ENVIRONMENTAL GEOSCIENCES

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Lecture-11

Geological Work of Glaciers

Welcome to the SWAYAM NPTEL course on Environmental Geosciences. So, we are continuing module two in which we have already discussed the types of weathering, erosion, transportation, and the geological work of wind and river. This is lecture five in which we will discuss the geological work of glaciers. In this lecture five, the important concepts will be an introduction to glaciers, the formation of glaciers, types of glaciers, and the geological work related to glaciers. So first of all, we will understand what a glacier is.

Glaciers are massive, persistent bodies of ice that form over long periods in regions where the accumulation of snow exceeds its melting and sublimation. Instead of rivers of water, there are rivers of ice, which are generally called glaciers. They are a crucial component of the Earth's cryosphere, that is, the frozen parts of the Earth, and play a significant role in shaping landscapes, regulating global climate, and sustaining freshwater resources. Now we will discuss the formation of glaciers. Under the influence of pressure and moisture, the snowflakes change into a granular ice mass known as névé in French and firn in German.

As the snow compacts, it loses trapped air, becoming harder and more dense. When the ice becomes so thick that the lower layer becomes plastic, outward or downhill flow commences, and an active glacier comes into being. On a level surface, snow fields slowly gain in thickness and do not ordinarily cause the ice to move. Along the slopes of hills, on the other hand, the increasing weight of the mass is at length sufficient to make the ice flow or creep downwards. Such bodies of slowly moving ice are generally called glaciers.

Very good examples of glaciers are in the Himalayan region, where we have the Gangotri glacier and the Siachen glacier. In the adjacent figure, you just see the percentage of air

that has been given. In the case of snow, 90% air remains. Coarse and grained snow, 50% air. Firn, 20-30% air.

And glacial ice, you can see 20% air remaining as bubbles. So, this is all about the formation of glaciers. Now, next, what are the types of glaciers? Generally, there are three major types of glaciers. First is the valley glacier.

It is also known as a mountain or alpine glacier. It is a narrow strip of ice accumulation confined within the two walls of a pre-existing river valley. In the adjacent figure, you can see the two walls of the valleys are there, with the glacier in between. They form at high altitudes in mountainous regions where the temperature is favorable for their formation. The second type is the Piedmont glacier.

When the ice mass moving through the steep surface of the mountain reaches the foothills or the plain area, it creates a Piedmont glacier. Piedmont means an area from the foothills to the flat plain land. These are intermediate in form and origin between valley glaciers and ice sheets or continental glaciers. They take the shape of bulb-like lobes, so Piedmont glaciers take the shape of bulb-like lobes. The third is the ice sheet or continental glacier. This is the third type of glacier. These are huge covers of ice. Continental glaciers are vast, continuous masses of ice that originate in high latitudes and cover portions of a continent or island.

Continental glaciers flow outward in all directions. These are considered unconfined glaciers because they flow over a landscape and generally are not affected by heat. So, three types of glaciers have been discussed. Now, what is the geological work of glaciers? So, these glaciers also perform some geological work in nature.

So, we will discuss these things. Glaciers, like other geological agencies such as wind, rivers, etc., perform their work in the following ways. Here, they are also involved in glacial erosion and glacial deposition. So, one by one, we will discuss these things. Glacial erosion is the process by which glaciers shape the landscape through movement and abrasion.

As glaciers flow, they pick up rocks and debris, grinding against the bedrock beneath, a process called abrasion, which creates smooth, polished surfaces and striations. Glacier erosion is a powerful force contributing to sediment transport and deposition downstream, shaping ecosystems and influencing hydrological systems in cold and high-altitude regions. Erosion by glaciers takes place because of plucking, rasping, and avalanching.

Now, plucking. It may be broadly defined as the loosening and breaking of rock masses by the pressure of glacier ice. It is also called frost wedging or glacier quarrying.

During the summer months, the surface parts of the glacier may partially melt. This meltwater seeps down along the sides of the ice mass, finding its way into cracks and fractures in the rocks along the edges and at the head of the glacier, as shown in the figure. At night, or when the temperature drops, this water freezes, thereby breaking up the rock by frost action. Second is the rasping or glacial abrasion. It is the term used to describe the scraping or abrasion by glacier action.

It is the pushing action by the glaciers. The front edge of glaciers functions as a bulldozer, pushing and scraping the ground in front of the ice. Ice itself is capable of abrading only soft rocks. But when it is carrying along its stone fragments and rock pieces, it acts as a powerful abrading medium. So, this is about the rasping.

Third is the avalanching. Avalanching is the process of mass wasting. Along the margins of a valley glacier, the valley sides are scraped and blocks are broken off, which become frozen into the ice and are carried away. This leads to undercutting of the sides of the valley and paves the ground for slumping, sliding, and diverse avalanches, which bring great quantities of rock waste onto the top surface of the glacier, as shown in the figure. Now, after this, we will discuss glacial deposition.

Glacial deposition is the process by which glaciers lay down the sediments and debris they have transported during their movement. Glacial deposition takes place when the ice begins to melt and the glaciers slow down and vanish, losing their transporting power. As glaciers advance or retreat, they leave behind a variety of landforms and deposits, shaping the landscape in unique ways. What are the key processes of glacial deposition? First is the direct deposition from ice. That is till.

Deposition by meltwater. That is outwash. Deposition in glacial lakes. That is varves. And dropstones. So these are the key processes of glacial deposition. Now, first is the direct deposition from ice. That is till.

When glaciers melt, they deposit unsorted and unstratified material, known as till, directly onto the ground. This material ranges in size from fine silt to large boulders. Second is the deposition by meltwater, which is outwash. Meltwater streams flowing from glaciers transport and sort sediments. The resulting deposits, known as outwash, are

typically stratified and sorted by size, with coarser materials settling closer to the glacier and finer materials carried further away downstream.

Third is the deposition in lakes, that is, varves. Sediments settle in glacial lakes, often forming thin layers called varves, where each layer represents a single year of deposition. Thicker, coarser layers are typically deposited in summer, while finer, thinner layers are deposited in winter when meltwater flow slows. Fourth is the drop stones. Rocks carried by glaciers can become embedded in icebergs and transported over long distances.

When the icebergs melt in bodies of water, the rocks drop to the bottom, forming drop stones. Now we will discuss glacial topography. Glacial topography is a climate accident that happens to the normal cycle of erosion. That is, the climate gets very cold and the river freezes. The geological action of glaciers, erosion, and deposition together constitute glaciation. Glacial topography is of two types.

First is valley glaciation, and second is continental glaciation. Now, the topography of valley glaciation. Valley glaciers erode by all three methods, i.e., plucking, rasping, and the avalanching method. There are many sets of features resulting from glacial erosion and glacial deposition, which are based on the topography of valley glaciation. Now, features of glacial erosion based on the topography of valley glaciation are, first, the cirques.

These are circular depressions formed by plucking and grinding on the upper parts of the mountain slopes. These are also known as corries or amphitheaters. The second feature is the hanging valley. Tributary glaciers also carve U-shaped troughs. But they are smaller in cross-section, with floors lying high above the floor level of the main trough, that is, the main glacier valley.

Such types of valleys are called hanging valleys. Here, you can see the figure of the hanging valley also. Now, the third is the arête. This name is applied to the sharp ridges produced by glacial erosion. Where two cirques intersect from opposite sides, a jagged, knife-like ridge called an arête results. It is also known as a comb or serrate ridge.

The fourth type is the horn, where three or more cirques grow together. A sharp, pointed peak is formed by the intersection of the arêtes. Here, you can see the three or more intersections of the peak here. Here, you can see where three or more cirques are going together. A sharp, pointed peak is there, and this is called a horn. Peaks are also called horns.

Now, features of glacial deposition are based on the topography of valley glaciation. The unstratified, unsorted debris dropped more or less in a random fashion by a glacier forms deposits known as moraines. Three types of moraines are known, based on their location in the valley. Lateral moraine, medial moraine, and terminal moraine. Lateral moraine

These are circular depressions formed by plucking and grinding on the upper parts of the mountain slopes. These are also known as corries or amphitheaters. Medial moraine: this name is applied to the sharp ridges produced by glacial erosion. Where two cirque walls intersect from opposite sides, a jagged, knife-like ridge called an arête results. It is also known as a comb or serrate ridge. Third is the terminal moraine, where three or more cirques grow together.

A sharp, pointed peak is formed by the intersection of the aretes. These peaks are known as horns. This is all about valley glaciation. Topography because of valley glaciation. Now, the topography of continental glaciation. Like valley glaciers, continental glaciers prove to be a highly effective eroding agent.

But continental glaciers erode only by plucking and rasping methods, not by avalanching methods. There are two sets of features resulting from glacial erosion and glacial deposition based on the topography of continental glaciation. Features based on the topography of continental glaciation are, first, the striations. The slowly moving ice scraped and dragged away much solid bedrock. Left behind were smoothly rounded rock masses bearing countless minute abrasion marks, scratches, which are called striations. The second feature is the Roches Moutonnées.

They consist of asymmetrical mounds of rock of varying size with a gradual, smooth, abraded slope on one side and a steeper, rougher slope on the other. The stoss side, that is, the side from which the ice was approaching, is characteristically smoothly rounded, and the other side, the lee side, where the ice plucked out angular joint blocks, is irregular and blocky. They are also known as sheep rocks. Sometimes, very hard rocks like volcanic plugs offer great resistance to the ice flow and stand as pillars in the glaciated valley. These structures are called crags, and the lee side, which is sloping in this case, is the tail.

Now, features of glacial deposition based on the topography of continental glaciation. The term glacial drift includes all varieties of rocks and debris deposited in close association with glaciers. The various types of depositional features are, first, the drumlin. Glacial drumlins are oval-shaped hills made of glacial till, sand, and gravel that were left

behind by a moving glacier. The uphill sides are blunt, and the downhill sides are smooth and gently sloping.

The long axis of each drumlin parallels the direction of ice movement and thus serves as an indicator of the direction of ice movement. In the figure, you can also see a drumlin there. Next is the basket of eggs topography. The drumlins commonly occur in groups or swarms, which may number in the hundreds. The topography produced by them is peculiar and is known as basket of eggs topography. Third is the ground moraine.

Ground moraine is a thick layer of sediment left behind by a retreating glacier. So, it is the sediment of debris left after a steady retreat of ice. Now, the environmental impact of the geological work of glaciers. So, in this, we will discuss glaciers and their environmental impact. First is freshwater supply and habitat creation.

Glaciers store and release freshwater, supporting rivers and ecosystems, and create unique habitats like glacial lakes and wetlands. Second is landscape and soil formation. Erosion by glaciers reshapes landscapes into features like U-shaped valleys, while deposition enriches soils with glacial flour, fostering agriculture. Third is ecosystem disruption. Glacial advances and retreats alter ecosystems, change water flow patterns, and may cause natural disasters like glacial lake outburst floods.

Contribution to sea level rise: accelerated melting of glaciers due to climate change contributes significantly to global sea level rise, impacting coastal regions and ecosystems. Climate feedback effects: glacier retreat reduces albedo, increasing heat absorption and amplifying global warming in a positive feedback loop. Now, the conclusion of module 2. The interaction of weathering, erosion, and transportation driven by wind, rivers, and glaciers shapes Earth's landscapes, emphasizing their role as key geomorphic agents in sculpting the surface of the Earth. Each agent—wind, rivers, and glaciers—operates through unique processes.

Wind predominantly affects arid regions, rivers dominate in fluvial systems, and glaciers influence cold and high-altitude terrains. These forces not only degrade and erode but also transport and deposit sediments, playing a crucial role in soil formation, sedimentary rock development, and the creation of diverse types of landforms. Weathering prepares materials for erosion. Erosion moves material, and transportation leads to deposition, illustrating a seamless natural system influencing the Earth's surface features. These are references I have taken from the lectures.

I have attended the lectures. Thank you very much to all.