# Geomorphic Processes: Landforms and Landscapes

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## Lecture 25
## Tectonic Geomorphology (Part II)

Welcome back. In this lecture, we will discuss more on the morphology of the river influenced by active tectonic deformation. As I told in the previous lecture that fluvial system are the most sensitive one to the tectonic deformation. It can be altered in terms of the change in the channel pattern, drainage pattern and also the landforms. So you will be able to see the prominent landforms, which are formed in the regions, which are tectonically active. So active tectonics and river morphology, what is the relations let us see.

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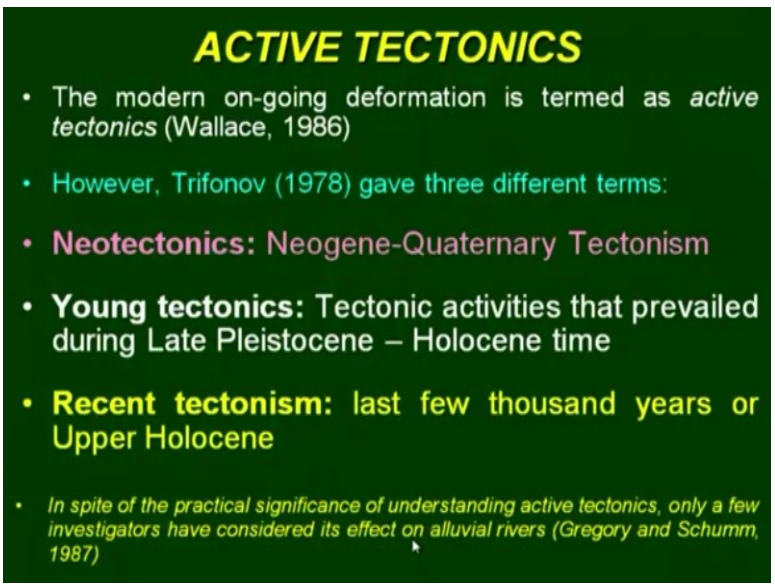


So active tectonics mainly can be defined as the modern ongoing deformation in terms of active tectonics. However, this has been given by Wallace in 1986, but Trifonov gave three different terms for the active tectonics. One is the neotectonics, which is neogene-quaternary tectonism, so this word which has been given here neogene-quaternary is basically in the tertiary, so please refer to the geological times, then you will be able to understand about the neogene and quaternary.

So this is the transition boundary of tectonic deformation during the tertiary and quaternary and then you have young tectonics. Young tectonics is again the transition phase or maybe the tectonic activity, which prevailed during late Pleistocene and Holocene. So this is again, we are talking about the quaternary era where the late Pleistocene and Holocene is there in the geological time scale. So the most younger or the youngest is the Holocene.

So recent tectonism in last few thousand years, then you can talk about the upper Holocene. So these are the three terms, which were being given by Trifonov neotectonism, young tectonics and recent tectonics. So whatever the ongoing deformation we see now is the recent tectonism. Inspite of practical significance of understanding active tectonism, only a few investigators have considered its effect on the alluvial rivers.

Now Schumm, this gentleman or the scientist along with his subordinates were the first to talk about more on the effect the alluvial river mainly because of the active tectonism. So they have also conducted few experiments, which helped us in understanding the influence of active tectonism on the alluvial rivers.

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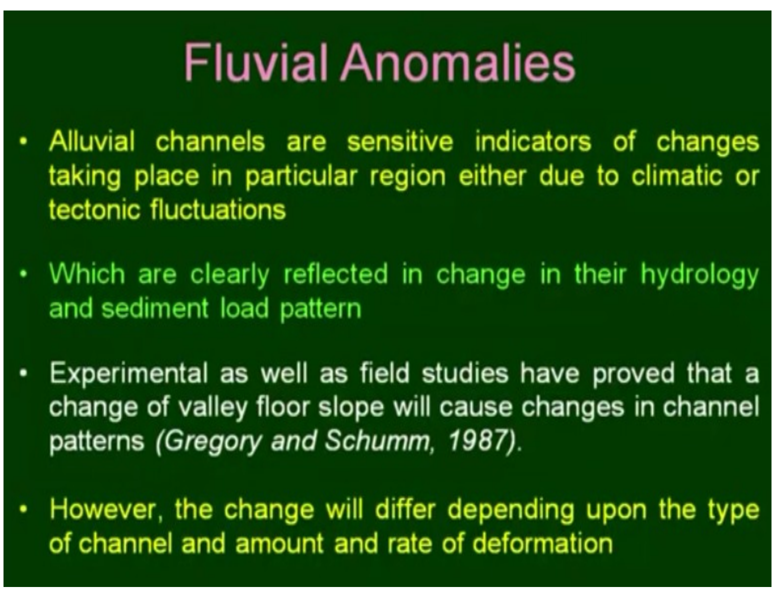


So coming to the fluvial anomalies, alluvial channels are extremely sensitive to ongoing deformation and they are sensitive indicators of changes taking place in particular region either due to climate or tectonism. So even the climate change can result into the change in the channel morphology. So fluvial landscape will be subjected to changes if there is climatic fluctuation or tectonic fluctuation.

So fluvial anomalies clearly reflect the changes in their hydrology and sediment load pattern. So if you consider that the climate change, then this basically will indicate about the precipitation, but the tectonic fluctuation basically talk about mainly the deformation and that will result into this, which can change the base level and change in the base level will affect the river base or river floor that can result into either the gradation or degradation.

That is erosion or deposition in the region, which can eventually affect the morphology of the channels. So morphology of the channel basically can, erosion can increase the sediment load or decrease the sediment load. So experimental as well as field studies have proved that change in the valley floor or the stream floor slope will cause changes in channel pattern. So the channel pattern will be affected.

However, the change will differ depending on the type of channel and amount and rate of deformation. So type of channel, whether it is meandering or it is braided or straight, so depending on the change of type of channel, the change will differ from place to place. So these are few important points, which you should remember about the fluvial anomalies. If there is a tectonic deformation or the fluctuation, the channel flow mainly or the valley floor slope will be affected and that will result into the change in the channel pattern, because the hydrological conditions will be disturbed.

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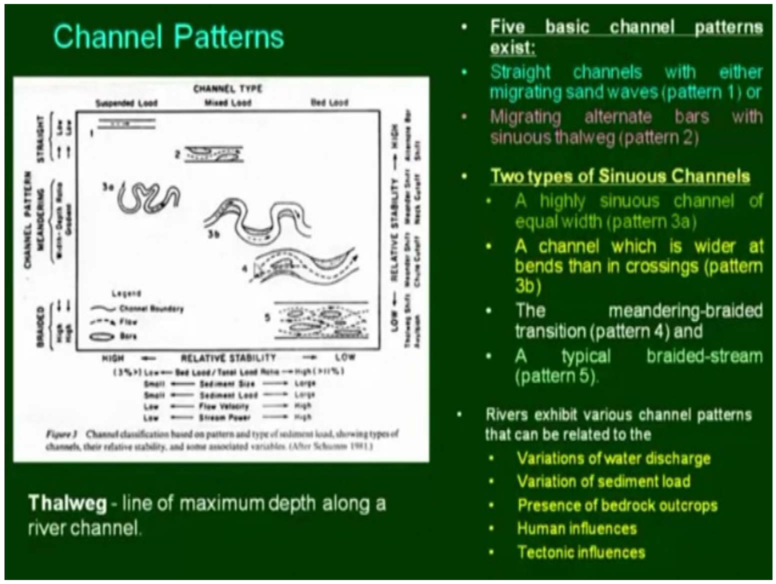


So change in pattern, this we discussed in one of the previous lecture. So the line of maximum depth along the meandering channel is termed as thalweg. So we have 5 basic channel pattern that exist and which have like the higher stability, if you are having straight channel and then if you move towards the right, then you get into the lower stability or relatively lower stability, where you are having the meandering channel.

So you have different pattern from straight, tightly meandering with same thickness of the channel, whereas slightly broader channel at the bents and you are having braided streams and so on. So this again, the channel pattern will vary as we were discussing in the previous slide that sediment load will also affect the channel pattern. So from suspended to bed load, the channel pattern will change from 1 to 5.

So straight channels with either migrating sandbars, pattern 1 or migrating alternate bars with sinuous thalweg pattern 2, then two types of sinuous channels, one is 3a highly sinuous channel with equal width and the channel which is wider at the bents, then in crossing. So if it is wider over here as compared to this one, pattern 3a, 3b, which has been shown as two types of sinuous channels, then pattern 4 is meandering to braided.

So meandering to braided is the transition channel pattern, which has been shown, so one is moving from the suspended to mixed load and bed load and then type 5 is the braided streams.

So river exhibits various channel pattern that can be related to either variation in water discharge, variation of sediment load, presence of bed rock outcrop, human influence, and tectonic influence. So if you are having these parameters, these parameters can affect the channel pattern.

So right now what we are talking about is the tectonic influence. So tectonic influence can also, whereas these parameters if you take, the variation in discharge, sediment load, presence of bed rock, human influence can also alter the channel pattern and the pattern can move from one that is pattern 1 to 5 under such conditions.

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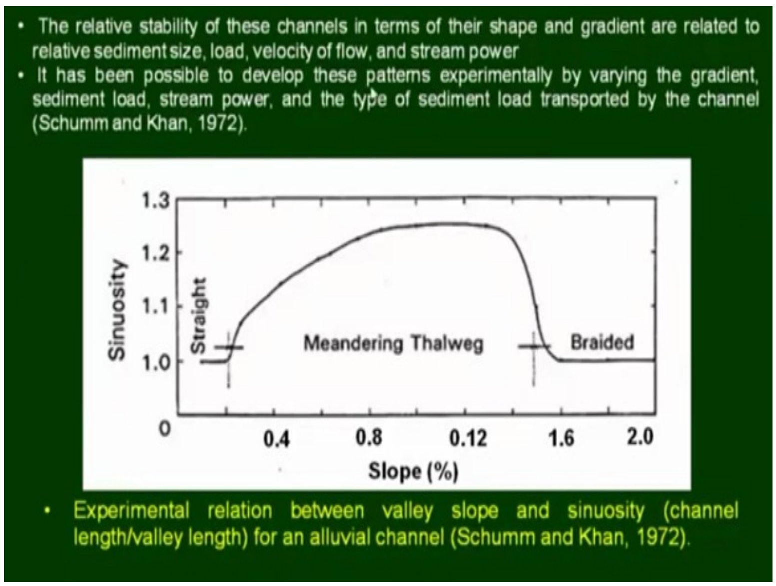


So this, it shows that if you are having straight channel and if the slope increases, then it may result into, get into the main ring channel and main ring get into the braided channel. So experimental relation between valley slope and sinuosity that is the length by valley length. That is channel length by valley length that is your sinuosity, so one can measure the sinuosity. So if you are having more sinuous channel, you will have the different ratio and if you are having less sinuous channel, you will have different ratio.

So the relative stability of these channels, which we were talking in the previous slide in terms of their shape and gradients are related to relative sediment size, load, velocity flow and stream power. It has been possible to develop these patterns experimentally by varying the gradient, sediment load, sediment power, stream power and the type of sediment load transported by the channel.

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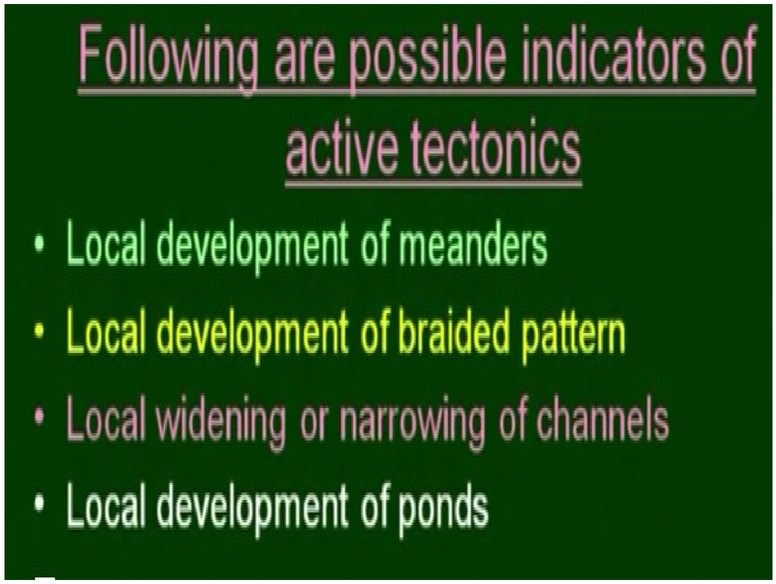


Now following are the possible indicators of active tectonism, one is local development of meanders, local development of graded pattern, local widening and narrowing of channel, local development of ponds, so these are few indicators, which one can take into consideration to identify the active tectonic deformation in particular area. So please remember this, this can help you in identifying the active regions.

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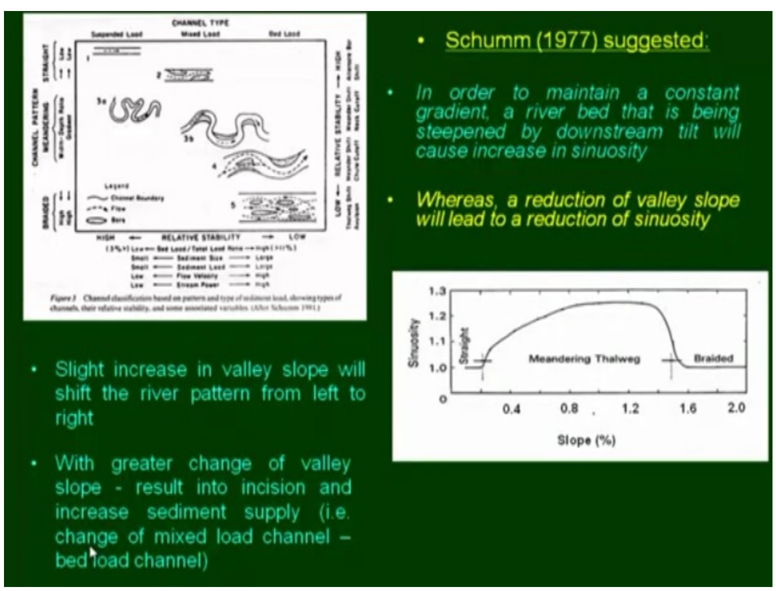

So in 1977, Schumm suggested that in order to maintain a constant gradient, a river bed that is being steepened by downstream tilt will cause increase in sinuosity, which has been shown here. So the straight channel will be subjected to get into the meandering thalweg, where you are having the increase in sinuosity and further whereas reduction in slope, so reduction of the valley slope will lead the reduction of sinuosity. So if you reduce the slope, the sinuosity reduces.

If you increase the slope, the sinuosity increases. Slight increase in very slope will shift the river pattern, which has been given here, so slight shift will lead the river pattern to shift or to change from left to right that is straight will get into meander and meander will get into braided. So with greater change of the valley slope results into incision and increase sediment supply. That is the channel of mixed load or that we can say the change of the mixed load channel to bed load channel. So with the greater change in the valley slope will also change the sediment supply in the region.

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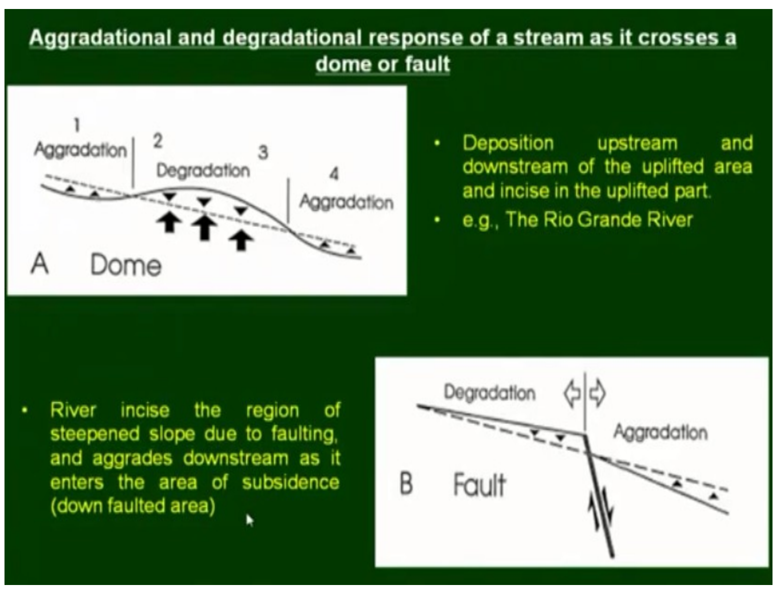


So gradation and degradation response of a stream as it crosses the domes. So what you see is, so basically you are looking at the uplifted area and subsidence area and S, we were talking in the previous slide that the river will try to maintain its slope all the gradient. So it will try to remain in equilibrium. So the gradient if it is altered because of the uplift or subsidence will result either into aggradation or degradation, so either into the valley fill or erosion.

So this example A, which has been shown here, so what will happen, the area between 2 and 3 will degrade because the area is getting uplift. The dotted line is the profile of river profile, which will also try to remain in equilibrium. So the portion in the upper ridges will aggrade, whereas this will degrade because of the change in the slope here and because of the change in the slope here. So this will aggrade, this will aggrade and this portion will degrade and until it comes into equilibrium.

So deposition of stream and downstream of the uplifted area and incision in the uplifted area will occur. This is the example of the Rio Grande river in US and then second example is of the subsidence. So if there is an area, which is down faulted from here along the fault and this is the river gradient, which was in equilibrium and the new gradient is this one, so this will try to degrade here erosion and bring back the area to this one.

So this portion will aggrade, this portion will degrade. So river in size the region of steepened slope due to faulting, because this slope has been steepened here. So this was the slope and this is steepened. So again it will try to come to this equilibrium. So this portion will be incised and this portion will be aggraded. So downstream aggradation will take place and as it enters the area of subsidence, down faulted area.

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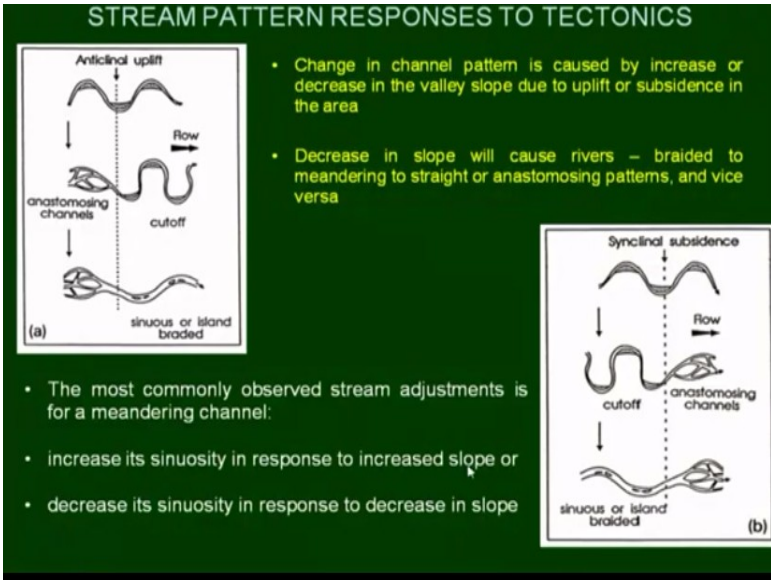

So stream pattern response to tectonics again this has been shown here. So if you are having a decline here, then the pattern changes from, for example shown here. So it is anastomosing. It will get into this sinuous channel and if you are having from anastomosing or the braided river, it will get into the demeandering one. Similarly the pattern will change if you are having syncline or subsidence. So one is the uplift and this is the axis of the uplift, this is the subsidence one.

So change in channel pattern is caused by increasing or decreasing the valley slope due to uplift or subsidence in the area, decrease in slope will cause rivers braided to meander to straight or anastomosing pattern and vice versa. The most common observed stream adjustment is for a meandering channel, increase in sinuosity in response to increased slope. So the sinuosity increases if the slope is increased.

So you have steepened slope and decrease in sinuosity if you reduce this. So here down faulting and here uplifting, if it is there so decrease in slope will decrease the sinuosity. So please remember this also.

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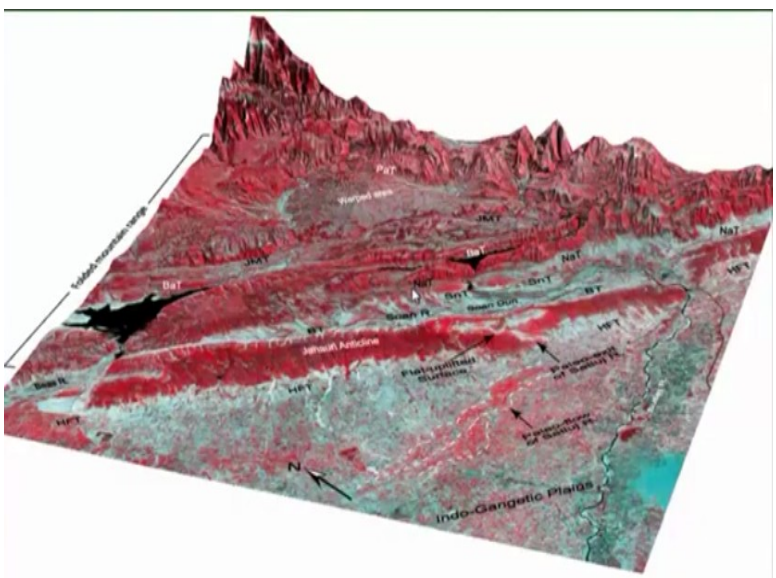


Now example of the tight meander, which we observed in the higher Himalayas. So from this region if the faulted mountain front, this Jwalamukhi thrust and the channel which is flowing across this mountain front or folded mountain has been affected and this sinuosity changes. So this portion if you see, here is marked by this one.

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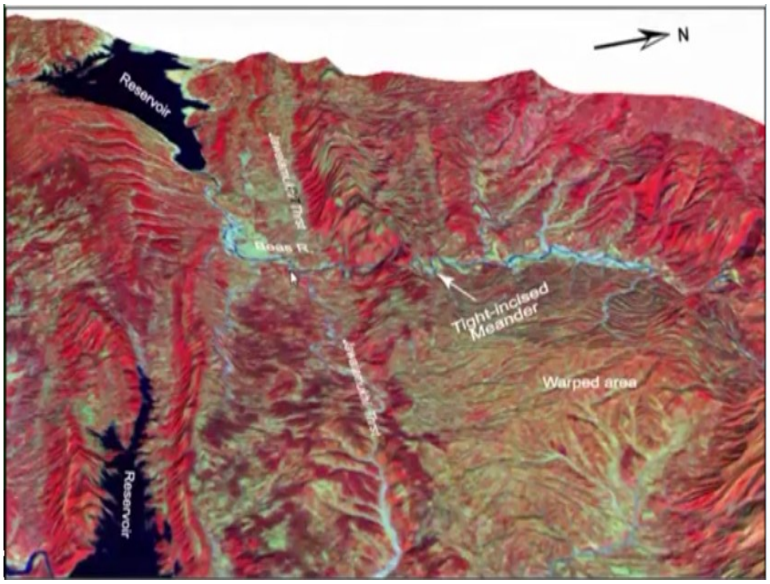


So Jwalamukhi thrust is lined up here and then this is the folded mountain chain. So what is happening here, the river which is flowing coming closer to the mountain front, it shows tight meandering. As it leaves the mountain front or the folded mountain, then it becomes straight. So this is a very good indicator of the area under the influence of the tectonic deformation.

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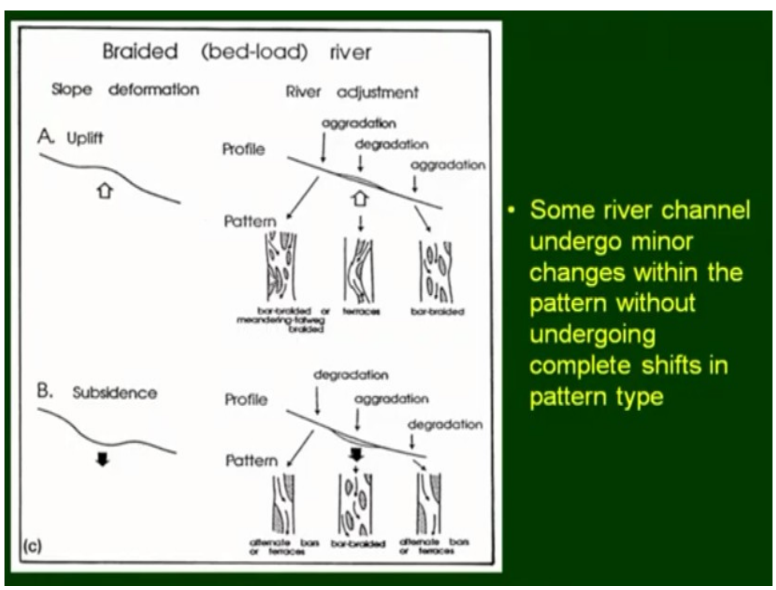


Again another one example, what do you see here is the braided bed-load stream. If you are having an uplift and what you have in the subsidence, so some river channels undergo minor changes within the pattern without undergoing complete shift pattern. So this is, this whole system or the drainage pattern remains as braided, but slight changes have been seen. So what you see is the braided bars meandering thalweg here.

And this portion, it degrades and it enters into mostly the formation of terraces, but is of course with the alternate bars here and then, finally aggrade. So it is again braid bar, so braid bar sinuous channel and braid bar. So this will result into the area formation of the alternate bars and meandering, whereas these two sides on the either side where the aggradation is taking place, we will see the formation of straight channel with braid bars.

And in terms of the subsidence, again the upper ridges will degrade and the portion, which is subsided will aggrade. So the portion where the aggradation is there, we will see the braid bars and braided bars. Similarly what you have seen in this region, so aggradation braided bar and the degradation you will have alternate bars and straight channel in this case and straight channel in this case, whereas in this case, the degradation, you have slightly sinuous channel.

So overall pattern remains as braided bed-load river and slight change where the uplift and subsidence has occurred.

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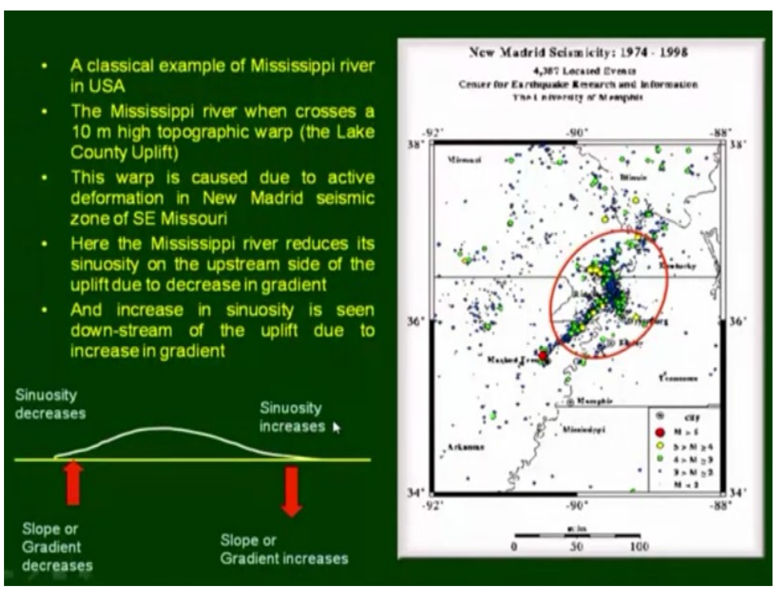


So classical example is from the Mississippi river in US where the sinuosity changed in the location of the uplifted area and this is well marked by the concentration of the seismicity or the earthquakes and this region is the region where large magnitudes in the stable continental regions. These are termed as stable continental, has occurred New Madrid region. So the location of the seismic events have been showed here and the maximum magnitude right now based on this one, that is between 1974 and 98 seismicity is of magnitude greater than 5.

So the Mississippi river when cross 10 meter height topographic warp, that is termed as the lake county uplift. This warp is caused due to active deformation in New Madrid region of Missouri. Here the Mississippi river reduces its sinuosity. So in the uplifted area, the sinuosity reduces. The sinuosity on the upstream side of the uplifted area due to decrease in gradient, because you have uplifted the area over here, so in the upstream the slope has reduced.

So decrease in gradient will decrease the sinuosity whereas an increase in gradient in the downstream of the uplift has increased the sinuosity. So upstream and downstream, the sinuosity changes. So in the upstream area, the gradient has decreased. So this if you take the profile, consider that this is under the equilibrium and this is the profile after the deformation and the area of warp area, topographic warp. So the slope has reduced over here.

So this will decrease the sinuosity. So slope and gradient decreases, so sinuosity decreases, slope and gradient increases, so the sinuosity increases. So this is very commonly observed in one of the most active region in US and such anomalies can help in identifying the active regions. So please remember this that slope or the gradient decreases, sinuosity decreases and slope and gradient increases, sinuosity increases.

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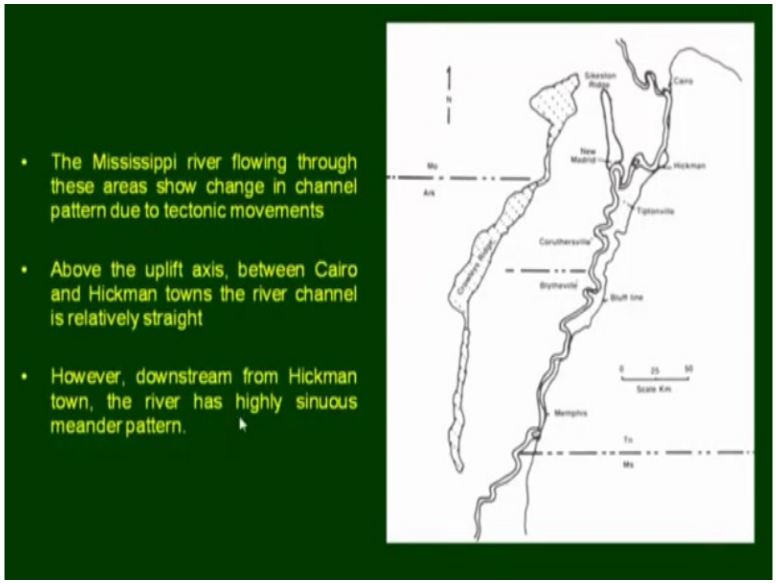


So this is the example or the sinuosity, which has been seen here, so in the upstream the sinuosity decreases because of increase in the slope here, sorry decrease in slope here and increase in slope here, the sinuosity decreases. So the Mississippi river flowing through this area shows change in the channel pattern due to tectonic movement above the uplift axis between these 2 regions that is Cairo and Hickman. Hickman is located here.

So between Cairo and Hickman, the channel is relatively straight. So we can see here the channel is relatively straight. However, downstream from Hickman town, the river has highly sinuous meander. So this portion is highly sinuous. So this is the portion here, which is highly sinuous.

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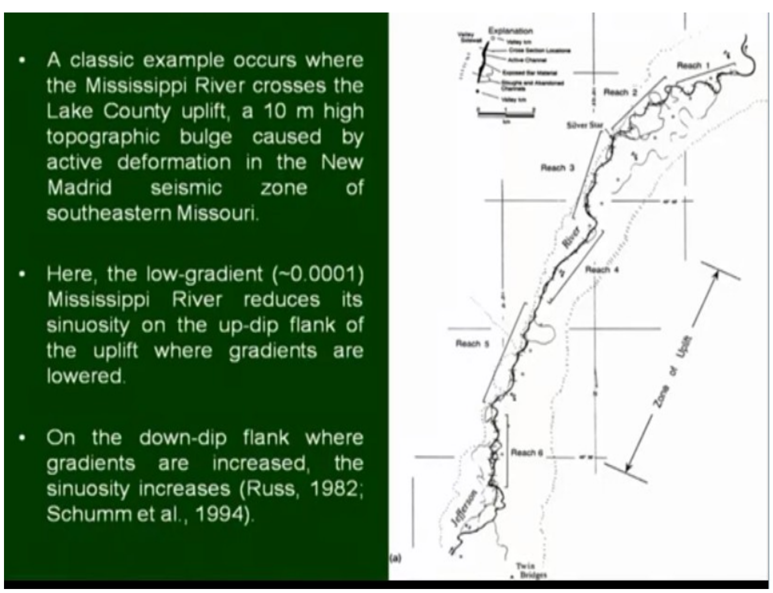

So finally a classical example that occurs where it crosses the county region 10 meter high topographic bulge caused by active deformation in the New Madrid region. So here the low gradient of Mississippi reduces the sinuosity up-dip flank because the gradients are lowered on the down-dip flank, where the gradients are increased, the sinuosity increases. So we will stop here and we will continue in the next lecture. Thank you so much.