

Scaling the Earth's Interior

A wedge of Earth

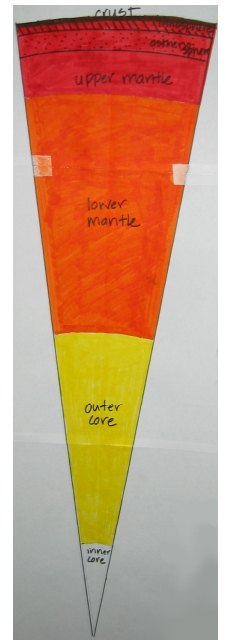
By Eric Muller and Lori Lambertson

Introduction:

Students can create a scaled slice of the earth's interior. By measuring, coloring and labeling, their creation, students can see the relative sizes and differences in composition of earth's internal structures.

Materials:

- Paper – 3 sheets of standard 8.5 by 11in sheets per student
- Protractor
- Meter stick
- Pencil
- String with loop at one end.... at least 70cm long.
- Transparent tape
- Protractor
- Colored pencils, crayons or felt pens (optional)

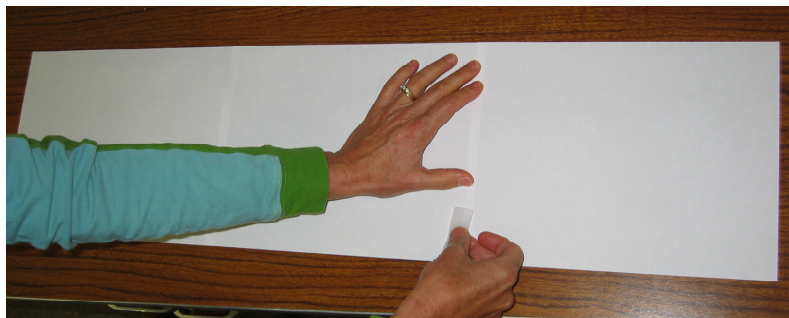


Assembly and to do and notice:

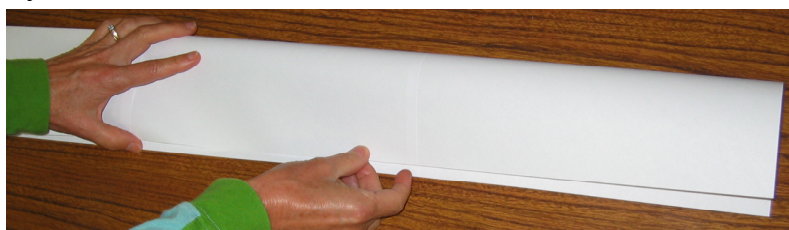
Part 1

Making the Wedge

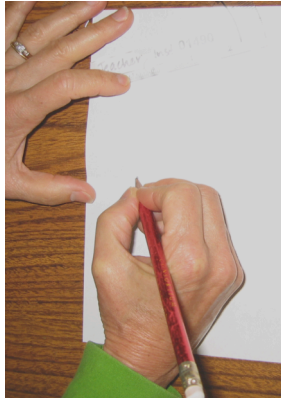
1. Have students figure out what the interior angle of each slice should be to create a completed circle. (The total degrees in a circle, 360, divided the number of students will give you the correct angle for each student's slice. For example, if you have 20 students, then divide 360 degrees by 20 to get 18 degrees per student wedge....30 students is 12 degrees etc.)
2. Tape three sheets of paper together end to end so that you have a taped sheet that is about 33 in long or a total of about 85cm long (length might be a little shorter because of overlap)



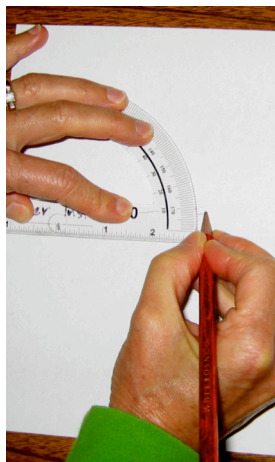
3. Fold the taped sheets of paper in half (long dimension). This will allow you to easily find a centerline.



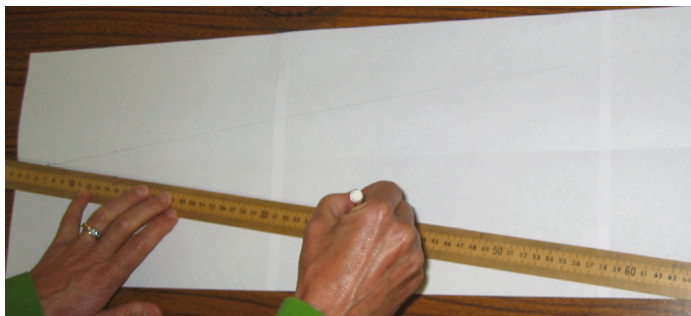
4. Place a pencil dot near one end along the centerline.



5. Using the pencil dot as your zero, measure half of your desired angle on each side of the centerline for your wedge. For example if you want to create an 18° wedge, measure 9° on each side of the centerline.



6. Using a meter stick, extend the two lines from the dot through the marked angles to create your wedge.



Part 2

Marking the layers. This should be done in two phases: marking the major layers then adding details to these layers.

A. Marking major layers: crust, mantle and core layers

1. Calculations need to be made to scale your earth wedge appropriately. Given that the radius of the earth is 6371km. This would be a good opportunity to encourage your students to come up with an appropriate and easy to use scale.

Here's the scale we use:

1:10 million or 1 cm = 100 km

In our scale, 1 cm on the model represents 100 km in the actual Earth. Since the radius of the earth is 6371km, on our model the earth radius (length of wedge) will be the scaled to 63.7 cm.

For more help with scaling, see the last page of this document.

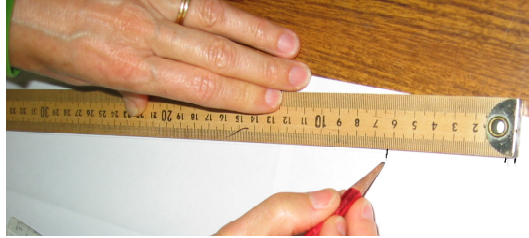
2. Students should complete the attached blank table (end of this activity). Their numbers should be checked before they continue.
3. Here is a completed data table:

Materials	Name of Layer	Average depth in Km	Scaled depth in cm	Wedge Color
Rock	Crust	35	.35	Brown
Rock	Upper Mantle rigid	670	6.7	Red
Rock	Lower Mantle	2885	28.9	Orange
Metal	Outer Core	5155	51.6	Yellow
Metal	Inner Core	6371	63.7	White

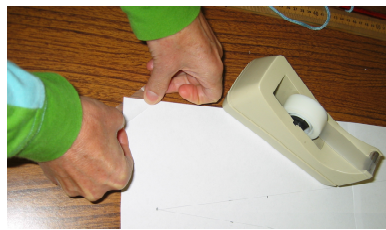
4. Mark the scaled radius on the paper. This is the surface of the earth.... the place we live! Remember to place the "zero" of your meter stick at the dot (or vertex of the wedge).



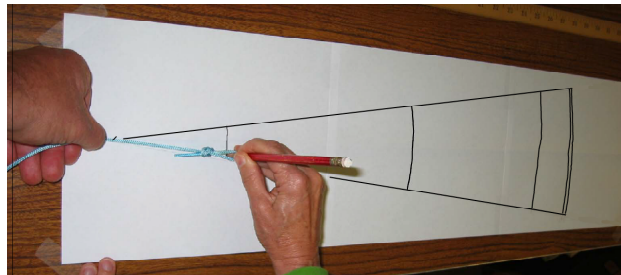
5. Since you now know the location of the surface, you can mark the depth of the layers. These measurements need to use the surface as your starting point. So.... turn your meter stick around so that the zero is now located at the surface of the earth. Mark your layer depth on one edge of your wedge only.



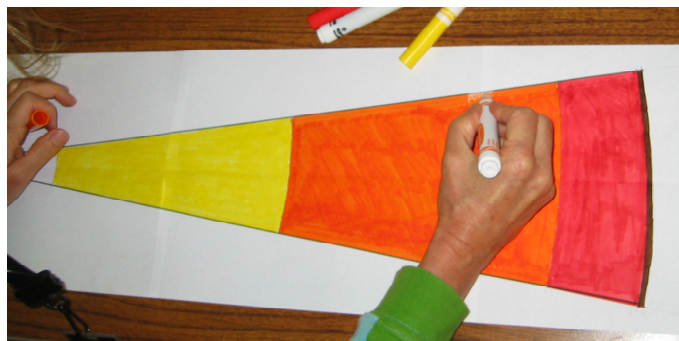
6. Your wedge represents a portion of the earth's interior and the boundary between each layer makes an arc. You need to make a simple compass out of string and a pencil.
7. Tape the paper to the table before you draw your arc.



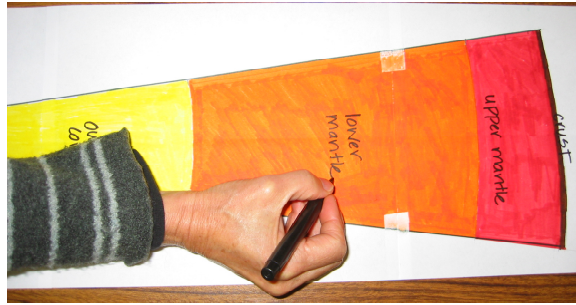
8. To extend your layer mark across the whole wedge, hold the string firmly at the dot (the vertex of the wedge). Place your pencil at the appropriate measurements for each layer. Draw the arc for each layer.



9. Now, color your layers.



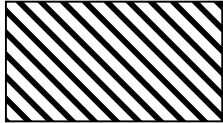
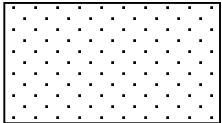
10. Now label your crust, mantle and core layers.



Part 2B

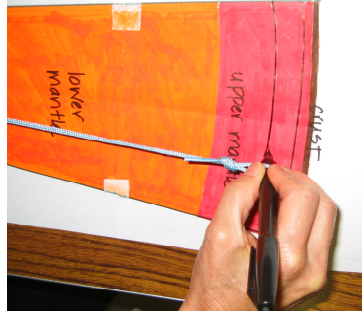
Marking details in the layers: the lithosphere and asthenosphere

1. Calculations need to be made to scale the rest of the details in your earth wedge using the same scale:
2. Students should complete the attached blank table (end of this activity). Their numbers should be checked before they continue.
3. Here is a completed data table:

Materials	Name of Layer	Average depth in Km	Scaled depth in cm	Wedge Shading
Rock	Lithosphere includes- Crust and upper-most mantle	100	1	Diagonal Lines 
Rock	Asthenosphere Upper Mantle, just below lithosphere	100 - 300	1 - 3	Dots 

4. Use the surface of the earth on your wedge to start your measurements. Starting at zero, measure toward the core to mark your new layers.

5. Use your string, just like in part 2 to draw the arcs of each layer.



6. Fill in the layers with your chosen shading pattern.

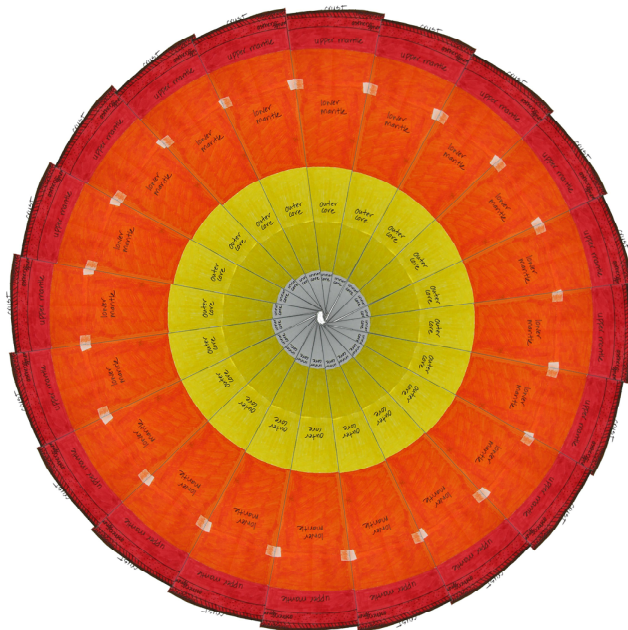
7. Label each layer.



Optional:

If every student (or student group) has made a wedge and the angles have been calculated correctly, the wedge can be mounted on a wall as a circle.

1. Add tape to the backside of your wedge.
2. Cut along the edge of your wedge.
3. Place each wedge next to each other in a circular pattern and tape the wedges next to each other.



What's going on?

Going from the core of the earth towards its surface:

The earth's inner-core is a contained sphere about 5000 km deep within the earth. Even though the temperature of the inner-core is estimated to be as hot as the surface of the Sun (~6000 Celsius degrees), the enormous pressures keep the core in a solid state (The over-laying layers of earth cause pressures in excess of 3 to 4 million atmospheres). This solid spherical core is believed to consist primarily of iron and nickel.

The outer-core, like the inner-core, is also composed primarily of iron and nickel, but unlike the inner-core, this portion of the earth is thought to be a shell of liquid metal. The fluid motions of this metallic region are theorized to be the origin of the earth's magnetic field.

The next layer is the mantle and is approximately 2900 km thick. This extends from the top of the Inner-core to the Mohorovicic discontinuity (also known as the Moho or crust-mantle boundary). This region, composed of hot dense rock, constitutes the majority of the earth's volume. The main components of this rock in order of abundance are: silicon, oxygen, iron, and magnesium.

The section closest to the core is the lower mantle. The interface between the core and the mantle is as pronounced as the earth's surface and its atmosphere. Rock at this depth is under substantial pressure and is relatively solid (30 to 100 times the viscosity of the upper-mantle).

Above the lower mantle is the upper mantle. The pressure and heat in this zone allows rock to flow in what's known as a plastic manner. The rising and cooling of hot mobile molten rock is believed to occur in this layer. This method of heat dissipation is called convection and is considered one of the possible driving forces of plate tectonics.

At the top of the upper mantle is an important layer known as the asthenosphere, an area of viscous rock that enables the lithospheric plates above to slide around.

Riding over the top of the asthenosphere, is the lithosphere. This thin layer, relatively speaking, consists of huge plates that migrate over the surface of the globe. The lower portion of this layer, though solid is still considered part of the mantle. Firmly joined above to this lower portion of plate, is the layer we live on, the crust. The crust is the thinnest, most

buoyant and brittle of all the layers. Even though scientists can't see the separation between these two connected layers, they know it exists because of changes in seismic velocities due to density. This seismic boundary is known as the Mohorovicic discontinuity.

As you progress further outward, you finally reach the surface of the crust. This surface is the earth's interface with sky, water, life and light.

Resources:

Earth Walk Activity: a walk of the earth's interior - By Eric Muller
This is a good kinesthetic activity for learning about the details of the structure of the earth's interior. Original article is from the September 1995 issue of "The Science Teacher" magazine. It can also be found at:



http://www.exo.net/~emuller/activities/earthwalk/earthwalk_total_version.pdf

Earth Anatomy Poster- by Eric Muller

This is a good resource for classroom display. The poster can be obtained from Tufts University's Wright Center for Science Education.

A downloadable version can be seen at:



http://www.tufts.edu/as/wright_center/products/svl/posters/erth.html

Larry Braile of Purdue University has a similar activity. Professor Braile's website has many earth science activities: <http://www.eas.purdue.edu/~braile/>

The full text of this activity can be found at:

<http://www.eas.purdue.edu/~braile/edmod/earthint/earthint.htm>

Inside the Earth published by the United States Geologic Survey is the definitive source of information on the geology of the earth's interior.

<http://pubs.usgs.gov/gip/dynamic/inside.html>

Data Table of composition and depth
of major Internal layers of the Earth

Materials	Name of Layer	Average depth in Km	Scaled depth in cm	Wedge Color
Rock	Crust	35		
Rock	Upper Mantle rigid	670		
Rock	Lower Mantle	2885		
Metal	Outer Core	5155		
Metal	Inner Core	6371		

Data Table of composition and depth
of upper internal layers of Earth

Materials	Name of Layer	Average depth in Km	Scaled depth in cm	Wedge Shading
Rock	Lithosphere includes- Crust and upper-most mantle	100		
Rock	Asthenosphere Upper Mantle, just below lithosphere	100 - 300		

More help with scaling the Earth's Layers:

Choosing a scale:

The radius of the earth is 6371 km. We want to “fit” a wedge that represents this distance on our three pages (whose length is approximately 1 m). What is a convenient scale for us to use? We know we can fit 63.7 cm on our page. What's the scaling factor?

Earth's actual radius:

$$6371 \text{ km} = 6.371 \times 10^3 \text{ km} \times \frac{10^3 \text{ m}}{1 \text{ km}} = 6.371 \times 10^6 \text{ m}$$

Our scaled earth radius:

$$63.71 \text{ cm} = 6.371 \times 10^1 \text{ cm} \times \frac{1 \text{ m}}{10^2 \text{ cm}} = 6.371 \times 10^{-1} \text{ m}$$

Scaling factor:

$$\frac{6.371 \times 10^6 \text{ m}}{6.371 \times 10^{-1} \text{ m}} = 10^7$$

Each 1 cm will represent 100 km. Therefore, the first measurement, the depth of the crust – which is 35 km - will be less than 1 cm on our model.