LABORATORY ONE

Observing and Measuring Earth Materials and Processes

OBJECTIVES AND ACTIVITIES

A. Know how to make a scale model of Earth, calculate its fractional scale, and use it to understand the relative proportions of Earth's physical spheres.

ACTIVITY 1.1: Basketball Model of Earth's Spheres (p. 1-7, 21-22)

B. Understand some basic principles and tools of direct and remote observation that are used by geoscientists and apply them to identify Earth materials, observe and describe processes of change, make a prediction, and describe a plan of field geology and lab work that you could use to test your prediction.

ACTIVITY 1.2: Remote Sensing of Earth and Exploring for Copper (p. 8-13, 22)

C. Measure or calculate length, area, volume, mass, and density of Earth materials using basic scientific equipment and techniques.

ACTIVITY 1.3: Measuring Earth Materials and Relationships (p. 14-16, 23-24)

D. Develop and test physical and quantitative models of isostasy based on floating wood blocks and icebergs. Then apply your quantitative model and your measurements of basalt and granite density to calculate the isostasy of average blocks of oceanic and continental crust.

ACTIVITY 1.4: Density, Gravity, and Isostasy (p. 17-18, 25-26)

E. Analyze Earth's global topography in relation to your work and a hypsographic curve, and infer how Earth's global topography may be related to isostasy.

ACTIVITY 1.5: Isostasy and Earth's Global Topography (p. 18-20, 27-29)

STUDENT MATERIALS (Remind students to bring items you check below.)

_____ laboratory manual
_____ laboratory notebook
_____ pencil with eraser
_____ metric ruler (cut from GeoTools sheet 1 or 2)
_____ calculator
_____ blue pencil or pen

INSTRUCTOR MATERIALS **(Check off items you will need to provide.)**

ACTIVITY 1.1: Basketball Model of Earth's Spheres (p. 1-7, 21-22):
_____ drafting compasses (one per student)
_____ extra metric rulers (for students who forgot them)
_____ extra blue pencils (for students who forgot them)

ACTIVITY 1.2: Remote Sensing of Earth and Exploring for Copper (p. 8-13, 22):
_____ extra metric rulers (for students who forgot them)

ACTIVITY 1.3: Measuring Earth Materials and Relationships (p. 14-16, 23-24):
_____ extra metric rulers (for students who forgot them)
_____ small (10 mL) graduated cylinders (one per group of students)
_____ waterproof modeling clay (at least 1 cubic cm. per student)
_____ gram balance (one per group of students)
_____ wash bottle or dropper bottle, filled with water (one per group)
_____ paper towels to clean up spills

ACTIVITY 1.4: Density, Gravity, and Isostasy (p. 17-18, 25-26):
_____ extra metric rulers (for students who forgot them)
_____ gram balance
_____ wood blocks about 8 cm x 10 cm x 4 cm. **Do not use cubes** because they float diagonally. Pieces of pine 2 x 4 studs work well. For variety, give some groups pine and others a more dense wood like walnut (one block per group of students).
_____ small bucket or plastic basin of water to float wood block (one per group of students)
_____ paper towels to clean up spills

ACTIVITY 1.5: Isostasy and Earth's Global Topography (p. 18-20, 27-29):
_____ large (500 mL) graduated cylinders (one per group of students)
_____ pieces of basalt and granite that will fit into the large graduated cylinders (one piece of each per group of students)
_____ gram balance
_____ wash bottle filled with water or dropper (one per group)
_____ paper towels to clean up spills

INSTRUCTOR NOTES AND REFERENCES

1. Refer to Laboratory 1 on the Internet site at http://www.prenhall.com/agi for additional information and links related to all parts of this laboratory.

2. Metric and International System of Units (SI): refer to laboratory manual page x.

3. Mathematical conversions: refer to laboratory manual page xi.

4. In Activity 4 of this laboratory, students explore the isostasy of a floating wood block. You can make this more of a real-world inquiry by providing students with two or more densities of wood. For example, pine and walnut work well because students can easily see that the pine blocks float higher than the walnut blocks. This makes it easier for students to conceptualize how isostatic differences between granitic and basaltic blocks may explain Earth's hypsographic curve.

5. Hydrous minerals of Earth's Mantle. Hydrous minerals include not only the obviously hydrous minerals like gypsum, but also minerals like amphibole and pyroxene that are "nominally hydrous" (actually hydrous even though they are generally regarded as anhydrous). See David R. Bell and George R. Rossman's 1992 paper on this (*Science*, v. 255, p. 1391–1397). Shortly after the *Science* article was published, *Science News* quoted Bell and Rossman as estimating that the mantle may contain a volume of water equal to 80% of the volume of the world's oceans. Even if this Bell and Rossman estimate of mantle water seems high, one must still account for the hydrous and nominally hydrous minerals in Earth's crust. Therefore, having students assume that the solid Earth may contain water equal to 80% of the volume of the world's oceans may be a conservative estimate.

   For information on recycling of water into Earth's mantle, refer to: C. Meade and R. Jeanloz. 1991. Deep-focus earthquakes and recycling of water into Earth's mantle. *Science* 252:68–72.

ACTIVITY 1.1 ANSWERS AND EXPLANATIONS

1.1A. See completed basketball model on next page**.** Students should realize that it is nearly impossible for them to draw separate lines for hydrosphere and atmosphere (because they are so narrow compared to the diameter of the basketball. Crust will be about the thickness of a pencil/pen line. You could have students use another color of pencil for crust (i.e., as done in red on the completed model on the next page).

1.1B. Have students refer to manual page 7 for help. The radius of the basketball model is 0.119m (119 mm) but the actual radius of Earth is 6,371,000 m, so the ratio scale of model to actual Earth is 0.119 to 6,371,000. Dividing 6,371,000 by 0.119 reduces the ratio scale to 1: 53,537,815. Thus, the basketball model is 1/53,537,815th of the actual size of Earth.

Fractional scale: 1/53,537,815 **Ratio scale**: 1:53,537,815

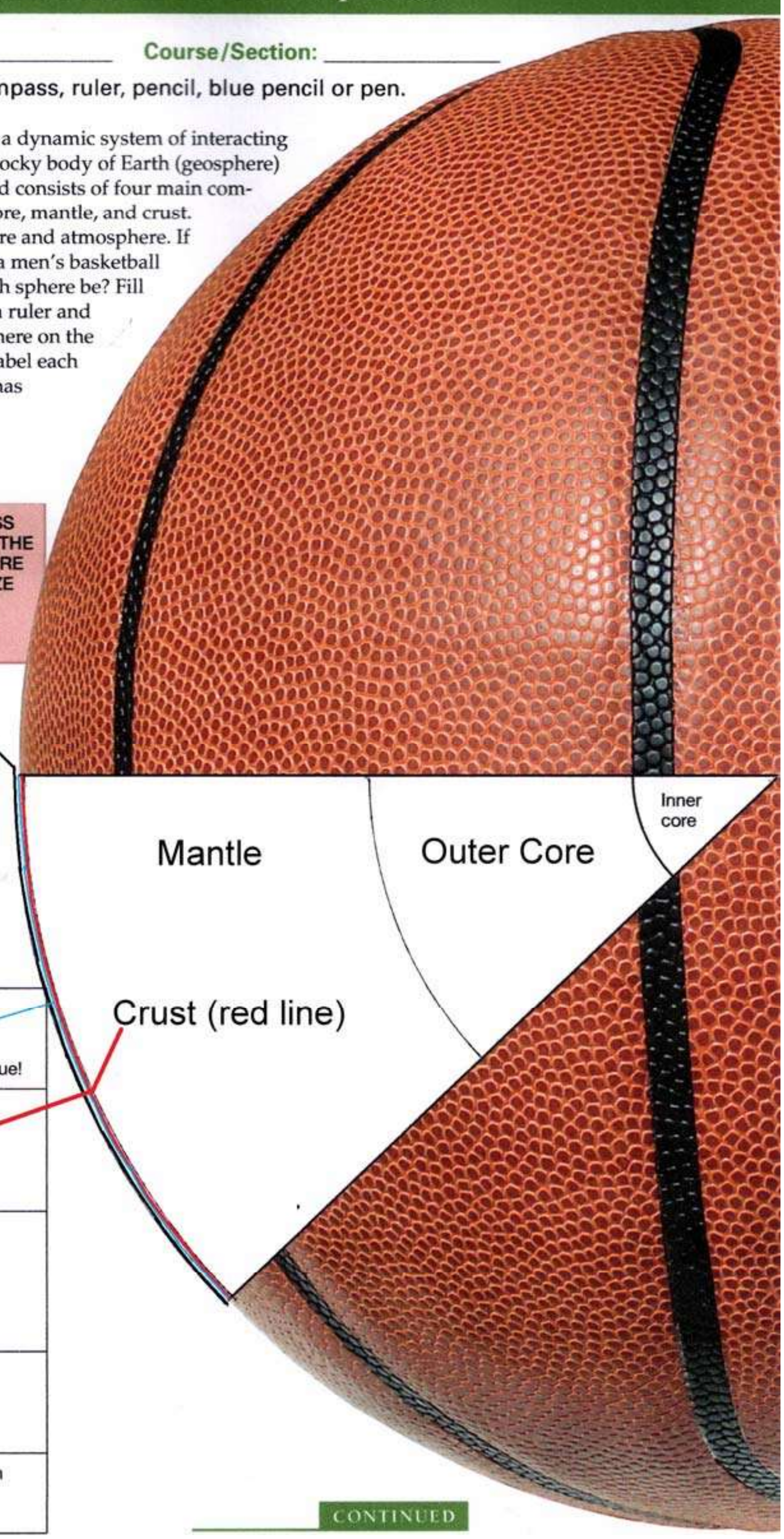
ACTIVITY 1.1 Basketball Model of Earth's Spheres

Name: ______________________ **Course/Section:** ______________

Materials: Calculator, drafting compass, ruler, pencil, blue pencil or pen.

A. Geoscientists conceptualize Earth as a dynamic system of interacting material spheres (subsystems). The rocky body of Earth (geosphere) has an average radius of 6371 km and consists of four main compositional layers: inner core, outer core, mantle, and crust. These are overlain by the hydrosphere and atmosphere. If Earth's geosphere had the radius of a men's basketball (119 mm), then how thick would each sphere be? Fill in the chart below, then draw (with a ruler and drafting compass) and label each sphere on the pie-shaped slice of this basketball. Label each sphere. For example, the inner core has already been done.

SPHERE	ACTUAL THICK-NESS	THICKNESS IN MM, IF THE GEOSPHERE IS THE SIZE OF A BASKET-BALL
Atmosphere: mostly nitrogen (N), oxygen (O), and argon (Ar) gases in air. Nearly all of the materials in air occur in a sphere just 16 km (10 mi) thick (troposphere). "Space" (no air) begins about 1000 km above sea level.	16 km	0.3
Hydrosphere: mostly water (H_2O, ocean) in a liquid state.	3.7 km	0.07 Draw in blue!
Crust: mostly oxygen (O), silicon (Si), aluminum (Al), and iron (Fe).	25 km	0.47
Mantle: mostly oxygen (O), silicon (Si), magnesium (Mg), and iron (Fe) in a solid state.	2900 km	54.2
Outer Core: mostly iron (Fe) and nickel (Ni) in a liquid state.	2250 km	42.0
Inner Core: mostly iron (Fe) in a solid state	1196 km	22.3 mm



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ACTIVITY 1.2 ANSWERS AND EXPLANATIONS

1.2A. Analysis of Figure 1.9, an astronaut's photograph and MODIS satellite image of the eruption of Sicily's Mt. Etna in the Mediterranean Sea in 2002.

1. Students should observe that some vents are erupting plumes of white material while others are erupting brown material. The white material is likely **steam or hot volcanic gases**. the brown material is likely **volcanic ash** (rock particles).

2. Using the graphic bar scale on the color reference map, students will estimate that the extruded brown material (volcanic ash, rock particles) has traveled 500 to 700 miles. It will land on Africa and parts of the Mediterranean Sea.

3. How did this eruption affect the atmosphere and hydrosphere?

Effects on the atmosphere:

- Water, carbon dioxide, and other gases are added to the atmosphere.
- Rock particles/dust/ash are added to the atmosphere.
- Carbon dioxide and sulfur dioxide can mix with water vapor in the atmosphere to make acid rain (rain with carbonic and sulfuric acid).
- Volcanic gases and rock particles form clouds in the atmosphere, preventing sunlight from reaching Earth's surface.

Effects on the hydrosphere:

- Water from inside Earth has been cycled to Earth's surface.
- Volcanic gases like carbon dioxide and sulfur dioxide lead to acid rain (rain abnormally rich in carbonic and sulfuric acid), which falls to Earth and acidifies lakes and streams.
- Parts of the ocean may be clouded with fallen rock particles/dust/ash.

1.2B. Analysis of Figure 1.10, true and false colored ASTER images of Chile's Escondida Mine and vicinity. This is primarily a copper mine, but it also produces some silver and gold. The copper ore is mined from large open pits. Notice how these pits appear in the images.

1. Location C. The existing pits are a bright pink color in the false-color image, and location C has that color. Locations A and B are green in the false-color image.

2. Plan of investigation for location C:

- Go to location C and collect rock samples (field work).
- Analyze the rock samples from location C to see if they contain copper ore (as in manual Figure 1.7).