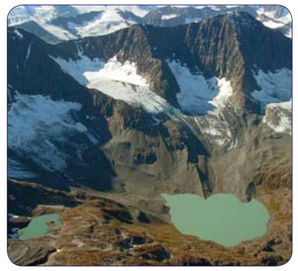
GLACIERS
OF THE NATIONAL PARKS



SELECTED NATIONAL PARKS AND MONUMENTS WITH GLACIAL LANDFORMS

ACADIA NATIONAL PARK, MAINE
APOSTLE ISLANDS NATIONAL LAKESHORE, WISCONSIN
BERING LAND BRIDGE NATIONAL PRESERVE, ALASKA
BOSTON HARBOR ISLANDS NATIONAL RECREATION AREA, MASSACHUSETTS
CAPE COD NATIONAL SEASHORE, MASSACHUSETTS
DENALI NATIONAL PARK & PRESERVE, ALASKA
DEVILS POSTPILE NATIONAL MONUMENT, CALIFORNIA
GATES OF THE ARCTIC NATIONAL PARK & PRESERVE, ALASKA
GLACIER BAY NATIONAL PARK & PRESERVE, ALASKA
GLACIER NATIONAL PARK, MONTANA
GRAND TETON NATIONAL PARK, WYOMING
GREAT BASIN NATIONAL PARK, NEVADA
ICE AGE NATIONAL SCENIC TRAIL, WISCONSIN
ISLE ROYALE NATIONAL PARK, MICHIGAN
KATMAI NATIONAL PARK & PRESERVE, ALASKA
KENAI FJORDS NATIONAL PARK, ALASKA
LAKE CLARK NATIONAL PARK & PRESERVE, ALASKA
MOUNT RAINIER NATIONAL PARK, WASHINGTON
NORTH CASCADES NATIONAL PARK, WASHINGTON
OLYMPIC NATIONAL PARK, WASHINGTON
PICTURED ROCKS NATIONAL LAKESHORE, MICHIGAN
PIPESTONE NATIONAL MONUMENT, MINNESOTA
ROCKY MOUNTAIN NATIONAL PARK, COLORADO
SAN JUAN ISLAND NATIONAL HISTORICAL PARK, WASHINGTON
SEQUOIA AND KINGS CANYON NATIONAL PARK, CALIFORNIA
SLEEPING BEAR DUNES NATIONAL LAKESHORE, MICHIGAN
VOYAGEURS NATIONAL PARK, MINNESOTA
WRANGELL-ST. ELIAS NATIONAL PARK & PRESERVE, ALASKA
YELLOWSTONE NATIONAL PARK, WYOMING, MONTANA, AND IDAHO
YOSEMITE NATIONAL PARK, CALIFORNIA

American Geological Institute

National Park Service

GLACIERS
OF THE NATIONAL PARKS

GLACIERS represent powerful forces that can change entire landscapes—sculpt mountains, carve valleys, and move vast quantities of rock and ice. Glaciers have covered more than a third of the world in the past, and they continue to flow and shape the land in many places. They provide invaluable repositories of information about past climate and offer keys to understanding climate change. Visit the *Views of the National Parks* Website at **http://nature.nps.gov/views** to learn more.

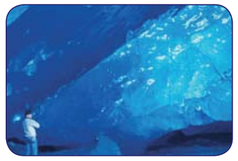
WHAT GLACIERS ARE

GLACIERS CONSIST OF ICE CRYSTALS, AIR, WATER, AND ROCK DEBRIS. The ice in a glacier entrains (collects) air, water, and rock fragments as it forms and moves. These components help the glacier carve the landscape and hold clues to the glacier's history and past climates.

A GLACIER MUST FORM ON LAND. Glaciers may extend into water, but they cannot initially form there. Expanses of sea ice (in the Arctic Ocean, for example) are not considered glaciers.

A GLACIER MUST MOVE. Glaciers move by deforming internally and sliding across flat terrain and down slopes. Only after an ice mass has attained a size, thickness, and shape that allow it to move and flow is it considered a glacier. Unmoving patches of perennial snow and ice are not glaciers.

WHERE GLACIERS ARE FOUND



Glaciers can form wherever elevation and climate factors are suitable for snow to collect and build up for years. The chances of a glacier forming are improved by little solar radiation, cool summer temperatures, and prolonged cold winters, which are characteristics of polar regions. Elevation also affects glacier formation. Glaciers exist at sea level at the South Pole but are confined to highlands in the middle and low latitudes. More than 200 glaciers have been identified in North America alone.

Glaciers and Climate Change

Glaciers tend to average out short-term meteorological variations and reflect variations that take place over decades or centuries. Monitoring glaciers also can help scientists determine whether climate change is regional or global, and the widespread geographic distribution of glaciers makes them useful for studying global climate fluctuations. In addition, glacial ice contains a record of past climates and atmospheres, which is extremely useful for understanding and predicting the effects of current climate change.

CREDITS: Project: Jim Wood (NPS), Jessica Ball (AGI), Jason Betzner (AGI), Geoff Camphire (AGI); Design: Angela Terry Design; Front images (left to right, down): Courtesy Nate Verhanovitz, NPS; Bruce Molnia, 2005, Pedersen Glacier: From the Glacier photograph collection. Boulder, Colorado USA: National Snow and Ice Data Center/World Data Center for Glaciology; © Bruce Molnia, Terra Photographics, ESWIB; © Bruce Molnia, Terra Photographics, ESWIB*; Courtesy American Geographical Society, NPS; Courtesy NPS, USGS Photographic Library; Courtesy Commander John Bortniak, NOAA Corps, NOAA Photo Library; © Bruce Molnia, Terra Photographics, ESWIB*. Large image on far right: Courtesy of iStockphoto. Back images (first column, top to bottom): Courtesy J. Burghardt, NPS; © Bruce Molnia, Terra Photographics, ESWIB*. (panoramic photo at top, center): Matt Nolan, 2004, McCall Glacier: From the Glacier photograph collection. Boulder, Colorado USA: National Snow and Ice Data Center/World Data Center for Glaciology. (second column, top to bottom): Courtesy Nate Verhanovitz, NPS; © Bruce Molnia, Terra Photographics, ESWIB*. (third column): Copyright © Michael Collier. (fourth column): NPS photo. (* Earth Science Week Image Bank.)*

TYPES OF GLACIERS

Glaciers are classified by their location and form.

- Covering large areas in polar regions, **ICE SHEETS** and **ICE CAPS** have similar forms but different scales. Ice sheets are larger (typically greater than 50,000 km^2). The glaciers that cover Antarctica and Greenland are ice sheets. The glacier that covers part of Iceland is an ice cap.
- An **ICE SHELF** is a very thick sheet of ice that is attached to land, but terminates in water and is mostly afloat. When large sections break off an ice shelf, **ICEBERGS** are formed.
- A **VALLEY GLACIER** flows between the walls of a mountain valley and may originate in an icefield or a cirque.
- A **CIRQUE GLACIER** is a small ice mass that occupies a rounded bedrock hollow. These are the most common type of glacier found in the mountains of the western United States.

PARTS OF A GLACIER

- **ACCUMULATION ZONE:** the part of a glacier's surface where more snow is deposited than lost each year.
- **EQUILIBRIUM LINE:** boundary between areas of yearly gain and loss on a glacier's surface where accumulation equals ablation.
- **ABLATION ZONE:** the part of a glacier's surface where more mass is lost than deposited each year.
- **TERMINUS:** end of a glacier, also known as the foot, nose, or snout; the site of substantial melting as well as the place on ice shelves where icebergs form.
- **BED:** ground over which a glacier flows.

HOW GLACIERS MOVE

Most glaciers move too slowly for us to see. Parts move at different rates, and entire glaciers may shrink or grow with changes in climate and snow supply. A stable glacier moves but doesn't change size or location, because its forward movement and accumulation rate equal its ablation rate due to melting or calving. To advance, a glacier must accumulate more ice than it loses. Glaciers can recede if the amount of ice lost exceeds that gained. A glacier may surge when some of its ice becomes unstable and moves rapidly down-glacier, at up to 100 times its normal velocity.

SURFACE FEATURES OF GLACIER MOVEMENT

- A deep, nearly vertical fissure or crack in a glacier, a **CREVASSE** is created by stresses resulting from different flow rates over an uneven bed surface.
- **ICEFALLS** are steep, highly crevassed surfaces that occur on parts of a glacier that flow over convex bedrock.

Carving the landscape

Glaciers erode the landscape in two ways. First, a glacier can pick up rocks loosened from bedrock by freeze-thaw processes and carry them away (**GLACIAL PLUCKING**). Second, sediment and rock frozen to the bottom and sides of glaciers scrape the rock they flow over, scouring the landscape. This may leave large **GOUGES**, small **STRIATIONS**, or a finely **POLISHED** surface on rock. The sediment carried by a glacier eventually can be ground so fine it becomes **GLACIAL FLOUR**.

FEATURES OF GLACIAL EROSION

- **CIRQUE:** steep-walled, semicircular hollow created by glacial excavation high in mountainous areas.
- **GLACIAL BASINS:** closed bedrock basins formed by glacial excavation, many containing lakes.
- **HANGING VALLEY:** glacier valley ending in a cliff where it meets a deeper glacier valley.
- **HORN:** high, sharp, steep-sided pyramidal peak formed by the confluence of several cirques.
- **U-SHAPED VALLEY:** valley with a U-shaped cross section carved by a glacier.

Glaciers pick up pieces of rock by freezing around them. These fragments range in size from sand and pebbles to car- or house-size boulders, and can be transported along the base, at the surface, and within the body of a glacier. Processes of deposition operate at the base, the surface, and the edges of a glacier. Debris can also be carried far from the glacier's margins by water. Deposition is continuous, and may occur in one location (in a stable glacier) or as a sheet (in an advancing or retreating glacier). Material deposited by one process may also be picked up and re-deposited elsewhere by a different process.

FEATURES OF GLACIAL DEPOSITION

- **DRUMLIN:** low mound of till (unsorted glacial sediments) with a long axis parallel to ice movement.
- **ERRATIC:** large boulder left by receding glaciers, differing in composition from the surface it is deposited on, and possibly striated or polished.
- **ESKER:** long, low ridge of sand and gravel deposited by meltwater.
- **OUTWASH:** sediment washed out from a glacier and deposited in a flat area below.
- **KETTLE:** long, shallow depression formed when a block of ice is buried in outwash and melts, leaving a pit behind.
- **KETTLE POND:** pond or lake formed when water fills a kettle.
- **MORAINE:** accumulation of till and other sediments deposited by a glacier, which can be ridges (medial, lateral, or terminal moraines) or flat-lying (ground moraine or till sheet).

Learning Activity:

Edible Landscapes

Grade Level: 6-9

OBJECTIVE

Discover ways that landscapes are moved and shaped.

MATERIALS

Chocolate chip ice cream, ice cream scoop, paper towels, baking sheet or pan (one per group), spoons, graham crackers, pretzel sticks, round candy pieces, tin foil, plastic gloves, paper, pens.

PROCEDURE

1. On a sheet of paper, label the front "Diagram" and the back "Observations."
2. Line the baking sheet with tin foil and put on a pair of plastic gloves.
3. Crumble graham crackers into small pieces and spread onto the baking sheet.
4. Sprinkle candy on top and press pretzel sticks into the graham cracker crumbs.
5. Place a large scoop of ice cream on top of your mixture.
6. On paper, sketch and label your edible landscape.
7. Compact the ice cream by lightly squeezing and pushing down on it.
8. Observe and record what happens to the mixture.
9. Drag the ice cream across the mixture.
10. Record observations.

GROUP DISCUSSION

1. What do you think the ice cream represented?
2. What did you do to simulate the pressure exerted on a glacier from gravity or snowfall?
3. What do you think the graham crackers represented?
4. What did you do in your experiment to represent glacial scouring?
5. What do you think the chocolate chips in the ice cream and candy you sprinkled in the graham crackers represented?
6. What do you think the pretzels represented?
7. Identify ingredients in your experiment by labeling each with the glacial component that it represents.

** This lesson plan was adapted from an activity in the "Views" Glaciers Curriculum Guide developed by Kristen Lucke Nein (University of Colorado-Denver). For the complete lesson plan and teacher's discussion guide, please visit "Views of the National Parks" at http://nature.nps.gov/views/*