



8A Topographic Mapping

How do you make a topographic map from a 3-dimensional surface?

Topography is the shape of the surface of an area and includes the elevations of land formations like mountains. The topography of a region is represented by a topographic map.

A topographic map is the two-dimensional representation of a three-dimensional land surface. Scientists use these types of maps to understand the effects of geologic processes on Earth's surface. Topographic maps show the difference in elevation through the use of contours. Contour lines connect points of equal elevation. Contour lines are drawn at specific intervals known as the contour interval. Once the contour lines are present, details are added to show land use using standard mapping symbols.

In this investigation, you will use a model land surface to make a contour map.

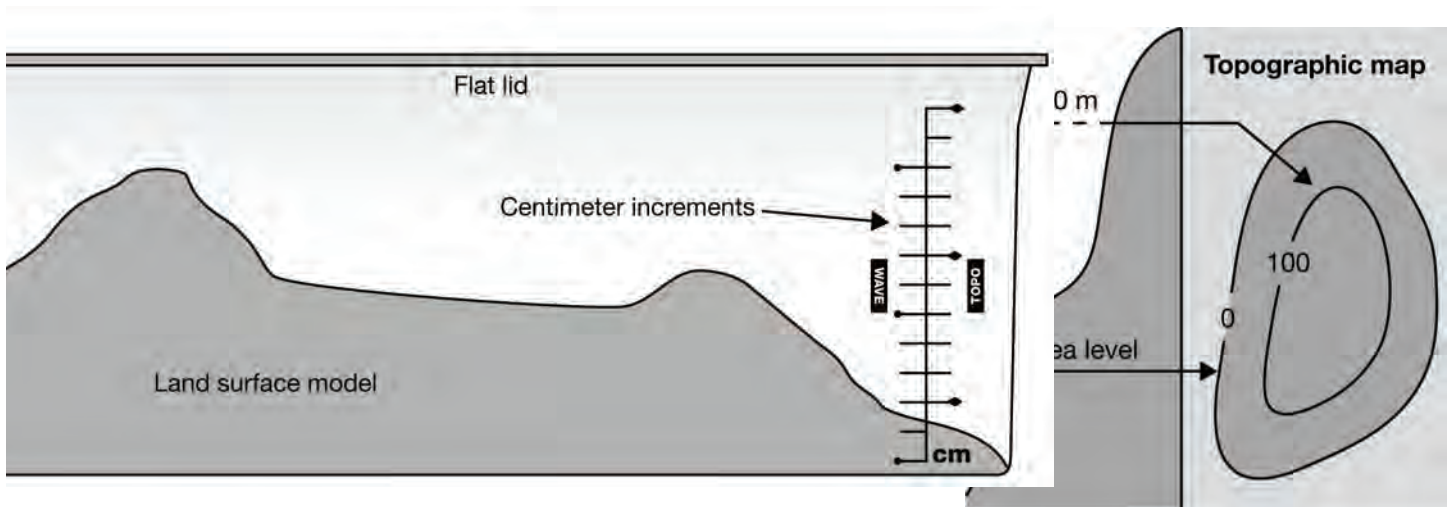
Materials

- GeoBox with the topo form (white land surface model) and topo lid (the flat lid)
- Container to hold water (or use a bucket from the stream table)
- Beaker to transfer water between containers
- Overhead projector markers (thin)
- Pencil
- Colored pencils
- Tracing paper
- Water colored with food coloring
- A metric ruler

1 Making a topographic map

1. Note that the GeoBox has a sticker on the side. Each mark on this sticker represents one centimeter. Pour water into the GeoBox up to the first centimeter line.
2. Place the topo lid on the GeoBox. Stand over the GeoBox so that you are looking down on the topo form. With the overhead projector marker, outline the perimeter of the land surface onto the lid. This will be considered “sea level,” or the 0 meter contour line.
3. Now, using your marker, number each centimeter above sea level. Use the sketch below to help you with this step.
4. Remove the topo lid and add water until the water level reaches the 1-centimeter mark. Replace the lid. Trace the “coastline,” the line along which the water and land

meet, onto the lid. All points on this line are 1 cm above sea level. They form a contour line, a line of equal elevation.



5. Add water to the level of the 2-centimeter mark. Replace the lid and again, trace the “coastline.” All points on this line are 2 centimeters above sea level.
6. Continue this procedure until the topo form is covered with water.
7. Now you have a contour map of your land surface. Use the tracing paper to trace what is on the lid. Each partner makes his/her own contour map. The elevation for each contour represents 100 meters. Draw the contours as solid lines. Indicate the elevation as shown in the graphic at right.

2 Labeling your map

1. Each partner will now finish his/her own map, which is now on tracing paper. Add details showing land-use using the USGS topographic map symbols (see next page). Make sure the following features are on your map. With your group or with the whole class, define any terms you do not understand.
 - Geographic north
 - A contour interval
 - A graphical scale
 - A verbal scale
 - A numerical scale
 - A river
 - A depression
 - An airport
2. Color in areas on your map where appropriate. Water is shown in blue. Densely populated areas are shown in gray or pink. Wooded areas are in green and open areas in white. Individual buildings are solid black shapes.
3. When your group is finished, write a title on your map. Also, write your name or your group’s name on the map.



3 Thinking about what you observed

- a. What is the direction that your river is flowing? _____
- b. What is the difference in elevation between the start and end of the river?

- c. What is the overall total change in elevation in your map? _____
- d. What is the highest elevation in your map? _____
- e. By looking at your map, what area is the steepest? *Remember: Look at the contours to see how close or far away they are from each other.*

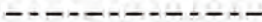
4 Exploring on your own

1. Obtain a topographic map of your local area. See if you can find where you live and some of the landmarks around you.
2. Besides scientists, who might be interested in a contour map? Why would it be useful to those people?

3. See if you can find out where the closest benchmark is in your local area. A benchmark is a place where the exact elevation is known. A marker is placed in the ground at that spot. There is an **X** on the marker with the exact elevation inscribed in it. (Hint: Benchmarks are noted on topographic maps.)

Topographic Map Symbols

Boundaries

City 

Small Park 

Buildings and related features


Building 

School 

Athletic field 


Forest headquarters 

Airport 

Well (other than water), windmill or wind generator 

Picnic area 

Campground 

Winter recreation area 

Contours

Contour line 

Depression 

River mileage marker 


Railroads

Railroad, single track 

Railroad, multiple track 


Rivers, lakes and canals


Perennial river 

Perennial lake/pond 

Roads and related features

Primary highway 

Secondary highway 

Trail 


Highway or road with median strip 

Vegetation

Woodland 

Shrubland 

Orchard 

Vineyard 

U.S. Geological Survey used in compiling this information.



8B Bathymetry of the Sea Floor

How can we tell what kinds of features are on the sea floor?

Did you know that about three quarters of the surface of Earth is covered by water? People have used boats and ships to travel all over the oceans for hundreds, if not thousands of years. During most of this time nobody really knew what was beneath the surface of the ocean. Today we have detailed maps of the ocean bottom. Bathymetry is the mapping of the ocean bottom. In this investigation, you will learn how scientists have been able to find out what kinds of features are deep down on the sea floor.

Materials

- Blindfold
- Graph paper
- colored pencils (red, orange, yellow, green, blue, purple, brown, and black)
- pencil sharpener
- Side view depth diagrams A-H

Dolphins use sound waves to navigate, hunt, and visualize their surroundings. They make a series of clicking sounds and wait for the echoes of those sounds to return. This is called echolocation. The direction and volume of the echoes gives the dolphin an idea of what is in their general area. Let's find out what it might be like to be a dolphin and use echolocation.

1 Setting up

1. Clear an area in your classroom that is big enough for everyone in your class to stand in a large circle. You could also use a large open space like a gym, or even a field outside as well.
2. Your teacher will select one person to be the dolphin.
3. Your teacher will select three people to be fish.
4. Your teacher will select two people to be squid.
5. Your teacher will select one person to be a shark.
6. The remaining students will stand in a circle, and gently guide the dolphin back to the middle of the circle if he or she gets to the edge.

2 Doing the activity

1. The dolphin in this activity will wear a blindfold.
2. The dolphin will say "click!" every few seconds. When the dolphin says "click", the fish have to respond by saying "fish", the squid reply by saying "squid", and the shark responds by saying "shark". The replies represent the dolphin's clicks echoing back to the dolphin.
3. The shark swims randomly around the circle. The fish must stay together in a school as they swim around in the circle, by walking together with baby steps. The fishes and the shark must always swim forward at all times. They may not move backwards or stop. The squid can swim around in any direction, stop, and move backwards. The squid and the shark should move at a regular walking speed as they swim around.
4. The dolphin tries to capture his prey, the fish and the squid, and avoid his predator, the shark. The dolphin can stop swimming, but not move backwards.

5. The dolphin captures his prey by tagging them lightly when it sounds like they are near, using echolocation.
6. The dolphin must avoid the shark. If the dolphin bumps into the shark, someone else gets to be the dolphin.
7. The game is over when the dolphin catches all the fishes and both squid.

3 Thinking about what you observed

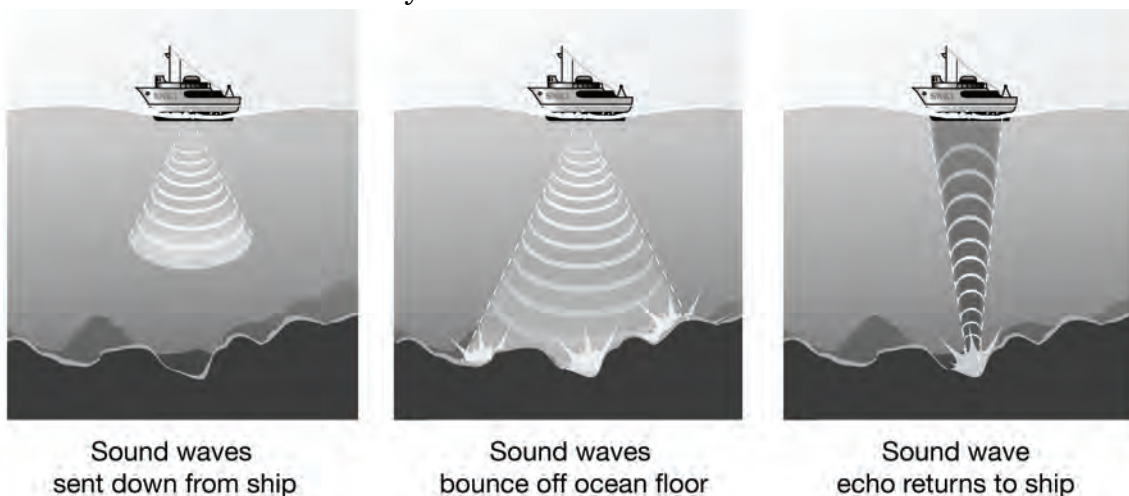
a. How did the dolphin know where the fishes, squid, and shark were?

b. When a dolphin makes clicking noises under water, how do you think it can tell the difference between a fish and a shark?

c. Why do you think scientists call this process echolocation?

4 Man-made echolocation

In the early 1900's, scientists and engineers tried to use sound waves to measure the depth of the ocean. Sound travels about 340 m/sec in air. That's pretty fast! But in saltwater it travels even faster, about 1500 m/sec. Ships carry devices that use sound waves and echoes in a system called SONAR. SONAR devices send out bursts of sound waves, and then listen for the echoes of the sound waves when they bounce back off the bottom of the ocean.



**5 Stop and think**

- a. How fast does sound travel through saltwater?

- b. In saltwater, how far would a sound wave travel in 1 second? In 2 seconds? In 3 seconds? How about 10 seconds?

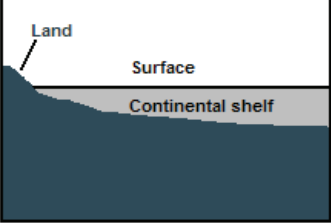
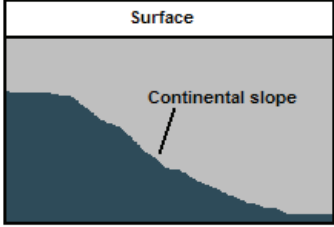
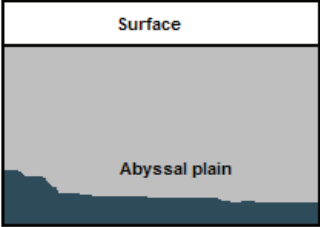
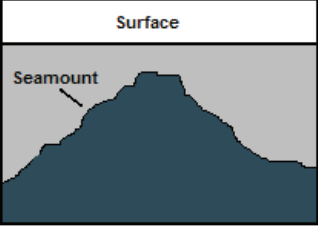
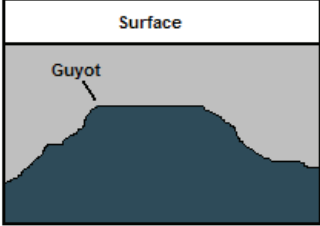
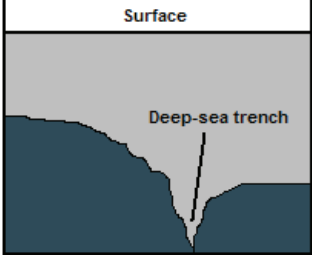
- c. What is the relationship of the depth of the water to the total distance the sound wave travels?

- d. When you find out how far a sound wave has traveled, how can you tell how deep the water is?

6 What's down there?

The use of SONAR has helped identify many different features and regions of the ocean bottom that can not be seen from the surface. These features have distinctive variations in their shapes and locations.

Table 1: Features and regions of the ocean bottom

<p>Continental shelf</p>  <p>A submerged border of a continent that slopes gradually and extends to a point of steeper descent to the ocean</p>	<p>Continental slope</p>  <p>The transitional area between the continental shelf and abyssal plain</p>	<p>Abyssal plain</p>  <p>The flat, deep ocean floor. It is almost featureless because a thick layer of sediment covers the hills and valleys.</p>
<p>Seamount</p>  <p>A mountain rising from the ocean seafloor that does not reach to the water's surface.</p>	<p>Guyot</p>  <p>A flat topped seamount that shows signs of being above the water's surface in the past.</p>	<p>Deep-sea trench</p>  <p>A long, narrow depression of the deep-sea floor having steep sides. The deepest part of the ocean</p>

7 Stop and think

- a. How could you use the information a SONAR system provides to identify the kinds of ocean bottom features and regions in Table 1?

- b. What is a seamount that rises above the surface of the ocean called? _____

- c. What do you think causes the flattened top of a guyot?

- d. If you were taking SONAR measurements, how would you know that there was a deep-sea trench beneath your ship on the ocean bottom?



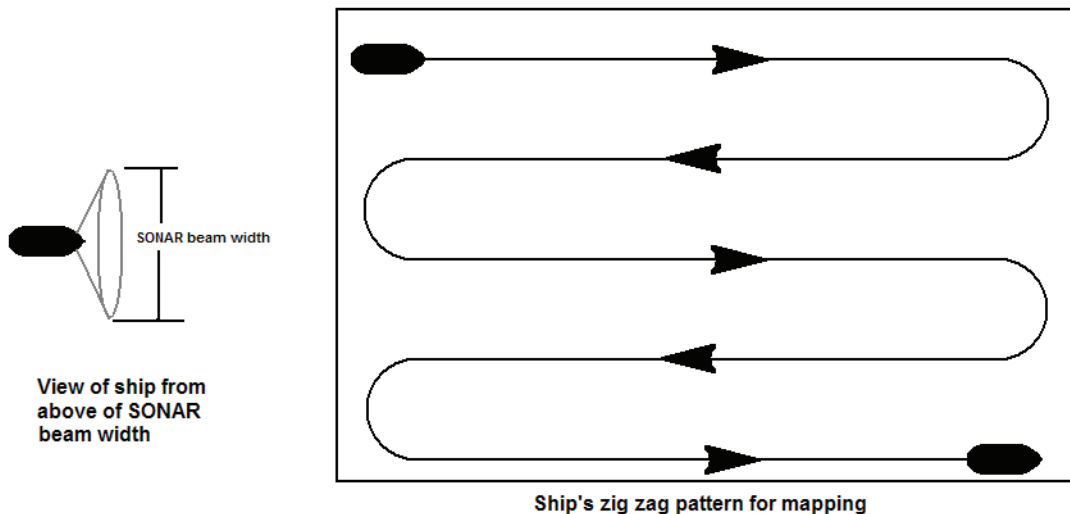
e. How would you know you were going over a seamount?

f. What would happen to your SONAR readings as your ship went from the continental shelf into the continental slope?

8 Mapping the ocean bottom

To make a map of the ocean bottom, ships have to travel back and forth in a zig-zag pattern over large areas and take readings from their SONAR equipment all along the way. The sound waves spread out to the side of the boat, so each pass the boat makes can measure depth and indicate features in a wide swath. The beam's width depends on the kind of SONAR equipment the ship has and the depth of the water.

Table 2: Beam width and a zig-zag mapping pattern

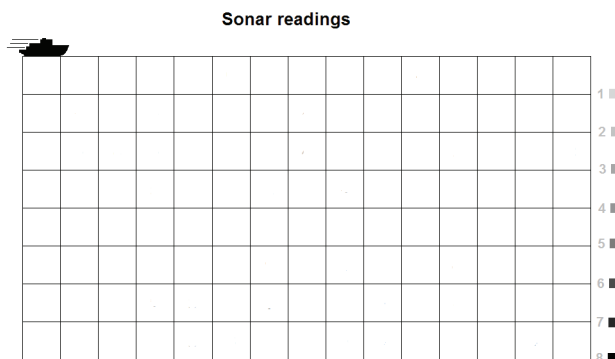


a. Why do you think a ship follows a zig-zag pattern?

b. How does the width of a ship's SONAR beam affect how many zigs and zags the ship needs to make to get a complete map of an area of the ocean bottom?

9 Readings and depth

1. Your group will be in charge of one set of readings made on a SONAR mapping expedition. You will be given one part (a zig or a zag) of the entire map.
2. The readings indicate how many seconds a SONAR reading took to return to the ship.
3. Your group's task is to create a side view of the terrain under your ship based on the data collected on one pass over part of the whole area.
4. Your teacher will give you a side view depth diagram for your group. Each SONAR reading tells you how long the sound took to return to the ship at that location.
5. Mark the depth of the water based on how many seconds the SONAR sound wave took to return to the ship.
6. The depth will be color coded. Mark each depth according to the color indicated on the depth readout diagram.



10 Making a bathymetric map from your readings

1. Each group will have a completed color coded side view depth diagram.
2. Your class will make a color coded bathymetric map based on the diagrams produced by all groups.
3. Each group will transfer their color coded depth information, from their side view diagram onto the bathymetric map grid, an overhead view of the area.
4. Once all the groups have transferred their color coded depth information, the bathymetric map is complete.

11 Thinking about your observations

- a. What kind of information does your color coded bathymetric map tell you?

- b. The readings on your side view depth diagram indicated how many seconds the SONAR signal took to return to the ship. How would you turn this information into actual depth readings?



- c. Convert each color into the actual depth it represents on your bathymetric map.

Table 3: Finding the depth of water based on sound travel time

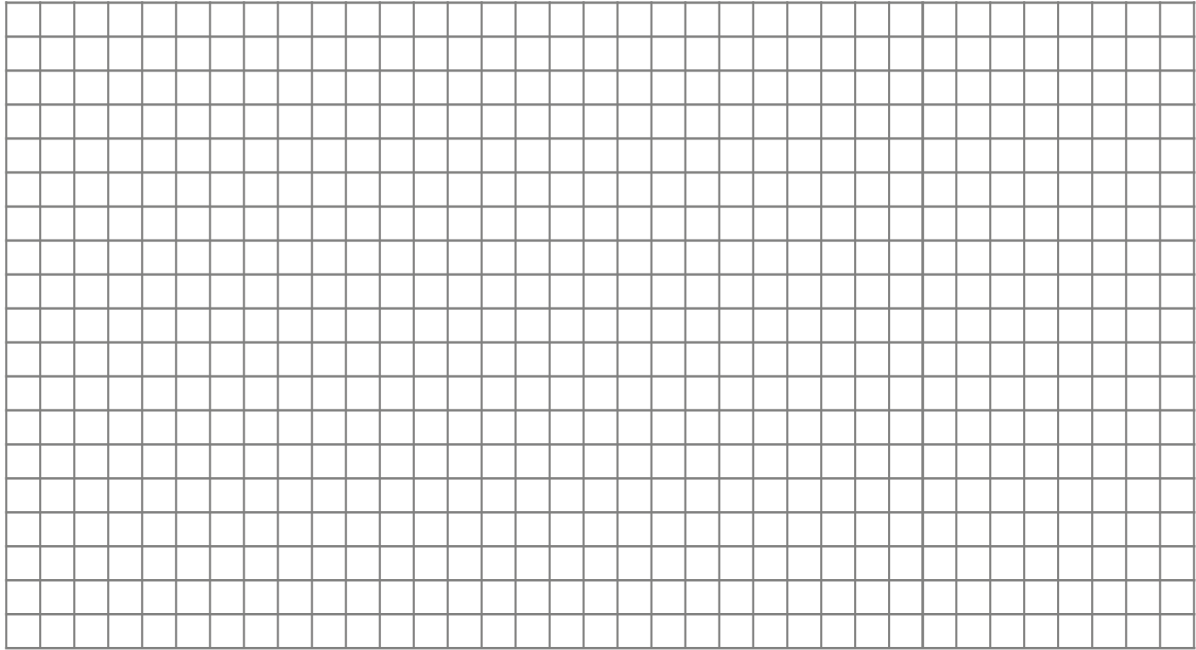
Color	Time sound took to echo off ocean bottom (seconds)	Speed of sound in salt water (m/sec)	Total distance sound traveled (m)	Depth of water (m)
red	1	1500		
orange	2	1500		
yellow	3	1500		
green	4	1500		
blue	5	1500		
purple	6	1500		
brown	7	1500		
black	8	1500		

- d. Using information from part 6 of this investigation, what kind of features can you identify on your color coded bathymetric map?

- e. Use a piece of graph paper to make your own small color coded bathymetric map that shows a seamount, a guyot, and a deep sea trench.

Title: _____

y label: _____



x label: _____

- f. **Challenge:** How could you use the information represented by different colors to add contour lines to your bathymetric map?



12 Exploring on your own

a. What does SONAR actually stand for?

b. Near the coast we sometimes see the bottom of the ocean. In deep water, how far does visible light penetrate down into the water? What are the different zones associated with light in the ocean?

c. Research: Who was Marie Tharp and what major project did she help accomplish before anyone else?

d. Research: What other animals use echolocation?



9A Time and Tree Rings

Do tree rings tell a story?

If you look at the cross-section of a tree, you will see tree rings. Tree rings tell a story about the growing conditions of the tree. The number of rings that a tree has equals its age.

Careful examination of tree rings can give detailed information about the age of a piece of wood and the growing conditions a tree experienced during its life time. Scientists compare tree rings to a catalog of tree ring history to figure out the age of certain wooden objects like old ships, log cabins, and archeological artifacts. In this investigation, you will determine the age and growing conditions of several samples of wood by examining tree rings and tree core samples yourself.

Materials

- Microscope slide of a tree cross-section
- Tree cross section
- Pencil
- 7 paper strips representing tree cores, a set of 4 and a set of 3 (included as a graphic in the lab)
- Two blank pieces of paper
- Graph paper
- Scissors
- Tape
- Ruler
- Colored pencils
- Magnifying lens

1 How do trees grow?

Each year, a tree gets larger by one ring. It is easy to count tree rings because each ring has a light and a dark band.

Tree rings (and the individual light and dark bands) vary in width depending on the growing climate. Wet, warm years allow for more growth than cool, dry years. A wide ring means the tree grew during a wet year. A narrow ring band means the tree grew during a cool, dry year.

- Look at the microscope slide of the tree cross-section. Use the magnifying lens to help you see the details. Write a short paragraph describing what you see.



- You will see small holes in the tree cross-section. What are these holes? Come up with a hypothesis that answers this question.

- Looking at the slide with your eyes, how many tree rings do you see? _____

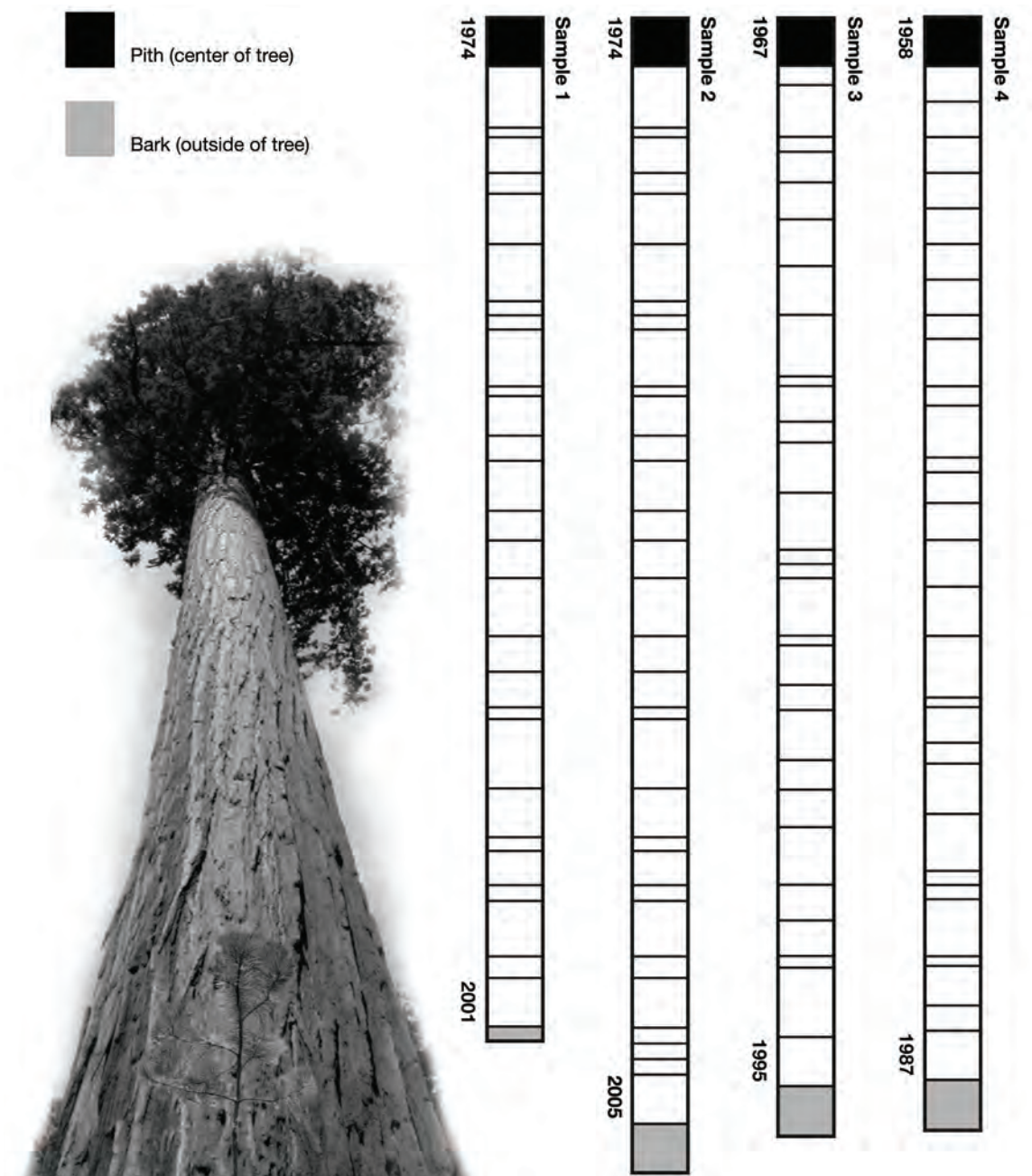
2 Investigating tree rings

1. Tree cross-section:

Now, look at the tree cross-section. Use a magnifying lens to help you see the rings. Notice the width of the bands. Look at the bark and the pith. See if you can figure out the age of the tree. Remember that one ring (one year's growth) includes a light band and a dark band. Discuss what you see with your group. *NOTE: The pith and bark are not counted in determining the age of a sample. The youngest wood is under the bark.*

2. Tree cores:

Cut out the four paper strips on the next page. The strips represent tree cores from four different trees. The trees are the same species and grew in the same woodland.





- Determine the age of each tree by counting the rings (one ring includes a wide light band and dark line). Record your answers in Table 1.

Table 1: Tree core data

Sample	Age of Tree	Year Cut or Cored	Year Growth Began
1			
2			
3			
4			

- Look for patterns in the rings. Line up all the samples by matching the patterns before taping them onto a blank piece of paper. Color the overlapping sections so you don't lose track. Figure out the age of each tree and record this information, and the years that the trees began growing and were cut in Table 1.
Note: These matching patterns indicate the trees grew in the same woodland and help prove what the climate was like in the past for an area.
- More tree cores:**
Now look at the three new tree cores (see next page). Write down the age of each core. Then, cut out the paper strips and line them up.

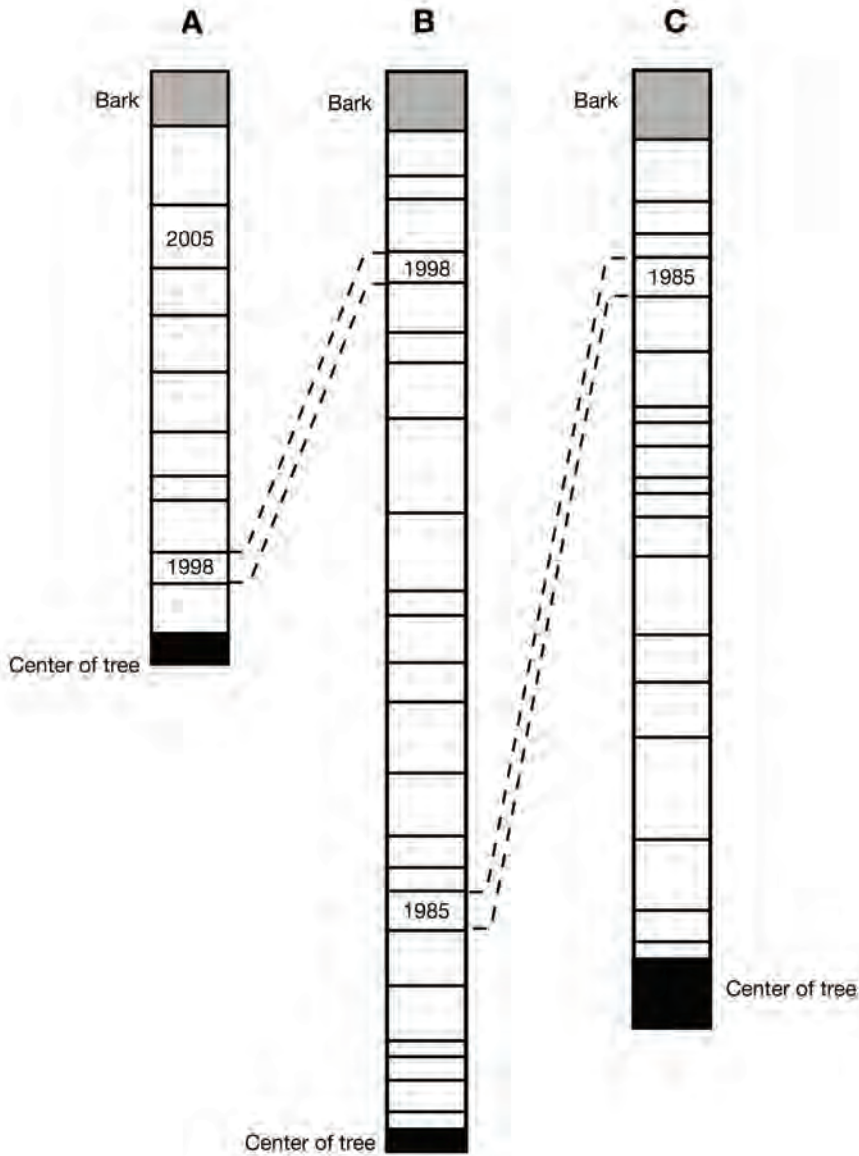
6. Use the information for the age of each core to figure out the width of the ring for each year listed below. Two years have already been done for you: 2006 and 2005. Measure the width of each tree ring for each core sample, and record them in Table 2.

Table 2: Tree core data

Year	Tree ring width (mm)	Year	Tree ring width (mm)	Year	Tree ring width (mm)
2006	10 mm	1993		1990	
2005	8 mm	1992		1979	
2004		1991		1978	
2003		1990		1977	
2002		1989		1976	
2001		1988		1975	
2000		1987		1974	
1999		1986		1973	
1998		1985		1972	
1997		1984		1971	
1996		1983		1970	
1995		1982			
1994		1991			



7. Make a graph of this tree core data. Plot the ring-width data (on the y -axis) against time (on the x -axis). One ring includes a wide light band and dark line. Label the graph appropriately.



3 Thinking about what you observed

The set of four ring cores:

- a. What kind of growing season existed for the first four cores in 1967? How can you tell?

- b. If poor tree growth is mainly caused by drought, which years were probably drought years? How can you tell?

- c. Did this woodland have more years of drought or plentiful rainfall? _____

- d. Why might a climatologist be interested in tree ring data from this woodland?

The set of three ring cores:

- a. What does your graph show about the three cores (A, B, and C) and the climate?

4 Exploring on your own

- a. Global warming (caused by an increase of carbon dioxide in the atmosphere) is a current environmental topic that concerns scientists. The result of global warming is an increase in Earth's average temperature. Due to global warming, what differences would you expect to see between tree rings of today and tree rings in the future (100 years from now)?



b. What factors can influence the growth of trees? List all the factors you can think of.

c. Trees are like the history books of a forest. But, what other objects in nature can we observe and measure to tell us something about certain environments? You may want to go to an outdoor location to brainstorm answers to this question.

d. What is a dendrochronologist and what does one do?



9B Sedimentary Rocks and Relative Dating

What can sedimentary rock tell us about its age?

Sedimentary rocks are formed from the compaction and cementation of separate particles called sediment. Sediment can consist of materials such as sand, clay, silt, pebbles, and gravel.

As time passes, sediment that is weathered from rock and/or eroded from the land gets deposited somewhere else. In certain environments, where weathering and erosion are slow, layers of sediment can build up faster than they are removed.

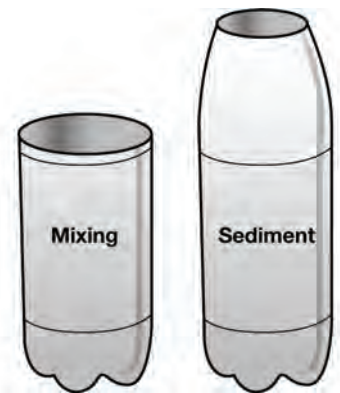
In this investigation, you will model the formation of sedimentary rock, observing how sediment size plays a part in its development, and gain an understanding of how scientists are able to place events in the sequence that they occurred, using these rock layers.

Materials

- Two 1-liter plastic soda bottles (labels removed)
- Scissors
- Permanent marker
- Soil mixture (one part topsoil to one part sand)
- Newspaper
- Beaker
- Metric ruler
- Spoon

1 Setting up

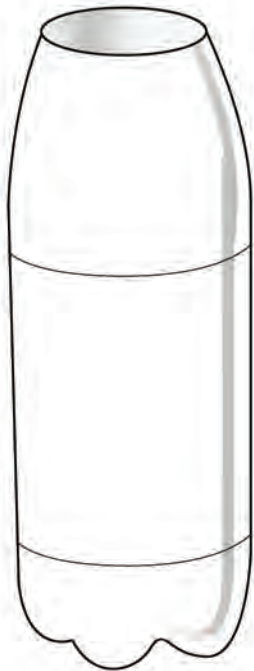
1. Gather the items needed for this investigation. Cover your work area with newspaper. At the end of the investigation, you can wrap up the newspaper and throw it away to ease your clean-up.
2. Ask your teacher to make a slit in your first plastic bottle just below the bottle's shoulder. Then use your scissors to cut all the way around the bottle. You should have an open cylinder with straight sides. This bottle will be used for mixing.
3. Your teacher should make a slit in the second bottle just above the shoulder. Then use your scissors to cut all the way around this bottle. It will be used for holding your sediments. See the diagram to the right before you cut your bottles.
4. Label the first bottle "mixing" and the second bottle "sediment."
5. Add water to the sediment bottle to a depth of five centimeters.
6. Add the soil mixture to the mixing bottle to a depth of three centimeters.
7. Add water carefully into the mixing bottle and mix it to make a "mud slurry." Add just enough water to make it the thickness of a thick milk shake.
8. Pour your mud slurry into the sediment bottle and mix it into the water.
9. Allow the sediment bottle to stand undisturbed for two minutes or until you can see layers forming.



2 Stop and think

- Once you see layers in the sediment bottle, make a sketch of the layers in the first bottle below, labeled "first slurry". Be sure to draw and label the following in your diagram: floating debris, fine particles, and coarse particles.
- Where in your bottle did you find the coarsest sediment? Where is the finest sediment?

- Is there a change in color from bottom to top? Explain why or why not?



First slurry



Second slurry



Third slurry



Fourth slurry

3 Doing the experiment

- Now you will be adding more sedimentary layers to your bottle. The procedure is slightly different than the first trial.
- Examine the water level in your sediment bottle. You need only five centimeters of water over the settled slurry. Carefully pour off excess water into a wastewater container.
- Add 1 centimeter of sediment to the mixing bottle. Then, add water until the new mud slurry is much thinner than the first slurry you made.



4. Have one of your team members continuously stir the slurry for twenty seconds. Do the next two steps quickly.
5. Pull your spoon through the water in the sediment bottle just over the surface of the settled slurry, a little off-center.
6. Immediately add the new slurry to the sediment bottle while the water is still swirling.
7. After two minutes, sketch the layers you see. Use the bottle diagram labeled “second slurry”. Pay special attention to thickness, sediment size, and the angle in which layers formed (i.e. slanted, straight across, etc.).
8. Repeat steps 2 through 7 until you have added three slurries to the original for a total of four slurries added to the sediment bottle. Stop the process if your sediment bottle gets too full.

4 Thinking about what you observed

a. Wipe off the sides of your bottle. Carefully examine the sediment in your bottle. Is each slurry you made represented by a distinct layer? If so how many layers do you see?

b. Are the sedimentary layers in your bottle the same thickness?

c. Which size sediments settled into the bottle faster: larger or small particles? Explain your answer.

d. What will happen to your sedimentary layers when the water evaporates?

e. What kinds of environment/s would cause sediment layers to be deposited over time on top of each other?

5 Exploring further

- a. Label the sedimentary layers in your sketch from oldest to youngest. How do you think geologists can figure out the age of sedimentary rock layers in areas such as the Grand Canyon?

- b. Do you think the age of the sedimentary rock layers from the Grand Canyon that geologists figure out would be the relative age (the age in reference only to the other rock layers in the area) or absolute age (the exact age)?

- c. What might be a way of figuring out the absolute, or exact age of the rock layers? Hint: what might be embedded in those sedimentary layers that the geologists could use to get an exact date?

6 Exploring on your own

- a. Examine the sedimentary rock samples. Classify these sedimentary rocks according to color, texture, and particle size. What types of particles do you think make up each of the rock samples?

- b. Based on the results of this investigation, where would you expect to find each of these sedimentary rock samples in a river system? Upstream near the source of the river or farther downstream near the mouth of the river?

- c. Go for a “rock walk” around your school or around your home. See if you can find samples of sandstone, shale, or conglomerate in these areas. Collect any other rocks that may seem interesting to you as well. Take these rocks back to your classroom and classify them according to their color, texture, and mineral size.



10A All Cracked Up

What is a good way to model Earth?

Using *models* is an important practice when studying science. Many of the objects that a scientist would study, such as a planet or a molecule, are much too big or too small to work with by hand. Models can help a scientist solve this problem. Some examples of scale models a scientist might build include shrinking a planet down to the size of a basketball or blowing up a molecule to the size of a tennis ball. These models make objects easier for scientists to conduct their research. Think about a geologist studying plate tectonics and continental drift—two concepts you will learn more about in Chapter 11. The geologist would likely build small scale models of each of Earth's tectonic plates in order to more easily understand how the movements of the plates affect one another.

Different kinds of scale models serve different purposes. In this activity, you will examine several geologic models of Earth to learn more about some of Earth's important features.

Materials

- Three objects that can serve as models of Earth.

Examples: a ping-pong ball, a baseball, a golf ball, an orange, a basketball, etc.

1 Procedure

1. You will be shown three different objects that can serve as models for Earth. Make a sketch of each model.
2. Write the name of each object in the first column of Table 1. Then, based on your understanding of Earth, determine each model's strengths and weaknesses. Write your evaluations in Table 1.

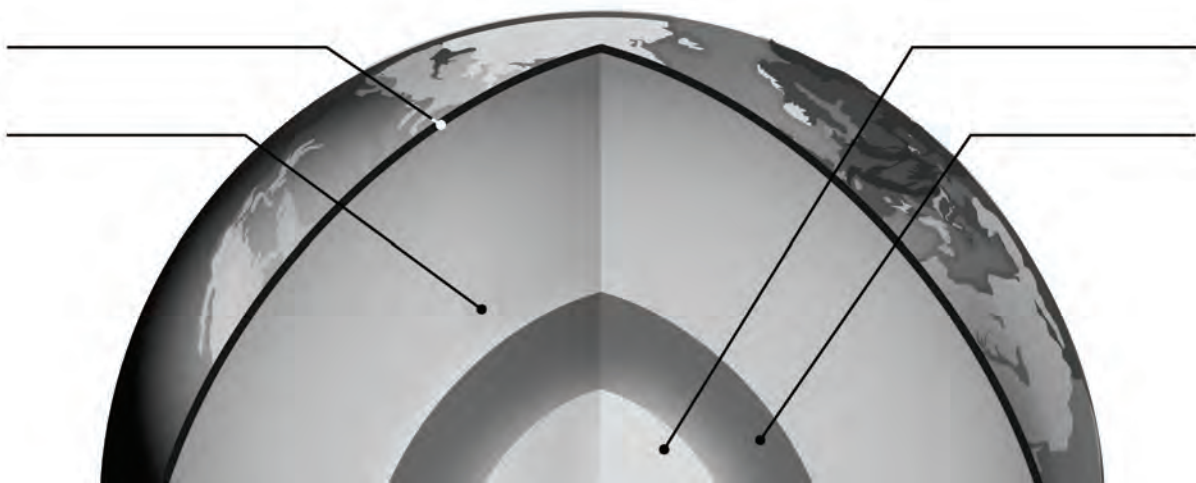
Table 1: Evaluating your models

Model	Strengths	Weaknesses

3. Of the three models, which do you feel is the most accurate for modeling the layers of Earth? Which model do you feel is the least accurate? Explain your reasoning behind both answers.

-
-
4. Your teacher will now conduct a short demonstration using a hard-boiled egg as a model for the interior of Earth. Record and sketch your observations of the egg model in the space below. Be sure to make observations and sketches of both the interior and exterior of the egg.

5. Based on the demonstration, label the layers of Earth in the diagram below.



**2 Discussion questions**

- a. Which layer of the interior of the egg corresponds to which layer of the interior of Earth? What part of Earth does the cracked egg shell model?

- b. What are two strengths and two weaknesses of the cracked egg model?

- c. How do Earth's layers compare in their composition and consistency with the egg layers?

- d. Earth's tectonic plates move relative to one another, unlike the eggshell sections which do not move at all. In some places plates move apart. In other places plates come together, and in still others, plates rub sideways against each other.

- What geologic event might occur where plates rub sideways against each other?

- What geologic formation might result when two plates collide?

- What geologic formation might form where two plates move apart?



10B Buoyancy and Mountains

How and why do objects float?

Solid objects float if they are less dense than the liquid in which they are placed. Objects sink if they are more dense than the liquid. You may have noticed that large ships are often made of steel. Ships made of steel float in water, even though steel is much more dense than water. Mountains, embedded in the continental crust, float in the upper mantle of the Earth. So how does a steel boat or a mountain float? The answer is in the concept of apparent density. You will soon discover how and why boats can be made of materials that are denser than water, and how a giant mountain can float.

Materials

- Displacement tank
- 1/2 stick of modeling clay
- Balance
- Disposable cup
- Beakers
- Graduated cylinder
- GeoBox
- Wood mountain blocks
- Metric ruler

Part I - Boats

Have you ever wondered how a boat made out of steel can float? Boats have even been made out of concrete, and they float too. Metal like steel, and materials like concrete are things that people usually are not surprised to see sink when put into water. So why would anybody try to make a boat made out of steel or concrete? Instead of these materials, you will use a piece of clay to investigate how these seemingly “heavy” materials can be used to make a boat that actually floats.

1 The density of clay

Find the density of your stick of clay before you change its shape.

1. Measure the clay's mass. Record it in Table 1.
2. Find the volume of your stick of clay using the displacement method:
 - Place a disposable cup under the displacement tank spout.
 - Fill the tank until water begins to run out of the spout (approx. 1,400 mL)
 - When the water stops flowing, remove the cup and replace it with a dry beaker.
 - Gently place your clay into the tank. Collect the water that runs out of the spout.
 - Quickly remove your clay and dry it with a paper towel. Do not allow water to mix with your clay or it will get very slimy.
 - The volume of the water you collected is equal to the volume of your clay. Use the graduated cylinder to measure the volume and record it in Table 1.



Table 1: Density data for clay

Substance	Mass (g)	Volume (mL)	Density (g/mL)
Clay			

3. Calculate the density in g/mL.
4. Did your stick of clay sink or float in the displacement tank? Use the density of your stick of clay and the density of water (1.0 g/mL) to explain why.

2 Making the clay float

You know that steel can be formed into a shape that floats. Can you do the same thing with clay? For this activity, you must use ALL of your clay. Mold it into a shape that you think will float.

1. Fill the container with water until it is about 12 centimeters deep.
2. When you are ready to test a shape that you have made, gently place it in the water in the container. If the clay sinks, take it out of the water and dry it off right away.
3. When your clay is dry, change the shape of your “boat” and try again.
4. When you have successfully made a boat that floats, take it out of the water. Dry it with a paper towel.
5. Measure the mass of your boat and record it in Table 2.

3 Why a boat floats

1. When a boat floats, it displaces a certain volume of water. Make a prediction: Do you think your boat will displace more water, less water, or the same amount as your stick of clay?



2. To find out, first prepare the displacement tank just as you did in step 1.
3. Place your clay boat in the water in the displacement tank. Let it float there while the water flows out of the tank.
4. Measure the volume of the water displaced by your clay boat. Record this volume in Table 2.
5. Use your mass and volume data to calculate the apparent density of your clay boat.



Table 2: Data for boat

Mass of boat (g)	Volume of water displaced by the boat	Apparent density of the boat

4 Thinking about what you observed

- a. Which displaced more water, the stick of clay or the clay boat? _____
- b. Assuming the mass of the clay did not change, how do you explain the difference in the volumes displaced by the stick of clay and the clay boat?

- c. Look at the boat's apparent density. Why is it different than the density of the stick of clay? What other substance has a density very similar to the boat's apparent density?

- d. Explain why a solid stick of clay sinks but a clay boat can be made to float.

- e. What would happen if you added “cargo,” like pennies, to your boat? Is there a limit to how much mass you can add before the boat sinks? Does the volume of displaced water increase or decrease when the boat gets heavier? Why? Try the experiment.

Part 2 - Earth’s crust and mountains

Unlike steel, concrete or clay, Earth’s crust is not shaped like a boat. For the most part it is solid, without a hollowed out section like the boat you made, and yet it floats. Beneath Earth’s crust is the mantle. The mantle is made of very hot rock.

5 Why Earth’s crust floats

- a. Based on what you learned in the first part of the investigation, how would you explain why Earth’s crust floats on the mantle?

- b. There are two types of Earth’s crust; continental and oceanic. Oceanic crust is on average about 15% more dense than continental crust. How do you think the difference in density would affect how both types of crust float on the mantle?

- c. What kinds of things would make part of Earth’s crust thicker than another part?

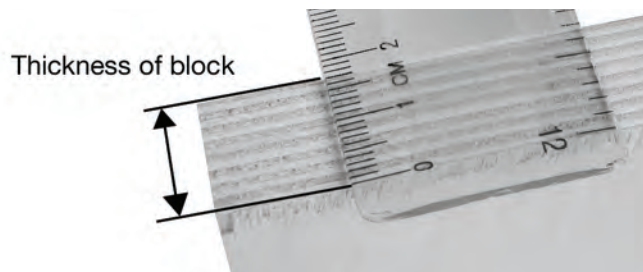
- d. Continental crust is usually much thicker than oceanic crust. Make a prediction; Would being thicker affect how continental crust floats on the mantle compared to oceanic crust? If so, how?



6 Testing your prediction

As mountains and mountain chains grow, the part of the crust they are on gets thicker and thicker. We are going to test your prediction of how getting thicker affects how the crust floats on the mantle by watching what happens when we build a mountain.

1. Fill the GeoBox with water up to the 5 cm line.
2. Measure the thickness of the largest mountain block and record your measurement in Table 3.
3. Place the largest mountain block in the water. This block represents Earth's continental crust.
4. Measure how much of the block is above the surface of the water, and how much is below the surface of the water. Record your measurements in Table 3.
5. Measure the thickness of the second largest mountain block. Record your measurement in Table 3. Add this measurement to the thickness of the first block and record the total thickness of all blocks in Table 3.



6. Its time to start building your mountain. Place the second largest block on top of the block in the water.
7. Measure the total amount of both blocks above the surface of the water, and the total amount of both blocks below the surface.
8. Repeat steps 5 -7 until you've measured all the blocks and completed the mountain.

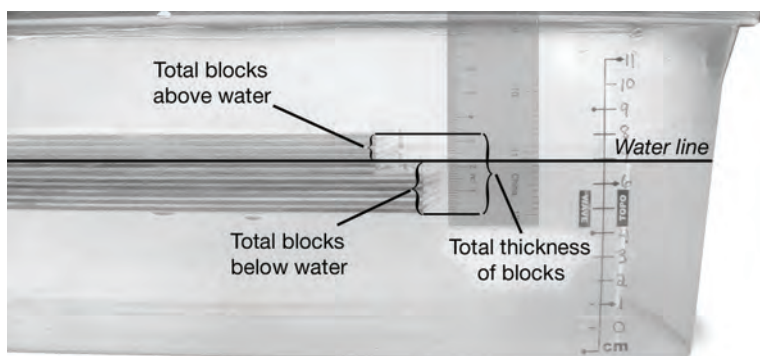
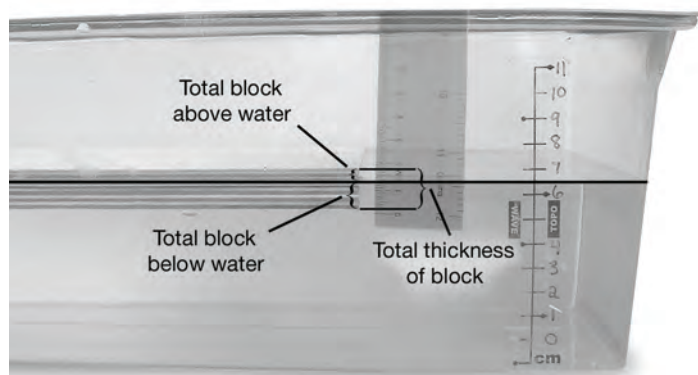


Table 3: Mountain blocks data

Block	Thickness (mm)	Total thickness of all blocks (mm)	Total amount above water (mm)	Total amount below water (mm)
First				
second				
third				
fourth				
fifth				

7 Thinking about what you observed

a. As the mountain grew taller, did its increase in height equal the thickness of each block you put on?

b. What happened to the total amount of all blocks under water as the mountain grew taller?

c. Did the total amount under water increase steadily as the mountain grew taller? Why or why not?

d. How does this activity relate to Earth's crust and mountain building?



- e. Predict what you think happens to the crust as its mountains and mountain chains slowly erode over many years through weathering and erosion? Take your mountain apart one block at a time and see if your prediction is correct.

8 Exploring on your own

- a. How thick on average are oceanic and continental crust?

- b. Where are the thinnest and thickest part of the crust, and how thick are they?

- c. **Research:** Find out the average densities of the mantle, oceanic and continental crust.

- d. **Challenge:** As the thickness of the crust decreases, what do scientists call the process that takes place? What else other than mountains can cause this same process to happen?
