Coring the Earth

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This is a follow up activity for students who have learned the layers of the earth.

Objectives: Students will simulate a core taken from the surface of the earth to its core and measure and identify the layers. Students will then mark the average temperature and pressure for each of the layers on their tubes. The class will discuss the implication of depth, temperature and pressure on the formation of rocks and minerals in the earth.

Equipment:

- Colored sand and funnels if needed
- square clear plastic tubes with tight fitting lids
- ruler
- fine tipped permanent markers
- calculator if determining density

Step 1 – determine the distance from crust to the center of the core

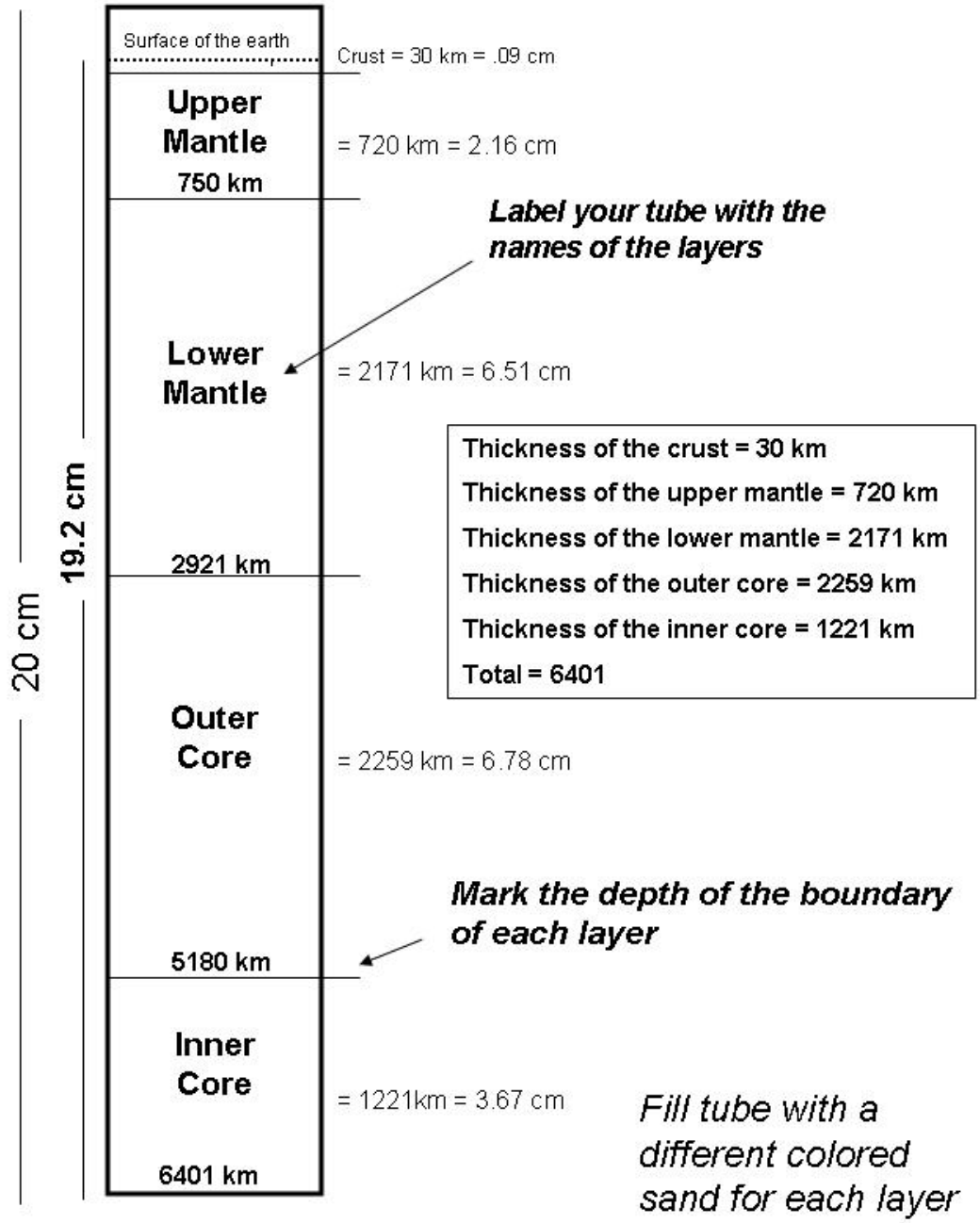
The diameter of the earth is approximately 12802 km, so how far is it to the center of the core?

The distance to the center is half that of the diameter, so 6401 km. We can round this off to 6400 km.

Using your ruler and your tube, determine the scale that will work best. For example, if you are using a 20 cm tube, an easy scale would be 3 cm = 1000km.

1. On one side of your tube, starting at the bottom, measure 19.2 cm and draw a line across. This line represents the surface of the crust. Mark this line “0 km.” You should have a little space left at the top.
2. Label the base of your tube “6400 km.” This represents the center of the core.
3. Using your ruler, mark off the distances to the upper mantle, lower mantle, outer core and inner core (see diagram). Mark across all four sides of the tube.
4. Choose 5 colors (except white) of play sand that will be used to represent the layers of the earth. Use the white sand to fill the space between the crust and the top of your tube.
5. Remove the top lid of the tube and with your first chosen colored sand, carefully pour to the line representing the top of the inner core/base of the outer core.
6. With your second colored sand, pour the next layer. Continue this procedure until you get to the top of the crust.
7. Between the top of the crust and the top of the tube, fill with white sand. Make sure you fill the tube full enough, so that when the lid is replaced, the sand does not mix between the layers. A cotton ball placed on top will help keep everything in place.
8. You should now have a tube filled with colored sand, with each color representing a layer of the earth.

3 cm = 1000 km

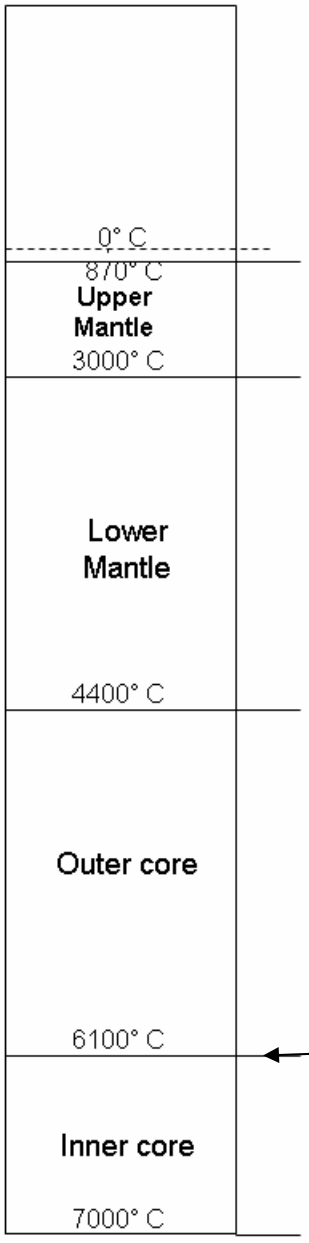

Surface of the earth
Crust = 30 km = .09 cm
Upper Mantle
= 720 km = 2.16 cm
750 km
Label your tube with the names of the layers
Lower Mantle
= 2171 km = 6.51 cm
Thickness of the crust = 30 km
Thickness of the upper mantle = 720 km
Thickness of the lower mantle = 2171 km
Thickness of the outer core = 2259 km
Thickness of the inner core = 1221 km
Total = 6401
19.2 cm
20 cm
2921 km
Outer Core
= 2259 km = 6.78 cm
Mark the depth of the boundary of each layer
5180 km
Inner Core
= 1221km = 3.67 cm
6401 km
Fill tube with a different colored sand for each layer

Step 2 – Temperature and Pressure in the Earth

We all know what the temperature is at the surface of the earth, but what happens as we go deeper? Volcanoes give as a clue that it must be hotter, as rocks that are solid on the surface are molten as they come up through the vent. In fact, the deeper you go into the Earth, the higher the temperature. This is called the **geothermal gradient**. However, we don't really know the temperature in the center of the Earth because we cannot measure or observe it directly. However, we do know that some minerals form at certain levels, and we can model the temperature and pressure of these minerals to estimate the temperature at certain depths of the earth.

You will show the geothermal gradient by marking temperatures on a different side of the tube from what you've already marked. Use the diagram to help you find the temperatures of the various layers.

Layer	Min Temperature °C	Max Temperature °C
Crust	0	870
Upper Mantle	870	3000
Lower Mantle	3000	4400
Outer Core	4400	6100
Inner Core	6100	7000



Approximate temperatures at the boundaries between layers

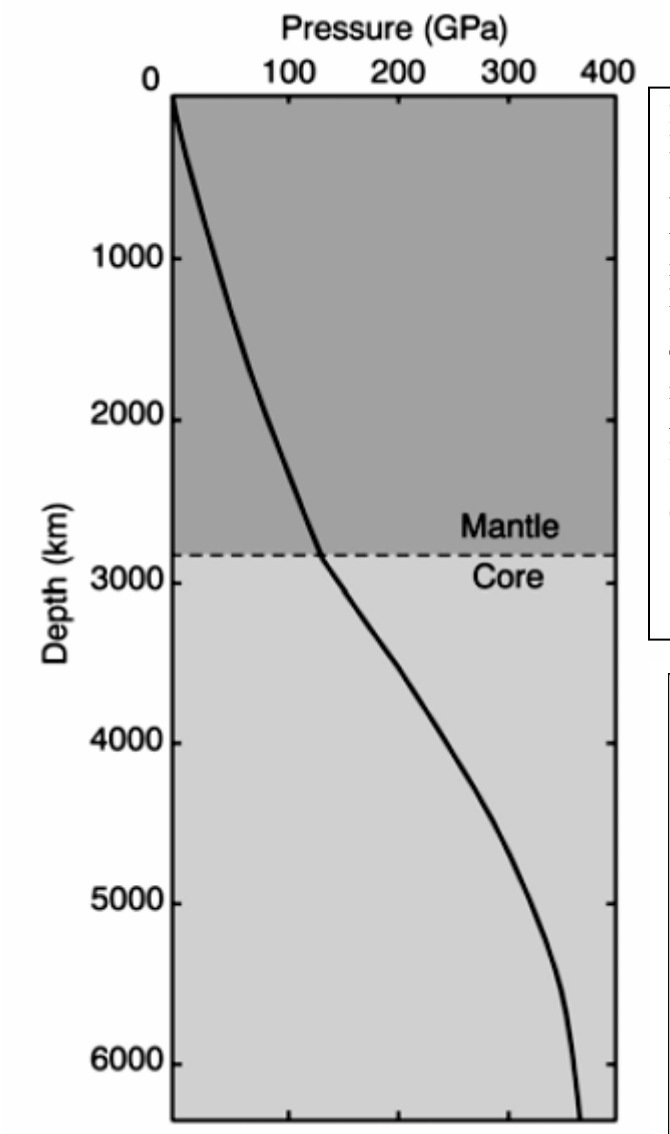
Layer	Min Temperature °C	Max Temperature °C
Crust	0	870
Upper Mantle	870	3000
Lower Mantle	3000	4400
Outer Core	4400	6100
Inner Core	6100	7000

Mark the temperature at the boundary between layers

Pressure

Pressure within the Earth also increases with depth. At the surface of the earth, pressure comes from the weight of the overlying atmosphere, and is known as atmospheric pressure. Pressure under the surface of the earth comes from the weight of overlying rocks. The pressure at the bottom of the mantle is ~136 GPa (1.4 Matm) (19,000,000 psi). It is estimated that at the center of the core, the pressure is ~310 GPa, (3.06 Matm) 3103 kb or 45,000,000 pounds per square inch (psi). This is 3,000,000 times the air pressure on at sea level!

Using the graph below, mark the pressure at various points in the earth.



Pressure =
Density x Acceleration due to gravity x Depth

You need to know the density of the layer and its thickness. Each layer is composed of different materials and so the density is different for each layer.

To calculate pressure in Pa, units must be in kg and m.
At 1300km (upper mantle)
P (Pa) = 3400 kg/m^3 x 9.8m/s^2 x 1,300,000 m
= 43,316,000,000 = 4.3 x 10^{10} Pa
Or 43 GPa

Data on the Earth's Interior

	Thickness (km)	Density (g/cm³) Top	Density (g/cm³) Bottom	Types of rock found
Crust	30	2.2	–	Silicic rocks.
		–	2.9	Andesite, basalt at base.
Upper mantle	720	3.4	–	Peridotite, eclogite, olivine, spinel, garnet, pyroxene.
		–	4.4	Perovskite, oxides.
Lower mantle	2,171	4.4	–	Magnesium and silicon oxides.
		–	5.6	
Outer core	2,259	9.9	–	Iron+oxygen, sulfur, nickel alloy.
		–	12.2	
Inner core	1,221	12.8	–	Iron+oxygen, sulfur, nickel alloy.
		–	13.1	
Total thickness	6,401			

You now have a representation of some of the conditions that exist in the earth from the surface to the center of the core. Where do most of the minerals that we find on the surface come from?