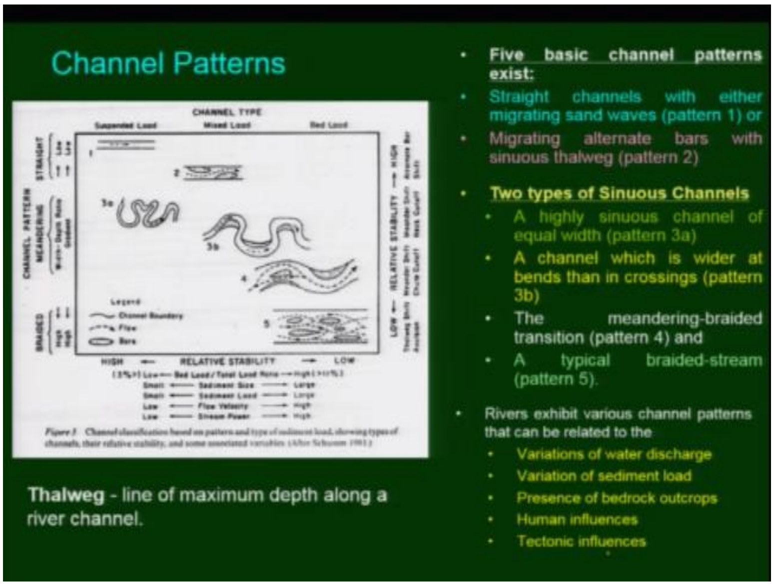
Earthquake Geology: A tool for Seismic Hazard Assessment

Prof. Javed N Malik
Department of Earth Sciences
Indian Institute of Technology – Kanpur

Lecture – 50
Tectonic Geomorphology (Part – II)

So welcome back and let us see how the general pattern changes because of the change in the slope and how it affects the sediment bed load and what different channel patterns evolves because of the change in the gradient and change in the discharge or change in the bed load supply in that particular basin okay.

(Refer Slide Time: 00:39)



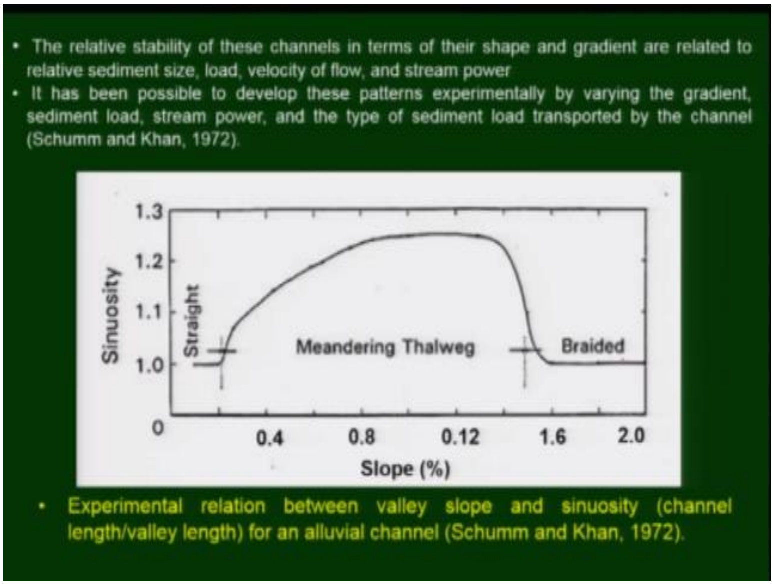
So, the channel patterns if you look at this figure, then it shows that there are at least total 5 channel patterns, which ranges from straight, then you have straight with sandbars here and then you are having meanders, then you have meanders but at some locations you have white channels here and then you are having braided and so on. Now, this also shows that the channel patterns will change and which will comprise of different bed loads.

So, mostly the straight channels will have suspended loads whereas we have mixed bed load and then coarser bed loads if you are talking about the braided channel pattern and all that. Let us look at that what it basically talks about. So, we have 5 basic channel pattern that exists. So, we have straight channels with either migrating sand waves or pattern 1 or we have the migrating alternate bars. So, we have this one, this is the pattern 2 with the sinuous thalweg. And then we have 2 types of sinuous channels, 3a and 3b.

So, 3a is showing highly sinuous channel with equal width, so the width remains the same throughout the channel along the valley, a channel which is wider at the bends, so you are having the channels that are comparatively wider at the bends than in crossing. Then you have the meandering and braided pattern, so we have channel 4, now the pattern 4 for and then a typical braided stream which has been shown here with the multiple channels and the channel bars in between. So, these are mostly these channels pattern which we will come across.

So rivers exhibit spurious channel patterns that can be related to 1 is your variation in the water discharge. So, if you are having the variation in the waters discharge, you will have the different channel pattern and variation the sediment load as we will be talking here. So, you have the sediment load suspended, mixed, and bed load here. So, presence of bedrock also will affect the pattern to change. So, these are the few important points which will affect the patterns which we are talking about from 1 to 5 and then of course is the human influence also plays an important role in altering the channel pattern and the tectonic influence.

(Refer Slide Time: 03:44)

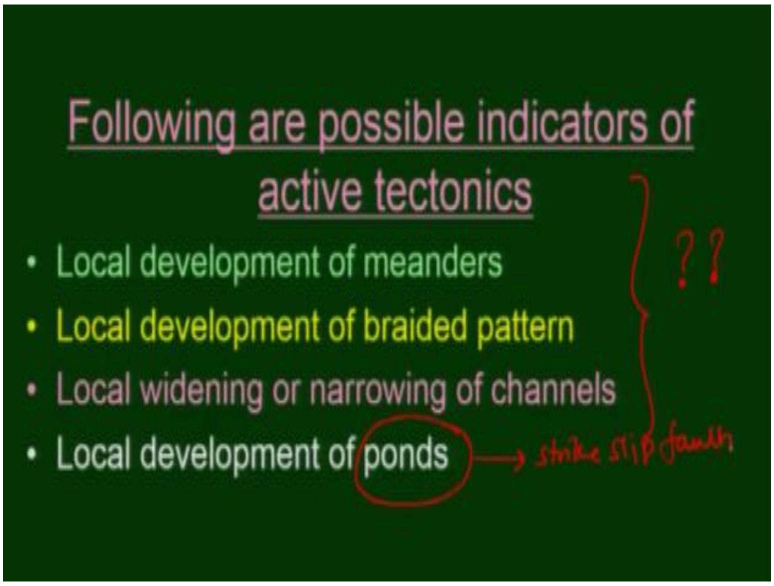


Experimentally and in field research groups have studied and identified the local change in the channel pattern because of changing the slope okay. So experimental relation between the valley slope you have and sinuosity, which has been shown here that so if you increase the slope, then you are having change in the channel pattern if you are having for example straight, then you will have meander channel and further if you change the slope, then you have the braided channels.

So, the relative stability of these channels in terms of their shape and gradient are related to relative sediment size, load, velocity of flow and stream power. It has been possible to develop this pattern experimentally by varying the gradient that is the slope of the channel bed, sediment load, stream power and the type of sediment load transport by the channel. So, either you are changing from the suspended to mixed load or bed load, then you will have different pattern or channel general pattern you will come across okay.

But here what has been shown is that if you change the slope, then you will get into the change in the sinuosity that is you are having straight, you will have meanders and then you will have braided.

(Refer Slide Time: 05:18)



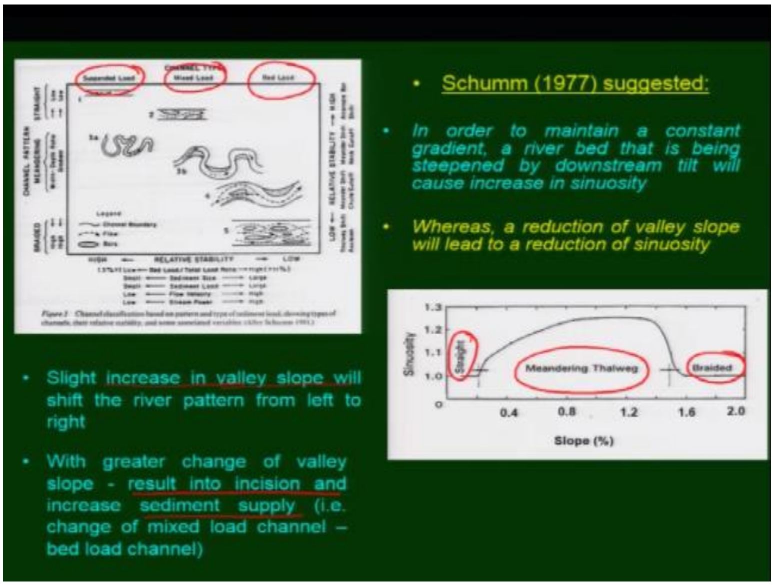
Following are the possible indicators of active tectonics that we usually look for on the local scale that is the development of the meanders, local mean there. So, for example, if you are having straight channel and suddenly you are getting into the meander channels okay, so that can also indicate some change and then again it becomes straight up here. So, that what we were looking at in one of the slide in the previous lecture that the typography which we had was something like uplifted here.

So, we had a very tight meander here and then we are getting into the slope down here almost straight main channels okay or less meandering and here we were having very tight meander. So, this is also because of the change in the slope here okay. Local development of the meanders or you can say local development of the braided streams steams or braided pattern can also indicate change in this local slope okay.

Widening of or narrowing of the channel can also be taken as a possible indicators of active tectonics okay, but at the same time, we need to look at or rule out the possibility of sediment flux coming in actually, whether it may be because of the increase in bed load can also change the channel pattern. So, that has to be looked into in detail before arriving to any conclusion that these are all tectonic indicators, but of course, yes, if you see this, then you have one question that why such change has been noticed locally at the drainage basin.

Then local development of ponds okay, and this we were talking about when we discussed about the strike-slip faults and all that okay.

(Refer Slide Time: 07:49)

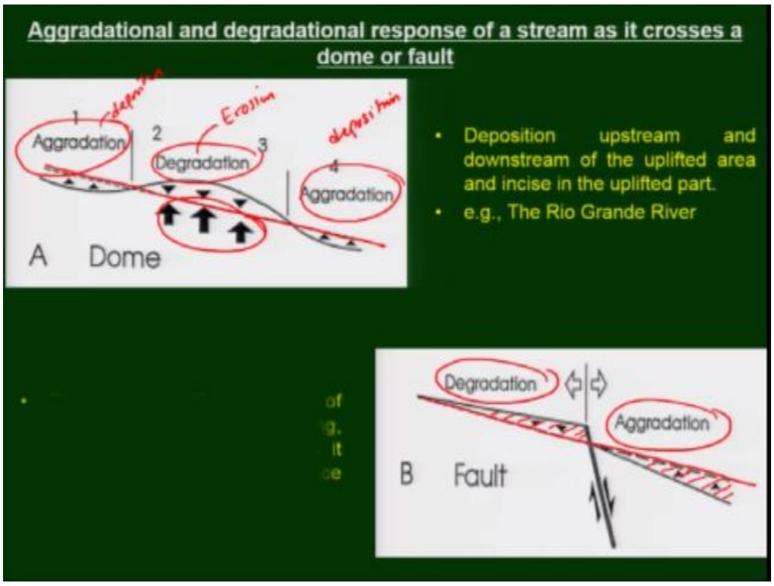


So, coming to again the same one, so if you have the change in the gradient, so in order to maintain the constant gradient of river bed that is being steepened by downstream tilt will cause increase in sinuosity. So, if you are increasing slope, you are making the slope steeper, then you may have the change in the sinuosity, higher sinuosity as it has been shown here, and similarly if you are having reduction of the valley slope will lead to a reduction in sinuosity okay. Now, slight increase in the valley slope will shift the river pattern.

If you consider this 5 river patterns, which have been given here so slight increase in valley slope will shift the river pattern from left to right. So, you will have if you increase the slope, when we are talking about the increase in valley slope, then we have from straight to meander and meander to braid okay. So, this is what has been shown here. So, you have from straight, you have to meander, and meander to braid. So, with greater change of the valley slope results into incision and increase in sediment supply also okay and that change the mixed load channel to bed load channel okay.

So, because if there is a change in the valley floor, because of the increase in gradient, it will result into the incision in the area and that will result into the increase in the bed load and then bed load also will change from mixed load to coarser bed load.

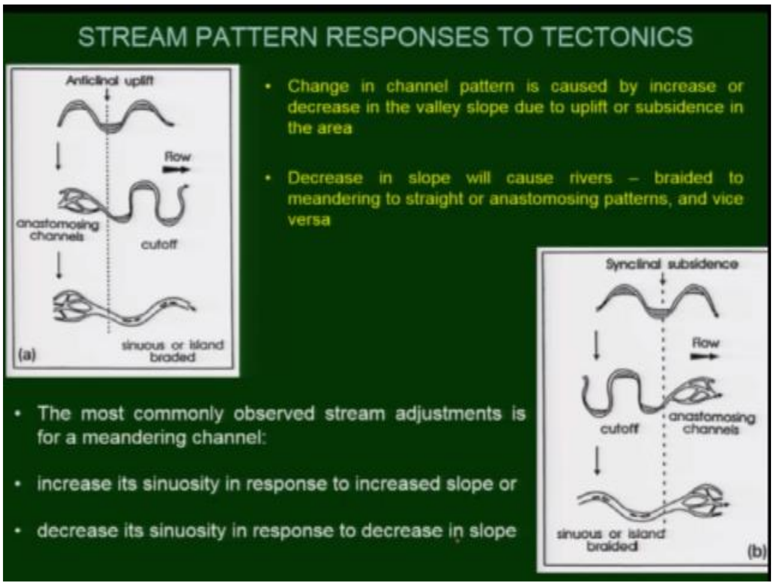
(Refer Slide Time: 09:40)



Now aggradation and degradation response of a stream as it crosses the domes or fault that is uplifted area in the region. So, for example if you are having, so this is the dotted line which is showing the profile, the nominal profile, and now if you try to uplift this okay, then what will happen this portion will be eroded okay. So, there will be an erosion here, whereas this portion will have deposition and this portion will also have deposition. So, aggradation here, aggradation here, and degradation in an area of uplift.

Similarly, if you are having the profile, you have the downfaulting a portion okay. So, you are having this portion going down. So, new profile is here. So, it will again try to come back to this one. So, they will be a deposition here, whereas this portion will be eroded. So this portion will get eroded and further this will get filled up. So deposition and erosion to maintain this profile. Similarly was the case of here, so it will try to maintain its profile.

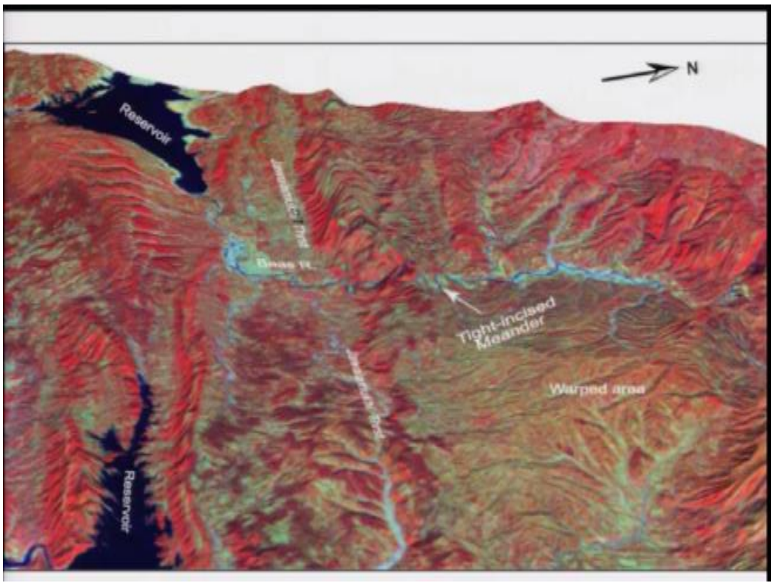
(Refer Slide Time: 11:10)



So, further in terms of the anticline and syncline change the channel pattern is caused by increasing or decreasing the valley slope due to uplift or subsidence in the area. So, this has been shown at the anticlinal uplift, if you are having the meanders, then it will remain as the changes further from braided to meander and braided to slightly meander and so on okay. So, the decrease, so basically that is change in the channel patterns is caused by increase or decrease in the valley slope, so decrease in slope will cause the reverse braided to meander to straight or to anastomotion okay.

So this will be the change which will be following and vice versa and this is what has been shown here that you will have the changes. So, the most commonly observed stream adjustment is for a meandering channel, okay. Increase in sinuosity in response to increased slope, decrease in sinuosity in response to decrease in slope.

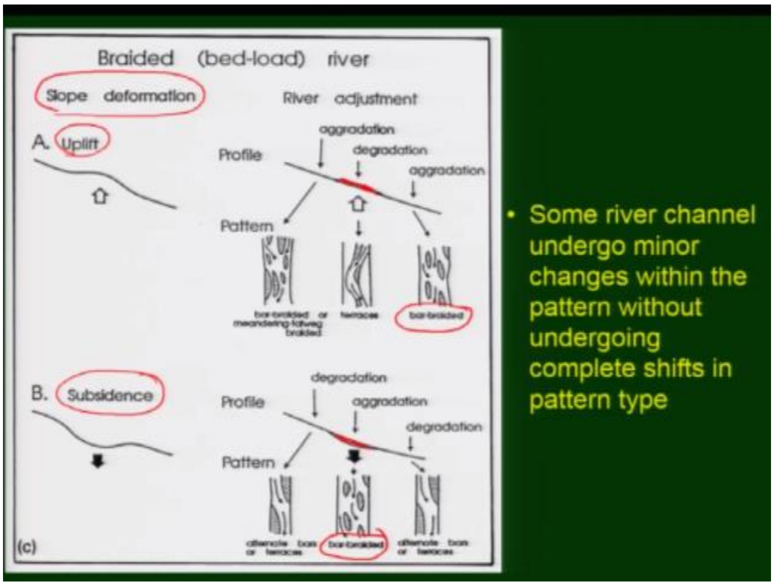
(Refer Slide Time: 12:22)



So if we take this one here, this area now, I will just discuss a little bit about this one. This is in Jwalamukhi Thrust here and this is what I was talking here is an upward area and Beas channel which is flowing across this here have shown as a very typical meandering pattern here that we interpreted as a tectonic geomorphology indicator of ongoing tectonics okay. So, this is the portion here. So the Jwalamukhi Thrust runs over here, this portion is the anticline and this is the upthrown side.

So, as it crosses the anticline, before crossing it, it shows a very tight meander. So, what you see here is straight meander to tight meander, tightly incised meander and then the sinuosity decreases here okay. So you have the slope increases here and then further the scope decreases here. So, you have this crossing topography and this we took as an indicator for your tectonic activity.

(Refer Slide Time: 13:44)



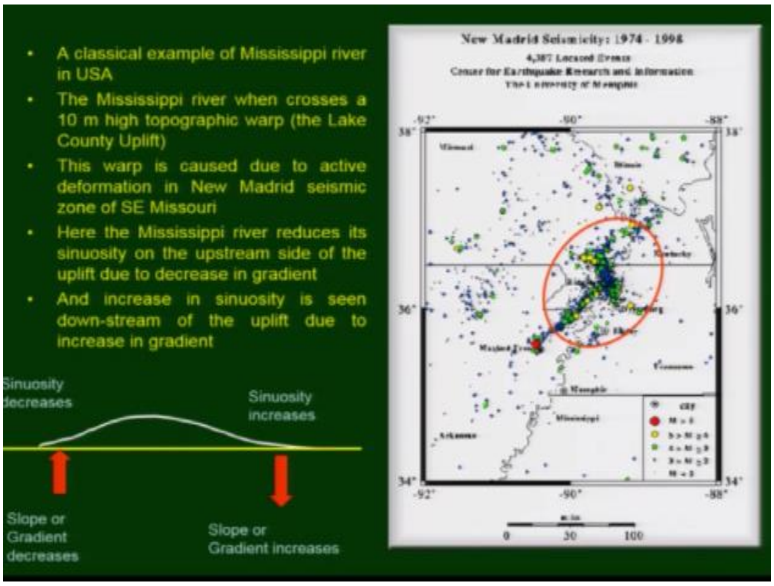
Some river channels undergo minor changes within the parameters without undergoing complete shift in pattern okay. So for example, if you are having the upper left, which will result into the slope, the slope deformation. So, what we see is the upper left here. So, this portion will be aggradation. The uplifted portion will undergo erosion and then aggradation here. So, what we see is that if you are having the braided meandering, then there is a formation of terraces and the braided will change into meander.

Then further if you are having the steepening of the slope here, then it goes into the braided channel. So, here because there will be a lot of erosion and slope is also steepened here, so the bed load the material will be a more supply of material. So, bed load increases and the slope increases will result into the formation of braided channels here. Now in case of subsidence, so this was in the case of uplift, and now looking at the subsidence, so change in the channel profile which is subsided here.

So, this forms sort of a basin, which will get aggraded. So, you will have the filling up of this portion, whereas this portion will get eroded. So, the aggradation here, whereas here we see a degradation; and it will have degradation on either side here. So, what pattern we will see is alternative bars here with terraces and braid bar here again because this slope is steepening here, more of erosion, more sediment has been brought in, and so you will have braid bar, similar to this one here and this one and then further the gradient is reducing here.

Then we will have the alternate bars which has been seen like similar to this one okay. So, you will have the alternate bars and terraces, whereas here you will have the graded bar system.

(Refer Slide Time: 15:58)

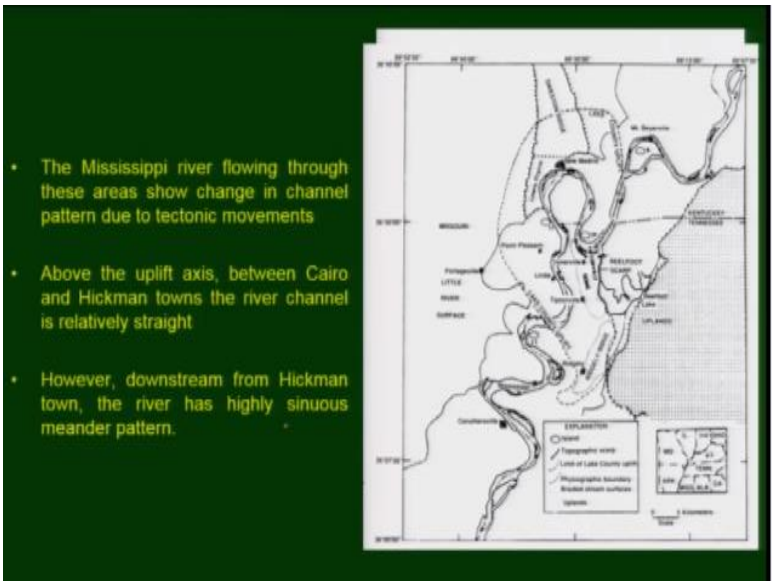


Now, the classical example if you take the area from US, New Madrid region, which shows some very interesting signature of the ongoing tectonic activity and this area is the part of the interpolate region where the region experiences a lot of microseismicity and also they found that this area is deforming and this portion is upwarping slowly. So let us see the details about this. So this is from Mississippi river. So this main channel is your Mississippi river here. So the Mississippi river when it crosses a 10 meter high topographic warp.

So this portion is the warped area where you also see the occurrence of microearthquakes and slightly moderate earthquakes with magnitude greater than 5 which has been marked here okay. So, this warp is caused due to active deformation in New Madrid seismic zone of Missouri. Here the Mississippi river reduces its sinuosity on the upstream side. So, the upstream side sinuosity reduces okay of the uplift due to decrease in gradient because decrease in gradient because this is uplifting, so it is reducing the gradient.

So, it will decrease the gradient and increase in sinuosity is seen downstream. Downstream, the sinuosity increases because of increase in gradient okay. So, if you look at this one, so in the upstream what we are having, the channel flow has been raised, so it has reduced the gradient, so decrease in sinuosity whereas here it has increased the gradient that is increase in sinuosity. Such local development or variation in the channel pattern can be taken into consideration to identify the tectonic influence in the region.

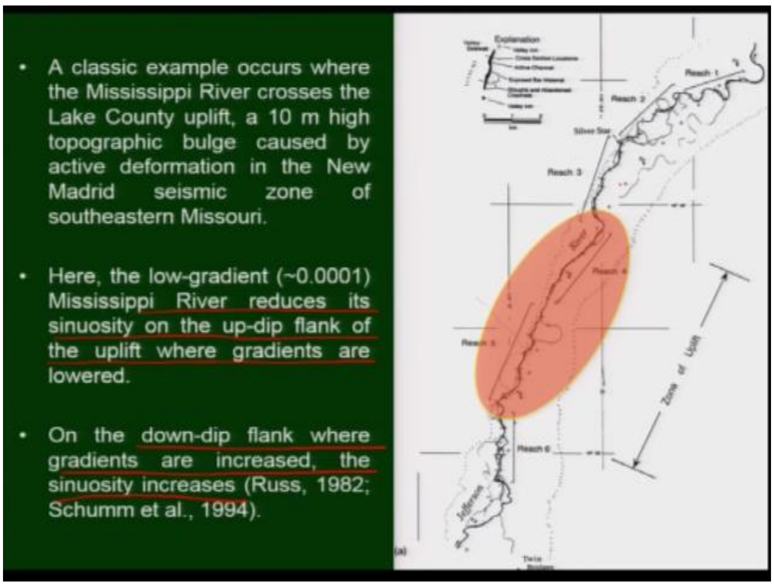
(Refer Slide Time: 18:05)



So, if we look in further detail of the Mississippi river, then this is what we will see that there is a decrease in sinuosity, increase in sinuosity and further you have the decrease in sinuosity further. So if you look into the detail of the Mississippi river and this what we have. So the Mississippi Rivers flows through the areas shows change in the channel pattern due to tectonic movement, okay. Above the uplift axis between you are having this as Cairo and the Hickman town, this is this one Hickman town here, the river is relatively straight.

So if you can see here, then you have relatively straight channel here, and then, however, in the downstream of this Hickman town, the river has high sinuosity, this becomes high sinuosity. So, you have the change in the channel pattern. So, the sinuosity is less, sinuosity increases, and then further the sinuosity is more so, high sinuosity in the downstream side.

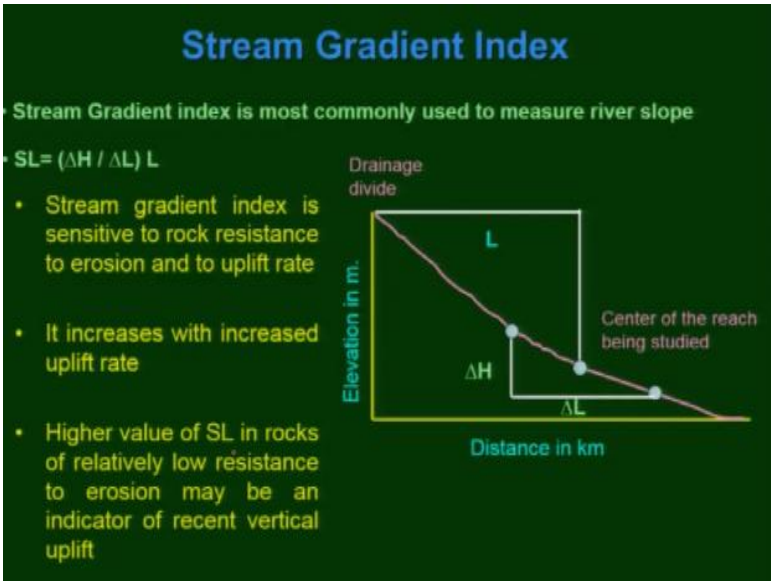
(Refer Slide Time: 19:25)



This is what it shows here okay. So, you have the change in the sinuosity here. So, upstream of the uplift, this portion is your uplift here. So, the sinuosity is different here, sinuosity is different here, and different in the uplifted far. So, this is a classical example where it crosses the 10 meter high topographic bulge, okay. So, low gradient reduces the sinuosity on up-dip flank of the uplift.

So it reduces the sinuosity at the up-dip flank and where the gradient is lowered on the downstream, down-dip flank where the gradients are increased, the sinuosity increases. So, here the sinuosity increases okay. So, again increase in slope increases sinuosity, decrease in slope decreases the sinuosity.

(Refer Slide Time: 20:24)

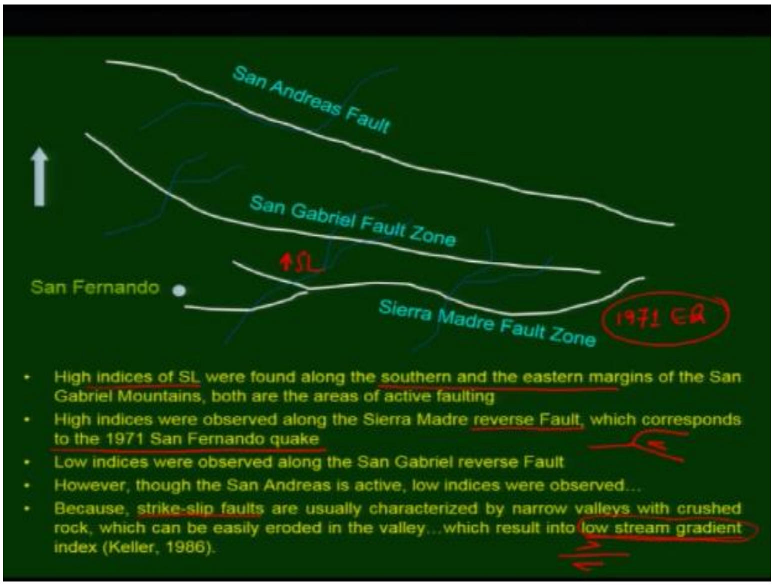


Now looking at the another important parameter, which you can use as an tectonic indicator is your stream steam radiator index okay. So, it is mostly what we are talking about the stream gradient or the stream slope. So, if there is any local change in the stream gradient that can be picked up by simple equation and the parameters which you can extract from the change in the elevation and the total length for any particular point. So, SL has been given as that is your stream radian index changes in the elevation change in length into total length.

So, if you take the elevation and the distance and strike the longitudinal profile and you want to measure sure the SL index at a given particular point at the center of this two points, then you are taking what the difference in the elevation here and the length here between the two points. So, this will give you that is your center reaches what you want to study okay and then the total length okay. So, this is the change in the length, but this one is your, so there is a difference between the upper reaches and the lower reaches and the elevation here you will get.

Then the distance right from the drainage divide that will give you the L okay. So stream gradient index is sensitive to rock resistance to erosion and to uplift rate, with the increased uplift rate. So, you will have the higher values of SL if you are having increased uplift rate. High values of SL in rocks of relative low resistivity to erosion may be an indicator of recent vertical uplift okay. We also try to look at what type of rocks through which the drainage flows okay, that also we will take into consideration.

(Refer Slide Time: 22:37)



Now, this is one good example from US again where they took into consideration the SL stream gradient index. So, what they found was, so you have like different faults here marked by white lines and the drainages, this is a rough sketch which shows the location of San Andreas fault and San Gabriel fault zone and Sierra Madre fault zone. So, what they found was high indices of SL were found along the southern. So this marks the north, so this is the southern portion and the eastern okay, so southern and eastern portion of San Gabriel fault okay.

So they found higher SL indices here okay, so higher SL indices. Now both are the area of active faulting, so along the southern side and the eastern side okay. So high indices were observed along the Sierra fault zone okay, which corresponds to 1971 okay, so 1971 earthquake, San Fernando earthquakes. So this was because of the earthquake. So they were able to talk about that there was high SL values okay. Low indices were observed along the

San Gabriel fault, okay.

So that is what they are talking about the south of this and the eastern side, they were able to see high SL indices and they correlated this with the event of 1971 and then low indices were observed along the San Gabriel fault. So, high SL in the southern side and the eastern side were because of this one and the low were observed along this one. However, though the San Andreas Fault is active low indices were observed. So again, you can talk about that a very recent event of 1971 was responsible and triggering the incision in this particular river along the streams okay.

So, then another reason which has been given here that why we see less SL values along the San Andreas Fault system because it is a strike-slip fault system. Strike-slip fault system as usually characterized by narrow valleys with crushed rocks which can be easily eroded in the valley which results into low stream gradient index. So, what is important here that we need to look at that whether we are having the reverse fault system or strike-slip fault system.

Even the fault is active, so sometimes we will come across low stream gradient index because the movement is strike-slip, whereas here the movement is reverse. So this is reverse faulting and here we are having the strike-slip faulting. So, I will stop here and we will continue in the next lecture. Thank you so much.