Encyclopedic Entry

glacier

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A glacier is a huge mass of ice that moves slowly over land. The term “glacier” comes from the French word *glace* (glah-SAY), which means ice. Glaciers are often called “rivers of ice.”

Glaciers fall into two groups: alpine glaciers and ice sheets.

Alpine glaciers form on mountainsides and move downward through valleys. Sometimes, alpine glaciers create or deepen valleys by pushing dirt, soil, and other materials out of their way. Alpine glaciers are found in high mountains of every continent except Australia (although there are many in New Zealand). The Gorner Glacier in Switzerland and the Furtwangler Glacier in Tanzania are both typical alpine glaciers. Alpine glaciers are also called valley glaciers or mountain glaciers.

Ice sheets, unlike alpine glaciers, are not limited to mountainous areas. They form broad domes and spread out from their centers in all directions. As ice sheets spread, they cover everything around them with a thick blanket of ice, including valleys, plains, and even entire mountains. The largest ice sheets, called continental glaciers, spread over vast areas. Today, continental glaciers cover most of Antarctica and the island of Greenland.

Massive ice sheets covered much of North America and Europe during the Pleistocene time period. This was the last glacial period, also known as the Ice Age. Ice sheets reached their greatest size about 18,000 years ago. As the ancient glaciers spread, they carved and changed the Earth’s surface, creating many of the landscapes that exist today. During the Pleistocene Ice Age, nearly one-third of the Earth’s land was covered by glaciers. Today, about one-tenth of the Earth’s land is covered by glacial ice.

How Glaciers Form

Glaciers begin forming in places where more snow piles up each year than melts. Soon after falling, the snow begins to compress, or become denser and tightly packed. It slowly changes from light, fluffy crystals to hard, round ice pellets. New snow falls and buries this granular snow. The hard snow becomes even more compressed. It becomes a dense, grainy ice called firn. The process of snow compacting into glacial firn is called firnification.

As years go by, layers of firn build on top of each other. When the ice grows thick enough—about 50 meters (160 feet)—the firn grains fuse into a huge mass of solid ice. The glacier begins to move under its own weight. It does this through a process called compression melting. The glacier is so heavy and exerts so much pressure that the firn and snow melt without any increase in temperature. (Most substances do not melt under pressure. Water is somewhat unusual.) The meltwater makes the bottom of the heavy glacier slicker and more able to spread across the landscape.

Pulled by gravity, an alpine glacier moves slowly down a valley. Some glaciers, called hanging glaciers, don't flow the entire length of a mountain. Avalanches and icefalls transfer glacial ice from hanging glaciers to a larger glacier beneath them, or directly to the valley below.

An ice sheet spreads out from its center. The great mass of ice in a glacier behaves plastically, or like a liquid. It flows, oozes, and slides over uneven surfaces until it covers everything in its path.

Different parts of a glacier move at different speeds. The flowing ice in the middle of the glacier moves faster than the base, which grinds slowly along its rocky bed.

The different speeds at which the glacier moves causes tension to build within the brittle, upper part of the ice. The top of the glacier fractures, forming cracks called crevasses. Crevasses are in the top 50 meters (160 feet) of the glacier. Crevasses can be very dangerous for mountaineers. They can open quickly and be very deep.

Moulins are another formation that carve into glaciers. A moulin is a deep, nearly-vertical pipeline in the glacier formed by meltwater on top of the glacier falling through a crack in the ice. Moulins are often much deeper than crevasses, going all the way to the bottom of the glacier.

Most glaciers move very slowly—only a few centimeters a day. Some, though, can move 50 meters (160 feet) a day. These fast-moving rivers of ice are called galloping glaciers.

Where a glacier meets the coast, it becomes a tidewater glacier. Its leading edge lifts and floats in the water, forming cliffs of ice that may be 60 meters (200 feet) high. Chunks of ice at the edge of the tidewater glacier break away into the water—a process called calving. Calving is a violent process. It results in large waves and loud crashes. Floating chunks of glacial ice, broken off during calving, are called icebergs.

Glacial Features

Although glaciers move slowly, they are extremely powerful. Like huge bulldozers, they plow ahead year after year, crushing, grinding, and toppling almost everything in their paths. Forests, hills, and mountainsides are no match for glaciers.

Sometimes, glaciers form on volcanoes. When these volcanoes erupt, they are especially dangerous. They send floods of water, ice, and rocks over the land and into the atmosphere.

Alpine glaciers begin to flow downhill from bowl-shaped mountain hollows called cirques. As the glaciers overflow the cirque, they move downward. They dig deep into the terrain, forming rugged, dramatic landscapes.

As they move, glaciers erode or wear away the land beneath and around them. Glaciers carry great amounts of soil, rock, and clay. Some of the boulders they carry are as big as houses.

Rocks carried hundreds and even thousands of kilometers by glaciers are called glacial erratics. Glacial erratics differ significantly from the landscape in which they were deposited. The Big Rock, for instance, is a 15,000-ton quartzite boulder near Okotoks, Alberta, Canada. The Big Rock was deposited from what is now northern Alberta, about 1,640 kilometers (500 miles) away, during the last ice age.

Embedded, or stuck, in a glacier's base, these large rocks grind against the ground like the prongs of a rake. They dig long grooves, called striations, in the surface of the Earth. Geologists can tell in what direction an ancient glacier moved by studying striations left in rock.

Glaciers eventually deposit their loads of rock, dirt, and gravel. These materials are called moraine. Piles of moraine dumped at a glacier's end, or snout, are called terminal moraines.

Lateral moraine forms along the side of a glacier. Medial moraine appears as dark lines near the center of the glacier. Supraglacial moraine appears on the surface of the glacier—dirt, dust, leaves, and anything else that falls onto a glacier and sticks. Ogives are frozen “waves,” or ridges, on the surface of a glacier.

When glaciers began their final retreat 10,000 years ago, they left behind many landscape features, such as lakes, valleys, and mountains.

Many hollowed-out areas carved by glaciers became lakes. Bowl-shaped cirques, where most alpine glaciers form, became mountain lakes. These alpine lakes are called tarns.

Glaciers can also create lakes by leaving depressions in the earth. The Finger Lakes in the western part of the U.S. state of New York were excavated during the last Ice Age. The lakes were once stream valleys. Along the streams, the glacier scooped out troughs that now contain deep lakes.

Glacial retreat created other features of the landscape. Materials deposited by a glacier as it retreats are called ground moraines. The jumble of rock, gravel, and dirt making up ground moraines is called till. Much of the fertile soil in the Great Plains of North America was formed from layers of till left by ancient ice sheets.

Glacial valleys exist on almost every continent. These valleys are scooped out as a glacier scrapes through them. There are no glaciers in Australia, but Mount Kosciuszko still has glacial valleys from the last Ice Age.

Distinctive mountain formations called aretes and horns are the result of glacial activity. An arête is a sharp ridge of rock that forms when two glaciers collide. Each glacier erodes a glacial valley on either side of the arête. Glacier National Park in the U.S. state of Montana is filled with deep glacial valleys and sharp arêtes.

An arête where three or more glaciers meet to form a peak is called a horn. These tall, singular landforms are also called pyramidal peaks. The Matterhorn in Switzerland and Italy (and its copy in Disneyland, California) is a glacial horn.

Roche moutonnee is a smooth, rounded rock formation created as a glacier crushes and rearranges rocks in its path. Roche moutonnee is visible in many hilly areas as outcroppings of flat rock.

In contrast to alpine glaciers, ice sheets do not create landscape features as they spread. They tend to smooth out the land beneath them.

People and Glaciers

Glaciers provide people with many useful resources. Glacial till provides fertile soil for growing crops. Deposits of sand and gravel are used to make concrete and asphalt.

The most important resource provided by glaciers is freshwater. Many rivers are fed by the melting ice of glaciers. The Gangotri Glacier, one of the largest glaciers in the Himalayan Mountains, is the source of the Ganges River. The Ganges is the most important source of freshwater and electricity in India and Bangladesh. (Electricity is created by dams and hydroelectric power plants along the Ganges.)

Many companies link glacial water to clean, fresh taste. Because water has been trapped in the glacier for so long, many people believe it has not been exposed to pollutants that liquid water is exposed to.

Glaciers dug basins for most of the world’s lakes and carved much of the Earth’s most spectacular mountain scenery. The dramatic, diverse landscape of Yosemite Valley, California, was sculpted entirely by glaciers during the last Ice Age.

Threats to Glaciers

The processes that remove snow, ice, and moraine from a glacier or ice sheet are called ablation. Ablation includes melting, evaporation, erosion, and calving.

Glaciers melt when ice melts more quickly than firn can accumulate. Earth's average temperature has been increasing dramatically for more than a century. Glaciers are important indicators of global warming and climate change in several ways.

Melting ice sheets contribute to rising sea levels. As ice sheets in Antarctica and Greenland melt, they raise the level of the ocean. Tons of fresh water are added to the ocean every day. In March 2009, a 160-square-mile piece of the Wilkins Ice Shelf broke off of the Antarctic Peninsula. Large icebergs created by such an event create hazards for shipping.

Large additions of fresh water also change the ocean ecosystem. Organisms, such as many types of corals, depend on salt water for survival. Some corals may not be able to adjust to a more freshwater habitat.

The loss of glacial ice also reduces the amount of fresh water available for plants and animals that need fresh water to survive. Glaciers near the Equator, such as those on the tropical island of Papua or in South America, are especially at risk.

The residents below Chacaltaya Glacier in Bolivia, for instance, depended on the glacier for almost all of their fresh water and electricity. Chacaltaya Glacier provided these resources to La Paz, Bolivia's largest city. Chacaltaya Glacier was also the world's highest ski resort. In 2009, Chacaltaya Glacier melted entirely.

A few glaciers may actually be benefiting from global warming. Although winter temperatures are rising, so is the amount of snowfall in areas like Pakistan's Upper Indus River Basin. Glaciers are growing quickly there.

Glaciers in Scandinavia also grew because of increased snowfall in the 1990s. But now the glaciers are retreating, or melting, at a very fast pace.

Less precipitation also affects some glaciers. In 1912, the glaciers on Tanzania's Mount Kilimanjaro covered 12 square kilometers (4.6 square miles). In 2009, Kilimanjaro's alpine glaciers had shrunk to two square kilometers (0.8 square miles). This reduction is the result of few heavy snowfalls.

VOCABULARY

Term	Part of Speech	Definition
ablation	*noun*	removal of material from the surface of an object, including melting, evaporation, or erosion.
accumulate	*verb*	to gather or collect.
alpine glacier	*noun*	mass of ice that moves downward from a mountain.
arete	*noun*	sharp mountain ridge created by the collision of two glaciers.
asphalt	*noun*	chemical compound made of dark, solid rocks and minerals often used in paving roads.
atmosphere	*noun*	layers of gases surrounding a planet or other celestial body.

benefit	*verb*	to be helpful or useful.
boulder	*noun*	large rock.
brittle	*adjective*	fragile or easily broken.
broad	*adjective*	wide or expansive.
bulldozer	*noun*	vehicle used for moving large obstacles, such as boulders or trees.
calving	*noun*	process where a glacier cracks and breaks apart.
century	*noun*	100 years.
cirque	*noun*	half-open, amphitheater-like hollow area near the head of a valley or mountainside resulting from glacial erosion.
city	*noun*	large settlement with a high population density.
clay	*noun*	type of sedimentary rock that is able to be shaped when wet.
cliff	*noun*	steep wall of rock, earth, or ice.
climate change	*noun*	gradual changes in all the interconnected weather elements on our planet.
coast	*noun*	edge of land along the sea or other large body of water.
collide	*verb*	to crash into.
compress	*verb*	to press together in a smaller space.
compression melting	*noun*	process by which ice or snow melts under extreme pressure.
concrete	*noun*	hard building material made from mixing cement with rock and water.
continent	*noun*	one of the seven main land masses on Earth.
continental glacier	*noun*	ice sheet that covers an enormous area.
coral	*noun*	tiny ocean animal, some of which secrete calcium carbonate to form reefs.
country	*noun*	geographic territory with a distinct name, flag, population, boundaries, and government.
crevasse	*noun*	deep crack, especially in a glacier.
crop	*noun*	agricultural produce.
crystal	*noun*	type of mineral that is clear and, when viewed under a microscope, has a repeating pattern of atoms and molecules.
dam	*noun*	structure built across a river or other waterway to control the flow of water.
dense	*adjective*	having parts or molecules that are packed closely together.
deposit	*verb*	to place or deliver an item in a different area than it originated.
dirt	*noun*	dry earth or soil.
dome	*noun*	shape that is half of a sphere.
dramatic	*adjective*	very expressive or emotional.
dust	*noun*	tiny, dry particles of material solid enough for wind to carry.

ecosystem	*noun*	community and interactions of living and nonliving things in an area.
electricity	*noun*	set of physical phenomena associated with the presence and flow of electric charge.
embed	*verb*	to attach firmly to a surrounding substance.
Equator	*noun*	imaginary line around the Earth, another planet, or star running east-west, 0 degrees latitude.
erode	*verb*	to wear away.
eruption	*noun*	release of material from an opening in the Earth's crust.
excavate	*verb*	to expose by digging.
extract	*verb*	to pull out.
fall line	*noun*	imaginary line along which parallel rivers plunge, or fall.
fertile	*adjective*	able to produce crops or sustain agriculture.
firn	*noun*	grainy ice that forms glaciers. Also called neve.
firnification	*noun*	process of compacting snow and ice into firn and glaciers.
flood	*noun*	overflow of a body of water onto land.
forest	*noun*	ecosystem filled with trees and underbrush.
fracture	*verb*	to break.
freshwater	*noun*	water that is not salty.
fuse	*verb*	to combine or meld together.
galloping glacier	*noun*	glacier that moves several feet an hour. Also called a surge glacier.
Ganges River	*noun*	(2,495 kilometers/1,550 miles) river in Southeast Asia emptying into the Bay of Bengal. Also called the Ganga.
Gangotri Glacier	*noun*	large glacier in the Himalaya Mountains, the source of the Ganges River.
geologist	*noun*	person who studies the physical formations of the Earth.
glacial erratic	*noun*	rock, deposited by a glacier, that differs from the geology and landscape in which it is found.
glacial period	*noun*	time of long-term lowering of temperatures on Earth. Also known as an ice age.
glacial retreat	*noun*	process by which glaciers melt faster than precipitation can replace the ice.
glacial valley	*noun*	depression in the earth created by a moving glacier.
glacier	*noun*	mass of ice that moves slowly over land.
global warming	*noun*	increase in the average temperature of the Earth's air and oceans.
granular	*adjective*	made up of small, rounded pellets or grains.
gravel	*noun*	small stones or pebbles.
gravity	*noun*	physical force by which objects attract, or pull toward, each other.
ground moraine	*noun*	materials such as earth and gravel deposited by a glacier as it retreats.

hanging glacier	*noun*	glacier that forms at the top of a mountain or valley but doesn't descend to the main glacier or valley below, instead calving in avalanches and icefalls to the valley or main glacier below.
hazard	*noun*	danger or risk.
helipad	*noun*	take-off and landing area for helicopters.
hill	*noun*	land that rises above its surroundings and has a rounded summit, usually less than 300 meters (1,000 feet).
Himalaya Mountains	*noun*	mountain range between India and Nepal.
horn	*noun*	mountain formation where three or more glaciers meet to form a peak. Also known as a pyramidal peak.
hydroelectric power	*noun*	usable energy generated by moving water converted to electricity.
ice	*noun*	water in its solid form.
ice age	*noun*	long period of cold climate where glaciers cover large parts of the Earth. The last ice age peaked about 20,000 years ago. Also called glacial age.
iceberg	*noun*	large chunks of ice that break off from glaciers and float in the ocean.
ice core	*noun*	sample of ice taken to demonstrate changes in climate over many years.
ice pellet	*noun*	rain that freezes as it falls to Earth. Also called sleet.
ice sheet	*noun*	thick layer of glacial ice that covers a large area of land.
Krakatoa	*noun*	island in Indonesia, site of major volcanic eruption in 1883. Also called Krakatau.
lake	*noun*	body of water surrounded by land.
landscape	*noun*	the geographic features of a region.
lateral moraine	*noun*	material deposited at the edges of a glacier.
Matterhorn	*noun*	(4,478 meters/14,691 feet) mountain in the Alps, on the border between Switzerland and Italy.
medial moraine	*noun*	material that is built up where two glaciers meet to form a new glacier.
military	*noun*	armed forces.
moraine	*noun*	material, such as earth, sand, and gravel, transported by a glacier.
moulin	*noun*	vertical shaft in a glacier created by surface water falling through a crack in the ice.
mountain	*noun*	landmass that forms as tectonic plates interact with each other.
mountaineer	*noun*	someone who climbs mountains.
ocean	*noun*	large body of salt water that covers most of the Earth.
ogive	*noun*	small ridges on top of a glacier that resemble waves.
outcropping	*noun*	layer of rock visible above the surface of the Earth.
paleoclimatology	*noun*	study of the atmosphere of prehistoric Earth.
plain	*noun*	flat, smooth area at a low elevation.

plastically	*adverb*	in a moldable, alterable manner.
Pleistocene	*noun*	epoch lasting from about 2 million years ago to 12,000 years ago.
plow	*noun, verb*	tool used for cutting, lifting, and turning the soil in preparation for planting.
pollutant	*noun*	chemical or other substance that harms a natural resource.
precipitation	*noun*	all forms in which water falls to Earth from the atmosphere.
prong	*noun*	pointed end of a fork, antler, or other tool.
pyramidal peak	*noun*	mountain formation where three or more glaciers meet to form a peak. Also known as a horn.
rake	*noun*	tool with pointed prongs for loosening soil.
river	*noun*	large stream of flowing fresh water.
roche moutonnee	*noun*	smooth, rounded rock formation created by glaciation.
rock	*noun*	natural substance composed of solid mineral matter.
Scandinavia	*noun*	region and name for some countries in Northern Europe: Iceland, Norway, Sweden, Finland, and Denmark.
sea level	*noun*	base level for measuring elevations. Sea level is determined by measurements taken over a 19-year cycle.
shipping	*noun*	transportation of goods, usually by large boat.
ski resort	*noun*	facility where people can ski for recreation or sport.
smoke	*noun*	gases given off by a burning substance.
snout	*noun*	end of a glacier.
snowfall	*noun*	amount of snow at a specific place over a specific period of time.
soil	*noun*	top layer of the Earth's surface where plants can grow.
stream	*noun*	body of flowing fluid.
striation	*noun*	tiny, straight groove left in rock from sediment trapped in a moving glacier.
supraglacial moraine	*noun*	material that builds up on the surface of a glacier.
tarn	*noun*	mountain lake formed by a melting glacier.
temperature	*noun*	degree of hotness or coldness measured by a thermometer with a numerical scale.
terminal moraine	*noun*	material deposited at the end of a glacier. Also called an end moraine.
terrain	*noun*	topographic features of an area.
tidewater glacier	*noun*	mass of moving ice that eventually reaches the ocean.
till	*noun*	rock, earth, and gravel left behind by a retreating or melting glacier.
tropical	*adjective*	existing in the tropics, the latitudes between the Tropic of Cancer in the north and the Tropic of Capricorn in the south.
trough	*noun*	a gently sloping depression in the ocean floor.

valley	*noun*	depression in the Earth between hills.
volcano	*noun*	an opening in the Earth's crust, through which lava, ash, and gases erupt, and also the cone built by eruptions.
water	*noun*	chemical compound that is necessary for all forms of life.
waterfall	*noun*	flow of water descending steeply over a cliff. Also called a cascade.

For Further Exploration

Articles & Profiles

- National Geographic News: Huge Greenland Glacier Disintegrating

Audio & Video

- National Geographic Video: Imja Glacier
- National Geographic Channel: Glacier Meltdown

Websites

- National Geographic Channel: Countdown to Armageddon—Filming on the Quelccaya Glacier
- National Park Service: Glacier National Park
- National Snow and Ice Database: All About Glaciers