Geomorphology
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Lecture - 52
Fluvial geomorphology, River System-I

So, friends welcome to this lecture series of geomorphology and this class we will continue with this river system. So, if you remember in the last class we are talking something about the stream ordering, Drainage density, stream competency, stream capacity. So, we found that mostly when we talk about this sediment load in the system river system, we do not consider this a solution load because it is in dissolved conditions and the bedload.

Once we say it is difficult to measure the bedload accurately, so that we assume it to certain extent, and suspended load is the most promising load through which we can calculate different parameters of channel. So, today we will continue about the river system again, and how the river transports how the system loads from one place to another? And what are these geomorphological features in erosional and depositional features they create and modify within this rivers journey from head to mouth.

So, if we see here the rivers journey, rivers usually begin in mountain terrains but not always. For example, we talk about the Himalayan rivers, mostly I am talking about mostly 99% of the rivers. They generate or they originate from this mountainous terrain but there are some rivers which generate below the mountains. There are plain-fed rivers for example, in the Himalayan terrains.

If you go in some of these rivers are the major rivers like the Ganga, Yamuna, the Brahmaputra, the Ghaghara the Kosi they generate they are originated from this mountains terrain. So they are called the mountain-fed rivers. And some of these rivers they are generating from these piedmont. So, and some of these rivers they are generating from the flood plains, so that the plain-fed rivers the foothill-fed rivers.

So that means not necessarily whenever we are talking about the river system, not necessarily always the rivers are all generating or the originating from this mountains. So depending upon their position, either it is foothill-fed, that is coming from the Piedmont by the recharges

from groundwater that the plain-fed rivers are coming out from the plains. So they are this groundwater fed rivers.

So that means depending upon this conditions the river can be defined either it is a mountain-fed river the foothill-fed river or there is plain-fed river like this, but mostly the river they generate from this mountainous terrains, they flow downhill on flat land and into the sea.

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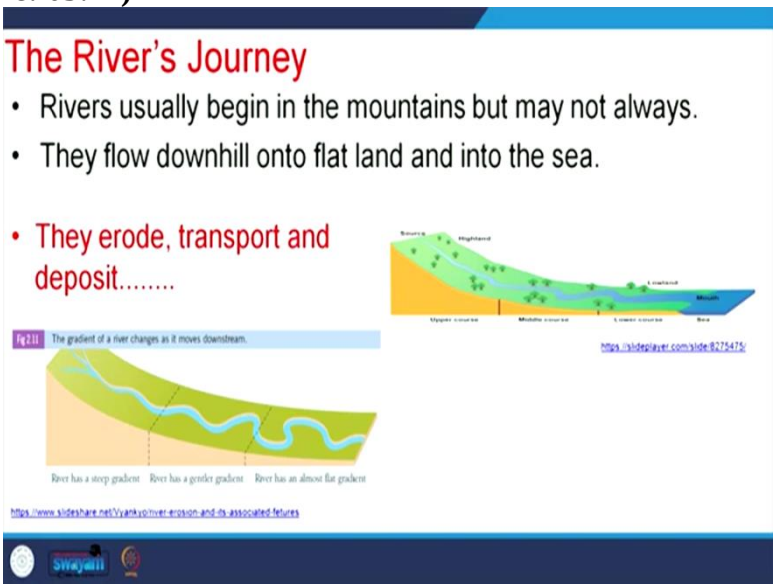

So, they erode transport and deposit. So, that means the river starting is the source and it is some source to it is the mouth of the river from source to mouth, it transports the sediments it erodes these region is mostly it is erosional region characterised by erosion and in between there will be transportation and there will be deposition there.

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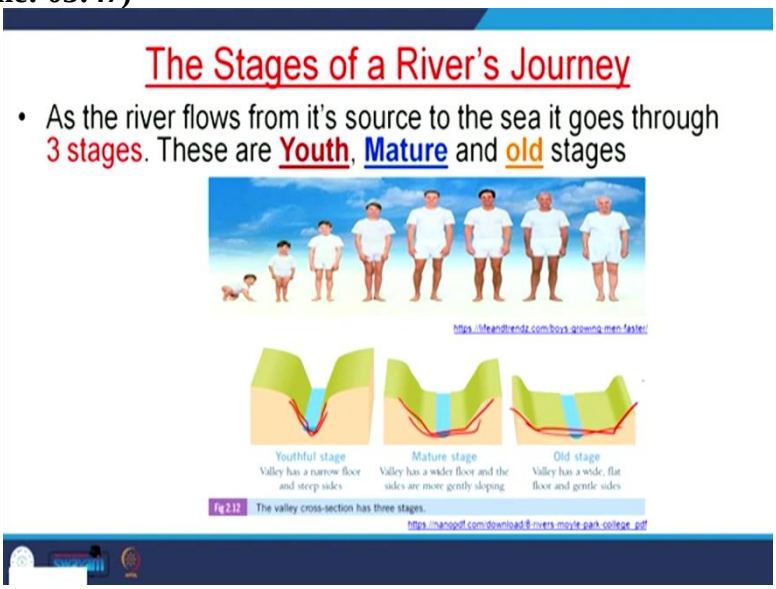

So, here during this river journey from this origin, or this from head to mouth, like this human life cycle, it moves through youth stage, mature stage and old stage. So if you see these figures here, in this youthful stage, you are getting very narrow valley and gradually the valley width increased and finally valley width again increased. So, similarly in the human life cycle also during growth, we have different modifications in these systems.

Similarly, what the mental modification physical modifications like that similarly, this river journey from this youth stage through mature stage towards old stage. There will be modification in channel morphology and the modification in the amount of water, the sediment amount of sediment, similar the style of transportation, so, that means each and every aspect of a channel that is modified from youth stage through mature stage to old stage and that is why this geomorphic features either it is depositional or it is erosional.

So, characteristics geomorphic features are there, which is confined in a particular stage of river that is characteristics of a particular stage of river. Let us discuss it.

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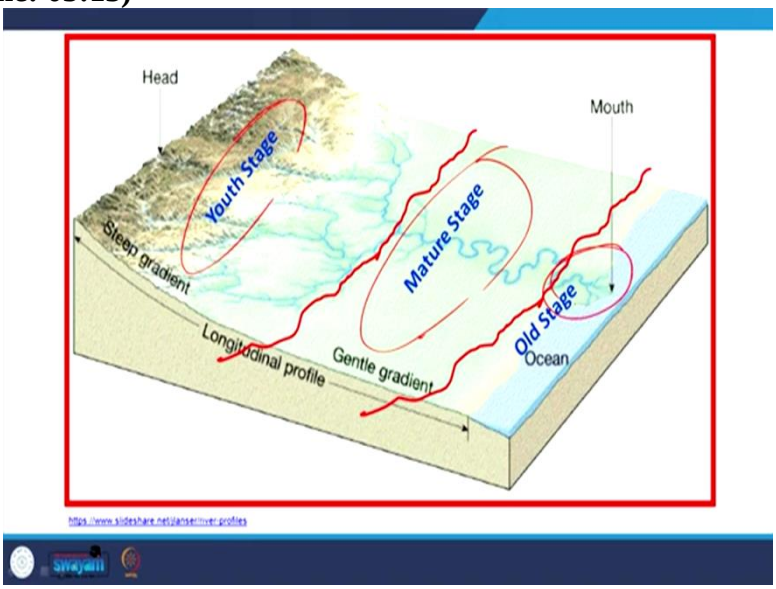

So, here, if we divide these river basins, this side is the youth stage that means mostly river is carrying out erosion in this area. And here it is mostly the transported some deposition and here most of the deposition that takes place in the river mouth in form of deltas.

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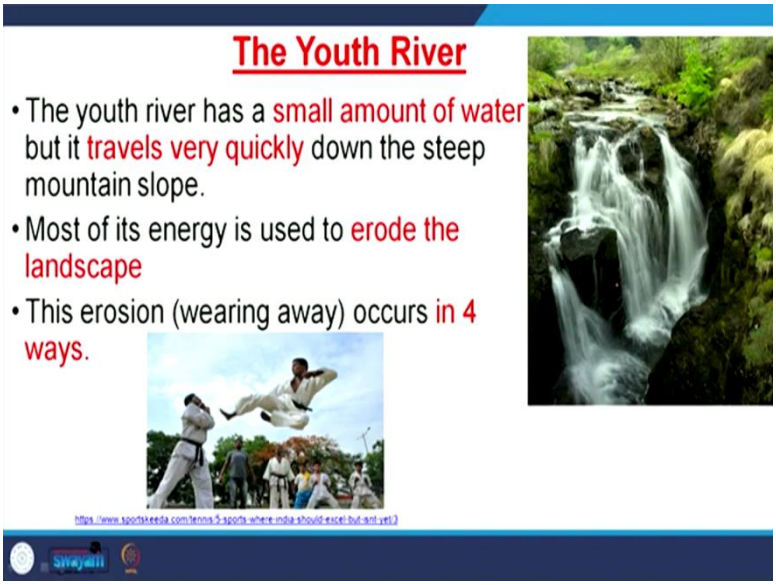

And the youth stage, the river in a small amount of water, but it travelled very quickly down to the steep mountainous slopes, most of his energy is used to erode the landscape and this erosion is occurred in 4 ways.

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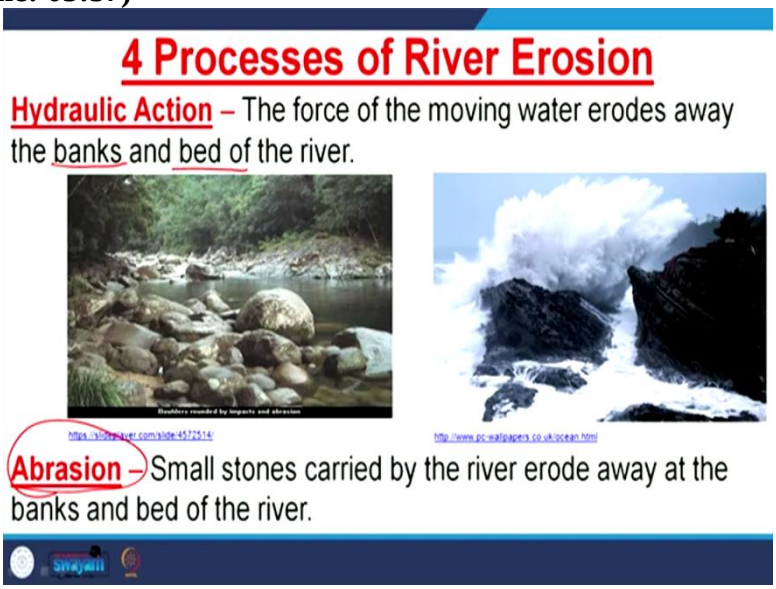

What are the 4 ways one is the hydraulic action. Hydraulic action means it is the water only responsible nothing else, only water, the force of moving water erodes away the banks and beds of the rivers. So, it is highly forceful channels highly force water is flowing forcefully, because it is confined in the narrow valleys, mostly in this upper reaches. They are in mountainous regions youth stage.

They are confined in narrow valleys and narrow valley is as it is confined its forces very high. So, this due to this waters own force, it erodes away the banks and the river beds. So, this is

called hydraulic action. So, once water is added with sediment, so, here, the system is called abrasion. Abrasion means, small stones carried by the river erode away at these banks and bed of this river. So, that means, if water is only associated with erosion, that is called hydraulic action, if water isolated with some sediment particle is added, it is called abrasion.

So, if you remember when we were talking about this a coastal plains geomorphology then the initial times notch during notch formation, the initial states the rate of erosion will be less because water will be associated only water is associated, but with increasing of time, when the sand particles added to that, to the rate of erosion increases, because the sand as well as water both are responsible for eroding this coastal cliffs.

Similarly, here the hydraulic action that means only water is associated, but abrasion once we see then with water, we are adding sediment and we are increasing the erosion capacity of a river. Then another is type of it is called attrition. Attrition means here during transportation, the particles they collide with themselves, so, that means, one particle is colliding with the other than others that means, here there is a tussle between the particles among themselves. So, as a result, the angularity of particles decreases, the roundness increases.

So, that means, here they hit of each other and finally, we are getting these rounded particles rounded clasts. So, this rounded clast products of attrition then, other type of erosion which is called solution that means, those rocks which are very sensitive to water solution minerals. So, that means, those minerals they become soluble in water and they are transported through solution and as we know the solution load it does not affect the hydraulic geometry of the system.

However, this amount of sediment which is suspended and what is the bedload, they affect this hydraulic geometry on the channel shape of this river. So, that means, though we have hydraulic action, abrasion attrition and solution, but here, when we talk about these river erosion only these sediment transported by saltation and bed load, they are more important.

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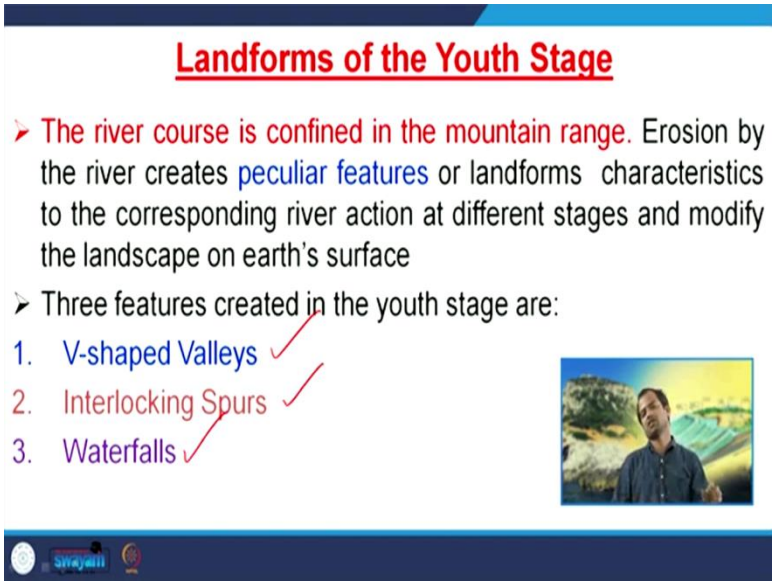

Landforms in youth stages the river course is confined in the mountain region or mountains which erosion by this river create peculiar features or landforms characteristics of corresponding river action at different stages and modify the landscapes on the earth surface. 3 features created in the youth stage first is the V-shaped valley then interlocking spurs, then waterfalls, these are the 3 characteristics erosional features, erosional landscapes in the youth stage. So what is V-shaped valley?

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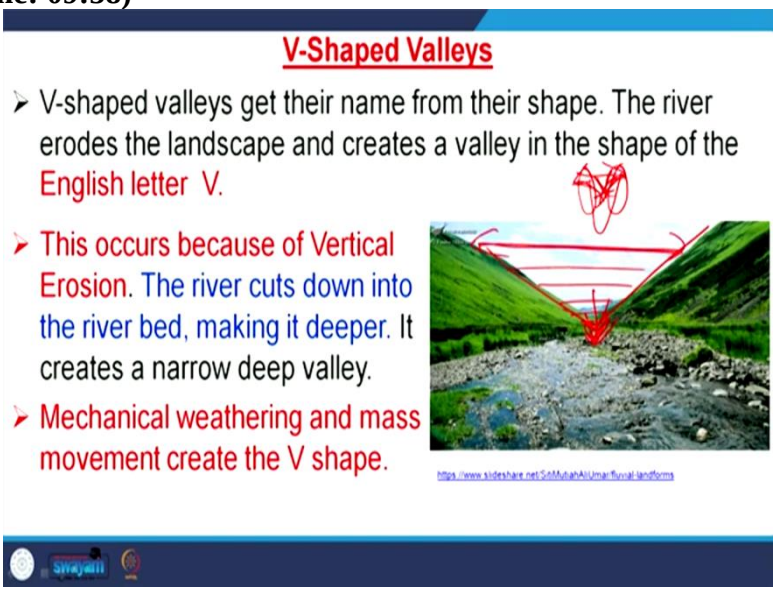

Here if you see this valley this of v-shaped looking v-shape. This width of the valley gradually decreasing and decreasing and finally 0. So, here this V-shaped valley that means it gets their name from this shape of English letter V. The river erodes the landscape and creates a valley in the shape of this V-shape. This occurs because of vertical erosion. This

river cuts down its riverbed making it deeper, it creates a narrow deep valley, mechanical weathering and mass movement creates v-shaped.

This is very important to understand here, mostly at this V-shape Valley, this erosion is downward. So that means the deeper erosion the riverbed erosion will be there. So now you see suppose we are creating a river where erosion is like that. So this part and this part, it will be mechanically unstable or geologically unstable. So finally there will be mass movement. If you remember when we are talking about this mass movement, mass transportation.

So, here there will be mass movement and there will be rockfall, topple or many other whatever this mass movement method are there. So, due to that severely widen takes place. So, finally, we will be getting a wider valley and it is V-shaped.

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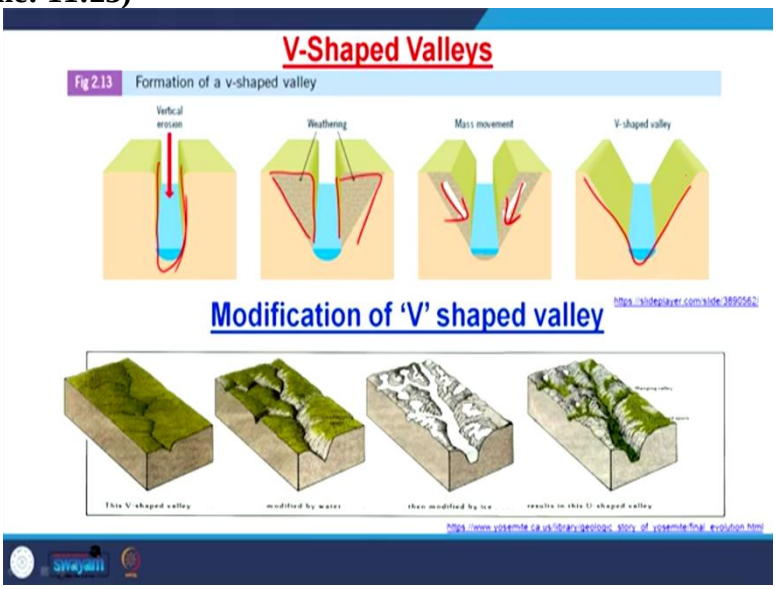

So, here is this vertical erosion at the youth stage and this part, this part of this rock mass it is finally moves down it is mass movement due to mass wasting. And finally, we are getting a V-shaped valley. But to be V-shaped valley of the rivers that can often modify by glacier at the upper reaches. So, the V-shaped valley it will be modified by the glacial movement and it will created to U-shaped valley as we know U-shaped valley is a glacial product.

And the upper reaches generally it frigid regions are the upper is the mountain region in the Himalayas and Alps and other areas, the V-shaped valley is created by these channels, it is often occupied by these glaciers and once glacier move through this valley, it widens. It shape changes. So, that modify this V-shape valley to U-shape valley. Then another feature

of erosion, it is the interlocking spurs. Interlocking spurs if you see here, one spur another spur, third spur, fourth spur that means they are interlocking.

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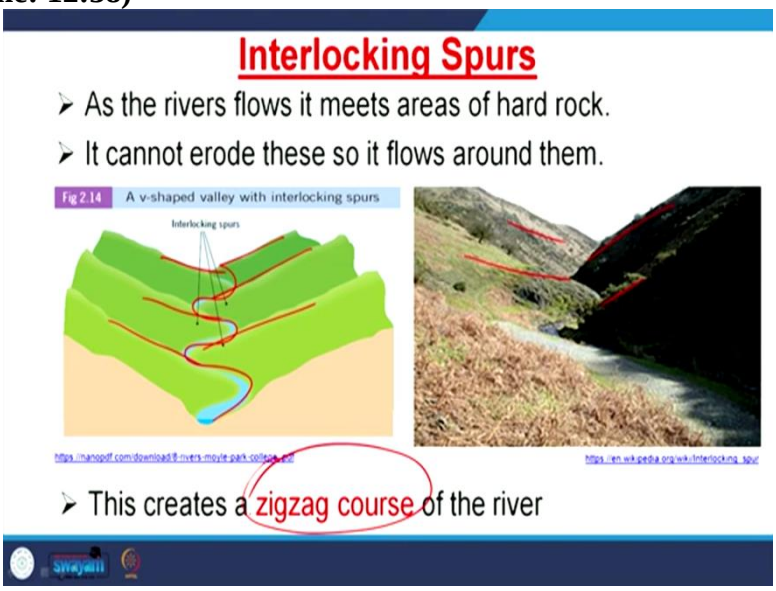

So, once they interlock, for example, here also there are interlocking spurs. So, once they interlock, we are getting a river channel, which is zigzag pattern. So, that means, as the river flow it meets areas of hard rock it cannot erode these so it flows around them. This creates a zigzag river course. So, interlocking spur is a product of youth stage of river erosion.

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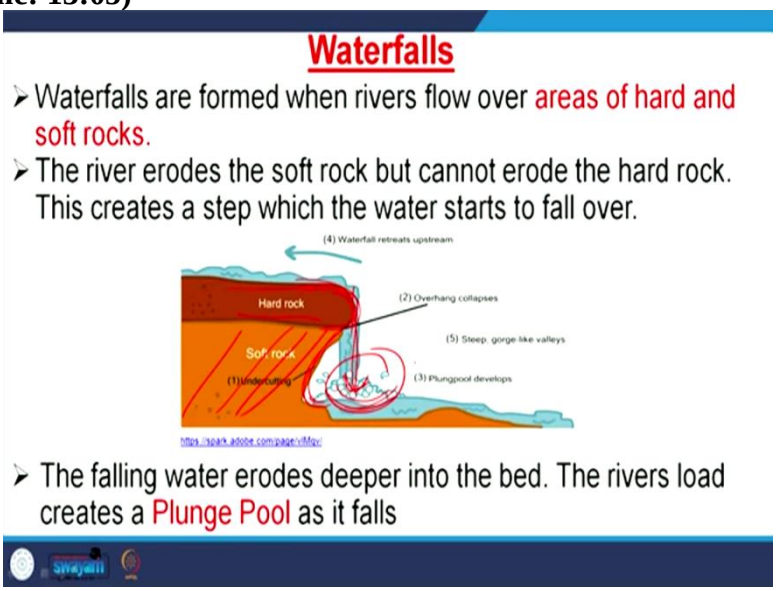

Then waterfall. Waterfall are formed when the river flow in areas of hard and soft rocks for example, if you see here, suppose we have hard rock and we have soft rock in below. So here suppose there is a fractures through this fracture, there will be erosion and finally if resistant more it will remain as it is and this lower part it is soft rock, they get eroded And finally there

will be a free fall of water from here to here and creates waterfall and here this is called plunge pool. This is a temporary pool is generated. This is called plunge pool.

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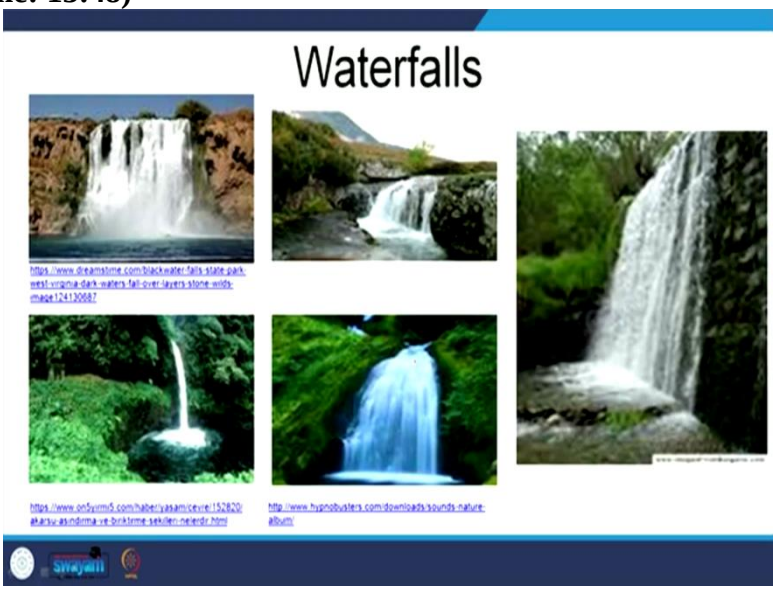

And these are some of these photographs of the waterfall worldwide.

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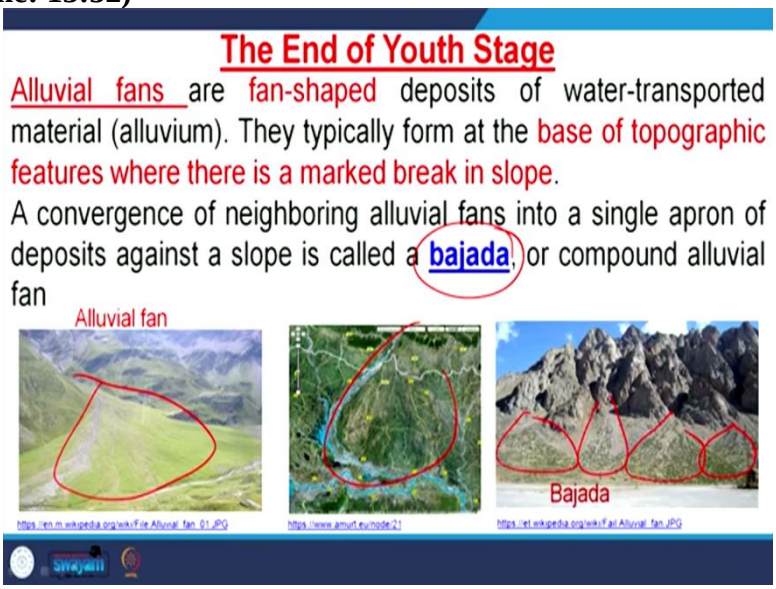

So, now, let us end the youth stage. Some where the youth stage has to be ended because we are waiting for this mature stage. So that means when there is a drastic change in slope, the youth stage of river ends. So mostly, here the feature that is called Alluvial fans. There is megafan, alluvial fans if you see the Ganga megafan, Gandak megafan, Kosi megafan, Sutlej megafans.

So, these mega fans of this alluvial mostly these are the alluvial fans, who alluvial fans they are formed at the slope break due to change in hydraulic geometry of these channels. And

mostly it is the slope break which is responsible to change the hydraulic geometry of the channel. So, the rivers which are confined earlier in narrow valleys very forcefully transporting or eroding this river valley and these surrounding areas. And they are transporting the sediments within a confined narrow channel.

So, once they reach at this slope break and the plane land, so they open up and the kinetic energy decreases. So, that is why what happens, they are not able to transport this amount of sediment they carry and finally, these sediments are deposited there and they create alluvial fans. So, the alluvial fans their correlations with each other. They join one alluvial fan joining to the adjacent alluvial fan and forming a particular type of topography, it is geological or geomorphologically, it is called bajada.

Bajada means, it is the coalescence of more than one alluvial more than 2 or more than 1 alluvial fan. So, that means it is here, one alluvial fan, it is joining with another alluvial fan, it is joining with another alluvial fan it is joining so, this is bajada. That means it is coalescence is of alluvial fans there, then comes to the mature stage.

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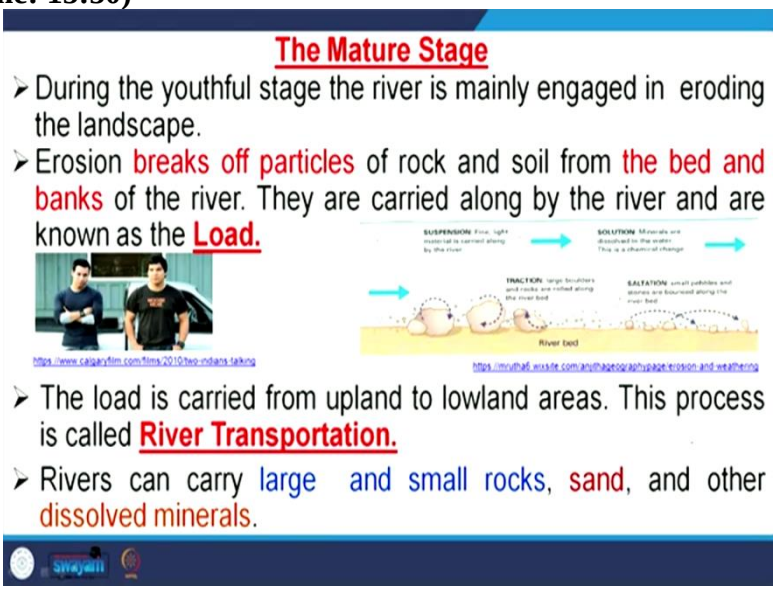

The mature stage during the youthful stage, the river mainly engaged in eroding the landscapes. Erosion breaks off particles of the rock and soil from the bed and these banks of the river, they are carried along this river and are known as the load. So, that means it is total load suspended load bedload. So, dissolved load. So, this total load of this sediment total amount of this material is carried by carried out by the sediment. It is called load.

So, the load is carried from upland to down land area, the process is called river transportation river can carry large amount of rocks, sand and other dissolved minerals. So, depending upon that the terminology is used either it is a bed load or it is a suspended load, it is a solution load like that.

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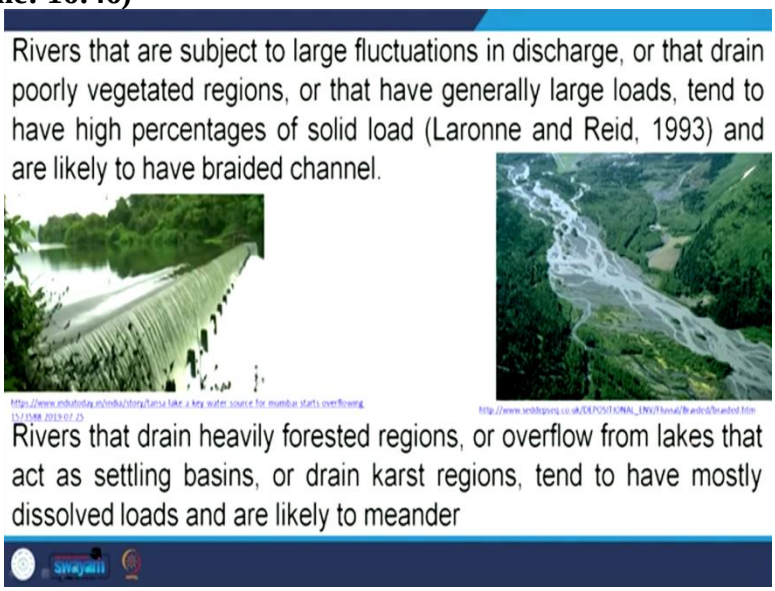

So, rivers that are subject to large fluctuation of discharge or that drain poorly vegetated regions or that have generally large loads tend to have high percentage of solid load and are likely to have braided channel. So, that means depending upon the load of river what type of channel morphology will be there if you remember, when we were talking about the channel morphology either it is the straight channel, meander channel, braided channel.

So, we are talking about the amount of load as well as the nature of the load either suspended sediment is there or it is bed load sediment is there. So, depending on that, so, it is either it is a braided channel or it is meandering channel or a straight channel. So, there are other anastomosing channel that will depends upon the load and the slope of the system. Rivers that drain heavily forested regions or overflow from lakes that act as settling basins or drain karst regions tend to have mostly dissolved loads and are likely to meander.

Because if we remember when we were talking about this experiment carried out by Schumm and Khan 1972 or 71. They are not able to create a meandering stream until unless 3% kaolinite clay was added to the system. So that means if we do not have this suspended load, we are not able to create meandering channels. So, that means, those channels which are

coming out from the karst regions are coming out from catchment area from plain. So, that means, they are suspended load is more as compared to the bedload.

So, those channels will tend to take these meandering channels rather than these braided channels. So, this loads irrespective of their origin, so they are transported. So, this transportation are 4 types.

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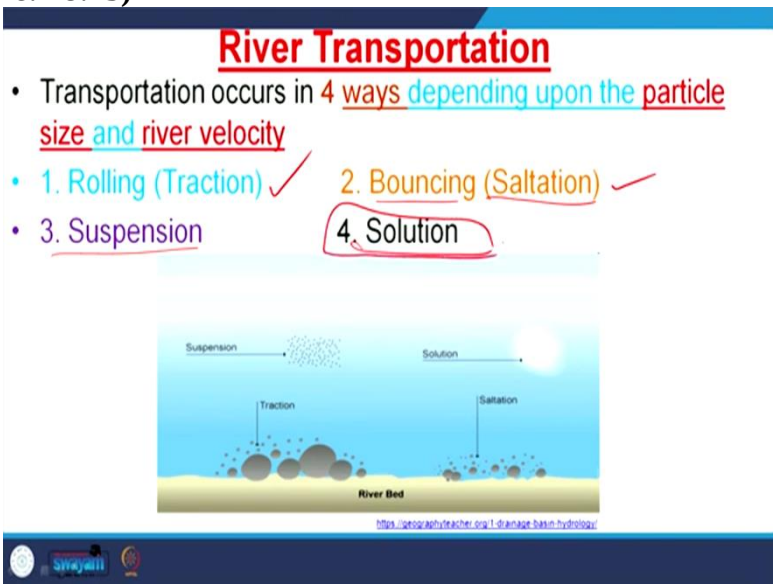

One is rolling type or it is called traction mode of transport. Then second is saltation mode of transport, it is bouncing that means jumping like that. And third is suspension and fourth solution, but this solution load it hardly affects. It does not affect to the hydraulic geometry of this river and this channel shape.

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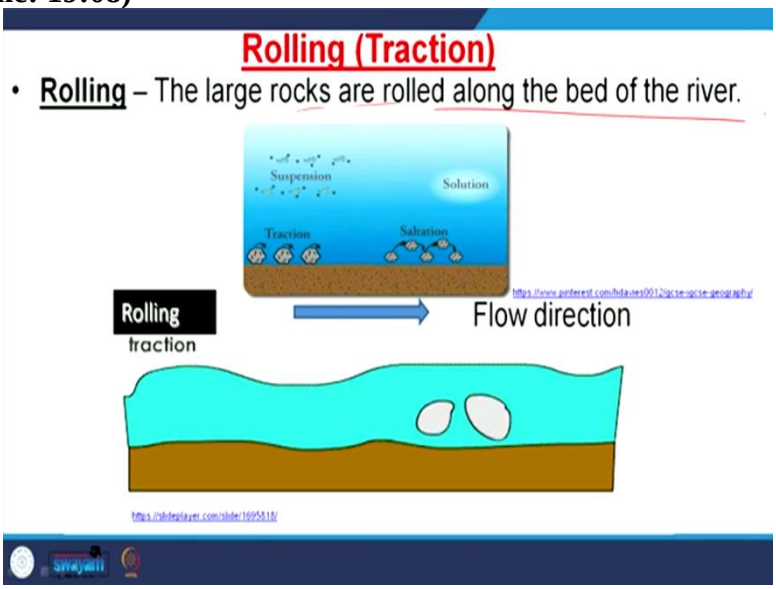

Here, the traction mode of transportation. Here, if you see these boulders, they are moving in the close to bed. That means on the bed they are rolling. So, the large rocks that roll along the bed of this river, it is called Traction.

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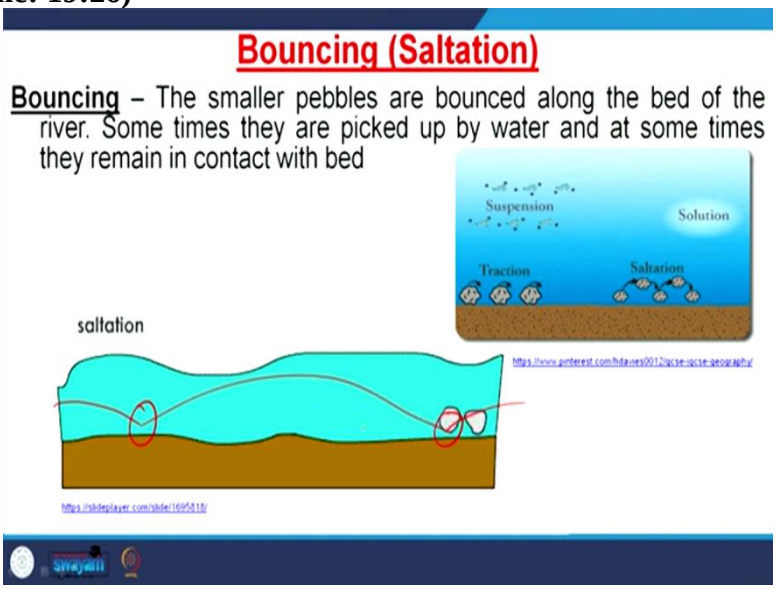

Then saltation, if you see here it is jumping and similarly there will be another jump there will be another jump. So, this type of jumping It is called saltation, it is bouncing the smaller particles or smaller pebbles, they are bounced along this bed of this river. Sometimes they are picked up by water and sometimes they remain contact with the bed. So these are these contact points. So there they are moving like jumping. So this is called bouncing back or this is called the saltation mode of transportation.

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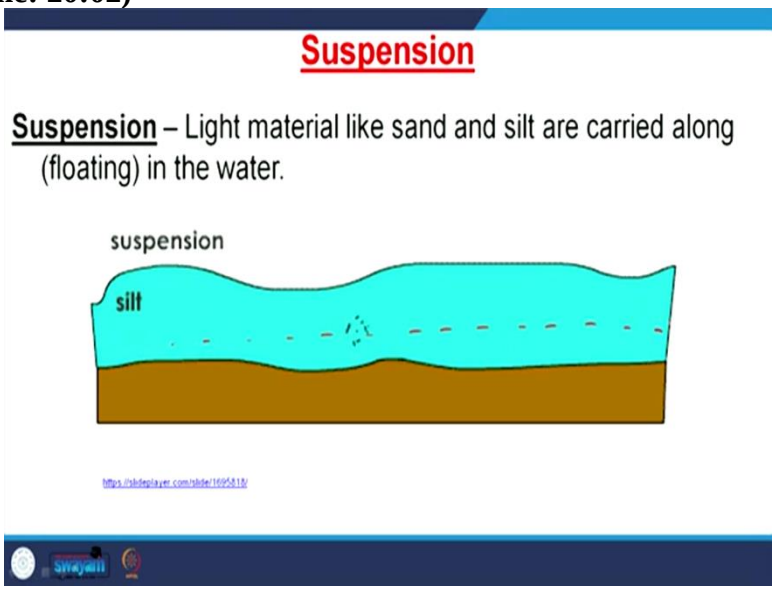

So, then the third one it is the suspension. Suspension means if you see, you always remain in the water, they do not touch the bed of river. So, that is suspended particles. So, mostly the

smaller particles the clay sized particles, they are transported through the river in the suspended mode. So, here light material like sand and silt are floating in this river.

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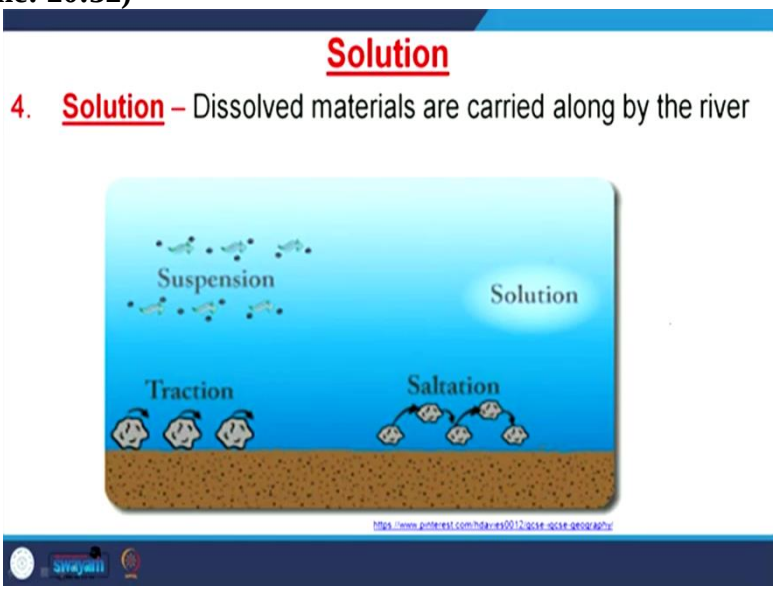

So, the fourth mode is the solution mode that means, these soluble materials they remain in solution and they are transported, but here this most important thing is that the solution transportation or the solution mode of transportation, it does not affect the hydraulic geometry of the river. It does not affect this channel shape. It does not affect this habit of this channel like either it will be meandering channel or braided channel or a straight channel. It will not affect. So, this other types of transportation, this bedload the saltation load the suspension load, these three this effect this channel hydraulic geometry.

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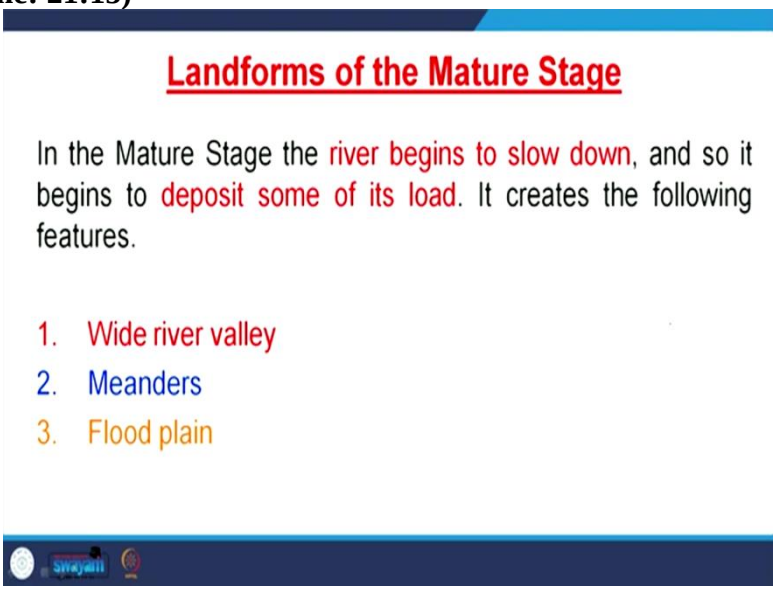

Then, landforms of the mature stage. In the mature stage the river begins to slow down and so, it begins to deposit some of its load, it creates the following geomorphological features first is wide river valley and then meanders then floodplains.

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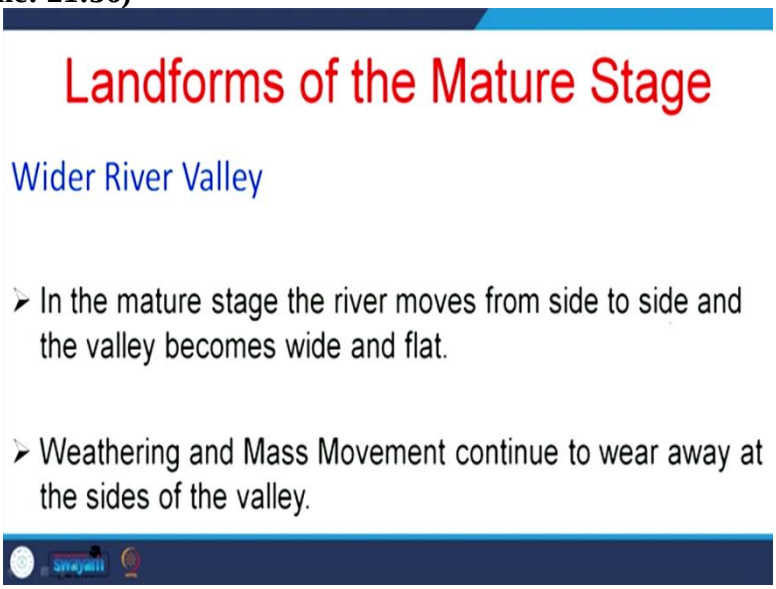

You see here this wider river valley in the mature stage the river moves from side to side and the valley becomes wide and flat. So, it is the flood plains. So, that means it is frequently changing river coarse within the flood plains that occur if you go to this if you see this satellite imagery of river Ganga or any river particularly this plain areas which are river flowing through plain areas, particularly in Bihar and Eastern UP we will find a number of channels paleo channels, there is within the flood plains.

So that means rivers change their course frequently within the flood plains. Weathering and mass movement continues to wear away of the sides of the valley. And that is why the river valley widens wider river valleys get in the mature stage.

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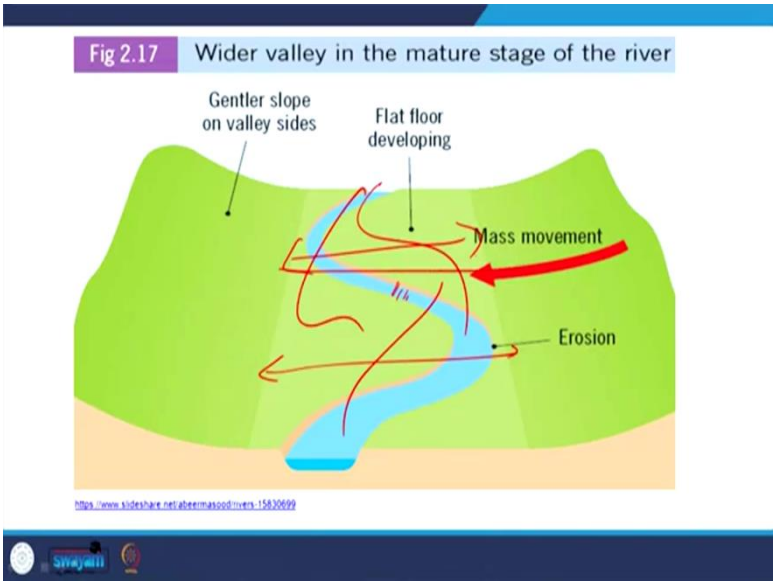

Here if you see here, this is the river valley, the width of river valley, but actually the river is confined here. So during flooding, the river may pass through here it may pass through here it may pass through so that means any part of this floodplain the river valley within that river valley, the river will migrate, so multiple channels are there. That is why during rainy time you will find only one channel of this much width, but during summer time you will find number of channels are there.

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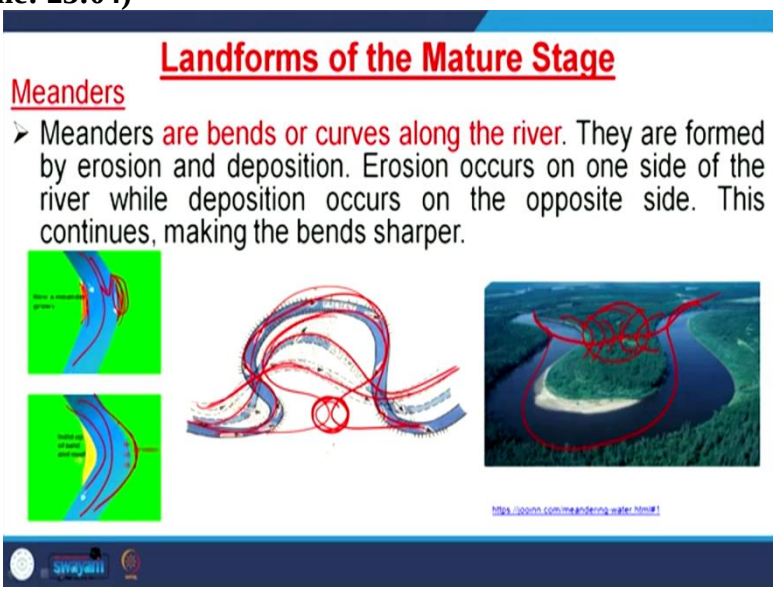

Then landforms in the mature stage another is the meander. The meanders, if you see here, gradually the curvature changes. And finally, this part of this river, if this is the transport direction, this part of this valley, it is getting eroded and these part it is deposited. So, similarly, with time, this river takes the shape if you see here original river was of this much, this was this travel this is the path of this original river with time this curvature changes.

And now, the curvature is changed of this, this part of this slide and which geological future it will find this will be move like this. And finally, this part will join together and this will cut off and this is called meandering river meandering that is called oxbow lake and it that is why it is called oxbow lake, it looks like this oxbow and here if you see, this is the system and with time this will increase and this will increase again gradually increase and finally, they will join here and the river will follow this path and this part will be abandoned.

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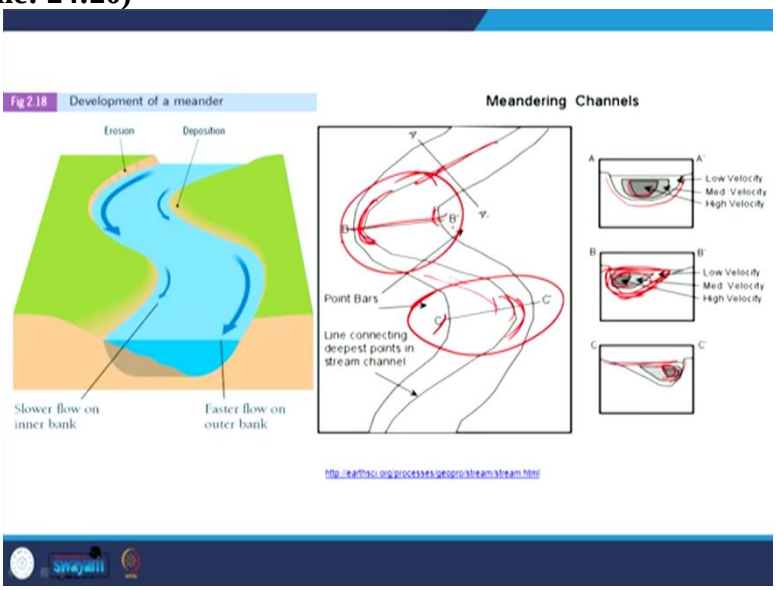

And in the meandering channels and meander that is a particular type of flow that we encountered that is called helical flow helical flow and if you see here, these velocity contours of these channels at the 3 different parts, this is A to A'. That means it is the straight coarse. Now, here B to it is one meander is here, another meander is here. Here, you see the velocity contours, that is low velocity and high velocity at the centre and these velocity contours they are uniformly distributed, symmetrical.

But here if you see, this is asymmetrical. So that means B to B', here we are getting high velocity in these regions. And here we are getting low velocity. So that is why this velocity contours if you see the distribution of this contour the arrangement of this contour that is asymmetrical arrangement is there. Similarly, in the other part here, if you see, this is also an asymmetrical arrangement, and the maximum velocity is this side, and the minimum velocity is this side.

So that means if it is straight course of river, the velocity distribution will be uniform and symmetrical through the channel width. But if a meander there is a particular type of flow that is called helical flow, helical flow, it is mostly responsible for this weathering and the erosion of this riverbank at this meanders.

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And these are some of these photographs of the meanders and this is if you see, this is an oxbow lake. So that means it is an abandoned meander. So if similarly here we are getting an oxbow lake oxbow lake means abandoned meander this means earlier the river was flowing in this way and later due to this change in hydraulic geometry and finally, this part was cut off and this formed in oxbow lake.

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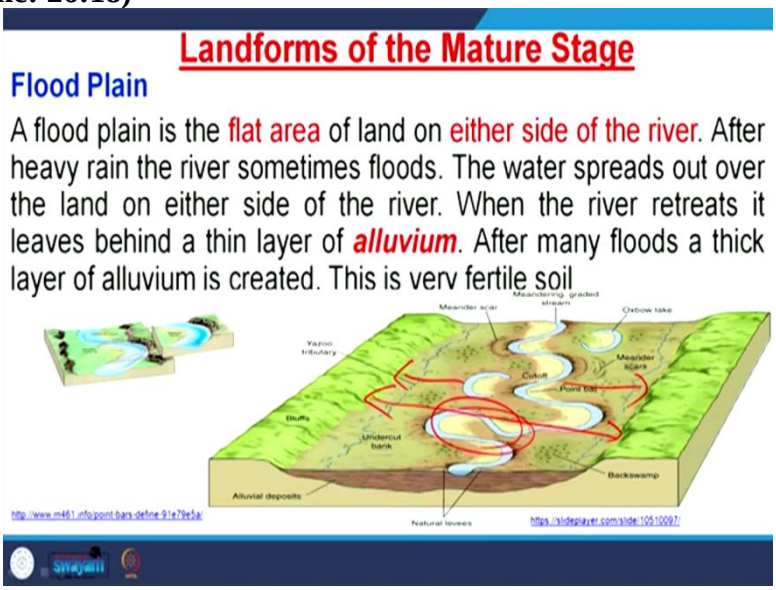

And the landform, in the mature stage and other is the flood plain. And here this is the width of this flood plain as we have discussed earlier also. So, within the flood plain, there are

frequent movement of these rivers from one part to another. And finally, the gradually if you move or if you confine yourself within this rivers, you will find mostly it is coarse grain particles and even from then fine grain particles are there.

So, as far as soil development is considered this flood plains, they are very good for soil development mostly it is away from the rivers and due to differential compactions. These rivers the flood plains due after soil development they are compacted and becomes and these rivers becomes alluvial topography to certain extent.

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Then at the old stage of this river nothing to do only the distribute water whatever this water is carried out by the river it is distributed to the distributaries and forms the delta. So, in the old stage the river is carrying lots of sand and silt. It is now flowing over flatland and so, it is moving slowly. Therefore, it begins to drop its load, it is called deposition, like erosion in the youthful stage is deposition also create many features of landforms.

For that it depositional feature and the most promising depositional features in the old stage of the river is the river delta.

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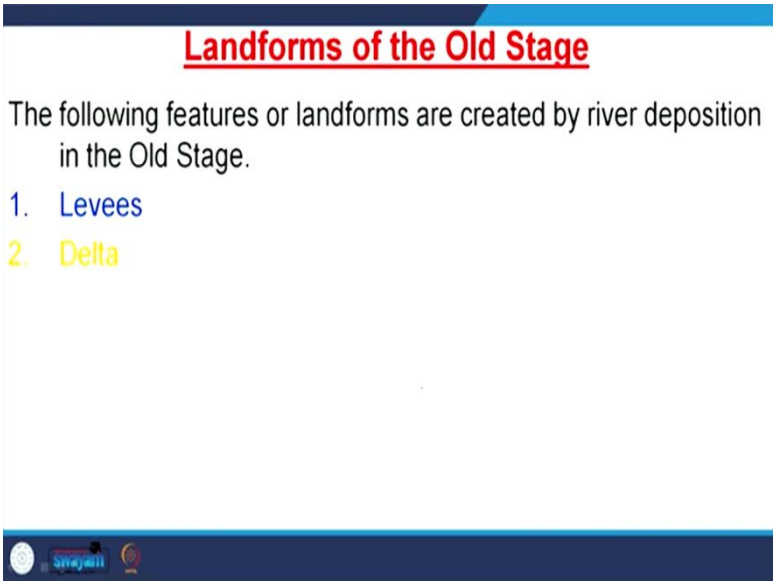

We have different delta and levees and deltas are mostly for hydrocarbon potential, mostly studied.

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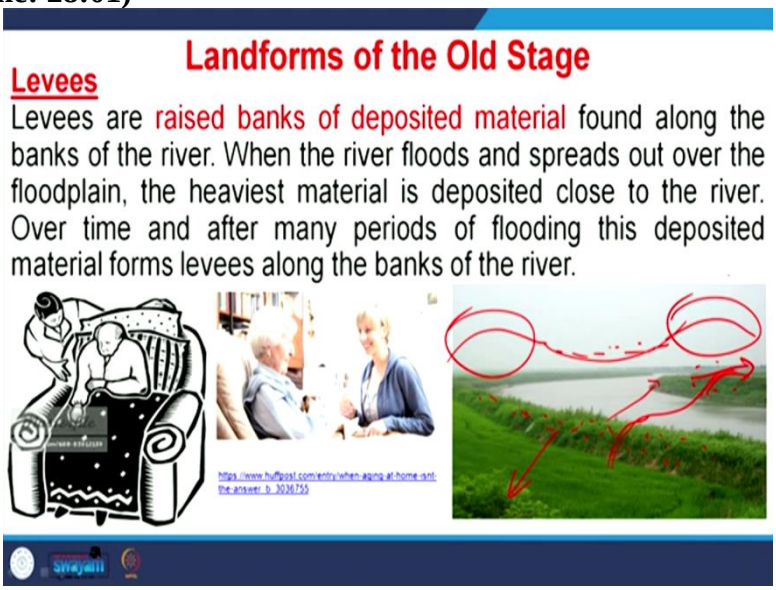

And natural levees if you see here, naturally levees if we see with this river and the both sides of river we have elevated topographies. So, that means, this topography will be look like this. So, that is natural levees that means during over flooding. So here, these coarse grained sediments mostly these sand their fine to medium sand or coarse sands are deposited here, coarse sand at the and gradually the grain size decreases.

So, once the grain size decreases with time, we are creating topography like this and topography like this and in between the river is flowing, this is the riverbed. So, this elevated topographies due to deposition that is called levees natural levees.

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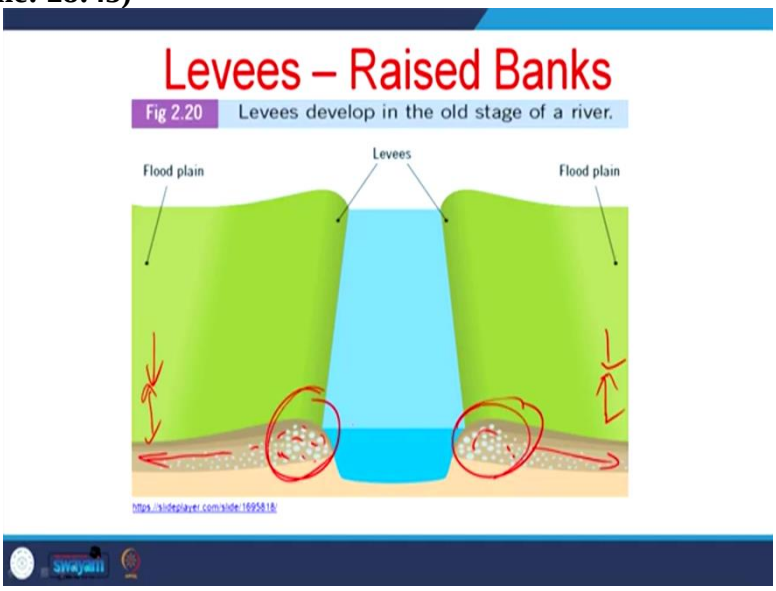

And here you see this is a block diagram here this coarser materials are here, coarser material is here, and gradually the coarseness decreasing and becomes more finer and finer. So here, we can get differential compaction effect. And as this is mostly it is sand, it hardly undergoes any differential compaction. So that is why this topography gradually decreases here and decreases here and becomes elevated here elevated here. So, this is called natural levees and the deltas, it is the most promising features in the old stage.

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There are many deltas in the east coast of India as compared to the west coast that it is interaction between this river as well as the terrain system. So I think we should stop here. This is all about these fluvial geomorphology and we will start with a new topic. Mostly it is glacial geomorphology in the next class, thank you.