

Planet Earth in Cross Section

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Objectives

Devise a model of the layers of the Earth to scale.

Background

Planet Earth is organized into layers of varying thickness. This solid, rocky planet becomes denser as one travels into its interior. Gravity has caused the planet to differentiate, meaning that denser material have been pulled towards Earth's center. Relatively less dense material migrates to the surface. What follows is a brief description¹ of each layer beginning at the center of the Earth and working out towards the atmosphere.

Inner Core – The solid innermost sphere of the Earth, about 1271 kilometers in radius. Examination of meteorites has led geologists to infer that the inner core is composed of iron and nickel.

Outer Core - A layer surrounding the inner core that is about 2270 kilometers thick and which has the properties of a liquid.

Mantle – A solid, 2885-kilometer thick layer of ultra-mafic rock located below the crust. This is the thickest layer of the earth.

Asthenosphere – A partially melted layer of ultra-mafic rock in the mantle situated below the lithosphere. Tectonic plates slide along this layer.

Lithosphere – The solid outer portion of the Earth that is capable of movement. The lithosphere is a rock layer composed of the crust (felsic continental crust and mafic ocean crust) and the portion of the mafic upper mantle situated above the asthenosphere.

Hydrosphere – Refers to the water portion at or near Earth's surface. The hydrosphere is primarily composed of oceans, but also includes, lakes, streams and groundwater.

Atmosphere – the layer of gas that surrounds our planet. Earth's atmosphere is composed primarily of nitrogen and is broken down into distinctive layers based on temperature profiles.

Troposphere – A 10 to 12-kilometer layer of the atmosphere next to the earth's surface in which temperature generally decreases rapidly with altitude and clouds form.

Stratosphere – The layer above the troposphere in which temperature increases with an increase in elevation. The stratosphere contains the ozone layer.

Mesosphere – The layer above the stratosphere in which temperature decreases with altitude.

Thermosphere – the outermost layer of the atmosphere located above the mesosphere. In this layer, temperature rapidly increases with altitude.

In this lab a model of the layers of the earth will be constructed to scale using cash register tape. The tape will represent a "column" of the Earth from its center to the outermost portion of its atmosphere. This cross-section model will be constructed to a scale of 1 centimeter equal to 100 kilometers or 1:10,000, 000. The ratio of 1 to

¹ Adapted from Tarbuck and Lutgens (1990) and Jackson and Bates (1984)

10,000,00 means that one unit of measure on a ruler is equal to 10,000,000 units of measure on a map or scale model. If there are 10,000,000 centimeters in 100 kilometers, then 1 centimeter is equivalent to 100 kilometers.

Note at this scale one centimeter of register tape equals 100 kilometers. The average width of a line drawn by a sharp pencil varies from 0.05 to 0.08 cm. Therefore the width of a pencil used to draw layers will range in scale from 5 to 8 kilometers.

Method

1. Cut a 90 cm piece of register tape. You may wish to secure each end of the paper to a table top with a piece of tape
2. Use a ruler and neatly draw a line perpendicular to the length of the tape roughly 10 centimeters from one end. This will be the starting line for all the layers.

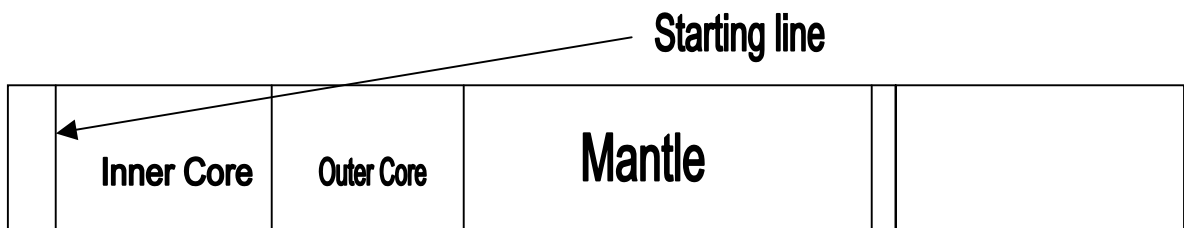


Diagram 1. Example of cross section model with solid layers.

3. Calculate the scale distances for the solid portion of the Earth and note it in the table below. To do this, divide the average thickness of a layer by 100 and round to the nearest tenth. Here is an example:

The radius of the inner core is 1276km. Thus $1276/100 =$ equals a 12.7 cm thick layer drawn on the register tape. Note the scale distances for all the layers on the data table below.

<u>Layer</u>	<u>Avg. Thickness</u>	<u>Scale in Centimeters</u>
Inner Core	1271 km	<u> 12.7 cm </u>
Outer Core	2270 km	<u> </u>
Mantle	2885 km	<u> </u>
Asthenosphere	200 km	<u> </u>
Lithosphere	100 km	<u> </u>

4. Using a pencil mark the layers of the Earth onto the register tape based on your calculations. Begin from the center of the earth and add each successive layer in order. Label each layer.
5. Calculate the scale distances for the atmosphere using the table below. Draw the layers of the atmosphere by marking the boundaries or “pauses.” Use the outer edge of the lithosphere as a starting point.

Boundary	Avg. Thickness	Scale Distance in Centimeters
Troposphere	12 km	_____
Stratosphere	50 km	_____
Mesosphere	80 km	_____
Thermosphere	140 km	_____

6. Refer to the background information in this lab and note the composition of the inner core, outer core, mantle, asthenosphere and lithosphere on to the model.
7. Refer to page 10 of the E.S.R.T. Note on to the model the temperature of the Earth's interior at 1000 km intervals.
8. Refer to page 10 of the E.S.R.T. Note on to the model the density of the inner core, outer core and mantle.
9. Color the inner core yellow, the outer core orange, the mantle red, the asthenosphere light brown and *lightly* pencil shade the lithosphere. Color the troposphere light blue the stratosphere pink, the mesosphere dark blue and thermosphere violet. Color the remaining space black.

What to Turn In

- Model (neatly folded or rolled up with name visible on outside) 30 points:
10 points for accuracy; 10 points for coloring and labels; 10 points for neatness
- Answers to questions.

Planet Earth In Cross Section Questions

Directions – Answer the following questions using the model, a ruler, a calculator & the Earth Science Reference Tables. Responses will be neatly written on a separate sheet of paper using complete sentences. Point values for each question are in parentheses.

Observation/Measurement Questions

1. List the layers of the solid Earth from least dense to most dense. (4)
2. What is the main composition of the Earth? (2)
3. Measure the model using a metric ruler. What is the radial thickness of the solid earth in kilometers? (2)
4. The actual radius of the Earth is 6,378 km. What is the percent error for the measurement from question #2? Show all work and circle the final answer. (4)
5. Analyze the scale model and determine two or more possible sources of error assuming that the scale distances are correct. (4)
6. Mount Everest is the tallest mountain on Earth, rising 8,850 meters above sea level. How high (in centimeters) would it appear to be on this scale model? Describe its appearance relative to the rest of the model. (4)
7. The average depth of the ocean is 4 kilometers. Describe where this would fit on the model and how thick would it be as a layer drawn to scale. (4)
8. The Earth is approximately 40,000 kilometers in circumference. What percentage of the Earth's circumference is represented by the width of the register tape? (4)

Inference Questions

1. What causes the layers of the Earth to be ordered by density?
2. Examine the model and determine the layer in which life on earth exists. Describe the thickness of this layer relative to the radius of the Earth.
3. The structure of the earth is concentric layers of increasing density. Based on this observation did the Earth form by the deposition of rocks forming layers or by the collection of particles of differing densities in space? Describe the process that would have resulted in the structure of the Earth.
4. Given that the Earth is a rocky body orbiting in space, why is the change in temperature greatest within the asthenosphere?

1. It was very helpful to have a completed model to use as a standard.
2. Demonstrate that the layers are drawn in an accumulated fashion as opposed to drawing each layer from the center of the earth.
3. Method #4 – Have student carefully look at the tip of their ball point pen then describe 5 to 8 kilometers in local terms (i.e. its from here to the mall – I used from the edge of our classroom windows to hill roughly 6 kilometers distant. Fortunately it was a clear day in Central New York!)
4. Atmosphere: note that the lines that separate layers are referred to as “pauses.”
5. Be sure they all use the same color scheme. At some point after all the models are completed the following nifty thing can be done. Stack the models. Poke a pin through the midpoint of the “center of the earth.” Attach to a bulletin board. Spread out the models like a fan. One could spread them out in all directions to get the full diameter of the earth. Compare this to the earth in space poster that every good earth scientist has hanging in their classroom and talk about scale, size of mtns. etc (but only for a few minutes because that’s old syllabus).
6. I spent some time at the end discussing why earth systems at the surface are fragile, the idea of interfaces, how the sun is the dominant source of energy and that the surface is an interface with the sun and the rest of the universe, etc.

Suggested Answers to Questions - responses could be but are not limited to ;)

1. The layers of the solid Earth from least dense to most dense are: lithosphere, asthenosphere, mantle, outer core, inner core.
2. The Earth is mainly composed of mafic, igneous rock.
3. Answers will vary – the model of the solid Earth should be approximately 63 centimeters in length.
4. Answers will vary. Most students construct models with 2% error.
5. Error results from the limitation of tools and student technique. Thematic rulers used measure to within a millimeter. So all measurement are accurate to within +/- 10 kilometers. The pencil width is equal to 7 kilometers. So if a student constructs the model using 10 pencil lines then the potential for error could be as much as 170 kilometers even if their technique is perfect. If a student does not place the ruler perpendicular to the width of the paper then each successive plot or measurement will also be off.
6. Mount Everest is 8.885 kilometers or 0.08 centimeters to scale – less than the width of a sharp pencil. Mount Everest would not be visible on this model.
7. If the average depth of the ocean is 4 kilometers then it would be 0.04 centimeters on the model. This would be half the thickness of a pencil line and therefore would not be visible on the model.
8. The answer depends on the width of the tape. Most answers are approximately 2%.

Inference questions

1. Gravity!

2. The pencil line that separates the lithosphere from the atmosphere is the area where life as we currently understand it exists. This layer is very thin compared to the radius of the Earth.
3. Deposition of sediments causes rocks to form in layers. The Earth is in layers of increasing density. It is unlikely that the earth formed by concentric layers of deposits with increasing layers. It makes more sense that a group of rocks with different densities clumped together. Gravity pulled the most dense particles to the interior.
4. The interior of the Earth is hot. Space is cold. The greatest energy transfer is occurring in the outer most layers of the Earth.