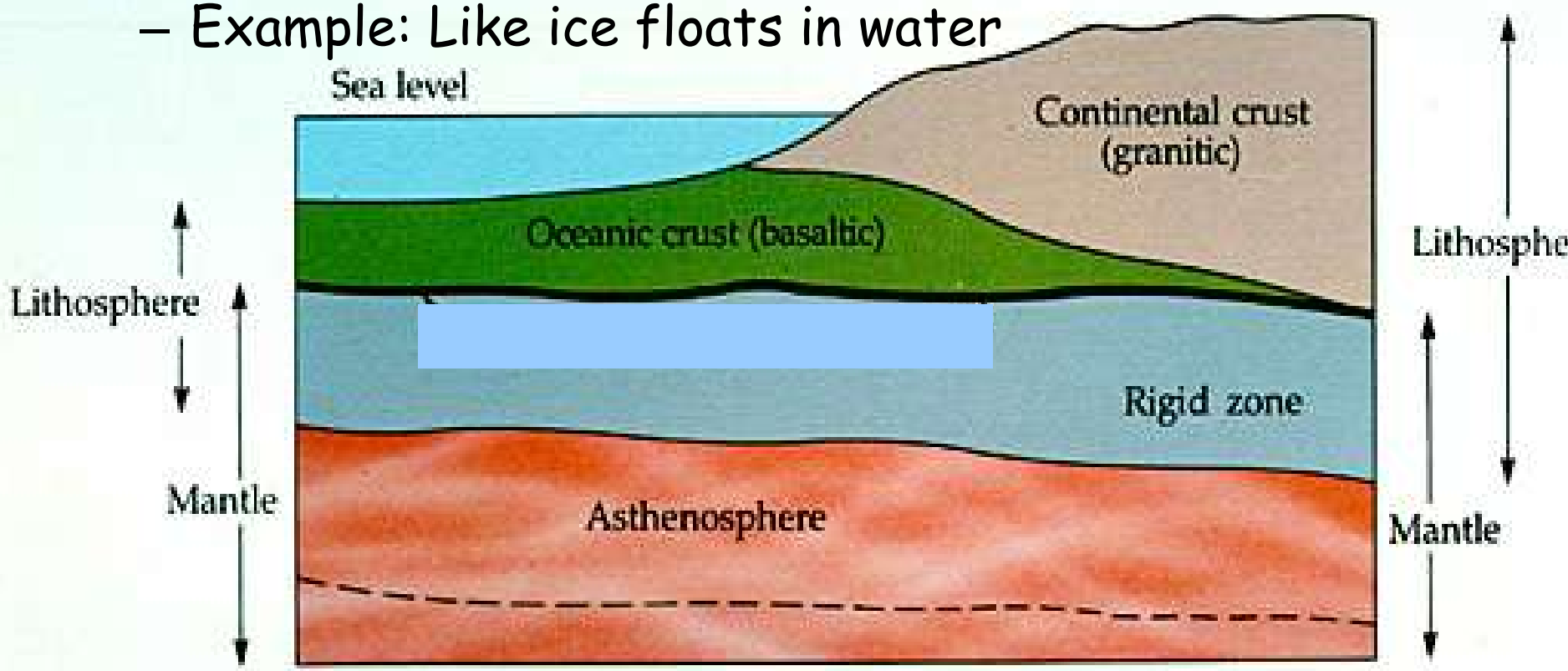
Crust


Continental crust
Oceanic crust
Lithosphere (sphere of rock)
100


Continental crust
Oceanic crust
Lithosphere (sphere of rock)
Depth (km)
100
200
Asthenosphere (weak sphere)
300
400
660

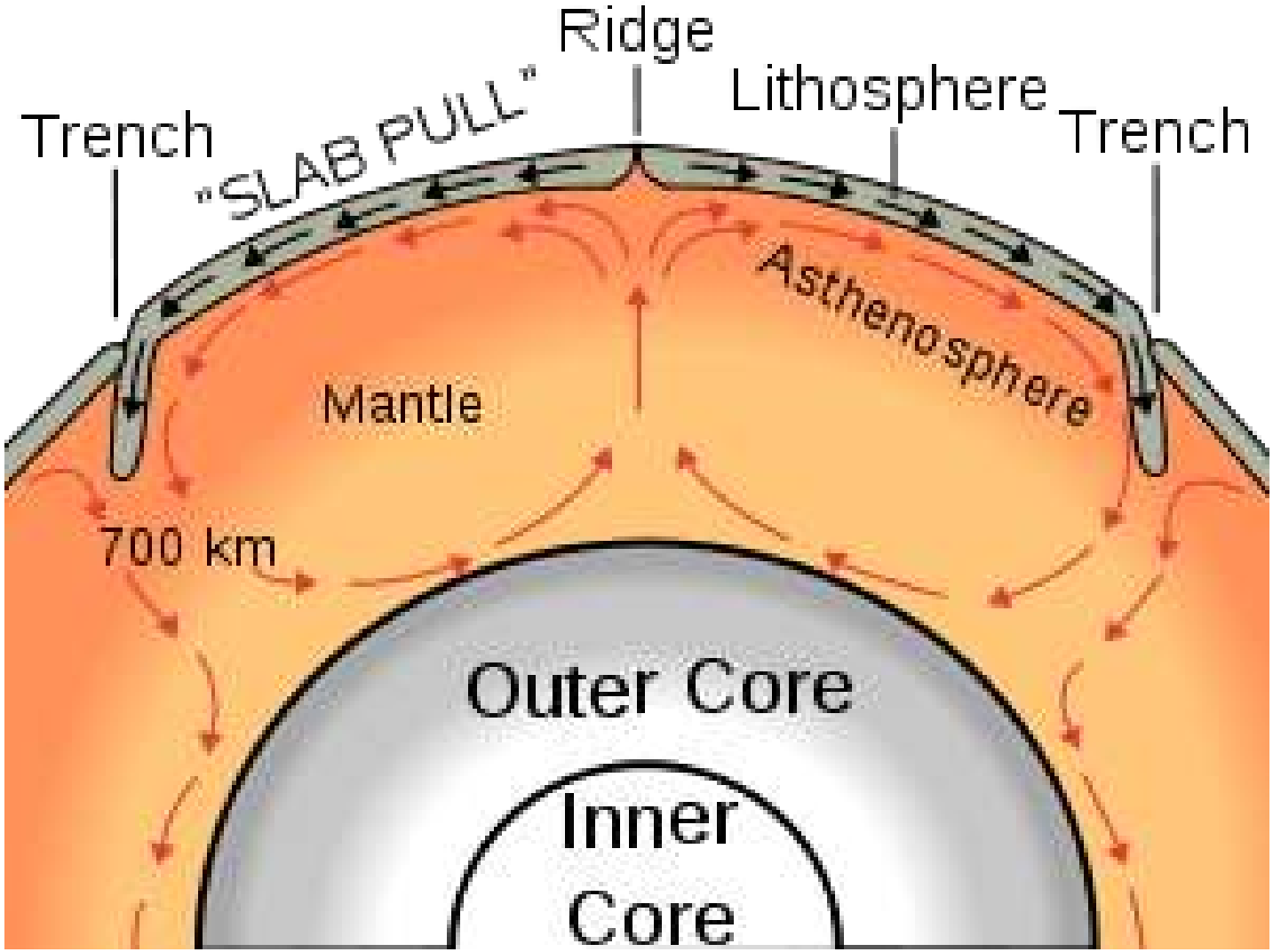
Lithosphere & Asthenosphere

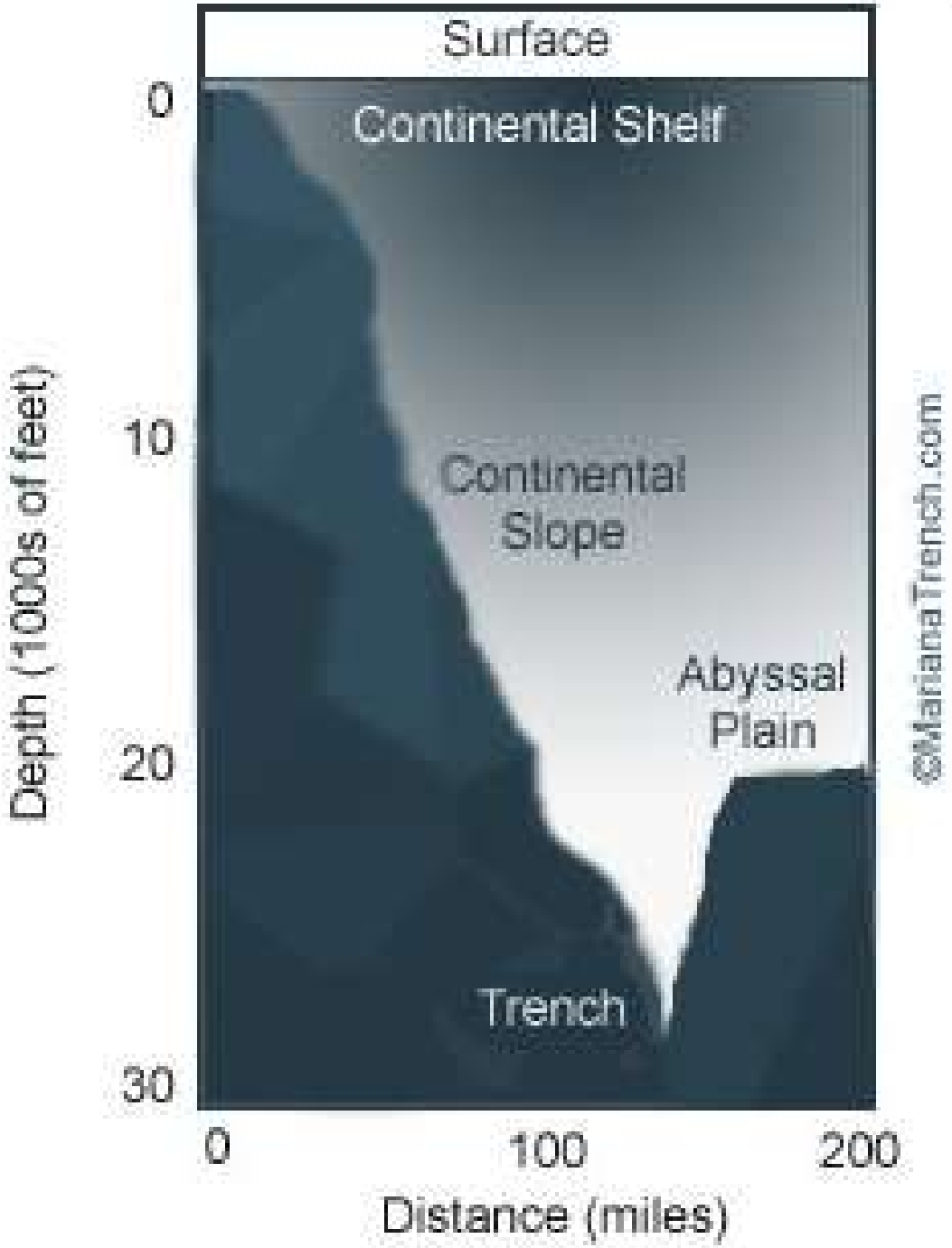
- The lithospheric plates essentially "float" on top of the asthenosphere.
  - Example: Like ice floats in water



Layer	Actual Thickness (km)	Composition What is it made of?	Temperature C°	Physical State (solid, liquid, gas)	**Scale Thickness mm**	**cm**
Lithosphere *"Rock Sphere"*	100	Rock (Top consists of the Continental and Oceanic Crust and the bottom consists of the Upper Mantle rock: Olivine, Pyroxene, Iron, Magnesium, Silica and Aluminum)	Varies, Top is Relatively Cool, bottom is Hot 1000°	Rigid Solid		
Asthenosphere *"Weak or Soft"*	560	Magma with Low Viscosity = it can flow	1000° to 3600°	Weak Solid "Plastic" Silly Putty		
Mesosphere *"Middle"*	2240	Magma with High Viscosity = does not flow		Very Thick		

Ocean Trench = steep sided depression in the Ocean floor, the deepest part of the Ocean




Surface
0
Continental Shelf
10
Continental Slope
Abyssal Plain
20
Trench
30
Depth (1000s of feet)
0
100
200
Distance (miles)
©MarianaTrench.com

How far down have we been?

Kola Superdeep Borehole, 2007

The **Kola Superdeep Borehole** is the result of a scientific drilling project of the former USSR, Russia.

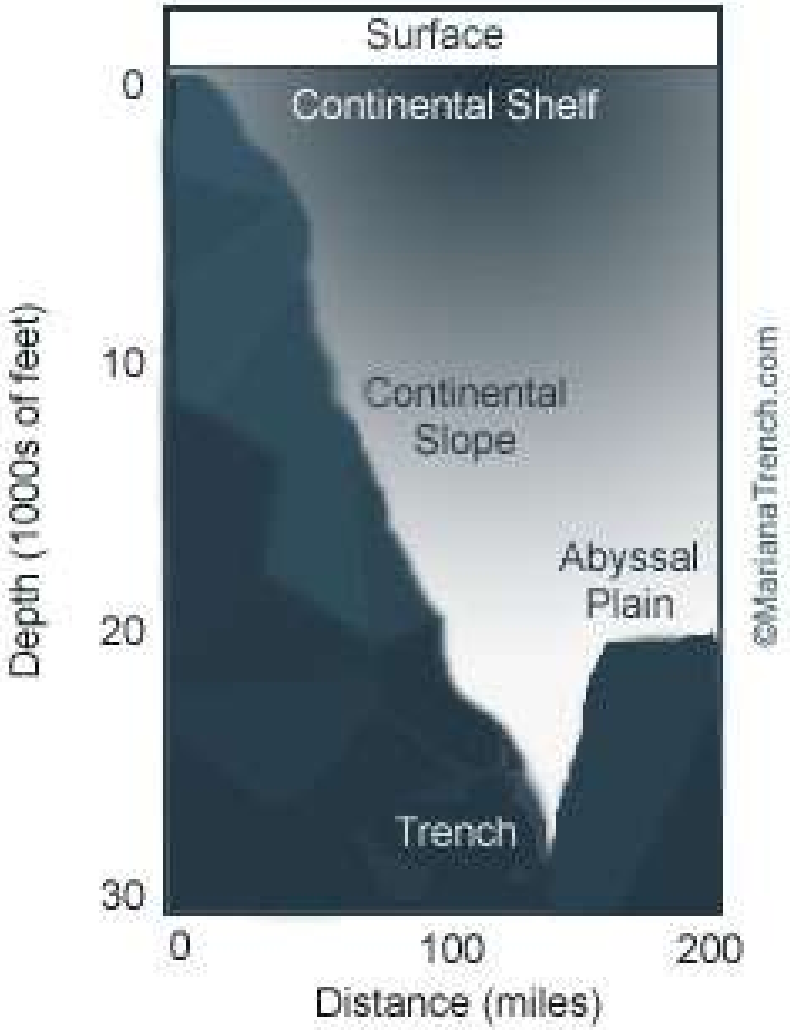
The project attempted to drill as deep as possible into the Earth's crust.

Drilling began on 24 May 1970 and in 1989 the hole reached 12 Kilometers (40,230 ft about 7.6miles) and is the deepest hole ever drilled.

Drilling ended in 1989 due to lack of funding, which was the same reason why scientists in the U.S. stopped drilling through the crust. Plus, the drill equipment could not function in the heat that they encountered 12km deep.

The continental crust at the Kola borehole is around 35 Kilometers (22 mi) deep.

Ocean Trenches



At least 22 trenches have been identified.

Of this number, 18 are in the Pacific Ocean, 3 in the Atlantic Ocean, and 1 in the Indian Ocean.

Questions:

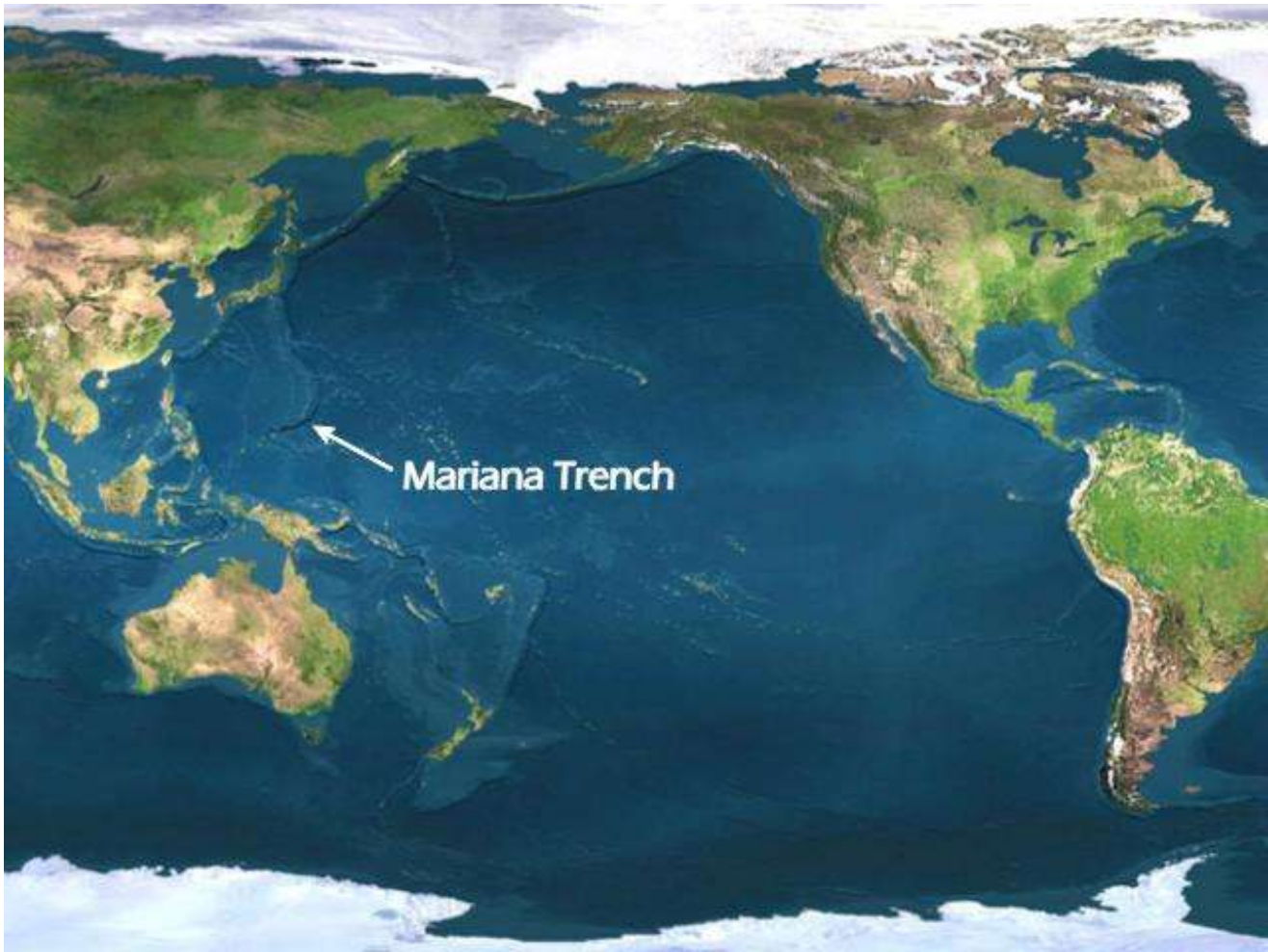
- What organisms live in an Ocean Trench?
- What is the deepest part of the Ocean?
- Do people still study the Bertha Rogers Well, Oklahoma?
- Lat/Long of Kola Borehole
- What are the width of these Boreholes?

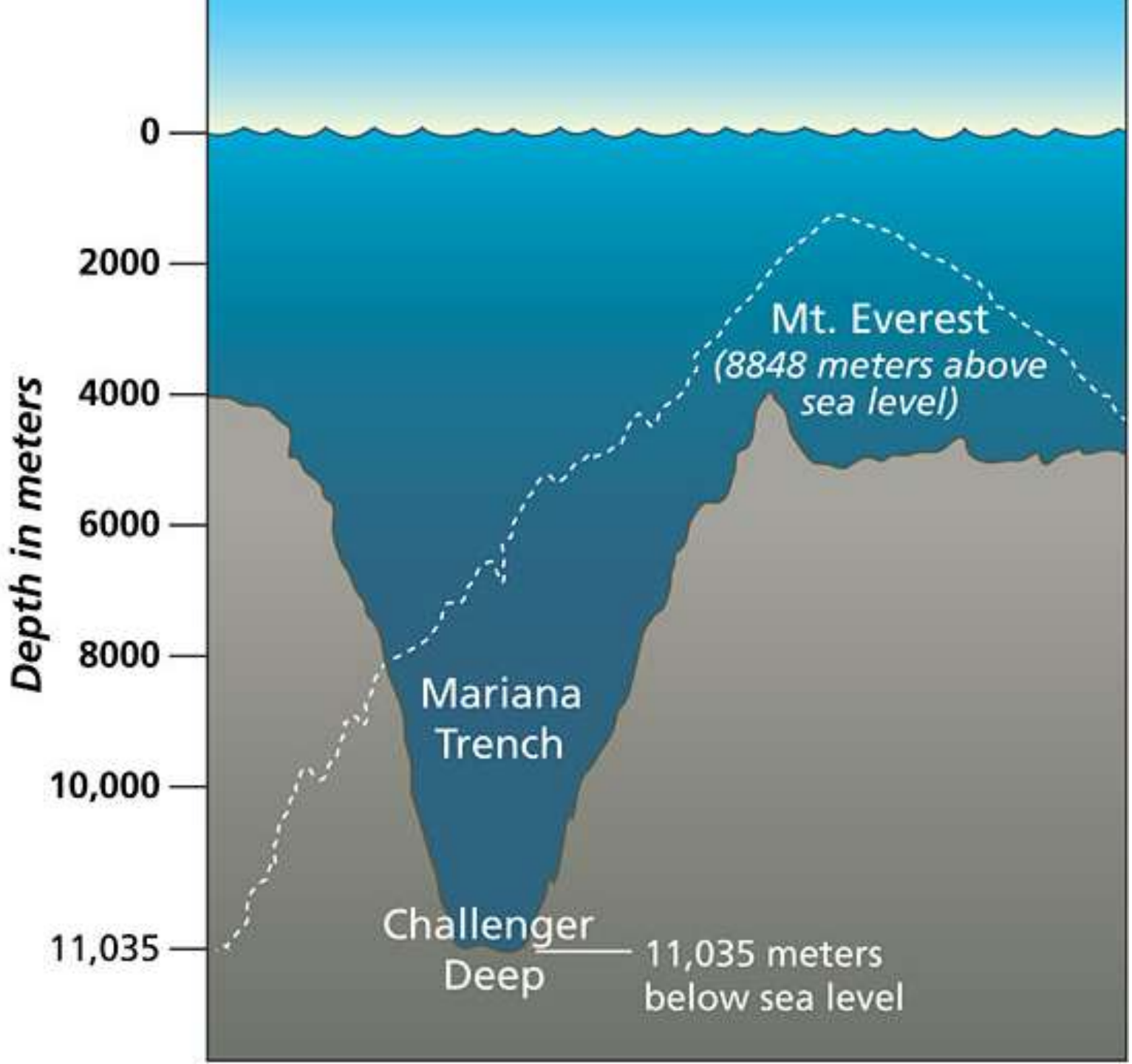
Answers:

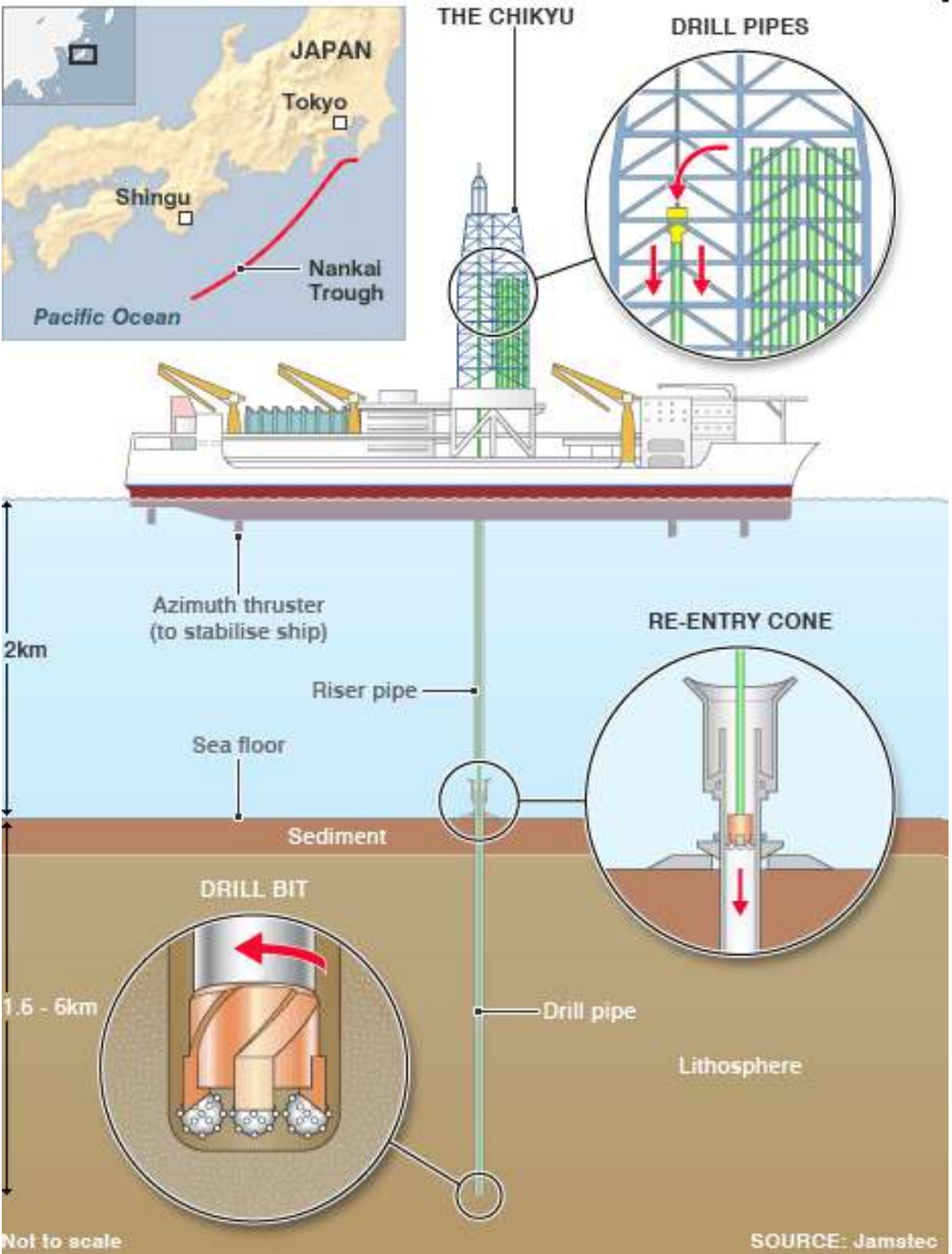
- Foraminifera, single-celled with shells like algae or mold
- The Mariana Trench (has a depth of 11km (36,000ft) below sea level.
- The well was plugged and abandoned after the drill hit a molten sulfur deposit. No natural gas was found. No visiting area.
- 69.4° North, 30.6° East
- About the circumference of a melon

The Mariana Trench is:
2, 542 km (1,580 miles) long and 69 km (43 miles) wide.

11.35 degrees North Latitude
142.2 degrees East Longitude



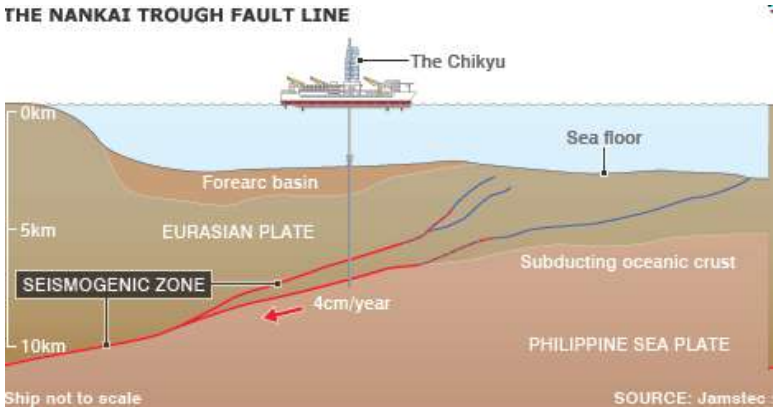

Depth in meters
0
2000
4000
6000
8000
10,000
11,035
Mt. Everest
(8848 meters above sea level)
Mariana Trench
Challenger Deep
11,035 meters below sea level



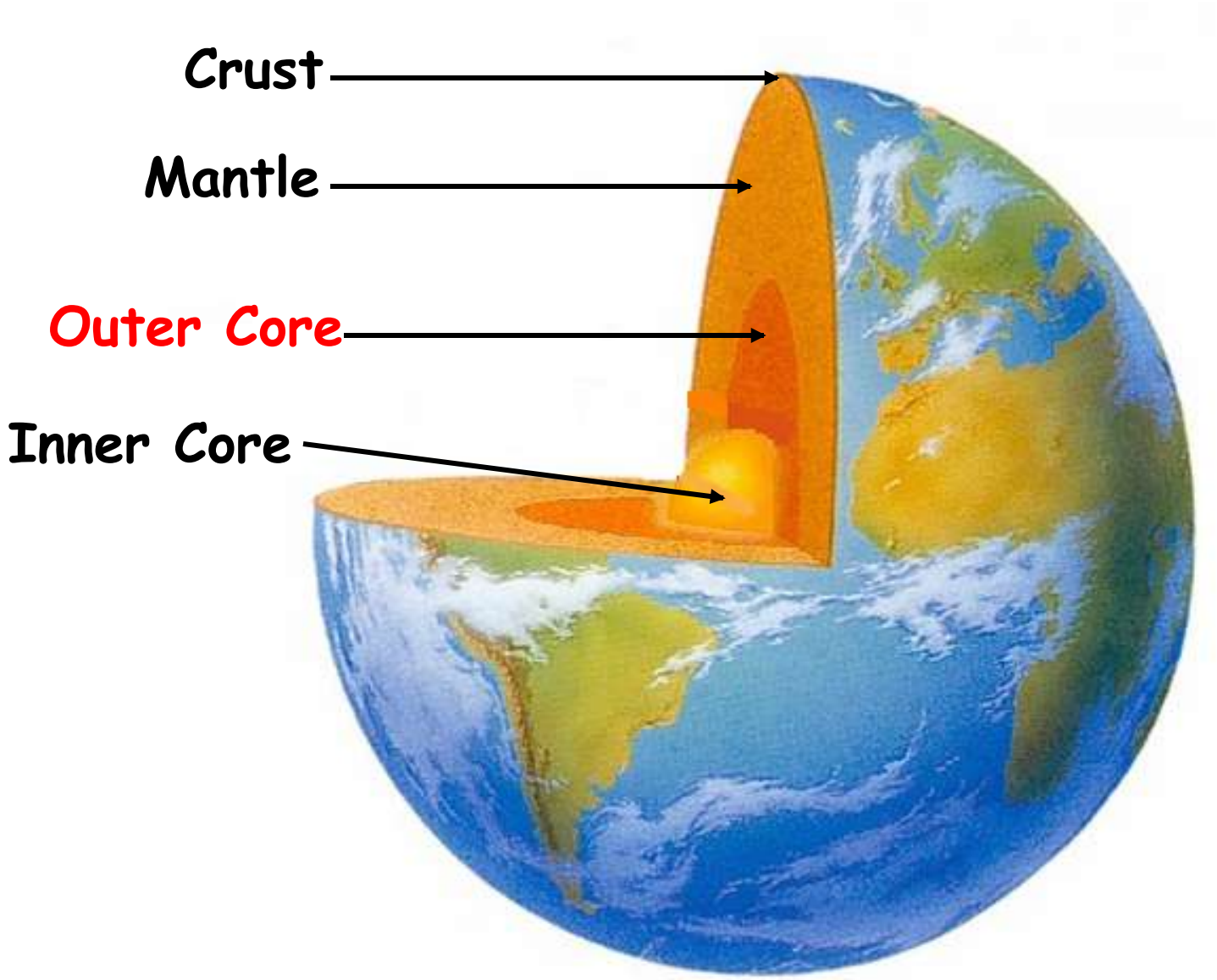
The Chikyu
Japanese Research Ship

- Cost six hundred million dollars.
- $200,000 per day to operate
- 1,000 31-ft. segments of pipe
- Can drill 23,000ft (7km) below floor
- Can drill 4km from Ship to sea floor

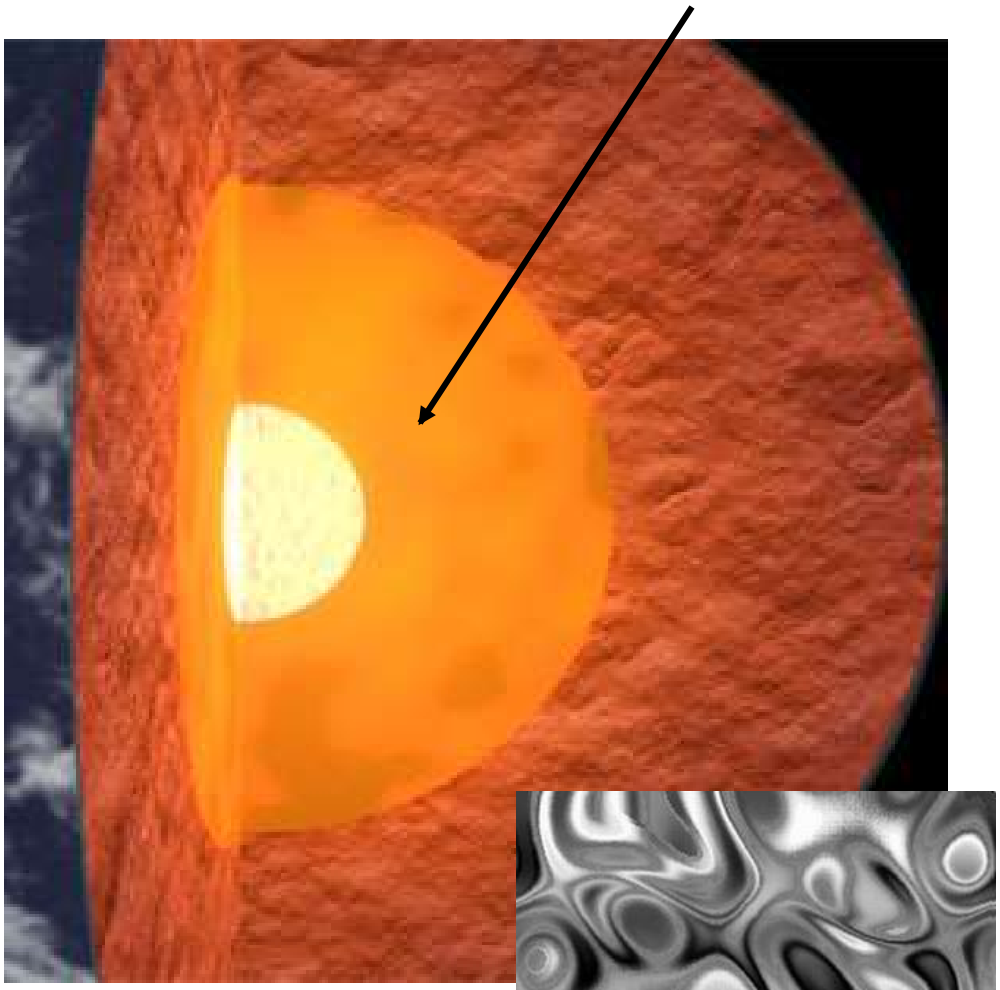
It is difficult to keep ship still because of the deep depth of the ocean.

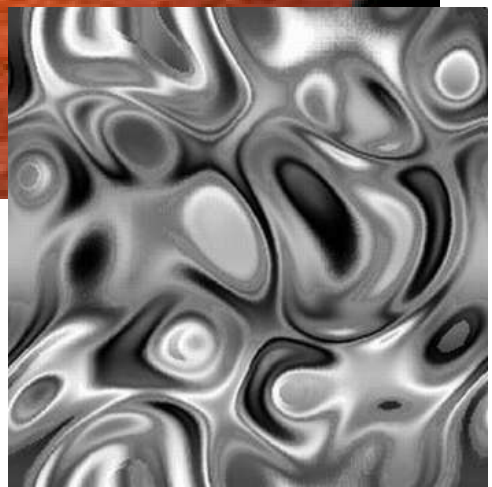


INSIDE THE EARTH



The OUTER Core





- Made of METAL
  - Iron and Nickel
- Physical State
  - Liquid
- Thickness 2,270km

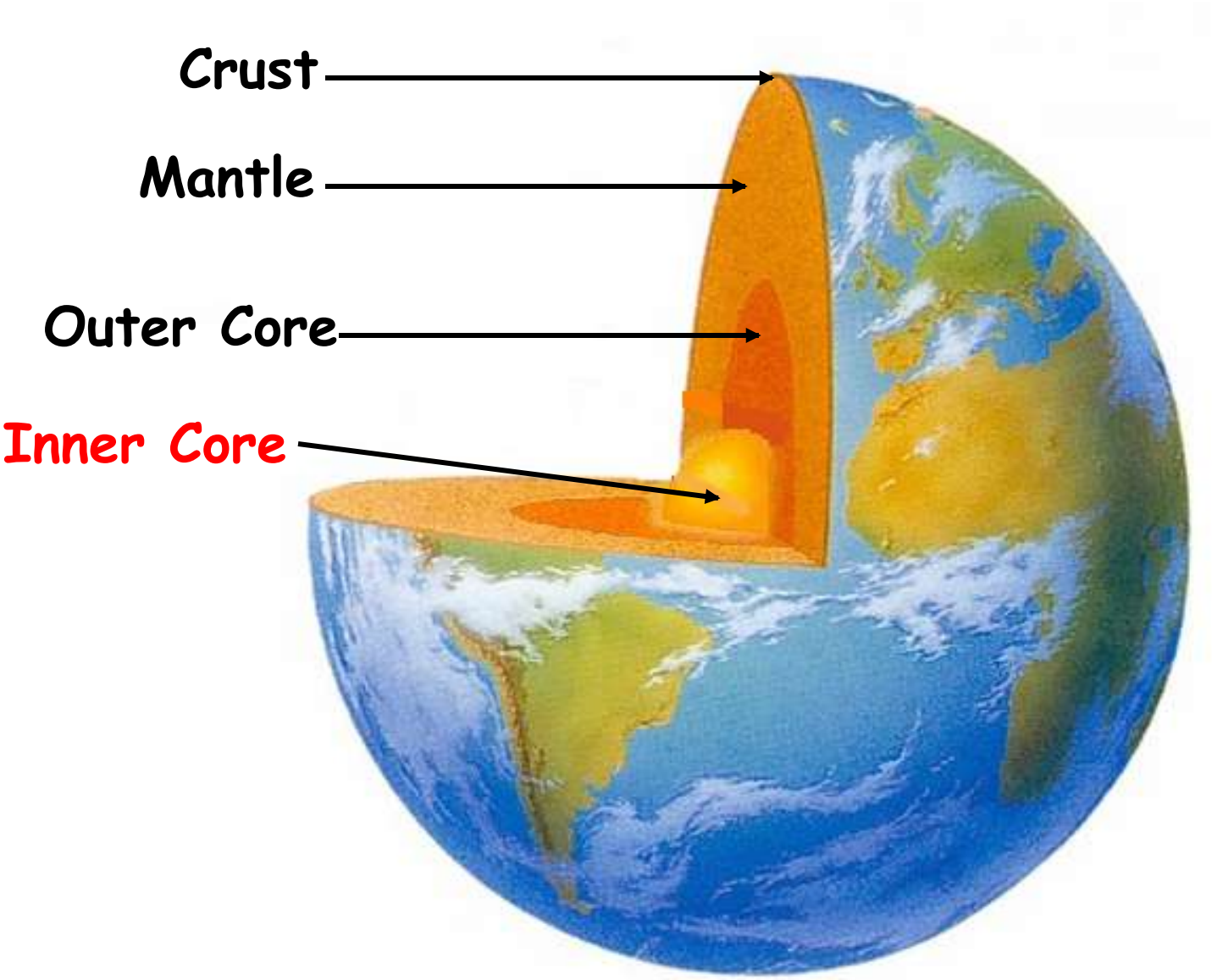
20,000 football fields

- Temperature

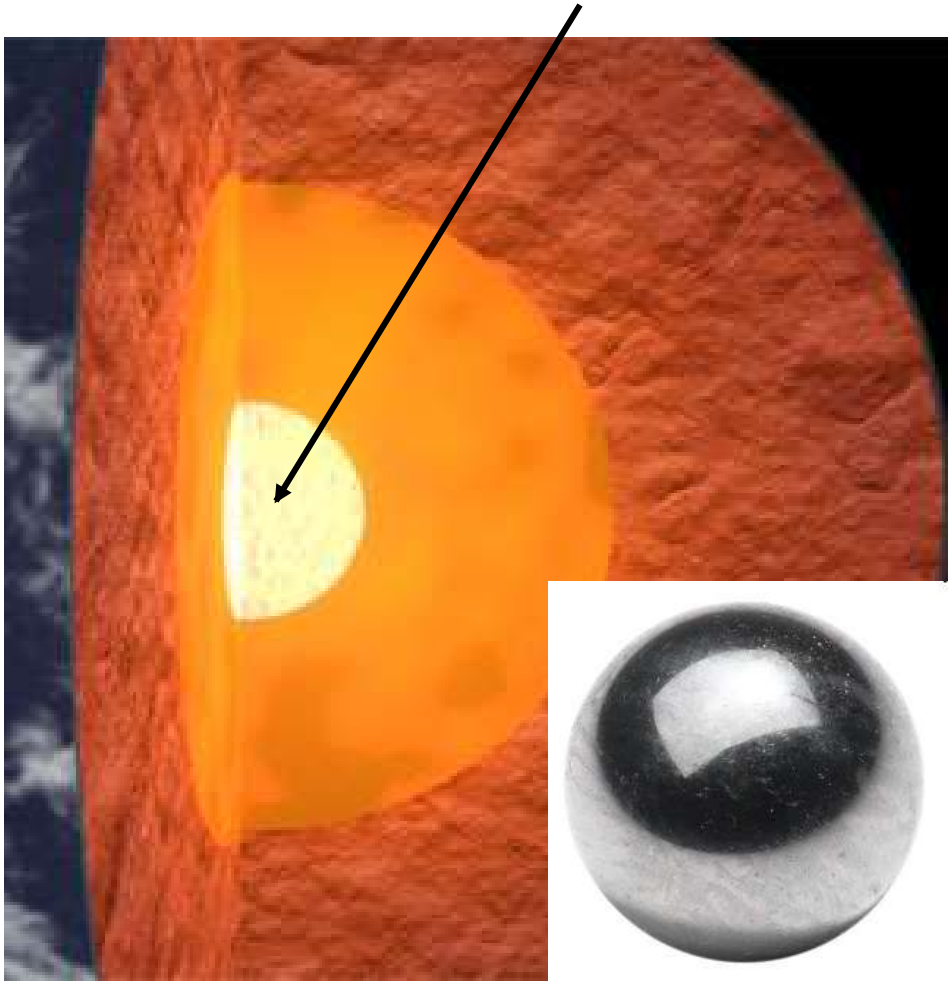
HOT, HOT, HOT!

3,600°C

INSIDE THE EARTH



The INNER Core
Center of the Earth



Made of METAL: Iron and Nickel

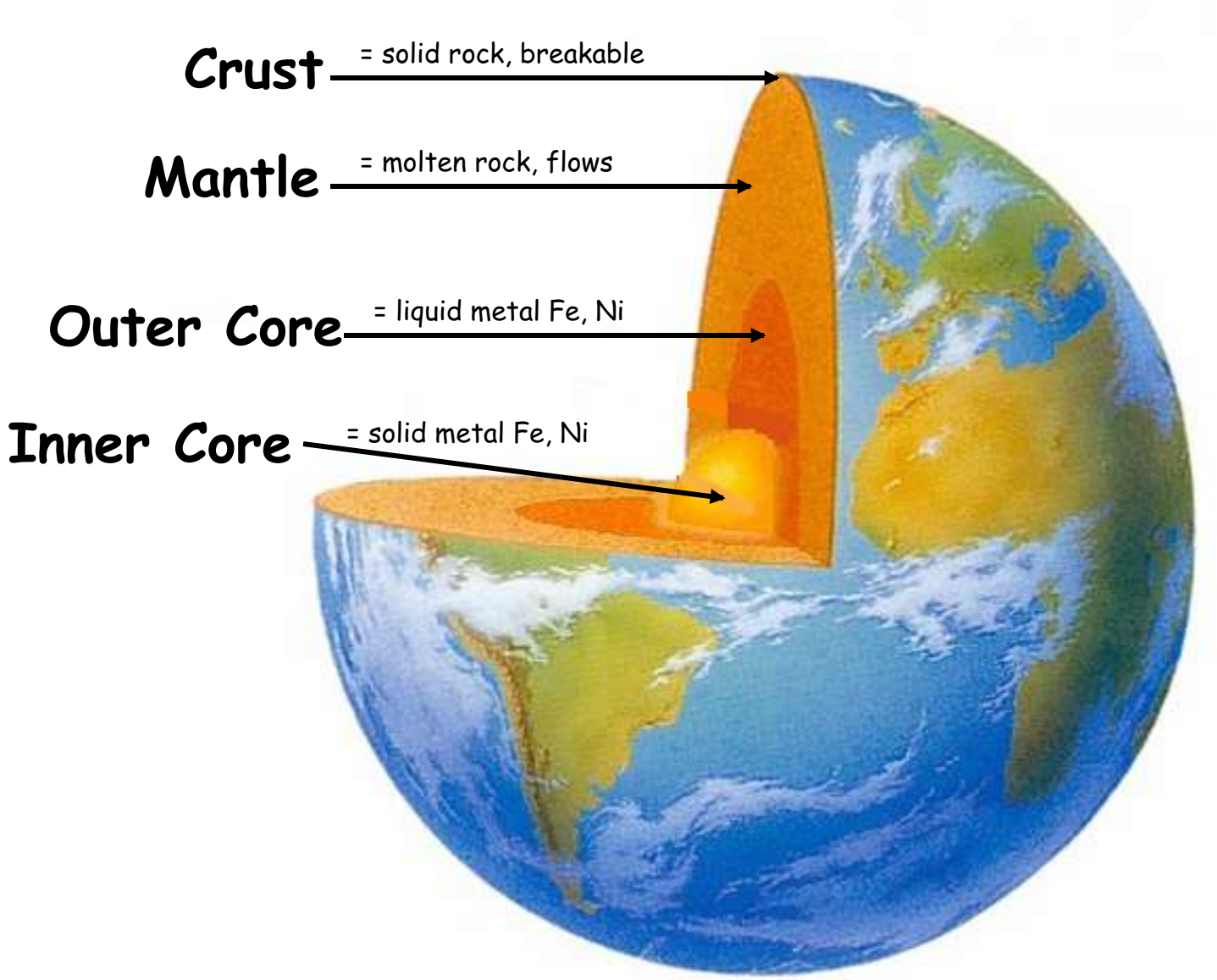
Physical State
Solid

Thickness 1,216km
11,000 football fields

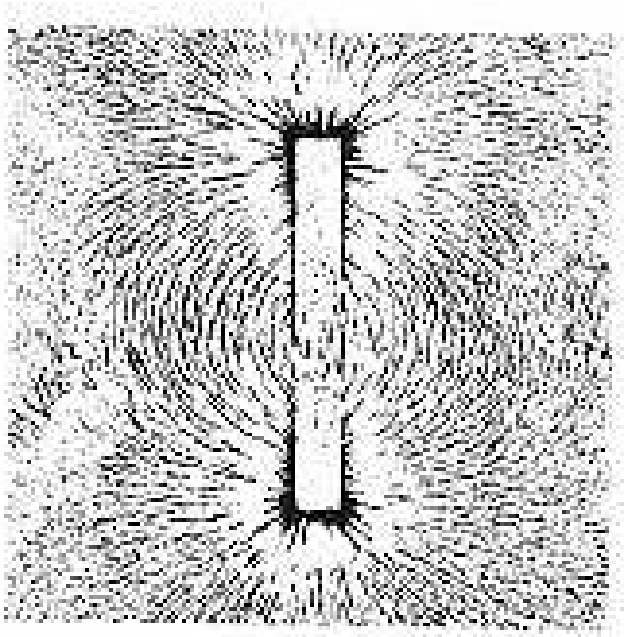
Temperature
4,200°C
almost as hot as the surface of the Sun

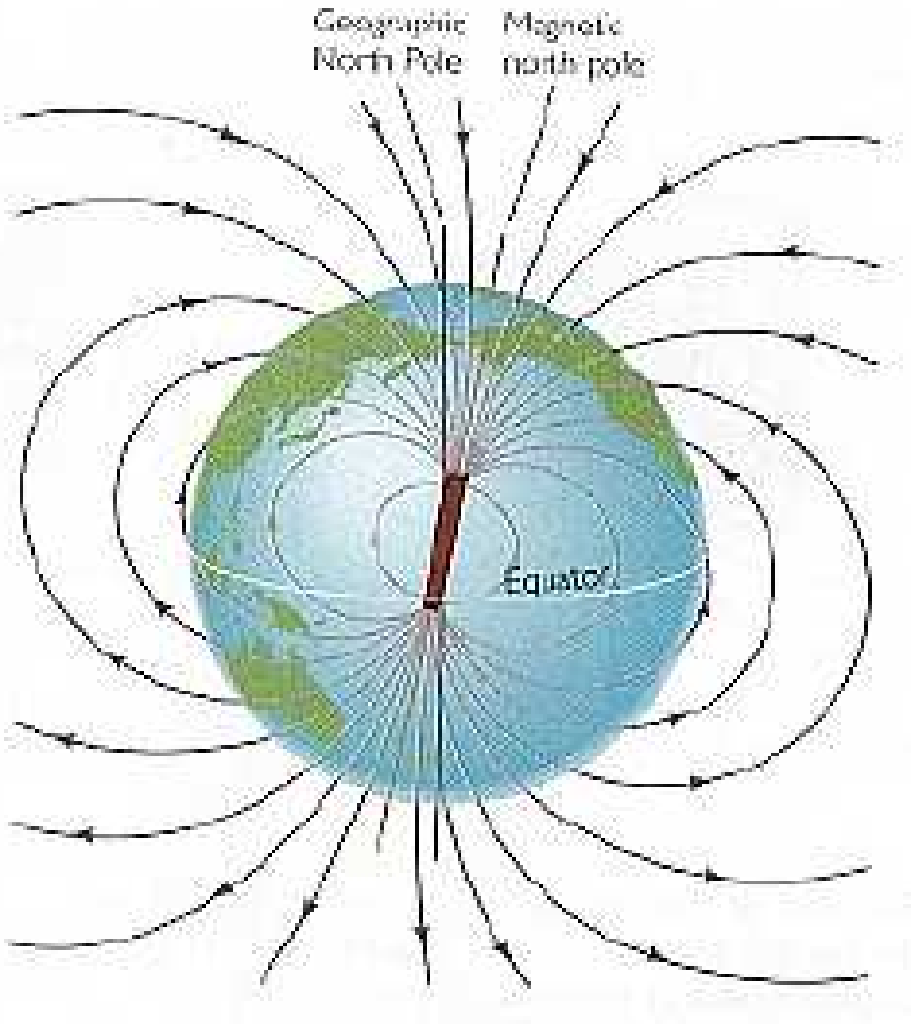
The most dense layer in the Earth.
Why is it a solid?

INSIDE THE EARTH



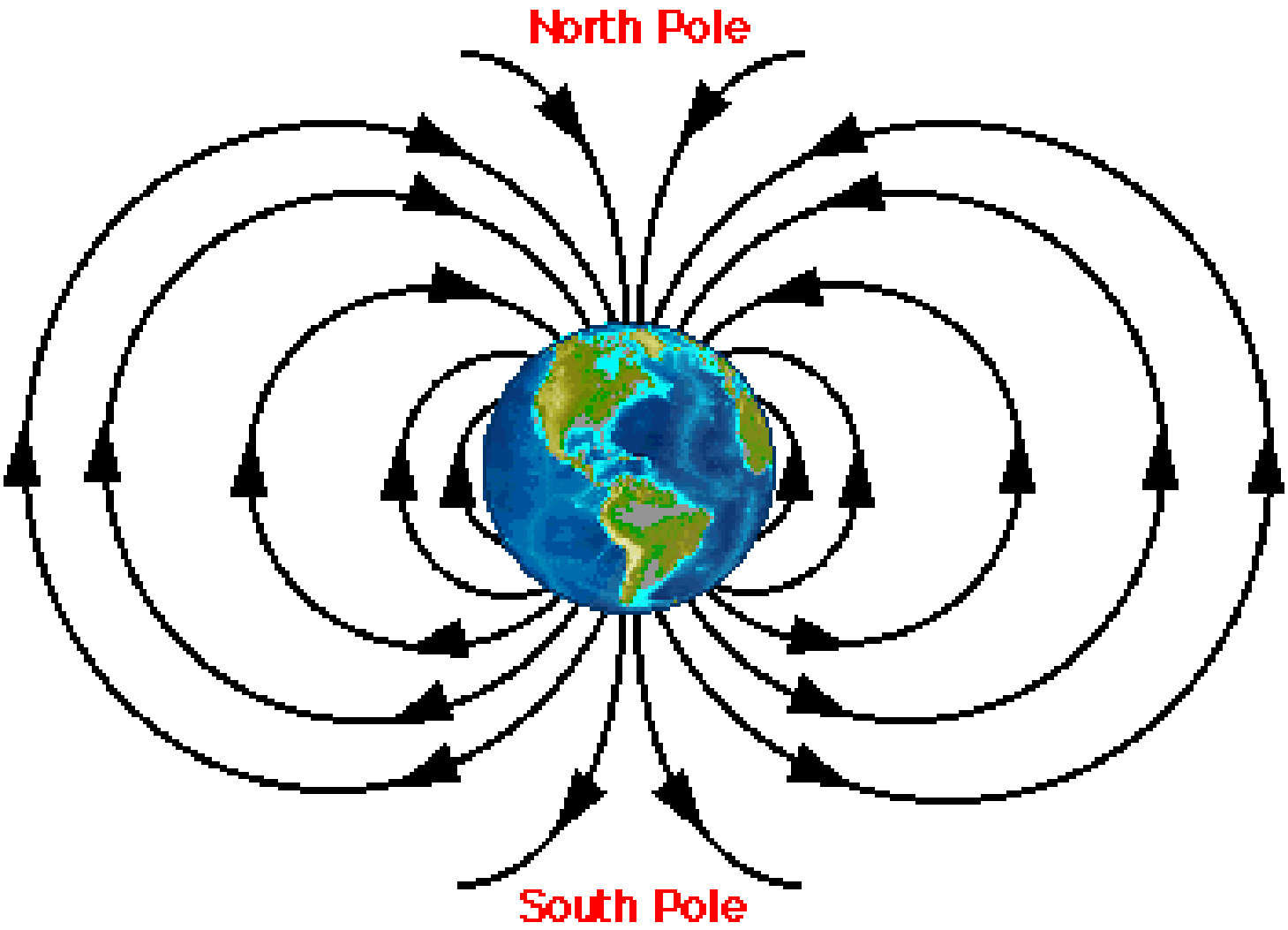
Earth's Magnetic Field



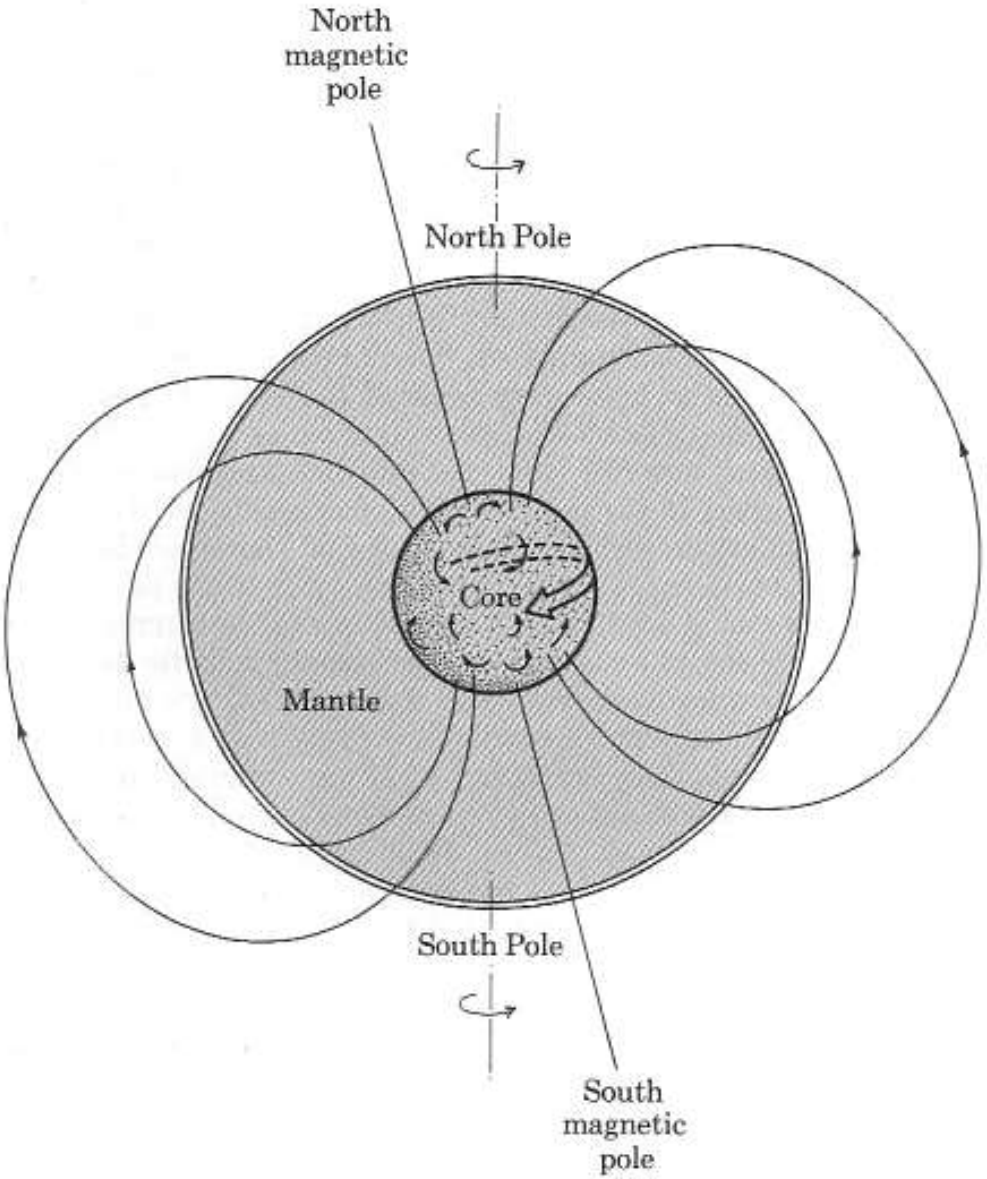


The Earth doesn't really have a large bar magnet inside.

What causes the Earth's magnetic field?



Dynamo Theory of Earth's Magnetic Field

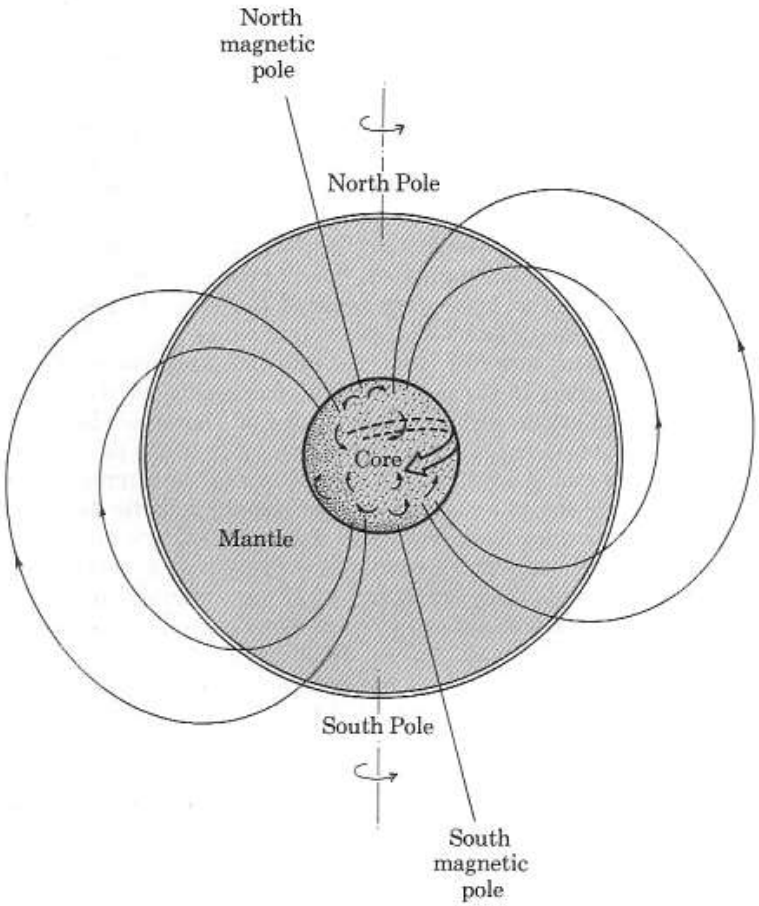


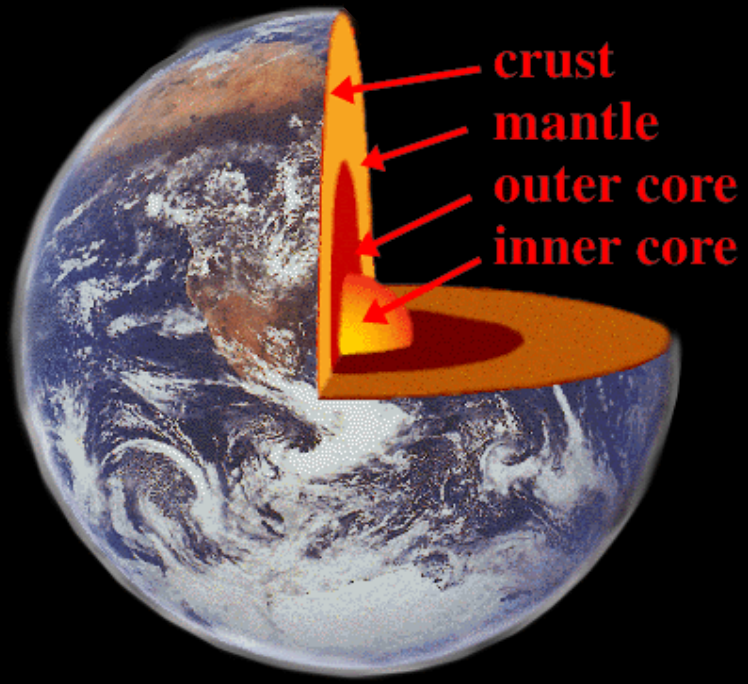
1. There must be a conducting fluid = liquid iron.

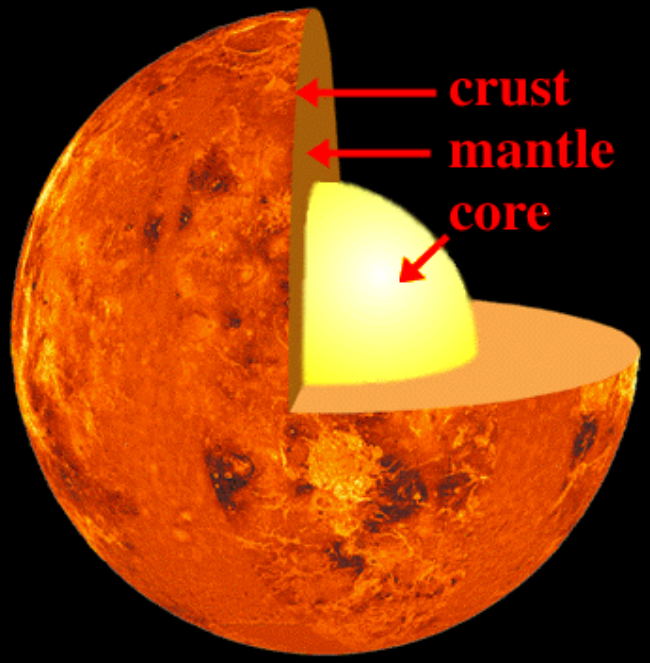
2. Liquid iron must circulate so rapidly in the Outer Core.

3. Earth must have a fast rotation: makes one revolution (spin) on its axis every 24 hours.

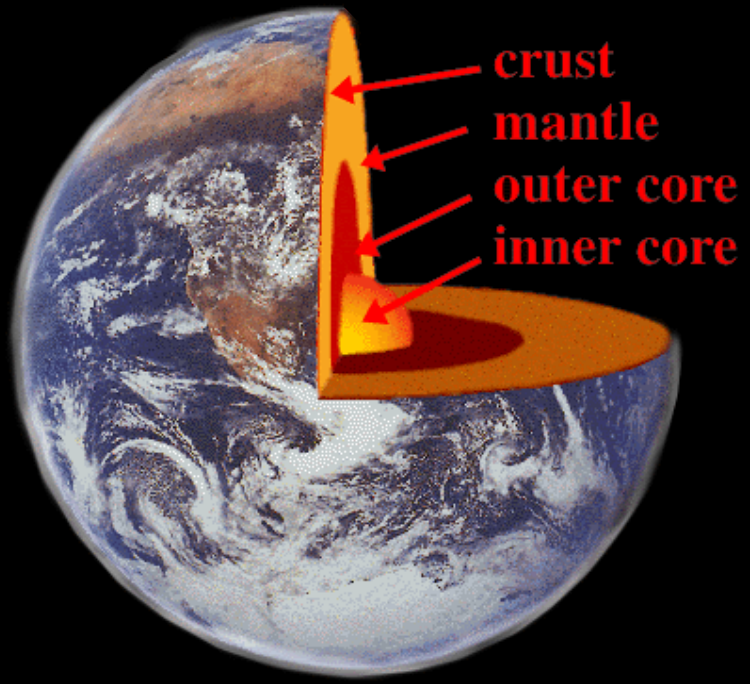
Large scale motions of conducting material (iron and nickel) in the core is generally accepted as the cause of the Earth's magnetic field.

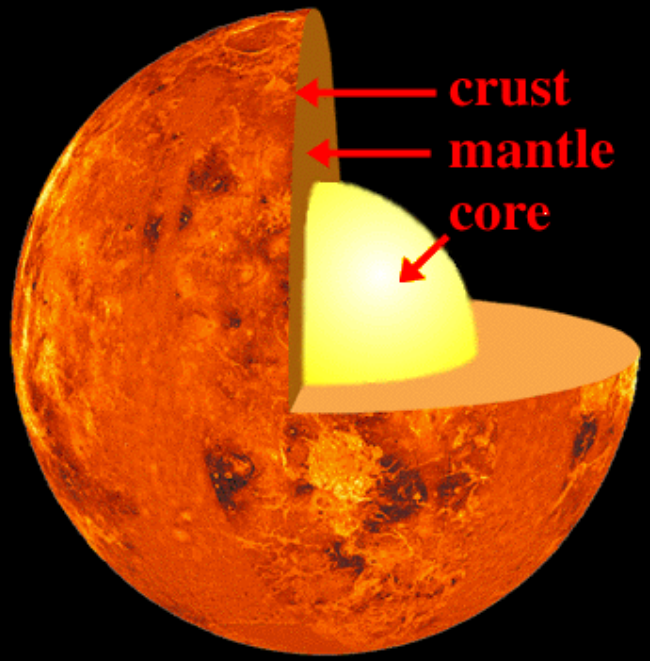




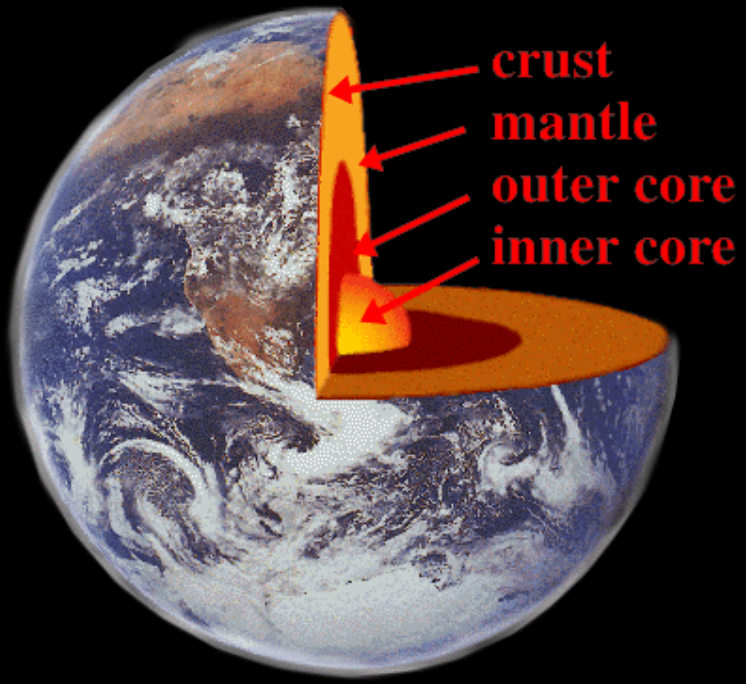


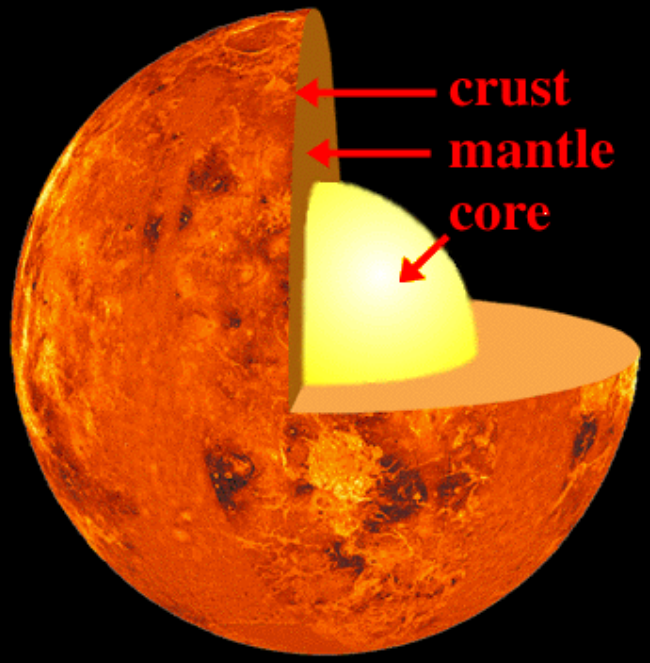
Venus, our nearest neighbor in space, is structurally similar to Earth, also having an iron core and a rocky mantle and crust.





But, Venus is spinning very slowly (once in 243 Earth days). So, one of the important ingredients of the dynamo theory is absent.



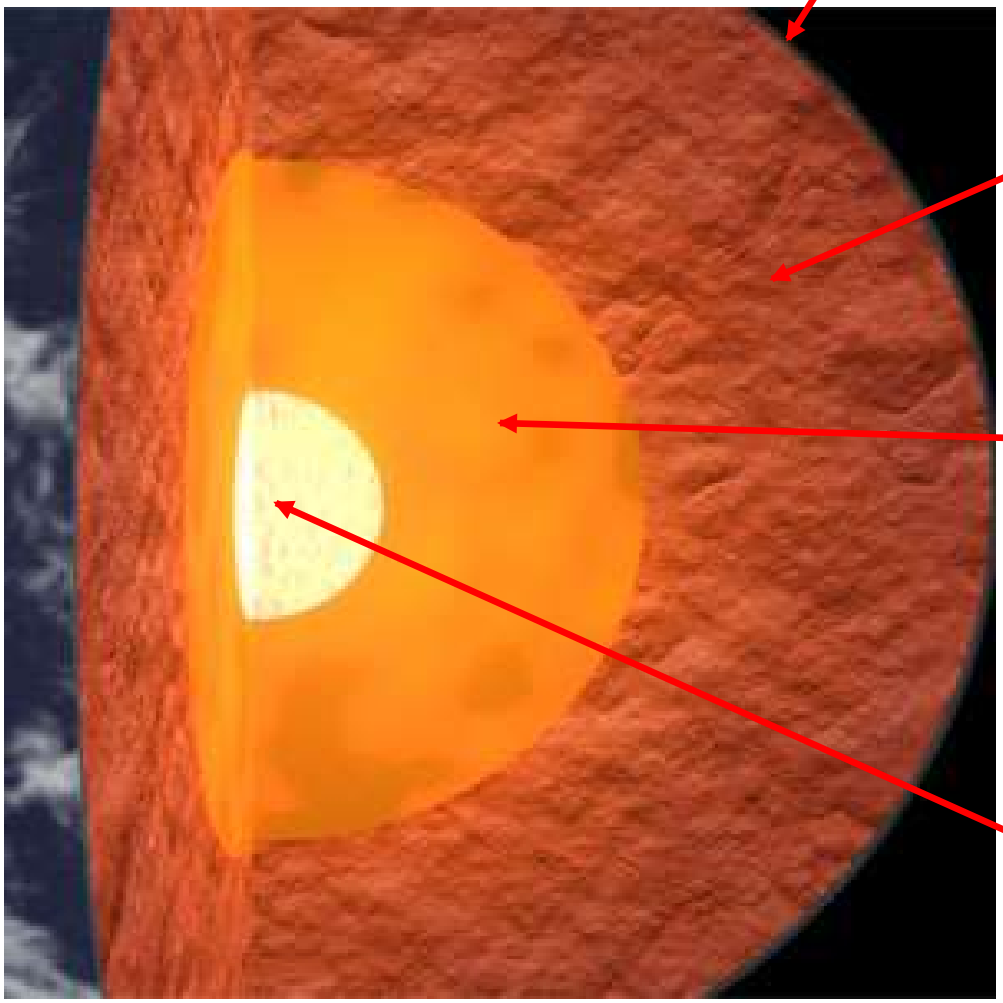


Thus, Venus would not be expected to have a magnetic field, and none has been observed.

Density

Density = Mass/Volume

Water: 1 gm/cm^3
Lead: 11.4
Copper: 8.9
Iron: 7.9
Zinc: 7.1
Aluminum: 2.7
Wood: 0.4-0.8

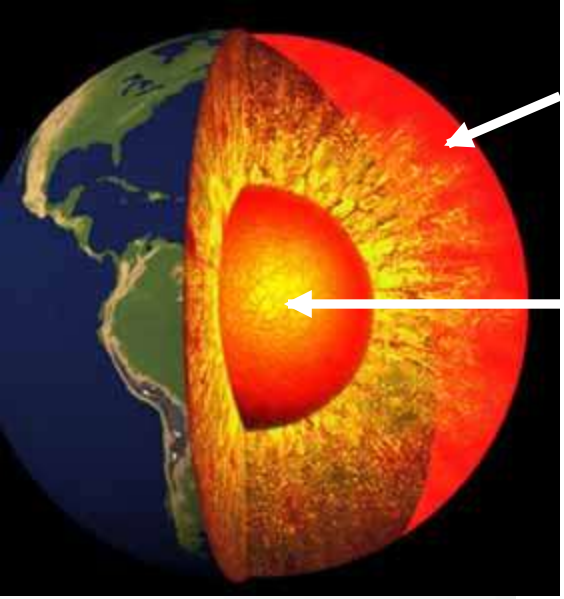


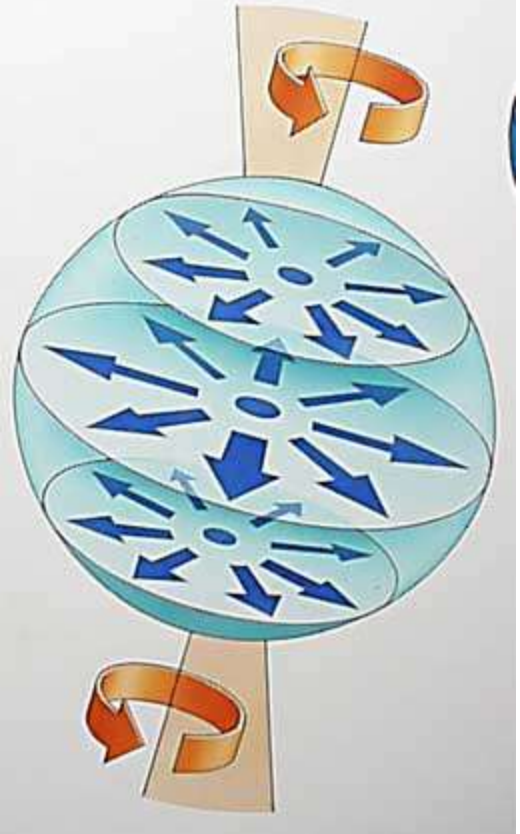
Crust
2.6 gm/cm^3 Continental
3.1 gm/cm^3 Oceanic

Mantle
3.5-5.7 gm/cm^3

Outer Core
10-12 gm/cm^3

Inner Core
13-14 gm/cm^3





-The Earth is layered.

-The material with the highest density is located at the center, inner core.

-The materials that comprise each successive layer outward toward the crust become progressively less dense.

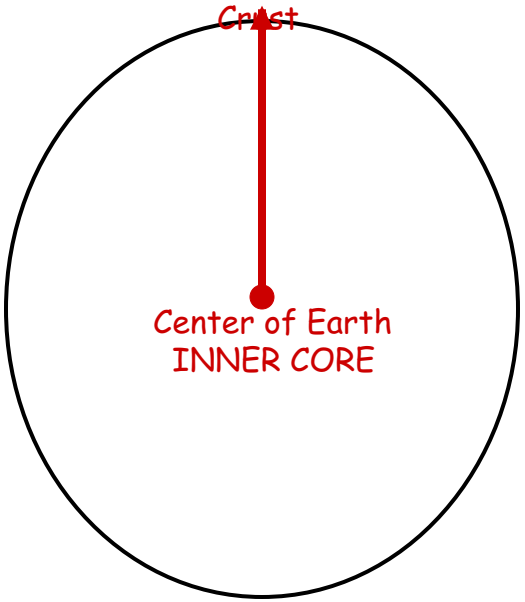
-Thus each less dense layer floats on top of the denser layer underneath.

Is your chart complete?

(Except for the scale thickness column)

Scale Model of the Earth's Interior LAB Exercise

* We are going to make a scale model of the Earth's radius.



Your Finished Product May Look Like

Outer Core

-thickness
-temperature
-composition
-phase

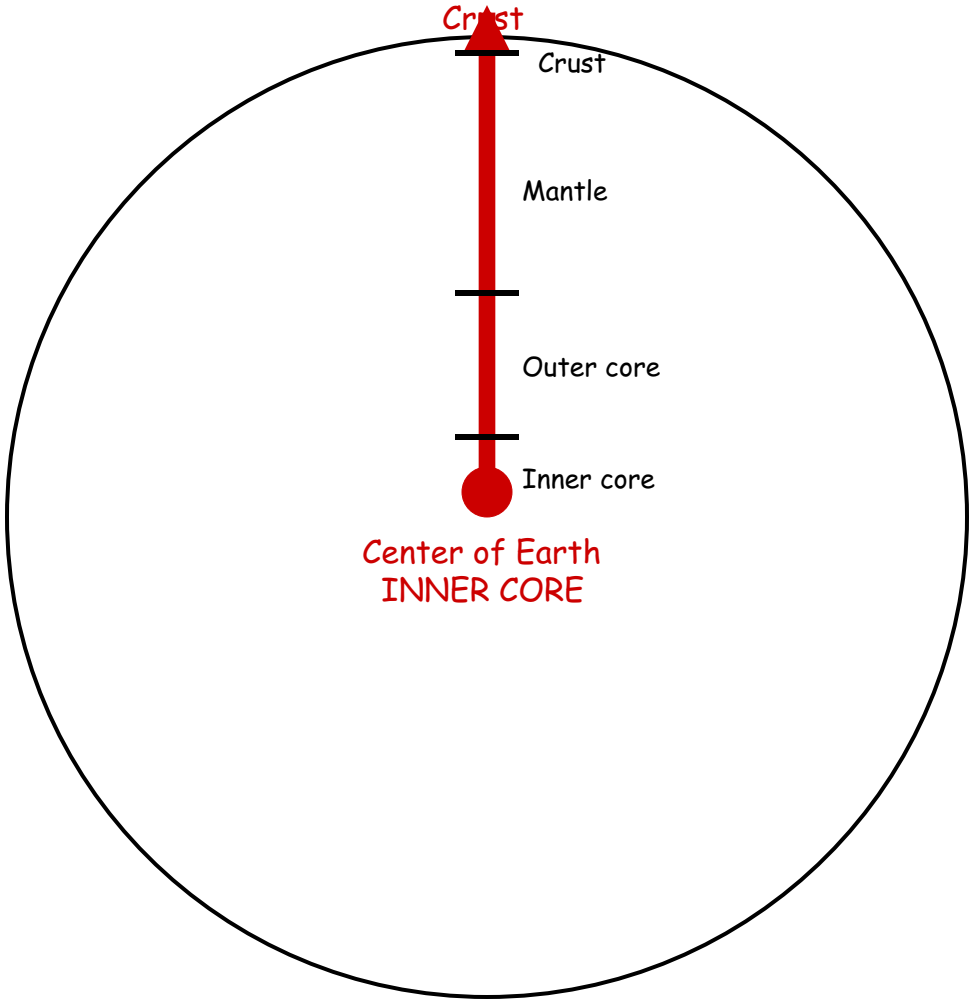
Outer Core

Inner Core

Inner Core

-thickness
-temperature
-composition
-phase

Center of Earth



To make your scale model:

- Cut a long piece of paper about 7 meter sticks in length.

- Supplies:
  - Ruler/meter sticks
  - Pencil
  - Markers
  - Paper roll
  - Scissors

Your Finished Product May Look Like

Outer Core

-thickness
-temperature
-composition
-phase

Outer Core

Inner Core

Inner Core

-thickness
-temperature
-composition
-phase

Center of Earth