Geomorphology
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Lecture- 49
Fluvial Process- V, Drainage Analysis

So, friends welcome to lectures geomorphology and today we are going to continue with the fluvial process and particularly drainage analysis. So, if you remember last class we are talking about these channel habits how different channel habits are formed with the changes to grain size slope and channel width and the water content. And finally, we found the channels which are narrow and deep, are more efficient as compared to the channels which are wider and shallow.

And the efficiency of a channel it depends upon its hydraulic radius and which is a measure of it is wetted perimeter and cross sectional area. So, remaining cross sectional area constant if wetted perimeter varies, then the hydraulic radius varies, and those hydraulic radius it is measure factor that defines how efficient the channel will be. So, today we will talk about this a drainage analysis what does it mean? What the drainage analysis says about this area? Either it is related to lithology related to slope related to climate related to tectonic and related to any other.

Suppose for example, alluvium whether this alluvium which type of material is consistent and what are these channel patterns and channel patterns formed and whether this channel pattern will remain as it is throughout its timespan, or it will change with time with the change in the climate and tectonics scenario, and how this channel pattern will be interpreted to infer what lies inside what structure of what lithology lies inside.

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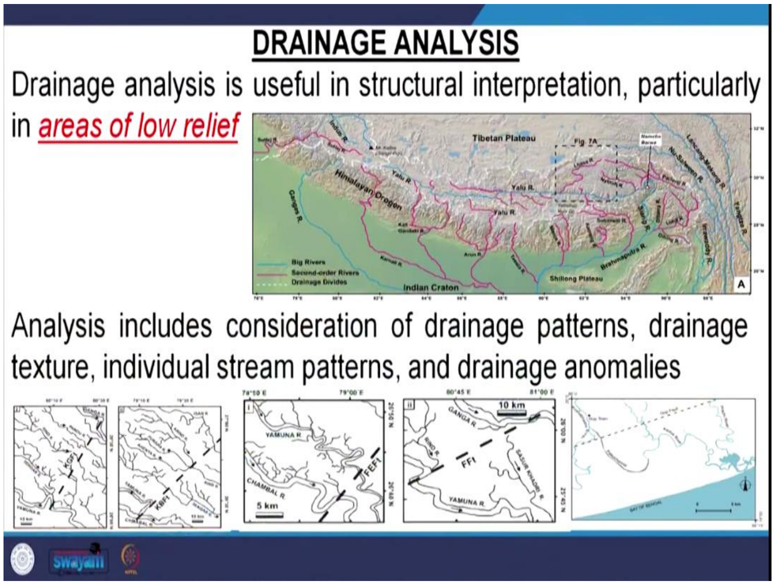

So, drainage analysis, it is a useful tool for structural interpretation particularly in areas of lower relief why the lower relief and why not in high relief, so why high relief areas more, mostly the mountainous terrains. They are very rock terrains and drainage has to adjust themselves. So here in the low lying areas, low relief areas where frequently change drainage they are frequently change their positions.

And they are free to move and this low relief areas generally mostly it is alluvium cover for example, we take this example of Himalayan and the Ganga plain, the Ganga plain, it is a lower relief area filled with alluvium. So, these are the alluvial channels and those rivers which are coming out of this Himalayas.

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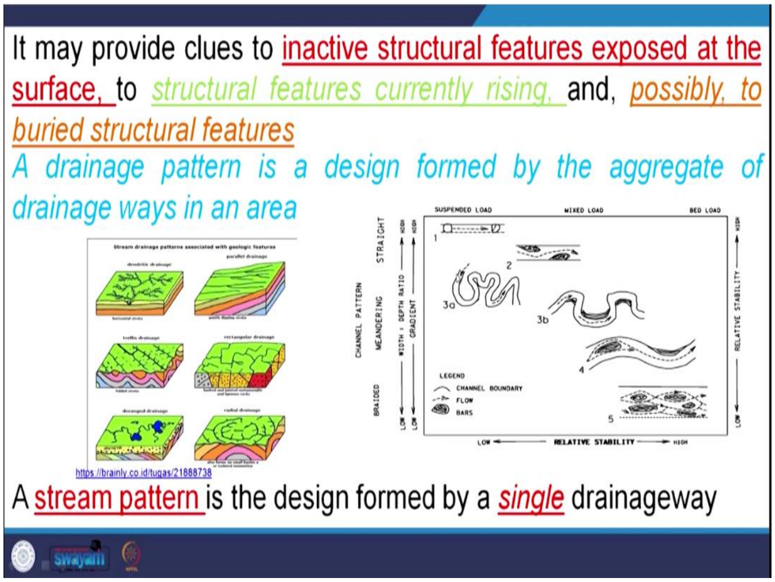

So, you will find their behavioral change at this Himalayan system as well as the same river the same channel which was flowing at this Himalayan system or this Ganga plain system so, this drainage analysis includes concentrates of drainage pattern. Drainage pattern that means, what type of drainage pattern is it? The either it is a dendritic pattern, a trellis pattern parallel sub parallel there are many drainage patterns are there.

So, it includes what is the drainage pattern first drainage analysis if you were asked to do so, what are the different parameters you have to calculate what and what basis you will calculate the drainage analysis or what basis you will carry out the drainage analysis it is mentioned here. So, first is drainage pattern, what is the different drainage patterns you are finding in this area then drainage texture either it is a coarse texture or it is a fine texture that means the drainage they are very channels they are very closely spaced or they are widely spaced.

Then individual stream pattern, individual stream pattern as we have already discussed individual streams either it is straight channel it is a meandering channel it is a braided channel. So, individual stream pattern how they change and drainage anomalies drainage anomalies is very important in terms of deciphering the structural patterns inside for example, if you see this figures are given here, these are this drainage pattern or this drainage anomalies from this Ganga plain these 4 this 1 2 3 4 photographs or through figures from this Ganga plain.

And this 5th one it is from these coastal plains of Indian east coast. Now, you see, suppose for example, this Chambal river is flowing here and you see there is sudden there is a change in meanders change in sinuosity of this river. Similarly, hare there is a change in sinuosity of these are anomalies. So, that means within a straightness of channel or particularly, if it is a straight channel or within that or braided channel, within that, you will find some exceptions.

Similarly, here if you see there is a channel offset and here if you see here, there is a channel offset is here and there is converging of stream are there that means all this this offset, the stream convergence, and this stream the stream offset, they are coinciding in a single line. Similarly here, this drainage offset and this offset there, and they are falling under a single line. Similarly, across along this line, you are finding that some of these new streams are generated here.

So, that means these are the drainage anomalies. By looking these drainage anomalies we can predict what type of structures we are expecting in this particular area. So, this drainage anomaly has been successfully used in recent days in deciphering, active dormant structures in these alluvial plains which has buried inside. So, though there is few anomalies that found along this along a straight line or along zone.

They are very much useful to deciphering the tectonic activity in recently, particularly in the Ganga plains, how this drainage anomaly has been used to decipher the active faults. There are a number of obligation very recently this came out here. Silt may provide clues to inactive structures or structural features exposed at surface to structural features currently rising and possibly to buried structural features.

So, mostly these drainage anomalies or drainage patterns, they are providing sufficient clues to find out what are the different structures either it is inactive structures or active structures and possibly buried structures, particularly in the Ganga plain. If we talk about the buried structures, we have basement faults several basement faults that lying kilometers distance kilometers depth, but though they are lying kilometers depth.

But still, their activities, their movement along this fault that affect the surficial topography in the minor topographic variation is there minor topography, relief variation are there and these minor relief variations also, that effect the drainage pattern and the drainage anomalies, but here you have to keep in mind that larger rivers like this Ganga, Yamuna and Ghaghara, Kosi this larger rivers or any larger rivers, they respond very less to this topographic height or lows of these structures as compare to the smaller river of their area.

Because smaller rivers smaller channels, they have less capacity and less competency also. And this channel strength is very low as compared to larger rivers. So that means, in other words, we can say they are less efficient than the larger rivers. So for example, suppose there is a half meter or 1 meter difference differential movement along a fault. This large rivers can cut through this differential elevation or the elevation difference and can readjust themselves.

With a few years or so, but at the same time, the smaller rivers which are cross cutting this elevation difference, may readjust themselves by abandoned channels by generating new stream by converging streams like that. So that means I want to say, even the same scale of movement along a fault, the larger rivers respond less as compared to smaller rivers. So that is why in a rivers in the alluvial plains for analyzing the drainage anomalies, we have to be careful choosing the rivers.

So in Ganga plain, particularly or the Himalayan terrain particularly, there are mountain fed river systems like the larger river which are fed from the snow and there perennial rivers that mountain fed river systems. And some of this river is rivers they are plain fed rivers they are just originating from these plain from this groundwater fed. And we have to analyze if we want to analyze this reagent tectonically. So, we have to confine our self for the plain fed rivers because they are more responsible to detect the changes.

So, changes can be detected very readily and this plain fed rivers as compared to the mountain fed rivers because they are capacity is more they can adjust themselves by cross cutting this elevation differences. So drainage pattern is a design formed by this aggregate of drainage ways in an area. So, drainage ways there is which way this drainage is flowing either straightway there is a sinuous way there are cross cutting ways.

So, these are these different type of drainage ways through which these channels are adjusted themselves. And finally, this defines the drainage way or the drainage patterns. A stream pattern is the design of this single drainage way. So once we say a drainage way that drainage pattern, that means number of streams in that area what is there the overall drainage ways to analyze, but once we say stream pattern stream patterns means here we are considering single stream rather than more than 1 stream.

So, stream pattern and drainage pattern are different stream pattern we only consider only 1 stream either it is sinuous stream straight or it is a meander or it is a braided like that, but drainage way that means in an area number of streams are there number of that means within a river system, there may be 1 sub basin is there some this so that means that defines the drainage pattern.

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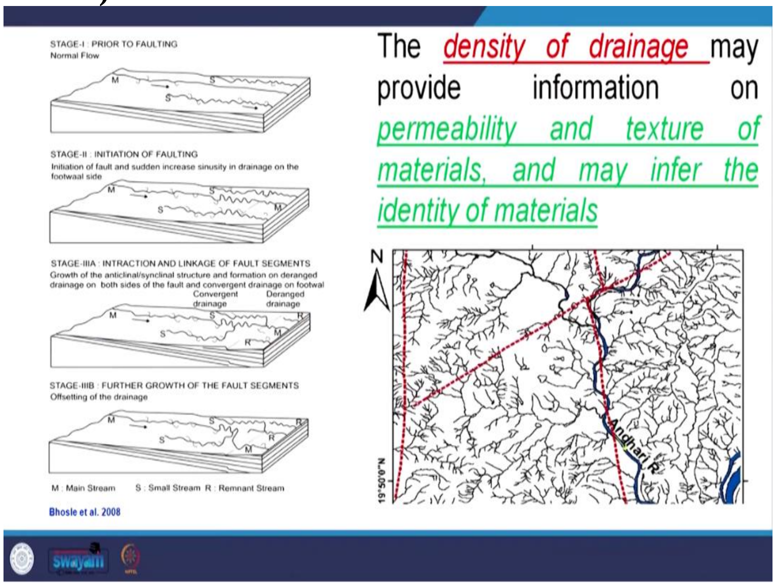

The drainage density drainage density is another measure of these drainage pattern calculations. So, drainage density provides information on the permeability and porosity on structure of this material and may infer this identity of materials. So, drainage density means how densely the drainage systems are arranged how densely the streams are arranged. For example, if you see this figure, it is given.

So, here this drainage area or this drainage basin is part of this Pranhita Godavari Valley. So, here this river this is Andheri river it separates 2 different lithologies and this left side to you it is Gondwana sandstone, and the right side is Granitic Gneiss Migmatite the peninsular massive complex. So, now if you visually see this drainage pattern, this drainage distribution, this Granite Gneiss Migmatite they are high they are showing high drainage density as compared to these sandstone and the Gondwana sandstone at the left hand side and separated by a fault.

So this main reason behind it that the sandstone being porous and permeable. They can allow this water to percolate down and that is why most of this water they percolate down and less are appearing at surface flow. However, this Granite Gneiss Migmatite, they are very hard compact, non porous, non permeable. That is why this maximum drainage system in this area they are surface expressions of the streams and other then there is down percolation.

That is why a drainage pattern that can give you overall idea, what type of material lies beneath there irrespective of lithology either it is porous or permeable, but there is no 100% measure from this laboratory but you have to go to the field to define whether it is a Granite Gneiss or it is imporous any other material is there. So, but in a laboratory and overall idea you can gain either you are dealing with a sedimentary terrain or a metamorphic terrain and igneous terrain and what is their overall topography what is their overall slope?

So, that can be defined here. And in the left side of this system, you will find this change of drainage system with time. So, for example, if you see here earlier these are gently sloping sedimentary strata there on which the streams are flowing here. So, now suppose for example, here a fault is growing, so, with time the fault the increases its length and also these differences, the elevation differences it throw increases and finally, full fledge fault is developed.

So, from here to here, this 4 figures if you see here at stage 1 to stage 4, so, you can see here this, stream earlier flowing here in a straight channel, it is time it is sinusity increases. And finally, this stream which has earlier flowing as an independent stream here due to increase in sinusity due to increase in elevation difference, it is strength is not enough to cross cut the elevation and finally it has to move like this, it has to move in this way and it is mixing here so that it is adjusting itself with the growing fault scenario.

So, finally, this is the modified pattern of this drainage system earlier in geological past when this 3 independent stream are flowing. Now you see, these streams are not independent instead; they are merged together and finally forming a single stream. So that means I want to say, these drainage pattern in 1 area, it does not remain constant for its lifespan. So with time with changing tectonic scenario with changing climatic scenario.

This changing block tilting due to faulting or due to subsidence this drainage pattern changes that is why we are getting some paleo channels. That means these are the channels, which through which this channel was flowing earlier, and now that they are find in the abundant form and the channel has diverted, it is position. So this is due to the tectonics, this climate effect or this local effect also, the local sediments effect also. So that means by looking at drainage pattern, we can say what type of scenario we are going to deal with.

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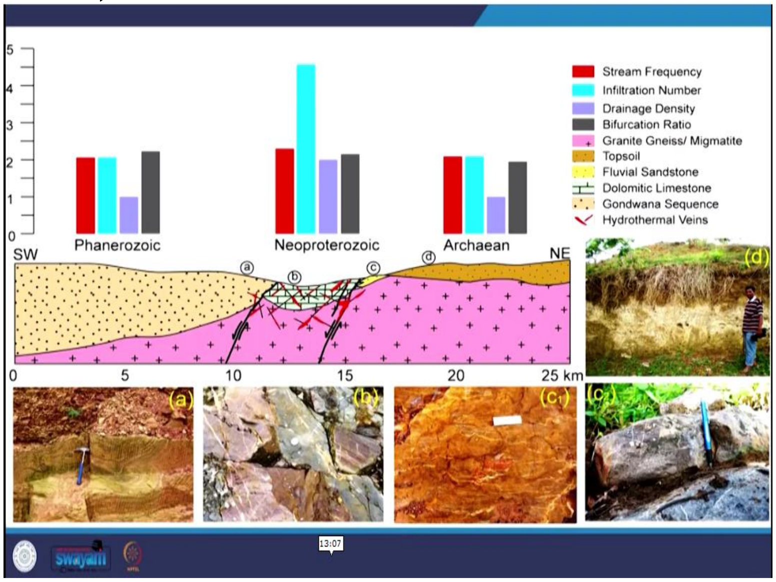

So, here, from this area, I have collected some data. This is from Granite Gneiss Migmatite, and this is Gondwana sandstone in between we have sedimentary patch, which is mostly representing the neoproterozoic or the Proterozoic sedimentary rocks. And by calculating the drainage parameters in these 3 different localities, we can find out what are these changes how the lithology is changing this slope and lithology they are influencing the drainage parameters.

For example, if you see this bar diagrams that is showing the stream frequency infiltration number drainage density bifurcation ratio of different streams of this overall area and this is Gondwana sandstone, it is Phanerozoic and here in between there is a limestone patch which is highly fractured because it is a fault zone which is fracture highly fracture and the fracture plains they are filled with hydrothermal fluid like calcite, like quartz veins are there.

And this side is Granite Gneiss Migmatite, and if you see here, this is topsoil that means it is a highly weather soil is there and if you see here, this is the Granite Gneiss Migmatite, and all these called peninsular Gneiss and here the soil development is there. This much thick topsoil development there. And this (a) this representing this photograph. It is from Gondwana sandstone, and here b it is the limestone.

You see this limestone, they are have fractures and filled with quartz and the calcite veins and this is c, this is the fluvial sandstone again it is fracture and it is filled with quartz veins and here these same region. There is another photograph you see there are cross cutting relationship of the quartz veins. And that means, I want to say though it is a sandstone it is porous and permeable, but this porosity and permeability has decreased significantly due to this hydrothermal fluid emplacement.

And in here, though it is Granite Gneiss at Migmatite, but this top part this top soil it is highly weathered and that is why you see this drainage characteristics and here the drainage characteristics they are looking similar, but not same but overall if you removing from this area where this topsoil is not there out soil is absent. So, this is totally non porous and non permeable. So, that is why in the previous figure we are showing there is a high drainage density is there, but in particular area, this is showing this high soil development is there.

So, that this drainage anomalies or drainage parameters here and here both are assuming to be same or looking same, but in between as it is hydrothermal fluid is emplaced here, this porosity and permeability is totally gone 0 and that is why you see this drainage parameter infiltration number abruptly increasing in this region. So, that means I want to say this medium porosity and permeability, this lithology in that defines what type of drainage texture will be there what type of drainage pattern will be there.

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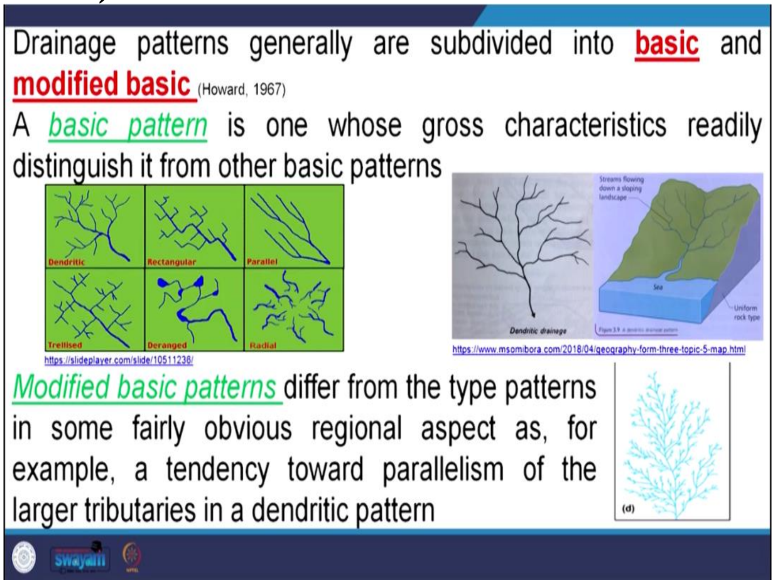

So, drainage pattern generally are subdivided into 2 types one is called basic type and modified basic type basic types means by looking at drainage pattern in appearance comes in your mind that this is a parallel pattern. It is a dendritic pattern like that these are called the basic types and modified basic type means within the basic type, there are local change for example, suppose there is drainage pattern for example, here if you see these are, this is represented overall it is a dendritic drainage pattern.

But if you see here, these streams, these streams, these streams, they are showing parallelism that means, within the drainage pattern, we did this dendritic system we have local parallelism. That means parallel drainage so this is some basic types. So, basic types, that means overall, we can say by looking at the drainage pattern how it looks like what is the first appearances is there that is basic type. And within that, if some subdivisions is there, it is called this modified basic types.

So basic pattern is one whose cross characteristics really distinguish from other basic patterns, so, that means by looking different drainage pattern we can say it is a drainage it is a dendritic pattern that is parallel pattern that is a trellised pattern rectangular pattern annular. So, these are the basic patterns of drainage patterns, but modified basic patterns differs from this type patterns in some fairly obvious regional aspect as for example, the tendency towards parallelism of this larger tributaries in a dendritic pattern.

So, that is modified basics. So, both modified basics and basic patterns that define the drainage pattern of an area. So, there are some drainage pattern which is called transitional to either with associated with or neither it is fully indicating a particular types of basics that means, these transition type that are more important in terms of tectonics and climatic changes because they are transferring from one pattern to another pattern, so that means their dynamic system is there tectonically more active areas generally there. So this type of transitional; type of drainage patterns.

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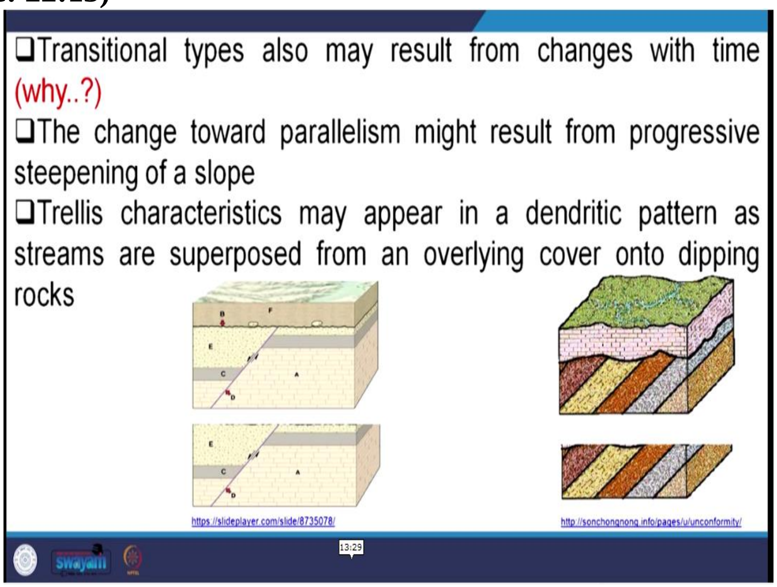

So, this change towards parallelism might result from progress steepening of slope steepening of slope, it due to upliftment, for example, here, you see, suppose, this fault is growing and in block is uplifting, so, a drainage pattern which is earlier represented by this dendritic pattern that may change and with time within the dendritic pattern we may develop some parallel pattern.

So, this is due to tectonic upliftment increasing of slope. Similarly, trellis pattern or trellis characteristics may appear in dendritic pattern as streams are superposed from an overlying cover into the dipping rocks. So, that means here the see this is a dipping rock of different rock types and if expression if it is expressed in the surface, so, there will be parallel drainage pattern will be developed. So, that means, I want to say a particular drainage pattern in a particular area that will define or that can give you clues in what type of structure lies beneath.

What type of lithology lies beneath whether it is a tectonically stable area or not whether this climatic changes affect this drainage pattern or not obviously, the tectonics and climate that combinely are independently the effect the drainage pattern of area so, by analyzing subsequent time series data that means within a time series with satellite imagery or in the toposheets within different time interval if we analyze the drainage pattern we compare the drainage patterns.

We can detect these changes and that change detection can overall lead to study the tectonic scenario the changing tectonic scenario or climate in scenario of an area are changing. Sediment production sediment capacity of a stream and sediment overall sediment production of an area.

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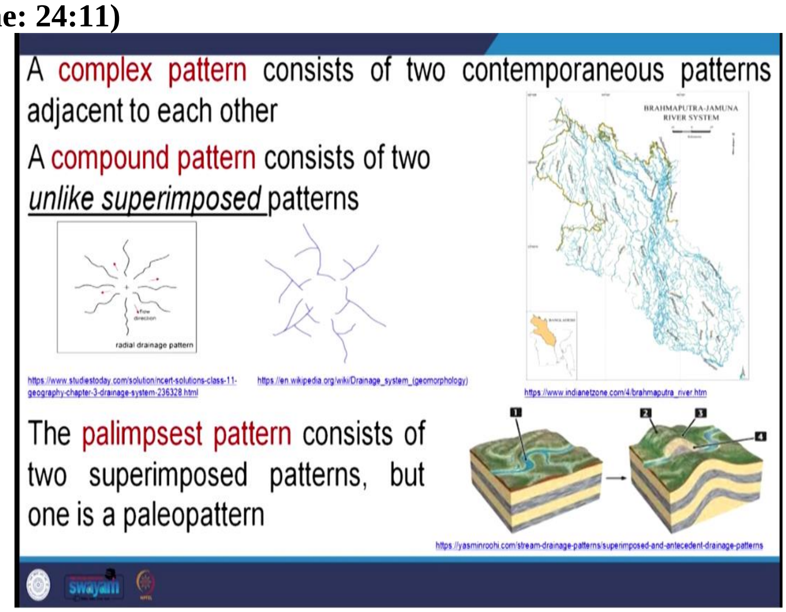

So, complex drainage pattern, a complex pattern consists of 2 contemporaneous pattern adjacent to each other. So that is called complex pattern that means once adjacent to each other means come to contemporaneous means the same times we in one region, we can develop a drainage pattern which is dendritic and the other side it is parallel. So that means we can say it is a complex pattern of drainage and compound pattern. It consists of 2 unlike superimposed pattern super imposed that means here suppose one is your dendritic pattern.

And the superimposed pattern is a parallel patterns. So we can say it is a compound pattern of drainage and the palimpsest pattern that consists of 2 superimposed patterns, but one is a paleo pattern. So, 2 superimposed pattern is there but one is paleo that means that is change taking place. So here the compound pattern and palimpsest pattern they are both similar. However, one is active and other is inactive that means in palimpsest pattern one is the dead type of drainage pattern and other types of drainage pattern is active which is superimposed on it.

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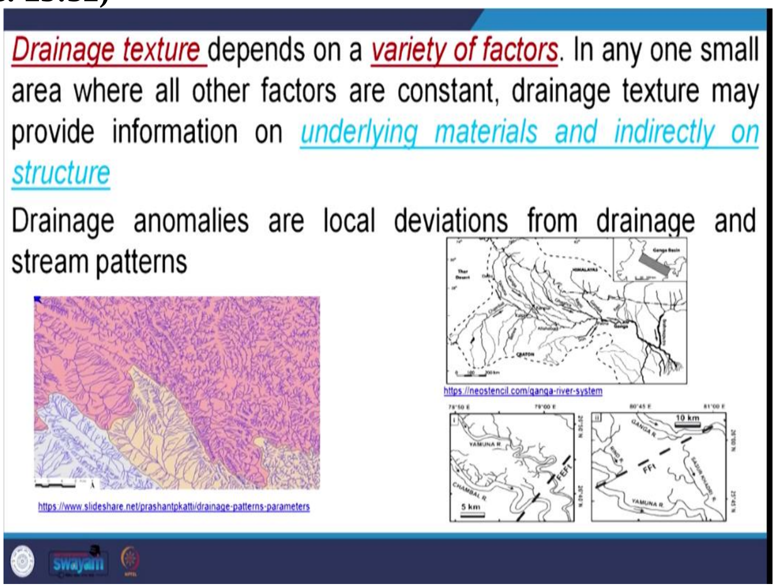

So drainage textures depends upon a variety of factors in any one small areas where all other factors are constant. Drainage texture may provide information on underlying material and indirectly on structures. So, for example, if you see this figure, it is indicating this side, this is fine drainage pattern that means minute drainage small streams but large number of See here, but here the streams are sparsely spaced, larger streams longer streams that means it indicates a sloping surface parallel patterns are there.

So parallel pattern that means a long linear slope, a long standing slope is there so parallel dense systems meander systems have been developed. Similarly, a drainage anomaly is local daviation from drainage and stream patterns, drainage anomalies are there. So as we have discussed anomalies that means it is an exception in a stream for example, here, if you see here, this is an exception you see overall is this channel is flowing and there is in exceptional high sinuosity is there they have exceptional high sinuosity is there.

Similarly here, channel offset is there is channel offset are there. So that was these are drainage anomalies. So drainage texture, drainage, anomalies, drainage pattern that define what type lithology what type of structure what type of tectonic scenario through which these channels are passing through

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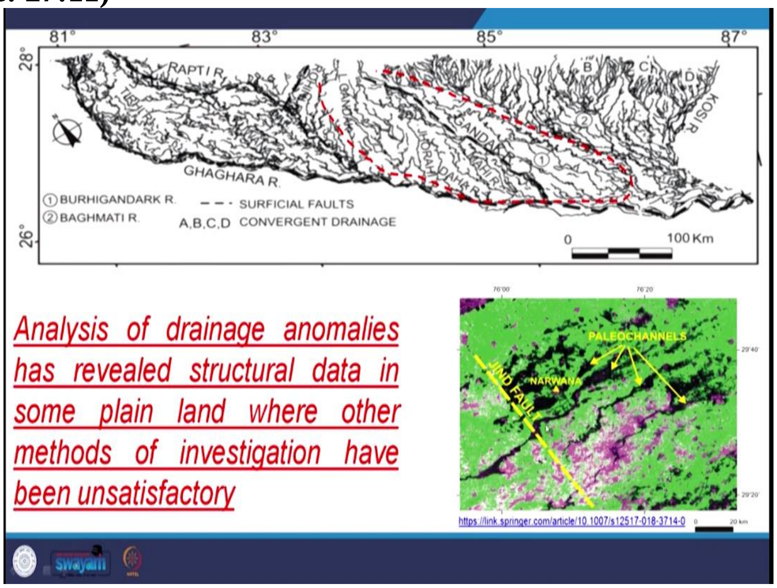

And analysis of drainage anomalies have revealed structural data in some plain and where other methods of investigation have been on satisfactory. For example, if you see here, this is the satellite imagery of Haryana and the see after the heavy rain, you will find this channels that filled with water and you see maximum of these channels there abrupt in here that abruptly ending here is abruptly ending here.

So, that means, this type of photograph they are particularly this photograph, or very useful to identify to the Jind fault. And these are these paleo channels. That means all these channels they are ending here. So, there is elevation difference. And due to this faulting activities the channels are abandoned and after the heavy rain it was filled with water and there is satellite imagery was taken at that time, which is indicating that the all the channels that are abruptly ending at this particular structure.

So, that means, this type of drainage analysis that will lead to identify what type of structures lies beneath which has buried structure particularly this type of drainage anomalies are a type of drainage pattern or analysis that are useful in plain areas rather than in a highly elevated mountainous region. Similarly, this is overall drainage pattern of the Ganga plain in part of this Ganga plain here, river Ghaghara and river Kosi is there within that you will find, if see here mostly the drainage pattern are parallel to sub parallel and this is due to this higher slope.

And here also we have parallel to sub parallel drainage pattern are there, and at this pediment areas you will find this parallel to sub parallel drainage pattern. But overall if you see here mostly it is finding this looking the overall it is a dendritic drainage pattern so that means I want to summarize here and conclude is here there drainage pattern drainage anomalies drainage texture that defines what type of structures lies beneath and how we can finely analyze these drainage patterns. And it will detect this type of active dead or dormant structures. So I think we should stop here and we will meet in the next class. Thank you.