Laboratory Practices in Earth Sciences: Landscape Mapping

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Welcome back. So, this was the part which we were discussing in the last lecture, which is basically the drainage pattern and how drainage patterns can tell us about the different subsurface rocks as well as the lithology or if we have any geological structures. So, we will see a couple of examples in this lecture and then we will also look at some morphometric parameters or the morphometric studies you can do using remote sensing data also and also the topographic maps and that again is related to your drainage basins and all that. So, this is an example which I would like to share with you when we were working in Sundun. Sundun is in the area which is located in Punjab and basically Punjab Himachal region and you have. So, you need to travel further north west of Chandigarh then you will actually reach the Sundun area.

So, Sundun is very much similar to what we call Dehradun and all that. So, this is an inter-mountain valley and dhun is a local word which has been used. So, there is a Pindjore Dhun also which exists between the sub Himalayas and the lower Shivalik hills and this is also the same and you are having sub Himalayas and the lower Shivalik hills here. So, I will just show you a couple of things here which we also like. Based on the drainage pattern we were able to pick up certain anomalies in terms of the landforms.

So, usually till date what you have learned from using the remote sensing data and all that you can generate such maps which has been shown here that is your what we call geomorphic map, but since we have added some tectonic features also in this like what we see is here is the fault scrubs and all that I will just change my pointer here. So, on the white you can see clearly. So, this is what we have marked as fault scrubs here. So, you can see this one over the fault scrubs. So, this portion I will just try to explain and we will discuss how the drainage pattern helped us in identifying such features.

So, in the previous one we had, we were talking about the dendritic pattern and then we were talking about the radial. So, you can see the dendritic over here. This is all the dendritic pattern we have and we were talking about the radial that will have some elevated portion in the center and then it goes on the either side. So, this area is basically composed of older material older than quaternary and partially some portions on the top is composed of quaternary sediments. So, what we saw here was that in particular this area was like indicating a very typical radial pattern ok. So, and that was a bit surprising here because here we were when we did not expect that such deformational features would be there.

And then other thing was that there was the area where we were looking at some very typical change in the channel pattern and that was local change local channel pattern change that we have discussed in the previous lecture that if you are having the local meanders ok, development of local meanders. And then so and even if the meanders are having like tight meanders ok. So, this basically is meandering. We are referring to the sinuosity of the channel. So, the sinuosity of the channel is like what I will just explain. So, if you are having a channel which is flowing in the meandering pattern and so you have some sinusity here, but if you are having very tight meanders like this then we say that it is sort of and the sinuosity is quite high here ok.

So, this is how we will be able to judge if there are local development of meanders and all that and we have looked at a couple of that does the indicators of we are we can say the active tectonics ok or I can say that active tectonic indicators or markers also you can say. So, this we have discussed in the previous lectures. Now, let us just look at what I was talking about, the radial pattern and all that. So, if you look at this area this is the area which is close to Nalagad and Dhanah and in the previous slide if you look carefully at this is the area I am going to talk about right now ok. So, this is your Nalagad and this is Dhanah area and just to give more idea about us that this I have already given that this is northwest of Chandigarh and the channel which is flowing here like this one this one is here Shatla's river ok.

So, we are looking in that domain. So, what we see here is that there is a fault which is controlling this whole topography and even the drainage here ok. So, that is what we were able to pick up and that was quite interesting. So, let us go ahead and see what evidence we see over here in particular this area. So, and then we will go to this part here.

So, first if you look at the close up of this what you see here is that you have a development of tight meanders locally ok. So, if I put my line here which has been put here, that is your active fault around Rajpur and further down. So, this is exactly the line which passes through ok. So, this is the line here and that is what we have marked as an active fault. So, if I take a cross section here and say this is A, this is B then it will appear something like this ok.

So, this will go like this and then and so the fault here is what we called a thrust fault ok. So, which is common in a compressional tectonic environment. So, this is your thrust fault ok. Now, let us see what exactly I am talking about in terms of. So, there is a deformation which is occurring here like we have compression going on this block is riding on the top of this, but when the then the in the in the area the drainage which is flowing across this is getting affected.

So, if you see carefully then you see a very typical tight meander over here ok. And as soon as the eye crosses the fault ok, the sinuosity reduces and it becomes more or less straight ok. So, any channel you take from here you will find that it is showing a very tight meander. And as soon as it crosses the fault then it becomes straight ok. And even this one also from here if you take then you have a very tight meander and this becomes almost straight and go and meet the major channel.

This one is the main trunk stream in that area and this goes and meets your shuttles. So, this is one evidence which is a clear indication of the ongoing deformation along the active fault ok. So, the another one this one what we found was that if you see that that what I was talking about that it shows radial pattern and when we went in field and found that this is a typical like domal structure or can we have a warp here and that is the reason why we are able to see a radial pattern. So, this part in some section we have discussed. So, if you are having a like the ongoing deformation in form of an uplift or you are talking about the that is subsidence, then the river will tend to have different processes which will be operated on along the gradient or along the river profile ok.

So, in case you are having an uplift, ok. So, if you are having an uplift here. So, in case of the uplift then you will have this portion will experience erosion ok. So, this is we are talking about erosion here and the upstream of the uplift ok, the upstream of the uplift and the downstream of the uplift will experience a gradation that is your deposition ok. So, these two areas will have the process which will result in deposition and this will have erosion ok.

And also the pattern here what you see is that you have braided bar braided channels suppose you are having then this portion will have like the it will have channelized flow of course, but we will have the landforms which will develop here will be terraces and further down will have the similar pattern which we were able to see in the upstream of the uplift. Now, coming to the subsidence where the profile here the profile if you take this as a channel profile here or river profile. So, this portion has been uplifted here ok. Now, in case you are having subsidence and if you draw this profile like this. So, this area is subsiding ok.

Now, this area is subsiding. That means that you are having a sort of profile which has gone down here. That means, you are having a sort of steepening of the slope and that gives you a sort of a gradation here ok. So, this is degradation here, this is you are having degradation downstream also ok. So, this is what you are able to see in both the cases ok. So, let us move further and then see what else we have in this one. So, this is a classic example from the Mississippi river in US ok, which shows a typical indication of when it crosses the uplifted area ok.

So, this is the area which is in the New Madrid region and where the Mississippi river this line black line is shown as in Mississippi river. And then this area is also experiencing extreme seismicity and also is famous for major earthquakes in this region. But usually if you look at the earthquakes which have occurred here are more than 7 also 7 magnitude, but the micro seismicity if you look at that then this area is also having like 5 greater than 5 magnitude earthquake and all that and and seismicity keeps continuing in this area. So, we say that this area is an active area. So, the Mississippi river crosses a 10-meter-high topographic warp ok.

So, you are talking about the topographic warp here like this. So, this is what you are having is around 10-meter topographic warp ok that is known as they have called this as and they call this as a lake county uplift. So, this warp is caused due to active deformation in the New Madrid seismic zone. So, this is the area of the New Madrid seismic zone and that the uplift or the warping has been caused by that. So, this is the area you have ok.

So, here the Mississippi river reduces its sinusity in the upstream ok. So, I have a sketch here. So, upstream suppose we had said that this is the flow direction then this is an upstream area. So, here what it says is that the Mississippi river reduces its sinusitis on the upstream side of the uplift due to decrease in gradient. So, what we are seeing is that suppose you are having this gradient here.

Now, there was an uplift here, which means, this slope has been reduced here. Whereas, at the downstream of you will have the increase in the slope ok. So, there is an increase in slope, this is a reduction in slope. So, keep this in mind. So, what we are getting here is that when we are having the reduction in slope the sinuosity is higher ok.

So, sinusitis reduces and decreases in the upstream of the uplift due to decrease in gradient this is one and increases in sinusitis increase in sinusitis seen in the downstream side ok and that is because of the. So, sinusitis decreases here. So, we are looking at like for example, so it will have like if the channel is flowing. So, here you will have an increase in you say decrease in sinusity ok that is reduce in sinusitis and then when it crosses this area then again you will have this area will have increase in sinusitis here. So, let us see that part here.

So, basically what I was talking here is this is what we are we are looking at. So, slope or gradient decreases ok because you are having an uplift. So, at that point you have decrease in density whereas, the slope is like you are you are increasing the gradient here because of the steepening ok. So, increasing the gradient where the sinuosity also increases. So, reduced gradient less sinuosity increases gradient higher sinusitis ok.

So, this was a very common example which has been observed in this area and that was related to your tectonic deformation ok. So, this is what has been shown here. So, in the upstream side you have a reduction in sinusitis because of the reduction in the gradient and in the downstream of the uplift you have increase in sinusitis. So, this is one very good example of the Mississippi river from the New Madrid region ok. So, this is again what has been shown here that you have.

So, in the uplift here the sinuosity is because of the reduction sinusitis decreases and the lower stream you have the sinuosity increases and the between there is very less sinus channel ok. So, usually we use this type of local development of meanders or local development of tight meanders or increase local increase in sinusitis local decrease in sinusitis and even for the braided streams and all that locally which are locally seen ok not on the regional scale then we have to see that what is the what are the reasons and what are the causes for that ok. Now, the stream gradient index is ok. So, this is an exercise which can be done using your remote sensing data or if you are having it because if you generate the digital elevation model or digital surface model and you extract the river profile from that. So, you can use this parameter to understand the influence of the tectonics and if this is this is what is usually most commonly done to understand the overall intensity of the tectonic influence on the landscape ok.

So, usually this as I have discussed many many times in our lecture is that the river profile is taken considering the elevation and the distance ok. So, and most commonly you will be able to see the river profile something like this ok. Now, if you want to judge or you want to know what is your stream gradient index in a particular given point ok. So, if you want to judge somewhere over here. So, you can take or you can take a stretch of the area and in that stretch what is happening you can do that ok.

So, what parameters you need or what information you need for this to know the A c l index is the difference in height and difference in elevation you can take. And so, the so, considering this area you can have the difference in elevation at the at this point and then length of the difference in length you can take ok. And the center points you will use to take your this is because you are studying. So, suppose you are having this drainage I will have another sketch of for you. So, that we can explain, suppose this is the drainage.

So, if you are wanting to study this stretch then this will be your center point ok. And then from the center point you will calculate the length actually. So, that will get you this part. So, with this you can calculate the A c l index ok. So, the stream gradient index is sensitive to rock and rock resistance to erosion and to uplift.

So, this will also talk about the incision in the area and whether this is triggered by uplift or it is related to subsidence. That is basically we are talking about the sensitivity of the area under the influence of your tectonics. So, it increases with increased uplift rate that is the A c l index will increase ok. Higher value of A c l in rocks of relatively low resistance to erosion may be an indicator of recent vertical uplift ok. So, you can also talk about the tectonic events also in that area.

So, this is what I was talking about. So, suppose you are having a basin here. So, this is a basin taken and then this is a main trunk stream and you want to analyze the A c l of this region. Then what you see is this from the center point you are going to get this l here ok and the difference in the in these two points at these two points you will give you delta l and the elevation difference you can say you will get from this ok. So, if you are having this is the simple equation delta H by delta l into l. So, you are having the elevation difference 40 minus 20 and then you are having this delta l is 2000 meters. That is the difference in your length.

So, if you take that that will give you the A c l index. Now, like a low A c l index in this strike slip faulting environment, ok. So, what we find here is that so, higher value of A c l in rocks with relatively low resistance to erosion may be an indicator of recent vertical uplift. Now, there is an area which is of course, an active region in the US and is a part of the San Andreas fault system which is having multiple like subordinate faults which are in the area. Now low A c l index because the low A c l index is indicative of that there is no not much erosion.

So, there is not much tectonic activity in this area ok, but this region which I am talking about close to San Fernando is an active region ok. Because this area has experienced earthquakes and this is one of the most active regions that is your San Andreas fault system. So, why this low A c l index in this is because if you see a low A c l values you will say that there is not much tectonic activity in the region. The reasons given here are that high indices of A c l were found along the southern and eastern ok. So, this is your north here so, this one is if you take north here then this is your east ok.

So, it says that the low sorry high indices of A c l values were found along the southern and the eastern margin of San Gabriel mountains ok. And this is along this line both are the areas of active faulting. High indices were observed along this reverse fault, that is this one Sierra Madre fault region which corresponds again to a 1971 San Fernando earthquake. Low A c l low indices were observed along the San Gabriel reverse fault that is this one ok. However, though the San Andreas is active, low indices were observed ok.

So, what basically I want to emphasize here is that we usually look for if there is a tectonic activity then there will be a high A c l index ok. But here some regions are showing high, but the active regions also these are all active faults, but this area that is your San Gabriel fault system is showing low indices ok. And the San Andreas system fault is showing low indices ok. So, why is it so, this is because strike slip fault is usually characterized by a narrow valley ok. With crushed rocks which can be easily eroded in the valley which results in low stream gradient index.

So, this is one of the reasons we have to look at and keep in our mind before we come down to any conclusion. Now, another parameter or that you can use to identify the tectonic activity is the basin asymmetric factor ok. Now, the basin asymmetric factor is how the basin is if we say that ok the basin is very much symmetry then how it looks like. So, we can say that ok this is my basin here and then this is at the center I am having the main trunk stream and then I am having the basin where the streams are flowing. So, this is my trunk stream which is flowing in the center here, but asymmetry when we say then we are having the basin for example, like this ok.

And the stream is flowing somewhere at the side over here ok and then we are having the streams which are or you have like if the basin either it is like this or you are having the basin over here and the stream is the main stream is flowing somewhere over here ok. So, this is your symmetric basin. So, you are having some symmetry here and this is asymmetric ok. Now, basically what the drainage here is going to which has usually developed is one factor which is very much important is your slope. So, if there is change in the slope of the area and that could be resulted because of the tectonic tilting tectonic tilt then you can get into having the asymmetric basins.

So, you can find out the AF that is the basin asymmetric factor ok and that can tell you what is the whether the area has gone under the deformation or not ok. So, this is how it has been calculated: simple ok AF that this AR is this portion of the basin ok. So, here it is right, but you can have even the areas over as I have shown. So, this will be this portion we are taking or what you are looking at this one ok. So, this is the area you are taking this will be your AR and then the whole total will be this one ok.

So, this whole total basin area is your AT ok and this one is your AR. So, if you take that then that will help you in understanding. So, the tilt factor. So, AF is less than 50, suggesting tilting of the left-hand side and uplift on the right-hand side ok. So, this is what in the case of what example is shown here ok.

So, there is a tectonic tilt on the left-hand side. So, this portion has been going up and has tilted ok. So, we can say that this portion has moved up and this is tilted over like this ok and that has resulted into. So, the left-hand side. So, this is the left-hand side of the basin and this is the right hand side of the basin ok.

So, that you can talk about the tectonic tilt here ok. So, if you look at the AF if the value is coming less than 50 suggest the tilt of the left-hand side. So, this is a tilt of the left-hand side and uplift on the right-hand side of the basin. So, basically you are talking about the right-hand side of the basin here and this is your left-hand side of the side of the basin ok. So, this is what we are talking about the uplift here. So, uplift upliftment on the right-hand side of the basin and the tilt which goes is on the left-hand side.

So, tilt is in this direction this is what is been given here. So, this is your right-hand side and this is your left-hand side ok. So, and this is the direction of the tilt. So, there are more parameters here which you can use to even identify the tectonic influence. This is another one is the valley floor valley a valley floor width to valley height ratio ok. And this is quite interesting again, similar to the previous two ones like if you are having the valley, usually we talk about if you are having the valley is something like this ok.

So, if you look at this. So, this is your width we are talking about is the width of valley floor width and then you are talking about the height ok. And finally, we are working on the ratio between these two oks. So, this is we can say this is the right side and the right side and this one is your left side ok and this is the base of the elevation of that ok. So, this is an equation which was given by Bull and Mcfadden way back in 1977. So, it is valley floor indices if you want to talk about then you have the you need to take talk about the this that is the left-hand side elevation and the right-hand side elevation ok.

So, with this you can reconstruct that. So, valley incision is another important aspect which can be used to define a relative uplift in the area ok. So, a cross valley profile can be constructed from topo maps and yes, I said that you can also use DEMs to extract this information. Valley height width can be measured from distance between the channel that is your VFW river channel marked by very narrow valleys crossing the mountains or the mountain fronts showing low value of VF ok even sometimes low less than 1 and large VF greater than are associated with broader valleys ok. So, this is basically what we are trying is that if you are having V shape valleys then you will have VF will be less than 1 ok and if you are having large wider valleys like you are having rounded or you can say U shaped valley broad valleys then you will have VF will be greater than 1 ok.

So, what this indicates is ok. So, what we did was that if they were crossing, we took two like one of one of the major rivers and crossed the different tectonic lines or the fault lines. So, we took that this is what we have: MBT that is your main boundary thrust, Bursar thrust, Son thrust ok, Palampur thrust and Jwalamukhi thrust. So, this is in north west Himalaya mainly in the Himachal region where the Bursar flows across or it crosses many fault lines. So, we took the areas there and used the cross-value profile and then we looked at what is usually the activity which we are able to judge from this in terms of the tectonic activity ok.

So, as I said, we have crossed different fault lines. So, straight away from here what we have discussed in the previous slide is that if you are having the like V shaped valleys then this VF will be less than 1 ok. So, and if you are having broader valleys or U shaped valleys then VF will be your VF will be greater than 1 ok. So, with this information if you look at what we got the VF here is 11.49. So, this is again a broader valley and this is where we are having less than 1 ok.

Mostly we here we have slightly greater than mostly we are having like in two places we are having less than 1 ok. So, this indicates that this area is like this area is more active relatively more active this one ok and this one as compared to you are having this this is quite like sort of a dormant area or maybe not much of activity is taking place here, but these are to some extent this is also active, but not so much as compared to what we call Palampur thrust and main boundary thrust ok. So, if it has been suggested that a V shaped valley with low VF values less than your 1 ok. So, if you are having less than 1 then we are looking at that this is in response to your active uplift ok ok. Broad view U shaped valleys with high VF values as we have seen in the case of the Bursar thrust then the VF is greater than 1 is indicate that the either the because it is broader valley.

So, we have like the channel has tendency to move in this area and erode and it is due to stable base level nothing is happening much here. So, it will result in erosion and if not, if it is subjected to the tectonic uplift then it will have V shaped valleys ok. So, this will have less than 1 value and this will have greater than 1 value ok of VF ok. Now, coming to the hypsometric curves there is another exercise which we can do and again here what information we are using is related to the drainage basin here ok. So, a hypsometric curve describes the distribution of elevation across an area on land.

So, in this sketch what you see is that we have the elevation here and then horizontal distance and this is your area of the mean overall full drainage ok. Now, the curve again in this we are going to generate curves ok. So, curves could be different like different patterns may be like this ok, may be like that ok or this like this ok. So, what exactly this type of curve is talking about where we will be mostly trying to plot the A by A that is the relative area and you are having h by h that is your relative height ok. So, the curve is created by plotting the proportion of total basin height that is your relative height.

So, total basin height is this one based on what we will get that is your h by h you will see that is your total relative height against the proportion of total basin area that is your relative area that I was talking about this is your A by A this is relative area and so and this one is your relative height and this is what the curve we see that this type of curves will be we will be getting ok. Now, what the shape of the curves has to tell us about ok that we will learn ok. So, total height is the relief within the basin that is your maximum elevation minus the minimum elevation then the total surface area that is A you are looking at this is the entire basin area A ok. And then you are having area A is the surface area which is within the basin above a given height. So, this is supposing given the height above that you are having this is the basin area shaded basin area.

So, that is what you are talking about here. So, which basin portion you want to study that again will depend. So, the last point we will see is this curve. So, what it says is that the value of relative area always varies from 1 at the lowest point in the basin ok.

So, the lowest point will be this one here. So, it will be 1 here and 2 here. So, from 1 to 0 and that will be 0 0 will be at the highest point in the basin. So, this is what we usually try to look at and that you will obtain based on the values you are going to generate of the given area of the relative that is the given basin based on the relative height and relative that is the thing ok. Now, this is how we see the curves ok. So, this type of curve will be generated where you will have the h i index or the h i values you will be able to see and again we are plotting the relative height and relative area. So, if you have this type of curve, that is, you can say that concave curves and that you are having convex curves and in between a mixture of that.

So, that will indicate to you that you will also have values also, but you can talk about how this is an older stage of the river. Whereas, we are looking at the concave then convex one then you will say that this is the youth stage and this could be indicative of or could be indicative of active uplift in the area or ongoing active tectonics in the region ok. Now, this is some part which can be used to understand the local development of meanders and all that. So, in terms of you are having an uplift here and then you are having subsidence. So, if you have like what type of channel you have before the uplift region that will result in different types of meanders.

So, for example, different types of pattern river patterns for example, you are having before just above this is what is like showing the anticlinic areas ok. So, if you are so before that, if you are in the upstream you are having a meandering channel. So, this will get into the braided and then further down if you are having this down, faulting this is up and this is down here. So, here again from meander it will get into the braided type ok.

So, that is what has been given here. So, if you are having low sinuosity the sinuosity may increase in the in the or or downstream, but if you are having a meandering channel then you will have a braided channel here. So, that is what has been explained here for this one: he is having you meandering or you are having straight responses you are having in a submousing ridge. So, that will get into the meandering channel. So, with this I will end here and we will discuss more about the remaining part like GPR and the using total station and RTK in coming lectures and also, we will be putting more labs. I hope you will enjoy this course. Thank you so much. Thank you.