

EXPLAINING GLACIERS, ACCURATELY

A geologist and two fourth-grade teachers team up to improve hands-on lessons that show how glaciers can change the Earth's landscape.

By Mary Faw, Nancy Scott, and Mari Tate

What happens when a geology graduate student and two fourth-grade teachers collaborate on lessons for the classroom? They discover interesting and practical ways to explore geology and other scientific concepts, that's what! This collaboration was made possible by the National Science Foundation GK-12 Partnership for Reform Through Inquiry in Science and Mathematics (PRISM) program. Through the program, we participated in five weeks of summer professional development together and then coplanned and co-taught together 10–20 hours a week during the following academic year.

The glacial erosion lessons shared here grew out of the geologist's frustration at finding glacial erosion labs erroneously showing glaciers eroding by *pushing* rocks. Although the concept that glaciers erode a mountain or a continent by *pushing* the rocks is a popular explanation in numerous age-appropriate erosion labs, it is *not* an accurate portrayal of how glaciers transform the Earth.

Our goal was to find a way to show and explain glacial erosion more accurately in a way that elementary age students could understand. The task proved challenging; however, working as a team and relying on each others' areas of expertise, we were successful in developing geology lessons that did just that. After completing these activities, most of our students were able to explain the processes of glacial *plucking* and *abrasion* and describe how they change the shape of the Earth's surface.

Glacier Basics

So, if glaciers don't *push* rocks, what do they do? Glaciers erode the Earth by two mechanisms: plucking and abrasion. *Plucking* is when the glacier "plucks" pieces of rock from their parent rock (or a mountain). This occurs through a series of events, beginning with the glacier melting a little bit. Scientists believe that the glacier floats on the melted water. The rock then freezes to the bottom of the glacier during seasonal or global cooling. The water also seeps down into cracks in the rock, and water that was

in the rock cracks is now ice, which expands the cracks (see Figures 1 and 2). The glacier itself accumulates snow and ice on its surface, and under this added weight and pressure, the glacier slides down the mountainside.

This glacial movement will cause some rocks to break off and move along with the glacier. Rocks also freeze into the glacial ice and are contained within it (until the glacier recedes or breaks off into chunks of icebergs). When the glacier recedes, the glacier will melt a bit and deposit many of the rocks that it once contained. The rocks may be deposited in perpendicular piles in relation to the glacier's movement, known as *drumlins*, or in parallel ridges in relation to the glacier, known as *moraines*.

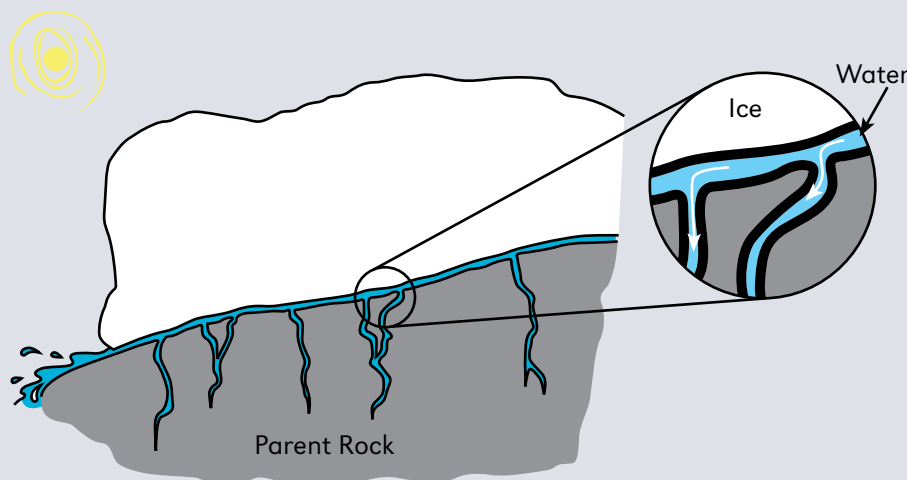
The second form of glacial erosion is called *abrasion*. Abrasion basically sands and polishes the parent rock. While scientists cannot observe abrasion actively occurring, abrasion leaves "footprints" in the rocks called *glacial striations*. Glacial striations are typically found as elongated grooves on rock surfaces. These are created by the rocks that are attached to the base of the glacier scraping the surface rock as the glacier moves (see Figure 3, p. 24). This scraping or abrasion creates *rock flour* (sand, silt, or dust) and also creates grooves on the surface of the rock (glacial striations).

Due to the complex processes described above, we needed to develop an activity that accurately portrays these phenomena. Since glaciers do not simply push rocks like a bulldozer but in fact carry them within the ice and "sand down" parent rocks, we took on the challenge to demonstrate glacial erosion in an accurate way that students would understand. Our first step was to demonstrate the process of plucking.

Figure 1.

Plucking.

In warmer weather (usually the summertime), glaciers melt a little bit. Scientists believe that glaciers float on the meltwater, just as an ice cube will float in your glass of water. This meltwater flows down into the parent rock, where it can melt and refreeze many times.



Glacial Hitchhikers (Plucking)

We began this lesson by first asking the students what they knew about glaciers. We used pictures from websites as a springboard for opening discussion with the class (see Internet Resources). Asking open-ended questions about the glacier pictures, we were able to ascertain the students' knowledge level and start them thinking about glaciers. For example, we showed the students a picture of a glacial valley without the glacier (Glacial Valley 002.jpg 2006 from the

St. Charles Community College, see Internet Resources). Then we showed the class a picture of a retreating glacier with moraines forming in front of it. We asked the students how they thought those mounds of dirt got there. Most students weren't exactly sure how these elements formed but guessed it had to do with glacial movement.

After the students had a chance to express their ideas of how the valleys and the hills were formed, we explained that this phenomenon has been studied by scientists called *geologists*. These geologists have determined two main types of erosion: plucking and abrasion.

Next, we conducted an exploratory activity to demonstrate glacial plucking. This activity can be done as a whole-class demonstration or as a small-group activity—we did it as a teacher demonstration. Materials needed are a small plastic container (at least 3 in diameter), dirt (potting soil), pebbles, small rocks, water, and ice cubes. Place a layer of dirt at least 1 in thick in the container, along with some pebbles and small rocks. The dirt and rocks represent the land and the mountains. Pour some water on top (enough so that the top layer is saturated and there is some pooling). The water represents the melted glacial ice. Then place some ice cubes (at least three), representing the unmelted glacier, on top of this mixture, and place the container in the freezer overnight. Leaving this in the freezer overnight simulates how rocks can become attached to a glacier—in a much faster time period of course!

Before placing the glacier model in the freezer, we asked the following questions to guide the students' thinking:

- What do you think will happen when the water freezes?
- What do you think will make it possible for the water

to be able to “pick up” the rocks and soils?

- Will the water freeze and become strong enough to hold the rocks and pebbles to the ice cubes?

The students then drew their predictions on a worksheet (see NSTA Connection) and recorded their reasoning. Many students believed that the ice would not be able to pick up the rocks, and so they drew the rocks being left in the container. Before our introductory discussion, many students did not think the water would freeze around the rocks and pebbles and that the rocks and pebbles would become attached.

When discussing glacial behavior with students, keep in mind that the size, shape, and density of the rock *does not* influence the glacier's ability to pluck the rock. The main factors that influence a glacier's ability to erode are the rate of glacial movement, the thickness of the ice, hardness of the rocks at the glacier's base, and the ease of which the parent rock can be eroded. Another factor is the *shape abundance*, for example, when there are more rocks at the base of the glacier, more “sanding” occurs, and if the rock is rounded, it produces less friction than an angular rock would against the parent rock.

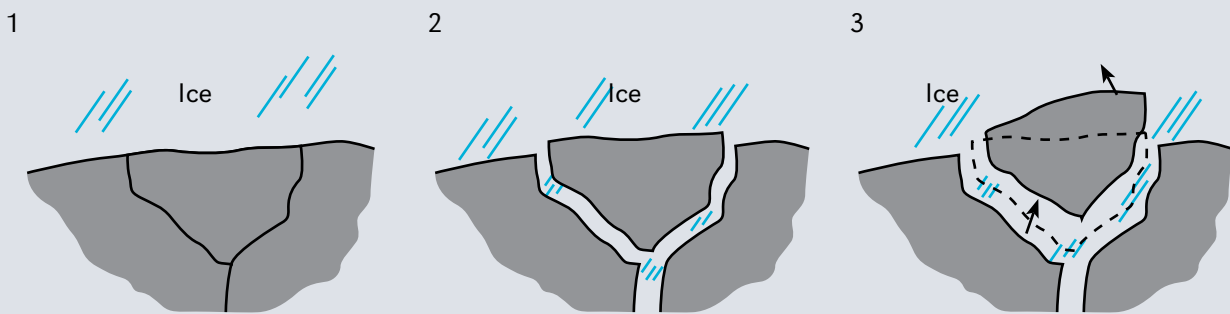
The next day, remove the frozen glacier from the freezer and take the glacier out of its container by wiggling the sides of the container while it is upside down (or cut the container with scissors to remove the ice block). The ice should now contain rock fragments. Have students then draw a picture of how the glacier looked when it was removed and compare it to their prediction. Students may notice that some of the dirt or rocks remain in the dish, which just means that the water did not infiltrate down that far, or that there was not enough water to freeze in such a way that it would freeze together.

Figure 2.

Plucking, continued.

When the water freezes, it will expand. You can experiment with this by filling a plastic water bottle all the way to the top, sealing it tightly, and then placing it into a freezer overnight. When the water freezes, it will expand and will cause the water bottle to bulge and possibly break. When water freezes in the cracks

of rocks, the ice will detach the rock from the parent rock, and over time they may break off of their parent rock. These rock fragments can be as small as pebbles or as large as a boulder. These boulders can be as large as a car! So you can imagine that the parent rock must be very large.



Then, discuss with students how plucking changes the shape of the Earth and produces landforms such as glacial moraines and model the process. To do this, take the frozen glacier model and place it on top of a mound of dirt (about half a small bag of potting soil will suffice), and ask the students to imagine that the glacier formed on top of the mound, and the rocks frozen inside the glacier were found on top of the mound, too. Slide the glacier down the mound of dirt (explain that glaciers normally move quite slowly) and then stop the glacier at the bottom of the mound and let the glacier melt (at least an hour, maybe overnight, depending on when the lesson is conducted and how warm the room is). Next, ask the students what happened to the rocks within the glacier when the glacier melted (the rocks were deposited at the bottom of the mound). How did this change the shape of the Earth? (Rocks are moved from place to place, sometimes leaving a depression as they are plucked and deposited elsewhere.)

It should be explained to the students that real glaciers form in frigid regions, such as the top of mountains or the Earth's poles. Our using dirt as the material the glacier travels over is a matter of convenience. Despite this limitation, the model demonstration does help students see for themselves that ice can carry rocks in its mass, countering their earlier ideas and predictions.

Groovy Glaciers (Abrasion)

The second method that glaciers use to erode and shape the Earth's surface is *abrasion*. To engage the students in the activity, we first showed them pictures of glacial striations (see Internet Resources). Then, we led the students in a discussion on how they think those grooves could have been formed. Most students thought that "they were always that way." We chose to not reveal how the features actually formed, so that students would continue to question their formation. Instead, we conducted an activity that explores how glacial striations form using small pieces of wood, sandpaper, ice, and various types of rocks (granite, limestone, and sandstone).

To introduce the exploration, we rubbed sandpaper against wood. We asked the students which material was getting worn down the most when they were rubbed against each other. Because students could see the dust being formed as the wood was sanded by the sandpaper, they knew that the wood was being worn down the most.

Following this, we divided the students into groups of about 2–3 and gave each group a sample of granite, limestone, sandstone, wood, sandpaper, and ice, asked them to explore which type of material could be used to change the surface of the rocks. We stressed that they could not bang the rocks but had to rub materials against each other. The students then recorded their

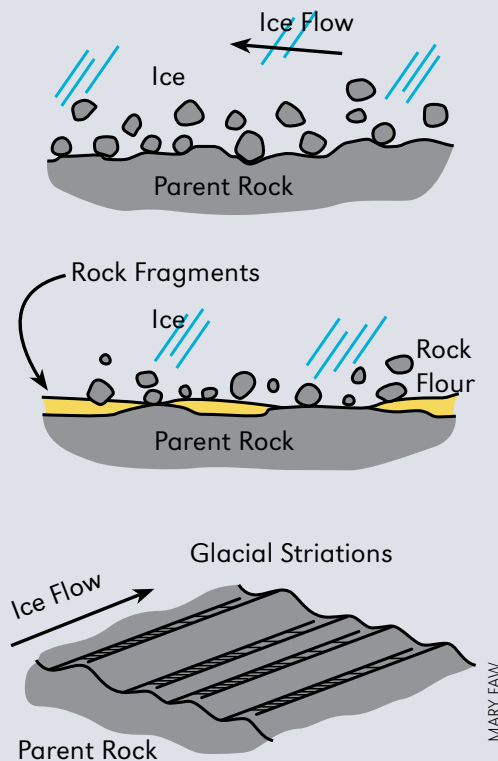
observations and inferences on a chart (see NSTA Connection). Students found that certain objects were easy to erode and could be eroded with many of the materials, and they found that some objects, such as a granite rock, could not be eroded. Then, they answered the question, "Why are certain objects able to erode some objects but not others?"

After the exploration, we talked about their observations and discussed which materials could make marks on which objects. For it to represent abrasion, the mark needs to be a gouge or a scratch or show that material has been removed by rubbing. Students may find that the limestone may leave a streak on the granite, which does not indicate that the limestone is capable of eroding the granite. Our students noticed that nothing seemed to affect the granite rocks. This is because the

Figure 3.

Abrasion.

The second way glaciers erode rocks is called *abrasion*. Think of abrasion as rubbing sand paper on a piece of wood. After you have rubbed the wood for a minute or two, dust will begin to form. Glaciers do the same thing to rocks! Imagine for a minute how much force would be needed to sand down a solid rock, such as granite, into sand or dust. Glaciers are able to "sand down" rocks because of rock fragments that stick out of the glacier at its base. These rock fragments act like the grains of sand glued to sandpaper. As the glacier slides along the parent rock, it polishes the parent rock and it creates dust. Scientists call this dust *rock flour*. Abrasion also creates *glacial striations*, which often look like long, parallel lines that are depressions in the rock.



granite rocks were the hardest material that was given to them. To prevent the possible misconception that granite could not be eroded by any means, we discussed that granite was not the hardest material in the world, just the hardest of the samples given. Since scientists have found glacial striations preserved in granite rocks and other rocks that are very hard like granite, you may ask the students what is needed for the striations to be made. Students knew that it would take an object that was harder than granite to erode it, but they did not know what materials were harder than granite, so we provided this information. (These striations are able to form in hard rocks because of the huge amount of force and weight that the glaciers exert on the granite rocks, along with the types of rocks rubbing against the parent rock. It may also be suitable to mention that over a great amount of time, water can erode many things, including the harder rocks, and that the great amount of pressure exerted by glaciers will also erode harder rocks.)

We discussed as a class what types of rocks would be needed to create grooves in other rocks and why. By this point, students understood that they needed a rock that was harder than the rock having a groove created in it. Students continued to explore, recording their results on a worksheet (see NSTA Connection). Would a sandstone rock contained inside the glacier be able to create a groove when dragged across the surface of the sandstone (limestone/granite)? If a chunk of limestone rock was contained in the glacier, would it be able to make a groove in the granite (limestone/sandstone)?

You may also show your students illustrations that the geologist made to help our students understand abrasion (Figure 3). By the end of the explorations, students understood that glaciers are a powerful erosive force; that glaciers take a great amount of time to erode; that *glacial plucking* happens when a rock is pulled out of its parent rock; and that *glacial abrasion* can happen when a rock of equal or greater hardness is rubbed against the parent rock. They also understood that ice can carry extremely large boulders, which many students did not think possible before. The students also understood that it is not the ice itself causing the glacial striations, but that it is the rocks being carried by the ice.

Final Reflections

All of us—geologist, classroom teachers, and students—benefited from our collaboration. Working with the fourth-grade teachers and students helped the geologist develop ways of communicating tough scientific concepts without using scientific jargon. For the teachers, until we researched this topic and worked with a geologist, we had believed the glacial “bulldozer” school of moraine formation. Having a geologist work with us helped us to educate ourselves. As a result, our students learned more

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Standard D: Earth and Space Science

- Changes in the Earth and Sky (K–4)
- Structure of the Earth System (5–8)

National Resource Council (NRC). 1996. *National science education standards*. Washington, DC: National Academy Press.

accurate information about the processes of glacial erosion, and they were interested and engaged while doing so. Bring on the next collaboration! ■

Mary Faw (mfaw81@yahoo.com) was a graduate student in geology at Bowling Green State University in Bowling Green, Ohio, at the time this lesson was developed. Nancy Scott and Mari Tate are both fourth-grade teachers in Washington Local Schools in Toledo, Ohio.

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Reference

Tarback, E. J., and F.K. Lutgens. 1999. *Earth: An introduction to physical geology*. New Jersey: Prentice Hall.

Internet Resources

NSIDC

<http://nsidc.org/glaciers/>

St. Charles Community College

www.stchas.edu/faculty/ewilson/Photos/Glaciers/

University of Wisconsin–Madison

www.geology.wisc.edu/maher/air/air04.htm

Yellowstone National Park

www.nps.gov/yell/slidefile/geology/glacial/Inside%20Yellowstone%20Park/Page-2.htm

NSTA Connection

Find the worksheets used in this unit at www.nsta.org/sc0904.

