Earthquake Geology: A tool for Seismic Hazard Assessment

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Lecture – 46
Geomorphic Markers for Fluvial Environment (Part- I)

Welcome back, so until now we have discussed about the different type of faulting environments and also discussed some case studies. Now another important aspect which has been left out as, the geomorphic markers. Now this will form a base for studying any landforms and different tectonic environments. So we will try to see that what are all those landforms which can be used to identify or delineate the tectonic influence on the landscape?

And this is important for even when we want to talk about the reconstruction of the tectonic history so not only just looking at the Paleoseismic signatures like what we did in ancient earthquake signatures from the sediments but we need to study the landforms also which is important part, having the issues related with the epidemic or the corona virus, we will try to see that if we can complete this whole lecture series or not but let us see let us go ahead with that.

So now most important part which we see on the Earth surface is the processes which are linked with the fluvial in the coastal landforms, and now the coastal landform is also important because now after this we will be talking about the signatures of the Paleo earthquakes and associated giant tsunamis from Andaman and Nicobar area where we did extensive research and we have been doing this research since class more than 10 years or so.

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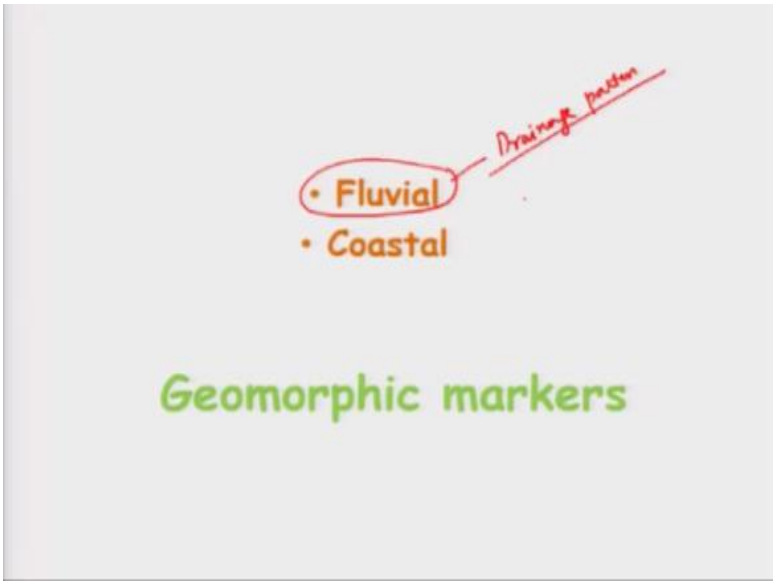

So let us get started with the fluvial landscape and of course to some extent this we have talked in our basic courses about the fluvial landforms and the most important part which usually we use as an indicator is here in the drainage part. So drainage pattern on the surface is extremely important for us to identify the subsurface structure.

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So channel pattern and fluvial landforms.

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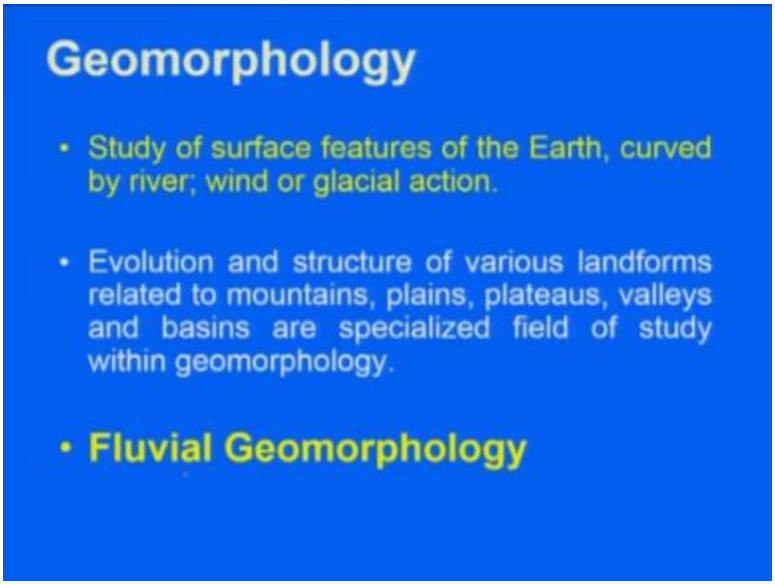

If we look at then what we have is that basically we look at the geomorphology and the features which are curved by river; wind and glacial action, and basically this talks about the evolution and the structure of various landforms related to mountains, plains, plateaus, valleys and basins and this specialized field usually we call as in part of the earth sciences.

We call geomorphology, so we are looking at in, as studying morphology of the surfaces and this branch is known as geomorphology. So since, we will be looking at more first the fluvial geomorphology that is related to your river action. Hence we call this as a fluvial geomorphology and similarly if you have, we are looking for the coastal then we will talk, this will say this as coastal geomorphology.

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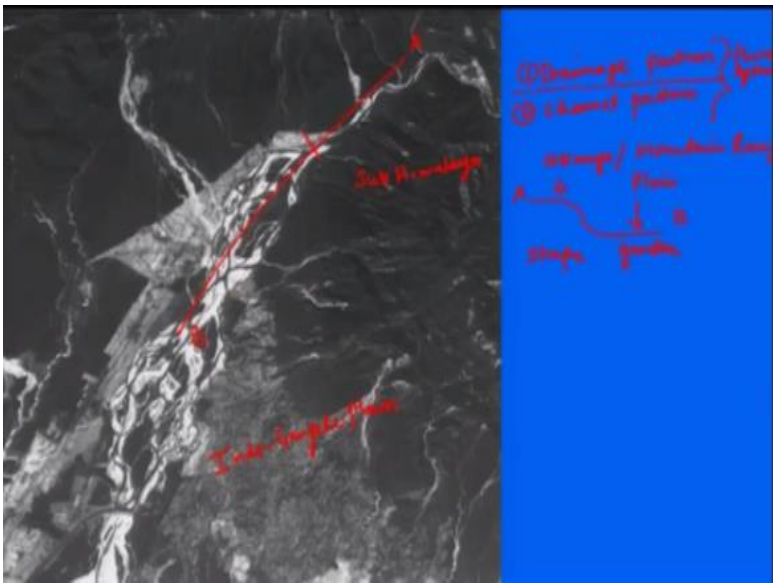

Now if you look at this picture what it shows that there is a drastic change in the channel pattern. So one is your drainage pattern and another is your channel pattern. There are two part of the fluvial system, but they help us in identifying the change in the gradient. They also helped us in identifying if there is any influence of tectonic or climate in the region locally or on the regional scale.

So if you look at this picture this is a satellite photograph of (()) (04:22)) from Himalayas and which shows clearly that there is a very confined channel here but as soon as it flows down from this part you see it is and branching out in multiple channels and the width of the channel also if you see here is less as well as the width of the channel here is a comparatively more.

Now these are some clear indicators which help us in identifying straight away that there is some geomorphic boundary or change in the gradient. So what we have we see this one is your southern Himalayas and then further here we are having the Indo-Gangetic plane. If I have to draw a sort of an cross section here or across this line for example, then what I will see from for example, if you take this as a and b, then the topography which will get something like this.

So we are having the hill ranges or you can say mountain ranges and then further here what you have is the plane area. So there is a drastic change or here in terms of the elevation. So change in the gradient from steeper to gentler is causing this change. So these event have to keep in mind when you are studying the geomorphic features and trying to identify the tectonic influence.

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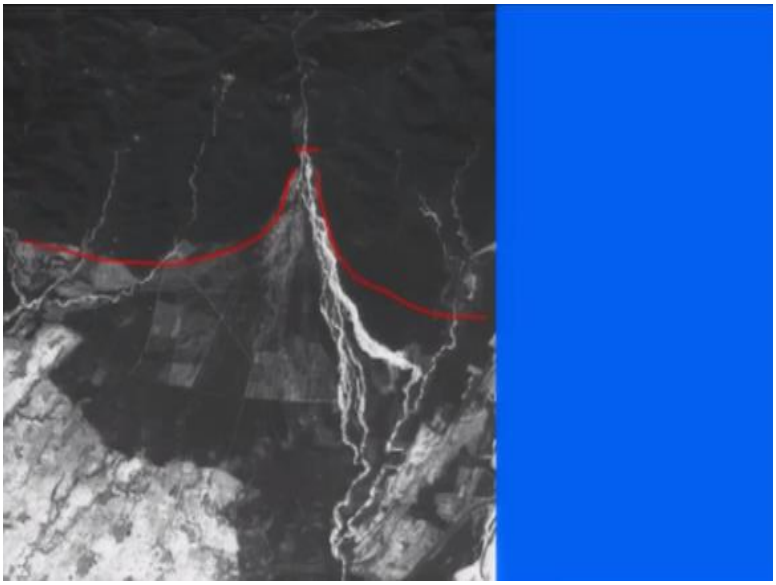

Again in other pictures, photograph so this you have the front here, suppose I am just putting very rough line here, so you have this one and there is a break here somewhere. So the change in the channel pattern here also and so we will see that what type of different landforms will come across in such fluvial system.

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So fluvial landforms basically, we have if there is a sudden change in the gradient then we will see the formation of the alluvial fan because what happens is, this again parameters which are involved as one as the gradient. If then second is the carrying capacity or by the river or stream and third is your bed load. So usually when a river flows through the confined area to an unconfined area the gradient changes there of course.

But it will not be able to carry the material that is your bed load further and it will start dumping the material on the low-lying plane areas. So that will result into the formation of alluvial fans and then alluvial fans usually has been seen, so if you are having the boundary here and the stream is coming here and then getting into the plane areas, then it will have the multiple channels.

And the landform which will be formed which will be something like in a shape of a fan and the loose material we have, which includes right from gravel to clay will be we term as an alluvial. Hence this feature or the landform has been termed as alluvial fan. So fan is the shape of the features or the landform which is associated with this. Now another important part which we will come across is that in the proximal part here.

We will see the course or deposits and in the medial part you will see comparatively medium to find or we can see medium and further you will see mostly fine deposits. So this sorting will be seen in most of the alluvial fan deposits.

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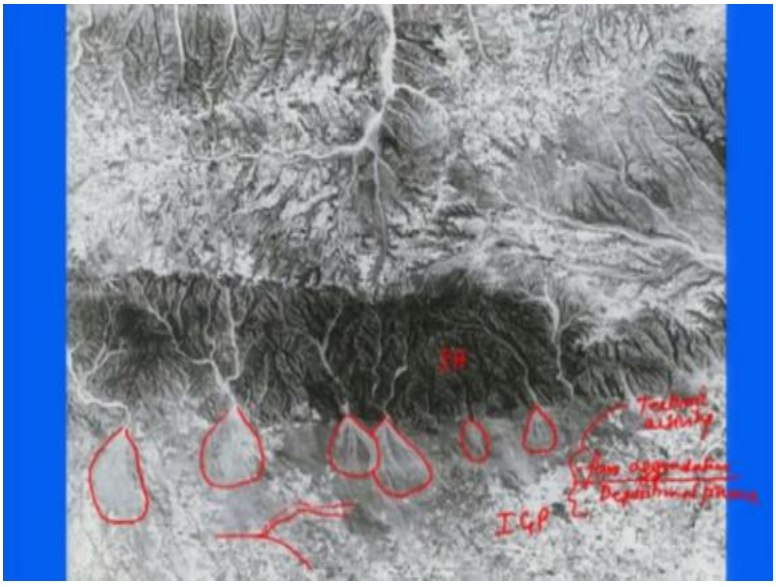

Similarly another photograph satellite photo from the Himalayas, north-west Himalayan region. So this part is here Indo-Gangetic plain and this is your sub Himalayas and at the base here you see the formation of the alluvial fan. These are the colluvial fans which have been mark here. So smaller streams are having smaller fans here, this I will just put a line here that you can make out easily this is one, another one is here.

So I am putting a very rough boundary here and then prominently which we can pick up. So these are all fan areas and even you can see the spot here. Now why this is important because in some time this deposition of the fan or we can say the fan aggradations that is here, we return this as a depositional phase. Now this can be triggered because of tectonic activity also.

So suppose there is sudden change in the elevation over here because we have this Himalaya which is forming like sub-ducting plate going up like going down and then overwriting Tibetan plate is there. So if there is uplift here because of the certain event, then this may trigger the degradation phase and our result into the formation of alluvial fans. So sometimes the deposition phases or the phase of aggradation of alluvial fans are also correlated with the tectonic activity.

Second is that, if these fans are argon displaced by the active fault, along the active fault and resulted in the formation of this scarps then that those are also important because that we can date and we can talk about that when exactly that event took place.

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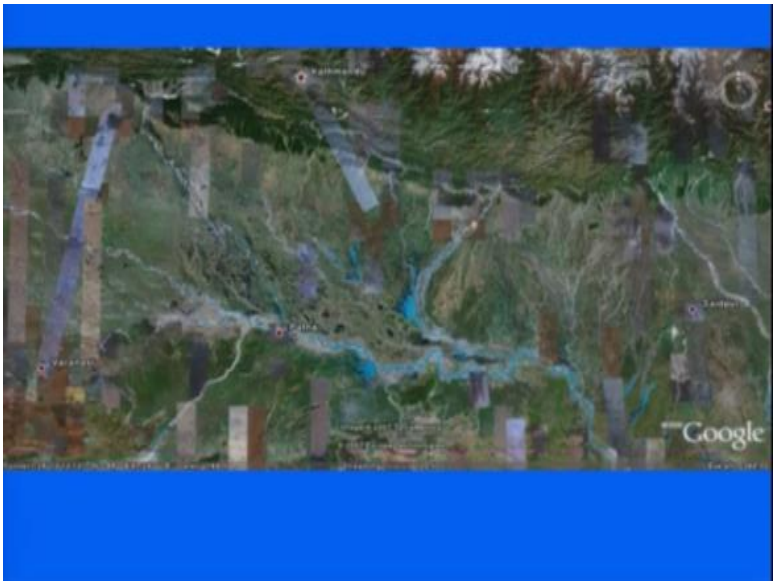

There is another example of the change in the channel pattern. So the previous slide which we were talking about the channel pattern, so here also we can see the channel pattern also as well as the formation of the alluvial fan here. This one of the excellent example in the near Bihar, where we have this a Kosi river which flows like that and the present course, but it has not multiple channels which you can see even if you can enlarge.

And try to look at the Google Earth image you can see here and this channels are all Paleo channels which rivers tends to reoccupy again and again during different flooding events.

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So there is a close-up of that, so you can see on the surface here many channels which have been left out and these are all the Paleo channels of the Kosi River.

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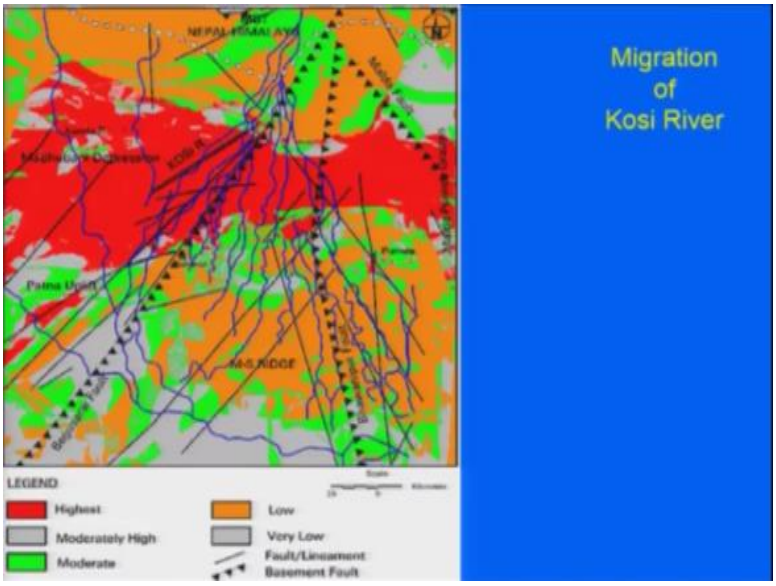

So people have talked about that this particular fan area of the Kosi was formed because of the tectonic control along the Begusarai fault and this Bhawanipur fault. So these are the two faults which were responsible for creating a depression here and allowing the sediments to get deposited in this basin. That may be true but of course we do not have any clear evidence to prove this hypothesis.

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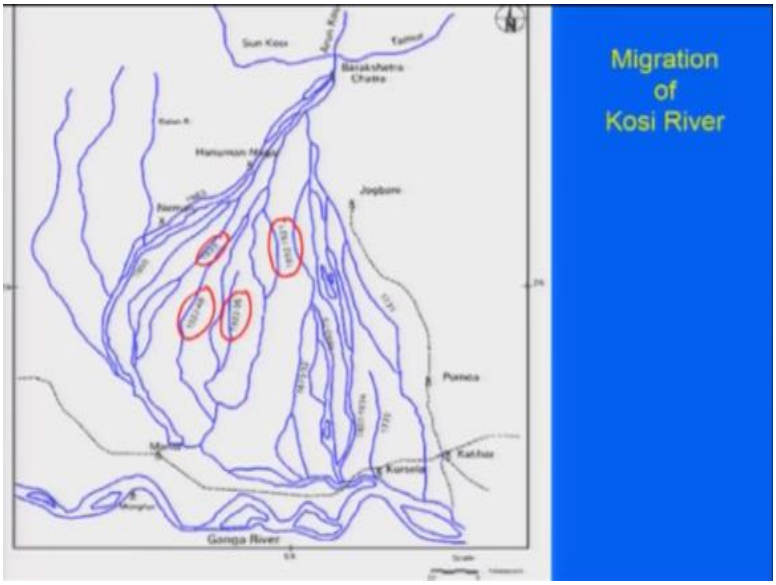

But as I told that since this channel here is confined and then get unconfined here. This is the present channel here but it keeps occupying its own channel in different phases. So these are the years which have been given here during which these channels will be occupied. So if this area is extremely vulnerable during the flooding events, so likewise it shows here is 1920 to 1948, it remains the channel course we flowed through this one 1933 here and then 1950 here.

Since 1950 it is been flowing along this one, in 2008 during the extreme flood this real this portion was been reoccupied, now and the reasons which have been given here for the reoccupying its own channel is because of the extensive or high energy flood events but at the same time it has been also related to the amount of sediments which it brings and because of the morbid load dumped in the channels here.

The channel cross section area is getting shallower the reasons for the erosion which has been highlighted is one is because of the extensive like deforestation in the Nepal part but at the same time what I feel is that it is possibly the another factor which affect here is because of the active tectonics because the ongoing deformation will make the material more fragile or the rocks in the sediments more fragile.

Which are subjected to erosion and that can bring more amount of sediment flux into the Basin. So that may also be one of the reasons why we are having a more amount of deposit so the material getting into the Kosi River.

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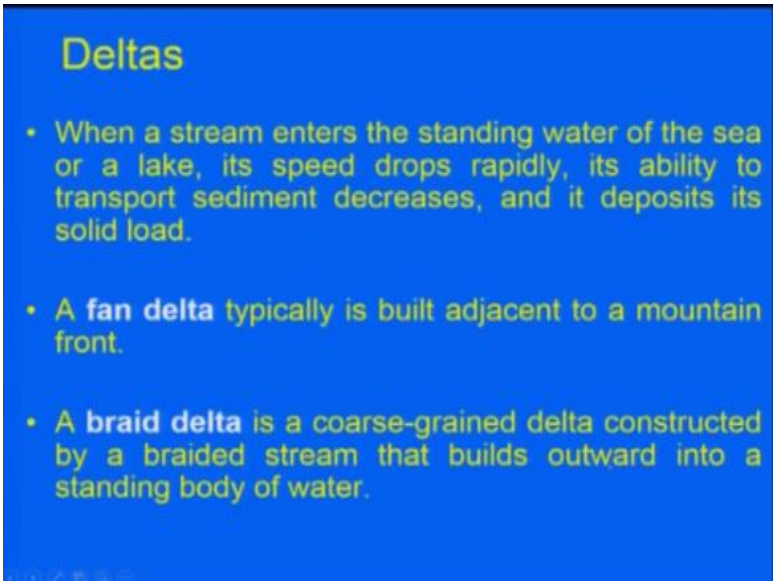

Now another important is the deltas those were, we are talking about the alluvial fans. Now coming to the delta part we usually see, so if we look at like you have the initial journey of the river from its origin, so we have the watershed here and then in between we have like the river getting into, so I will just put a section here and that can explain you. So if we have to classify the, like this we have the topography here which goes like that.

So journey ends the river in ocean and this is the plain areas and this is your watershed areas, where, so here you have more of tributaries getting into the main channel but at this place you will have the formation of the alluvial fan and here also again you will have the, so we have what we call is the, this will be your the trunk stream which will be carrying the material and getting into the ocean.

So you have more of tributaries here and then at this place you will have the formation of alluvial fans at this portion and again you will have the distributaries over here. Where the stream enters into the standing water either it is sea or lake, and this remains the same but the speed drops down and its ability to transfer the sediment decreases. So this remains same here as well as at this point and it will tend to deposit or I would say dump the material in the low-lying areas.

Now coming to the next point here that what, so again it is and you can term this as a fan delta but the delta term comes from again the shape of a triangular fashion. So this has been termed as the delta, which are usually seen close to the where the river meets ocean. Now the

fan deltas can also be seen to if they are adjacent to the mountains and the braid deltas usually are coarse-grained deltas.

So you have fine grain as well as coarse-grain deltas which are been built due to the stream action and the streams;

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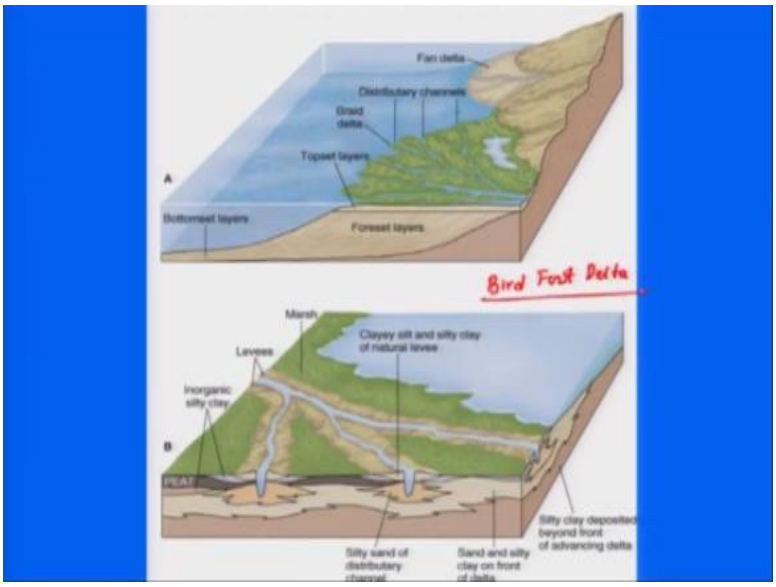

Meeting the major water bodies so basically the braid deltas will have multiple channels and that what we call distributary channels, where as the, then we also see a fine grain deltas and fine grain deltas, will have not many channels and they are typically like what we call the braid foot delta.

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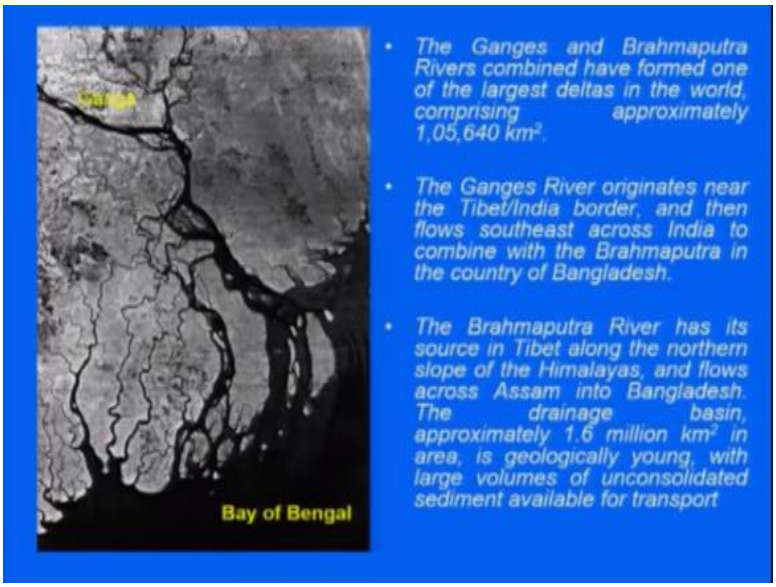

So this is an example from one of the largest delta. We have from the Ganges and Brahmaputra River and the elevation here is not so much it is some places, it is less than around 1 meter or so. So in other problems which such regions will face is that if there is a fluctuation in the sea level because of the climatic conditions then most of the areas will get in undated and large portion of the like area and the population will be affected because of that.

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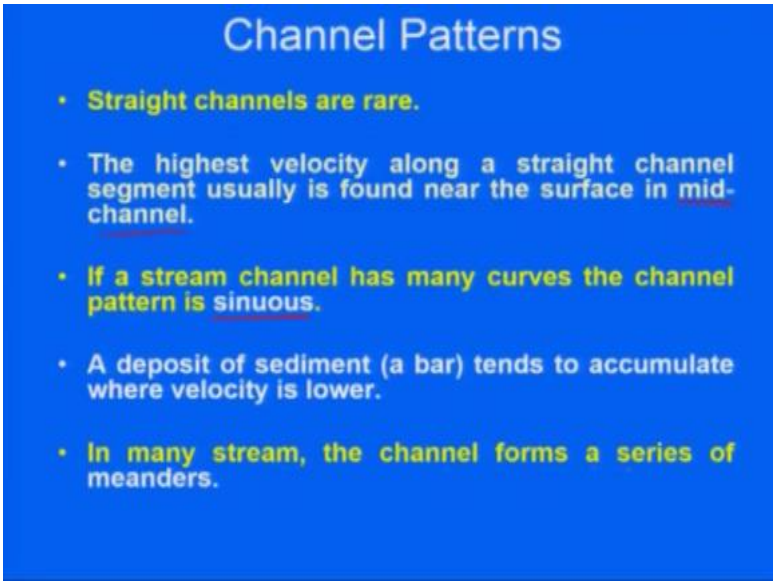

Now coming to the channel patterns we have straight channel patterns are mostly rare but what we see is the combination of the straight and other channel and this channels will have the highest velocity along the straight channel segment usually is found in the mid channel. So you have the, and if a stream channel has many curves the channel pattern is termed as sinuous channel.

So straight channels will be something like that, and if you have the curved channels then we term this as a mid-channels or sinuous channels. Then the deposits which have been seen here is again in the sinuous channels will be finer to coarser and if you take the cross section of the sinuous channels, and then the straight channels here, so what we see is the straight channel, for example I will put here B and then this one will be your A dash, B dash.

So A dash and B dash will be something like that, A and B sorry so this portion will have the highest velocity, whereas in the A dash and B dash you will find that this is something like, so this portion will have the maximum velocity and it will have the capability to erode, so this

is your A dash and B dash. So this is typically of the meander, so in any stream the channel forms a series of meanders.

So mostly not always you will find that the channel is pretty straight but of course we can see the combination of the straight channels and the sinuous channels also. So in many streams the channel forms a series of meanders.

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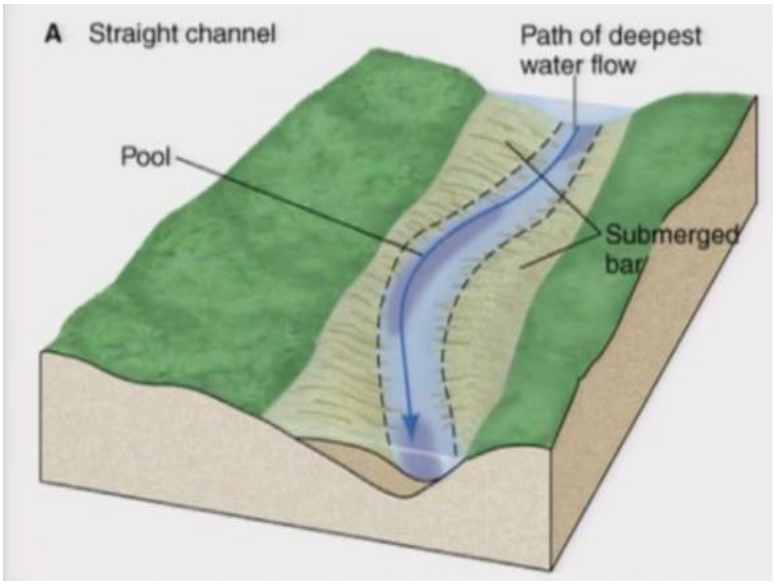

And this is for the straight channel so you will have the maximum energy conditions in the meander part.

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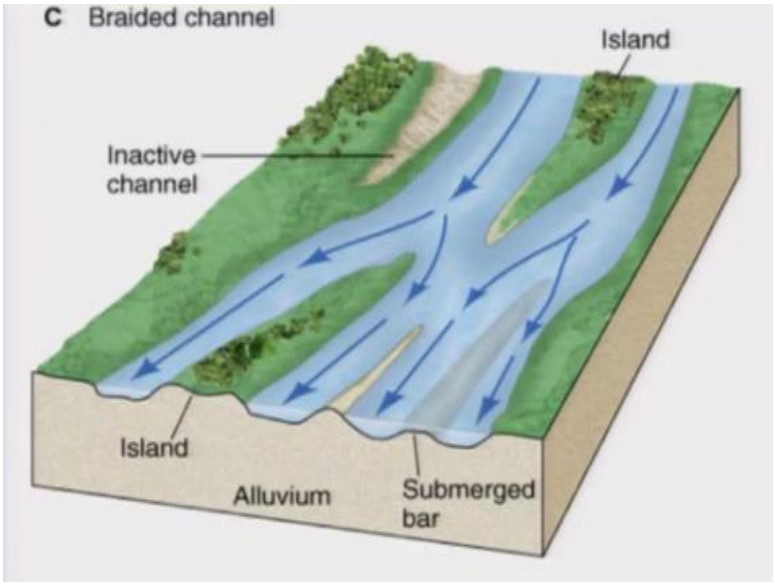

And in the braided channels this we will mostly what we see is the multiple channels coming in and these are the features which we can look at from the straight to me in there and

braided. So usually the braided channels will have multiple channels coming in and mostly what we see is the coarser deposits are been associated with the braided channels and along with that the formation of the braided channel will have like steeper slopes. So that is another important parameter which usually we take into consideration.

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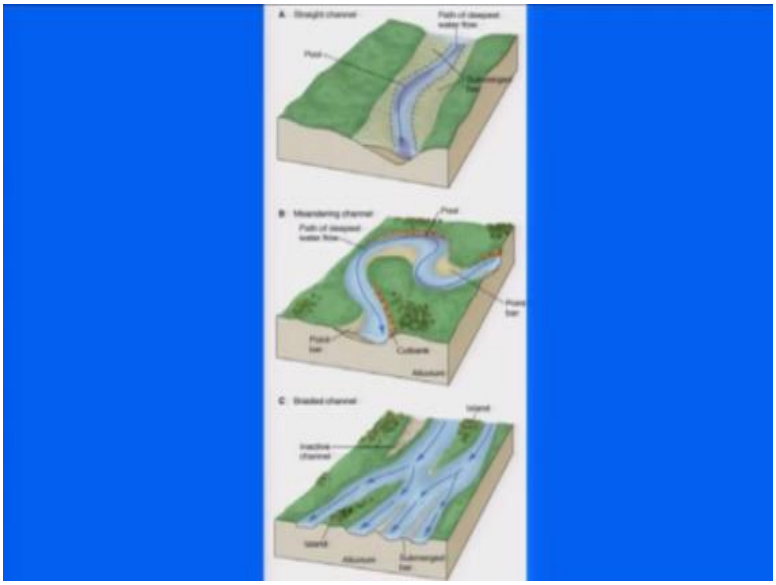

So any change in the channel pattern from straight to meander and meander to braided has to be taken into consideration to understand the local change in the slope conditions or the, we can say the channel gradient.

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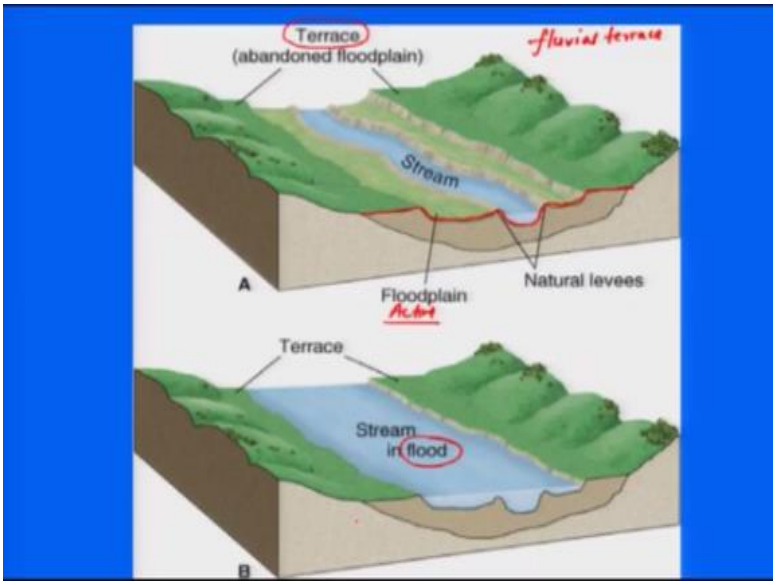

Now associated features most common which you will come across will be the older floodplains and those are being termed as that is abundant floodplains and these landforms are termed as terraces or you can find in literature calling this is a fluvial terrace. So the

cross-section if you see then you will find that this is something like this, so you have the younger floodplain here and the older floodplain is the abandoned floodplain.

And the feature which is with mark here is the natural levee which is usually is difficult to find out in the field but it will show slightly elevated portion near the bank and further away in the floodplain it will shallow down or dip towards or away from the channel. So now another aspect which is important here that this floodplain which is, which we can also say the active floodplain will have tendency to get like inactive (()) (23:47)) during the flood conditions.

So one feature, which you can keep in mind that, the active channel and active floodplain and the abundant floodplains.

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So braided channels usually what we see is the braided river exhibits new braided channels that split off and rejoin each other to give a braided appearance. They typically carry coarse-grained material down steep gradients.

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And meander channels will have tendency to have like the sinuous pattern and in some locations you will find because of the erosion capability on the outer side it will leave behind the cut off channels also. These are mostly seen in the flood plained areas. So how it forms as basically if we take that if you have not meander here for example there is a meandering channel. So this portion is having a capability to erode here.

And this portion is also having the capability to erode and it will keep migrating towards one another. So finally the time will come this both the channels or the boundaries will match and will leave behind the cut off channel. So these are also been termed as cut off channels or Oxbow lakes because the feature which we see is like an Oxbow so these are also being termed as Oxbow lakes.

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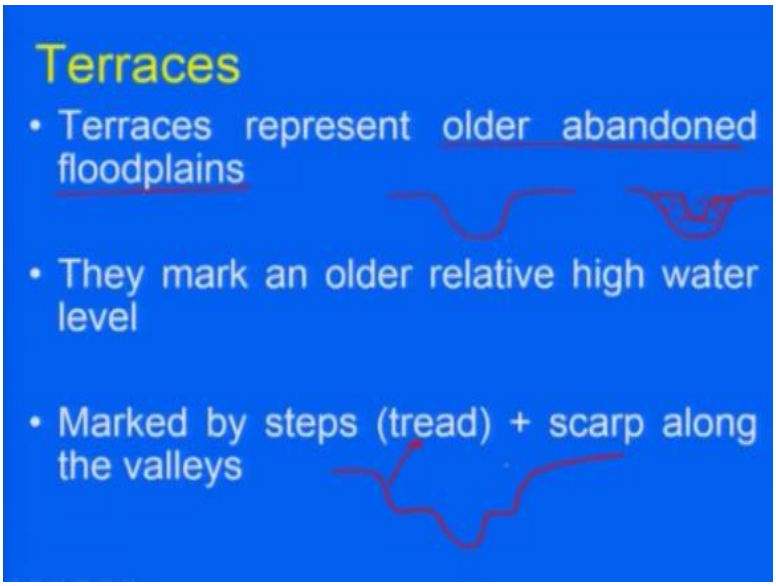

Now coming to another important feature which we were talking about the terraces, so if you have the channel will have tendency to keep grading so it will deposit the material and it will also erode. So what you will see is a formation of terraces. So this was the earlier profile of this channel and now what we have the terraces. So it has incised its own channel here, so this, what we see is like we call this as an terraces.

So you can name this on T0 and it can have multiple terraces also. So of course we what we have talked that this terraces are the indicative of the older floodplains that means the river flowed at this point in past. So they mark an older relative high water level because this was the point where it flowed in the past. Marked by step or tread + scarp along the valley so this will be like it will be marked like and a erosional bank along the so this will be your tread or scarp.

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So this is an example from Beas river which shows the formation of the terrace. So you have a flat terrace here, higher terrace and the river is flowing like that it goes like that and then you have any other younger terrace over here. So this is like we can say this as an T0 and this one is your T1, so T 1 is the older one and T 0 that is your higher terrace and this is your lower terrace. So this also indicates that there was some change in the base level.

Because of which the river tend to erode or incise its own deposited material. So for example if you if we draw a longitudinal profile so we will always try to maintain its profile in equilibrium, if there is any change over here, for example you say there is an uplift here, then

what will happen it will try to erode this portion and again come back to its original region and this region will have the formation of your terraces.

So this is very common, feature which will be seen and same so here, what we see erosion, suppose there is not subsidence here, suppose like that so you will try to aggrade here. So this portion will be erosion and this portion which is getting subsided you will have the deposition or you can say aggradations, and this will be your degradation. So I will end here and we will continue in the next lecture. Thank you so much.