

## GLACIERS

### What is a glacier?

Snow falls and accumulates on the ground everywhere in New York State. In the highest parts of the Adirondack Mountains, winter snow often lasts into early summer before it is completely melted. If the mountains were 1000 or 2000 meters higher, the reduced warmth of summer would not be able to melt winter snow. Each year more snow would accumulate and exert pressure on the underlying snow. This pressure would change the snow to ice and gravity would make the ice begin to flow downhill. This is how glaciers form. The reason that no glaciers exist today in New York State is that there are no places where the snow does not completely melt before the following winter.

Snow and ice exist as crystals. When snow falls, the flakes are usually light and feathery. After the flakes reach the ground and are buried under fresh snow, the delicate crystals gradually change to solid ice over a period of time that depends on such factors as speed of burial and temperature. Is ice a solid or a liquid? Ice is composed of water in the crystalline solid form. It fits the definition of a solid. Under short-term stress, ice behaves as a solid. An ice cube in an environment below freezing has a fixed shape. Hit it with a hammer and it breaks into smaller pieces. Yet, ice in a glacier flows. Glaciers do not flow because the ice is melting. They flow because solid ice responds to long-term stress by bending and deforming.

1. Briefly describe how glaciers form.

\_\_\_\_\_

2. Why are there currently no glaciers in New York State?

\_\_\_\_\_

3. What causes ice, a solid material, to be able to flow downhill like a liquid?

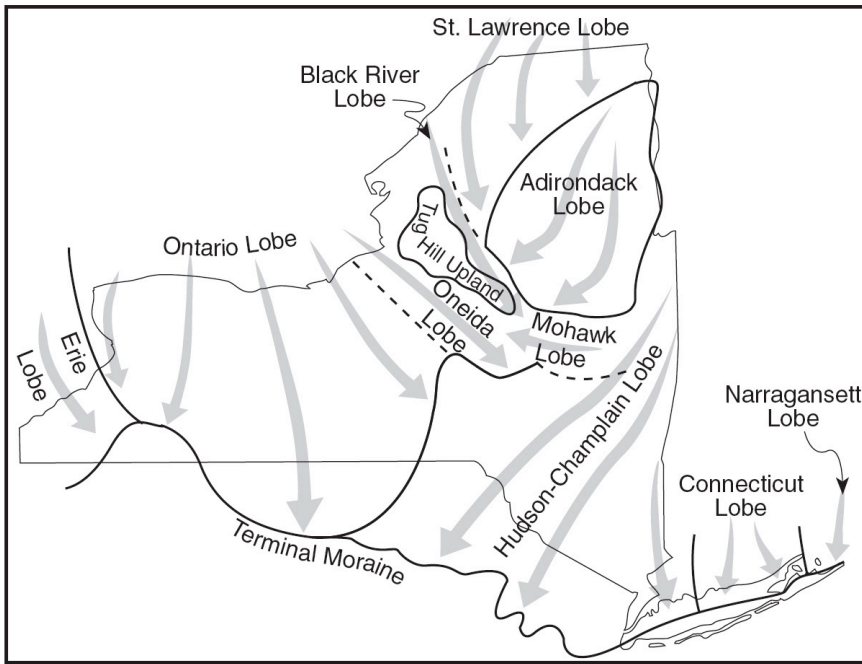
\_\_\_\_\_

<b>Types of Glaciers</b>	
<b>Continental Glaciers</b>	<b>Valley Glaciers</b>
<p>A continental glacier flows outward from a zone of accumulation to cover a large part of a continent. If the process could be speeded up, it might resemble what pancake batter looks like as it is poured onto a griddle. Ice sheets that are several kilometers thick now cover most of Greenland and Antarctica. Scientists have studied both regions to gain an understanding of ice caps and how they flow outward and down to the oceans. Ice flowing into an ocean breaks away from the main body of the glacier to float away as icebergs. Because ice is less dense than water, icebergs do not sink. Icebergs from Greenland and Antarctica are large enough to pose a threat to the shipping industry. A number of vessels, for example the Titanic, have sunk due to damage from collisions with icebergs. Fortunately, icebergs break up and melt before they can invade most ocean areas.</p>	<p>Once permanent ice has formed atop mountains, it begins to flow downhill under the influence of gravity. Valley glaciers, which begin high in mountain areas, flow from the high ice fields through valleys to lower elevations. Most valley glaciers descend to an elevation where it is warm enough to melt the ice as quickly as it advances. If the ice in the glacier is moving forward at a rate of 1 meter/day, but the ice is also melting back 1 meter/day, the front of the glacier will not appear to move. This is known as a dynamic equilibrium because the rate of flow and the rate of melting are in balance. Even though the end of the glacier may be in the same place from year to year, the ice is, in fact, constantly moving downhill. Ice in a small glacier may advance only a few millimeters a day while larger ones may advance a few centimeters a day. As gradient and volume affect the speed of water in rivers, they also influence the speed of ice flow in glaciers. Also, like the water in most rivers, ice moves fastest near the center and near the surface of a glacier.</p>

4. What is the main difference between a continental glacier and a valley glacier?

\_\_\_\_\_

The diagram on the left shows the extent to which the last continental ice sheet extended during the last ice age, approximately 20,000 years ago.



5. What general direction did the ice sheet move? Why do you think this is?

---



---



---

6. What do you think the “terminal Moraine” is and what does it tell us about the glacier that once covered New York State?

---



---



---



---

**How do Glaciers Cause Erosion?**

When a glacier advances down a valley or over a continent, the ice pushes, carries, and drags great quantities of soil and sediment. These loose materials have little chance of remaining in place when a mass of ice

hundreds or even thousands of meters thick moves over them. Ridges and knobs of bedrock are pried loose or rounded by the moving ice. Although ice is much softer than most bedrock, the rocks and sediment dragged along the bottom of a glacier scrape and scour the bedrock over which the glacier passes.

7. How can glacial striations (scratches) tell you the direction the glacier moved?

---



---

**Valleys**

In mountainous or hilly terrain, advancing glaciers seek the lowest passages and move through valleys first. Stream valleys often have a V-shape in profile, especially in mountain areas. Streams and the sediment they carry occupy only the bottom of the valley and do not erode the sides of the valley. The sides of a stream valley in mountainous terrain collapse under the influence of weathering and gravity, which often give them a steep but uniform slope of the V-profile. When a glacier moves down a mountain valley filling it with ice, the erosive action of the glacier and its load of sediment pluck, scrape, and scour the sides of the valley changing its profile to a broader U-shape. U-shaped valleys are strong evidence of glacial erosion.

8. Why do rivers create V-shaped valleys while glaciers create U-shaped valleys?

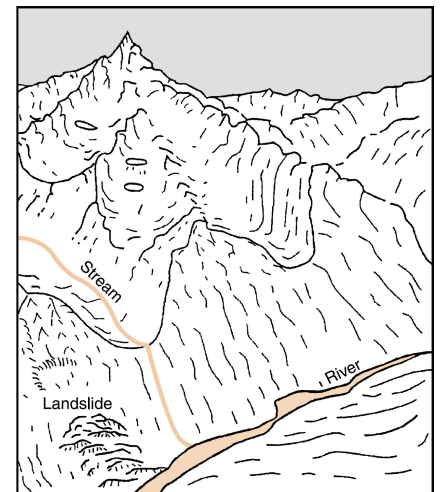
---



---

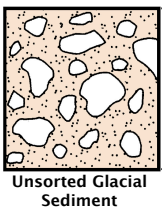


---



**How Can we Recognize Deposition Caused by Glaciers?**

Sediment transported by glaciers must also be deposited. There are several differences between sediments deposited by ice and sediments deposited by water or wind. Water and wind sort sediments. Moving ice transports and deposits sediment without regard to particle sizes. Therefore, sediments deposited directly by glaciers are unsorted and do not show layering. This unsorted glacial debris is sometimes called till. Stream sediments are deposited where streams flow, usually in the bottom of a valley. But a glacier can move its debris anywhere that the ice covers, even to the highest parts of New York State. Glacial sediments often cover the whole land surface with an uneven blanket of till composed of mixed particle sizes. Water and wind usually deposit the larger particles of their load relatively close to its source. On the other hand, glaciers carried their load of sediments, including boulders of granite and gneiss from Canada, hundreds of kilometers southward into New York State. In western New York State where the local bedrock is sedimentary, most often shale, siltstone, and limestone, these foreign rock types are especially noticeable. New York soils have a greater variety of minerals and they are more fertile than they would have been if they contained only local rocks. Large rocks that were transported from one area to another by glaciers are known as erratics.



Large rocks that were transported from one area to another by glaciers are known as erratics.

9. What is the main difference between sediment deposited by water and sediments deposited by glaciers?

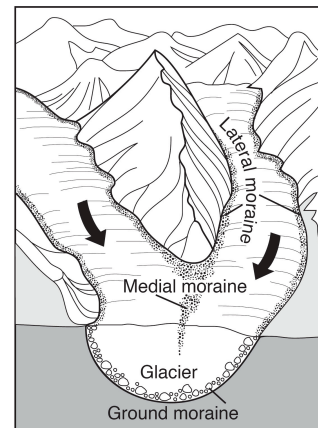
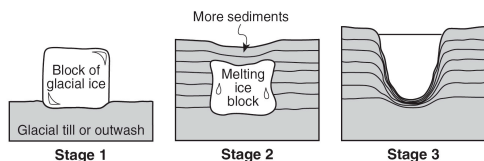
10. What is glacial sediment called? \_\_\_\_\_

11. What is a large rock transported by a glacier called? \_\_\_\_\_

### Moraines and Kettles

A moraine is a mass of till deposited by a glacier. Sometimes moraines form hills, often irregular in shape, where a glacier stopped advancing. This kind of deposit is known as a terminal moraine. Even though the front of the glacier was nearly stationary, ice continued to transport sediment to the front of the glacier where it was released. The barriers of sediment that close off the Finger Lakes are moraines. Smaller moraines can be found throughout the state. Most of these are places where the ice front stalled and dumped its sediment load over a period of time. Among the irregular hills in a moraine are depressions called kettles. A kettle is a small closed basin with no low level outlet. Some kettles form when a block of ice within the till melts, leaving a closed depression. Rainwater that runs to the bottom of the kettle can escape only by evaporation or by infiltrating the ground. Some kettles fill with water to become kettle lakes.

12. Describe what a moraine is in your own words.



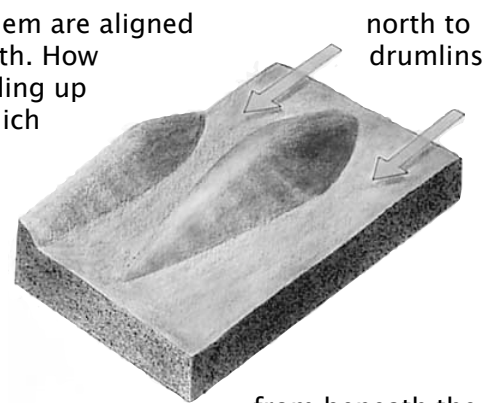
13. What does the location of a terminal moraine tell you about the glacier?

14. Describe the formation of a kettle lake.

### Drumlins

Drumlins are streamlined hills as much as 100 m high and 1 km long. Most of them are aligned south. They have steep sides, a blunt north slope, and a gentler slope to the south. How form is debated among scientists. One idea is that a glacier forms the hills by riding up and over sediment it is pushing forward. Thus drumlins show the direction in which the ice was moving. Within drumlins as in moraines, the unsorted and unlayered nature of till supports the idea that they are deposited by ice.

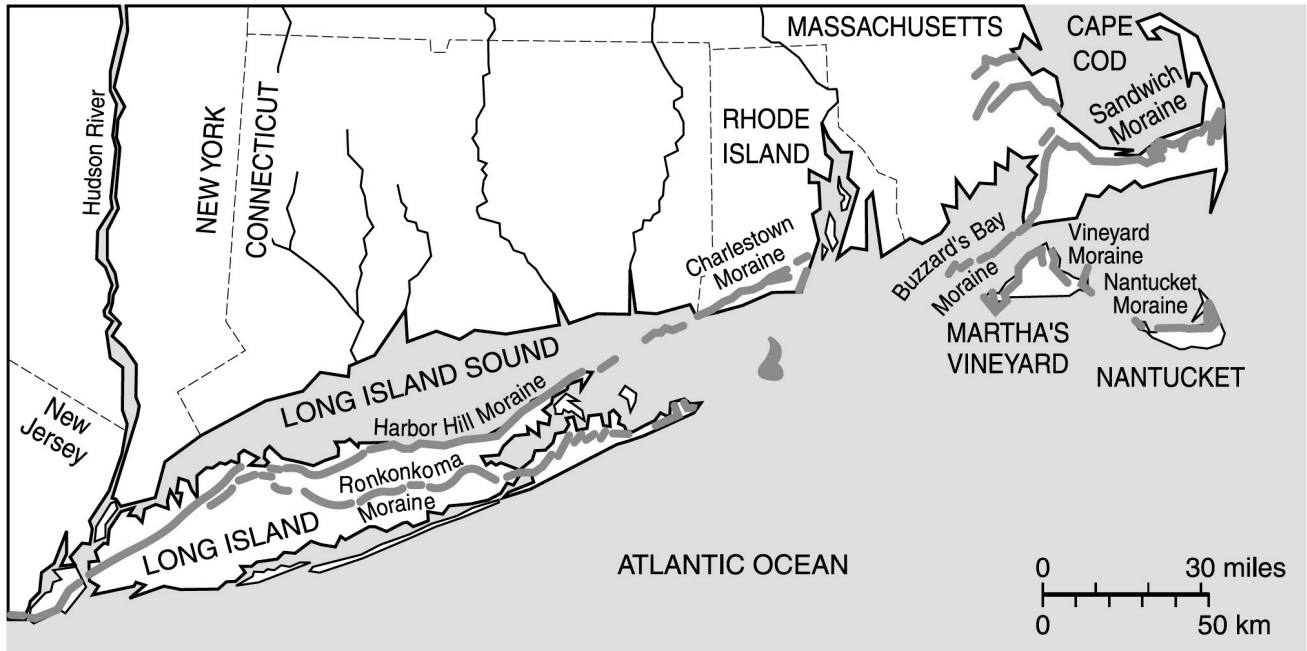
15. What important information can be gained by studying drumlins?



### How Can We Recognize Deposition by Meltwater?

At the end of a glacier there are usually large quantities of water. Some flows ice and more comes from the melting ice front. Sediments deposited by water from from beneath the melting ice are known as outwash. The principal difference between till and outwash is that outwash deposits, like other sediments laid down by water, are sorted and layered. Kettles and kettle lakes are common in outwash plains where blocks of ice caught in the outwash later melt leaving depressions. The difference between ice deposits and meltwater deposits can be seen very clearly on Long Island. Most of the island is made of sediments that can be traced back to glacial origin. The only bedrock on Long Island is in New York City at the far western end of the island. High hills of unsorted sediment in the Harbor Hill Moraine dominate the north shore of Long Island. The beaches of the north shore are composed of pebbles, cobbles, and even large boulders washed out of the moraine. These moraines were pushed into place by moving ice. However, most beaches on the south shore are made of sand washed out of the glaciers by meltwater. A few kilometers inland from the southern beaches are deposits of sand that show layering and sorting: strong evidence that the southern part of Long Island is made of sediment deposited by water, not by ice.

16.



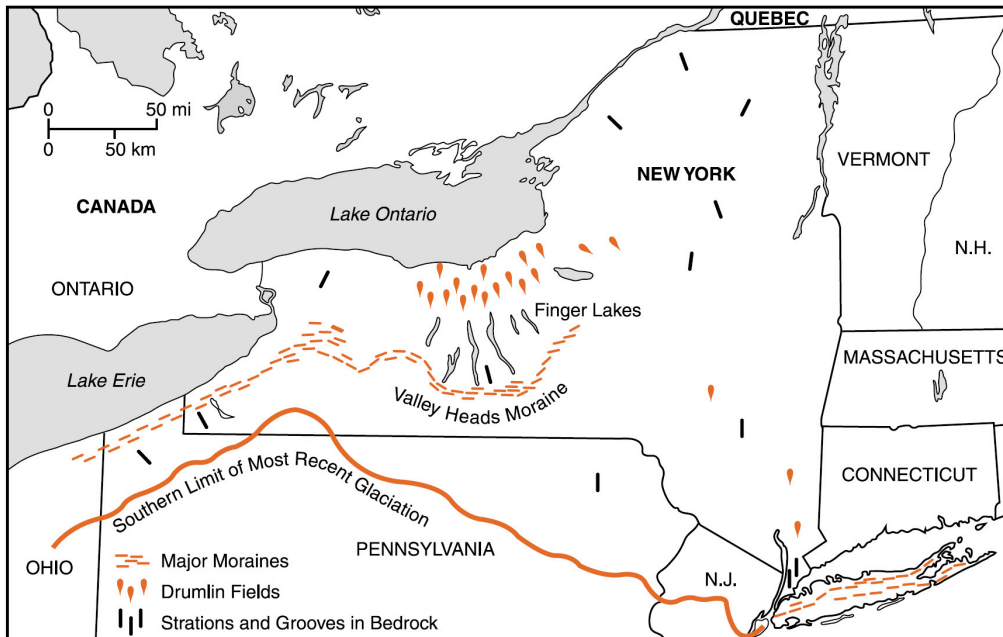
What

evidence proves that Long Island formed from glacial deposition?

---

17. Describe the sediment that will be found within a moraine?

---



18. According to this map of New York, what features found in New York state reveal that it was once covered by an ice sheet?

---

---

---