Geomorphology
Prof. Pitambar Pati
Department of Earth Sciences
Indian Institute of Technology – Roorkee

Lecture – 24
Landforms in Dry Region.

So friends welcome to this lecture series of geomorphology and in the todays class we are going to discuss about the landforms in dry region. See if we remember our earlier discussion we are talking something about the dry region in which there are certain characteristics features. First is it should be less rainfall or it is the evapotranspiration is more than precipitation. Second thing that the streams should be ephemeral and there will be water loss from upstream to downstream.

And 3rd is the soils has to be pore space of the soil has to be filled with secondary salts or the salts which is coming from this evapotranspiration of this water. And the dry region is also characterized by gravels and rocks which is frequently transformation of landform and frequency and intensity will be more. So with this conditions let us discuss about the landforms in the dry region. So the first and the foremost landform in the dry region is the desert plain and plateaus.

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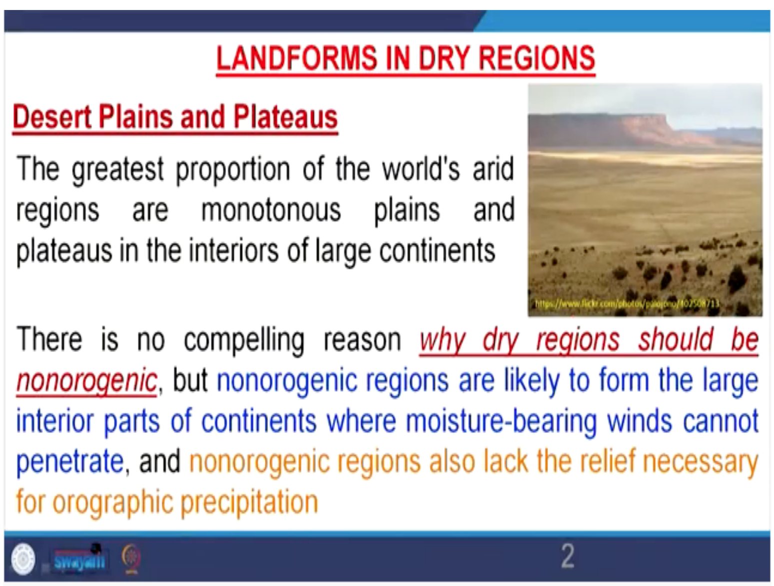

The greatest portion of the worlds arid region are monotonous plains and flats. The plateaus are in the interior of this continent. For example if you see this photograph these are the plain areas. These are plain areas and here the plateaus the mountains are there. So most part of this arid region are flat plains and these plateaus they are at the interior part of this continent. However this is very interesting here to mention that there is no compelling reason why? Dry regions should be nonorogenic.

There is no reason for that. Orogenesis and dry region 2 different things, 1 is external another is internal. But here we have to understand that the nonorogenic regions are likely to form large interior part of the continent where moisture-bearing winds cannot penetrate. Second thing is that the nonorogenic regions are lack of relief necessarily for orographic precipitation. Here 3 points are there you have to understand here.

First is the nonorogenic region that means lack of mountain building activities. So that means relatively tectonically stable regions. So once we have relatively tectonic stable regions there is new tectonic moment. So relief will be low erosion and weathering process dominant it will come down this relief to lower level to make it plateau. So once its make it plateau that means there will be no orographic precipitation.

Orographic precipitation means suppose we have this water vapor laden wind it is moving and it is somewhat it is hitting the mountain system it will move up it will cool down and will precipitate here. So this is called orographic precipitation. But as it is plateau flat-lying body so there is no hindrance to this wind to move. So that is why there is no question of orographic precipitation.

Second thing that once it is lying inside there is no orogenic process, no renewal of the orogenic process. So only the removal is no material is added only removal is dominant. So in that case it makes it flat and plateaus. So that means orogenic nonorogenic regions they are mostly governed by or that is mostly characterized by formation of plateaus and as these are if these places are these nonorogenic places they are lying at the interior of this continent here the moisture laden wind they cannot reach up to that distance.

So that means that is why mostly this region which is arid region are nonorogenic. In addition to that desert alluviation buries minor relief. Even if there is minor relief exists but desert alluviation this sedimentation of the desert mostly it is by wind, they burry this minor relief and this burial and exposure is a frequent change. Because wind sometimes it is buried here by sand. Sometime the sand will be again removed to somewhere else.

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Wind has been suggested as a levelling agent in the desert plains. If you see here this is the desert plain and these are these the wind lone activities the ripple marks wind ripples and this total system is composed of loose sand which is frequently transported, deposited, redeposited and reworked by the wind activity. Wind increases desert relief by excavating basins and constructing major dune landforms. It is very important to understand here.

Wind is increasing desert relief. For example suppose in this particular photograph if you consider here is a depression. It is called deflation halo or so and here is the dune. Now this relief deference will be somewhat suppose like this is not it. So now if again wind works again it will remove the material from here and deposit here. So the relief increases and it is not true that always relief will increase.

So that depends upon the frequency of wind transportation and deposition. It may happens during the reversal introduction this material will be transported from here and deposited here. So that means it is a constant change. It is not always true that wind will increase the relief.

There may be a relief peneplanation there will be change in relief frequent change in relief frequent change of landforms that is found in the desert region.

Where alluvial fans merge in the desert basin, a saline lake, playa may form. Here mud and salt accumulate to form the most levelling topography on the desert surface developed on the earth. So suppose we have playas. Playa that means this water it is rich in salts. So in mud and salt they will accumulate salt will precipitate, mud will accumulate and combinedly that will form a flat topography.

Sometimes you might have seen in TV screens that these type of topography people used to play in playground or some racing grounds. So this is the most levelling topography. This is due to these combination of the mud and salt together and mostly it is formed in the playas.

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Evaporation from playa creates mud cracks and salt cracks. It is characteristics of dry region and dry climate. If you see here in this photograph they are the salt cracks. Similarly mud cracks we know they are characteristics feature of arid climate, arid region but this playas of dried region and playa of semidried region have different characteristics. So we have to think upon depending upon the playa characteristics. What type of topography or what type of climate or what type of paleoclimate we are dealing with?

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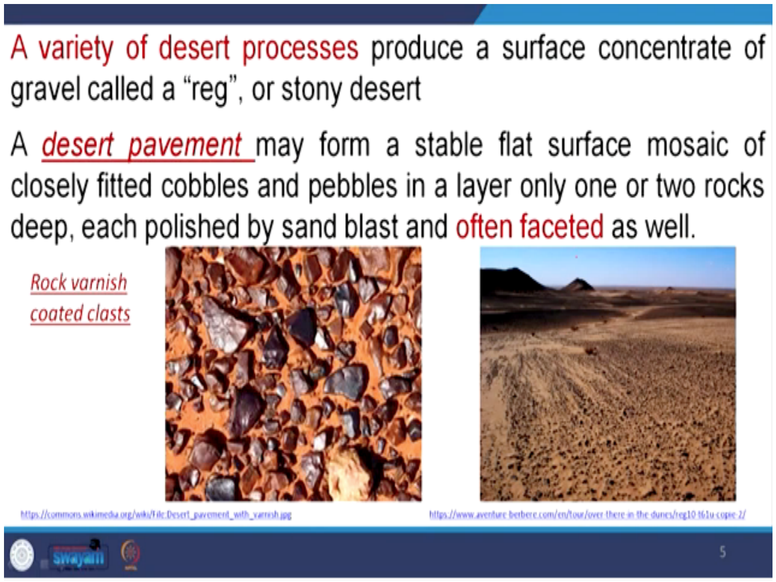

A variety of desert process produces a surface concentrate on gravel called reg or stony desert. It is there are 3 types of dessert 1 is stony desert, 1 is sandy desert, 1 is total rock body that means plateau rock plateau rock exposure. So here different type of desert processes are involved. So those different types. What are the different types? We will discuss here. Now one characteristics feature of this accumulation of these gravels that is called desert pavement.

Desert pavement may form a stable flat surface mosaic of closely filled cobbles and pebbles in a layer only 1 or 2 rock deep. Each polished by sand blast and often faceted as well. Here if you see this photograph the first photograph here you see we have mixture of sand and gravel and once we allow the wind to blow on it, it will blow off this sand these finer particulars. The silt and clay particles.

However the remaining will be reaching these gravels and after few years or few months or so now you see the top surface it is concentrating these gravels. Gravel population is more as compared to others. So the thickness of this plain the rock plain or these pebbles and cobble plain it is about 1 to 2 pebble or so. And very interesting thing is that here they are highly polished and sometimes often faceted.

Faceted means 1 particular face of a pebble or a gravel or a boulder it will be cut plain by the constant bombardment of sand particles on that face. So that indicates the direction of wind transport, direction of wind flows. So rock varnish create coated clast. rock varnish is creating coated clast. The clast will be coated.

So how it happens? How this? What is the mechanism of coating? We will discuss later times. Now here is the mechanism is elaborated with this help of figure. Now you see suppose we have a block being mixture of sand and gravels and we allow the wind to blow on it.

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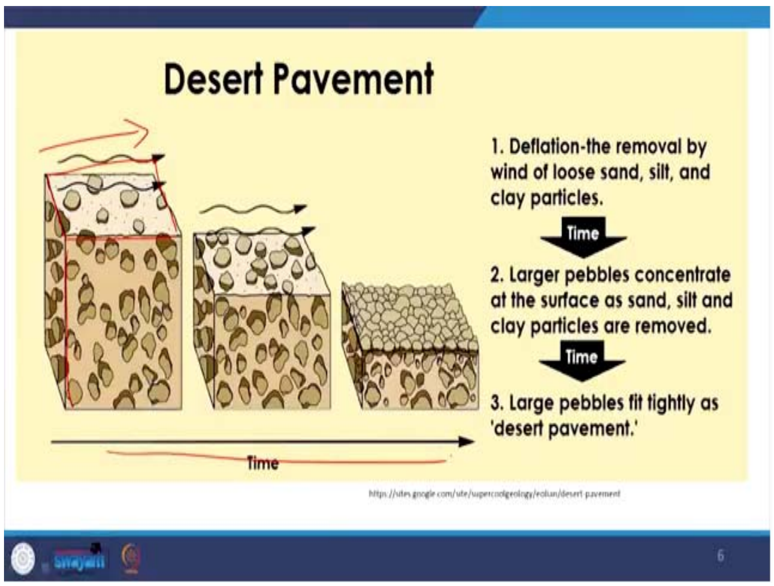

So here with time this axis it is increasing time. Here you see with time the number of gravels they are increasing on the surface. In this figure we have less number of gravel relative to this figure. Now you see the number of gravel is increasing and the height of the block is also decreasing.

That means the sand, silt, clay size particles from the surface that is blown out due to this wind action and finally if again it is allowed to continue after few times later you will find the surface it is concentrated with the boulders, the pebbles and cobbles of the larger fragments and the sand is totally wiped out. So this thickness of this spot it is about to 1 or 2 boulders or so and this is called desert pavement.

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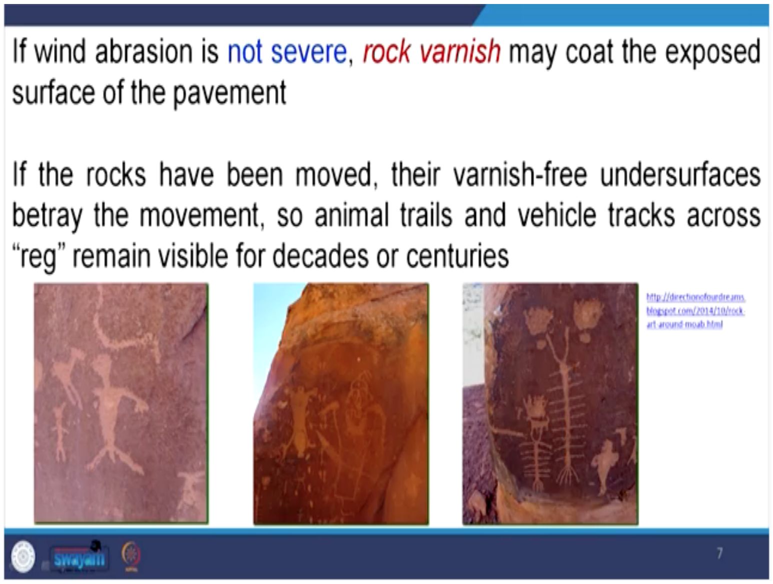

If wind abrasion is not severe then rock varnish may coat. It is very important here. Rock varnish and wind abrasion. They are 2 opposite things. So abrasion is more, the polish will be more and no coating will be there. And once we are getting the rock varnish in a desert so that means we can interpret here wind abrasion is not severe. It is not effective. So may coat rock varnish may coat the exposed surface of the pavement.

If rocks have been moved their varnish-free under surface betray the movement. So animal trails and vehicle tracks across the regs remain visible and decades to continue. Now if you see here you might have seen in a TV some discovery channel or somewhere these people of ancient times the stone age, they used to make some arts in this rock varnish and they are still remaining now after thousands of years.

So here the rock varnish, this is called rock varnish. It is a coating of iron, manganese all mixture of that. The coating that is on the surface so these are the arts of the ancient people, ancient civilization. So that can be stored and it is stored or reserved in the desert rock for hundreds of thousands of years. This is called rock varnish. This coating is called rock varnish. So this color of this coating that depends upon on which material it is coated.

For example if you see here this is mostly dark red color and it is somewhat brown or yellowish color. So this compositional difference will be there and now that people are using the rock varnish to date the time of this art and when this art was being drawn and what is the time of that people who were staying there? So that can be used based on the dating of this rock varnish. It is a separate part of the story.

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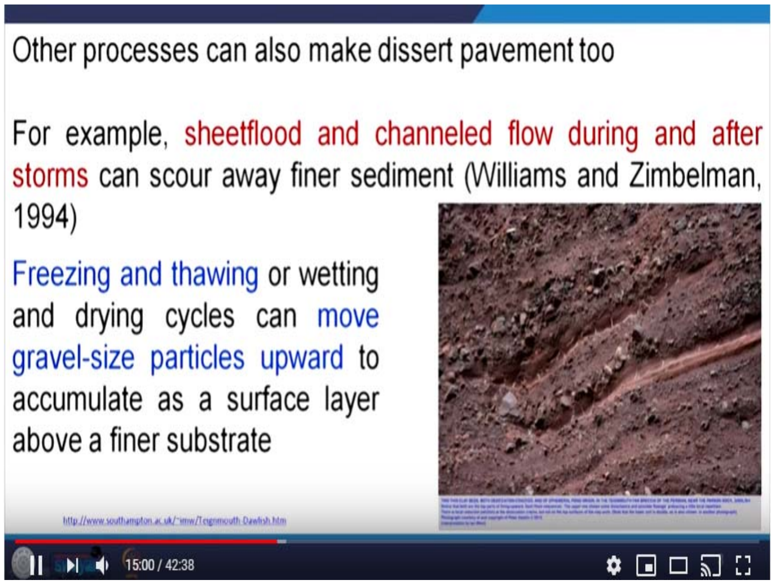

Not only this deflection that can cause the development of this desert pavement. There are other processes also, which is responsible for formation of or possibility to form these desert pavement. For example sheet flood and channelled flow during and after storms can scour away the Finer sediments and the remaining sediments will be rich in these boulders.

So it is called desert pavement Second thing that, the third thing, it is the freezing and thawing, wetting and drying. So we know in our earlier classes the creep is the action when there will be freeze or thaw or there will be heat and the release of heat there will be expansion and contraction. So during expansion the material is coming up. So once the material is coming up suppose, we have boulders, pebbles, and cobbles they are coming close to the surface. The gravel size particles they move upward to accumulate near to the surface layer above the substrate, and it forms the desert pavement.

So there are many mechanisms to form desert pavement however the wind deflection is the major process to form the desert pavement on the plain.

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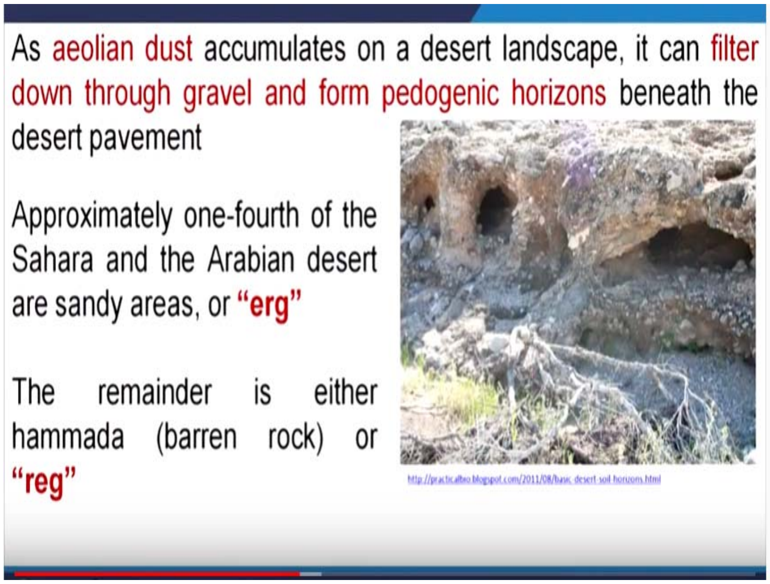

As aeolian dust accumulates on a desert landscape it can filter out down through the gravels to form pedogenic horizon beneath the desert pavement. Now since we have desert pavement that means it is accumulated with boulders, pebbles, cobbles. We have pore spaces through that very minute pore spaces. So now below is we have a sand and gravel mixture. Suppose there are dust falling down. So the dust that will through these pore spaces, through these gaps that will move down and will promote formation of the soil desert soil.

So approximately one fourth of this Sahara and Arabian desert are Sandy areas or erg. So rocky area that is called reg it is rocky areas and sandy area It is called erg so remember it is either hammada or reg hammada means only the rock body is exposed. So rock body is exposed if it is there it is called hammada then boulders pebbles cobbles dominated that is called reg and if it is sand dominated it is called erg.

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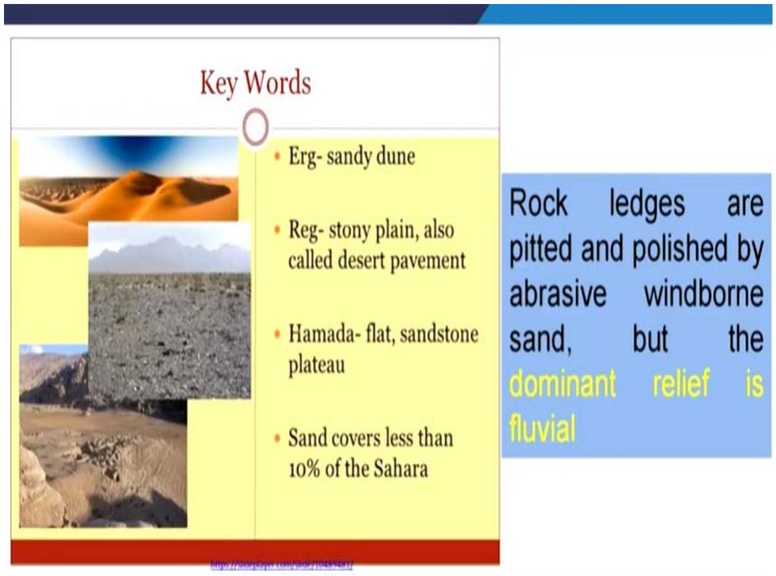

So here these three categories has been defined with the help of photographs here. This, we see sand dunes sand dominated that it Erg. Then here it is see clast dominated the fragments the pebbles, cobbles, boulders dominated that is Reg stony plain also called desert pavement. Then Hamada it is flat sandstone plateau see these are the flat plateau Hamada it is not necessarily it should have sandstone and for this particular photograph it is the sandstone.

Sand cover less than 10% of the Sahara. So that means you see Sahara the largest desert in the world. It is sand cover less than 10% so that means the remaining part it or the 90% or more than 90% it is the This Hamada and reg. Rock ledges are pitted and polished by abrasive windborne sand but the dominant relief is fluvial. It is very important to understand here though we are talking that the desert is dominated by wind. It is the loose fragments, which is frequently moving here and there, changing the landscape frequently.

But if you analyse the dominating landscapes of this world, arid zones landscapes in the world, you will see the dominant relief of this arid region it is governed by the fluvial process. Even if nowadays, if you will see this present days Saharas and this Kalaharis or whatever this deserts are there maximum relief difference or this geological work carried out by fluvial process is dominating rather than these wind world process. So that means I want to say those regions earlier it was dominated by fluvial processes. Fluvial process was active in modifying the landscape. Now due to climate change those are converted to arid zones and the wind is now continuously modifying the earlier remnant fluvial processes. So that means that is why it is called the dominant relief is due to fluvial erosion or fluvial work.

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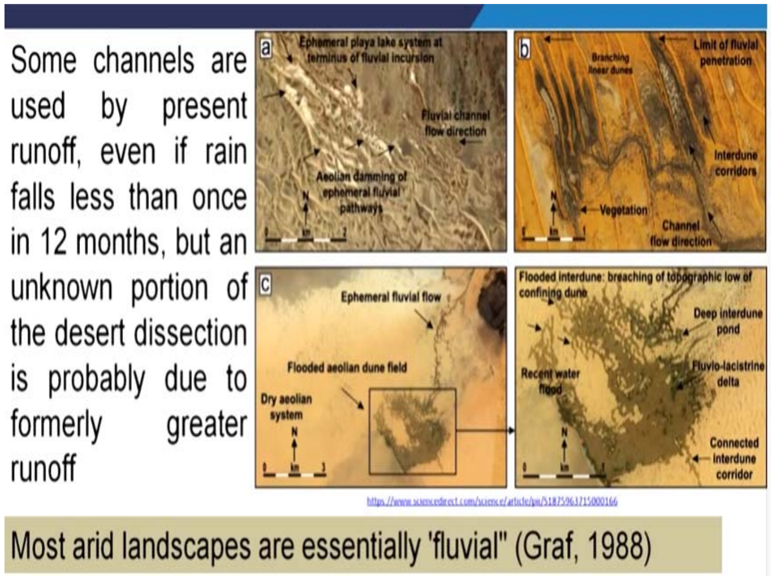

Some channels are used by present runoff even if the rain is less than half or in 12 months, but an unknown portion of this desert dissection is probably due to by this formally greater run off. So that means you see these are the photographs this is the Ephemeral fluvial flow similarly ephemeral Playa lakes. Then branching linear dunes, whatever the limit of fluvial penetration, so deep interdune ponds , fluvial lacustrine delta.

So that means here though we believe and we see this wind is frequently changing the landscape in the arid region, but this dominant landscapes of this arid region, it is governed by the present or this is annual or that is whatever once upon a time this fluvial process or the ancient fluvial process. Though that means I want to say even if there is very less raining once in 12 months or once in a 24 month, but there to once that will change the landscape to much extent as compared to this changes by wind.

So though wind frequently changing the landscape, but the intensity of change is dominated by or it is governed by the fluvial processes. Most arid landscapes are essentially fluvial see mostly arid landscapes is essentially fluvial that means here it should come in your mind that though rain is deficient precipitation is deficient even if less than once in 12 months, but that once that effects more as compared to the frequent effect or the continuous effect of wind.

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Now we see these photographs, these are the fluvial systems the river is flowing these are fluvial systems it is fluvial flow directions. So fluvial river is flowing there so these landscapes once upon a time it was dominated by fluvial process. Nowadays though raining is restricted once in a year or that once is dominating more in landscape development or penetration or defragmentation of the landscapes rather than this wind.

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So let us start with the mountain deserts. Mountain deserts, the desert basin and range province in Southwestern USA, the Mexico, the Pacific coastal deserts of Chile and Peru and the thin skinned fold mountains adjacent to the Persian Gulf. These are the example of mountain desert. Now see these imageries the photographs see these are the basin range and province, so it is an extensional basin extensions are going on here .

See there are thousands of grabens and horst. Similarly, this side the Peru and Chile whatever is the desert is situated here and around the Persian Gulf we have deserts. So these are dominated by mountains, so that is why it is called mountain desert. So desert, which is dominated by mountain areas.

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The area of this mountain desert they are small as compared to this continent size deserts of Australia and Sahara and the desert plains of Arabia, trans-Caspian former USSR and Western China. So though we have this mountain deserts but their area is small they occupy small area as compared to the other desert like Saharas, Kalaharis and other USSR, China whatever the cold and hot desert.

So these mountain deserts they are in small area. The cover landforms intermontane desert is the alluvial fan. So that means Intermontane this inter-mountain area is called an intermontane basin. So this intermontane basin suppose for example here you see this is a mountain run and this is mountain in this area this is called intermontane. So this intermontane area, it is occupied by alluvial fans. Alluvial fans that means these channels which is coming out from here and the channels which are coming out from here, they deposit their sediment in this place and this place, these are the alluvial fans.

So number of alluvial fans they are restricted within the Intermontane basin. The great apron of coalescing fans at the mountain front is called a bajada or bahada. We know it in the geomorphological term bajada is the coalescence of alluvial fan. For example, here we have alluvial fan we have alluvial fan we have alluvial fan so that means by coalescence of number of alluvial fans it forming a fan province, that is called bajada or bahada.

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Influent rivers decrease in discharge as they enter desert basins and deposit their entire sediment load as they spread laterally evaporate and infiltrate. Desert mountains are progressively buried by their own waste. For example if you see here, we have an alluvial fan. Here we have an alluvial fan here, we have a alluvial fan here, we have a alluvial fan here. So by combination of this we say it is a bajada.

Now you see once this alluvial fans forms so at the foot of this mountain they bury some part of this mountain from which they carry the sediment. So for example here so this much part of this mountain is buried under this fan. Now suppose we allow this fan to grow further addition of sediment.

So that means the fan will be of this mush size. Again, these the fan will be of this much size, this fan will be of this much size. So that means these fans they are continuously burying those part of this mountain from which they form, so that is why it is said the desert mountains are progressively buried in their or by their own waste. Waste means in this case waste is called sediments.

Then after the desert mountain or mountain desert, the most interesting and the most important part of this arid region, it is called pediment. Pediment and piedmont by listening it seems same but the difference is piedmont it is a depositional process. Piedmont is a depositional feature accumulation of feature. But pediment it is erosional removal of feature erosional feature. Here the sediments are removed by erosion. But in piedmont sediments are deposited.

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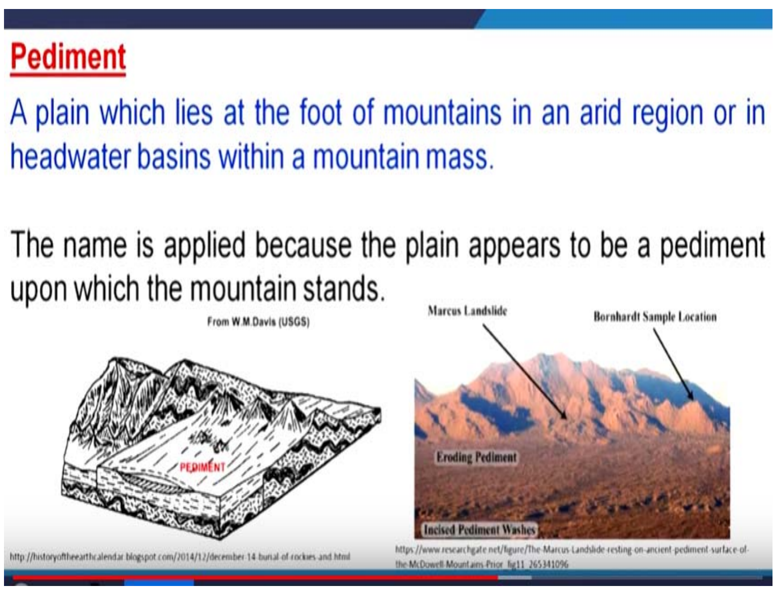

Here pediment is a plain which lies at the foot of the mountain in an arid region or in the headwater basin within the mountain mass. The name is applied because the plain appears to be a pediment upon which the mountain stands. Here if you see this model is given, this is the pediment surface. That means erosional surface that means it is a gently sloping plain through which erosional scars are there and material is being removed due to water action due to this ephemeral stream during raining.

And this part this gentle sloping plain it is sometimes covered by gravels. So this is pediment and if you look from a distance, you might see that this is your flat surface. And here a mountain is standing. So it looks as if the mountain is standing on the flat surface or these flat surface behave as the basement for the mountain. So that is why the term was going there. The name applied because the plain appears to be a pediment upon which the mountain stands.

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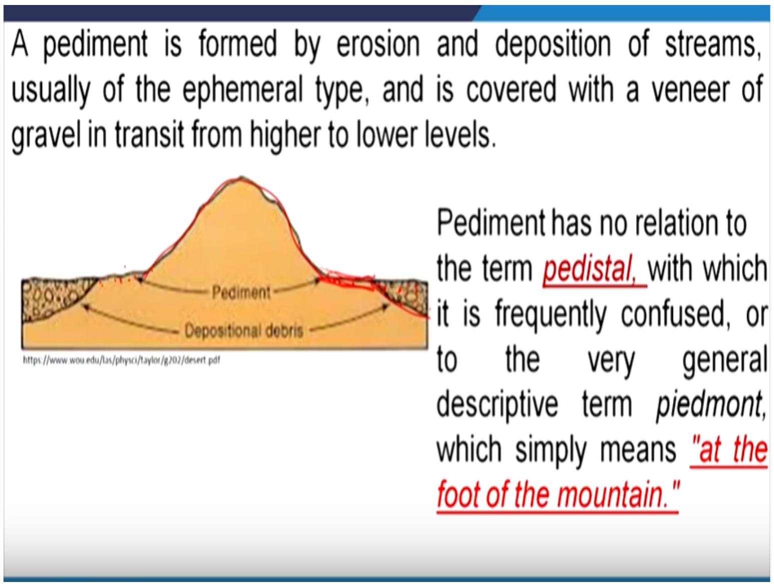

So now if you see this figure this is the mountain and this is the flat region. And here this region is covered with sediments, gravel. So this is called pediment so pediment means it is an erosional plain through which the sediment is being transported from this mountain to the plain region. So pediment is formed by erosion and deposition of streams usually of ephemeral types and is covered with veneer gravel transformed from the higher to lower level.

So sometime this part is covered with gravel and very thin gravel very thin gravel apron will be there. So pediments has no relation to the term Pedistal with which it is frequently confused or to be the very general descriptive term Piedmont which is simply at the foot of mountain. So here Piedmont is a depositional feature and pediment is an erosional feature.

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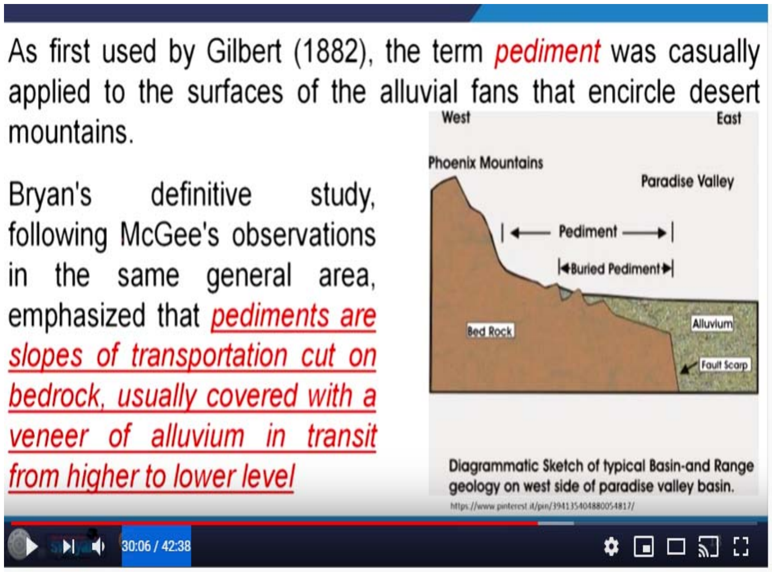

So this term pediment was first used by Gilbert in 1882 the term pediment was casually applied to the surface of the alluvial fans that encircle desert mountain. But Bryan's definitive study followed McGee's observation in the same general area, emphasized that pediments are slopes of transportation cut on bedrock usually covered with a veneer of alluvium of transit from higher to lower level.

Here it has to be understood for pediments are slopes of transportation through which the eroded sediment from this hill that will transported to the plain area to the nearby alluvial fans. So that means the alluvial here is the mountain, here is the pediment and here is the alluvial fan. So these region it is a flat region or gentle sloping region through which the sediment eroded from this mountain are being transported through ephemeral streams and deposited at the mountain front. That is on the alluvial fans so this is the difference between these two.

So usually covered with a veneer of alluvium thin alluvium cover in a transit from higher to lower level.

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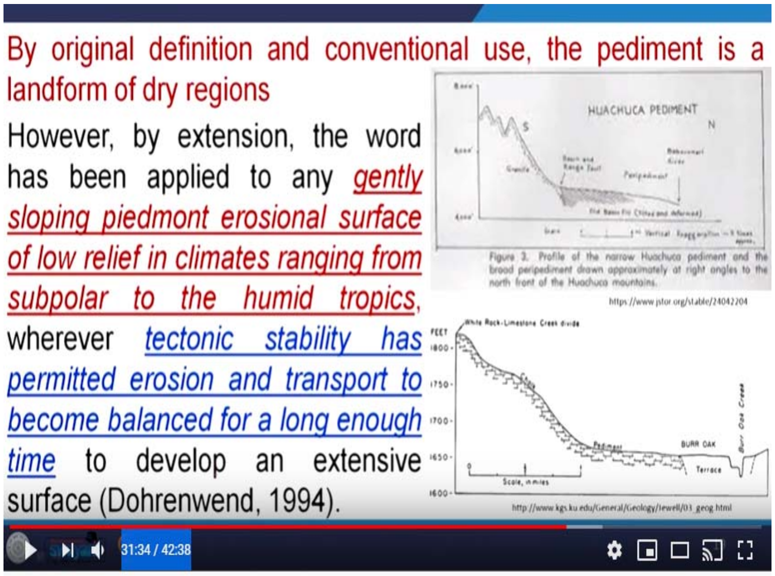

By original definition and conventional use. The pediment is a landform of dry regions. Earlier when this term was coined those slopes the transportation slope gently sloping transportation slope along the hill side of a dry region was used or defined to form this pediment. But later this term the circle of the term the application of this term was extended. The word has been applied and gently sloping peidmont erosional surface of low relief in a climate ranging from sub polar to humid region and tropics.

Wherever tectonic stability has permitted erosion and transport to become balanced for a long enough time to develop an extensive surface. Here it has to be understood here that it is a tectonic stable region, why if it tectonic unstable then there will be frequent change in topography and there will be no gentle sloping region exist. Because tectonic will change this topography. So pediment development itself indicate indirectly that the region is a tectonically stable region.

It is plain there is no climatic boundary. It is a gently sloping plain in the tectonically stable environment used for transportation of material or it is behaved as a transportation slope so this transported material through this gentle slope. It moves down from higher to lower level and deposited in the nearby alluvial fans by the ephemeral stream and this gentle sloping slope, gentle sloping surface. Sometimes its covered by boulders, pebbles and cobbles. So a thin sedimentary cover sometimes it is aproned with.

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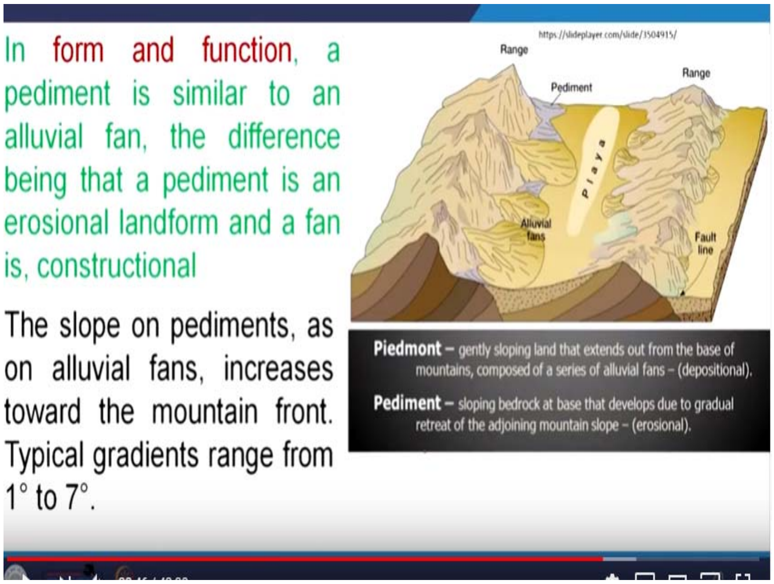

In form and function a pediment is similar to an alluvial fan and the difference being that the pediment is an erosional landform and a fan is a constructional. Now if you see here by from the top, you can see this is an alluvial fan and this is a pediment surface. This is a pediment surface and this is alluvial fan so by form and function both are looking similar. That means close to mountain front close to mountain front at the base of the mountain at the base of the mountain.

Here sediment is deposited but here sediment is eroded that means if you want to create a alluvial fan it would be here. And then the alluvial fan we have playas. So this slope of on pediment as on alluvial fans increases from this part to this part that means close to this mountain front the slope of the pediment is more so it is a gentle sloping surface like this here. This slope is more here, it will be less like this. And the slope varies from 1 to 7 degree.

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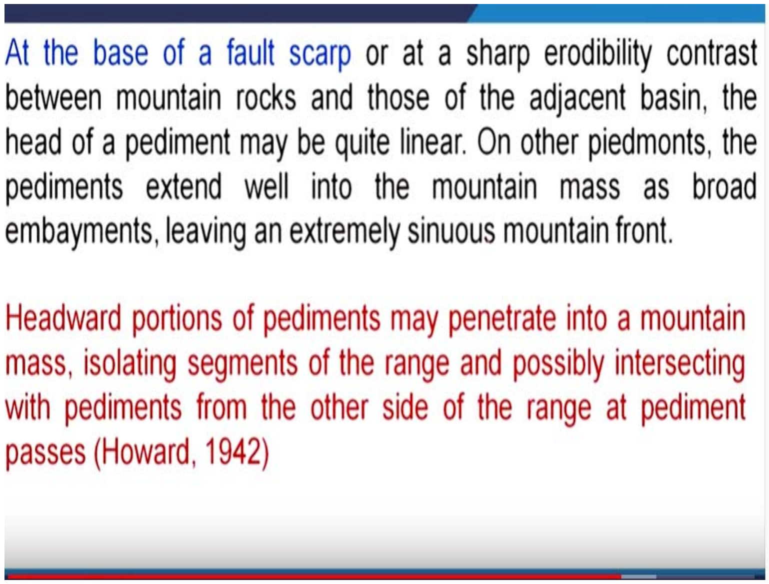

At the base of a fault scarp or at a sharp erodibility contrast between mountain rocks and those of the adjacent basin. The head of a pediment may be quite linear. On other piedmonts the pediments extend well into the mountain mass and broad embayment's leaving extremely sinuous mountain front. It is has to be understood here. Suppose we have fault scarp at the mountain base. So after this fault scarp or along this fault scarp the pediment will be strapped okay.

And sometimes the pediments surface it extends towards the mountain. Suppose for example, here is the lobe mountain lobe and here is a mountain lobe within these two lobe. There is a pediment surface it is extending inside this mountain and sometimes this extension from all sides or extension growth side, it isolate a lobe here a mountain a nose here isolate nose here. So headward portions of pediments may penetrate into the mountain mass isolating segments of the range and possibly intersecting with pediments from the other side and the range at pediment and it is called pediment pass.

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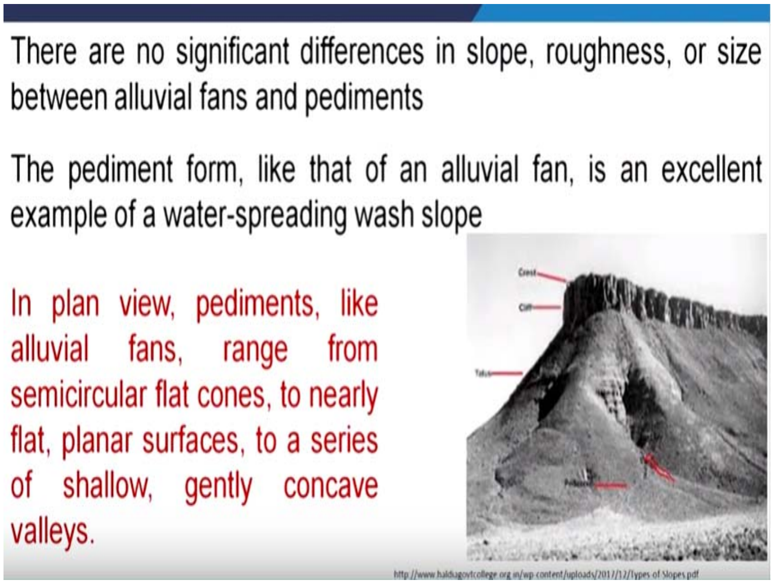

So here suppose in this figure it is given suppose we have a pediment surface here it is growing inside due to erosion and erosion. Similarly pediment surface here it is growing inside due to erosion . So a time may come due to extensive erosion the pediment from this side and pediment from this side, they will interact with each other they coalescence with each other. As a result his part of this mountain that will cut off from the main mountain body and this is called pediment pass.

This joint of pediment from other side of the mountain to this side of this mountain. So this is called pediment pass. So through this pediment pass a part of the mountain will be cut off from the main mountain body. So there are no significant differences in slope, roughness or size between alluvial fan and pediment. The pediment form like that of an alluvial fan is an excellent example of water spreading wash slope.

water spreading wash slope if you can remember when we were talking about slopes, some of the slopes they are water spreading slopes some of the slopes they are water accumulating slopes. So these are the function of contours they are function of slopes convex slope, concave slope and contour. So combination of this contour design or slopes design, this water spreading and water accumulating slope has been identified. So this pediment they behave as water spreading slopes.

In plan view pediments like alluvial fan range from semi-circular flat cones to a series of shallow gently concave valleys. You can see here we have alluvial fan and we have pediments. If you take a cross section both will like this. Concave up slopes and this is behave as a water spreading slopes.

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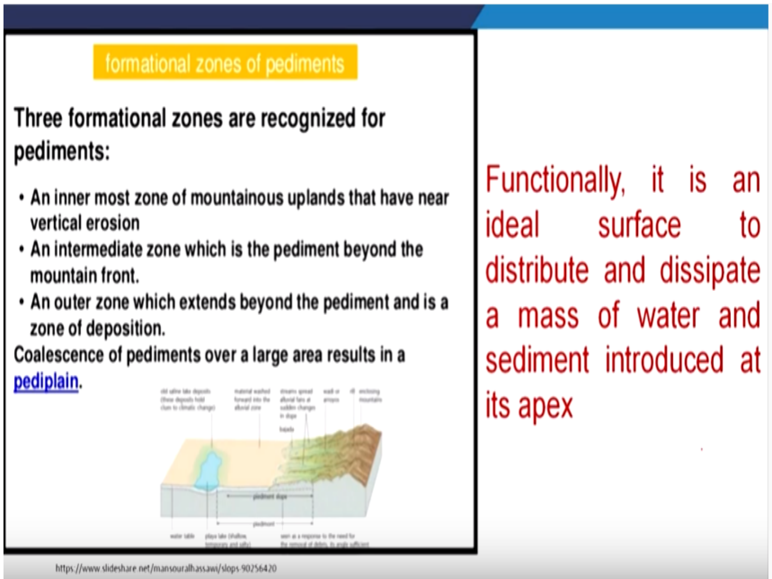

Formational zone of pediments here 3 formational zones are recognised for pediments. In pediments 3 zones has been classified. 1 is the inner most zone of mountainous uplands that have near vertical erosion. An intermediate zone which is the pediment beyond the mountain front. and the outer zone which extends beyond the pediment and is a zone of deposition. That means the third zone or the outer zone it is a transition between the pediment and the alluvial fan.

If the deposition of the alluvial fan starts from this outer zone of this pediment. Functionally it is an ideal surface to distribute and dissipate a mass of water and sediment introduced at the apex. So here if you see suppose we are creating a pediment surface. We are pouring water here with sediments. This will come and finally it will spread here. So that means alluvial fan and pediment both are in form and process both are same.

However alluvial fans are a depositional sites and pediments are erosional site and this eroded sediment they will be deposited deposition started from here. So this is the outer zone this is the middle zone, this is the inner zone. So 3 zones of the pediment had been classified. So coalescence of pediments over large area results in pediplain. Like coalescence of alluvial fan it is called bajada or bahada Similarly, the pediplains or the Piedmont or the pediments they coalescence with each other and forming a plain planar topography that is called pediplains.

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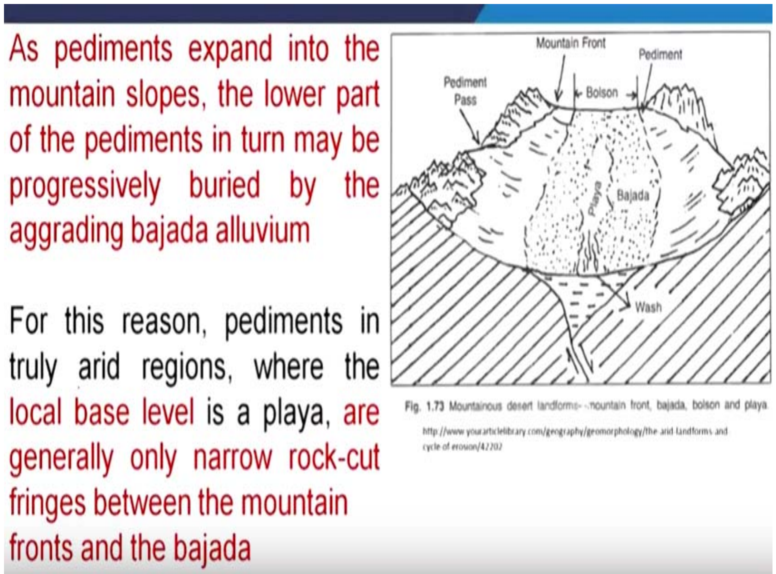

So as the pediment expands into the mountain slopes, the lower part of this pediment in turn may be progressively buried by the aggrading bajada or alluvium. So as we have discussed so far that the third zone or the outer zone where the alluvial fan starts. So once the alluvial fan grows, some part, it will cover some part of the outer part of this pediments. For this reason. Pediments in truly arid regions where the local base level is a playa are generally only narrow or rock cut fringes between the mountain front and the bajada.

Because if the base level will be far away, sediment has to be transported more distance. But if base level is here for example in this particular case the playa is the base level. So sediment has to be deposited here so more and more sediment accumulation the sediment will move in this upstream direction. So part of this pediment will be covered with the sediment. That is why in those area the intermontane basins where playas are there, the thickness or the width of this pediment will be very less.

Because much part of this pediment will be covered by this bajada’s these alluvial fans. So this is all about the pediment. I think we will discuss in the next class. Thank you very much. Thank you again.