Photogeology In Terrain Evaluation (Part-1)

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Lecture – 15
Drainage Patterns and Their Morphology

Welcome back. So, yesterday; in the last lecture, we were talking about that how drainage pattern can help us in inferring or delineating the subsurface structure or lithology.

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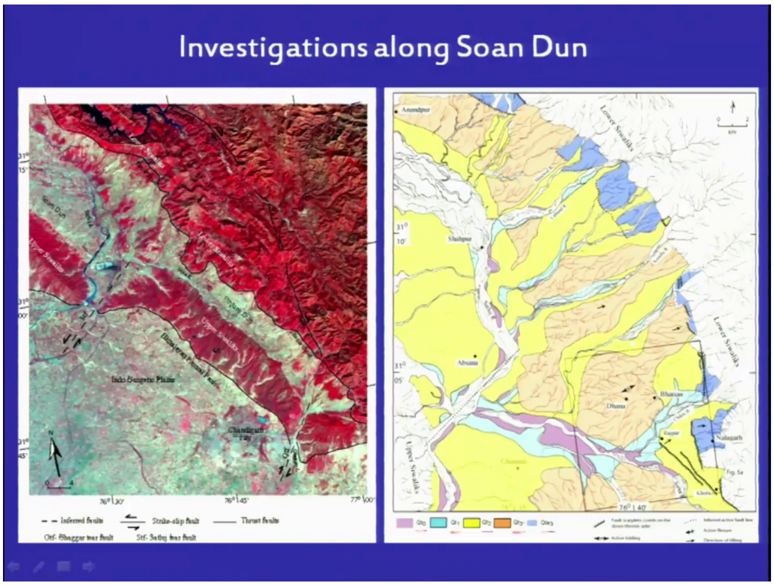

Now, this was the area as I told before that close to Chandigarh and we have the indo gangetic plain on this side and then you are having a very sharp boundary which marks the plate boundary between the Indian and the Eurasian plate and we have Siwalik hills which we say Siwalik or sub Himalayas.

Now, in this region particularly when we were doing survey so, before going to the field we prepared a basic preliminary geomorphic map. And this in this preliminary geomorphic map what we found was at the drainages at some, in some area were showing in typical radial pattern. We were bit surprised to see this that why in a flat area we are able to see such radial drainage, where there is no dome because in particularly if this area which you are looking at here is the region over here.

So, this is an inter mountain a valley between the two hill ranges I was just known as Soan dune, as I have already told that these dunes are the local terminology used for valleys intermountain valley. So, we have Deharadune, Binger dun, Soan dun. Similarly, like that and even the Katmandu is a valley so, within this valley how it is possible to see that there is a radial drainage.

At the same time what we also looked at because we were mapping some tectonic features and this these are the traces which we have marked as the active fault traces and this you will learn in the next part of this course a part two, where we will teach you how to identify such landforms and all that and tectonic features.

But in here I would like to very briefly mention that this for clients or the tectonic features we marked and we got very impressive signatures of this ongoing deformation on the surface and that is very well preserved in the and the drainage. So, let us we the close up view of this area what exactly it shows us actually so, this is an amine a panchromatic image of binger dun and Soan dun and the river which is flowing here is your Soan river. So, this is the reserves are river which is flowing and it is an tributary of the major river shut latch.

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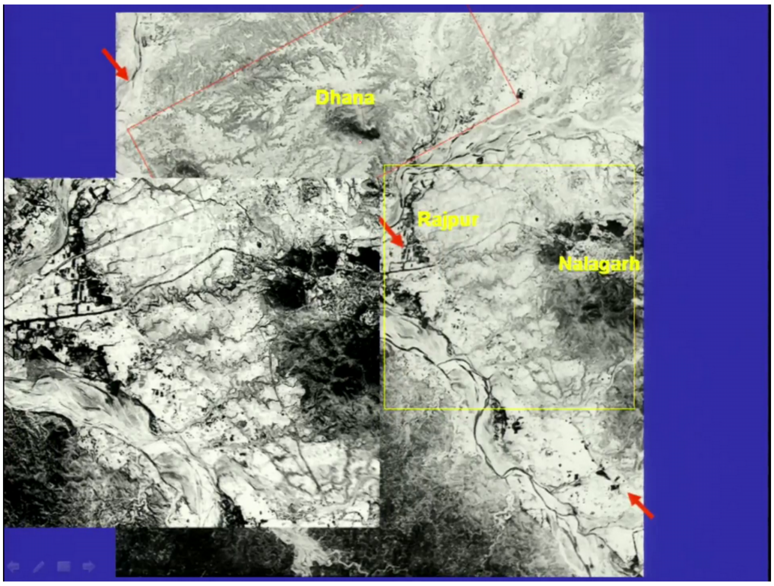

Now, you can if when I am I am putting my cursor here you will be able to trace out the some boundary over here, this is what we have marked as an active fall which goes like this here. I will show the close up of this, but before going to this part let us look at this region. Now, if you look at this region here this portion an very good example which shows an typical radial pattern. So, what we see if I trace out these streams here then you will be able to mark like let me take another color. So, if I trace out this drainage is here you can see this goes here smaller one is here I am just quickly drawing the major one so, that you can.

Now, what pattern you see here is that this is an elevated portion in the center and then you have in radial drainage which is flowing in all directions away from the center. So, this was one of the indication which we took into consideration that this is an typical up wharf area. So, we decided to go in field and check that whether this is or not.

So, this location is known as Dhana and then this is the area known as Nalagarh and the fall trace which we finally, conclude that it process through this here and then further here. So, these arrows are marking the trace of the tectonic feature close up of this if you look at then what you see here ok. So, will just remove these drainages so, that it is clear.

So, this is the trace here which we marked now what you are able to see here is that on the right hand side of this line that is what we call the fall time you have a very tight meander. So, if you see the meanders here it is very tight, but as soon as you crosses this line then you are having very almost straight challenge. So, this an clear example that the block on the right hand side is the hanging wall and it is getting deformed as compared to the fut wall on this side. So, this is your fut wall and this is your hanging wall and then fall trace goes somewhere over here.

So, you can easily demarcate such features on the earth surface using the drainage pattern also. So, channel morphology plays an very important role in identifying several such features. So, let us look at this one that is close to Dhana the field example of this so, this is what we have already discussed.

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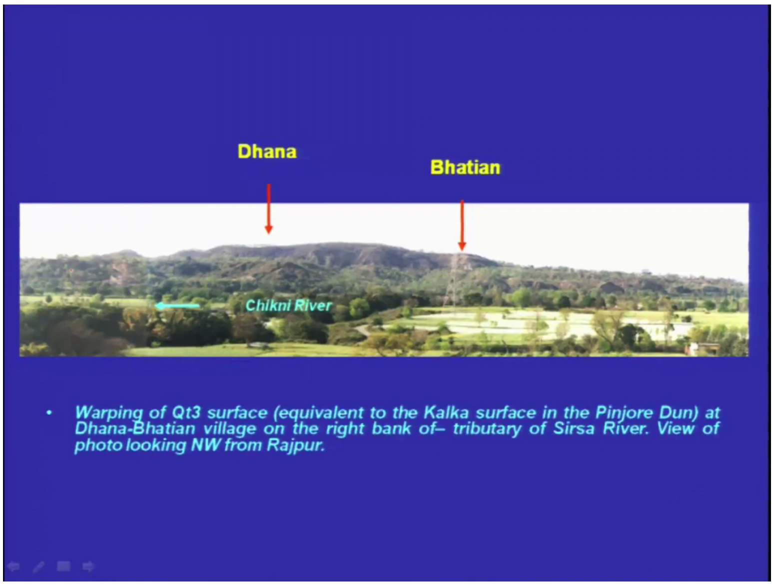

Now, go to field and then this is what we saw so, it is clear cut what area which was showing as the radial drainage pattern.

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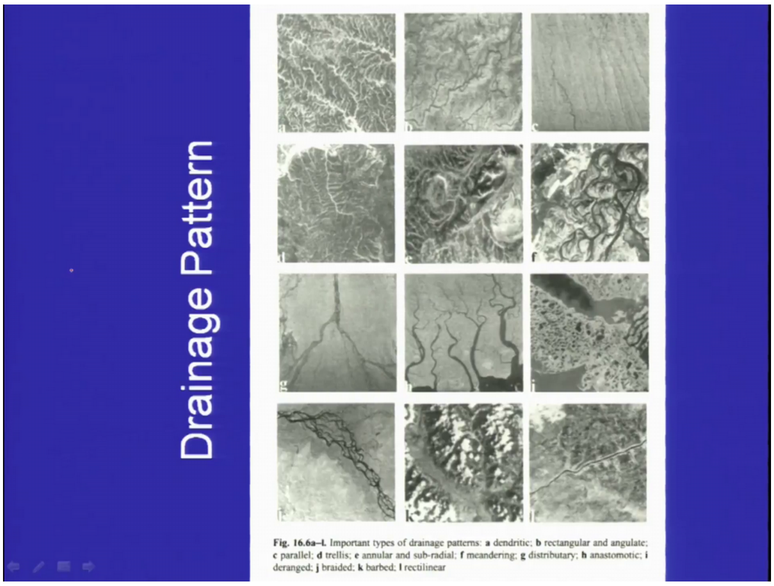

Now, we discussed few drainage patterns and here there are listed more. So, I request you to go through it, but few we will see we have already discussed and as I told that that some of the drainages will indicate you the lithology. Other the area is comprised by homogeneous material or it is an flat line or it is fractured with an right angle ok.

Either the drainages are flowing in the folder terrain where you have weakened harder rocks. So, and some of the examples are of parallel drainages which are very much similar to the consequent drainage which are developing over the slope.

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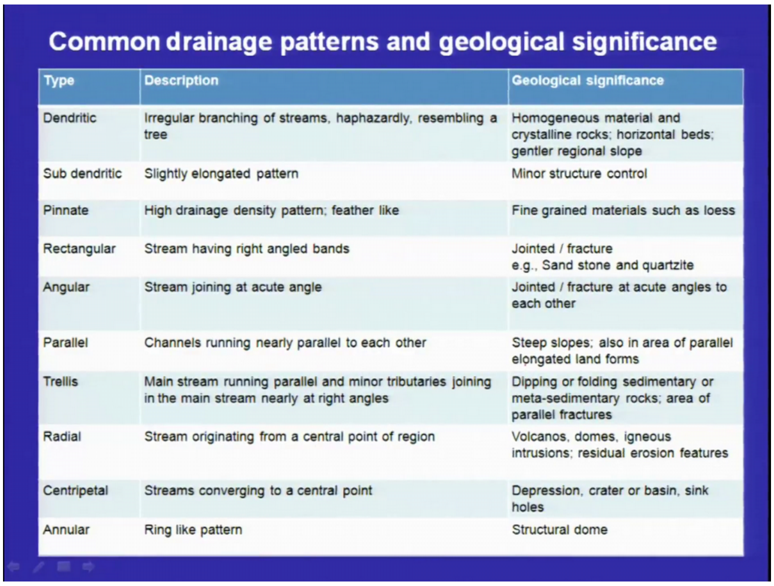

Common drainage patterns and geological significance

Type	Description	Geological significance
Dendritic	Irregular branching of streams, haphazardly, resembling a tree	Homogeneous material and crystalline rocks; horizontal beds; gentler regional slope
Sub dendritic	Slightly elongated pattern	Minor structure control
Pinnate	High drainage density pattern; feather like	Fine grained materials such as loess
Rectangular	Stream having right angled bands	Jointed / fracture e.g., Sand stone and quartzite
Angular	Stream joining at acute angle	Jointed / fracture at acute angles to each other
Parallel	Channels running nearly parallel to each other	Steep slopes; also in area of parallel elongated land forms
Trellis	Main stream running parallel and minor tributaries joining in the main stream nearly at right angles	Dipping or folding sedimentary or meta-sedimentary rocks; area of parallel fractures
Radial	Stream originating from a central point of region	Volcanos, domes, igneous intrusions; residual erosion features
Centripetal	Streams converging to a central point	Depression, crater or basin, sink holes
Annular	Ring like pattern	Structural dome

So, these are few more subgroups or subtypes and they main types which has been given here Dendritic patterns, Sub dendritic, Pinnate, Rectangular, Angular, Parallel, Trellis, Radial, Centripetal, Annular and the description of the same is been given here. So, I would request you people to go through it and we can move ahead in this course. So, for example, the rectangular drainage if you take and most commonly found as a dendritic, but you look at that rectangular stream having right angled bands. So, what does the geological significance is joints in fractured example in sandstone, in quartzite sandstone a sedimentary rock or say it is an metamorphic rock ok.

Then if you look at the dendritic pattern irregular branches of stream haphazard resembles a tree, tree like pattern. So, it is an homogenous material horizontal beds gentler slope etcetera. So, go through it this will help you in interpreting your observations which you will be doing based on the satellite photo interpretations.

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Now in Drainage Basin Evolution and Morphometry, Drainage Patterns we will see few examples here which will help us in inferring our observations.

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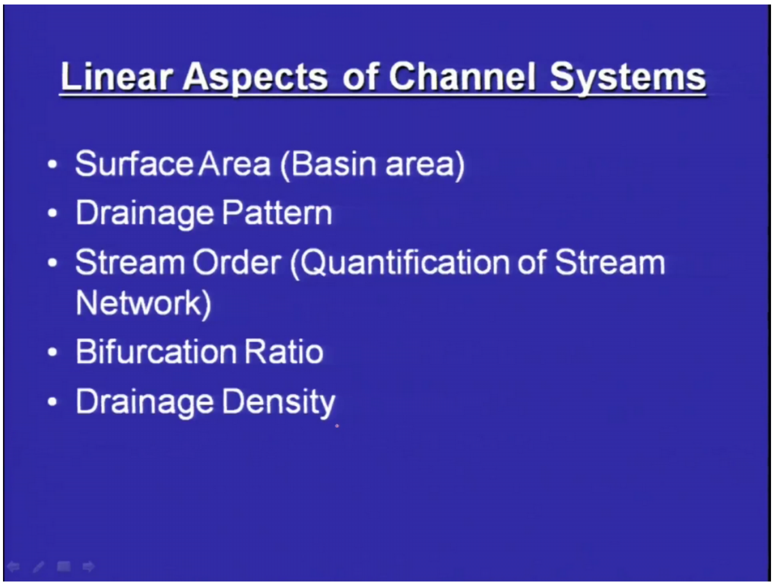

So, fluvial geomorphology we have linear aspects of the channel system then aerial aspect of the channel system of the drainage basin, channel geometry and then process domain ok, but we are not going to talk all here, but few which are important for us we will discuss. So, the linear aspect of channel system if you take usually what we look at is the basin area is on the surface area. Drainage pattern we are interested in and the stream order. Now, stream order of course, you can use because most of the hydrologist will use this in quantifying the stream network and which is useful for the flood hazards and all that ok.

And even though this can help in identifying the subsurface lithology then coming to the bifurcation ratio is also important. How the lower order and higher order streams are been seen, in the basin how they are distributed. Then drainage density, drainage density will again play an important role in become a important role in runoff when there is an heavy rain and then this will play an important role the drainage density.

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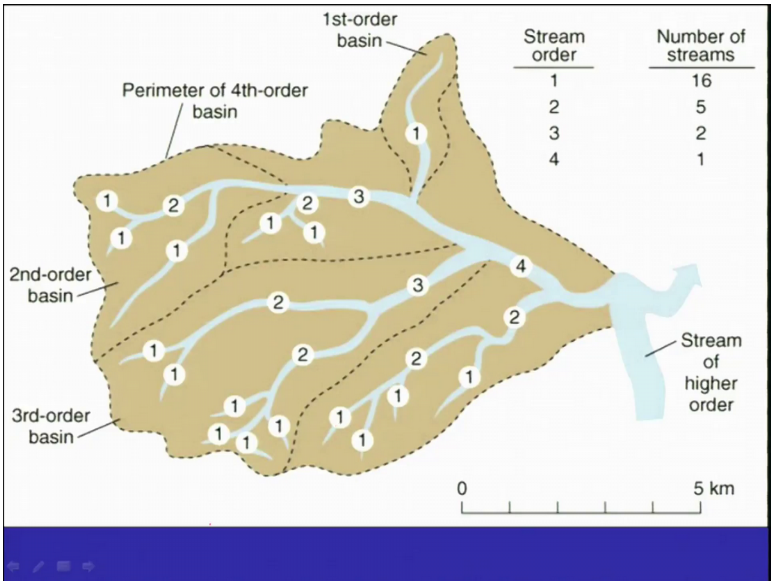

So, if you have to look at like any drainage basin as we have been talking about that each major trunk stream will have its own drainage basin and of course, those smaller drainage basins which we are we can call them as a sub basin ok. And this is the boundary what we call the basin boundary of this trunk stream and within that we have small tributaries.

So, smaller streams soiling making the next higher order stream this is what is been shown here this what we call stream ordering. So, we have at the place where the basin or the river originate or the smaller tributaries originate and goes and meet the major one. So, you have the first order stream you have first order stream.

So, when two first orders stream meets at a point the downstream portion of the river will become the second order and similarly if two second order stream meets then it becomes third order, two third orders stream meets and it becomes fourth order and this is how the ordering has been done .

And you can then calculate the based on the stream order the number of streams you are having say like first order you are having 16 and this will help you in getting the bifurcation ratio of the basin area.

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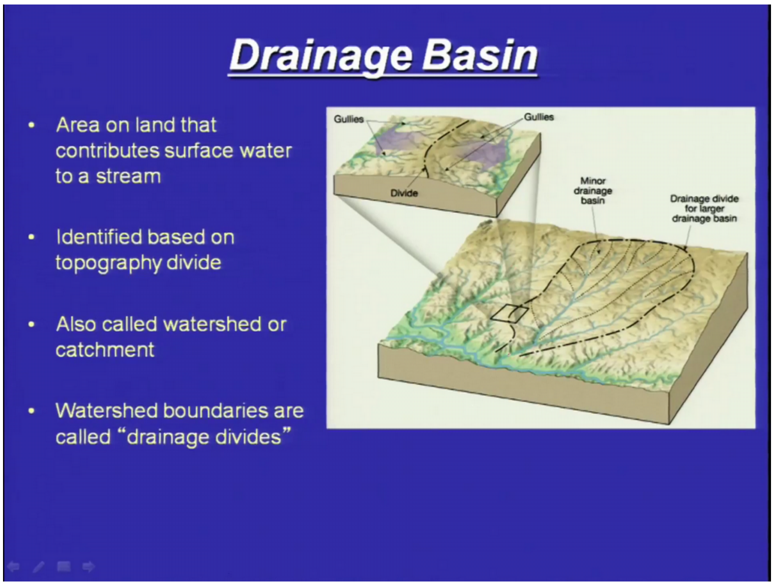

So, area on land that contributes surface water to the; to a stream like this is the drainage basin. Identified based on the topographic divide also called as the watershed or the catchment area ok. So, watershed boundaries are called drainage divides this is the example for that. So, you are having one stream here another one here this is a major stream and of course, they are the tributary of this major one.

So, this are the sub basin of other stream actually so, this is the divide between this basin and this basin here.

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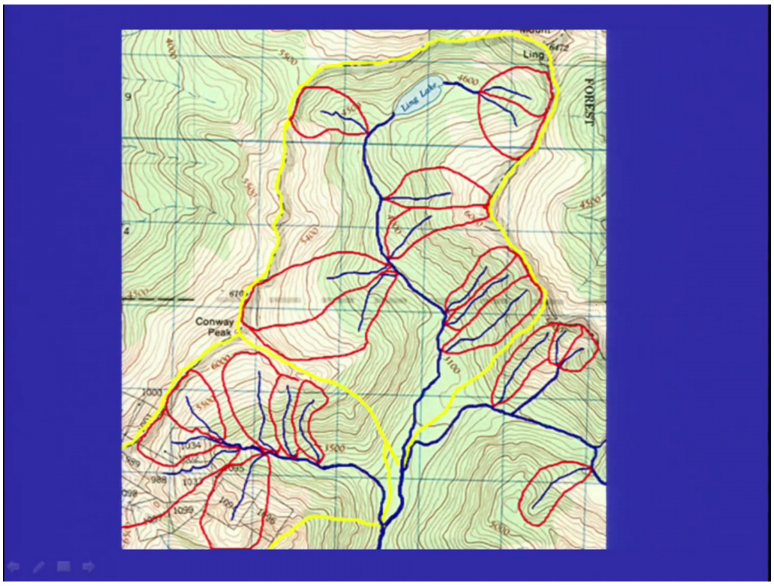

So, this is how it is been shown that you have major streams and then you have the sub basins of that ok.

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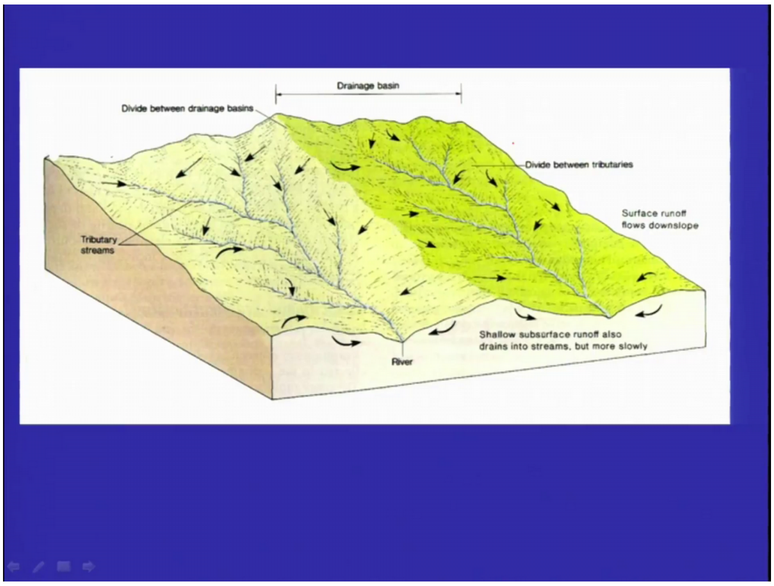

And this is shows the drainage divide between the two drainage basin. So, you have one basin here another one here. So, we are having this streams flowing in this direction coming here and meeting the major streams something like that so, those are the smaller tributaries of that main stream.

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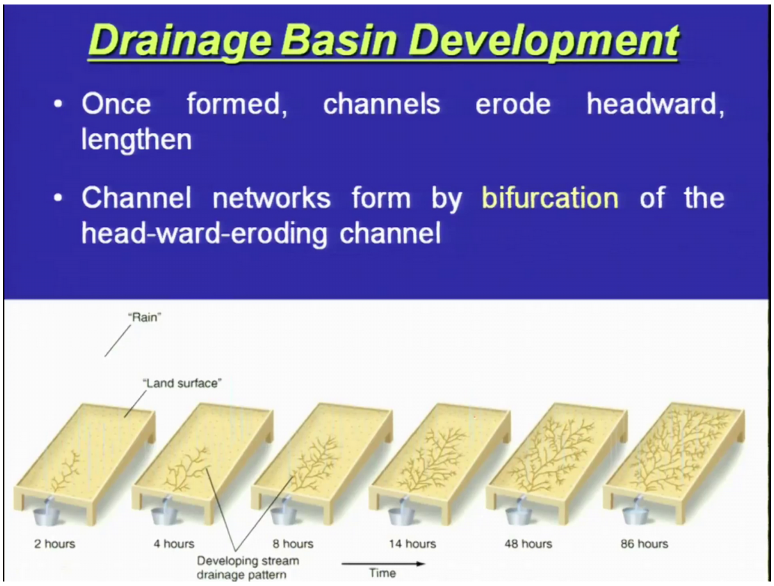

Now, as I was talking about that how they about the head-ward erosion and the development of the; or you can say the how the basin will evolve over the time. Now, this is an very simple example which has been given here of course, you need a slope and you need a precipitation ok. So, once form that channel erode and lengthen its area or it will keep on adding the are the more streams here that is the channel network forms by bifurcation of head-ward eroding channels.

So, what is been shown here that over the time same amount of precipitation there is slope is the same. In 2 hours, in 4 hours, 8 hours; what is happening is? Smaller streams are developing slowly and slowly and you are what you are able to see is that this is the fix point, but the drainage is evolving in the head-ward side ok; so, towards the upland so, this is what you can look at the development of the drainage basin.

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Now, this is an example from Great Rann of Kutch which shows an very typical example smaller is basins and all if you see a very typical tree like features here ok, typical tree like features you can see or here the; so, this is what we call this as an dendritic drainage you have the main stream and then you are having the tributaries. So, slowly what is what will happen well that this keep out this will keep on growing actually? So, next it will grow here this probably will merge and then so, on if you look at the close up here.

So, you have smaller stream now another important point is that since we have we classify that looking into the pattern. We say that this is a dendritic pattern so, this indicates not there has to be in homogeneous flat area or homogeneous material with an flat surface. Of course, yes this area is comprised of mostly the tidal flat material or the tidal flat deposits which are almost homogeneous silty clay mostly and fine sand. So, there is an homogeneous material which also is reflected in the dendritic pattern.

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Now, this observation just to show that how over the time the river or the fluvial system will evolve and different landforms will be formed ok. This we were doing field in Andaman and what we observed was that when the sea water was coming in this is a beach here and then flowing back. So, while going back there was there is an definitely what we see in a slope break in the slopes here. So, when if it will return back to the ocean of course, what you will be able to see is that distributed network and this is what we were able to see.

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And this is typical of delta what you see in the major or a system or the major rivers when they are meeting the ocean ok.

So, what we found is that we have the channel here I will show the close ups where I will show the terraces and all that. So, this is on the very miniature scale very small scale, but we were able to see some fascinating landforms here and then you are having braided system, over here you are having braid bars, you also have meandering system here ok. Let us see the close up somewhere over here what we are able to see here this one see this is the; what I was talking about the river bank.

So, you have a terrace here and then similar terrace continues here, but over here you have a meander and you have multiple terraces. So, one is this one another is in this one and third one is sitting here. So, these are the; this how the terraces will form over the time ok.

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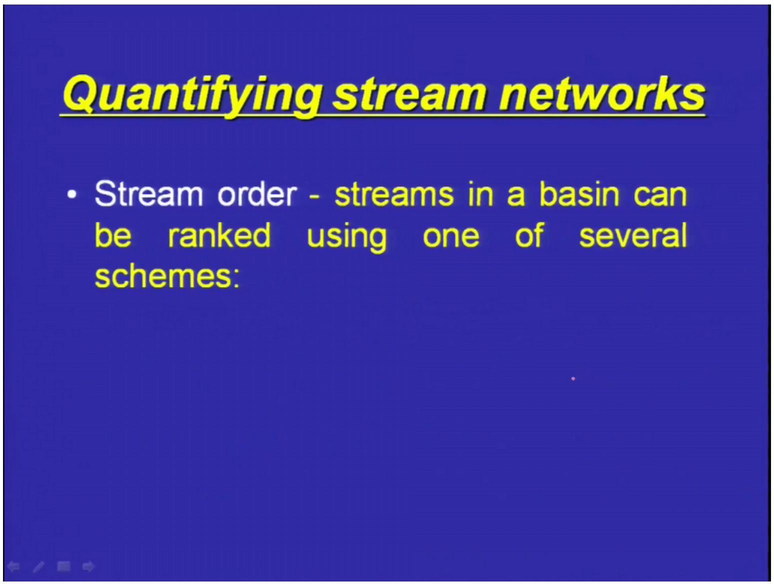

Now, quantifying stream network stream order usually what we say is that steam streams in a basin can be ranked using one of the several schemes ok.

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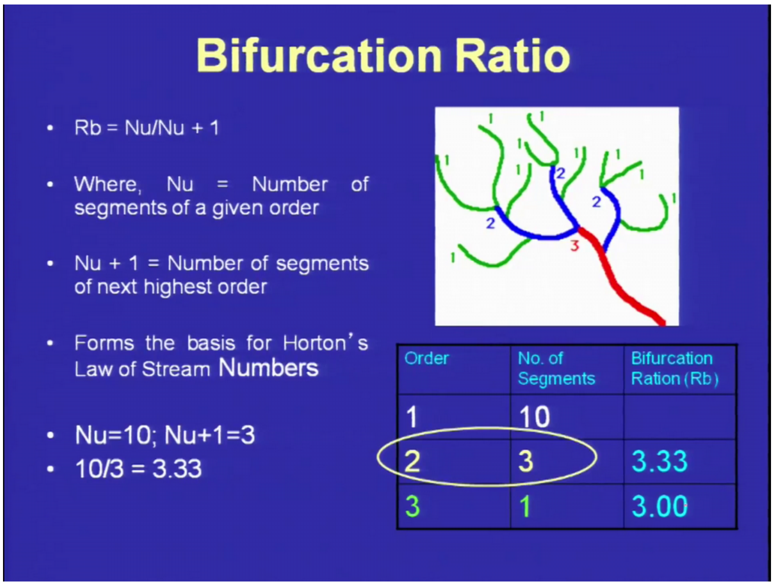

So, we have this is one of the scheme which I have already discussed. So, if you are having lower order streams then you have joining the low to lower or a steam joining giving rise to in higher order streams ok. Now, if you have to come up with an bifurcation ratio as I told that we can have number of streams and then you can based on the number of streams of one particular order, you can talk about the bifurcation ratio. Now, what is the bifurcation ratio let us look at this so, it has been denoted by Rb where which is equal to in Nu by Nu plus 1.

So, Nu is the number of segments of a given order so, if you are having given order 1 then you will have that number. And then Nu plus 1 is your number of segments that is the stream model of the next higher or the highest order ok. So, you are you are looking at the ratio between that ok. So, which forms the on the basis of this is on the base of Horton's law of stream numbering.

So, if suppose you are having Nu is 10 then Nu plus 1 is 2 here so, for example, what you are taking is have this one second order stream and this one is the first order steam. So, you are having 1, 2, 3, 4, 5, 6, 7, 8, 9, 10; so, 10 is your first order and then you are having second order. So, next higher order is your second orders we are having 3 streams of that. So, the ratio between the first order next higher order will be your 3.33 and so, ok. This is useful in some cases so, this is how you will be able to see are the first order and the second order ratio second order and the third order ratio and so on.

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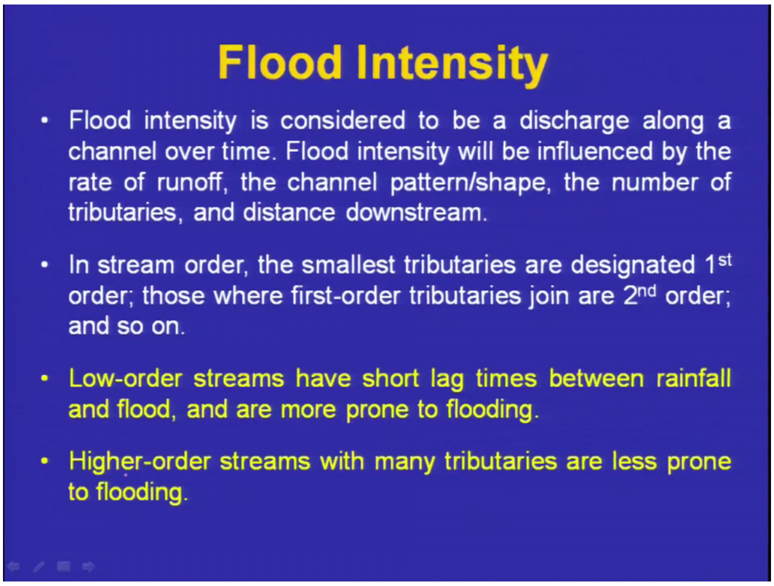

Now, this is important when people are talking about the discharges and all that take the flood intensity. So, flood intensity is considered to be a discharge along a channel over the time and flood intensity will be influenced by the rate of runoff. So, if the runoff is very high then also you will have floods, but if runoff is very less and you may not come across the flooding event ok.

So, they a channel pattern and the shape will also play an role along with the runoff. The number of tributaries that is what we were talking about the bifurcation ratio as well as this will also talk about the drainage density and the distance. So, when you are extracting the information of any drainage basin and this can be kept in mind ok. This can help you in talking about; whether this area will have higher floods in the intensity of the flood will be higher or less that you can talk ok.

So, in stream order the smallest tributaries are designated at first order this we have already discussed and those were first order tributaries joints two is first order then you have second order and the third order so on. So, usually it is been observed that low order streams have shorter lag time between rainfall and flood. So, when are the rainfall start when the precipitation the water falls on the surface, then the time taken by the lower our stream will be very less because they are very short. Hence, the time lag will be very less so, they will have the bank full flow very quickly as the rainfall started and the between the flood and are more prone to flooding.

So, you will have if you are having floods number of higher or lower order stream then also it is not quite actually whereas, the higher order streams with many tributaries are less prone to flooding. So, this is an in general it is been understood that this will happen ok.

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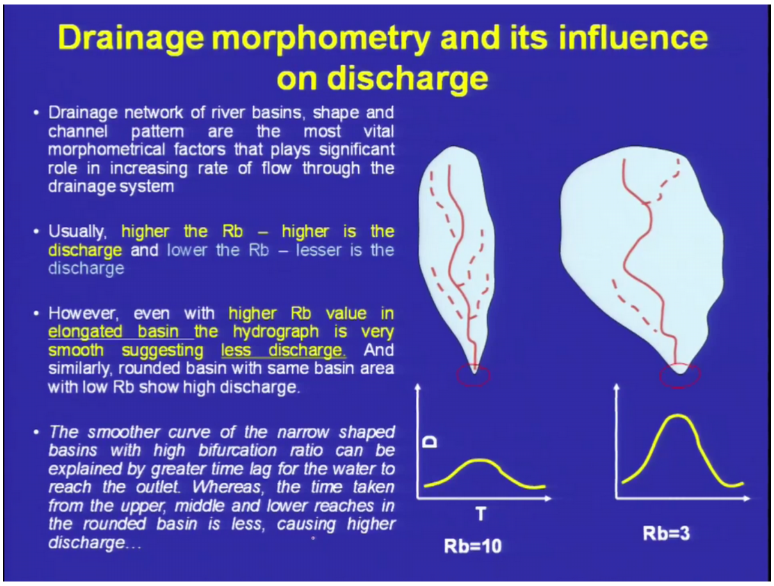

Now, drainage morphometry in discharge if you look at this is one in one of the example which has been given here. That usually it is what has been seen that if you are having the higher bifurcation ratio will lead to the higher is the discharge and the lower bifurcation ratio lower is the discharge ok.

But as I told that the discharge will depends on the shape of the basin the distance that is also again very important and they runoff in the region, that is the lithology will also play an important role ok. So, drainage network of river basin shape and channel pattern are the most vital morphometrical factors that play significant role in increasing the rate of flow through the drainage system.

So, with this understanding let us see one example somewhat exactly happens. However, even with higher bifurcation ratio or higher bifurcation values in elongated basin the hydrograph is very smooth suggesting less discharge. So, hydrograph is again the time lag and then you are having the amount of precipitation you are having ok.

And similarly in terms of the rounded basin with the same basin area with low Rb value shows higher discharge, but what we were talking here that if you are having low Rb values then you will have low discharge, but here low Rb value shows higher discharge. The reason is here for example, so one you are having the elongated basin where you have the Rb value is quite high that is the bifurcation ratio is were quite high and this is your hydrograph ok.

So, if you look at this one here. So, what we see he is in a bifurcation ratio for this elongated basin is almost like 10. So, what you should have been we should have expected is and a higher Rb, higher discharge at this point ok. Now, what has happened is that if you see the hydrograph here it shows very smooth so, time lag is quite high between the flood peak flood and the rainfall and over the time ok.

So, this is because the because of the distance the so, the smoother area or this now the rounded basin is having very fast peak; we get that like the flooding event at even with the lesser Rb values ok. So, what are the reasons for this? So, one most important reason is the smoother curve of the narrow base narrow shape basin this is we are talking about this one with higher bifurcation ratio that is 10 can be explained by greater time lag.

So, the time lag was much higher for the water to reach the outlet this is an outlet here ok. Where is the time taken from the upper middle and lower reaches in the rounded basin because the basin is rounded? So, the distance are shorter no doubt the area is almost same, but that plays an important role. So, upper middle and lower reaches they rounded basin is less so, the time is taken by this region is less because it is does it since its less causing higher discharges. So, this also one can keep in mind.

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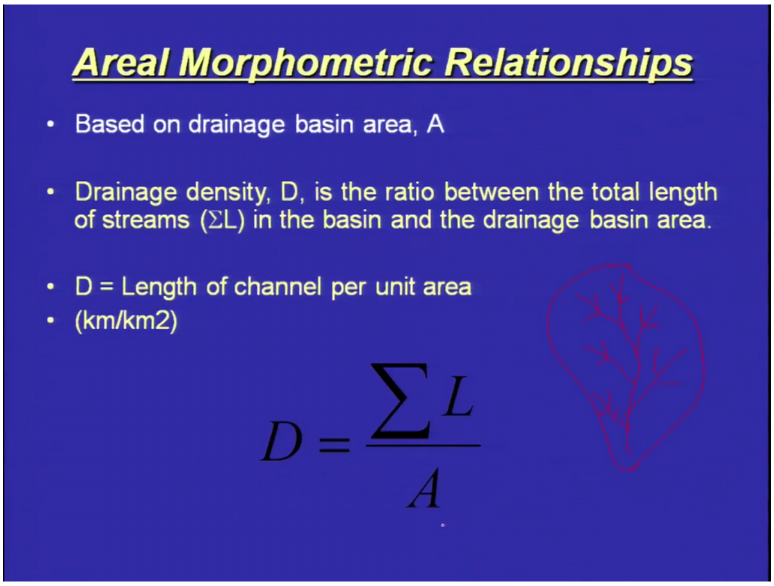

Now, areal morphometric relationships if you take this is an very extremely important one is the drainage density ok. Now, the drainage density is been considered as it is based on the drainage basin area A and then drainage density D is the ratio between the total length of the streams ok. So, all streams you take into considering sum up which are you encounter in the within the basin and the drainage basin area ok.

So, what you are doing is that you are having this one basin area here and then you have a major stream you are having smaller streams here. So, what you are doing is that you are taking into consideration the ratio between the total length so, you will take the total length of the streams which are available irrespective of their order.

So, you will consider that you sum up this and then you will take the ratio between with the drainage basin. So, it has been given as the D length of the channel per unit area. It is given in kilometer per kilometer square so, you are taking length per kilometer square area ok. So, it has been given as sum of all length of the streams which you will encounter within the basin by the basin area.

So, this exercise also we will do it and you will be; we will try to identify that what is the drainage density of a particular basin.

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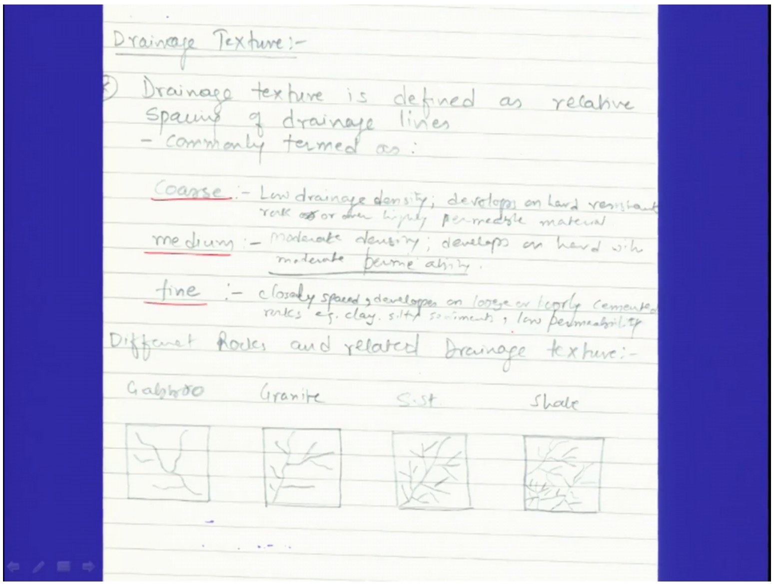

So, we will do one lap on this now this is along with the drainage density this is another important part which we call is a drainage texture ok. So, the drainage texture is defined as relative spacing of drainage lines commonly termed as coarse, medium and fine. So, in terms of the coarse what you have is the low drainage density, develops on hard resistant rocks or over highly permeable material ok.

Then you are having medium, moderate density develops on hard rock with moderate permeability, fine closely spaced develops on loose or poorly cemented rocks; example like material like clay also silty sediments with a low permeability. So, what does that indicate that low permeability and high permeability here that it will allow. So, when there is an rainfall or water comes on the surface it will percolate down into the ground ok.

So, if it is percolating down very fast hence we are having a highly permeable material. So, it will give lesser number of streams developed over the surface that is will lead to the low drainage density. So, you will have low drainage density and you will see very few streams on the surface. Hence you designate that as an coarser drainage texture ok. Medium you are having for example, in granite or sandstone, but in terms of the shale; the shale is the material with the rock with a low permeability ok.

So, what is happening is that the stream will keep on the water will keep on flowing and carving the in the surface and will result into the closely spaced drainage developed ok. So, this will give you like similarity of dendritic pattern, but it will be closely spaced. So, I was showing one example from Great Rann of Kutch, that shows very typical drainage which is we can texture which is which we can classify as an fine texture of or the drainage fine drainage texture.

So, this also can help you in identifying so, in terms of the metamorphic rocks this is grainer and gabbro you will have mostly the coarser drainage texture. In granite you will have medium and sandstone also medium to fine, but in shale you will have fine drainage texture ok.

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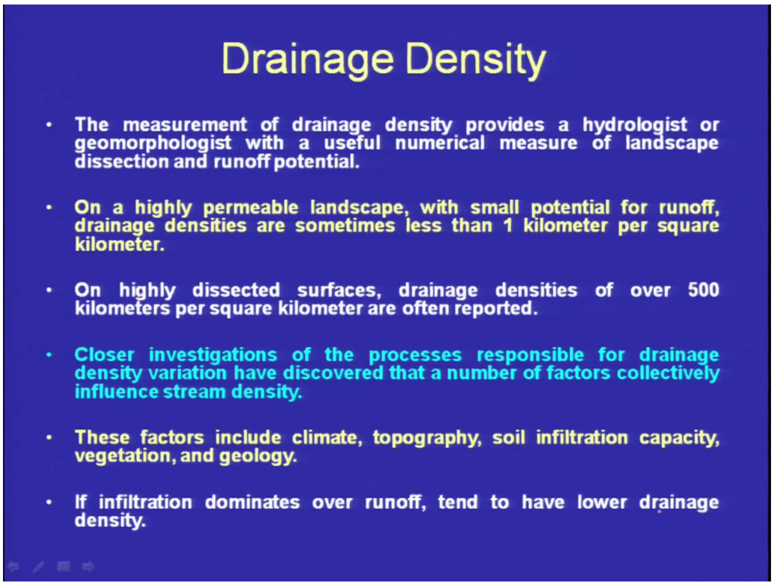

So, in short the drainage density the measurement of the drainage density provides and hydrologist or a gemorphologist with a useful numerical measure of landscape dissection and runoff potential. So, if you are having highly dissected land form so, you can also talk about that this is this area is having more number of streams ok. And you have the potential of runoff main trees so, this can also helps in identifying that what is the subsurface geology.

So, on a highly permeable landscape with small potential for runoff because if it is permeable that runoff will be too less ok; the drainage density are sometime less than 1 kilometer per 1 kilometer square. So, this is in the case of the permeable so, everything whatever the water is coming in most of the water is getting percolated. Then on highly dissected surface drainage density of over 500 kilometer per kilometer are often reported this is these are the areas where you are having high drainage densities ok.

So, closer investigation of the processes responsible for drainage density a variation have discovered that number of factors collectively influence the drainage density, where this factors includes climate. Because if you do not have enough water you will not have drainage development topography, you do not have slope you will not see any drainage development.

Soil infiltration capacity if you are having porous material or porous soil then you will have very quick percolation and you will not allow the formation of the drainage. Of course, the vegetation can play an important role and the geology what we are talking about here, but here we can say that final let us talk about the rocks and the soil also .

So, if you are having hard rocks, you will not be able to see much of the drainages are forming there like what we were looking in gabbro metamorphic rock. We are having very coarse drainage texture ok, if infiltration dominates over runoff tends to have lower drainage density ok. So, if you have very high infiltration rate, then you have lower drainage density and you will have coarser drainage texture rocks ok.

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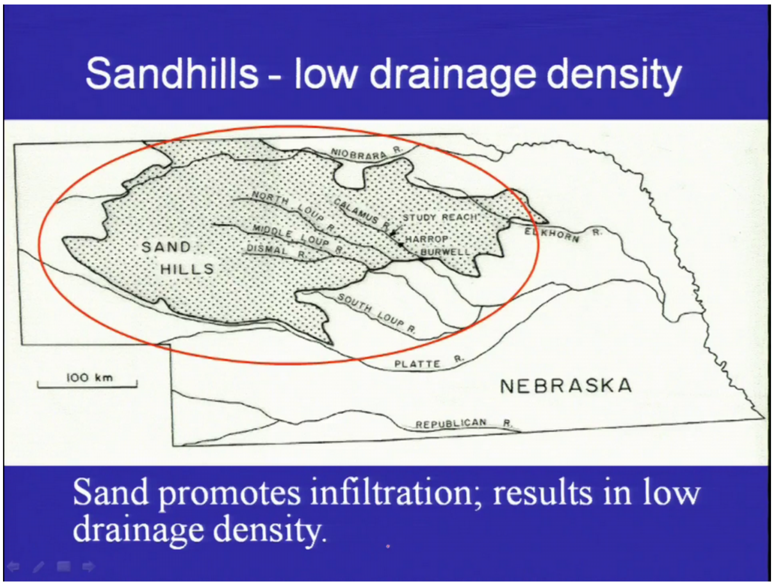

So, this is one example if you look at within the same basin at some location you have very low drainage density and this was the reason because this portion of the area is comprised of Sandhills ok. So, Sandhills again it is an porous material loose material so, though the water coming on the surface will faster it percolated down and you will not see much of the drainage development.

So, this shows that this area is having coarser drainage as well as the drainage density is very less so, sand promotes infiltrations results in the low drainage density. So, I will end here.

Thank you so much.