

## What is a Fjord?

Fjords are deep valleys with steep sides, formed by glaciers. They're usually on the coasts of continents and filled with water.

Over the past five million years, glaciers have migrated over continents then melted back, nearly 50 times.

Modern fjords formed during the last glacial advance, from around 100,000 to 20,000 years ago, when glaciers covered a quarter of all land on Earth.

Since so much water was locked up in glaciers, sea level was 400 feet lower than today.

In the high latitudes, especially on the western edges of continents, prevailing winds brought moist sea air that fell as snow. Glaciers became so thick and heavy that they formed deep channels through rocky coastlines as they moved to the sea.

In places, they cut valleys 3,500 feet deep down to sea level, then cut another 3,500 feet into the ocean floor.

When the glaciers finally melted and retreated, they left valleys sometimes 7,000 feet deep, with more than half of that below sea level.

This left the western coasts of Norway and Chile completely dissected by fjords. If you took a boat along Norway's coastline, bypassing the fjords, you'd travel 1,600 miles.

But if you sailed along the edge of land, slipping into and out of every one of its 1,200 fjords, it would be an incredible 18,000 miles.

Here, and in places like New Zealand, fjords define the coastal character of the landscape.



Infrared-enhanced image of College Fjord, Alaska, United States. Snow appears white, glaciers appear bright blue, and land surfaces with vegetation on them appear red. Although the two-dimensional image makes it appear that the glaciers along the western side of the fjord simply fill in great ravines, in reality, the glaciers tumble down from hanging valleys toward the water over steep hillsides like frozen waterfalls.

Credit: Jesse Allen, NASA Earth Observatory, using data provided courtesy of the NASA/GSFC/METI/ERSDAC/JAROS and U.S./Japan Aster Science Team, public domain, via Wikimedia Commons



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# Background: What is a Fjord?

**Synopsis:** Sculpted by glaciers, fjords are the steep-sided water-filled valleys left behind as glaciers retreat. Some are remarkably deep, extending thousands of feet below sea level. Most fjords occur along coastlines and are inundated by seawater, while inland freshwater fjords are drowned in their own meltwater lakes. These spectacular ice age landforms are reminders of Earth's dynamic climate.

- Glaciers form when so much snow accumulates that its sheer weight causes it to compress into great tongues of ice that flow outward or downward (ED-028 Secrets of the Glacier).
  - For about 30% of its history, Earth has been glaciated, having seen five great ice ages over the past 2.5 billion years (ED-069 Greenhouse-Icehouse Earth).
  - The most recent, the Quaternary Ice Age, began 2.58 million years ago at the start of the Pleistocene Epoch, although continental glaciation commenced in Antarctica as long as 34 million years ago.
  - Pleistocene glaciers covered 25% of Earth's land area compared to 11% today.
  - Global sea level was more than 400 ft (120 m) lower than modern sea level, exposing continental shelves surrounding Earth's landmasses.
- During the Pleistocene, huge volumes of snow accumulated both over continental shield regions and in mountainous areas storing large volumes of Earth's water as ice.
  - Continental glaciers occur when extreme amounts of snow collect over vast expanses of land and winter snowfall exceeds summer snowmelt.
    - The sheer weight of the snow compresses it into thick ice sheets that flow outward as long as snow accumulation continues to recharge it.
    - Great walls of ice many thousands of feet thick bulldoze everything in their path.
    - When recharge slows, continental glaciers retreat, leaving behind a flattened and eroded landscape characterized by a variety of glacial landforms.
  - Alpine glaciers form when extreme snow collects and compacts in the mountains.
    - Mountain glaciers flow downslope within existing valleys as long as their accumulation zones are recharged by snowfall.
    - These heavy tongues of ice carve away rock along the sides and bottom of the valley to create deep U-shaped valleys through which the river of ice flows.



A glacier in eastern Greenland flows through a long, narrow valley carved by the movement of ice. It becomes a fjord where the edge of the glacier meets the sea, marked by floating ice and icebergs. The photograph was taken with a camera aboard NASA's P-3B aircraft on April 25, 2012.

Credit: Jefferson Beck and Maria-José Viñas, public domain, via Wikimedia Commons

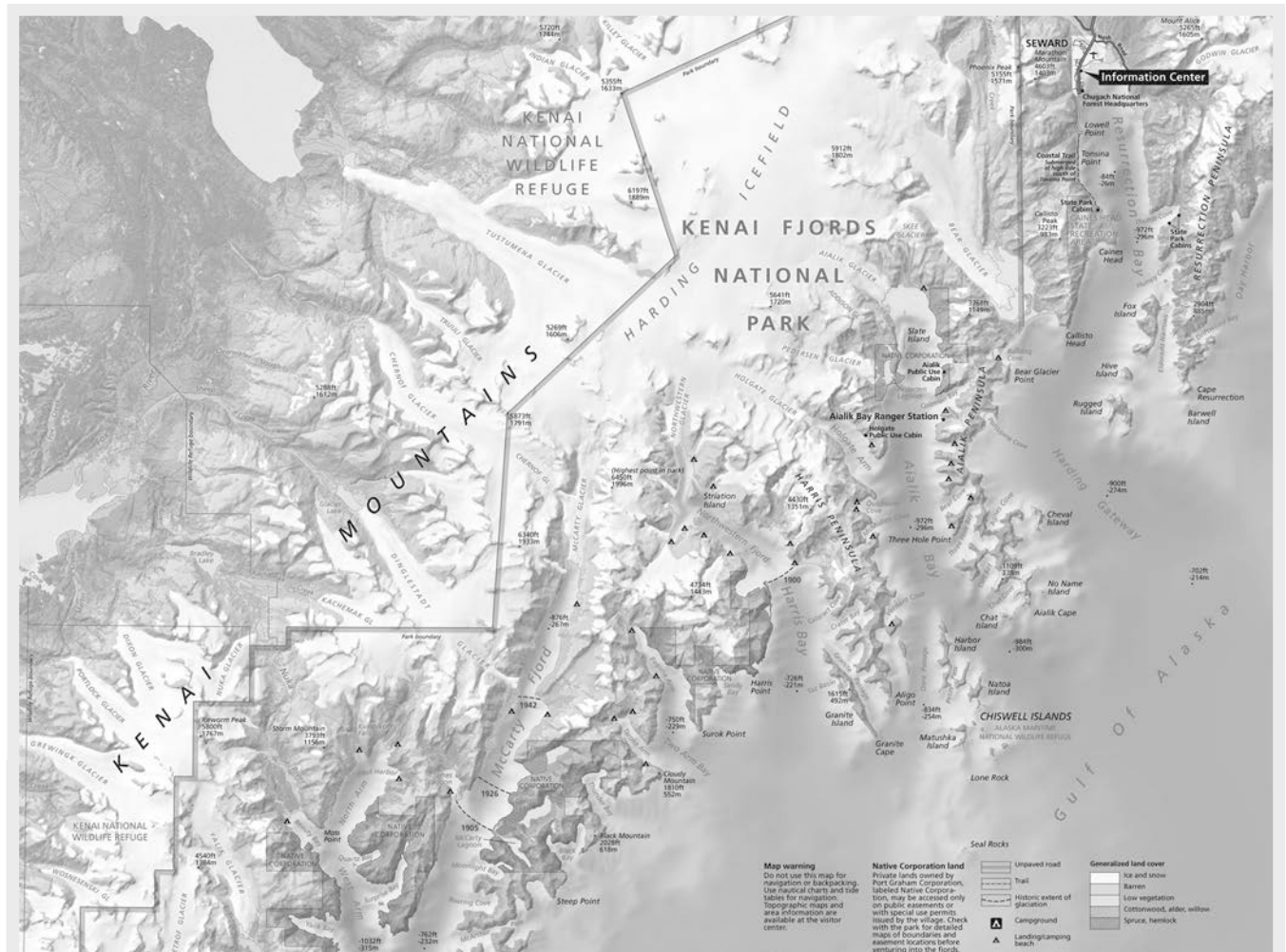
## References: What is a Fjord?

Fjord - an Overview | ScienceDirect  
Fjord | New World Encyclopedia  
What Is a Fjord and How Is It Formed... | Norway Today  
Fjord | National Geographic  
Glacial Landforms | Geo.Hunter.CUNY

Contributors: Juli Hennings, Harry Lynch

# Background: What is a Fjord?

- The last glacial maximum occurred around 20,000 years ago. We currently live in a warmer mild interglacial of the Quaternary Ice Age known as the Holocene Epoch, which started around 11,700 years ago.
  - When temperatures warm and snow supply decreases, alpine glaciers retreat back toward their source, leaving steep-sided U-shaped valleys with terminal moraines, deposits of earth and stone, marking the furthest extent of the ice.
  - When these are inundated by water, we call them fjords.
  - The word fjord comes from Old Norse fjörðr, which means “lake-like water body.”



Years marked on this map of Alaska’s Kenai Fjords National Park illustrate how fjords form as glaciers retreat over time.

Credit: National Park Service

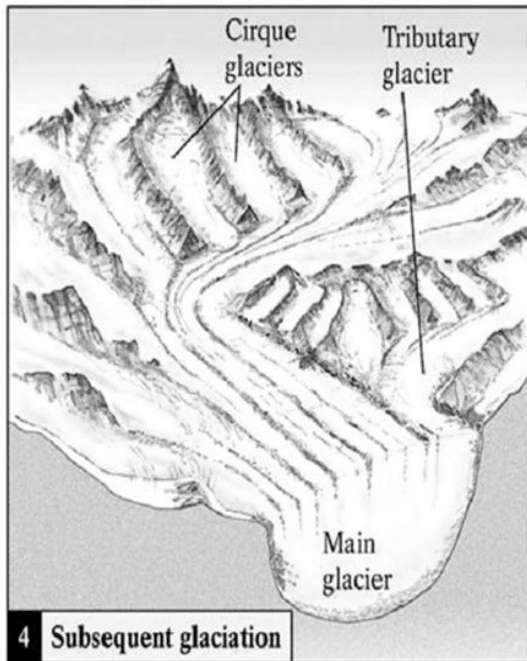
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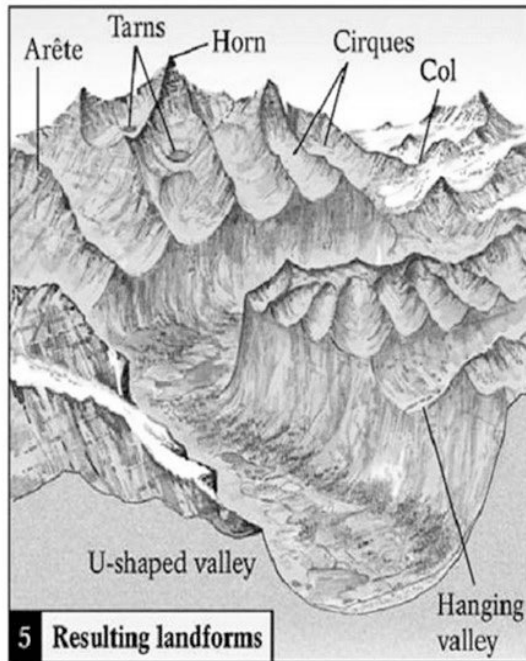
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# Background: What is a Fjord?



4 Subsequent glaciation



5 Resulting landforms

Artist's sketch of how alpine glaciers form post-glacial landscapes. If the figure on the right was inundated by seawater it would be a fjord.

Credit: ESA

- Terminal moraines cause fjords to be shallower at their seaward end, influencing water circulation and oxygen depletion in their depths.
- Fjords are found in latitudes ranging from around 40 to 80 degrees in both the northern and southern hemispheres.
- Fjords are particularly prevalent where prevailing westerly winds cause orographic lift of weather systems over seaside mountains, resulting in plentiful snowfall to feed their accumulation zones. Western Norway and Spain (Galicia), western North America, southwestern New Zealand, and western Chile are examples.
- Some fjords are extremely long, reflecting the extent of the alpine glaciers that formed them.
  - Greenland's Scoresby Sund is 220 mi (350 km) long.
  - Norway's Sognefjord is 126 mi (203 km) long.



Geirangerfjord, Norway is 9.5 miles (15 kilometers) long, connecting to the sea through 84 miles (135 kilometers) of larger fjords. Its walls are so steep that there is virtually no habitable area along the shoreline. In the distance, the Seven Sisters (De Syv Søstre) waterfall plunges 1,350 feet (410 miles) from a hanging valley.

Credit: I, Fgmedia, via Wikimedia Commons

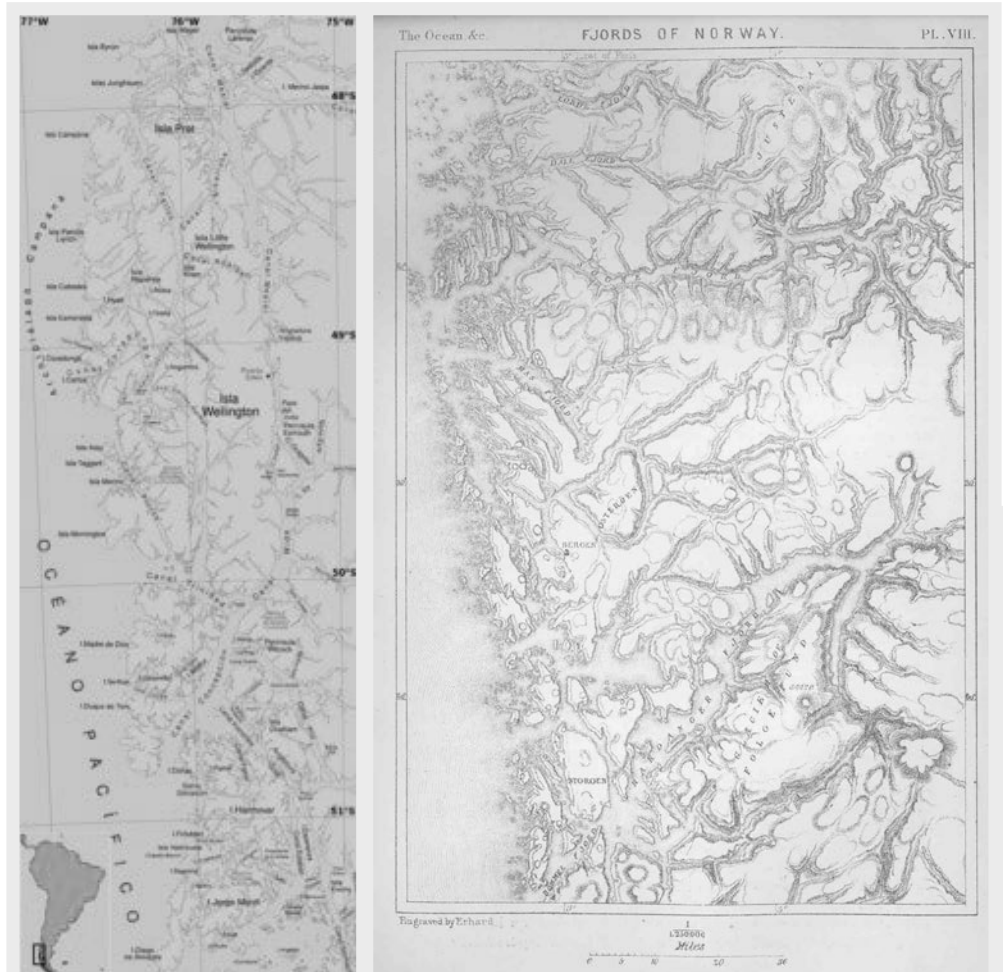
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- During the Pleistocene, when sea level was more than 400 ft (120 m) below today's sea level, glacial ice excavated valleys that stretched down to the paleo shoreline, but some fjords are far deeper than that.
  - Adjacent to 3,300 ft (1,000 m) mountain cliffs, Norway's Sognefjord cuts down to 4,290 ft (1,308 m) below modern sea level.
  - Chile's Canal Messier is 4,226 ft (1,288 m) deep.
  - The glaciers that formed these fjords must have been so thick and heavy that they gouged far below Pleistocene sea levels as they met the oceans.
- Post-glacial isostatic rebound causes uplift of land surfaces, which may strand some fjord mouths above sea level over millennia (ED-129 Ice Age Rebound).



Fjords along the contorted coastline of southern Chile (left) compared to fjords along the coast of Norway (right). Norway has more than 1,200 fjords. Excluding fjords, Norway's coastline is 1,600 miles (2,500 kilometers) long, but including its fjords, its contorted coastline is 18,000 miles (29,000 kilometers) long.

Left Credit: Createaccount, via Wikimedia Commons

Right Credit: Élisée Reclus, public domain, via Wikimedia Commons

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