Volume of Earth's Layers

Overview:

The core of Earth consists of iron and nickel. It includes a solid inner core and a liquid outer core. As Earth rotates, the molten metals of the outer core move in a turbulent, rotating manner, creating electric currents. These currents are believed to generate Earth's magnetic field. In this way, the energy of motion is transformed into electromagnetic energy. In this activity, students calculate the volume of Earth's layers (inner core, outer core, mantle and crust) to help them conceptualize the tremendous strength of the magnetic field generated in Earth's outer core.

Objectives:

The student will:
* understand that Earth's magnetic field is generated by motion in Earth's outer core;
* calculate the volume of a sphere;
* find the volume of Earth's layers; and
* calculate the percent of Earth's volume that each of Earth's layers comprise.

Materials:

* Calculators (see "Teacher's Note" on Teacher Instructions page)
* VISUAL AID: "Earth's Layers"
* STUDENT WORKSHEET: "Volume of Earth's Layers: Part 1"
* STUDENT WORKSHEET: "Volume of Earth's Layers: Part 2"

Answers to Student Worksheets:

Volume of Earth's Layers: Part 1:

Chart Answers (may vary slightly due to rounding)
1. $9,198,106,667 \ km^3$
2. $178,109,000,000 \ km^3$
3. $936,127,000,000 \ km^3$
4. $15,748,845,840 \ km^3$

Volume of Earth's Layers: Part 2:

Chart Answers (may vary slightly due to rounding)
1. B) outer core

Volume of Earth's Layers

Activity Procedure:

1. Explain that many scientists believe that Earth's magnetic field is generated by Earth's molten outer core. Although this core comprises a relatively small percentage of the total volume of Earth, the magnetic power it generates is strong enough to pass through billions of cubic kilometers of mantle and crust, and surround Earth with magnetic field lines that extend far into space. To gain an appreciation for the strength of the magnetic forces in Earth's outer core, students will calculate the volume of each of Earth's layers, and determine the percentage that each layer represents of Earth's total volume.

2. Show the class a ball and ask students what methods they might use to find the volume of the ball or other spherical object. The formula for finding the volume of a sphere is **Volume = 4/3 π r³**.

3. Show VISUAL AID: "Earth's Layers" and ask students how to find the volume of each of Earth's layers. Explain that to find the volume of each layer, they must first determine the volume of each sphere enclosed by a layer of Earth, then subtract the volumes of Earth's smaller layers from the larger ones.

4. Distribute calculators and STUDENT WORKSHEET: "Volume of Earth's Layers: Part 1." Due to the large size of the numbers being used, the calculator on a computer may work best for this lesson. In either case, students may need to round numbers to complete this activity.

5. Explain that in this activity, students will calculate the volume of each of Earth's layers (inner core, outer core, mantle and crust). Demonstrate how to calculate the volume of Earth's inner core by using the formula **Volume = 4/3 π r³**. The radius of the inner core is 1,300 kilometers. Write the following calculation for your students:

    Volume of Inner Core = 4 ÷ 3 x 3.14 x 1,300 km x 1,300 km x 1,300 km
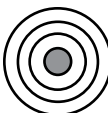   = 9,198,106,667 km³

6. Ask students to perform calculations and complete the chart on their worksheets.

7. Demonstrate how to calculate the volume of individual layers by subtracting the volume of all interior layers from the volume of the sphere formed by the layer in question. Ask students to perform calculations and complete questions 1-4 of their worksheets.

8. Distribute STUDENT WORKSHEET: "Volume of Earth's Layers: Part 2," and explain that students will calculate the percent of Earth's total volume each layer comprises. Demonstrate, then ask students to complete the chart and question on the worksheet.

9. Discuss student results. Which layer or layers comprise the least of Earth's volume? Which layer comprises most of Earth's volume? Which layer of Earth generates Earth's magnetic field?

Teacher's Note: Most handheld calculators will not accommodate the larger numbers used in this lesson. Therefore, students may use their computers to perform the calculations necessary to complete this activity.


Volume of Earth's Layers: Part 1

Directions to complete the chart: Use a calculator and the information in the chart below to find the total volume of the sphere enclosed by each of Earth's layers. The formula for finding the volume of a sphere is **Volume = 4/3 π r³**. For this activity, round π to 3.14. Record results under Total Volume. Remember to include units in each answer!

Note: If your calculator does not display numbers large enough for this activity, use your computer.

Sphere enclosed by:	Diagram	Volume of a sphere= 4/3 π r³											
		4/3			x	ϖ	x	radius	x	radius	x	radius	=	Total Volume
Inner Core		4	÷	3	x	3.14	x	1300 km	x	1300 km	x	1300 km	=	
Outer Core		4	÷	3	x	3.14	x	3550 km	x	3550 km	x	3550 km	=	
Mantle		4	÷	3	x	3.14	x	6450 km	x	6450 km	x	6450 km	=	
Crust		4	÷	3	x	3.14	x	6480 km	x	6480 km	x	6480 km	=	

Directions for calculations: Use answers from the chart above to help calculate the volume of each layer of Earth. The volume of the inner core was calculated on the first row of the chart.
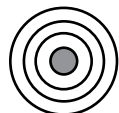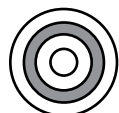
1. What is the volume of the inner core? _____
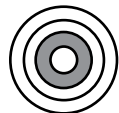
2. Calculate the volume of the outer core by completing the formula below.

   _____ - _____ = _____
   Total Volume of sphere enclosed by Outer Core   Total Volume of Inner Core   Volume of Outer Core Layer

3. Calculate the volume of the mantle by completing the formula below.

   _____ - _____ = _____
   Total Volume of sphere enclosed by Mantle   Total Volume of sphere enclosed by Outer Core   Volume of Mantle Layer
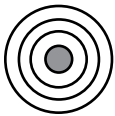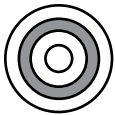
4. Calculate the volume of the crust by completing the formula below.

   _____ - _____ = _____
   Total Volume of sphere enclosed by Crust   Total Volume of sphere enclosed by Mantle   Volume of Crust Layer

Volume of Earth's Layers: Part 2

Directions: Earth's magnetic field is generated by the movement of molten iron and nickel in Earth's outer core. Although the outer core makes up a relatively small percentage of Earth's total volume, the magnetic field it generates is strong enough to pass through billions of cubic kilometers of mantle and crust, and surround Earth with magnetic field lines that stretch far into space.

Calculate the percentage of Earth's total volume each layer makes up by completing the formulas in the chart below. Information from the STUDENT WORKSHEET: "Volume of Earth's Layers: Part 1" will be needed to complete the chart below. Don't forget to answer the question at the bottom of the page!

Layer	Volume of Layer (km³)	÷	Total Volume of Earth (km³) *(see Total Volume of Sphere enclosed by Crust)*	=	% of Earth's Total Volume
Inner Core		÷		=	
Outer Core		÷		=	
Mantle		÷		=	
Crust		÷		=	

1.   What layer of Earth generates Earth's magnetic field?

   A)   Inner Core
   B)   Outer Core
   C)   Mantle
   D)   Crust