ENVIRONMENTAL GEOSCIENCES

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Lecture-9

Geological Work of Wind

Welcome to the NPTEL course on Environmental Geosciences. We are discussing Module Two: types of weathering, erosion, transportation, and the geological work of wind, rivers, and glaciers. We have already completed the types of weathering, erosion, and transportation in Lecture One and Two. Today we will discuss Lecture Three, which is the geological work of wind. In this third lecture, the geological work of wind, wind erosion, wind deflation, wind abrasion, deposition by wind, sand dunes, types of sand dunes, and erosional features will be discussed.

Now we will learn, one by one, the different concepts related to the geological work of wind. The Earth is surrounded by an envelope of gases called the atmosphere, and the moving air is called wind. The vertical movements of the atmosphere are termed air currents. Wind is one of the major geological agents of change on the surface. Wind plays a crucial role in shaping landscapes, especially in dry regions like deserts.

Wind action is conspicuous in semi-arid and arid regions but is particularly strong in deserts. What is the role of wind in geology? See, there are several roles. We will discuss them one by one. First is erosion.

We have already learned about erosion in the earlier lecture. Now, wind erodes rocks and soil, especially in arid regions, by removing fine particles and shaping landscapes like deserts. Transportation: wind transports sediments, such as sand and dust, across vast distances, forming features like sand dunes and loess deposits. Deposition: wind deposits sediments in areas with reduced velocity, creating landforms such as dunes, sandbars, and dust layers. Weathering: wind carrying abrasive particles causes mechanical weathering of rocks, breaking them into smaller fragments.

So big rocks break into smaller and smaller fragments. Soil formation: wind plays a role in soil formation by redistributing the organic and mineral materials present in it.

Landform creation: wind shapes various landforms such as deserts, valleys, and coastal features. So we have seen that the moving air is called wind, and this wind is bringing many changes to the landscapes on the Earth's surface. Now, what are the key geological processes related to the geological work of wind?

Generally, wind erosion is termed as aeolian erosion, and the aeolian topography is created by the geological action of wind, which can conveniently be divided into the following three stages. First, erosion. Second, transportation. Third is deposition. Again, in erosion, there are three different processes: deflation, abrasion, and attrition. Now, about wind erosion, we will discuss first. Erosion is a process that includes the destruction of existing rocks and the removal of the product from the site of destruction.

We have learned this in the earlier slides. Now, wind erosion refers to the processes by which wind removes and redistributes surface materials, primarily in arid and semi-arid regions where vegetation cover is sparse and loose dry particles are abundant. These geological processes play a significant role in shaping the landscapes. The wind accomplishes erosion by three means: deflation, abrasion, and attrition. The figure also tells us about, as you can see in this figure, that the deflation process is mentioned here.

Small particles have broken, and this is abrasion. And the third one is attrition. This is attrition. Now, one by one, we will learn about these three different processes of wind erosion. Deflation is the process of removal of loose soil or rock particles along the course of the blowing wind. So this is deflation. Here you can see the loose soil or particles that are remaining at the top of the existing rock, along with the course of the wind, moving further ahead.

So, this is just a process of the removal of loose soil or rock particles along the course of the direction of the wind. This process operates well in dry regions with little or no rainfall. Wind processes do not have much erosive power over rocks or over the ground covered with vegetation. However, wind moving with sufficient velocity over dry and loose sands or bare ground covers dust. It removes huge quantities of material from the surface, which is known as deflation.

So, in some deserts, deflation may remove the sand from a particular location to such an extent that a depression touching the water is known as a blowout. You can see here blowouts; these are the blowouts. So, in some deserts, deflation can be seen where the sand is just being removed from a particular location, exerting a depression so that it touches the water, and these are known as blowouts. Now, about abrasion: abrasion is the

sandblasting action of wind with sand against the rocks. So, it is just the sandblasting action of wind with sand. The loose particles that are blown away by the wind serve as tools of destruction.

So again, suppose in this rock, if the loose particles are generated, then these loose particles will move further and will hit the next part, again breaking into smaller particles. So, the loose particles which are blown away by the wind serve as tools of destruction, and when they move over some rock surface, they bring about a scraping of the surface. Just removing the top portion of the rocks. So, while in transit, wind-borne particles often collide with one another. So, small particles often collide with one another, and what they are doing: wind is a powerful agent for the wear of rock surfaces when equipped with sand and dust particles. So, this type of erosion involves polishing and altering of the rock surface by a natural agent like wind, and this is called wind abrasion or abrasion.

So, these are in the figure also; you can see the different stages of development of landforms due to wind erosion. So, in the next figure, you can see the formation of pedestal rock due to wind erosion. Earlier, the rock was in this shape, but because of the wind, you can see the wind direction is given. So, this portion, this portion, this portion has totally been removed because of wind abrasion. So, this is about abrasion. Next is wind attrition.

So this is the third process of erosion, attrition. Wind attrition refers to the process by which particles carried by the wind collide with each other or with surfaces, resulting in the gradual breakdown of those particles into finer particles. So, these processes play a significant role in shaping landscapes, particularly in arid and semi-arid regions where wind is a dominant erosional force. Attrition is the grinding action. The sand grains and other particles that are lifted by the wind and carried away do not travel in a straight path.

Their path is determined by their density and the velocity of the wind. So it moves in a zig-zag path. So you can see in the figure also that the particles are colliding with each other, resulting in the gradual breakdown of those particles into finer particles. So this is about attrition. We have learned about the three different processes of erosion: deflation, abrasion, and attrition. Now, what are the factors affecting wind erosion? See, in the earlier slides also, we have seen that areas covered by thick vegetation are least affected by wind erosion.

Marshy lands and saturated soil are not affected by wind erosion. Land surfaces such as dust, silt, and sand are easily eroded by wind. So in the figure also, we can see that thick

vegetation is least affected by winds. Marshy lands and saturated soil are not affected by wind erosion, whereas land surfaces such as dust, silt, and sand are easily eroded, as we are seeing in this portion. They are easily eroded because of the wind. So these factors generally affect the processes of wind erosion. Now, wind transportation: after erosion, the second part is transportation, so about wind transportation.

So this is totally dependent on wind velocity. There are generally three different methods of wind transportation. First is traction, second is suspension, and the third is saltation. Traction, where particles are moved through rolling and creeping. So when the eroded particles or broken particles from a rock surface move in the direction of the wind, by rolling and creeping, by rolling and creeping.

So, this process of rolling and creeping is generally termed as traction. The second process is known as suspension. The light-density clay particles may be lifted by the wind from the ground and move along with the wind, which is called suspension. Here, the particles which are too heavy to remain in suspension but too light to be transported by traction are transported through a series of bounces. So, lighter particles are generally transported through a series of bounces. Saltation is the third process of transportation.

Very light particles like dust, cloud, smoke, etc., move quickly with the wind but settle very slowly, remaining in suspension in the air. The heavier and coarser sediments are lifted up with high velocity and short distances above the ground, up to 2 meters. They are picked up and dropped again during the transportation process of bouncing and jumping, which is called saltation. So, this is the third process, which is saltation. So, it remains in suspension for a certain time but then moves again by being picked up and dropped during the transportation process, which involves bouncing and jumping.

So, this is called saltation. Now, deposition. The third process is deposition. So, aeolian deposits; generally, wind erosion is aeolian erosion. So, aeolian deposits also exist.

So, aeolian deposits, landforms, and deposits made by windblown sediments are generally referred to as aeolian deposits. Wind is an excellent agent for sorting materials according to their size, shape, or weight. The rock particles in aeolian deposits are generally well-rounded and are sorted according to their size and weight. Pebbles and boulders cannot be carried away and are left behind to form lag deposits. So, when pebbles and boulders remain in the same place, they are called lag deposits.

The clay and silty fractions are deposited as loess, which does not show any stratification. Wind deposits take two general forms. First is the sheet, and second is the piles. Sheet deposits are the dust deposits laid down over a large area. It remains spread over a large area in the form of a sheet.

Whereas pile deposits include various types of dunes, which accumulate from sand and silt carried in saltation. So, in the figure, if you see, the sand eroded from this place, sand eroded from this place, and then sand deposited here in calm air. So, Aeolian deposits generally have two different forms. One is the sheet, and second is the piles. Now, these aeolian deposits are again of two types. Accumulation of sand is generally called sand dunes, and deposit of silt is generally called loess.

So, sand dunes are mounds or ridges of sand shaped by wind, common in deserts and coastal regions, whereas loess, or fine silt or clay, is deposited over large areas by wind, creating fertile soils typically found in temperate regions near deserts or glacial plains. So, in the figure, you can see these are the large areas of wind, and these are creating fertile soils. So, this is termed as loess, whereas the sand dunes are mounds or ridges. You can see the ridges and mounds here. So, in this figure, the two different types of Aeolian deposits have been shown very clearly.

Next, now Aeolian deposits. In Aeolian deposits, we have seen that sand dunes and loess are two types of important deposits. So, about sand dunes. A sand dune is defined as a broadly conical heap of sand with two slopes on either side of a ridge or crest. The wind generally deposits sand in mounds. These mounds are called sand dunes.

So these sand dunes have the mound. When the mound is in the form of a hillock or a ridge with a crest, then it is generally called a sand dune. So this is about what a sand dune is. Now, next is how these sand dunes are generally formed. So, in structure, a dune has a gentle slope on the windward side and a steep slope on the leeward side.

Sand dunes have a gentle slope of 5-50° generally on the windward side and a steeper slope of about 20-30° on the leeward side. So, the shape of a dune is controlled by the amount of sand supply, wind velocity, constancy of wind direction, and the amount and distribution of vegetative cover. So, generally, the shape of the dune is based on these factors. The sand traveling through the wind accumulates wherever it meets any obstruction, like a boulder or some bushes. So, generally, this wind, which is traveling and carrying the sand, accumulates or gets obstructed because of these.

As the accumulation of sand grows, it traps even more sand in that place. So, this is about the dunes. Now, what are the different types of dunes? The sand dunes are of different types like transverse dunes, barchans, longitudinal dunes, star dunes, and parabolic dunes. So, one by one, we will learn about these different types of sand dunes.

Transverse dunes have their longer axis at right angles to the direction of the wind, as it is clear through the figure. They are formed in areas with strong winds where more sand is available. Long asymmetrical dunes that form perpendicular to the wind direction are formed when the source of sand is elongated and transverse to the wind direction. A single long slip face remains present in this type of dune. Next are the barchans.

Barchans are crescent-shaped dunes. The convex side of which faces the wind direction. In the figure, you can also see the convex side. This is the convex side. The wind direction is on this side. So it is crescent-shaped.

The horns or wings of the crescent point in the direction of wind flow. It remains in the direction of wind flow. The horn can be seen here. Now, barchans are formed where the wind is nearly unidirectional. They occur in groups in areas with greater sand supply.

Crescent-shaped dunes whose long axis is transverse to the dominant wind direction. The horns are directed towards the leeward side. The concave side is leeward, and the convex side is windward. Formed from a unidirectional wind, it is generally shaped by a unidirectional wind, and a single slip face remains present in the barchans. So this is about the second type of dunes, that is, the barchans.

Next are the longitudinal dunes. They are formed when the direction of the wind is constant, more or less parallel to the wind direction. Crests may be sharp or rounded. The sand dunes that are elongated in the wind direction are called longitudinal dunes. These dunes usually develop in strong wind areas where a small amount of sand is available.

Sinuous dunes that can be more than several kilometers long and their height may go up to 100 meters. Longitudinal dunes are also called saifs. So this is about your longitudinal dunes. Next is the star dune. Large pyramidal or star-shaped dunes with three or more sinuous radiating ridges form a central peak of sand.

They have three or more slip faces. They do not grow along the ground but grow vertically. So this is something you can see in the figure as well. Next are the parabolic dunes. Crescent-shaped, U-shaped dunes with their open ends facing upwind, oriented

transverse to the dominant wind direction. They are concave on the windward side and convex on the leeward side, with sand migrating downwind.

The arms of the dunes are stabilized by vegetation, while the central portion, less anchored, remains more mobile. They are commonly found in coastal or semi-arid regions with strong consistent winds and sparse plant cover. Unlike barchans, parabolic dunes have tips pointing upwind, and they often exhibit multiple slip faces due to variable sand movement. So this is the description of the parabolic dunes. Next, deposits of silt or loess.

The finest particles of dust traveling in suspension with the wind are transported a considerable distance. When dropped under favorable conditions, these particles accumulate in different constituents, forming paper-thin laminae, which aggregate together to form a massive deposit known as loess. The suspended load transported by wind consists mainly of silt and dust particles. When it settles, it forms a blanket deposit of silt, which is known as loess. These deposits are typically non-stratified and have a greyish-yellow color.

Loess is composed of many minerals, including quartz, feldspar, hornblende, and calcite, and deposits of loess are very fertile. So, this is about the description of loess. Now, what are the erosional features because of the geological work of wind? So, important erosional features and the associated landforms are generally hamada, yardang, pedestal rock, ventifacts, and oasis. So, these are because of the geological work of wind; we are getting these types of landforms on the earth's surface. So, first is the hamada. Due to deflation, when the loose particles are swept away, only the hard mantle is left behind, and it is known as Hamada. Hamada refers to a barren rocky desert landscape characterized by exposed bedrock or closely packed angular rocks with minimal or no sand cover.

In the picture, also, you can see the Hamada. It is a bare rock surface from which the thin cover of sand has been blown away by strong winds. It forms in arid regions where wind erosion removes finer particles like sand and dust, leaving behind a stony surface. Hamadas are typically found in deserts, such as the Sahara, and are often inhospitable due to the lack of soil and vegetation. Next is the Yardangs, a group of furrowed topographic forms produced by wind abrasion, which is elongated in the direction of prevailing winds and is usually strongly undercut, known as Yardang.

So, in the picture, you can see the grouped or furrowed topographic form present there. Yardangs are streamlined ridge-like landforms sculpted by wind erosion in arid environments. Formed in soft sedimentary rocks or unconsolidated materials, yardangs are shaped by abrasive action as wind blows sand, erodes weaker layers, leaving behind elongated ridges aligned with the prevailing wind direction. The next landform is the pedestal rock. A wide rock cap standing on a slender rock column, produced because of wind abrasion, is known as pedestal rock.

It is a tabular mass of more resistant rock resting on undercut pillars or softer material. They are very often elongated in the direction of the prevailing wind and are generally known as zeugen. It is also known as mushroom rocks. They are flat-topped rock masses with slender supporting rock stems. The top is commonly referred to as the overhang and the support as the pedestal.

The overhang and the stem are of the same rock that has been eroded by the winds, quite unevenly, resulting in the mushroom-like appearance of the rock mass. They are generally a few meters in height. Next are the ventifacts. These are the pebbles faceted by the abrasive effects of wind-blown sand. Ventifacts with one smooth surface are generally called einkanters; with three smooth faces, they are generally called dreikanters; and when only two abraded faces are left, they are called zweikanters. So this is about the ventifacts in different forms; you can see in the figure also, wind is blowing, and the three abraded surfaces have been shown because of the pebbles faceted by the abrasive effects.

Next is the oasis. Water-filled depressions known as oases are places where vegetation grows in deserts. Stack is another term used for a depression created by deflation. An oasis is a fertile area in a desert where water is available, supporting vegetation and often human settlements. Oases form around natural water sources such as springs, underground aquifers, or temporary rivers.

They provide vital resources for desert ecosystems, enabling the growth of plants like date palms and crops, and serving as refuges for wildlife. Examples are the Siwa Oasis in Egypt and the Al-Hasa oasis in Saudi Arabia. So now, just concluding the lecture on the geological work of wind, we have seen that the first is erosion. Erosion comprises three different methods: deflation, abrasion, and attrition. A few factors also influence the erosion processes; for example, vegetation reduces erosion, while loose surfaces like dust and sand are easily eroded. The second process is transportation.

Generally, there are three types of transportation: traction, saltation, and suspension. The third process is deposition, with two important types of deposition: sand dunes and loess. And the fourth is the types of landforms made by the geological work of wind. We have seen that hamadas, pedestal rocks, yardangs, and ventifacts are some of the landforms which are formed because of the geological work of wind. So wind plays a vital role in shaping landscapes, particularly in deserts, through its erosive, transportive, and depositional actions.

Thank you very much to all.