Geomorphology

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

Lecture – 25
Pediment Evolution

So friends, good morning and welcome to this lecture series of geomorphology. Today, we will discuss about this topic which is called pediment evolution. So before moving to understand the evolutionary part of this pediment we must clear what this pediment means to you? So if you remember our last discussions pediment and piedmont this sounds similar. But to distinguish this piedmont is a depositional feature along this mountain front the sediments deposited by fluvial action by gravity.

So irrespective of the deposition the cover of sediments along this mountain front it is called piedmont. However pediment is in erosional forms or erosional structures where this deposited gravels or these rocks of the mountain which is exposed which is being eroded and it is forming a gentle sloping plain and if you looking from a distance it seems that from this gentle sloping plain this mountain is standing and this is called pediment.

So not only the pediment form at this mountain front due to erosion. There are many other places there pediments are found and second thing that the width of this pediment if we remember correctly the width of a pediment it depends upon the rate of sediment production, the rate of sediment removal and the tectonic activity along this mountain front. So if an area or a mountain front it tectonically less active.

That means for larger time span it remains stable then wide pediment will form. But if the reverse is true is mountain front for example the Himalayan system. The Himalayan system is tectonically active very frequently there are thrust movement, there are earthquakes that means it is seismically active. So that due to this seismic frequent, seismic activity there will be more sediment production and those sediment will pass through this plane and will deposited along this mountain front.

So that the part of this pediment surface is buried. Similarly the slope if it is gently sloping then more sediment will be there. If it is steeply sloping sediment will be easily removed. But whenever we talk about this pediment surface we always think it is in gently sloping plain developed due to erosional processes to 5 to 7 degree dip. And sometimes this pediment surface either it be covered by thin film of sediments mostly consisting of gravels.

And sometimes it is covered with only rock surfaces. So irrespective of their characteristics either it is rock surface or it is rock surface covered with thin film of sediment of gravel composition. So this whole system it is called pediment. So that means it is indicating an erosional surface.

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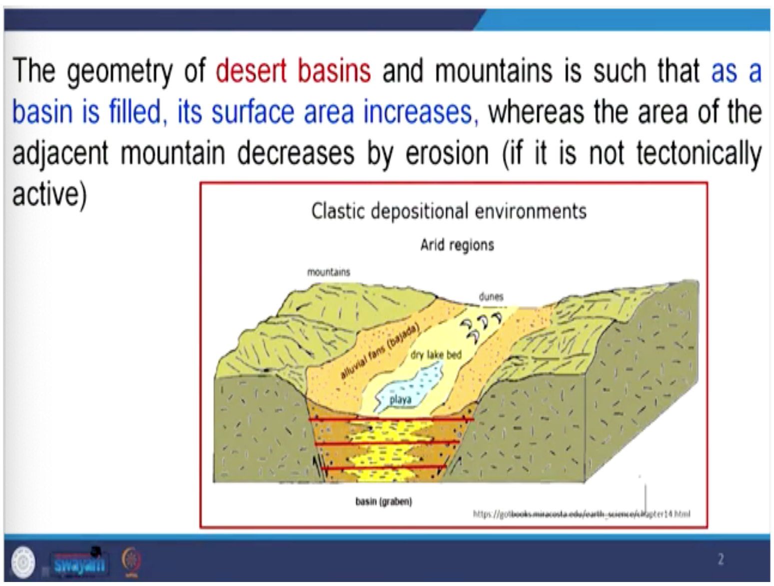

This geometry of the desert basin and the mountains is such that as a basin is filled its surface area increases whereas the area of this adjacent mountain decreases by erosion. So if you see here for example this is the block diagram and this is the desert basin or it is called playas. Now from this mountain this sediment is carved out and finally forming the alluvial fans or the bajada and these are this pediment surface. These are the pediment surface here.

Now you see suppose when this fault was there and newly formed fault the basin was of this much depth. So whatever the sediment produced from this adjacent area that was deposited at this level. So this part was filled up and once this part is filled up so this area of this desert basin was less. But once this part is filled up so this area slightly grows. Similarly again this part is filled up the area finally up this much.

So that means once the mountain basin the playas or whatever the basin inside this intermontane basin it is filling up the area of this mountain basin is increasing. So once the area of this mountain basin is increasing gradually it is encroaching this pediment surface from both sides. So that is why this width of this pediment along this mountain front is gradually decreasing and decreasing.

If it is tectonically active basin that means 1 fault is there, another fault is there, third fault is there, fourth fault is there like this. So if this happens that means subsidence and sedimentation takes place. So this increment of this desert basin may not be true because whenever there will be sedimentation and there will be again subsidence the area remains same. But it is only possible if the area remains tectonically relatively stable.

So that whatever the accommodation space is created due to faulting or due to tectonism it is being filled up gradually by sediments. But if the same time again it subsides again faulting takes place then the area remains same. So these statement holds good only if it is not a tectonically active basin.

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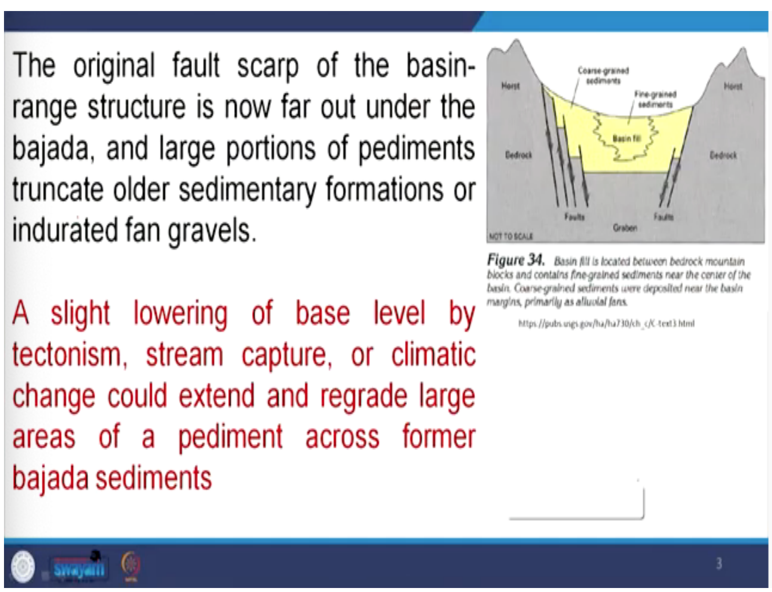

So now you imagine whenever basin was formed so the fault was here. So this was this the mountain width was this much. Now with more and more stretching more and more faults are added to the system. So earlier the sedimentation was going on here. Now the sedimentation going of this much width. Then the sedimentation is occurring in this much width. So gradually the basin is filling up.

So the original fault scraps of the basin-range structure is now far out under the bajada and large portion of the sediments truncate older sedimentary formations or indurated fan gravel. So what does it mean? What is this indurated fan gravel? That we know the pediment surface it is covered with gravel with more and more time this becomes consolidated indurated like that. So here when the initially fault was formed the sediment thickness was very less.

So with more and more addition of this fault this mountain front gradually increasing the distance from this ancient faults or the older fault. Because you see whenever the first fault was formed first set of fault was formed this mountains width is this much. If next stage of fault is there the mountain width gradually decreases up to this. The 3rd set of fault formed the mountain width decreases like this.

So that means more and more fault we add to the basin the more we are going distance away from this mountain front. So those areas which was or the accommodation space which is created by the addition of a faults repetition of these faults those accommodation space is completely filled up by the sediments. Because once faulting is there, rupturing it is there that means breakage of rock is there.

So more breakage of rock, more faulting, more sediment production. So that is why if you imagine in the initial stage of this faulting. Here this much area in which the sediments was occupied. Now this much area I am talking about the cross section this much area the fault the sediments is occupying and this much area the sediment is occupying. So the older faults now they are at large depth as compared to younger fault.

Now you see the thickness of the sediment along this younger fault is only this much and subsequently relative older fault it is this much, 3rd older fault this much that means once more and more distance we are going away from this mountain front we are going to more deeper side and towards the older fault and finally the sediment thickness were increasing gradually. That is why the width of the pediment were losing and losing.

A slight lowering of the base level by tectonism, stream capture and climate change could extend and regrade large area of the pediment across the former bajada sediments. Now here you see suppose we are lowering the base level whenever talk about the base level we always talk about with relative to the mean sea level. However these are the intermontane basins we are talking about in the desert environment these are the intermontane basins.

Here these base level refers to the playa or the local basin level which is the isolated basin within the intermontane basin is an isolated basin. We are talking the base level with respect to this intermontane basin. So suppose we are lowering the base level by tectonism. So stream capture occurs because it is the natural process whenever there will be lowering of the base level erosion will be more. So the stream capture will occur.

So stream capture there only be terraces along the stream path or climate change extent regret large area of a pediment across former bajada. So that means suppose we are lowering this base level the depositional level whatever the streams they were coming here for example in this figure it will be easily understood suppose we are lowering the base level that means we are creating accommodation space in this area.

So these streams which are coming up they will deeper erode their sediments. So whatever this bed level was there that will again lower and lower. So more lowering that means more dissection along this pediment. So that means the pediment surface they gradually degraded and once they degraded this pediment again that means width increases more as sediment form they come and deposit in the intermontane basin.

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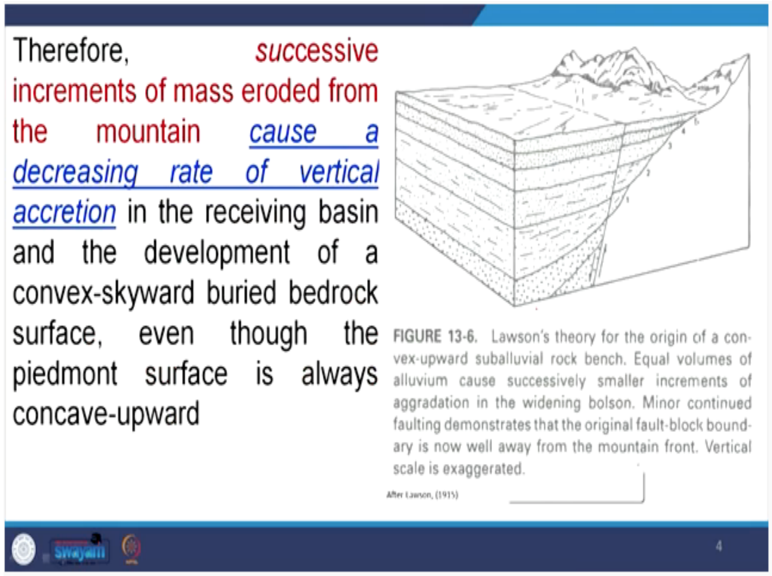

Therefore successive increment of mass eroded from this mountain cause a decreasing rate of a vertical accretion. This is very important to understand here and in the receiving basin and the development of a convex-skyward buried bedrock surface even though the pediment surface is always concave-upward. This is important points are here to discuss one is the successive increment of mass eroded from this mountain front.

Because you see whenever in the last class we are talking something about the pediment itself it is derived from this mountain front so it is said the mountain is completely buried or it is gradually buried by it own waste. Own waste means here in the sense waste means sediment. So more and more sediment is eroded more and more pediment surface is filled up. So that means it seems even the mountain surface the part of this mountain front it is burying down.

So that is why mountains are buried due to its own waste. So now you see successive increment of this mass eroded from the mountain cause a decreasing rate of vertical accretion. Vertical accretion means addition that means vertically we are adding the things adding the materials that means sediments. We are vertically adding sediments in a basin so that is called vertical accretion.

Now since in this particular block diagram given here suppose there is a fault which has formed at this mountain front and it created a basin. Once it created the basin in the both side for example in this figure it will be easily understood. It is creating basin whatever the sediments eroded from this side and it will confined here. So that means here the basin area is less and sediment is more.

Because basin is narrow now this is a fault and this is a fault this both side it is mountain. So is this is the basin space available and we are creating sediments we are transporting sediments from both side and filling it up. So that means more sediment has to be accommodated within a less space. So that the thickness will be more here you see this is the thickness of the sediment, this is the thickness of the sediment, thickness of the sediment is not it.

So gradually and gradually once we fill the basin that means we are increasing the surface area and once the surface area is increasing that means whatever the sediment produce those sediment that will spread along this whole surface area. So that is why once we had less surface area or less space available the sediment which was being produced at that time they were deposited with much thick sediment.

But once the surface area increased and the sediment which has produced from this mountain front sidewise so there will be deposited and spread along this whole area. So that the sediment thickness will be relatively less as compared to the earlier. That is why cause a decreasing rate of vertical accretion. Decreasing rate of vertical accretion means now vertical accretion it becomes thin. So here earlier the rate of vertical accretion was more because much thicker sediment was deposited within less time.

But here the same area with the area increased and the sediment remains same. So once the sediment remains same so the same sediment it is deposited spreading along this whole basin. So that is why the thickness of the sediment is more. So the rate of vertical accretion decreases but here if you see once this is the sediment deposited again this is sediment deposited then 3rd sediment deposited.

So all those sediments they are truncating along this pediment surface. This is the pediment surface or the erosional boundary pediment surface. So it is creating a skyward formation that means convex of slope waxing slope is there. So that is why this development of a convex skyward buried bedrock surface even though this pediment surface is always concave upward. Now you see this whole along this though it is concave-upward it is going downward it is concave-upward. But in this main position here in this position this truncation of this sediment layers they occur along this eroded surface or erosional surface and giving a local convex upward slope.

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Some pediments seem to have resulted from intermittent sheetfloods separated by interval of surface weathering and rill works. These pediments are smoother and more nearly planer here. Some pediments seem to have resulted from intermittent sheetfloods they are if you see here this is 1 photograph of sheetflood. So sheetflood generally it occurs in the mountainous regions in arid regions.

So this is probably arid region one we see that means it is very less rainfall even if once in 12 months or so or more than that. So whenever there will be flash flood when there will be heavy rain whatever this sediment was there this eroded sediments are there that is a fragmented sediments are there. Those sediments through the water they came down heavily there really it sediment starts water it is coming.

And we know these are the ephemeral streams and the soil below that it is totally dry and so that the rate of soaking of water is much more. So rate of percolation of water downside or down the slope is much more. That is why what happens? When there is a flash flood and these ephemeral streams are full of water and moving down so due to this percolation underground the strength of the stream suddenly decreases.

So whatever the sediments were there and they are just spread along this mountain front this is called sheetflood and this is a photograph showing this sheetflood deposit. If you see here this sediment you can see the thickness of the sediment or the upper part of this sediments mostly they are angular unsorted and there is no arrangement. So these are the result of sheetflood deposit.

And some pediments seem to have resulted from this sheetflood deposit and interval with the surface weathering and rill work. Once there will be a sheetflood and this sediment eroded by these sheets they will be spread along this mountain front they create a layer. Now suppose this interval of rain again it will be stopped here because the interval will be more. This is due to the arid region.

So now for example 12 months or 14 months or whatever this interval is there we leave this sediment as it is. So that means rilling starts that means the erosional processes start. So due to this rill action these are this rills you see due to this rill action so those pediment surface which is formed by this sheetflood deposit they started erosion started weathering. So due to rill action this erosion starts.

The pediments these type of activities by which this pediments form they are smoother and nearly planer because they are deposited on a plane but those which are formed by the prolonged erosion so this surface will not very smooth. But once those sediments or those gravel surfaces which are formed by this sheetflood deposit that means it is spreading. So these represent a smooth surface as compared to these pediments formed by other process.

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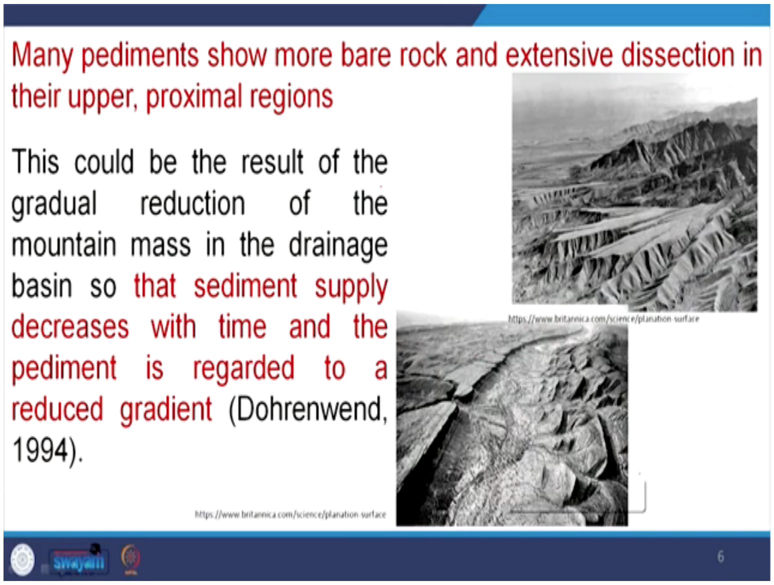

Many pediments show more bare rock and extensive dissection in their upper and proximal region it is very interesting to know here. Now for example we have a mountain front in considering this figure we have a mountain front and from this mountain front we are creating a pediment plain, pedi-plain is here. So this pediment plain at this initial or this proximal part and this distal part you see there are many dissections many rill activities.

This could be the result of gradual reduction of this mountain mass in the drainage basin so that sediment supply decreases with time and pediment is regarded to a reduced gradient. This is the main reason for this type of dissection in the proximal and distal part. What does it mean? Suppose we are creating sediments and suppose it is a tectonically relatively less active basins or inactive basins due to sheetflood we created a pediment surface the whole sediment is spreading along this mountain front.

You leave it for next stage of flash flood. So this sediment production gradually decreases is not it? So once the sediment production gradually decreases the rill action becomes more active because nature always wants to make it peneplain. So that is why so whatever this area remains whatever this pediment surface remains they dissectional due to rill activities. So that means that sediment supply decreases and this pediment is regarded to a reduced gradient.

Gradually once this sediment supply decreases so that means the slope will decrease. Because this suppose this is the mountain and we are creating more sediment we are supplying more sediments to the system so that means it will look like this. But if the sediment supply becomes less sediment supply is reduced so this area it will start erosion removal of this material so removal of this material due to the rill action.

So that means once this material is removed that means gradually the slope is decreases. So that means this is an evolutionary process of this pediment. So more and more sediments we add more is the slope. So sediment supply reduce they were decreasing the slope is not it? So those type of reduced slope activity of this pediment they are mostly found in tectonically less active basins or tectonically less active mountain front.

But if the tectonically it is more active that means frequently we are adding sediment and the sometimes they are removing. So slope may remains like this. But if sediment supply is less then slope will be like this. So this angle of this pediment plane angle of this pediment surface they depends upon the rate of removal and the rate of supply of sediments. Now another interesting case here suppose we have 2 sets of rocks or rock separated by plane either it is a fault plane or it is a depositional plane.

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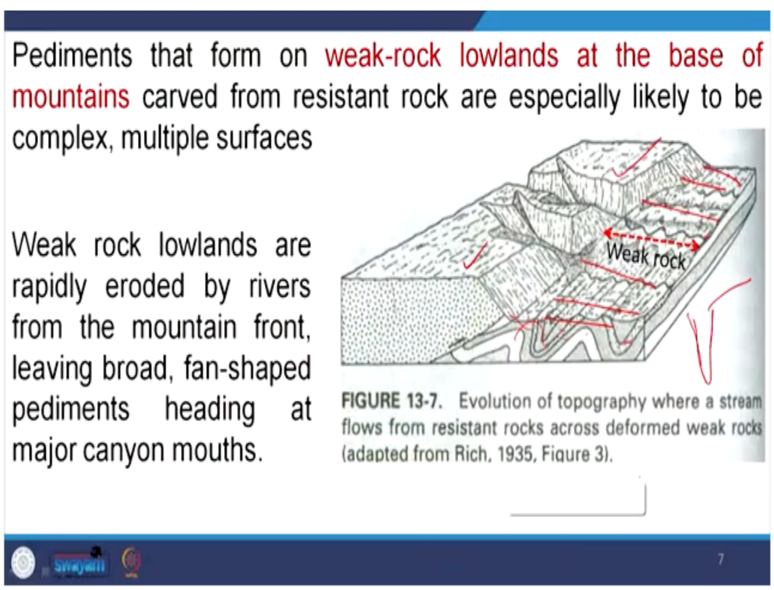

And here suppose this part is consists of weak rocks and these are the hardening strong rocks. So here the pediment characteristics will be different how? Pediments that form on weak-rock lowlands at the base of the mountain carved from the resistant rock are especially likely to be complex multiple surface. Why multiple surface is there? For example if you see suppose this part is composed of soft rocks and a variety of rocks not only 1 rock, it is variety of rock.

So we know the variety of rock that means the degree of erosion will be different of different rocks is not it? Suppose a rock which is more prone to weather so that will weather to a deeper level and which is relatively more resistance relatively resistant rock that will erode to a lower level. So we have pediment surface at different levels. So that means 1 is at a deeper level, 1 is at shallower level and 1 is this level.

So there are multiple surface of pediment forms. Weak rocks lowlands are rapidly eroded by rivers form the mountain front leaving broad fan-shaped pediments heading at major canyon mouth. So this is the things whenever there is soft rocks the river cut to deeper level. So canyons are formed, gorges are formed and pediment surface they form sidewise of this canyon or the that gorge.

Now imagine suppose we are creating a gorge here. So once the gorge is created that means here this side is soft rock, this side is soft rock. So that means if you remember our last class when we are talking about these slope evolution. So this part will be erode down, this part will be erode down, this part will be erode down and this part will erode down gradually this part erosion starts and finally this slope will be converted to like this form.

So once these part is suppose whenever there is a gorge formed this upper part this is pediment surface it was filled with gravels eroded from this mountain front. Now once this system getting eroded from both sides these gravel mass they are falling within the system. Once the gravel mass forming with the system so that means this pediment surface is gradually reducing and reducing. So these are cut across erodible rocks but are protected from deep dissection by an alluvial veneer or coarse gravel transported from this mountain canyons.

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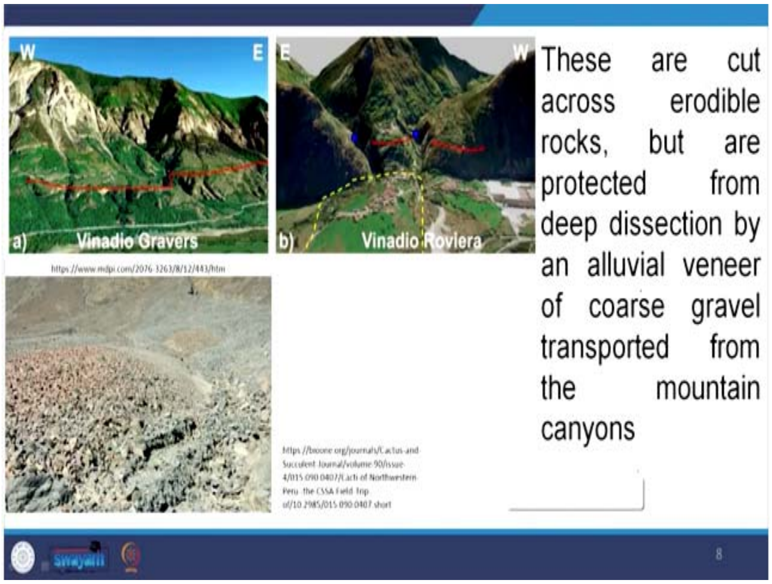

That already we have discussed there suppose here is a mountain canyon is there. So mountain canyon means these are the pediment surface so whenever there was no canyon was not formed so sediments which are eroded from this mountain systems are they are coming through this rivers and channels they are spreading here. So these are the gravels they are the gravel fields. Now due to this contrast of this hardness of these rock competency of the rocks the gorge is formed here.

And due to this formation of these gorge this river they cut deeply. So that those boulders they are lying here and there in the surface. So once this gorge it is both side of the slope it is eroded and finally it is coming to this level. This material the gravels which are deposited in both side they are coming down. So once they are coming down that means the thickness or width of this pediment it is gradually decreasing. Similarly the thickness of the pediment surface is also gradually decreasing.

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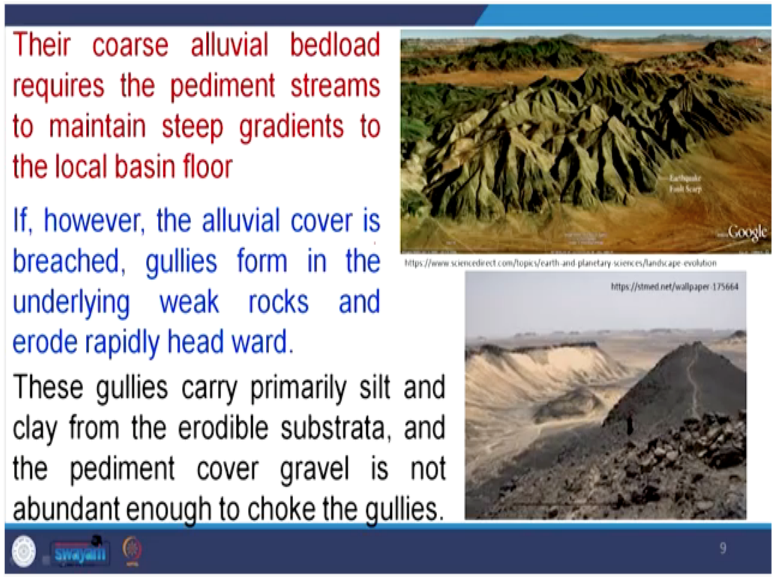

Their coarse alluvial bedload requires the pediment streams to maintain steep gradient to the local basin floor. If however the alluvial cover is breached gullies form in the underlying weak rock and erode rapidly head ward. It is this part is very important to understand here. Suppose for example in this case this a gorge is forming, here is gorge is forming, this is an alluvial fan, this is the pediment, this is a alluvial fan, this is a pediment or so like that.

So now you see this pediment surface we know it is always covered with gravel thin film of sediment. Now suppose this is these are the weak rocks and filled with sediments. Now we are creating the gullies on the surface. So once we are creating the gullies that means it will promote weathering it will promote erosion. So once they erode the material that means they are removing this resistive covers from the surface.

Once they remove the resistive covers so the low lying weak rocks they will start eroding and finally weak rock they will create silt and clay sized particles. So finally this stream earlier it was moving through gravels now they will start transporting the silt sand and clay sized particle. These gullies carry primarily silt and clay from the erodible substrate and the pediment cover gravel is not abundant enough to choke the gullies.

So that means here in the evolved situation where there is this rivers were transporting earlier the boulders now these same river they are transporting these small particles like this clay and silt to through their riverbed. And we know the silt and clay they choke the riverbed. So the vertical aggradation will take place.

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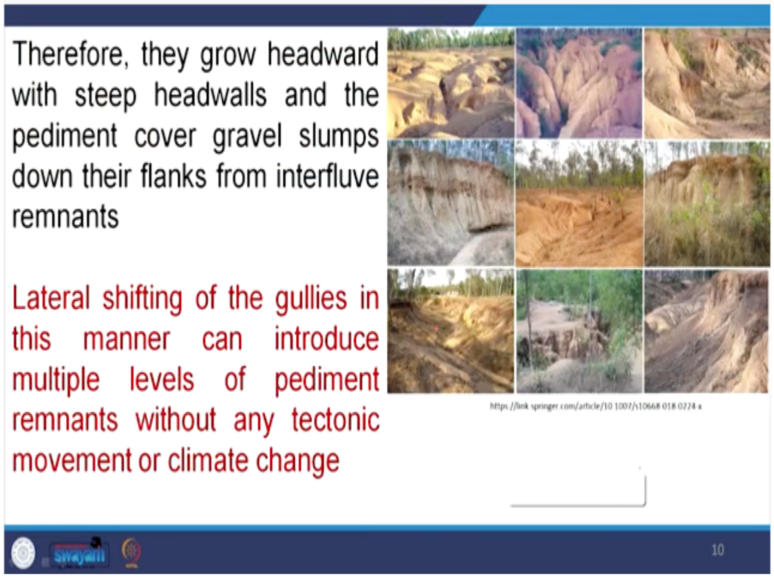

Therefore they grow headward with steep headwalls and pediment cover gravel slumps down their flanks from the interfluve and interfluve remnants. Now here is a very interesting to understand here. Now once this is a gorge form the gorge from through these gullies. These materials are slumping down. Lateral shift of gullies in this manner can introduce multiple level of pediment remnant without any tectonic movement and climatic change.

So here very important to understand yet there. No tectonic movement is there. No climate change is there. But there are multiple level of pediment this is due to this contrasted competency. So that means if the competency contrast will be there, there will be hard rock at the upper part and this low resistant rock or the soft rock in the lower part. These type of pediment evolution takes place.

And that is why there will be different level of a pediment formation without introducing here tectonics without introducing here climate change. So that means whenever in a mountainous region you see the different level of pediments are there. So not necessarily to understand this evolution you have to introduce the climate change or you have to introduce the tectonic processes.

So that means I want to say tectonics, climate and this type of rock contrasting in hardness, contrasting in this competency of the rock all contribute for this evolution of this pediment. So that means we have to think on which ground we want to locate and what is the best solution for it?

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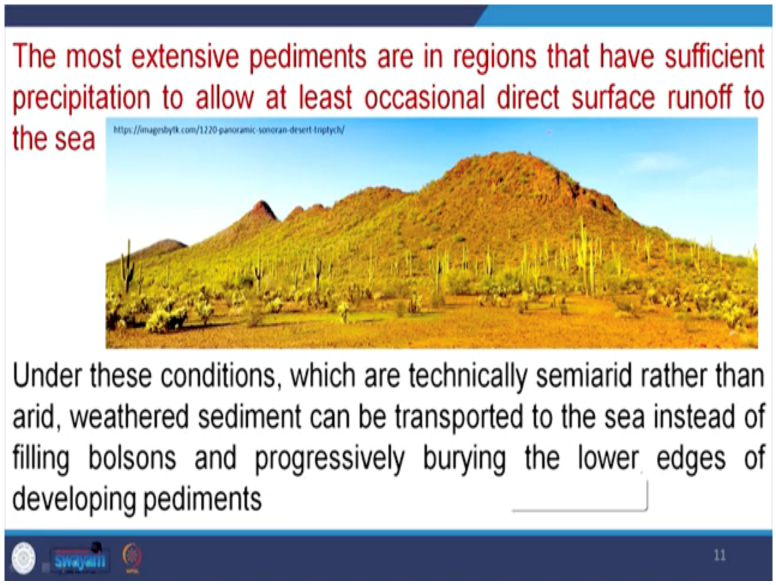

So now you see the most extensive pediments are in regions that have sufficient precipitation to allow at least occasional direct runoff to the sea why? Because we know whenever we are accumulating sediments at their local base level higher than the main base level that means we are suppressing the pediment surface. So if it from that level we are directly removing the sediments that means we are exposing the pediment surface.

So that is why the most extensive pediments more wide pediment we will get in those areas or those regions that have sufficient precipitation to allow at least occasional direct surface runoff to the sea. So that means there should be heavy rain, there should be cloud burst type of material. So that the sediments will be directly removed without accumulating at the intermontane basin. Even it from the intermontane basin itself the sediment will remove to the main base level.

Under these conditions which are technically in semiarid rather than arid weathered sediments can be transported to this sea instead of filling the bolsons. Bolsons means this intermontane basin the playas and progressively burying their lower edge of the developing pediments.

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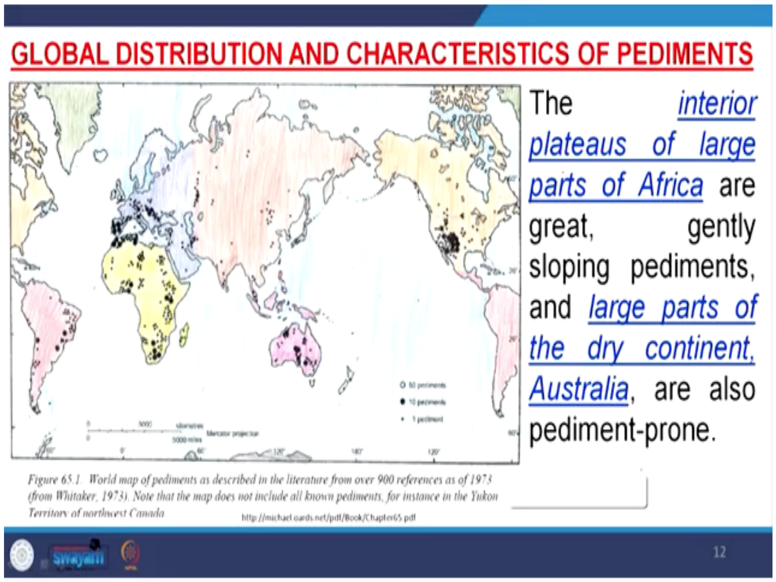

Now, if you see the global distribution and characteristics of pediments mostly the interior plateaus of large part of Africa are great gentle sloping pediments and large part of the dry continents Australia are also the pediment prone areas. Similarly here you see this is pediment 1 pediment, this is 10 pediment, then 50 pediment. So here this distribution of this pediments along the globe most of this pediment surface most of the erosional surface they are concentrated in African plain.

Similarly, here and these are the distribution. So global distribution of pediment they are distributed here in this figure. And it is seems this erosion is going on there. Erosional surface is exposed either due to climatically, due to tectonically and due to this competence of different rock adjacent to each other. So irrespective of that these pediments are distributed throughout the globe. So this is all about your pediment class and thank you very much for your attention. we will meet in the next class. Thank you.