Earthquake Geology: A tool for Seismic Hazard Assessment

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Lecture – 47
Geomorphic Markers for Fluvial Environment (Part- II)

So welcome back, so in previous lecture we discussed about the terraces and now let us see further, how we can differentiate between the aggradational terrace and the depositional terrace or degradation terraces. And what are the names of the terraces or terminology used for the such surfaces formed when there is an incision and the sediment in-section as well as the bedrock. So this is another example from the same River Basin, where you can clearly see two terraces.

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One is here and another one is this place here. Okay and then the third one is sitting somewhere over here, so you have T0 and you have this T1 and then T2, so at least three terraces you can mark here easily. So we will see how these terraces are formed and;

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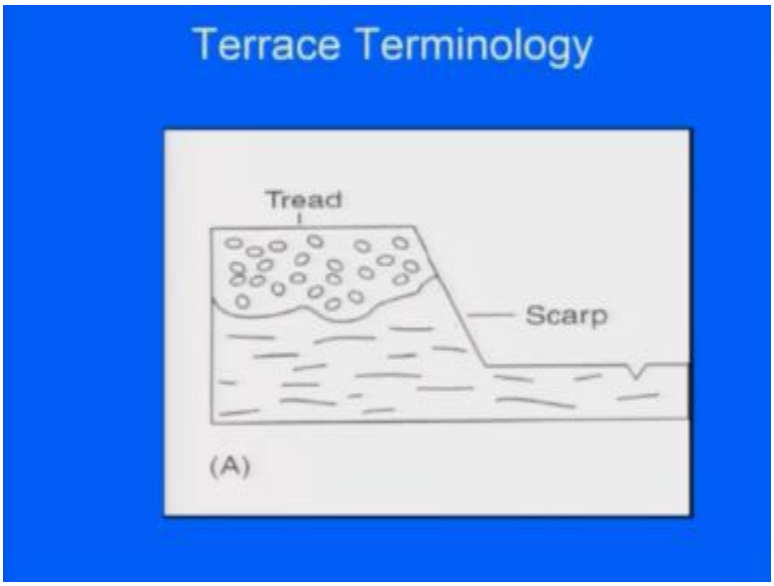

What are the reasons for that? So terminologies which have been used, which we discussed basically will have an erosional Scarp along the bank of any river and that having a flat surface will say that term that as a Terrace.

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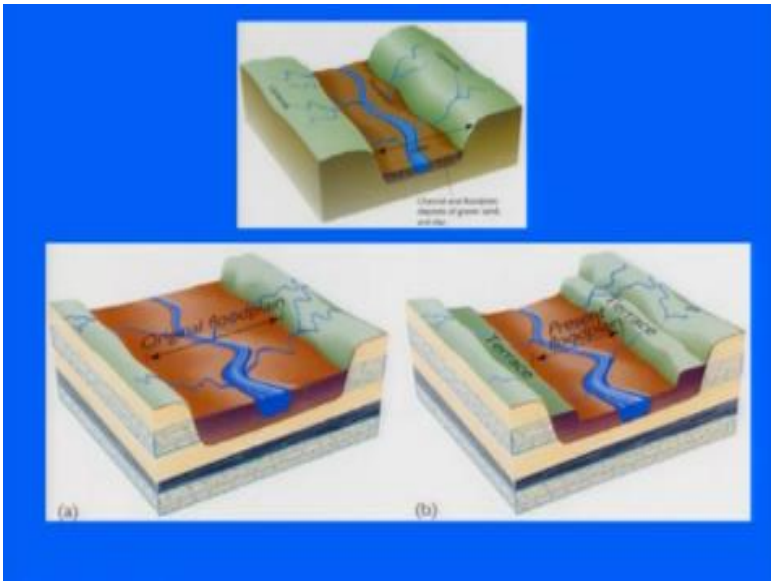

So this we have also discussed in one of these slides, so I will just move ahead so these are all abundant terraces or the floodplains older floodplains and this portion is marking the present floodplain area.

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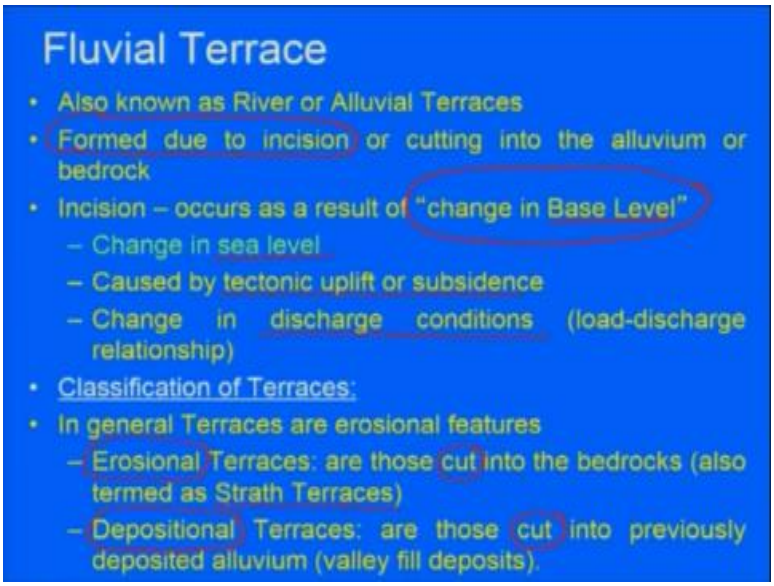

This portion we have already discussed so we will go ahead. Now fluvial terraces also known as river or alluvial terraces, again they are comprised of the loose material comprising of or made up of gravel to clay sized particles form due to incision or cutting into the alluvium or bedrock, incision occurs as a result of change in base level, so this what I was talking about, is that if there is a certain change in the base level, then so the base level could be your ocean or it could be your Mountain front.

So these are the 2, which we should take into consideration, when we are talking about the base level. So if suppose channel is coming into poaching into any major rivers or at the ocean and if there is it not change in the base level, here so this channel will try to incise and if there is in local change, then also it will result in two, so suppose there is not change here then it will incise this portion.

So, let us see; what are the factors which are responsible for the change in pace level, so change in sea level is also considered as a change in the base level of any major drainage system. caused by tectonic uplift or subsidence change in the discharge conditions, that also will affect the and the base level if there is an excess deposition that will also change in result into the change in the gradient or will elevate the and the channel floor.

And further, the classification of terraces we can have in 2 forms; that is one is your, erosional. Of course, this is in general we talked about this as an erosional feature. But we can have the erosional terraces are those, cut into the bedrock also termed as strath terraces and then we have the depositional terraces are those cut into previously deposited alluvium, so in both the cases we have the incision.

So you have the either it is an erosional terrace or we are talking about the depositional terrace in both the cases, this landform is formed due to incision. This is the important part here and the incision can be resulted because of the change in the base level, so the change in the base level could be your change in the sea level due to tectonic uplift or subsidence or due to change in the discharge conditions. So lets us see examples of strath terrace in coming slides;

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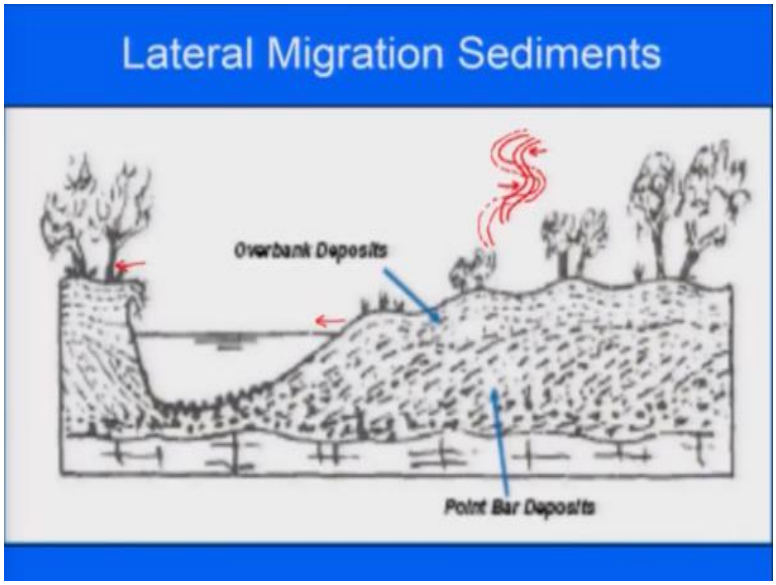

And before that, the most common in the floodplain areas what we see is the lateral migration of the river banks or the river channels, So there is an typical profile of the maintained channel where this portion is deeper this shallower here. This portion has the capability of erosion whereas this portion will show you mostly the deposition and since it has an capability of eroding here, this will keep moving laterally in this direction.

And this portion will also keep moving laterally in this direction along the channel. So you have the, so for example you have the first channel which was flowing here the next phase may be

possibly, it will move further this side here, so it will keep changing, its course because of its tendency to erode so you will have the lateral shift from here so this from here. Then we have erosional terraces which are, so these are the features which have been termed as point bars.

So point bars usually if we take the cross-section here or the channel forms here. So mostly you will find that deposits out here and they are termed as so if you see in the plant view and this is a cross-section which has been shown here or we if I put exactly the cross-section which has been shown here. Then you will have something like this. So you have a point bar here and you have the erosional bank.

If I put here A and this is your A and B here, so you will see very much exactly, so this portion will have high energy conditions this will have low, so this will be the erosional bank this will be the depositional bank.

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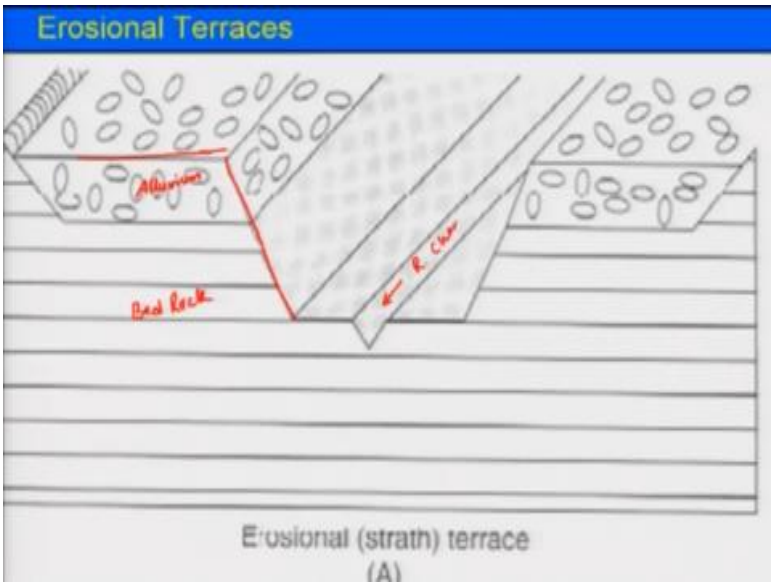

So further the erosional terraces, so if we have the incision when the alluvium and bedrock and if we see this in-section here, then so we see in the exposed section so this is the present-day channel. So if you see this, then we term this as an erosional terrace or strath terrace.

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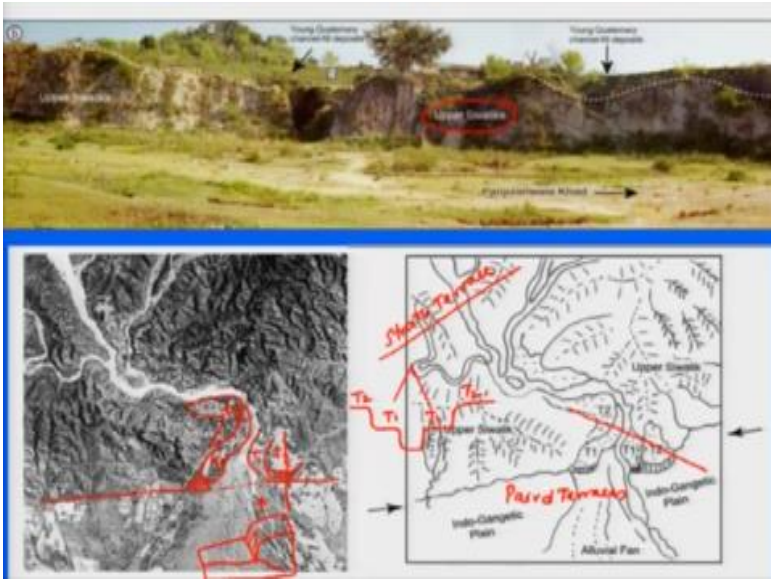

So, let us see this example, in the Himalayas. Okay, so this is a photograph which we took from one of the channel or close to the mountain front or here so what we see is the terrace here, the photograph has been taken from here looking at this terrace here and this is your mountain Front, so we have the scarp here that we will talk later. So this is a fault scarp, here and then we have the terrace which have been marked it is a two terraces.

Okay, so we have the T 2 here, the higher one and the T 1, is this one, so T 1 and this one is T 2 or you can also say that this is T 0 and T 1. Now what we saw is that we have the incision and the Younger Quaternary channel filter deposit, as well as the channel has inside the bedrock that is upper Siwalik, hence this Terrace we term this as an strath terrace, ok and this is the sketch of this one.

So what we see is the terrace over here, so this has been marked as this one, here so you have this scarp, here so this scrap is along the fault line. So, this terrace has been displaced along the fault and it is been uplifted and then you have another terrace, which is sitting over here this one is the older terrace. So you have T1 here and this is T2 and since we are we were able to see the terraces on either side of the bank such terraces are been termed as paired terraces.

So, if we take the cross-section here or maybe like that, then what you see is you have paired terraces, so you have T2 here and T 1, T 1 and T 2 so it is very typical of the pair terraces and

since it has the younger one the T 1 has incised into the bedrock. Hence we will turn this as a strath terrace, now such features are important for us to talk about the tectonic activity because and since it is close to the front so this, if such terraces are been identified and they are almost a direct indication of a tectonic uplift along the front.

And if we suppose to take the cross-section, here across this line then what we see is and you are having the front here and then you are having the displacement. So this is the, so if I draw this in 3D. Then you will find something like this. So you have a scarp here and this is the fault which passes through so this is an uplifted part moved up along the thrust fault.

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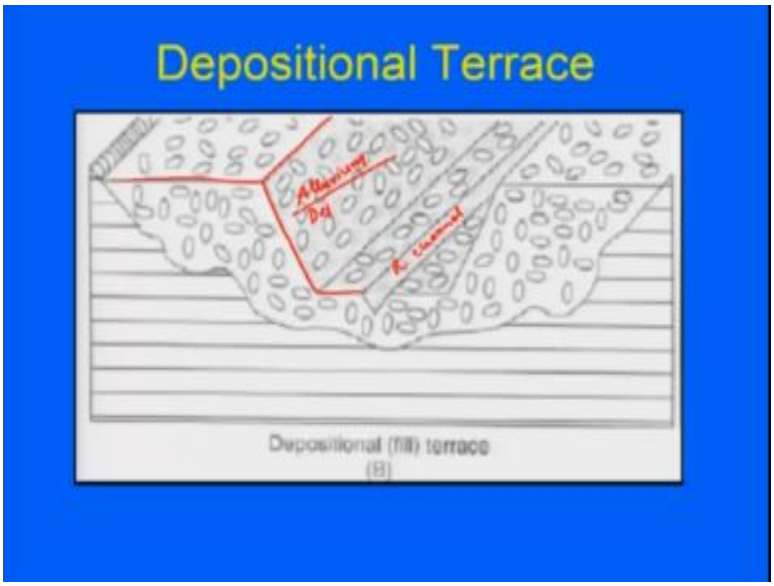

Depositional terrace, now what is the difference here is not, it is not the section which you see here, it only shows the incision in the alluvium, so it is shown; so this is your river channel and the incision what we see is within the alluvium hence such terraces have been termed as depositional terraces.

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So the most important feature that what I was trying to identify about tell you, is that we need to identify even the displaced terraces, which has been shown here. This photograph is from Pakistan were, the 2005 Muzaffarabad earthquake rupture took place and the portion which you see here is nothing to do with the erosion, related by the river but it is because of the uplift here.

So this portion is up with respect to this one, so this is your footwall and this is your hanging wall and fault runs somewhere over at the base here.

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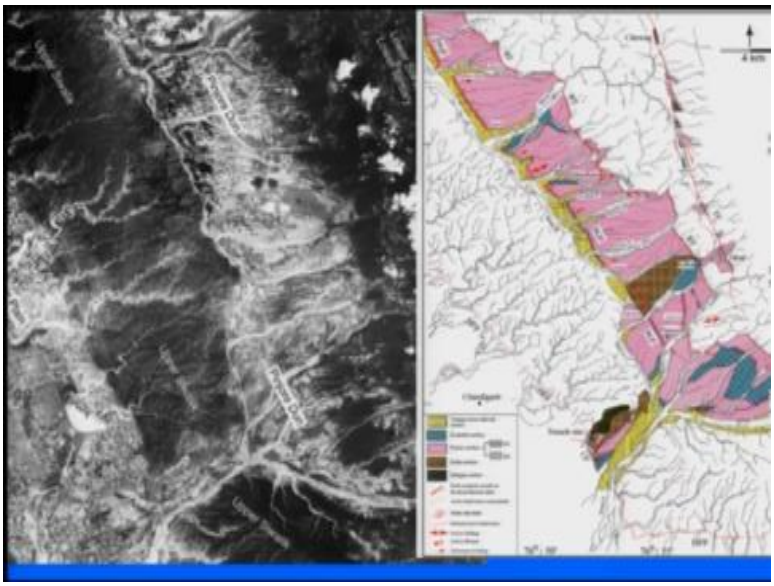

So similarly, what we use, how we use this information is that we try to map and prepare a detailed geomorphic map, where we highlight the different levels of terraces or the surfaces, not only the terraces but also alluvial fan surfaces because the alluvial fan surfaces will be

commonly seen along the base of the front that is your Pitman zone and as well as the formation of the terraces here.

So, if the multiple terraces are been displaced along any given fault kind then that indicates that that fault has remained active since long. So this satellite photograph is from northwest Himalaya, where we have the Chandigarh city is sitting in the indo Gangetic plain and then comes to the, we have towards North, if you move we have upper Siwalik and Pinjore Dun, it is the inter-mountain valley between two hill ranges.

So, we have this is the tertiary hills of the tertiary lower tertiary or lower Siwalik hills. So in between we have the Intermountain Valley, so again this is a very flat region where we see the alluvial fan deposits and then we also see multiple terraces so viewing this in three dimensions using the high-resolution satellite photo with stereo vision. We prepare this map, which shows what we have extracted and we have extracted drainage.

We have extracted the landforms here and more striking one, what we see here is at this portion which has been marked here, the rain bank of the river it shows the presence of multiple terraces, so at least what we have to if you see the yellow one here you have the younger terraces then you have another terrace which is been named as Kausalya terrace, Pinjore terrace is Kalkan and concur.

So you have at least 1, 2, 3, 4 and 5 terraces here and in between the Pinjore terraces which were further classified as a middle terrace and a high terrace in this region. Now of what important point to be noted here was noted and their fault has displaced all these terraces including the younger one also not this youngest one but at least somewhere or this has displaced there. So all 5 terraces, we have been displaced along this.

Where the Pinjore dun fault has displaced the older terrace not is Ganga terrace, which is the older one as well as the younger and the Pinjore terrace, which is the 3rd which is listed here. Now if we did the terrace or the surfaces then we will be able to talk about that, when exactly this event was took place or when this event took place or at least. We will be able to bracket the

event between having the age of the old terrace and the younger terrace, so that we can do and correlate that what we call the technology morphology with the paleoseismic studies.

So, basic map is extremely important to be prepared before we get into the paleoseismic studies. And have the understanding of different landforms that is extremely important. So, that what we do before we get into the field and start doing our hunting for the Paleo earthquake signatures, so now if we look at this, other than the terraces we try to identify how the surfaces have been deformed.

For example, if you see here in this map we have some arrows which have been indicated with the different symbols, where we have double arrows so this are indicating a short of a warping here and this shows, the tilting on the opposite side that is usually we find that the defined surfaces from the hilly areas towards the plane will be sloping in this direction. But this is sloping in the opposite direction.

So these are again and indicators of the tectonic movement which resulted into the back tilting. So if you have usually the alluvial fans and then form here if I put the topography then you will have something like this. So the slope will be in this direction but what we see here is that at some locations. For example, this portion, so this portion is showing the tilting in this direction. So, if I take this section here, then it looks something like that.

So it has a back tilting. So this all been termed as back tilting scarps and these signatures or the which we found here was, the scarps now these escarpments along this line and that is what your fault line is and they are back tilted it again so a next photograph, I will show from this portion, where we mark the back tilting here as well as the en echelon faults which we picked up which displays the dip in your surface.

So this is a photograph from there this region and this shows the portion of the back tilt, so this comes over here, this is portion here at Mandhala and these are the features;

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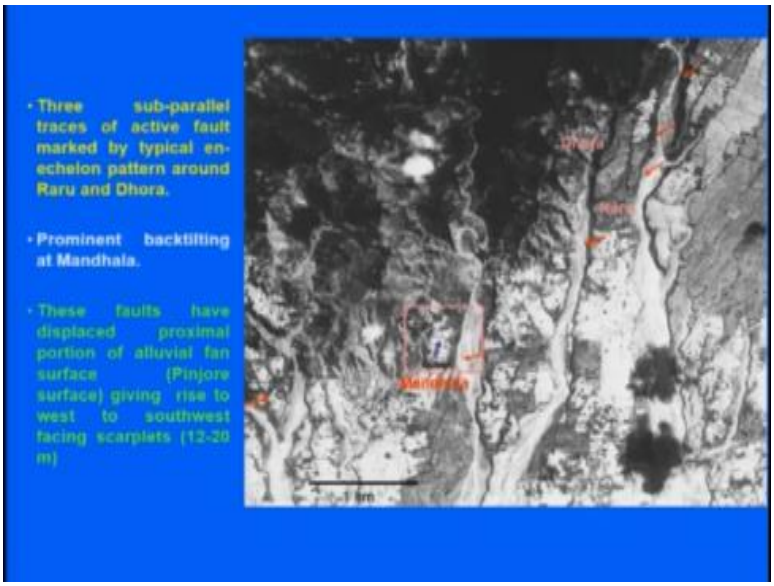

Which you can see over here, so the arrows marked that so the back tilting, which comes here is a Mandhala and Raru and Dhora, so you have the en echelon faults here so the typical like this you will be able to see very prominently. When you see the image in three dimensions, but the tonal variations also help us in identifying because there is a dark portion here, which shows that there is a cliff here and similarly over here also, so we have this and back tilt here.

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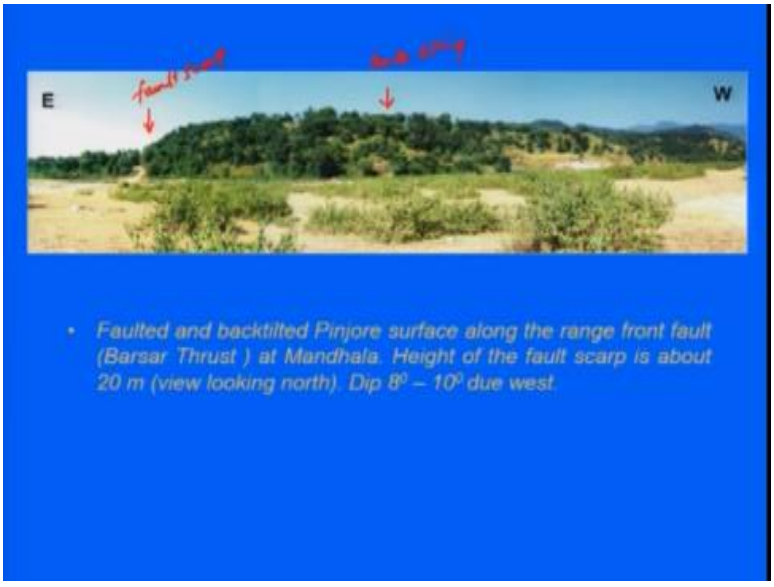

So if you see in the field, what we were able to pick up so the photograph was taken from this portion viewing that side not exactly this one over from here. Photograph was taken from in this bank and we are seeing this portion here so the next photograph which you see is the topography

along this line from the crown to this one here. So we have this one, so this is east and this is west, so you see the topography and then typical.

So this portion we turn this is an fault scarp and this one is what the feature will take into consideration is the back tilting? So the general slope should have been something like that but what we see is this portion is uplifted here and then back tilted. So this is the scarp profile, so this will be a fault scarp and this is your back tilt. So, if you dip this surface then you will be able to talk about that event when exactly this event took place.

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Again another, one along and in the Pinjore valley, so you have the fault scrap, the fault is running here, this has been termed as fault scarp and you can see this one here is the back tilt and this is typical of the feature, which has been formed along the low angle for trust falls. We have the, so you will have the formation of the fault scrap here and then back tilting.

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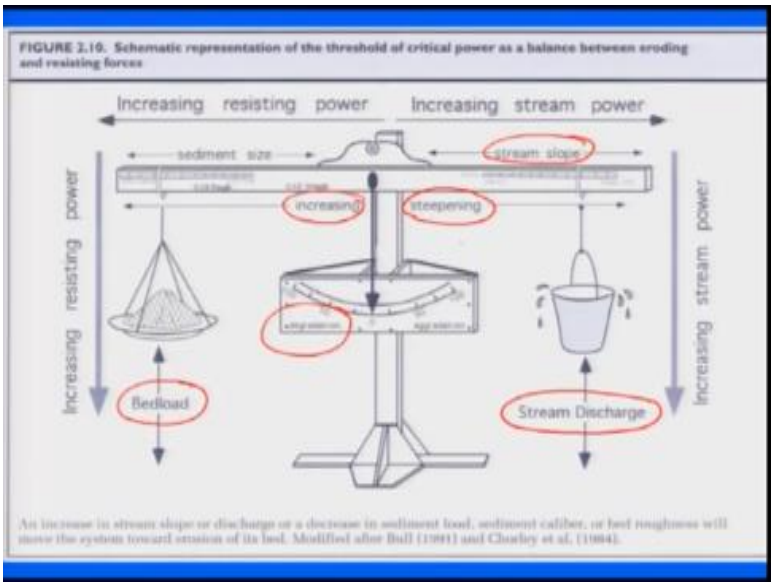

Now, coming to another one part which is again an important point which we were talking about that is one is the base level change and also the formation of the river terraces and where the sediment supply will also play an important role. So this schematic diagram represents the threshold of critical power and as well as, a balance between erosion and resisting forces. So what did source here is that you have the sediment size?

And which increases and decreases here and the as the sediment size increases. So you have more resisting power because of the internal friction between the sediments and that will result in the degradation and also increase in the bedload, whereas here if you talk about this stream slope, then if you are steepening the slope then you are increasing or decreasing this stream power. So increasing in the sediment size and the slope correlation so this steepening of the stream slope will result into degradation.

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Now with this, let see that how different terraces can be classified here, where we can term this terraces, either they are erosional terrace or degradation terrace and as we discussed that, if the terraces are formed cutting its own deposits then we term that as an aggradational terrace and if the terraces which are formed cutting the bedrock, then we term that as a degradation terrace or we can also call as an strath terrace.

Now it is well-established that the change in the stream power affects the fluvial process that is either the river aggrade or degrade along with steam power, other factors which will be playing an important role is the sediment load. Then you have stream capacity to carry the sediments and then roughness. This is what we are talking about the resistive nature of the river bed and that will also influence the aggradation and degradation process.

Now if a river neither aggrades nor degrades, then it is considered to be in a state of equilibrium, but otherwise if erodes or not deposit then it is not exactly in the equilibrium condition, so any change in the basin and which is related to your base level. Then it will try to come back into the equilibrium state. So increase in the slope of the river + increase in discharge + decrease in river bed roughness + decrease and sediment load will like result into, river to erode.

Whereas decrease in slope of the river, decrease and discharge and increase in river bed roughness + increase in sediment load the river will aggrade. So this part you should keep in

mind, when we talked about whether the river is an aggregation of phase or river it is a degradation of phase so this is a gradation and this is what we are calling as an aggradations phase.

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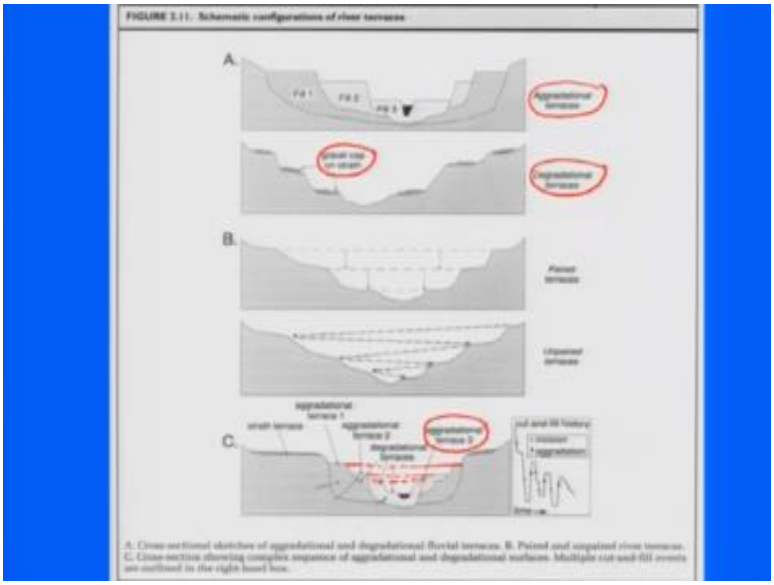

So what we see here is the gradation of terraces, so mostly we will look at the terraces, which have been cut and filled, so a river aggrade and then degrades. So there are all terraces which have been formed in its own alluvium or after because of the incision its own alluvium these have been termed as aggradational terraces. But when we see that the terraces are being formed cutting the deposits, as well as the bedrock.

Then we term this as in degradational terraces and they are also being termed, as strath terrace. So usually what we will see is on the bedrock you will find along the cliff, will find some fluvial deposits which are also in the part of that terrace, then we have the Paired terraces. As we have discussed about this and unpaired terraces will not have the systematic profile on either side. So; now in case of the gradation and degradation terraces if we take here.

Now, if you classify this, what we see here is that these are all the aggradational terraces. These are all aggradational terraces and these are also aggradational terraces which we were looking at here. But this portion is your degradational Terrace whereas this one is a aggradational terraces. Now how we will be able to differentiate even though this. We can see that this has been incised

in its own alluvium but this was the phase of aggradation 1, this was the phase of aggradation 2 and this was the phase of aggradation 3.

So what happened was that the first incision, which took place here was this one. Hence, we will term this as an aggradational terrace whereas this part was later on so it was not but that is the process where we see the curtain fail, so first aggraded and degraded was this one only, but then we had a phase of degradation. Hence these terraces have been termed as or categorized as in degradational terraces, so I will stop here and will continue in the next lecture thank you so much.