**A Super Cool Type of Mass Movement!**

**Glacial Flow (Slip, Sliding Away)**

**Part of the Cryosphere**

Scientists use the word “Cryosphere” to describe all locations on Earth where water is found in solid form, including areas of snow, sea ice, glaciers, permafrost, ice sheets and icebergs. Like other Earth systems, the Cryosphere is constantly changing as snow and ice go through cycles of accumulation and melt and get pushed around by wind, ocean currents, and other dynamic forces.

This lesson focuses on "land ice" (glaciers).

**Visit the National Snow and Ice Data Center's (NSIDC) “All About the Cryosphere” page to study other components of the Cryosphere.**

Despite their massive sizes and seeming permanence, glaciers are always on the move. Gravity pulls glacial ice downhill and causes it to deform under its own weight. As glaciers move across the landscape, erosion and deposition of soil, rock, and debris change the underlying surface. Past glaciers are responsible for many beautiful and sometimes strange geological features such as rolling hills in Ireland, fjords in Norway, and giant boulders in New York City's Central Park. Most glaciers creep along at a pace that's too slow to detect with the naked eye (about a foot a day). But sometimes conditions are just right to cause glaciers to **surge** forward at speeds up to 100+ feet per day!

Discuss within your group, factors that may influence the rate of glacial movement; essentially what may affect the rate at which a glacier moves?

For the remainder of this lesson, we will focus on one variable/factor.

The variable will be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Models are representations of real world conditions/phenomenon, and can be used to test how something works. Today we will make a model of a glacier (flubber) and observe how it moves. We will use the flubber to simulate glacial ice. *(Flubber is a polymer that has the properties of both a liquid and a solid. The molecules in the flubber are loosely arranged and can slide past each other.)*

**Materials:**

 • 2 tsp Borax powder • books to prop up chute

 • 1 1/3 cups warm water • ruler

 • 1 1/2 cups warm water • timer

 • 2 cups white glue • rubber gloves

 • 2 mixing bowls

 • stirring spoon or stick

 • airtight container or zip lock bag

 • chute made from PVC Pipe or cookie sheet

 • permanent marker or blue tape (to mark the terminus)

**Recipe to make the glacier model “flubber”.**

1. In the first mixing bowl, combine 1 1/2 cups warm water and 2 cups glue. Stir until well mixed.
2. In the second mixing bowl, combine 1 1/3 cups warm water and 2 tsp of Borax powder and stir until the powder is fully dissolved.
3. Combine the contents of the two-mixing bowls, and stir until a glob forms. *Get a feel for the properties of the flubber. Stretch it slowly. Pull on it quickly. How does it behave?*
4. Use your hands to knead the mixture in the bowl until it is well mixed (approx. 2-3 minutes). Discard any leftover liquid. *Flubber can keep up to two weeks if kept in an airtight container. Flubber likes to stick to cloth, carpet, and you may use vinegar as a solvent.*

**Procedures:**

**Trial 1**

1. Prop up one end of the PVC pipe chute with books so the glacier will be able to flow downhill, measure the angle and record, \_\_\_\_\_\_\_\_\_\_\_\_\_\_.
2. Place the entire "glacier" at the top of the chute. **(Leave 5cm of space at the top of the chute, so that the glacier doesn’t expand over the back.)**
3. With a permanent pen, mark the front end of the glacier (the terminus) on the container or chute. *(You may also draw a straight line on the top of the glacier to observe how the middle and sides of the glacier move at different rates.)*
4. Set your timer for 5 minutes.
5. Mark the final location of the glacier terminus.
6. Measure the distance the glacier traveled from start to finish at the center, the left side, and the right side of the glacier.
7. Determine the rate of flow for all three by dividing distance by time. [Distance glacier traveled (cm) / Time (min)]
8. Record your results in the data table.

**Trial 2:**

1. Predict how the glacier, with a different slope, will flow compared to trial 1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Set up the experiment again, as in trial 1. Make sure you have recorded the new angle. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Mark the initial location of the glacier terminus.
3. Set your timer for 5 minutes.
4. Mark the final location of the glacier terminus.
5. Measure the distance the glacier traveled from start to finish at the center, the left side, and the right side of the glacier.
6. Determine the rate of flow for trial 2, and record your results.

**Trial 1 Date Table: Glacier Terminus Movement (cm) (\_\_\_\_\_\_\_\_\_angle)**

|  |  |  |  |
| --- | --- | --- | --- |
| Time | Center of terminus | Left side of terminus | Right side of terminus |
| 5 minutes |  |  |  |
| Rate of Flow (cm/min) |  |  |  |

**Trial 2 Date Table: Glacier Terminus Movement (cm) (\_\_\_\_\_\_\_\_\_angle)**

|  |  |  |  |
| --- | --- | --- | --- |
| Time | Center of terminus | Left side of terminus | Right side of terminus |
| 5 minutes |  |  |  |
| Rate of Flow (cm/min) |  |  |  |

**Clean up area and WASH hands.**

**Discussion questions:**

**1:** When the glacier initially flowed, what shape did the front of the glacier take?

**2:** What part of the glacier flows the fastest? Why would this be the case?

**3:** Why is it important for scientists to find out how fast glaciers are moving?

**4:** What other variables that affect the rate of glacier movement could we test?

**Key Vocabulary:**

**ablation**

processes (melting, evaporation, sublimation) by which snow and ice are lost/removed from a glacier.

**accumulation**

processes (precipitation) by which snow is added to a glacier.

**Cryosphere**

the set of all locations on or beneath Earth's surface where frozen water exists.

**glacier**

a mass of ice that originates on land, usually having an area larger than one tenth of a square kilometer; many believe that a glacier must show some type of movement; others believe that a glacier can show evidence of past or present movement.

[**glacier**](https://nsidc.org/cgi-bin/words/word.pl?glacier) [**surges**](https://nsidc.org/cgi-bin/words/word.pl?surging%20glacier)

 the glacier flows more quickly, sometimes moving 10 to 100 times faster than it normally does.

**mass balance**

the difference between accumulation and ablation in a glacier; if accumulation is greater than ablation, mass balance is positive; if accumulation is less than ablation, mass balance is negative; if accumulation = ablation, mass balance is zero (equilibrium).

 **terminus**

the front of a **glacier**, usually the lowest end, and is also called a glacier toe or snout.

**Resources:**

<http://serc.carleton.edu/eslabs/cryosphere/3c.html> (**Science Education Resource Center (SERC) at Carleton College)** SERC is grant funded by the National Science Foundation.

<https://nsidc.org/> (**National Snow and Ice Data Center)** NSIDC is supported by NASA, the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), and other federal agencies, through competitive grants and contracts.

Glacier Background Information for Teachers

The following information is from the article, "*All About Glaciers.*" National Snow and Ice Data Center. Accessed 8 May 2017. https://nsidc.org/cryosphere/glaciers.

**Why do they move?**

The sheer weight of a thick layer of **ice**, or the force of gravity on the ice mass, causes **glaciers** to flow very slowly. Ice is a soft material, in comparison to rock, and is much more easily deformed by this relentless pressure of its own weight. Ice may flow down mountain valleys, fan out across plains, or in some locations, spread out onto the sea. Movement along the underside of a glacier is slower than movement at the top due to the friction created as it slides along the ground's surface, and in some cases where the base of the glacier is very cold, the movement at the bottom can be a tiny fraction of the speed of flow at the surface.

Glaciers periodically **retreat** or **advance**, depending on the amount of snow accumulation or evaporation or melt that occurs. This retreat and advance refers only to the position of the terminus, or snout, of the glacier. Even as it retreats, the glacier still deforms and moves downslope, like a conveyor belt. For most glaciers, retreating and advancing are very slow occurrences, requiring years or decades to have a significant effect. However, when glaciers retreat rapidly, movement may be visible over a few months or years. For instance, massive glacier retreat has been recorded in Glacier Bay, Alaska. Glaciers that once terminated in the ocean have now receded onto land, retreating far up valleys. Over the past several decades, scientists and researchers have begun to capture data and photographic evidence of this recession over time.

Alternatively, glaciers may **surge**, racing forward several meters per day for weeks or even months. In 1986, the Hubbard Glacier in Alaska surged at the rate of 10 meters (32 feet) per day across the mouth of Russell Fjord. In only two months, the glacier had dammed water in the **fjord** and created a lake.