Engineering Geology

Lecture-11

Glaciers

Glaciers are made up of fallen snow that, over many years, compresses into large, thickened ice masses. Glaciers form when snow remains in one location long enough to transform into ice. What makes glaciers unique is their ability to flow. Due to sheer mass, glaciers flow like very slow rivers. Some glaciers are as small as football fields, while others grow to be dozens or even hundreds of kilometers long.

Presently, glaciers occupy about 10 percent of the world's total land area, with most located in polar regions like Antarctica, Greenland, and the Canadian Arctic. Glaciers can be thought of as remnants from the last Ice Age, when ice covered nearly 32 percent of the land, and 30 percent of the oceans. Most glaciers lie within mountain ranges.

An ice cap is a dome-shaped glacier mass flowing in all directions, such as the ice cap on Ellesmere Island in the Canadian Arctic. An ice sheet is a dome-shaped glacier mass exceeding 50,000 square kilometers. The world's ice sheets are confined to Greenland and Antarctica.

Glaciers

Glaciers begin to form when snow remains in the same area year-round, where enough snow accumulates to transform into ice. Each year, new layers of snow bury and compress the previous layers. This compression forces the snow to re-crystallize, forming grains similar in size and shape to grains of sugar. Gradually the grains grow larger and the air pockets between the grains get smaller, causing the snow to slowly compact and increase in density. After about a year, the snow turns into firn—an intermediate state between snow and glacier ice. At this point, it is about two-thirds as dense as water. Over time, larger ice crystals become so compressed that any air pockets between them are very tiny. In very old glacier ice, crystals can reach several inches in length. For most glaciers, this process takes more than a hundred years.

For further information:

https://www.swisseduc.ch/glaciers/earth_icy_planet/glaciers03-en.html

Major Types of Glaciers

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. 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.

Movement of Glaciers

- 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 with the underlying ground's surface. 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.
- Sometimes a glacier slides over a thin water layer at the glacier's base. The water may result from glacial melt driven by pressure of the overlying ice, or from water working its way through glacier cracks to the base. Glaciers can also slide on a soft, watery sediment bed. This basal sliding may account for most of the movement of thin, cold glaciers on steep slopes. Warm, thick glaciers on gentle slopes owe less of their movement to basal sliding.

Movement of Glaciers

- Glaciers periodically **retreat** or **advance**, depending on the amount of snow accumulation or melt that occurs. This retreat and advance refers only to the position of the terminus, or snout (the end of a glacier, usually the lowest end), of the glacier. Even as it retreats, the glacier still deforms and moves downslope, like a conveyor belt. In other words, a retreating glacier does not flow uphill; it simply melts faster than it flows.
- 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.

Types of Glaciers

- **Mountain/Alpine glaciers**

These glaciers develop in high mountainous regions, often flowing out of icefields that span several peaks or even a mountain range. The largest mountain glaciers are found in Arctic Canada, Alaska, the Andes in South America, and the Himalaya in Asia.

- **Valley glaciers**

Commonly originating from mountain glaciers or icefields, these glaciers spill down valleys, looking much like giant tongues. Valley glaciers may be very long, often flowing down beyond the snow line, sometimes reaching sea level.

- **Tidewater glaciers**

As the name implies, these are valley glaciers that flow far enough to reach out into the sea. In some locations, tidewater glaciers provide breeding habitats for seals. Tidewater glaciers are responsible for calving numerous small icebergs, which although not as imposing as Antarctic icebergs, can still pose problems for shipping lanes.

Mountain/Alpine glaciers

Tidewater glaciers

Valley glaciers

Types of Glaciers

- **Cirque glaciers**

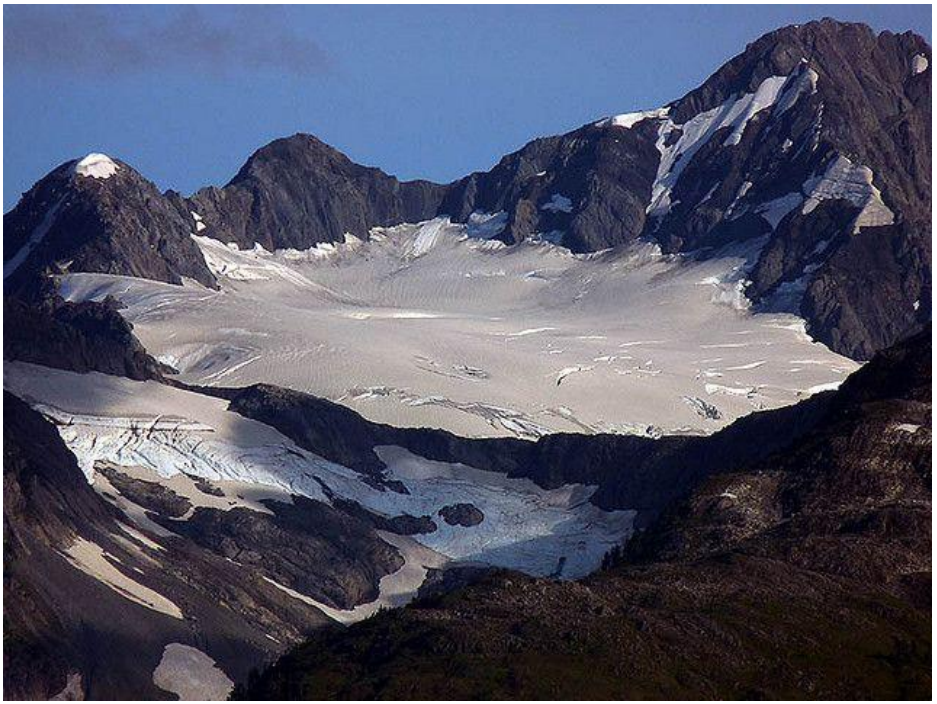
A cirque glacier is formed in a cirque, a bowl-shaped depression on the side of or near mountains. Snow and ice accumulation in corries often occurs as the result of avalanching from higher surrounding slopes. If a cirque glacier advances far enough, it may become a valley glacier. Additionally, if a valley glacier retreats enough that it is within the cirque, it becomes a cirque glacier again.

- **Ice aprons**

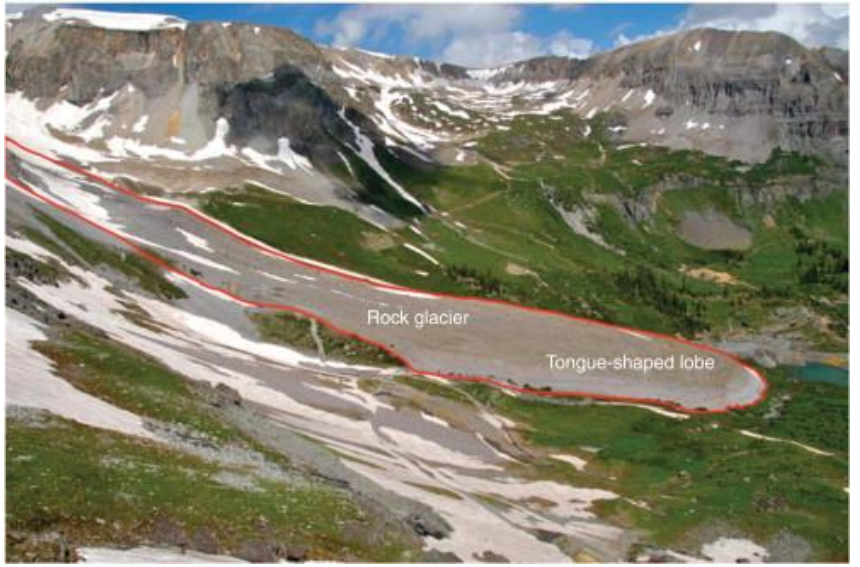
These small, steep glaciers cling to high mountainsides. Like cirque glaciers, they are often wider than they are long. Ice aprons are common in the Alps and in New Zealand, where they often cause avalanches due to the steep inclines they occupy.

- **Rock glaciers**

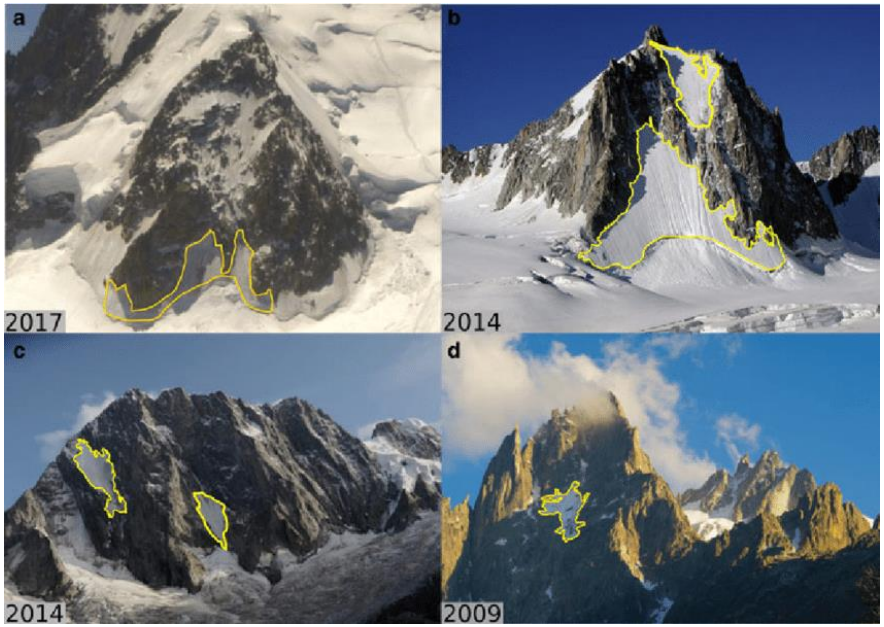
Rock glaciers are combinations of ice and rock. Although these glaciers have similar shapes and movements as regular glaciers, their ice may be confined to the glacier core, or may simply fill spaces between rocks. Rock glaciers may form when frozen ground creeps downslope. They may also accumulate ice, snow, and rocks through avalanches or landslides.



Cirque glaciers



Rock glaciers



Ice aprons

Types of Glaciers

- **Ice sheets**

Found now only in Antarctica and Greenland, ice sheets are enormous continental masses of glacial ice and snow expanding over 50,000 square kilometers. The ice sheet on Antarctica is over 4.7 kilometers (3 miles) thick in some areas, covering nearly all of the land features except the Transantarctic Mountains, which protrude above the ice. Another example is the Greenland Ice Sheet. In the past ice ages, huge ice sheets also covered most of Canada and Scandinavia (the Scandinavian Ice Sheet), but these have now disappeared, leaving only a few ice caps and mountain glaciers behind.

- **Ice caps**

Ice caps are miniature ice sheets, covering less than 50,000 square kilometers They form primarily in polar and sub-polar regions and are smaller than continental-scale ice sheets.

- **Ice fields**

Icefields are similar to ice caps, except that their flow is influenced by the underlying topography, and they are typically smaller than ice caps.

Ice Sheets

Ice field