Geomorphology
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Lecture-02
Process of Landform Development

So, friends welcome, so today we will discuss about the process of landform development. So, in the last class we were talking something about the processes, what are their involvement in the landform development.

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And here one is process another is landform development, that means what type of processes are involved in the formation of a landform. And it is important to understand here is that whether one process is involved to form one landform or several processes are involved for one landform, so this is important to understand here.

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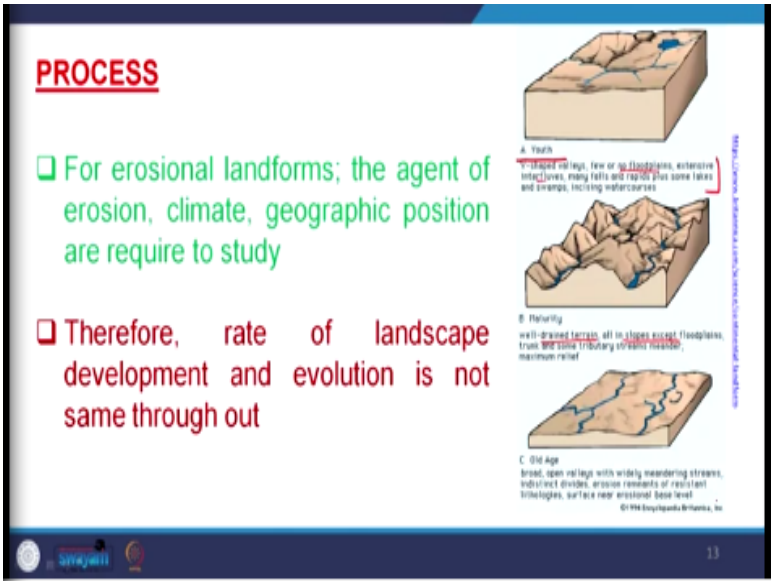

So, what are these processes, for erosional landforms, the agents of erosion is climate, geographic positions, and they do parameters record to study. One is climate, climate is the main culprit to form the landforms. For example in arid climate, different landforms are formed which are characteristics of arid climate only. Similarly, or glacial in cold climate, the glacial landforms are formed, so they are characteristics of glacial landforms only.

Similarly, some of this landform their characteristics of Eolian system, some landforms they are characteristics of fluvial landforms. So now, if we can identify those characteristics landforms we can talk about the geological past what type of processes are involved in their formation. Therefore, the rate of landscape development and evolution is not same throughout, that means sometimes some geological past the processes what working at a higher rate and it may not be same throughout its history.

So, for example suppose we are taking a million of year timescale within that million year timescale, suppose one process is same process is continuing, but the rate of working the rate of change in these processes is not same throughout. So, that involves the formation of landscape development. So, that means to form one landform, suppose for example forming a relict mountain, process involved is the erosional landforms, erosional processes.

That erosional process maybe due to weathering and erosion by river, maybe weathering of erosion by glacier's, maybe weathering and erosion by landslides. So, that means weathering and erosion process it can be divided or it can be done by 3 different agents or more. So, that means mountain system is one, the product is one in front of us the product is simply a mountain form but to form that mountain there are different processes are involved.

So, that means these are these keys to understand whether one process is involved to design your landform or more than one processes are involved to design a landforms. So, if different processes are involved, whether it has been recorded within the land system, within the recorded within the rock body, that has to be unraveled. For example, if you see here this figure, we have a landform mostly it is a fluvial landform.

In fluvial landforms there are 3 figures are here, one is called the youth stage, youth stage means where the rivers originates, slope is very high, erosional capacity is more. So that means those landforms will form it is characteristics of those features. What are these products, V shaped valley, then no floodplains, extensive interfluves, many falls and rapids.

So that means you see those geomorphic landforms, they are characteristics of the youth stage. Similarly, if you are coming to mature stage, you are getting the landforms well dealt Terrains very less slopes, flood planes. So, if we are getting those type of landforms, that means the process, which are characteristics in mature stage of a fluvial system, they are responsible. Similarly, you are coming to the old stage, those processes which are in characteristics of old stage they are involved for formation of this landforms in old stage.

So, that means, I want to say some of these characteristics processes, they are concentrated they are restricted to a particular geographic position at particular geological times. So, those processes has to be raveled and better to be correlated.

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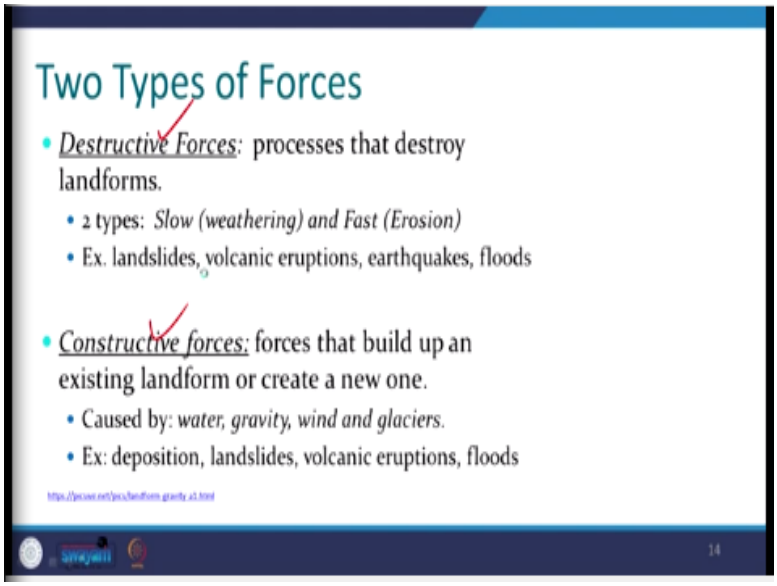

So, here we have given the processes that we have discussed earlier. There are 2 types of forces, one is destructive force another is constructive force.

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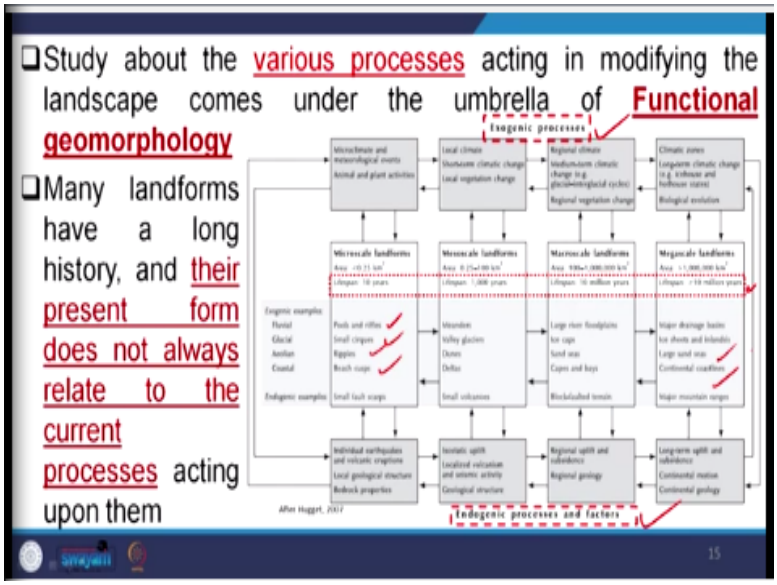

So, now various processes acting in modifying the landscapes comes under the umbrella of functional geomorphology, functional geomorphology that means the product is a function of some process, product in front of us, it is the landforms they are the products. So functions the processes, so those processes either single handedly or in combination they will modify the system and finally gives us the product.

So, we are looking at the products only, by looking the products, by looking those involvement of the processes within the rock body, we are going back and unravelling geomorphological history in geological history. So, if you see here these processes some of these processes are surfacial processes and some of the processes they are not surfacial they are concealed in between.

So, those who are acting on the surface they are called exogenic process, exogenic process that means surface of the earth, erosion it is a surface of earth process. Fluvial erosion, it is a surface of earth process, landslide it is associates on the surface of the earth process, so these are the exogenic processes. And some of the processes they are called endogenic processes, endogenic process they are not expose to the surface.

So that means they are acting but their activity is confined within the earth surface but their activity influencing the surfacial process. That means a product or a landform is a function of both exogenic and endogenic processes. So exogenic processes, that means we are looking on the surface, yes a river is cutting it is valley. But endogenic process, we feel it, we evaluate it, but we cannot see it.

So many landforms have long history and their present form does not always related to the current process. That means, for example suppose we have mountain fronts, for example we take the example of eastern ghats, we have relict mountains. So that means this mountain formation, the process involved nowadays may not be the same process involved in geological past. So, that is why this product is a function of many processes of endogenic and exogenic region.

So if you take this lifespan suppose for example we are taking a lifespan of process of 10 years, 10 years of process involvement we are getting pools and riffles, small cirques, ripples, beach cusps, that is small event, small geological features. Similarly if we are increasing the time span suppose getting tens of million years major drainage basins, large scale sand seas, continental coastlines, these are the products.

So that means for involvement of endogenic and exogenic process, the product is same but the surfacial processes sometimes dominant, sometimes the endogenic processes dominant. For example, suppose there is a plate moment, there is a volcanic eruption but before eruption that is a magma pool beneath the earth surface. That means, it is supplying higher heat flow, higher heat flow if it supplying, so that means it is affecting the surfacial process, it is promoting erosion, it is promoting evaporation.

So, rivers will evaporate it is water and become dry, these are the endogenic process. So, that means some processes that are not exposed to the surface but affecting the surfacial process, these are the endogenic process.

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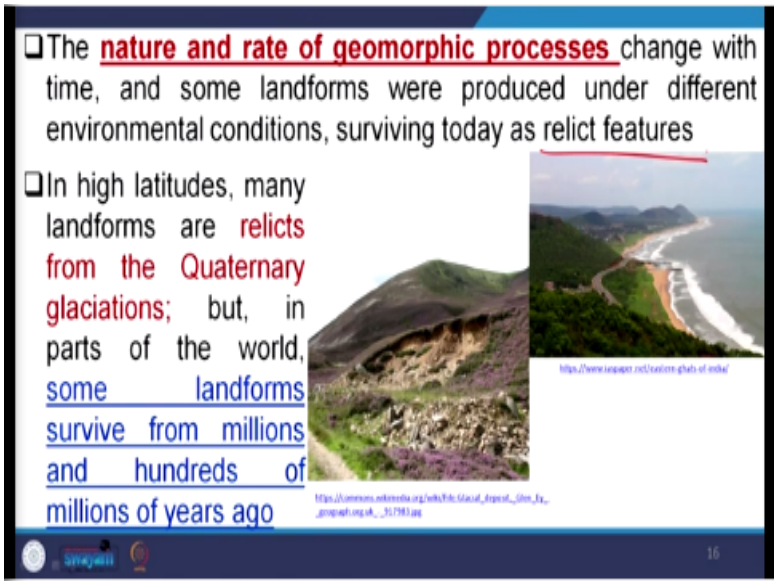

The nature and the rate of geomorphic process change with time and some landforms were produced under different environmental conditions, surviving today as relict features. That we are talking about relict feature, relict feature means the product is evidenced many geomorphic processes that acting in the past. So that means whatever the process nowadays it is acting may not be same process were acting in the geological past.

Many processes acted together and finally the giving the product to us, this is the relict features. Eastern ghat mountain fronts, that the relict features, if you go to the river mouths, river mouths these esturine they are the relict features. Because they were produced during the early phase of

the quaternary where the sea level changes eustatic sea level changes was there, they are the relict features.

In high latitudes many landforms are relict, the are relict of quaternary glaciers. If you see in the quaternary, there was high level glaciations, worldwide there are glaciations and glaciations means glacial features are involved both the erosional features and the depositional features. So, if you go to the higher latitudes, so they are the relict feature, so that means, nowadays there is no glacier, it is dominant by fluvial environment.

But though the fluvial system which acting 24X7 to modified system, modify the geomorphology. But the last glacial effect it is there, that means those landforms were formed in the early quaternary. Nowadays they are existing and it is promoting this fluvial system to act, fluvial system to modify them, But still they are existing, the landforms are existing, they are the relict landforms.

So that means some of this landforms if you are talking about the quaternary that means we are talking about this 2.6 million years back. But some of the landform they are surviving from billion years old, they are also the relict landforms. So, that means the relict landforms which are existing today, that means they are evidence that the process is not acting at higher rate, so that it can peneplain them.

Even if the process was acting, the landforms they are remained as intact, so that means some of these processes they are acting as a higher rate to modify the system, some of the processes they are acting at very slow rate. So that it is taking long time or even if millions of years scale to modify the system, so that is why this relict landforms are existing. Historical dimension of geomorphology comes under the domain of historical geomorphology.

Historical geomorphology, it is very important to understand, historical geomorphology means geomorphological history. That means place remains same but different geomorphological process they are acting in geological past. So geographic position remains same, for example if you take this image here the photographs here.

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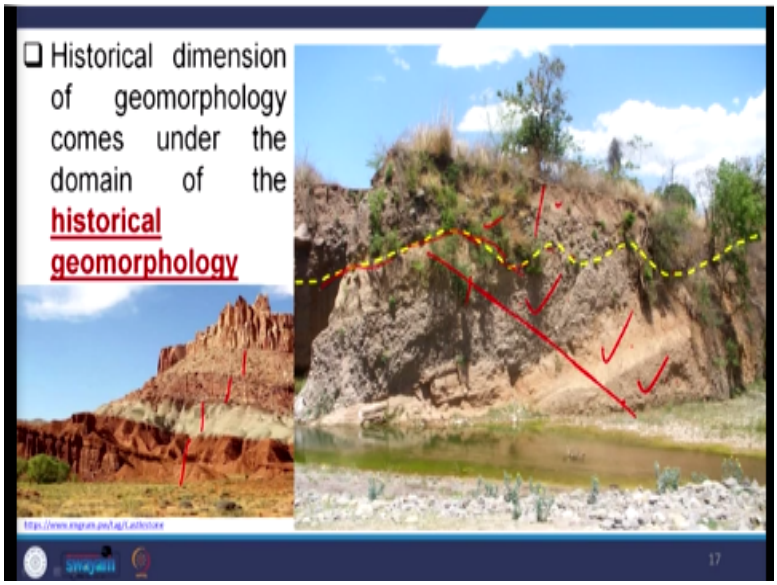

We have different layers, rock layers, one layer here, another layer here, another layer here, another layer here. Similarly here if you see, layer 1, 2, 3 and finally we are getting an erosional surface and then again. So that means I want to say, geographical position is same but the geomorphic processes are different in geological times. So, if we can correlate, if we can arrange those geomorphological processes from bottom to top.

That means we are unravelling the geomorphological history, that is the historical geomorphology, is not it. So if you see here for example this photograph is from the Himalayas, now we see we have fluvial conglomerate. Then we have sandstones, then again we have a conglomerate, then we have a erosional surface, then we have conglomerate, then sandstone and soil.

So, now you see this conglomerate sandstone conglomerate it is this total system from this to this, it is by fluvial origin, it is a fluvial process was acting there. But if you see here this is an erosional surface if the erosional surface that means this area was beyond deposition or the above the depositional level. So, now the question arises if fluvial process was involved formation of the system from here to here.

So, at this geological time where the fluvial processes were there because this area was beyond or above the depositional level. So now the 2 cases arises either the area was beyond or above the depositional level or this fluvial system or the depositional system was not existing there. So, if the first is true, we know the Himalayan system it is mostly the tectonically active region. In tectonically active region if we uplift something above this river depositional level.

So something can happen or if we remove this depositional system from this place, so that means in a tectonical active region we do not have any river system, that means the river was diverted or there is a climatic change the river was dried up. So that means there are many possibilities are there. So a geomorphologist the main work is to unravel the most possible geomorphological history, what was the reason behind it.

So that is why geomorphological history unraveling, we need rock exposures until unless we have exposures, we are helpless, so what to study. So studying a geomorphological history of a region we need proper exposure and proper preservation of rock record. For example, suppose we do not have rock record. There was a disaster environment, there was a disaster geological disaster, there was a flood high flash flood, but subsequent events, they wiped out its evidences.

We cannot study even if there were processes involved, but this process do not have any rock record. So, the means to unravelling the geomorphological history of region, we must have a rock record in front of us. For historical geomorphology the golden rule is present is key to the past, what does it mean. So, that means, we have rock record, some processes we have to identify, now how to correlate whether these particular process is involved there, that means we have to see the present.

The modern environment, modern geomorphological environments, what type of process give rise what type of product we have to correlate with the past. So, that means in front of us what are the processes are going on and what are the products. If you can precisely correlate then the same system we were taking here and putting in the rock record then we can say yes, these are the process and this is the product. Similarly these products are available, so that means we can correlate the process, so present it is key to the past.

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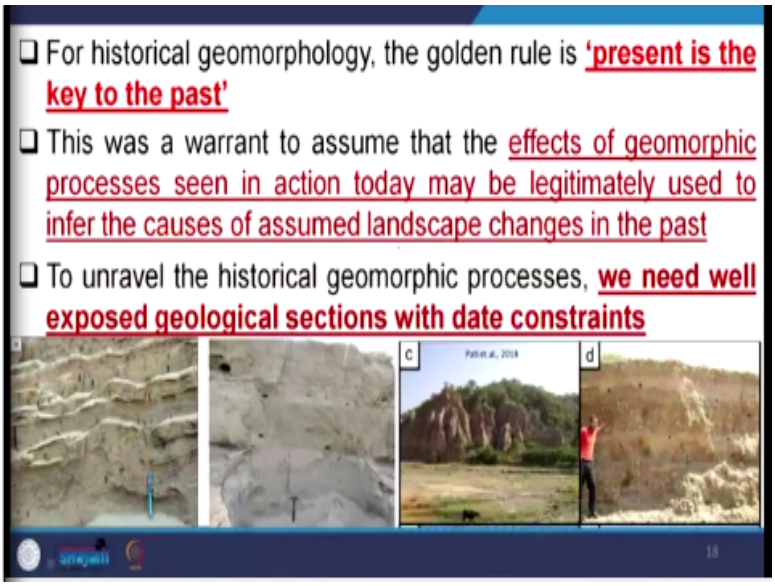

This was in warrant to assume that effect of geomorphic process seen acting today maybe legitimately used in for the causes of assume landscape changes in the past. To unravel the historical geomorphic process we need exposed geological section within date constraint, that is important. We should have exposed geological sections and we should have date constraints, we should have time, without time everything is gone.

So, that means, once we are saying it is a geomorphological process was involved, now the question arises when it was working. So what duration it is working and when it was acting, it is also important. So, if you can answer those 2 questions, one is process was involved, this is the product and this process was started from this years ago or this million years ago, it continued up to this million years ago, so to the rate of working of the process that can unraveled.

So, that means we have process, we have rate of working and we have product, if the 3 things can be correlated, then it is complete solution to a geomorphological problem otherwise we do not have.

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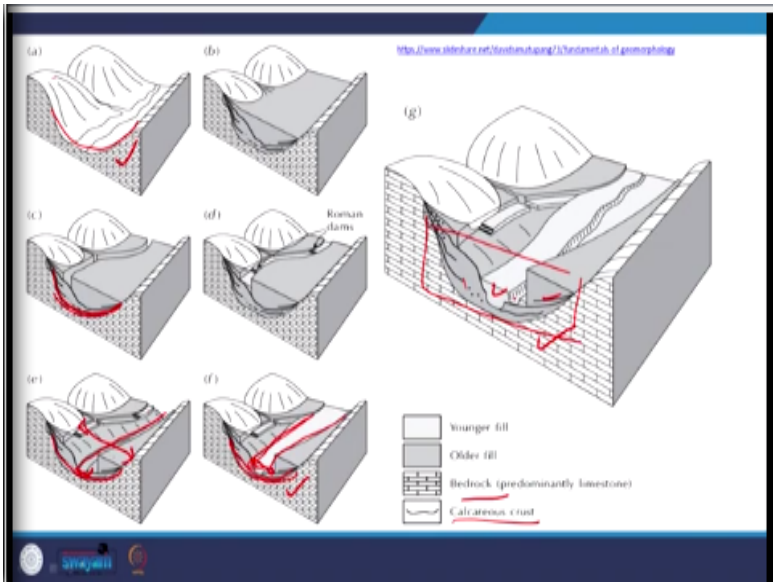

So for example here this figure if you see in figure a, if you see this is limestone, it is exposed to hundreds of suppose say thousands of years. We know limestones they are very prone to chemical weathering. So after thousands of years of or hundreds of years of exposure, we are creating a surface erosional surface here mostly it is called calcareous crust. Now you see if this is so, now we are creating a valley, a valley is created.

And the valley that means valley is created means fluvial system will develop. So once the fluvial system is developed this valley is filled with fluvial sediment. Now you see this fluvial sediment, once it is developed due to some reason this fluvial system change its course. So now you see this fluvial system within the system there is a river which is passing through and this is the riverbed and this is the floodplains, so now the river is cross cutting its own floodplain.

So, we will have a riverbed sediment, we will have the floodplain sediments. Now if you see here again the river with time it widens it valley. So, the present day river course the sediment is enveloped here. So we have bedrock, we have past depositional system, the product is this, we have the present depositional system, the product is this. So now if you see here, in this figure, we have a complete rock record of this bedrock then the older fills then the younger fills.

And if you concentrate here, this is the modern day river sediments. So, we are taking the cross section that means, we are getting the complete rock record and through the rock record we are

correlating this process and products and the time duration when and what time duration it was acting. So that means in this valley if you want to unravel the geomorphological history, it is only and only possible if the exposure is there.

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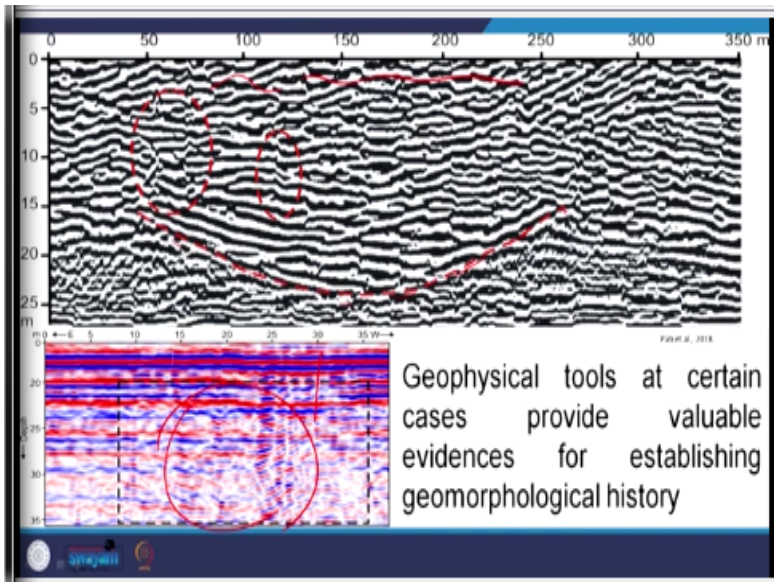

For example if you see here, these 2 are the ground penetrating radar profile. In ground penetrating radar profile, if you see here the red mark, it is a paleochannel surfacial sediments that burying it. If we do not have this geophysical profile or this radar profile, we cannot say whether in the past a fluvial system was active here, is not it. So that means some cases similarly here this is a paleochannel buried under sediment.

Nowadays, there is no channel existing there, it is completely a peneplain area, soil development is there. So it is buried under soil, soil development means the area is exposed and area is undergoing active erosion, so that is why soil formation is going on there. So that means present day geomorphology it is simply it is beyond the depositional level or above the depositional level, and it is exposed to the surface, soil formation is going on.

But if you see this radar profile and if we date it, for example suppose we date it at 10,000 for example it is 10,000 years back. So that means if we remove the surfacial sediments we are removing 10,000 years from the geological time. Then we see at this particular geographic region, a river was existing, active channel was existing, active deposition was going on.

And with time the river was dried up it is filled with sediment, it is promoted soil permission and now there is no signature of a river profile was existing. So, that means certain cases, we have this geophysical tools they are helpful in unravelling the geomorphological history but at many cases, it is not possible. So, that is why rock record is the best medium to study the geomorphological history.

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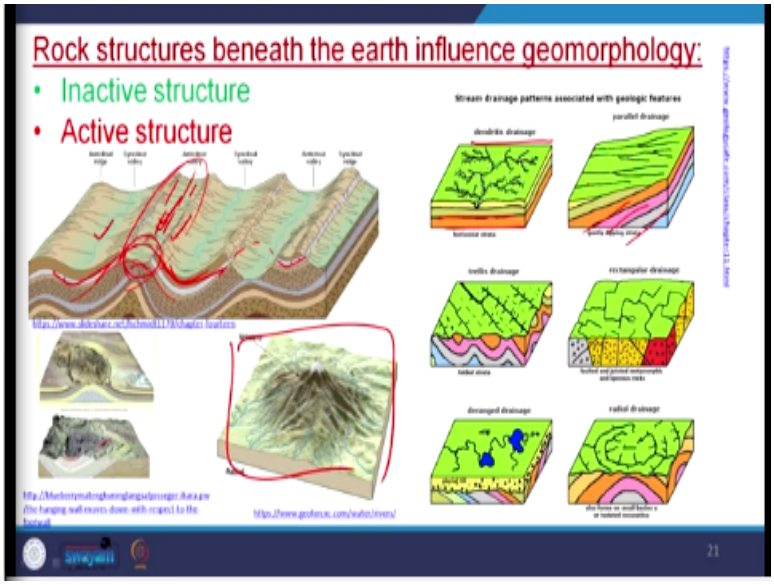

Now, the rock structure beneath the earth this influence the geomorphology. So, there are 2 types of structures, one is called active structures another is called inactive structures. Inactive structures means, that means the structure was formed in the geological past, it is not reactivated. So, whatever the activity was, there it is in the geological past suppose we are considered to unravel the geological history of quaternary.

But the rock structure beyond that beneath that, that were active beyond the quaternary, within the quaternary or within the timescale we are taking to study the geomorphological history within the timescale it is not active. So these are called inactive structures, for example if you see this figure suppose it is a fold. So that means if you consider the initial time of this fold we have a valley and a hill was existing here.

Similarly, we have valley here a hill was existing here similarly we have a valley here, so that means valley, hill, valley, hill adjacent to each other. But nowadays if you see here, we have a valley existing at the top of this mountain, so these are called the anticlinal hills and synclinal ridges. So, if you remember the last class we are talking about the relict features and the relict features, they say about the degree of maturity of the topography.

So, this is called mature topography. mature topography means here if you see, we have a an anticline and due to anticline this part is under pressure, the rocks are extended stretched. So, once we are stretching the system that means we are creating some fractures, some fractures parallel to you are stretching something fractures. So due to this fractures these zone becomes a weak zone and the rocks are removed from here.

So that means we have a valley here, now we are creating a valley here. So many of this relict features they show, the anticlinal valley and synclinal ridge. If you go to the Precambrian of Himalayas, you go to the Precambrian of this peninsular India you will find many types or many such type of a relict structures ok. So that means they are in the subsurface, but they are acting the surfacial processes.

Similarly some of the structures they are expose to the surface, for example here, you see, this is exposed to the surface, the valley it is exposed, the hill it is exposed. Here, this is volcano, this is exposed to the surface, the folds that is exposed to the surface. And if you see the geomorphological process, for example here concentrate here in this particular figure, it is the volcano here.

And if you the volcano is here, can see the rivers, the channels, they are radiating in all directions . They are creating a radial drainage system that means it is affecting the geomorphology, affecting the geomorphological process, affecting the fluvial processes is not it. Similarly if you consider these, these are the subsurfacial structures. For example, suppose we have horizontal strata where creating a dendritic drainage on that.

We have a inclined strata, gentle dipping strata, we are creating mostly parallel drainage. Similarly if we have anticline-syncline, anticline-syncline we are getting the parallel drainage system the trellis drainage system. And rectangular drainage system you are getting the fractured rocks.

So that means I want to say subsurface structures, subsurface rock arrangement, it affect the surfacial geomorphic process to certain extent. This we are talking about the inactive structure, that means once it was the structure was formed and later on it was not activated, this is affecting. So, this is called the time taken to respond a geomorphic system to a particular event. For example, suppose we have a fault and on this fault across this fault we are creating a drainage system.

So across this fault if you are creating a drainage system with time the fault scarp will be eroded. At present we have 2 topographical difference, one is up thrown block another is the down thrown block, a river which is coming from the up thrown block it will erode the fault scarp and finally deposit in the system is not it. So now the question arises to what extent to what time frame or to what time scale the faults scarp will exist.

That depends upon the climate, that depending upon the rock type, that depending upon the surfacial processes involved to peneplain them. So suppose the rate of erosion is more or the rocks involved in the fault, it is very fragile the fragile rocks. So that means the fault scarp will erode very easily and finally within a few hundreds of years, few thousands of year these 2 sides of the fault the up thrown and down thrown block they would be peneplained.

Like the Ganga plain, it is most of the alluvium, if we are creating a fault on the surface, and creating topographic difference, it will take hundreds of years to peneplain the system. Because the Ganga plain, the sediment is very friable, it is unconsolidated to sediment, the fluvial system is very active, is not it. So that is why this up thrown block will erode very fast and will deposit sediment on the down thrown block.

So now, the time taken to respond the geomorphic process to that faulting event is very less, hundreds of years, thousands of years. But if the same throw of a fault occurs in peninsular India, it is mostly hard rock, peninsular gneissic complex, hard rock, sediment supply is less, fluvial system is very sparsely disseminated. So that means even if after millions of years this faults scarp will remain as it is or very slight modification.

So, that means, I want to say the fluvial or the sorry, the system response to a particular event the geomorphic system response to a particular event, the time taken for respond varies from place to place, varies from time to time. For example, the same time, same process, same faults scarp, it is in the arid region. The same faults scarp it is in the humid region the time taken to peneplains varies from place to place, varies from climate to climate, varies from time to time.

So, that means, this inactive structure means, those structures which was formed at geological past and if it is present day it is existing. So that means, I want to say the geomorphic system responds to that particular structure very little and very slow. But if it is there in otherwise if the geomorphic system acting very fast. So that means that faults scarp within very small time it will peneplains.

And another type of structure it is called active structure, active structure means the structure was either it is present in the past and it is continuing it is existence, it is continuing it is activity today or a new active structure is present or creating today simultaneously with the geomorphic process. That means this rock structure which is creating today and the geomorphic system which also acting today.

But in inactive structures, the rock structure was present in the past but the geomorphic processes that is acting today, so this is the difference between. For example, if you see here we have active structures.

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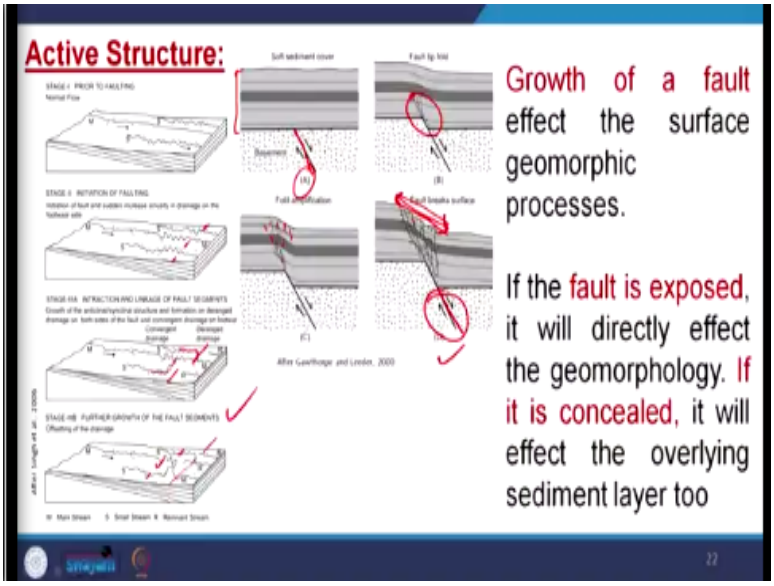

For example if you see this figure, this is a fault in the basement level, in the basement level if we are creating a fault, these are the sediments, cover sediments. So that means in a, if you see this figure A, we are creating a fault in the basement level, in B, the sediment close to this basement it is affected. So now if it close to basement is affected in figure C, gradually if you see this overlaying sediment is affected and finally small scale faults are forming on the surface.

And here in the figure D, if you see there are number of small scale faults, creating a fault zone on the surface. So at this sub surface we have only one fault it is in the hard rock, it is in basement. But in the surface we are creating number of faults, we are creating a fault zone, so that means a geomorphic processes where creating on the surface of an wide area. And here at the same time, these fault is active and the geomorphic process is also active, at the present day geomorphic system, these are called active structures.

That means rock structure which is present at the subsurface, it is presently active and it is activity, it is influencing the surfacial process, it is called active structure. Similarly if you see here, here a fluvial system it was working without affecting of any structure. With time if you see, we are creating a fault across the river course. So with time the fault grows, the length of the fault grows similarly depth grows.

So with time if a full fledge fault is created, now you see here, the river was going on here smoothly. And here due to this activity of the fault, due to activity of the growth of this fault, the fluvial system some changes occur within the fluvial system. And finally, if you see here, some of the river which are going independently, now they are merged with each other and finally, some of these paleochannel remained here.

So, this is affecting the present day structure, and this present day geomorphic system, and this structure is active nowadays, so this is called active structures. So, active structures they affect more to the present day geomorphic system as compared to the inactive structures.

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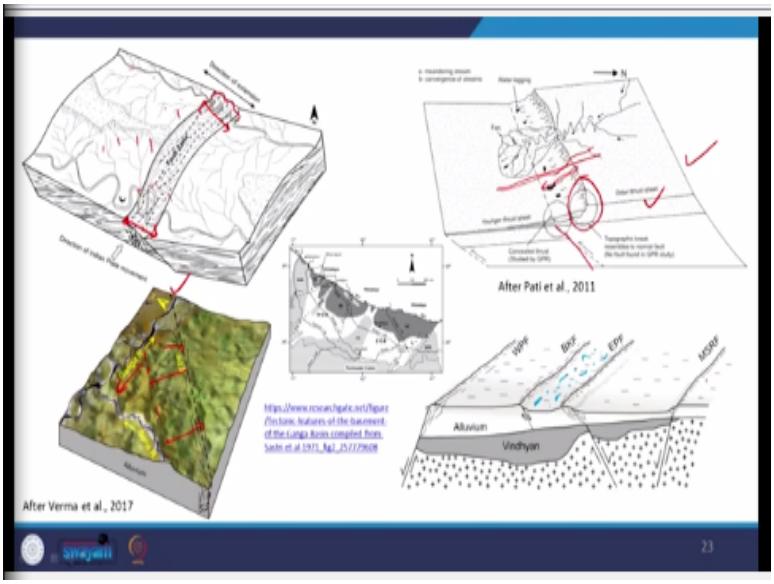

So, some other examples here, we have a fault here and surface this fault is representing a fault zone. If it is fault zone is there, now you see this river which is coming or it is moving smoothly within that fault zone you see, the sinuosity changes the sinuosity changes. Similarly here sinuosity changes, we have some erosional topography close to this fault. So, these are the active structures, it is affecting the surfacial process.

Very interesting example is here for east Patna fault in the Ganga plane, east Patna fault it is a subsurface fault which covered with sediment and this is the digital elevation model around it. Now, if you see this is the east Patna fault and now if you can see the fault zone how this

topography is changing there. Now, this is the effect of this fault is there earlier, the Sone river was somewhere here.

If you see the satellite imagery, you have seen that the Sone river has changed it course, this is the effect of fault, this is the effect of active structure. So, that means a mighty river Sone it is changing its course due to this fault effect. So, that means the subsurface structure, the subsurface active structure, it is influencing the surfacial process, the fluvial process, the river process.

Similarly, sometimes if you see here sometimes these structures they mislead the geomorphologist and one example is here from the Ganga plain. If you see here as a laymen if you walk from here to here, what you will get your come in plain and finally you are coming higher side. So, it is looking like normal fault at a topographic difference normal fault but this subsurface study by geophysical method, it is proved that this is not a normal fault.

This is a reverse fault here and due to this reverse fault this area is uplifted and this is the faults scarp erosion. This is the faults scarp retreat, due to this retreat you are find a topographical difference here and it is looking like normal fault but it is a reverse fault. So some of this photographs if you see here, this is Monghyr-Saharsa Ridge fault, East Patna fault, west Patna fault. So all those faults if you arrange and this geomorphology of the Ganga plain is correlated.

Then we will find these active structures they are influencing the surfacial geomorphology either it is erosional process, it is the depositional process, any type of process if you involve. This subsurface structures they influence, how we can say whether this is a active structure or inactive structure. In active structure, I have already discussed that it is formed it was formed in geological past and present day it is activity is 0.

But the geomorphic system is responding to that event was acted in geological past ok. But the active structures if you see, we have fluvial geomorphology an example fluvial geomorphology effect by fault mostly in the alluvial plains. Alluvial plains it is totally peneplained area almost

flat, lack of an topographic prominence. In that area it is very difficult to identify whether an active structure is existing or not.

In hilly Terrains we have exposures if it is fault there you go to a river valley, you will find this existence of this fault. But in plane area which is concealed totally on the alluvial planes, it is difficult. That is why this fluvial geomorphology plays an important role to identify this active structures on the peneplained area. Here some of these examples of how this fluvial geomorphology is used to study the active structures in a geomorphic system, one is your drainage convergence.

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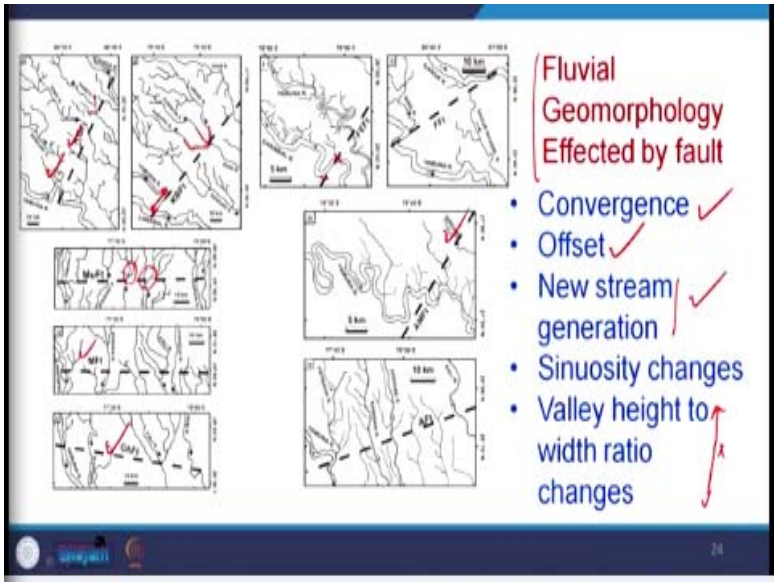

If you see along these faults or across this fault for example, if you see this fault, see 3 channels 1, 2, 3 they are converging here. Similarly here, there is a drainage convergence here there is a drainage convergence here there is a drainage convergence. So, not always the convergence drainage always indicative of fault, no not necessarily. But, if there are fault existing there are maximum chance that there will be a drainage convergence at along this fault zone.

But not necessarily wherever you will find a drainage convergence you will say, yes it is a fault is existing here, no not necessarily. So that is why to find out a fault there are many geomorphic evidences are there. One of is there is the convergence drainage another is, offsets it is very

prominent characteristics of active fault. For example, if you see here there is an offset of here there is an offset of here.

So, offsetting streams either it is normal fault or it is the reverse fault or it is a straight slip fault that 3 possibilities are there ok. New streams generation, new streams generation is another point why once we have a fault in the alluvial system, we have a topographic difference. So, once we have a topographic difference, that means we are creating some gullies, some later on gullies will converted to valleys.

And finally the first order streams will develops, you see any of this fault if you see, we have new streams generated we have new streams generated we have new streams generated, generation of new streams everywhere you will get new stream generation, it is due to the topography difference. So that means, I want to say these are some of these parameters, they are used to studies these active structures on the surface.

Then valley height to width ratio, this is a very important parameters but this is not true in case of alluvial rivers. Because alluvial rivers either it is up thrown or it is down thrown it is filled with alluvium, very mobile elements. That means it can easily be modified during a flood if you see this Ganga plain rivers or any alluvial plain rivers in the world. During a flood there will be river valley will highly migrate either this way or that way.

So, it will completely modify this river valley system, so that is why this parameter does not hold good for alluvium rivers. So, now another example is here that in a global scale, how these structures that affect geomorphology.

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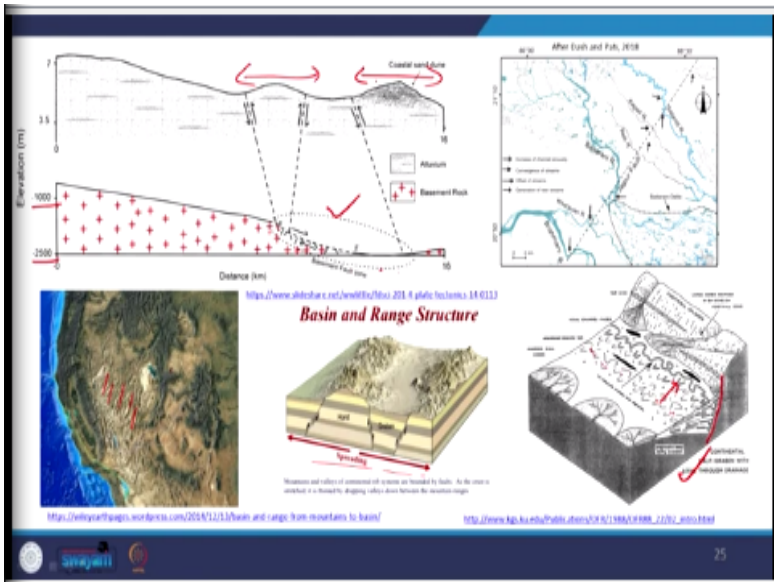

For example, in a global an example if you take this basin and range province of USA. Here you see number of ridges, number of valleys, this is due to extension. This due to extension, so that means we are creating horst and grabens horst and grabens number of hundreds of horst and grabens are there. So hundreds of horst and grabens, that means ridge-valley ridge-valley ridge-valley like this, so we will get parallel drainage system.

So, here if we are having half graben here if we have half graben, half graben means one side it is bound by normal fault. So, now we see, we have this side we are bounded by normal faults and at the initial time a river was existing here and flowing in this way. Now, more and more sediment fill, more and more loading, now you see, this system is bending downward.

So, the fluvial system which was existing here, now it is migrating to this site. Similarly here another example of surfacial structure, how it is affecting the surface, here the basement fault zone in Indian east coast. Now, if you see the basement it is fault zone, it is a existing 1000 meters below, that means one kilometer below a basement fault is existing from 1 kilometer to 2.5 kilometer below.

Now if you see the subsurface structures, we are getting small scale faults, and it can be well correlated. So, that means, I want to say this subsurface structures, they act very precisely, very actively to influence the surfacial system. So, we can conclude here though we have structures in

the subsurface, they can active or inactive. If it is inactive, that means, the fluvial system or any geomorphic system, they can act freely without any hindrance.

But if we have an active structure if we have an active structure here that activity occurs in time to time that influence the fluvial system or any geomorphic system in the surface actively. So this is the conclusion of the system, thank you very much.