Geomorphology
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Lecture -27
Aeolian Processes and Landforms-II

So friends good morning and welcome to the lecture series of Geomorphology. Today, we are going to discuss about this Aeolian Processes and Landforms. If you remember our last class we are talking something about this Aeolian process, its significance, its activity how a wind is affective geomorphic agent to erode this material from this bare rock surface and how it transports and how it deposits and we concluded that the wind velocity increases with height.

And mostly the arid regions either it is dry arid or cold arid the wind plays major role in shaping the Earth's crust and the shaping is either by erosion or by deposition. So among this geomorphic agents the wind has the capacity to move this particles against gravity and it may deposit those particles on the hill top taking from the base of the hill and mostly this wind plays major role in the arid region reshaping.

So velocity of the wind is not same throughout a region itself also. For example, if the wind is blowing on sand surface that is free sand is there and wind is blowing its velocity its absorbed however the same wind if it moves from this sheet of sand to a barren rock surface then its velocity increases. So that means depending upon this area, depending upon this material available and this wind velocity changes,

That is why the size, shape and morphology of this depositional features by the wind also vary with time and space. Once wind deposits some material and due to changing of this wind velocity, the changing of the wind direction it modifies that same feature same topographic features or some depositional feature and its modification, the degree of modification depends upon this wind velocity and we found that there are a process of abrasion.

There are process of attrition, there are process of that is these are these processes which are mostly responsible for erosion and a desert pavement is formed by continuous deflation or continuous removal of these finer particles and the remaining coarse particles mostly pebbles

and cobbles they form a layer on this rock surface or this desert surface and that is called desert pavement. So now let us discuss about how this velocity changes of wind from different type of materials they reshape those depositional features.

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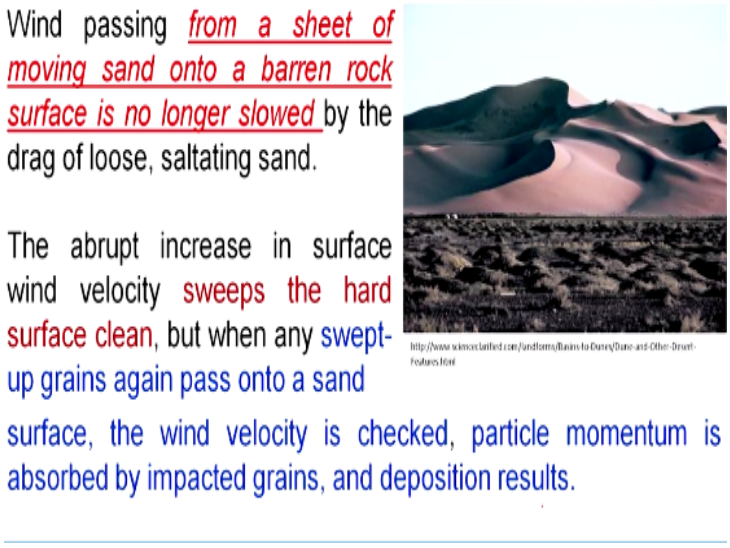

Wind passing from a sheet of moving sand onto a barren rock surface is no longer slowed down by this drag of the loose, saltating sand. However, if this wind it is moving from barren rock surface to sand its velocity it absorbed by the sand grains, but if reverse is true then that means this wind is blowing from this sand particles or this sand sheet to a barren rock surface its velocity it increases. The abrupt increase in surface wind velocity sweeps the hard surface clear and clean, but when any swept-up sand grains pass into the sand surface the wind velocity is checked.

Particle moment is absorbed by impacted grains, deposition results. So that means this decrease in velocity of wind it results deposition. So until unless this velocity of wind comes below a threshold limit a certain size particle that remains in the wind that is why those particles which are silt and clay size particles they remain suspended in the wind and may travel hundreds or thousands of kilometer without settling down. So these are mostly formed the lowest deposits and the aerosol deposits.

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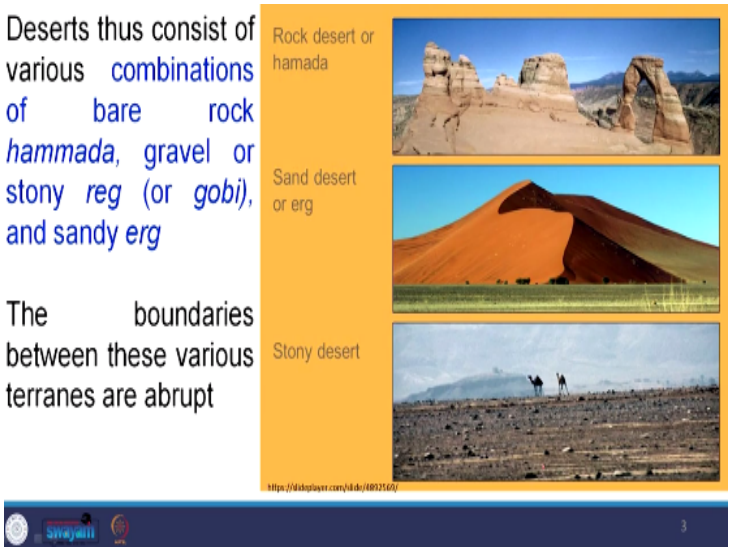

Deserts thus consists of various combinations of bare rock Hamada, gravel or stony reg or sandy erg. So now we have three different types of surfaces available on this desert. One is your Hamada that is bare rock nothing is there, no vegetation, no sand no rock particle, only clean rock surface. Second thing that reg is gravels gravelly environment and second thing is that erg means sand it is sand environment.

So that means 3 different environment they change their position in the sense they do not move, but this sand particles, the gravels, the dusts they move and finally with some permutation and combination this sum of this deposition topography, depositional features they form and that is why they changed the topography that means the elevation, the elevation changes, the depressions are there, somewhere the sand is accumulated somewhere the sand is removed out.

So that is why the topography of this desert they change by this wind activity. The boundaries between these various terranes are abrupt because there is a sudden fall up or sudden rise of this wind velocity. So that is why different domains are separated, but that does not mean that separate domain will remain separated forever. So that means it may possible the sand from the stony desert it may move to the Hamada surface.

And from this Hamada surface it will move to this stony desert. So that means depending upon the wind velocity, depending upon this domain so these positions changes and as a result this micro topography of this wind dominated area or the arid region it changes with time.

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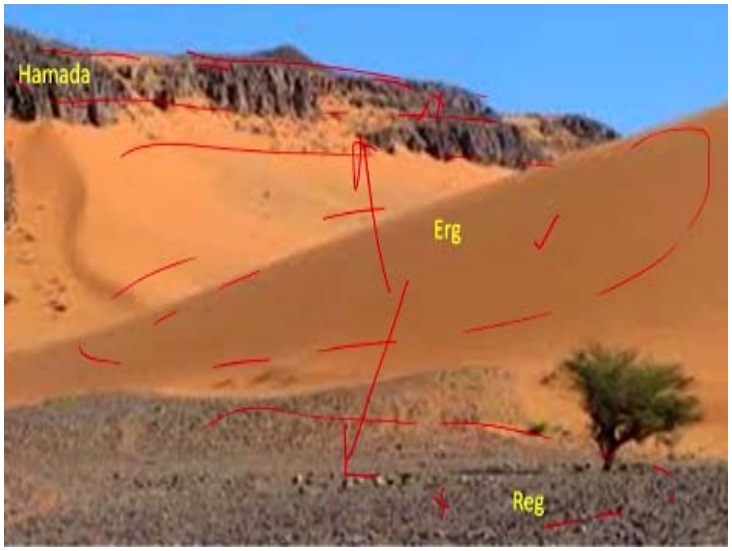

So here is a photograph showing 3 different types of materials or types of these positions of Hamada reg and erg. Now you see this is Hamada which is totally stony and it is looking like a plateau here and ergs now you see this area this is ergs means sandy dominated and this is reg this is stony dominated or gravely dominated. So sand may migrate here from here to here and sand may migrate from here to here.

So mostly this change in micro topography is due to the sand sheet movement or sand migration. All others it this is total immovable this is somewhat movable and this is most moveable. So this micro topography of a desert it mostly modified by the erosion or deposition of this component that is erg.

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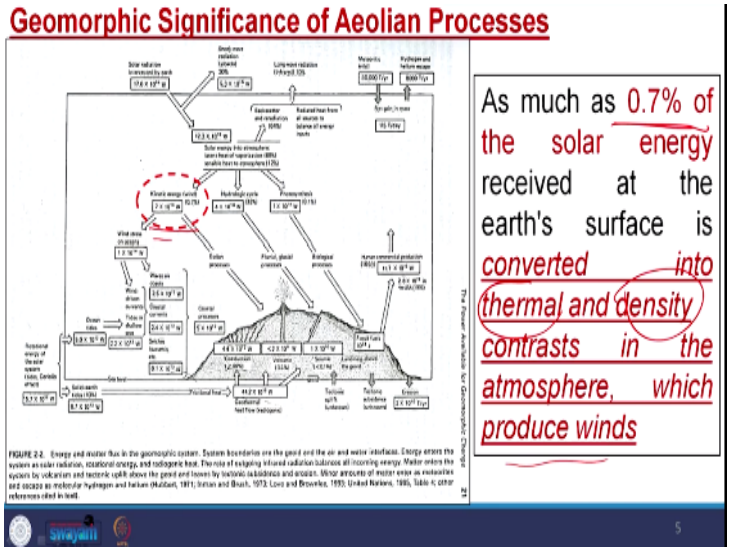

So if we consider the energy involvement in a geomorphic system we know in our earlier classes when we are talking about this energy and mass distribution we found that the Sun is the ultimate source of energy for all these geomorphic processes and this Sun energy it is converted to different types of energy absorbed by different agents and converted to some kinetic energies. Now if we take this energy which is received by this earth not which is transmitted or reflected back only we are considering here the energy which is coming to this earth.

So if we consider it to be 100% this wind energy this is 0.7% is compared to this total solar energy absorbed. So this 0.7% it is very negligible as compared to this total energy system. So this as much as 0.7% of the solar energy received at the Earth's surface is converted into thermal and density contrasts of air. Thermal contrast as well as density contrast of air the atmosphere which produces wind.

So once wind is produced either thermal contrast or density contrast this wind try to move from high density to low density here from high temperature area to low temperature area. That is why in diurnal changes in a one day there will be change in wind direction from water mass to land mass and from land mass to water mass and that is why in between suppose for example we take this example of the coastal plains.

Coastal area it is also dominated by sand now imagine in the day time there will be change of wind direction as compared to this evening time so that these sand particles through the sand particles the wind has to move in this way and a reverse direction in the day and night times. So that is why there will be a constant modification of this geomorphology. There will be constant modification of the position of this depositional features and that is why there will be a diurnal variation of this.

There is a total within a 24 hours there will be variation of a geomorphology along the coastal plains. So that means once density contrast and thermal contrast it creates wind, the wind movement starts and which is responsible for modification of this geomorphology of this wind dominated areas.

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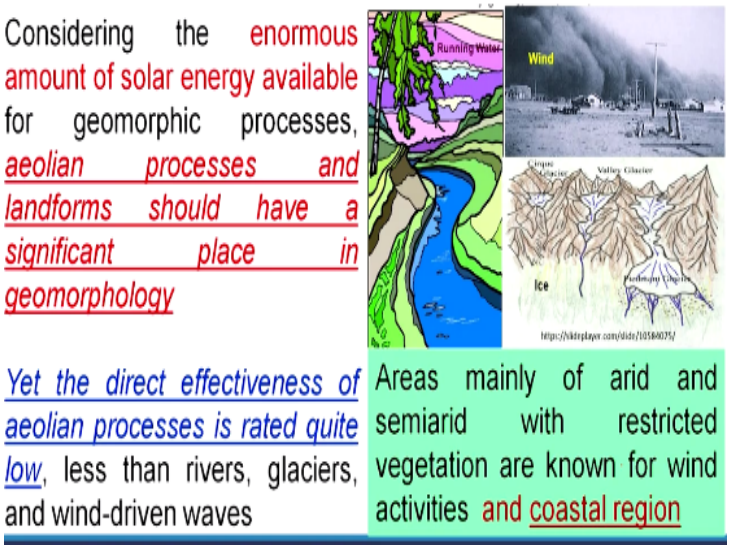

Considering the enormous amount of solar energy available for geomorphic processes Aeolian processes and landforms should have a significant place in the geomorphology. However, so far it is discussed that this wind is restricted either in the arid region or in the coastal region some part of this coastal region. So that means it is not as effective as the other geomorphic agents like water and river this coastal system and as well as the glaciers.

So yet the direct effectiveness of Aeolian process is related quite low relatively quite low and less than the rivers, glaciers and wind-driven waves. Areas mainly of arid and semi-arid with restricted vegetation are known to form wind activity as well as coastal regions too. So that means those areas wind is effective which is vegetative less no vegetation or very sparse vegetation is there then this element these particles the rock fragments they are loose.

And second thing that there will be no raining or it is the arid region very less moisture is available. So those areas very effectively allow the winds to modify its geomorphology.

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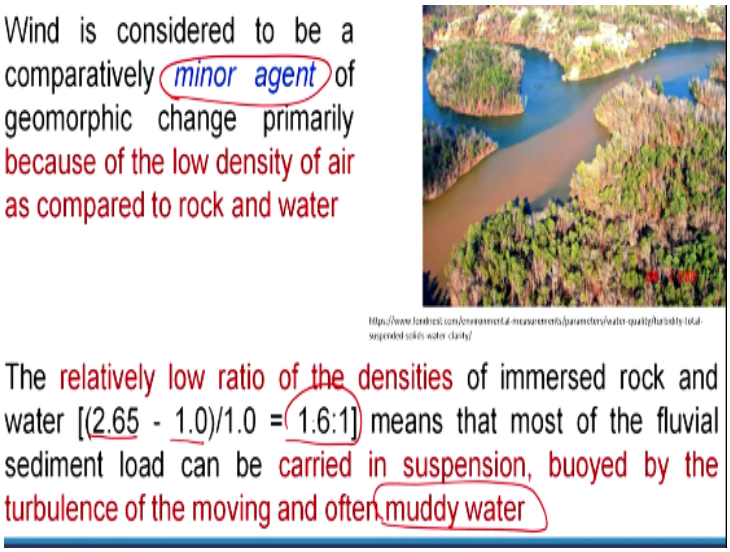

Wind is considered to be a comparatively minor agent you see here it is comparatively minor agent of geomorphic change primarily because the low density of air as compared to rock and water because the process and product here wind is the agent will work here it has not enough strength here density is very less as compared to water and glaciers and it has to move through the rock fragment it has to modify the rock fragment which is much more dense as compared to this wind is concerned.

So that means there is a huge density contrast between the product as well as these processes. So relatively low ratio of densities of immersed rock and water that means we are talking about this muddy water once the rock and water is immersed together so that means here that means water becomes muddy water and it is sediment laden water. So relatively low density contrast of immersed rock and water. So mud water its densities 2.65 and water density is 1.

So this densities contrast is this much means that most of the fluvial sediment load can be carried in suspension buoyed by this turbulence of this moving water often the mud water. So that means the density contrast between water and this rock is relatively low as compared to this wind and rock. So that is why due to this less density contrast the river action or the water action is more and it is more felt as compared to the wind action.

And second thing is that if you see a map this wind is restricted in a particular environment, glacier is restricted in a particular environment, but a river system it is well organized and well distributed through the Continental System. So that means more area is affected by a rivers as compared to wind and glaciers.

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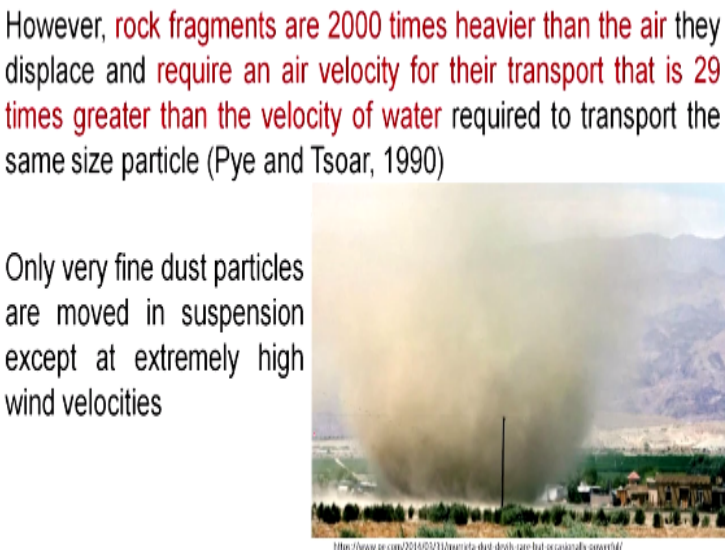

However, rock fragments are 2,000 times heavier than air and they displace and require an air velocity for their transport that is 29 times greater than the velocity of water required to transport the same size particles. So that means if we take this particle size constant whatever the energy required to transport that particle from one place to another place whatever energy is required by a river is less than 29 times than this air why this is due to this density contrast.

That is why only the fine dust particles are moved in the suspension except extremely high wind velocity. So that is why these small particles maybe clay and silt size particles they are more affected by this wind actions as compared to these other larger particles and sand is moved by this wind activity however its distance is restricted, but this clay and silt size particles they can travel thousands of kilometers.

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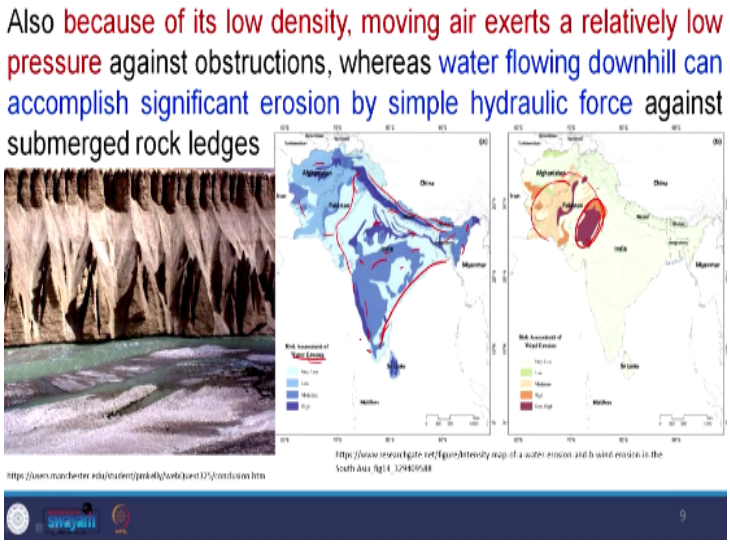

Also because of its low density moving air exert a relatively low pressure against obstructions whereas water flowing downhill can accomplish a significant erosion by simple hydraulic force against the submerged rock edges. When we will talk about the fluvial geomorphology we will talk about the hydraulic action hydraulic action means our hydraulic force means here water only involved in erosion there is no particle, no rock fragments is associated only water alone is associated.

So that means if we are comparing air and water only water then the air is less effective as compared to water and air will start erosion until unless there will be association of particles. So that is why this density contrast is different so water alone can erode rock materials, but wind cannot alone but wind need to have this rock particles rock fragments either silt clay size particles. So those particles if it is associated through air then it will erode the system.

Otherwise simply air cannot erode the system because there is less density contrast is there. So here this is the figure if you see this the water is you see risk assessment of water erosion so that is why this water erosion is everywhere that means water is more effective, but as for wind is concerned wind is restricted up to this region or only Indian context is concerned this part there is Rajasthan Thar Desert part it is only effective by the wind.

However, the Indian context you see this distribution of water effect. So that is why there is a restricted environment by this wind that wind can work here.

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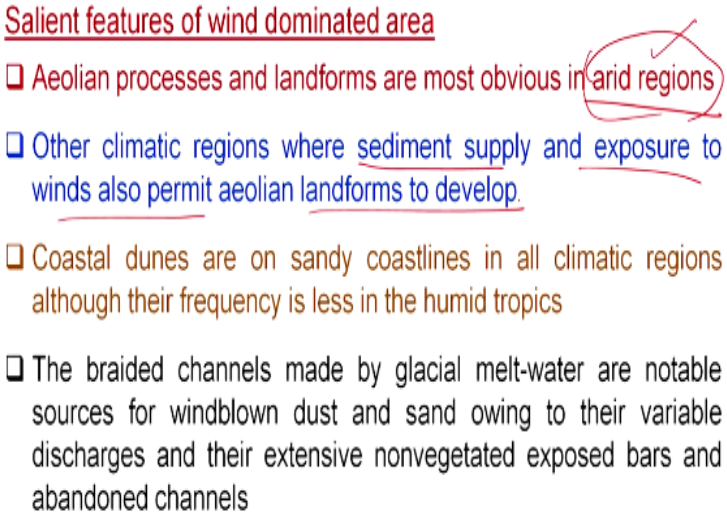

Then salient features of wind dominated area. First is Aeolian processes and landforms are most obvious in arid region this region should be arid then other climatic regions where sediment supply and exposures to wind is also permit Aeolian landforms to develop. So that means not only it is restricted in arid region, but dominantly in arid regions. So other regions other climate region where sediment supply and exposure to wind also permits Aeolian landform to develop.

Sediment supply would be there and exposure is there to wind. So then in those areas that will modify the system. Coastal dunes are on sandy coastlines in all climatic regions although their frequency is less in the humid tropics. So coastal areas that also affected by wind. The braided channels made by glacial melt water as notable source for windblown dusts and sand owing to their various discharges and their extensive non vegetated exposure bars and abundant channels it is very important to understand.

Here we are talking about the glacial outwash plains the ephemeral streams at the arid region and the glacial outwash plains where glacier melts it is converted to a fluvio-glacial environment, the braided streams are emerging and those are also the ephemeral in nature so those ephemeral streams are braided streams these sediments which is lying there that is modified readily by this wind action and produces huge dust.

So those areas exposed to the surface where bare rock body, less vegetation, less moisture content so those are responsible and they are allowing wind to modify their surface and produce transportation sediments.

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So broadly we can say the arid region, the coastal plains and the flood plains of these fluvial systems and outwash plain of the glacial systems they are the source and geographically potential region to work by the wind and if you see this geological map of this Indian subcontinent particularly the Indo-Gangetic Plain you will see number of ridges Aeolian ridges within the fluvial plain. So those Aeolian ridges they are nothing this is the wind action.

And reworking of this fluvially deposited sediments mostly silt and clay and forming the ridges. The ridges mostly they are occupied by the loess that is loose material mostly silt and clay size particles.

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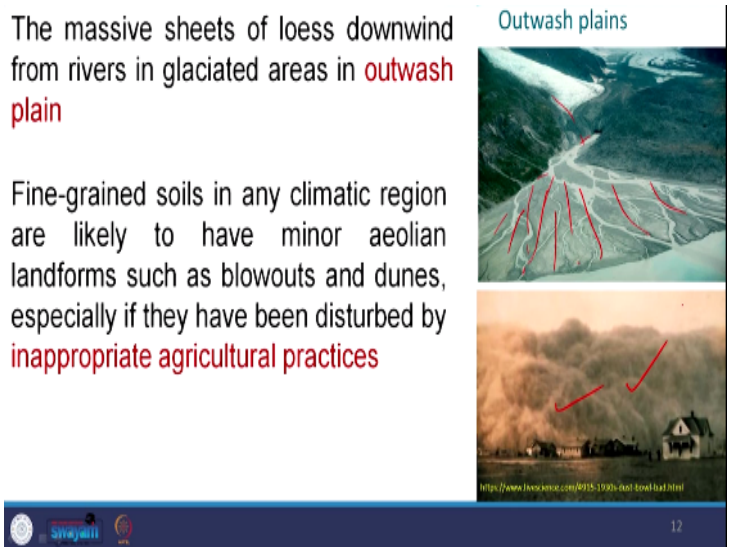

The massive sheets of loess downwind from the river in glaciated area in outwash plain that we are discussing so far. Fine-grained soils in any climate region are likely to have minor Aeolian landforms such as blowouts and dunes especially if they have been disturbed by inappropriate agriculture practice. This is a very important and the historical thing to remember here. In 1930 there is a problem in U.S that is called dust bowl.

So this dust bowl is nothing it is due to inappropriate farming techniques. So that means we expose many part of this or large part of this Earth's surface to work by this wind so that huge dust can be taken off by the wind and it is called the Dust Bowl here is a photograph is representing the Dust Bowl and here these glaciers and this is the glacier outwash plain, these are this alluvial fans it is forming and these ephemeral streams and areas these sediments deposited here.

That will be reworked by the wind and will be redistributed like this and so that means this dust bowl that is due to inappropriate farming and due to lack of vegetation and due to availability of fine material sediment material those are the suitable conditions which are responsible for effective work of wind redistribution of sediment modifying the landscapes.

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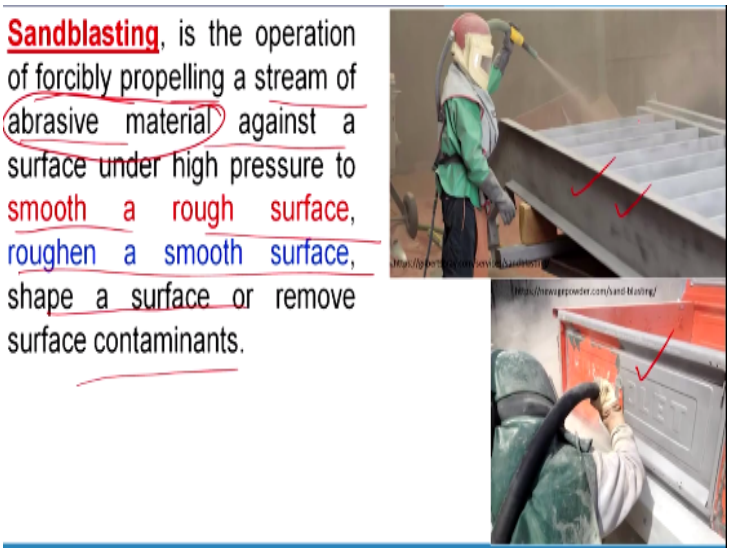

Then sandblasting you can say it is an artificial bombardment of the sand particles to the surface with pressurized air. So that means if we are simply pressurizing air it will hardly affect the rock, but once sand particle is added to it so that means its power, its erosional capacity increases several thousands of folds. So that is why here if you see some photographs are given this is for sandblasting by some of these companies.

It is the operation of forcibly propelling a stream of abrasive material or it is sand abrasive material here is the sand against a surface under high pressure to smooth a rough surface. So that means you imagine whenever in a arid regions the wind is blowing having the sand particles having silt particles or dust clay particles with that and the same wind is interacting with the nearby these mountainous regions so its work is to smoothen the surface they are often as decreases smoothness increases.

So it is smooth a rough surface and roughen a smooth surface whenever there is a smooth surface is there if it is bombarding there the particles the sand particles is being bombarded there so it will become rough and the rough surface becomes smooth. So that means either positively or negatively this wind is working to peneplain the surface. So the shape of a surface or remove the surface contaminations it is due to this particular part is restricted to this type. and that is for this in a sandblasting of instruments or materials.

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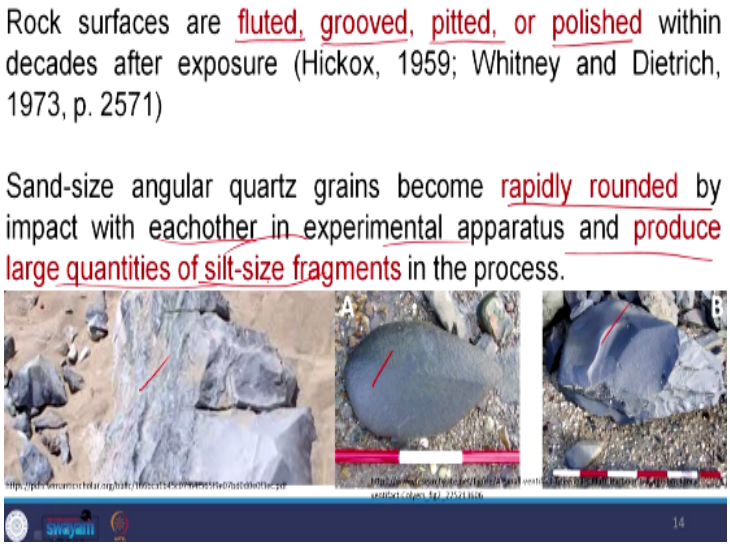

Rock surface are fluted, grooved, pitted or polished within decades after exposures. So it is fluted, fluted means grooves like flute like linear structure. Similarly grooves that means small linear ridges that is grooves, pitted pitting a point are polished that is polish occur so polishing occurs within the decades after exposure to this wind. So if the wind is containing this type of silt sand and clay particles and is interacting with this surrounding rock materials.

So this type of activities may be seen here this type of change may seen here. Sand size angular quartz grains become rapidly rounded by impact with each other in experimental

apparatus and produce large quantity of silt size fragment in this process so this process is called attrition. So that means we have different sands, we are mixing together and allowing to interact with each other. So by this process the angularity of sand decreases.

And those material, this angularity whatever the material is removed from this angles that are the silt and clay sized particles. So that means huge dust is produced so this process is called attrition process that means during transportation the sand grains themselves they collide with each other and finally they reduce their angularity and the product is or the sand, the silt and clay. So this rapidly rounded by this impact with each other in the experimental apparatus.

And produce large quantity of silt sized fragments in this process and if this wind is blowing these silt size particles they can transport it to large distance and due to decrease of wind that sand will remain there. So that is why there is a contrast of grain size separation that is why the sorting increases. The silt particles they remove sand are relatively coarser material they lie there and forming a contrast in the sorting.

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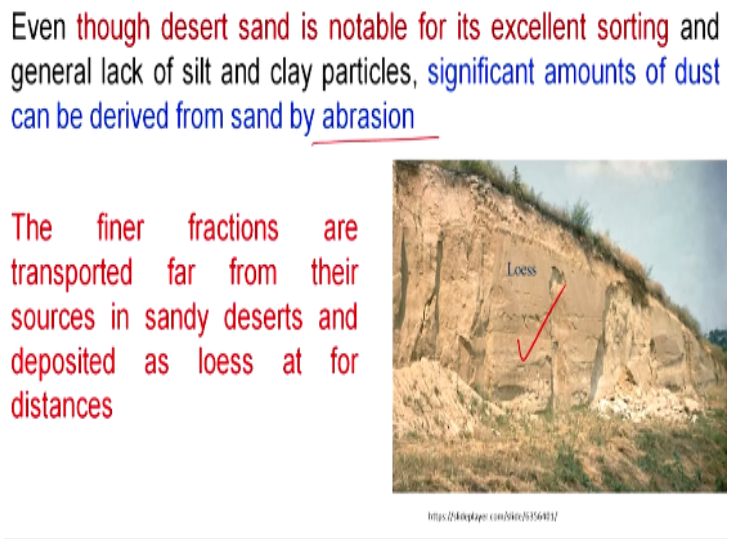

Even though desert sand is notable for its excellent sorting and general lack of silt and clay particles significant amount of dust can be derived from sand by abrasion. Abrasion means it is the interaction of sand and wind to a rock surface. The finer fractions are transported far from their source and in sandy deserts and deposited as a loess for larger distance. If you see here this is loess deposit that means in a desert environment at the periphery of the desert will get the lowest deposits like in Punjab, Haryana in Indian context.

If you see Punjab, Haryana there is the periphery of the Thar deserts. So Thar deserts it is dominantly of sand, but the periphery we are getting loess deposits so this loess are nothing this is the silt and clay sized particles which are transported by the wind from the desert and they are deposited at the peripheries. So this is the sorting contrast here loess and there inside this desert we have sand. So how wind erodes whatever we are discussing so far it is erosion.

Removal of this material and transportation from one place to another place and depositing, but what is the mechanism, what are the process by which wind erosion starts. So wind erosion these 2 prominent mechanism of wind erosion are deflation and abrasion. Deflation means it is simply plucking of finer material, removing of fining material that means selective approach here that means if we have a mixture of materials size materials they allow wind to blow on it.

The fine particle will be separated out and the coarser will be remained there that is called deflation and abrasion that means we have sediment-laden wind having some sand silt clay particles and we have rock surface. So this wind it is coming and hitting this and removing some part either it is a flute action or groove action or pitting action we are removing some part from this rock so that is called abrasion.

So deflation and abrasion are the 2 prominent process by wind erosion and in addition to this when the sand particles are in movement those sand particles interact within themselves, they reduce their angularity. They becomes more polished and this process by which this size reduction takes place that is called attrition. So deflation, abrasion and attrition.

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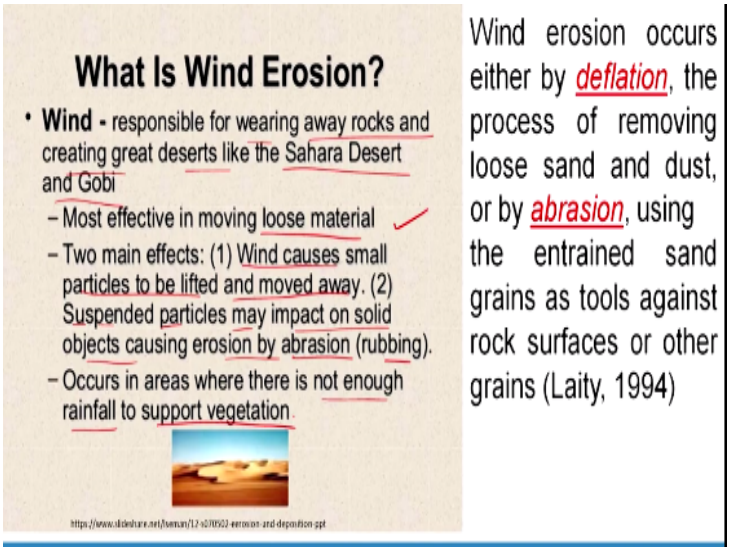

Wind responsible for weathering of rocks and creating great deserts like Sahara Desert and Gobi deserts. So many thousands of square kilometers area can be affected by wind. Most effective in moving loose materials. Two main effect one is wind cause small particles to lifted and removed away. The suspended particles may impact on solid objects causing erosion that is called abrasion or rubbing occurs in areas where there is not enough rainfall and vegetation. So these are the conditions those conditions satisfied wind abrasion or wind erosion takes place with deflation, abrasion and attrition.

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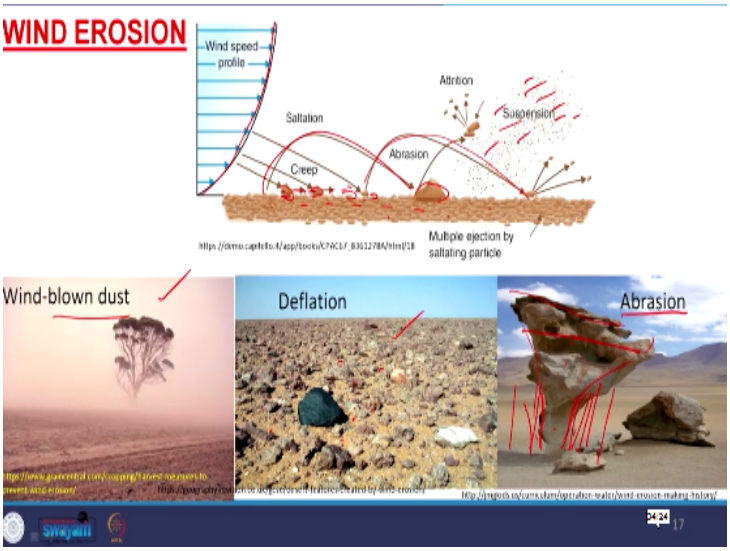

Now if you see here in a velocity profile we have wind speed increasing with height and here the material larger and smaller and again smaller the mixed particles are there. The smallest particles silt and clay they are moving in suspension mode, sand it is moving in saltation

mode and some particles which are larger than the sand mostly the coarser part they move very slightly and this is creep mode or this is rolling mode.

So this product is windblown dust very fine particles if you see this picture it is very hedgy sometimes in Delhi, Haryana, Punjab area it looks very hedgy it is not visible due to this type of windblown dust what is called the aerosol effect. And it is deflation that means you see the upper surface it is here that means enriched with larger particles and the smaller the sand particles it has been removed then it is abrasion here you see this is the pedestal rock it is standing here.

And this is polished and this is the abrasion the process is called abrasion that means a hitting of wind and sand mixture to this rock and if you see here this base is thinner as compared to this upper part. Why because though the wind velocity increases or the wind speed increases from bottom to top, but its sediment-laden capacity it is mostly sediments they are transported within these limits. So that is why this side or this part or this level it is experience more abrasive effect as compared to the upper part.

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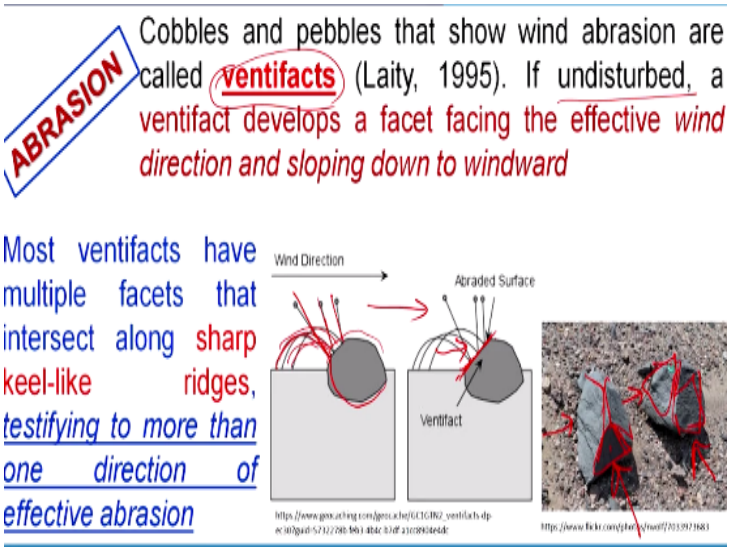

Then abrasion. Abrasion is the cobbles and pebbles that show wind abrasion are called ventifacts. So the terminology you have to remember here these ventifacts they are the cobbles and pebbles or boulders. They are eroded by wind action they are eroded by abrasive action of this wind and forming a faceted pebbles that is called ventifacts. If undisturbed a ventifacts develops a facet facing the effective wind direction and sloping down towards the wind.

If you see this figure here for example, we have a boulder and we allow the wind to move with sand particles these are the saltating effect of these sand particles here they are hitting and it is reflected back. If you see after some times this part of the surface of this pebble it is removed and this becomes smooth and becomes angular. So this is called facet this facet pebble. What it indicates? It indicates wind abrasion and wind direction on provided that these pebbles or the boulder is not moved from its original position.

For example, if you see here this is the wind direction and here there are photographs of 2 ventifacts. Here you see this is a surface and this is another surface similarly this is one surface this is second, this is third that means it is indicating 3 different direction of wind transport provided that these pebbles or boulders have not removed from its their original position. So that for here if you see this face and this face they are indicating this is the direction of wind transport.

Similarly, this face and this face they are indicating this direction of wind transport. So that means by looking their smooth surface the faceted surface we can say from which direction the wind was prevailing. Most ventifacts have multiple facets that intersect along a sharp keel like ridges testifying to more than one direction of wind transport that we are discussing here this ventifact they are indicative of wind directions.

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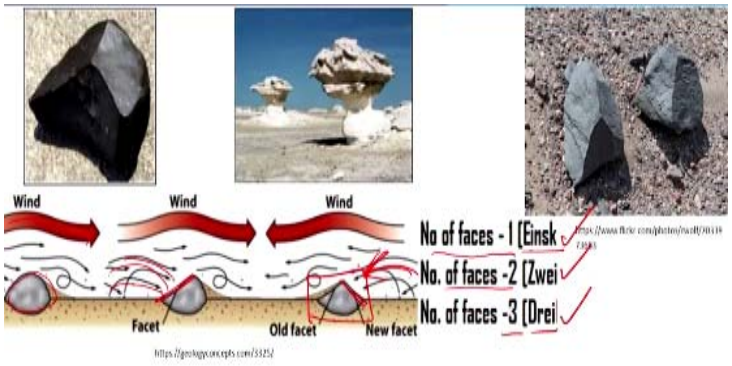

Smaller cobbles and pebbles are likely to be moved by a great variety of processes, so their facets have little significance for determining the directions of effective winds (Sharp, 1949)

And if it is two face if it is one face it is three face. For example, if it is number of face is one for example here this is number of face is 1 in that case it is called Einskenter. If it number of

face is 2 that is called Zweikenter and if it face is 3 that is called Dreikenter. So Einskenter, Zweikenter, Dreikenter these are nothing this is the number of faceted faces, faceted pebbles. So here this photograph showing the same thing the pebble is here intact and wind is allowed to blow.

And it is sand saltating effect of the sand it is forming a facet surface and during this change of wind direction suppose this is the day time wind and this is the evening time or night time wind, due to this change in wind direction you see again one face is developed here. So that means if this whole system is undisturbed this pebble is undisturbed by looking this facets we can say this is the wind direction change in wind direction.

Smaller cobbles and pebbles are likely to be moved by a great variety of process so their facets have little significance for determining the direction of effective winds. So that is why in this case we do not consider the smaller ones because by increasing the wind speed or by any means by animal activities these small pebbles and cobbles they change their position. So that is why they cannot be used authentically to derive the wind direction properly in a geological environment.

That is why relatively larger fragments, larger cobbles and pebbles they are very much helpful in determining the wind direction in a arid region. So I think we should stop here, we will meet in the next class. Thank you very much.