National Park Service
U.S. Department of the Interior

Acadia National Park

P. O. Box 177
Bar Harbor, ME 04609

207 288-8822 phone
207 288-8831 fax

Fire & Ice Post-Visit Activity Squished by a Glacier

Objectives:
Students will:
- Investigate the effects of glaciers on sea level
- Experimentally derive the relationship between the amount of ice and the amount of sea level change
- Use a topographic map to explore the impact of a rising sea level on MDI

State Learning Results Addressed (Grades 5–8):
Science and Technology: E.1, E.8, F.4, J.1, J.2, L.4
Mathematics: A.3, B.2, C.1, C.3, F.3, G.2, H.1, H.3, H.4, K.1

Materials:
- Tub of water
- Blocks of ice
- Foam block
- Ruler
- Copies of handouts
- Copies of a topographic map of MDI

Activity:
See handouts.

Cecily Swinburne – COA 2007

EXPERIENCE YOUR AMERICA™
The National Park Service cares for special places saved by the American people so that all may experience our heritage.

Experiment:

Description: Continental plates float on top of the mantle. When ice is piled on top of the plate, it causes the plate to sink into the mantle. In this activity you can show how the quantity of ice relates to the amount that the plate sinks into the mantle.

Note: This activity demonstrates the isostacy equation that says that the amount that the crust sinks is a distance equal to the depth of the ice times the ratio of the density of ice to the density of the mantle (x = Depth ice * Density of ice / Density of Mantle). This relationship is only valid for large expanses of ice (on the scale of tens and hundreds of square miles). At the time of the last glaciation, most of Maine was covered by the sheet of ice, so the isostacy equation is relevant; if only MDI were covered, it would not be applicable. For ice covering small areas, the rigidity of the crust will distribute the weight, and the sinking of the crust will be negligible (e.g., big buildings don't cause the crust to sink).

Materials:
- Beaker/tub of water or a denser fluid if available
- Blocks of ice
- A block of foam or plastic (anything that is flat and floats will work)
- Ruler

Notes on materials: The tub of water represents the mantel, and the block of foam/plastic represents the plate. You will then add ice to the plate and measure how much it sinks. The plate will need to be several inches thick so that a couple blocks of ice can be added to it before it completely sinks. It is important that the base of the ice has the same area as the top of the plate. This is most easily accomplished by cutting the plate to fit the container in which the ice is being made. You may have some difficulties getting the ice to balance on top of the plate, especially if the plate is small. The larger the plate, the more stable it will be.

Preparation:
- Freeze blocks of ice. They need to have the same base area (the heights can vary, but it is probably easiest to keep them consistent as well). I recommend finding a can/tray from packaged food to use as a mold, perhaps a Styrofoam meat tray. Keep the height of the ice pretty thin, around 1 cm, so that you can pile on a couple blocks before the plate completely sinks. Make sure that the ice is thick enough that you can get it out of the mold without breaking it. You will want 3-4 blocks of ice for the activity.
- Cut the Styrofoam plate to the size of the ice blocks. Try to get a thick piece of Styrofoam so that you can add a couple blocks of ice before the plate completely sinks.

Activity:
- Fill a tub with a few inches of water.
- Place plate on the water and mark the starting water level on the side of the plate.
- Measure the thickness of the first block of ice.
- Stack the block of ice on top of the plate and measure the new height of the water on the plate.
- Repeat the last step one or two more times.
- Calculate the amount that the plate sunk for each block of ice on top of the plate.

- Graph the relationship between the height of ice on the plate (x-axis) and the amount that the plate sunk (y-axis).
- Plot a best-fit line for the data and calculate its slope. What is the meaning of the slope?
- The ratio of the density of ice to the density of water is ~0.9. How does that compare to the slope of your line?
- Create an equation for the distance that the plate sinks in terms of the height of the ice.
- Generalize the equation for a liquid and solid of different densities.

Continuations:

- Repeat the activity with a plate of a different density to show that the density of the plate does not affect how much it sinks when ice is added. Discuss why that is.
- Explore how the ice must cover a large amount of the plate. Try balancing the ice over a small area. Explore why that is.

Lab Handout:

This experiment will explore the effects of glacial ice on the Earth's crust. The crust or continental plate will be represented by a piece of Styrofoam, and the mantle, on which the plate floats, will be represented by water. You will then add blocks of ice, representing different thicknesses of glaciers, to the plate and measure the effects.

1. Put the Styrofoam plate into the water and measure the water level on the plate.
2. Measure the thickness of a block of ice and then place the block of ice on top of the Styrofoam plate. Measure how much the plate sunk.
3. Repeat step 2, one to two times, each time adding the new block of ice on top of the previous block(s). Record your answers in the table below.

	Thickness	Height of water on plate
The Continental Plate	----------	
Ice Block 1		
Ice Block 1+2		
Ice Block 1+2+3		

4. Graph your data below; make sure to include labels.

Distance Plate Sinks into Water

Thickness of Ice

5. Draw a best fit line on your data and calculate its slope. What is the meaning of the slope?

6. The ratio of the density of ice to the density of water is ~0.9. How does that compare to the slope of your line?

7. Create an equation for the distance that the plate sinks in terms of the height of the ice. Be sure to state what units you are using.

8. Can you generalize this equation for a liquid and solid with densities other than those of water and ice?

Squished by a Glacier – Follow-Up Questions **Teacher Copy**

During the last glaciation, Acadia National Park was covered by an estimated one mile of ice. The ice weighed so much that it caused the Earth's crust to sink. (Remember that the crust is floating on top of the liquid mantle like a boat floating on the ocean. If you add more weight to a boat, it will float at a lower level.)

If ice has a density of 56 lbs/ft^3 and MDI has an area of 108 square miles, how much did the one mile of ice on MDI weigh?

$56 lbs/ft^3 * (5280 ft/mile)^3 * 108 miles^2 = 8.9 * 10^{14}$ lbs

As you saw in the experiment, the amount that the crust sinks is proportional to the density of the ice divided by the density of the liquid on which the plate is floating (the mantle). If the density of the mantle is 205 lbs/ft^3, how much would one mile of ice cause the crust to sink? (1 mile = 5280 ft)

Density ice / density of mantle = Depth crust sinks / thickness of ice
$56 lbs/ft / 205 lbs/ft^3 = x / 5280 ft$ *$x = 1442 ft$*

Cadillac Mountain is 1530 feet high. If the crust were to sink as much as you calculated above, how tall would Cadillac Mountain be?

1530ft-1442ft=88ft

Glaciers are made of ice. Where did that ice come from and how might that affect sea level?

The water to make the ice came from the ocean, which means that the ocean has less water in it and so sea level will drop.

The continental crust is sinking. What is the oceanic crust doing?

Since there is less water in the ocean, there is less weight on the oceanic crust. In the same way that the continental crust is sinking, the oceanic crust is rising. This will moderate the observed change in sea level.

What signs do we have that sea level used to be higher than it currently is?

There are elevated sea caves and cobble beaches that must have been formed at sea level. On MDI these features are at a current elevation of around 250 feet.

On MDI, there are coastal features at around 250 feet above the current sea level. What would the island have looked like? Would it have been more than one island? On the topographic map, outline where sea level was when those features were formed.

Trace the 250 ft contour line.

Squished by a Glacier – Follow-Up Questions **Student Copy**

During the last glaciation, Acadia National Park was covered by an estimated one mile of ice. The ice weighed so much that it caused the earth's crust to sink. (Remember that the crust is floating on top of the liquid mantle like a boat floating on the ocean. If you add more weight to a boat, it will float at a lower level.)

If ice has a density of 56 lbs/ft^3 and MDI has an area of 108 square miles, how much did the one mile of ice on MDI weigh?

As you saw in the experiment, the amount that the crust sinks is proportional to the density of the ice divided by the density of the liquid on which the plate is floating (the mantle). If the density of the mantle is 205 lbs/ft^3, how much would one mile of ice cause the crust to sink? (1 mile = 5280 ft)

Cadillac Mountain is 1530 feet high. If the crust were to sink as much as you calculated above, how tall would Cadillac Mountain be?

Glaciers are made of ice. Where did that ice come from and how might that affect sea level?

The continental crust is sinking. What is the oceanic crust doing?

What signs do we have that sea level used to be higher than it currently is?

On MDI, there are coastal features at around 250 feet above the current sea level. What would the island have looked like? Would it have been more than one island? On the topographic map, outline where sea level was when those features were formed.