Laboratory Practices in Earth Sciences: Landscape Mapping

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Welcome back. So, after talking about the different landforms, luvial landforms now we will look at a few terminologies which have been used for the drainage which we see on the surface. So, mostly what we will come across because there is a very simple principle that if you are having a slope in any terrain and if you are having precipitation then you will be bounced to see the formation of drainage. So, if you are having a slope in this direction as it has been shown in this figure also. So, you will see the development of the drainage. Now, what are the terms which have been used for such drainage that we will quickly look at and that you will be using when you are identifying the different terrain and also the different drainages ok.

So, these are also termed as the parallel drainage, but in general they are termed as consequent streams ok. So, the stream following the slope developed on the development of slope may be due to sudden tectonic uplift because the natural slopes are not usually seen because the slopes are seen because of the tectonic deformation mostly. And then we have the so, these are termed as consequent streams and subsequent streams are not exactly following this slope they are developed. So, this is what has been shown here that they are almost straight angles to the original slope of the land ok.

So, the slope we see here is the topography we are having. So, the slope is in this direction because this is in folded terrain and then we are having the slope here. This is a valley here ok, but if there is erosion which is taking place here. So, this is almost the right angle to the slope. So, those such streams are termed as subsequent streams. Then if the stream is crossing the folded areas ok, then they are termed as antecedent streams and then there is another one which is what we call the superposed streams which are incising the inclined surface and then which is been covered later on by the flat depositional stratum which has been made by because of the deposition.

So, if it is incising that then we term this as a superposed stream or drainage. Stream piracy again is a common process which one can come across in any area and this is basically because of the headboard erosion of the drainage evolution. So, time will come when this one of the drainage basins will breach the divide and you will see that the whole drainage has been taken up by one of the drainage systems. Then that is what we call stream piracy. Now, coming to the drainage pattern, the geometry of the stream network

in a region that reflects aspects of underlying geology.

So, as I said, there is a difference between the drainage pattern and the channel pattern. So, this you should keep in mind and till now you must have understood that the drain drainage pattern we will just see, but the channel pattern mainly is the straight meander and braided one. Now, I will show a couple of examples from the Himalayan region and then we will move to the general part of that: what are the different types of drainage patterns and what exactly talks about the subsurface one. So, if you look at this one this is a shaded relief map of and this exercise again you are going to do in your labs. So, this is the area of north-west Himalaya and we must be aware about this town Rupad and Sharpur.

So, and this one is your Kangra valley here it goes to the Kangra valleys here and this is the town Kangada and Dharamshala. So, if you carefully look at the overall landscape then you will be able to see that there is a divide here in the frontal part of the Himalayas and then you are having the drainages which are flowing in either direction. So, this is the drainage divide. So, you will be able to pick up the drainage very easily from the digital elevation model. This is again another example that you can use satellite data to generate a 3D perspective view of the terrain and you can rotate it or put it at different angles as you wish to view the terrain in the best way.

Now, coming to this part again , we will be talking in the labs about how to extract the drainage, but as what I was showing here is the same area and this is the part where I was talking about the drainage divide. So, you can clearly demarcate the drainage divide and this is based on what we have been talking about. One of the other drains is flowing in one direction and another one is in a different direction. This portion is again in a flat area on the top where you are having the drainage which is flowing away from here and this is in this direction and the darker one is the major trunk stream. So, you can also talk about the order of streams here based on the extraction which we have done of the drainage. So, this you will be doing in one of your lab exercises.

So, what we see is the darker lines, darker streams or thicker ones are the higher order streams and that is the trunk streams and what you see here is this one where I am putting the cursor and this one is your Bias River and this one is your Sutlej. So, the most common drainage pattern which one can come across in the areas is the dendritic which will be like if you are having a tree and then you are having the tree stems which are going to be like that. So, you will see in the dendritic pattern then you have the radial pattern which again indicates about the landform and then you are having a trellis pattern. Trellis pattern is mostly seen in the folded terrains. So, you are having the harder rocks and softer rock combination and mostly what has been seen here is that the trunk stream is crossing this

area and the tributaries will be almost at the right angle.

So, you are having softer and harder rocks. So, you will have the resistance rocks are this one which are marked by darker color and then less resistance rocks will allow the formation of the lower order streams and that will be almost at right angle unless you see in folded terrain and then you are having in the if you are having a fractures in the terrain then you can come across on this type of rectangular drainage that will be almost at the right angle that. So, investigation along the Soandoon what we did was that this was the area which we were looking at and we prepared a detailed map and that what you are going to this is image and not what right now I am showing is in lancet image and false color composite. So, what we usually expect you to do is that you prepare such a type of geomorphic map. So, what we have in this map is basically all the drainage has been marked here and then you are having the terraces which have been marked in different colors which have been named here as QT0 and QT1, T2 and T3 and so on.

So, these are the different terraces which have been seen here and then along with that we have also marked the false active faults here ok. So, this part we will try to cover if possible if you are having enough time left out with us then we will try to teach how what are this landforms and what are the important what is the importance of this in terms of the earthquake hazard. But right now what I would like to show you is that there was an area which we never expected that this type of feature would come across, but based on the drainage we were able to judge what exactly this area is showing and then we checked in the field also ok. So, if I would say that if you carefully look at this area particularly then what we can make out is that there is a stream which is flowing here in this direction and there is another stream which is flowing or may not many streams which are flowing in like that ok. So, you have a short of an domal structure.

So, this is the center here and the drainage is moving away from this ok. So, it is quite possible that this is an elevated portion and then you are having a slope on either side ok as what we were looking at in the radial drainage ok. So, this is typical of the radial drainage. So, when we looked here in this area this is a close up view of that. So, this one is the close up view.

So, if you carefully see what I was showing here that you have streams which are flowing like that ok over here and then some few streams are going like that ok and then over here like this like this here and then the stream is coming out here like this ok. So, this is the elevated portion that we can see here because this drainage is going away from the center. So, this is typical of the domal area. So, dome is something like if I put it in a cross section then it will look something like this ok. So, it has a slope on either side.

So, now look at let us look at what we see in the in field actually. So, this is the village known as Dhana and this is not very far from Nalagar. So, what we inferred that there is an sort of an fold fault here and this area is been whopping because in the the folded terrains mostly what we see is that there is an the displacement which is taking place and this can result into a short on formation of of a domal structure or folding here ok. This I am putting in the section here. So, this is a top surface.

So, this is exactly what we inferred ok and there is another fault which goes here which has even led to an indifferent pattern of channels here. So, first look at this one here. What we see is that because of this blocking of results because of the fault not exactly blocking, but this because of the deformation here in this area. So, if you put in a cross section this will be seen as something like this ok. So, you have a short of an uplift here. So, on this surface what has happened and one then further below what we see is ok in terms of the drainage here and over here ok.

So, this is a close up of this and if I carefully mark the streams here all the streams then you will come across that this area is showing it is coming like this ok. We are meandering here and then going like this and then coming out like that ok. Again here you have the meander and this is what we are talking about. The tight meander in this area is ok and then it becomes almost straight. So, the sinusity decreases below this line ok and this is the uplifted area. So, if I say I was talking about that this is what we have.

So, this portion is showing tight meander and this is showing like the sinuosity reduces. So, this is typical of a tectonic plant. I am removing the line so that you can see clearly what I was talking about ok. So, this is a line here which is responsible for the change in the channel pattern. So, such changes in the channel pattern are also taken into consideration and sometimes it could be related to the tectonic deformation. Then coming to another part here this is what we were talking about. Based on the drainage pattern is the dana this is a close up of that again I am showing that this you can see now very clearly and what we are talking about the tight meander.

So, this is the portion in all the tenages which is showing a tight meander. Now the dana area when we looked in the field it was very clear that the topography is something like this ok. So, it was because of the domal effect. So, this is the area dana and this one is here bertian which is on the low lying area, but this is because of the drainage which we are showing we saw a short of in radial drainage it was because of the typical domal topography in this region. So, based on the drainage pattern one can interpret what exactly the lithology is subsurface and second is the structure that is the geological structures ok.

So, these are the typical drainages which have been observed ok. This is what we were

talking about when we were talking about the consequent streams. We can also term this as a parallel stream and we have recently seen that this is a radial drainage. And so, you will have like dendritic parallel tailings radial centrifugal then and so on and so on you will be looking at many such patterns ok. So, few of them have been listed here, from the type that is your dendritic right up to the annular and that description is also given here then how it looks ok. So, as I was talking about a trail, if it looks like a tree then what will be the geological significance ok.

So, then there is a homogeneous material and crystalline rocks horizontal beds, generally a regional slope and then if you are having sub-dendritic then you are having minor. Structural control that is your tectonic or we can say the geological structures. Then pinnate type is like you have fine grained material then rectangular streams you are having the area are jointed or fractured ok. Then you are having for example, if you are taking parallel then you are having steep slopes that you will also see and then if you are looking at the radial one then you can say that it is flowing through the folded sedimentary terrain or metacetametary rocks. And then you are having radial then you are having like domes or and and residual erosional features will be there then you are having for example, annular then you can structural dome ok.

So, these are the interpretations you can make out after identifying the different drainage patterns. So, this exercise also you can do and as I told you earlier we used to extract the drainage based on the satellite photographs or the satellite data used to draw with hand, but now you are having the soft words which can extract the drainage easily ok. So, dendritic pattern as we have talked about that most commonly we will see this drainages and what are the the information you can deduce from this ok. So, I have already discussed this part in the previous slide. So, I will just skip this, but you can go through and try to understand and recall when you are extracting the information from the satellite data.

So, the dendritic parallel then you are having the radial one. So, as I said, it could be related to the higher topography and then you are rectangular if you are having jointed and fractured terrain. Then trellis mostly in the folded areas where you are having weak and resistive rocks, annular again you are having concentric paths which will be seen and this could be because of the domal or basin effect ok. Now quantifying the stream network, basically the stream order in a basin can be ranked using one of the several schemes. So, we are having two: one is having shivri and another one is teler.

So, mostly we try to use the teler one. So, the difference here is what we initially discussed is that in this case in shivi, what we have is you are having the first order to first order which will make the second order and even if the lower order stream is joining this will become third order. But in this case, this will become third order here. So, two seconds

like second order plus even first order is joining then it will make it higher orders and that will tremendously increase the number here ok like it can go up very high. So, to avoid that, what is there in this teler one that you are having two first order streams ok.

So, 1 plus 1 will be 2 here second order and even if the first order is joining here this remains the second order only when 2 plus 2 or 3 plus 3 or any will be there or even one as I as we talked about 1 plus 1 then it will go into 2 in this case 2 plus 2 then joining then we will see third order and it is 3 in 3 then we will see higher order and that what we can make out here ok. So, how this became fourth order is based on this one here ok. So, you are having third order 2 third order streams joining here. So, this becomes your fourth order and that is how one can classify and as I told that earlier we used to trace out all this demarcate the first order second order and based on that we used to come up with the final order basin and here this you can see that in the here in this 4 and this place it is coming to 18.

So, this one is more advisable, ok. So, this is mostly used. So, having the fourth order basin here. So, now, so earlier as I told that we used to trace all this streams and then come up with the basin final basin the main basin what we are looking for and then we can also use this information for the bifurcation obtaining bifurcation ratios ok. But now you can do this very quickly using the software. You can extract these drainages using a DEM and then you can also go for the stream orders ok. So, you can do that very quickly using the software.

So, this part we will be initially. I have discussed that this is what we see in a stream order here and then we count the number of streams, how many number of streams we see of the first order, how many of the second order and so on ok. So, based on this will help in calculating the bifurcation ratio. So, when we are looking at the suppose this is the part which is which are with us then the bifurcation is been represented by a simple equation here that you have this is R b is bifurcation ratio and you are having N u plus the divided by the next higher order streams ok and that will give you the ratio here. So, the number of the segments here, for example, you are having here. So, you can also use that this is what is for the Hutton law, but we can use what we have discussed in the previous slide.

So, now, if you are looking at the first order then how many streams we are having this we say 10 ok. So, this is 1 here 2 3 4 5 6 7 8 9 and 10. So, we are having 10 here and then 2 second order is 3 we have we see here 1 2 and this is 3 here and third order is your final stream ok. So, the first we will not get, but the ratio we will get from the second one.

So, this ratio is 3.3 and then the ratio between the second and third order is around 3. Now, what is the importance of this because usually this has been used by the hydrologist

or to have the understanding of the flood intensity ok. So, the flood intensity is considered to be this to be a discharge along a channel over a time ok. Flood intensity will be influenced by the rate of runoff that is how much amount of water has been just moving without infiltration. The channel pattern shape and number of tributaries will also be important because these are the collecting streams which are going to pour water into the main stream and then distance downstream also ok. So, for example, if you are having streams coming here and so this is your merging point and then how much is downstream ok, what is the distance from here.

So, that will also play an important part ok from any drainage basin ok. So, from here this is like we have the collecting point here. So, what will be the discharge which we are expecting here at this point ok. So, these are the factors which will be affecting the flood intensity and all that. So, in stream orders the smallest tributaries are designated as we have discussed first order, those with the first order tributaries joints are second order and so on.

This is what we have already discussed in the previous two slides ok. So, lower order streams have shorter lag time between the rainfall. So, the lag time is between the rainfall and the flood events ok and are more prone to flooding ok. So, lower order streams what we are talking about is if you are having many first order streams ok, then that area is not at all good ok.

So, that will have a shorter lag time. So, this you should keep in mind ok when you are talking about higher order streams with many tributaries are less prone to flooding because that will have a higher lag time. So, this part you can keep in mind when you are talking about that ok. So, the drainage network of a river basin shape and channel pattern are the most vital morphometrics factors that play a significant role in increasing the rate of flow through the drainage system. Now, even with the higher R b values that is a bifurcation ratio values in elongated basins the hydrograph is very smooth suggesting less discharge ok. So, this is what you see is the less discharge even if you are having the higher bifurcation ratios.

Higher bifurcation ratios means you will have. So, like there is a rounded basin with the same area, I will just show the figure here. So, that you can understand this one. So, we are talking about two different scenarios: one is the elongated basin and the other is the rounded basin. So, the aim is to know what will be the discharge here in this case and what will be the discharge here as we have been talking about the shape of the basin will also play an important role. And of course, along with that the bifurcation ratio is also important ok.

But in higher bifurcation ratios you are expecting that the flooding will be very quick ok. But in this case what we see here is that the shape should also be taken into consideration ok. So, this is a discharge there is a time here. So, if you look at this one the hydrograph is gentle here, but in this case you are having a rounded basin the hydrograph is quite quick ok. So, these are the cases which have been talked about here . We are talking here like you have an elongated basin.

So, this one is your elongated basin and this one is your rounded basin ok. So, higher R b values in elongated basin the hydrograph is very smooth suggesting less discharge ok. So, this is less discharge. Rounded basin with same basin area. So, the area is the same ok the area is the basin area is the same . Usually if you just look at the basin area you can judge what will be the charge, but you need to look at the shape also ok.

So, a rounded basin with the same basin area having low bifurcation ratios shows higher drain discharge. So, this is like something unusual. What is the reason for that? The smoother curve of the narrow basin is your narrow basin here. So, if the smoother curve of the narrow basin with higher bifurcation ratio can be explained by greater time lag. So, time which has been taken to travel.

So, distance is also important ok. So, the time taken to have a full amount of discharge here is comparatively more than compared to the rounded one ok. So, it can be explained by the greater time lag for the water to reach the outlet whereas, the time taken from the upper ridges, middle and lower ridges in the rounded basin is less, causing higher discharge. So, even though the basin area is the same , the discharge varies because of its shape. So, the important point here is that you need to consider the shape of the basin also ok. The stream order and flood crush that is your hydrograph what we have seen here is that there is a discharge in time here ok.

So, whether it is like this or like this or it is smooth and very ok. So, what is the importance of this hydrograph and the stream orders and all that that we have discussed briefly ahead? The lower order stream tends to respond rapidly to any like even if it is stormy or it is a cloud burst and all that with a steep hydrograph. So, it will be very quick and because water has to travel a very short distance. So, this is a lower order stream that will not have a larger distance to be covered.

So, what is shown here is the lower order streams ok. Hence such streams provide less time for flood warning in the downstream resident because they have smaller drainage basins and carrying coarser and larger sediments of the for the given area ok. Whereas, the higher order streams with numerous tributaries have longer lag time between the storm and the downstream flood ok. Their hydrographs are less peaked ok. So, it will be like it

for in this case it will be something like this ok, but in this case you will expect that the hydrograph is quite peaked one ok. So, and covers a longer time period, flood warning time for downstream residents is longer.

So, if you are having higher order basins, then you are to some extent you have an time to give your issue and warning, but in terms of the lower order stream or the basin areas it will be you will be having less time to issue the warnings ok. So, now, you can use this information to talk about which area will have quicker flood and which areas will have the floods which will be slightly delayed ok and that you can issue the warnings and all that. So, this is what is the beauty of using the drainage pattern and all that and trying to look at the stream orders and then extract the information ok. So, using the satellite data you can do this actually. So, I will stop here and we will continue in the next lecture with more information on this aspect and also we will talk about as I have told in the previous lecture also that we are going to do one more exercise that is on morphometric analysis ok.

So, this is one of the parts of the morphometric analysis we will be doing. So, with this I will stop here. Thank you so much.