Soil Makers

Purpose

Students will understand the geologic phenomena of weathering and erosion. These processes, along with deposition, shape our landforms and contribute to the development of parent material in the soil formation process.

Overview

This lesson describes how the dynamic Earth system processes that take place in land, water, and air contribute to create sediment deposits where, once stable, soils can form over time. Students will model rock weathering and soil erosion by performing different investigations on mud pies and soil. Through their investigations, students should get a broad understanding of the natural causes that contribute to weathering and erosion. They will also test different variables to affect rates of erosion. A teacher-guided classroom discussion will familiarize students with other causes of weathering, erosion, and deposition that are not as easily testable in the classroom.

Student Outcomes

Students will be able to:

- Understand the causes and variables that contribute to weathering, erosion, and sediment and mineral deposition.
- Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation (NGSS 4-ESS2-1).
- Use models to describe a scientific principle or illustrate the relationships between systems or between components if a system (NGSS Science and Engineering Processes and Crosscutting Concepts: Systems and System Models). More specifically, model shapes and kinds of landforms in an area, interactions between land, air, water, and organisms, and the cycling of Earth's materials (NGSS 2-ESS2-2), (NGSS 5-ESS2-1), (NGSS MS-ESS2-1).
- Explain cause and effect mechanisms with models in the classroom and then draw similar conclusions to naturally occurring events in the environment (NGSS CCC: Cause and effect).
- Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes (NGSS MS-ESS3-1).

Science Concepts

Earth and Space Science

- Weathering and erosion create and move sediment around the surface of the earth.
- Landforms are the result of constructive and destructive forces. Destructive forces include weathering and erosion.
- Water, wind, ice, living organisms, and gravity affect Earth materials and surface processes and can change the shape of the land (NGSS 2-ESS2-1), (NGSS 4-ESS2-1), (NGSS HS-ESS2-5).
- The geosphere, biosphere, hydrosphere, and atmosphere interact in multiple ways to affect Earth's surface materials and processes (NGSS 5-ESS2-1).
- The surface of the Earth changes at different temporal and spatial scales (NGSS MS-ESS2-1 CCC: Stability and change), (NGSS MS-ESS2-2), (NGSS HS-ESS2-5).
- Soil consists of weathered rocks-sand, silt, and clay sized particles, and decomposed material.

Scientific Inquiry Abilities

Identify answerable questions.
Design and conduct an investigation.
Use appropriate tools and techniques to gather, analyze, and interpret data.
Develop descriptions, explanations, predictions, and models using evidence.
Communicate procedures and explanations.

Time

Activity 1: Up to 60 minutes

Activity 2: Up to 60 minutes

Total Time: Up to 2 hours

Level

Upper Primary: 3rd-5th grades

Middle: 6th-8th grades

Materials and Tools

See each Activity in *What To Do and How To Do It*

Prerequisites

Teachers: Read the Soil Introduction in the GLOBE Teacher's Guide for an in-depth understanding of soils, how to study soils, and why they are important. Then, read *The Scoop on Soils* with the class so they can learn about soils, the five soil-forming factors, and soil composition. Some information is provided in *Background.*

Optional: Perform the *From Mud Pie to Bricks* activity before starting Soil Makers and make extra mud pies to use for these activities.

Background

This activity will focus on the geologic processes of weathering and erosion. These processes are important to the study of the pedosphere because they contribute to the creation of parent material, one of the five soil forming factors (described below). The following section provides a brief overview of weathering, erosion, and deposition but further research may be helpful to teachers and students to get a better understanding of these complex processes.

Weathering is the *breakdown* of sediments and minerals on the surface of a rock from physical, chemical, or biological interactions.

Physical weathering causes a rock to break apart from mechanical processes. There are many physical forces that may act upon a rock, often due to weather and climate. One example of physical weathering is mineral or rock expansion, which causes the outer layers of a rock to break off into smaller pieces from repeated cycles of heating and cooling. Another common type of physical weathering occurs when cracks in the rock develop and grow. This can happen when salt crystals expand or when liquid water seeps into cracks then freezes and expands, causing the cracks to grow and the rock to break apart. Other interactions with water in the form of rain, rivers, and oceans can break up rocks from abrasion and impact from other suspended rocks or sediments. Additionally, there are other destructive natural forces such as lightning, wildfires, and landslides.

Chemical weathering is the disintegration of rocks by chemical processes and can change the composition of the rock. This can happen by dissolution- when acidic water dissolves rocks (typically occurs with limestone); oxidation- when iron in rocks becomes oxidized (much like how a bike will rust when left outside); and hydrolysis- when silicate minerals weather into clays.

Biological weathering is caused by living creatures and can cause both physical and chemical weathering. One example of biological weathering is when a plant grows in a crack in a rock and causes the crack to expand as the plant's roots grow. Other causes of biological weathering can be burrowing animals, human induced changes, and microbial activity, such as lichen breaking down and consuming minerals.

Erosion is the *movement* of sediments. Rock erosion can occur in similar ways to

weathering and is also often a result of weather and climate. Mechanical processes like wind, water, ice, and gravity can carry loose sediments away from the rock from which they came. Biological forces, like humans mining for minerals or animals using rocks for nests are also causes of erosion. Erosion can also affect sediments that have already settled. Soil can easily be washed away by water, leaving behind valleys, gullys, rills, rivers, and ever changing river banks. Landslides, natural disasters, and even day to day changes in weather can carry large amounts of soil and sediments to new destinations. Animals carry grains of sand with them between their toes and humans displace soil when they make way for buildings and parks or some day to day activities.

When discussing erosion, it is not only important to look at how it is occurring, but to also consider the amount of sediment or soil that is getting eroded. Slope angle, soil texture, and ground cover (vegetation) are the three main factors that control how much loose material is eroded. Steeper slopes, smaller sediments, and less vegetation usually result in greater erosion. When soil becomes eroded, it becomes an important topic for conservationists as soil erosion can affect food production (think about a farmers need for nutrient rich soil) and stream health (turbidity). Erosion can have impacts on human recreation (for example hiking trails getting washed out) and the availability of food and habitat for animals (NGSS 5-ESS3-1 and CCC: Influence of Science, Engineering, and Technology on Society and the Natural World: MS-ESS3-1). Check out the USDA Soil Conservation Service for more information about soil erosion and its protection.

Deposition happens when sediments stop moving and *settle* because of a change in the movement of water, wind or the flow of a glacier. Deposited sediments, soil, and rocks can add to or become a landform or land mass. Humans and animals can affect deposition when they move rocks and soil in actions like construction work or burrowing.

Weathering, erosion, and deposition create landforms that define our landscape. Valleys, mountain peaks, and sand dunes are just a few examples of landscapes that were created because of the complex interaction between weather and the rocks on Earth's crust. These three processes also help create the soil that makes up the *pedosphere.* Weathered sediments from rocks that have been moved by erosional transport will deposit and create a substrate for soils to develop over time.

Soil is a important resource to all living creatures on Earth. The development or formation of soils is dependent on five factors. The first is **parent material**, which is the material from which soil is formed. This includes bedrock, organic material, loose soil material (rocks and minerals of different sizes including sand, silt, and clay), that has been deposited by wind, water, glaciers, volcanoes, or by gravity. Next, the **climate** of an area (temperature, rain, wind, etcetera) will affect the rate of soil processes and contribute to the break down of parent material. The landscape or **topography** of an area will affect how the climate processes impact the soil. **Organisms**, the plants and animals, from microorganisms to humans, that live in and on the soil also affect how it is formed because of how they move and mix the soil. As well, the dead remains of plants and animals will enrich the soil as organic matter. Finally, all the factors mentioned above will assert themselves over **time**. Soil forming processes can range anywhere from minutes to thousands of years and are continuously being affected by human or natural disturbances to an area. To learn more about the importance of soil, as well as some of the characteristics of soil and soil horizons, check out the other GLOBE Learning Activities for the Pedosphere.

General Preparation

- Define weathering, erosion, and deposition to the students. Read *The Scoop on Soils* for an introduction to the five soil-forming factors and soil composition.
- Gather materials for the activity you will be leading.

  Note: *Material lists and instructions about the preparation for each activity are listed before each activity in What*

To Do and How To Do It.

The hands on nature of these activities can cause sediments to get into the air and possibly on students' clothes or in their eyes. Let parents know that their children will be working with soil and may get dirty so that they can dress appropriately. If available, provide aprons or protective clothing for students to wear during the activities. If possible, provide safety goggles for the students. Gloves may be worn if students desire but be aware of any material allergies.

What To Do and How To Do It

Activity 1: Weathering

Students will use various tools to act out different situations, refered to as "investigations" throughout the directions, that represent the geomorphic process of weathering. They will use mud pies as models of consolidated sediment or rock to explore causes of physical weathering by forces such as wind, water, ice, and gravity. By modeling these natural processes, they may begin to understand how landforms develop and materials move around the globe (NGSS CCC Cause and Effect).

Teacher Notes:

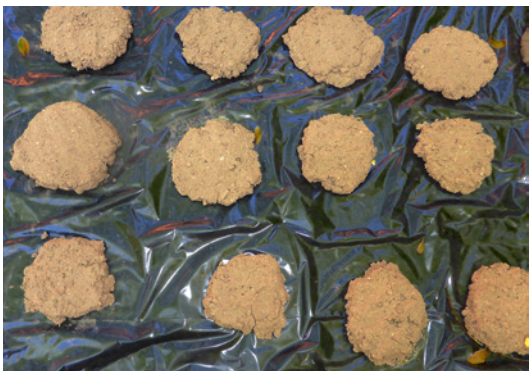
Materials

- Materials to be given to each student or group:
  - 2-5 mud pies
  - 1-2 ice cubes (can substitute with marbles or marble sized rocks)
  - Sandpaper (medium grit suggested)
  - Eyedropper (filled with water)
  - Spray bottle (filled with water)
  - Small plastic cup, tub, or wash-bin
  - Water
  - Worksheets
  - Optional materials: safety goggles and gloves
- Additional Materials for the classroom:
  - 1-2 frozen mud pies (Note: 1-2 frozen mud pies total for the class, not for each group)
  - Newspaper, butcher paper, or plastic drop cloth to cover the workstation
  - Paper towels or rags to clean up spills and accidents

Preparation

- **At least three days before starting the experiment:**
  - Prepare mud pies using soil and water.
    - Soil for the mud pies can be collected from outside or purchased from a store. If purchased, buy soil that most resembles a natural soil with some clay. Do not buy potting mixes with perlite or vermiculite.
    - Form mud pies by adding enough water to soil so that the soil is wet but not so much water that the mixture is runny. Take a palm-sized amount of mud and form into a patty by hand or put into a mold like a cupcake tin. Set all but 2-5 mud pies aside to dry completely in the sun or a warm place. It may take up to 30 minutes to make the mud pies and up to 3 days for them to completely dry by air. The number of mud pies needed will depend on class size.
  - Place 2-5 mud pies, still wet, in freezer and allow them to freeze overnight (these will be used to demonstrate ice's ability to break apart rocks in Activity 1 and will also be used in Activity 2 to create erosion). Keep frozen until needed.
- **At least one day before starting the experiment:** If using ice cubes, make them by filling an ice tray with water and freezing overnight.

Figure 1- Formed mud pies are laid out in the sun to dry.



- **Any time before starting the experiment:**
  - Copy the Weathering Worksheets for each student.
  - Introduce the concept of weathering to the class. The *Background* section has an overview of weathering and some examples, but further research is always encouraged. A great resource is www.soils4teachers.org. Students should be familiar with the three types of weathering (physical, chemical, and biological) and should include examples of each on their worksheets. Have students fill out Section 1 of their worksheets which asks for them to list causes of weathering. For students to fill out Section 1 of their worksheets, teachers may either lead a class discussion about weathering or students can do their own research on types and examples of weathering.
  - This activity will only explore physical causes of weathering so it is up to the teacher to review chemical and biological weathering in order for the students to have a more complete understanding of the phenomena.
  - In case of spills or accidents, lay down newspaper, butcher paper, plastic cloth, or some other protective surface on the table underneath the experiment. Keep paper towels or rags handy for spills and accidents.
- This activity can be done either individually or in small groups. If classroom materials are limited, set up different stations around the room for each investigation and have the students rotate around the stations.
- If weather allows, this activity can be performed outside.
- After each investigation, allow students time to fill out Section 2 of their worksheets. There is a box for students to to draw what the mud pie looks like after each investigation, but written observations may be substituted. There are drawing suggestions and questions on the worksheets to help guide the students but they should be encouraged to include any additional notes and observations as well. Drawings and/or written observations should include qualitative measurements about how much sediment was removed- a lot or a little, what sized sediments were removed- small or large (if the mud pies are made of various sized sediments), and comparisons to the results of the other investigations during the activity.

  Under the box, there is space for the students to answer "Type or cause of weathering?" For this, the students are asked to interpret *what natural event the materials they used represent.* Please note that neither the directions nor the worksheets have identified or labeled any investigation as representing any specific force/natural event. While certain forces were designed to be modeled in this activity, it is purposefully open to interpretation for the students to decide for themselves which natural process they feel they have acted out. For example, the sandpaper was designed to represent abrasive wind, where sediments suspended in air scrape across the surface of a rock. However, students may associate the sandpaper with the grinding and scouring of glaciers or they may see it as another abrasive force.

Student Tasks:

1. Tell students they will be conducting several "investigations" on the mud pies. Check for understanding that they will be “weathering” the mud pies throughout the activity and that the mud pies are a *model* for consolidated sediment or rock. As they observe what happens to the mud pies, ask the students to share their observations with a partner or in a small group as they fill out Section 2 of their worksheets. Encourage students to continue to add to their list of weathering causes in Section 1 if possible.
2. **Ice/Marble:** Tell students to firmly and slowly rub the ice cube or marble over the mud pie several times.
3. **Sandpaper:** Have students rub sandpaper over the mud pie. Encourage them to experiment with different speeds by rubbing more quickly or slowly. If available,

Figure 2- A student rubs sandpaper over a mud pie.

Figure 3- A student rubbing a mud pie with a large rock.

Figure 4- A student displays the weathering from rubbing a small rock on a mud pie.

have them use different roughness grades of sandpaper or other abrasive materials.

- When loose sediment begins to build up on top of the mud pie, tell students to gently brush off the loose sediments. *Note: Remind students to be careful of getting sediment in the air, and to be careful of their eyes. If available, have the students wear safety goggles.*

4. **Drip:** Have students use an eyedropper to drop water on the mud pie. Encourage them to try to drip water in one spot repeatedly.
5. **Spray:** Students will use a spray bottle to spray water on a mud pie. Encourage students to try spraying the mud pie at different angles and to try spraying one spot repeatedly. If available, have them experiment with mist and stream settings.
6. *Optional: Chemical weathering test.* When acids interact with carbonates, like acid rain on limestone, bubbles appear from the release of carbon dioxide. Fill an eyedropper with vinegar and drip it on a mud pie. If bubbles appear, that indcateds the presence of carbonates in the mud.
7. **Submerge:** Place a mud pie in a small cup, tub, or wash-bin. Have students slowly pour water over the mud pie until it is completely submerged. Then have students try sloshing the water over the mud pie by carefully moving the tub side to side. *Note: remind students to be careful as they slosh water.*
8. **Drop:** Place a plastic drop cloth, butcher paper, or newspaper on the floor in one area of the room. Have the students drop the mud pie on the drop cloth. *Note: Remind students to be careful- they are not to throw the mud pie or let it land anywhere else but the drop cloth.* Have students try dropping the mud pie from different heights. They should try dropping from ankle, knee, hip, and shoulder height. The same mud pie can be dropped several times, even after breaking.

- If weather allows, this step can be done outside on a hard surface with or without a drop cloth. Be sure to establish a clearly defined area where the students are allowed to drop the mud pies. Sweep the area afterwards to clear away the dirt.

Figure 5- A student watches fine sediments wash away as he drips water over a mud pie (drip investigation).

Figure 6- A student sprays a mud pie with a spray bottle (spray investigation).

Figure 7- A student pours water over a mud pie for the sub-merge investigation.

Figure 8- A student prepares to drop a mud pie from ankle height (drop investigation).

9. *Ask the class if they think the rate of weathering would be faster or slower on the smaller pieces of mud pie?* Encourage the students to try some of the previous investigations on the broken pieces of mud pie to help them answer the question.
10. After experimenting with the mud pies, bring the class together for a group discussion.

    a. Bring out one or two frozen mud pies to pass around the classroom. The students should be able to see the ice crystals that have formed in the mud pie. Do not worry if the mud pie breaks apart because it will only help to show water's ability to expand and break apart rocks as it freezes.

    c. Have the class compare answers about what cause/type of weathering each investigation represented. *Did the students come up with the same answers to each one?* Ask the students if any processes they came up with in Section 1 were not modeled during the activity and discuss ways they could investigate chemical and biological weathering.

Figure 9- A look at some of the differences in mud pie weathering from the different investigations.

Activity 2: Erosion

Students will use various tools to act out different situations, refered to as "investigations" throughout the directions, to explore the geomorphic process of erosion on loose material. They will use soil in a controlled environment (a paint tray or other alternative) to model erosion caused by glaciers, wind, rain, flowing streams, floods, and beaches. Additionally, they will have the option to test multiple variables to see which creates the greatest change. By modeling these natural processes, they may begin to understand the development of landforms and parent material for soil, as well as the movement of materials across the globe (NGSS CCC Cause and Effect).

Teacher Notes:

Materials

- Materials for each group:
  - Paint trays (at least one per group)
    - Alternative Options: aluminum foil pans or shallow plastic bins. If using one of these alternatives, also provide wood blocks, small planks, or books to create a small angle slope. Additional blocks/planks or books will be needed for some investigations (see below). Water, soil, and mud may get on the books or wood. Wrap these in plastic if you wish to keep them protected.
  - About ½ liter of loose soil per tray. The loose soil can be purchased from a store or collected from outside, either from school or from students' homes. If purchased, buy soil that most resembles natural soil. Do not buy potting mixes with perlite or vermiculite. The same soil that was used to make the mud pies in Activity 1 can be used for this activity as well.
  - About 1-2 handfuls of pebbles and small rocks (2-40mm diameter) per tray
  - Worksheets
- Materials for the Investigations:
  - **Glacier:**
    - 1-2 ice cubes and/or a frozen mud pie (whole or broken) per group (can substitute with a palm-sized or smaller rock)
  - **Wind:**
    - Hairdryer (alternative option: straws)
    - Stopwatch, timer, or clock
  - **Rain:**
    - Eyedropper (filled with water)
    - Spray bottle (filled with water)
    - 1-3 books or wood blocks/planks per group (to create greater slope angle)
      - Wrap books in plastic to protect from spills
  - **Flow/Flood:**
    - Water
    - Two 50ml graduated cylinders (only 1 needed for Flood)
    - 1-3 books or wood blocks/planks per group (to create greater slope angle)
      - Wrap books in plastic to protect from spills
  - **Beach:**
    - Water
  - Optional materials: safety goggles and gloves
- Additional Materials for the classroom:
  - Newspaper, butcher paper, or plastic drop cloth to cover the workstation.
  - Paper towels or rags to clean up spills and accidents.

Preparation

- **At least one day before starting the experiment:**
  - If using ice cubes, make them by filling an ice tray with water and freezing overnight.

Figure 10- A paint tray with lines drawn every 5cm (left) and the tray after being filled with a mix of soil and rocks (right).

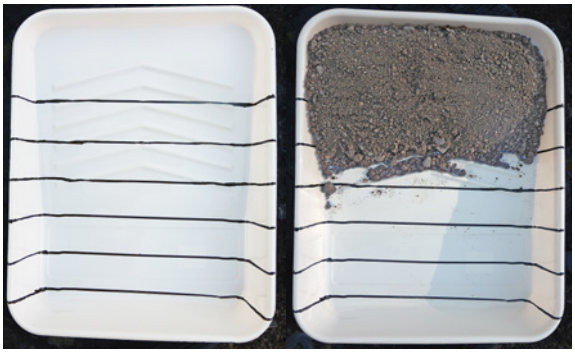


Figure 11- A side view of the paint tray. This tray needed a wood block placed under in in order to create a "neutral" slope angle.

Figure 12- Students add a wood block under the soil end of the tray to increase the slope angle before doing the "advanced" rain investigation.

- Use a waterproof or permanent marker to draw a line every 5cm across each paint tray (or alternative). Let lines dry completely before filling with soil.
- Prepare the soil trays. Firmly pack a mixture of soil and rocks in the raised end of a paint tray. If using a pan or bin, fill one half with the soil and rock mixture and then stack wrapped books or wood planks/blocks under the soil end of the pan or bin to create a small-angle slope (~3-15 degrees). Secure the pan or bin in place with tape or rubber bands. Prep time should take about 2-5 minutes per tray, pan, or bin. Keep additional soil available during the activity for students to replace lost soil when they repack their trays between investigations.
- Wrap additional books in plastic to have available to create greater slope angles (~15-40 degrees) during the advanced investigations.

▪ **Any time before starting the experiment:**

- Copy the Erosion Worksheets for each student.
- Introduce the concept of erosion to the class. The *Background* section has an overview with some examples and mentions some of the implications of erosion, but further research is always encouraged. Students should be familiar with the types and causes of erosion as well as the landforms that may be formed by erosion. Have students fill out Section 1 of their worksheets which asks for them to list causes of erosion and examples of landforms caused by erosion. For students to fill out Section 1 of their worksheets, teachers may either lead a class discussion about erosion or students can do their own research on causes and examples of erosion.
- Remember, this activity will only explore a few causes of erosion. In order for students to have a more complete understanding of this phenomena, it is up to the teacher to review other causes not explored in this activity, as well as check for understanding about how erosion can impact our world. If needed, students should be reminded that sediments that have stopped moving, or eroding, are "deposited" and that deposited sediments can contribute to the formation of soil by becoming *parent material*.
- An optional supporting experiment to explore the effect of plants on erosion is described under *Further Investigations*. If you plan on including this activity, be sure to prepare ahead of time. Please note that this activity requires additional materials that may need to be purchased or grown.
- In case of spills or accidents, lay down newspaper, butcher paper, plastic cloth, or some other protective surface on the table underneath the experiment. Wrap the books that will be used to create slope angles in plastic to protect them from spills. Keep paper towels or rags handy for spills and accidents.

- This activity is best done in small groups of 2-4 students. If classroom materials are limited, set up different stations around the room for each investigation and have the students rotate around the stations.
- Students will model several different causes of erosion and will have the option to test multiple variables to see how the amount of erosion changes under different conditions. Directions for testing additional variables are included in the Student Tasks section as “advanced.” The students can use the same tray throughout each investigation, including any "advanced" tests. Soil can be repacked or replaced and

water can be drained as needed between tests throughout each investigation.

- After each investigation, allow students time to fill out Section 2 of their worksheets. Unlike Activity 1, the natural events they are modeling are identified for them, but they should still be encouraged to consider other natural processes that could be modeled by their actions. Students will use the lines on the trays to assess how much sediment was moved and compare how far sediments of different sizes traveled. The worksheets have boxes for students to draw what the soil tray looks like after each investigation. Students performing multiple variables ("advanced" tests) should draw their tray after all the variables have been tested. Written observations can be substituted for the drawings. There are drawing suggestions and questions on the worksheets to help guide the students but they should be encouraged to include any additional notes and observations. Drawings and/or written observations should include information about what sized sediments were removed or affected (large pebbles or smaller sand, silt, or clay sediments), how much material was moved across the tray, if different sized sediments traveled different distances, and comparisons to the results from each variable tested as well as results from the other investigations during the activity. As well, students should be sure to use the correct terminology in their descriptions. For example, they should refer to the sediments that have settled in the bottom of their trays as being "deposited."

Student Tasks:

1. Tell students they will conduct several tests on their soil tray. Make sure students understand that they will be “eroding” the soil throughout the activity and that the soil models loose sediments or soil found in nature. As they observe what happens to the soil, ask the students to share their observations with their group as they fill out Section 2 of their worksheets. Encourage students to continue to add to their list of erosion causes in Section 1 if possible.
2. Throughout the experiment, the soil may need to be repacked or replaced between tests. After describing how much and how far the sediment moved across the tray on their worksheets, students can repack or replace the soil at one end of the tray as needed.

Figure 13- A student repacks the soil on her tray after an investigation.

3. **Glacier:** Tell the students to firmly and slowly rub an ice cube or frozen mud pie over the *surface* of the soil from the top of the soil pile to the bottom of the soil pile (downslope). A palm sized or smaller rock can be used as a substitute for the ice.

   ► Advanced: Use greater pressure when pushing the the ice, mud pie, or rock into the soil.

   ▪ Critical Thinking: *As a class, discuss how glaciers can erode by dragging rocks and sediments along the bottom of the glacier as it flows, by carrying rocks and sediments on top of the glacier as it flows, and by incorporating rocks and sediments into the glacier itself. Ask the students if these three processes were demonstrated using the ice and soil.* Have the students answer this question in the Observations/Notes section of their worksheets.

Figure 14- Students rub a rock (top) and a mud pie (bottom) over the soil tray to model glaciers carving out different landscape features (glacier investigation). After the photo was taken, the students compared the piles of sediment they created next to and below where they rubbed their rock and mud pie. In a natural landscape, these "piles" of glacially carried sediments, rocks, and other debris are called moraines.

4. **Wind:** Tell the students to point the hairdryer above and down the slope of the soil (see Figure 15). Using a low setting, have the students blow on one area of the soil for 1 minute continuously. *Note: Remind students to be careful of the sediments in the air, and to be careful of their eyes. Tell the students to warn their team that they are about to blow sediment in the air so it doesn't get in their teammates' eyes. Make sure everyone stands behind the person using the hairdryer. If available, also have the students wear safety goggles. If too much sediment is becoming airborne, dampen the soil with water using a spray bottle.*

   ► Advanced: Have students experiment with pulsing wind by having them alternate between blowing on the soil for 3 seconds and then turning the hairdryer off for 1 second. Repeat 5-10 times. Compare the results on the soil between the different lengths of time (continuous/pulse). Critical Thinking: *How were the "landforms" created in the soil similar or different? Did different amounts or sizes of sediment get blown away?* Have the students answer these questions in the Observations/Notes section of their worksheets.

   ▪ Straws may be substituted for the hair dryer. Students should start by softly blowing into the straw for several seconds. To test different variables, students can pulse air by blowing into the straw for one second at a time 5-10 times with breaks between the pulses. *Note: Make sure students are taking deep breaths between blowing into the straw and taking breaks as needed so that they do not get dizzy or short of breath. Also warn students to only blow through the straw and to not inhale air or soil through the straw. Be careful of airborn sediments. Have students stand away from the soil tray when someone is blowing on it. If available, have the students wear safety goggles. If too much sediment is becoming airborne, dampen the soil with water using a spray bottle.*

Figure 15- A student holds a hairdryer above the tray and behind the soil pile while directing the air down the slope of soil (wind investigation).

5. **Rain:**

   a. **Drip:** Have students use an eyedropper to drop water on the soil. Encourage them to try to drop water in one spot repeatedly to see if a "landform" is created. A squirt bottle may be sutbstituted for an eyedropper.

Figure 16- A student uses an eydropper to drip water on the soil tray (rain investigation).

   b. **Spray:** Tell students to use a spray bottle to spray the soil with water. Have the students try spraying the soil at different angles and try spraying one area repeatedly to see if a "landform" is created. If available, have them experiment with mist and stream settings.

   ► Advanced: Place books (or wood blocks/planks) under the soil end of the tray (or pan) to create a greater

Figure 17- Examining a washout in the soil during the rain investigation. Mudslides, or landslides, in nature often occur after large rainfall events when soil becomes saturated with water and flows downhill.

Figure 18- Students monitor the differences while using spray and squirt bottles on the soil. This class substituted an eyedropper for a squirt bottle for the drip investigation.

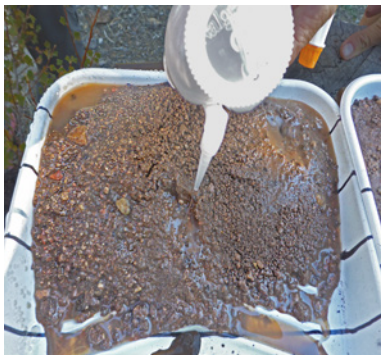


Figure 19- A student sprays one spot on the soil with a spray bottle on a "stream" setting (rain investigation).

Figure 20- Observing the landmarks and the different sized sediments affected by the squirt and spray bottles (rain investigation).

slope angle (15-40 degrees). **Do not exceed a 45-degree angle.** Have the students repeat the Drip and Spray investigations with the steeper slope. With their small group, have students share their observations and compare the results they got from the shallow angle and the steep angle. Then have them record their observations and comparisons on their worksheets. Make sure to remove the books so that their tray (or pan) is once again at the original small (or "neutral") angle before moving on to the next investigation. Drain water from the tray if needed.

6. **Flow:** Fill two 50ml graduated cylinders with 50ml of water. Have two students pour the water over the soil on opposite sides of the tray at different speeds. One student will pour their 50 ml of water slowly and continuously. The other student will pour a little bit of water out at a time until eventually all of the water has been poured out (pulse flow). Tell the group to compare and contrast the different sides of the tray.

Figure 21- Two students pour water over the soil during the flow investigation. The student on the left contnuously pours her water out. The student on the right "pulses" her flow.

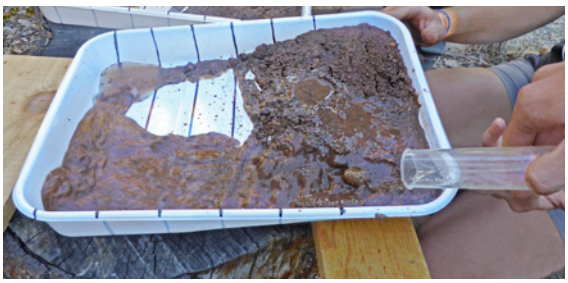
► Advanced: Drain out the water and repack the soil at one end of the tray. Stack books under the soil side of the tray to create a greater slope angle (15-40 degrees). **Do not exceed a 45-degree angle**. Repeat step 6 (Flow) with the greater slope angle. With their small group, have students to share their observations and compare the results they got from a shallow angle versus a steep angle. Then have them record their observations and comparisons on their worksheets. Drain out any water in the tray and return the tray to the original small (or "neutral") angle by removing the additional books before starting the next investigation.

- Critical Thinking: *Ask the students if the water flowed over or through the soil differently on each side of the tray.* Have the students answer this question in the Observations/Notes sections of their worksheets.

7. **Flood:** Fill up a 50ml graduated cylinder with 50ml of water, then have a student create a “flooding event” by quickly pouring all the water over the soil.

► There are no advanced options for this step.

Figure 22- Students perform the flow investigation with the tray at a greater slope angle.



8. **Beach:** Create a beach by filling one half of the tray or pan with soil and the other half with water. The water should reach the edge of the soil but not submerge most or all of the soil. You can use the same tray from step 7 (Flood) without draining the water and by adding more water as needed. If you are using a pan or bin, remove any books or planks so that the pan or bin lies flat on the table before filling it with water. Have a student gently move the tray or pan back and forth so the water flows over some but not all of the soil. *Note: remind students to be careful as they move the tray. They should be creating gentle waves in the tray and not spilling or sloshing water over the edge of the tray.*

   a. Leave the tray to settle for 5 minutes.

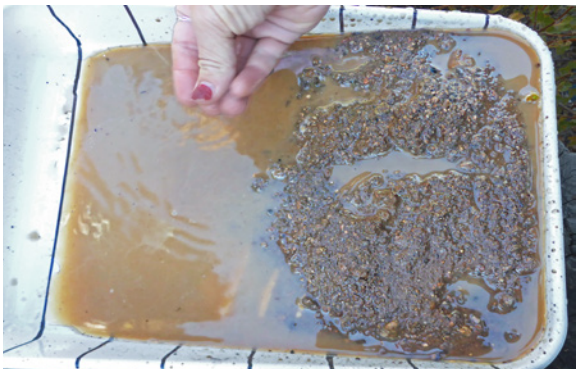
   b. Bring students back to the tray. Have the students discuss with a partner or the group what they see and feel has happened to the sediments that are in the water and the sediments that have not been washed away and remain in the soil pile. Critical Thinking: *Ask the group what are the differences between the sizes of the sediments in the water versus the sediments that remain in the soil pile?* Have the students record their answers in the Observations/Notes section on their worksheets.

   ▪ For a more in depth understanding of how sediments settle, try Part 2 of Elementary GLOBE Learning Activity *Getting to Know Soil*.

   ► There are no advanced options for this step.

Figure 23- A student creates waves by moving their paint tray back and forth to model a beach during the beach investigation.

Figure 24- A student feels the deposited sediments in the water after performing the beach investigation.



Assessment

Students should understand the scientific content relating to weathering, erosion, and deposition of rock and soil and be able to differentiate between these processes. Students should demonstrate higher order thinking skills such as understanding the connection between classroom models and real world events and be able to identify examples of natural processes of weathering, erosion, and deposition. Students should understand how weathering and erosion shape landscapes and help contribute to the parent material in the soil formation process. They should be able to take detailed notes about experimental observations and use their observations to draw conclusions about scientific processes. Students should be able to make comparisons between experimental results of different tests as well as be able to contrast results of similar tests in which a single variable has been altered. It is suggested that the students prepare a written report on the experiment in which they include a summary of their observations as well as include questions, hypotheses, and conclusions for the experiment.

Further Investigations

1. **How do the presence of plants affect erosion? (NGSS 2-ESS2-1)**

   - Repeat Activity 2 on trays that have vegetation. For this, you may use turf, Easter grass, wheatgrass, barley, or some other quick growing plant. Be sure to plan and plant ahead of time to allow the plants grow before starting the experiment. To save time, grass ot turf may be harvested from the outside if available.
   - If you are unable to use plants, toothpicks can be used as an alternative. Stick the toothpicks in the soil so they are sticking straight up and down and that about half the toothpick is buried in the soil. Place the toothpicks 1-3cm apart over all of the soil. They do not have to be placed in any particular pattern.
   - Before starting the experiment, have the students *hypothesize* about what effect the plants will have on the rate or amount of erosion and how the results will compare to the bare soil results. Have the students write their hypotheses on a separate piece of paper. During the experiment, have students write down comparisons to the bare soil results under their hypotheses.
   - Follow the investigation with a discussion about soil erosion and how the presence of plants help to prevent erosion. Discuss why soil conservation is an important topic. Some information about this is provided in the introduction. This activity can also be used to introduce the concept of infiltration, which is explored in the Infiltration Protocol as well as the pedosphere Learning Activity *Just Passing Through*.

2. **How do weathering and erosion affect you?**

   - Collect 3-8 photographs of an extreme weather event or natural disaster which has caused a lot of weathering and/or erosion, preferably one that has affected your local area. Show the students the phtographs and have them draw connections and comparisons between the investigations they performed during the activities and the natural event you have chosen to examine. They should identify which investigations best represent the natural event that is being discussed.
   - Have the students conduct research on an extreme weather event or natural disaster that can cause significant weathering and erosion that is different from the one used as the class example. Have the students write a short report on the event they chose or have the students include their research findings in their experiment reports. Have the students to draw connections to the activities they performed in class by identifying which investigations they performed during the activities best represent their chosen event (CCSS.ELA-LITERACY.RI.5.7), (CCSS.ELA-LITERACY.W.5.8).
   - Enhance student data by incorporating NASA data and images into projects. The Landsat satellites provide images and records of Earth's land. NASA Landsat Data is free and can be used to see changes to Earth's surface and damage from natural disasters from space. Learn more about the Landsat satellite mission at http://landsat.gsfc.nasa.gov/. There are also a variety of Landsat Educational Activities for grades K-12 for students to learn about remote sensing, using Landsat data, and exploring land changes over time.
   - Check it out! The NASA publication Geomorphology From Space: A Global Overview of Regional Landforms has a gallery of landform images from space. It was published for scientists to study landforms and landscapes and is available for free to the public online at http://disc.sci.gsfc.nasa.gov/geomorphology.

Soil Makers Activity 1: Weathering

Worksheet

Section 1:

What are some causes of weathering? List as many as possible before starting the activity.

_____

_____

_____

_____

_____

Section 2:

Draw a picture of your mud pie in the blank square after completing the investigation. Include details to show *how much sediment was removed (a lot or a little)* and *what sized sediment was removed (big or small)*.

Use the Observations/Notes section to include anything you were not able to show in your picture, such as *comparisons to the other investigations.* If there is not enough room for your notes, use an additional sheet of paper.

Under the question "Type or cause of weathering?" use your critical thinking skills to make an educated guess about what natural event(s) you modeled based on the materials you used and the actions you took.

Ice/Marble

Type or cause of weathering?

Observations/Notes

_____

_____

_____

_____

_____

Sandpaper

Type or cause of weathering?

Observations/Notes

_____

_____

_____

_____

_____

Drip

Observations/Notes

Type or cause of weathering?

Spray

Observations/Notes

Type or cause of weathering?

Submerge

Observations/Notes

Type or cause of weathering?

Drop

Observations/Notes

Type or cause of weathering?

Soil Makers Activity 2: Erosion

Worksheet

Section 1:

What are some causes of erosion? List as many as possible before starting the activity.

_____

_____

_____

_____

Section 2:

Draw a picture of your soil and tray in the blank rectangle after completing the investigation. Include and "landforms" that were created as well as details to show *what sized sediment was moved (large pebbles or smaller sand, silt, or clay sediments), how much sediment moved across the tray (a lot or a little)* and *if different size sediments move different distances (did pebbles move as far as silt?)*.

Use the Observations/Notes section to answer the "Critical Thinking" questions that are under the blank rectangle. As well, use the space provided to include anything you were not able to show in your picture, such as *comparisons between the results from the variables you tested* and *comparisons to the other investigations.* If there is not enough room for your notes, use an additional sheet of paper.

Glacier

Observations/Notes

Critical Thinking: Glaciers can erode by dragging or carrying rocks and sediments along the bottom of the glacier, on top of the glacier, and in the glacier as it flows. Were these three processes modeled during this investigation?

Wind

Observations/Notes

Critical Thinking: Compare the steady wind to the "pulse" wind. How were the "landforms" created in the soil similar or different? Did different amounts or sizes of sediment get blown away?

Rain

Critical Thinking: How were the results from the drip and spray tests similar or different? What happened when the slope was increased?

Observations/Notes

Flow

Critical Thinking: Did the water flow over or through the soil differently on each side of the tray (steady flow side versus pulse flow side)? What happened when the slope was increased?

Observations/Notes

Flood

Critical Thinking: What landform was created by the flood? What other natural disasters can cause similar amounts of erosion?

Observations/Notes

Beach

Critical Thinking: What were the differences between the sizes and feel of the sediments that are in the water and the sediments that remained in the soil pile?

Observations/Notes