Geomorphology
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Lecture – 60
Seismic Geomorphology

So friends, good morning and welcome to this lecture series of geomorphology. Today we will continue with this geomorphology through seismic profiles that is called seismic geomorphology. So, if we remember our last class we are talking about this process product relationship in a geomorphic environment and in seismic profile, we generally get the products and we interpret the process from the seismic profile and in the seismic profile of considerable length and considerable depth.

We interpret the lateral change in geomorphological process. Similarly, vertical change in geomorphological process that means with time and space, how the geomorphic processes that evolved that can be interpreted from this seismic profiles either it is a 2D or in 3D scale. So, today in this class we are going to discuss that how it happened? How is geomorphologist that interpret a seismic profile? So, it is best described in this workflow.

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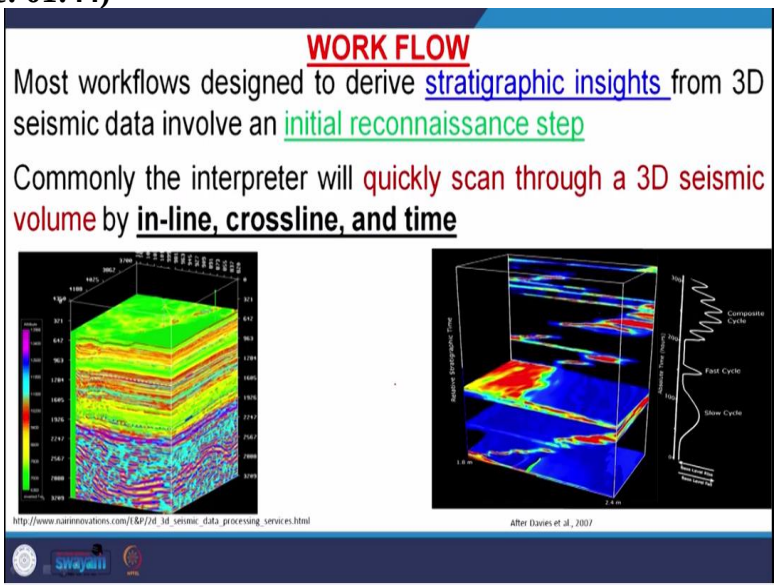

So, here the most workflow designed to derive stratigraphic insight from 3D seismic data involve an internal reconnaissance initial reconnaissance step, reconnaissance step means, you know,

then every geological work either it is the geological mapping or anything, we go for reconnaissance survey reconnaissance survey means it is a first look first instance how this area looks like how the things looks like. So, this is reconnaissance step.

So, here in this seismic profile also seismic interpretation as a geologist or an earth scientist, first the reconnaissance step or the reconnaissance survey, commonly, the interpreter will quickly scan through a 3D seismic volume by in-line cross line and time, in-line cross line and time we know that time is always verticaly it is time. Similarly, it is in-line or it is cross line. So, that means, in seismic cube given to an interpreter the first he has to rotate like this in an angle and at first instant.

How to it is look like that is the reconnaissance survey and experienced geologists. In the first reconnaissance interpret a lot or if you do not have any geological knowledge or geological background, even if these features are clearly shown, but it is very difficult to correlate or repeat is looking either it is geological or not. So, here commonly the interpreter will quickly scan through a 3D seismic volume by in-line cross line and timeline. So, here with vertical changes, lateral changes and longitudinal changes, how these changes is they are whatever the change is there or not, that can be interpreted from the first reconnaissance survey or the first look.

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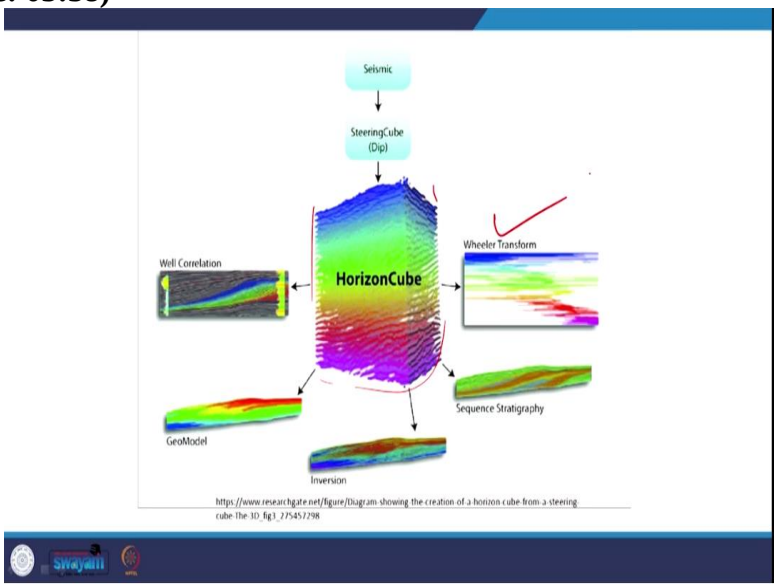

So, here it is a workflow or some processes involved here it is given we have this seismic cube and this is the cube the seismic given to you first it is there is geophysical processes led

processing is transformation then sequence stratigraphic information that will go for inversion then it is geo model is well correlation that means, different types of work. That means subordinate works are involved in the interpretation of a geo seismic cube in a proper manner.

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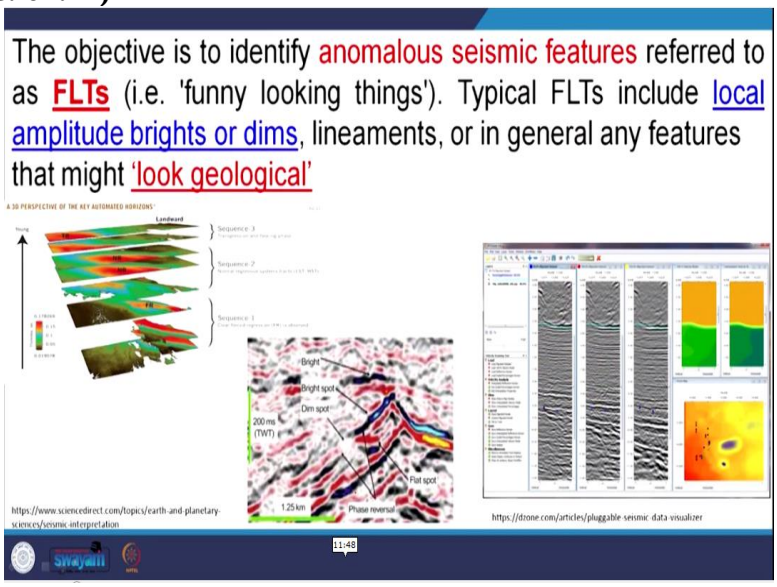

So the objective is to identify anomalous seismic features, referred as FLT. FLT means it stands for funny looking things. Funny looking things it sounds funny, but it is important. Typically, FLT's are funny looking things include local amplitude bright and dims as we know in the last class we are talking something about wherever there is an amplitude change either this amplitude change may be due to lithology or due to fluid content it may be due to density.

So, that means, everywhere there is a change in amplitude in this seismic profile once it is moving from surface to depth. So here the typical FLT includes local amplitude bright and dims lineaments or in general any features that might look geological that is very much important look geological, if you want to interpret this image for example, so, at a first look, I can say that yes it is looking like a fold or something something in the first instant is looking like a fold.

But whether it is a fold or not that will be discussed later. But at first instance if you have some geological knowledge that is looks like yes, it is a fold, is not it? So, that means features that look geological that is important, and that look geological that comes in our mind as a geologist. So, we should have sound geological knowledge, sound geomorphological knowledge or

depositional systems knowledge or the interpreters should have enough knowledge to interpret these features which are looking from funny looking thing as FLT it should look geological.

So that means geological process involvement, geological features and interpreters should have sound knowledge and that otherwise everything which is in front of you may be a very useful thing, but it is useless until unless we interpret it properly. So, that means, this look geological, it comes from your mind it should look geological,

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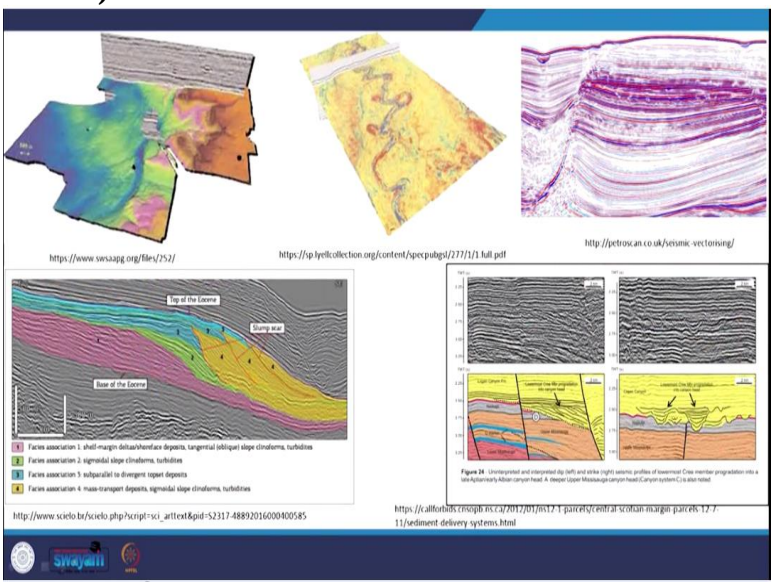

Here for example, some look geological point of view and say here if you see, suppose, it is a river system and it is distributing. So, now, in a plan view an seismic section in a plan view that means inline and that is a cross line view if you see here, so, that means how it is looking, branching out. So, that means if you are looking like a delta system, is not it? Similarly, here, it is looking like a meandering river system. Here it is a fault here it is a stratigraphic sequence, there is a sequence stratigraphic here we have some paleo channels.

So that means these features, these features, they are the look geological features. So, until unless we are able to distinguish these look geological features, how the geological processes involvement is there, which geological process are involvement is there to make this type of structure. If we do not have enough knowledge about this, that means we can miss it very easily.

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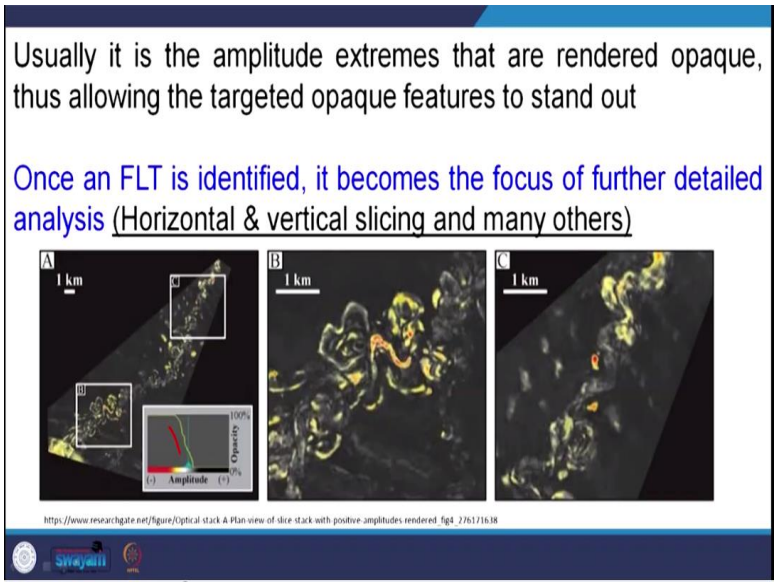

Usually, it is the amplitude extremes that are rendered opaque thus allowing the targets targeted opaque features to start out general in standard operating procedures, what we generally do the extreme amplitudes either it is a high amplitudes or these low amplitudes. So, these features it is under opaque. So, that means we make it opaque and other become transparent so that this opaque features that can be spatially correlated temporally correlated.

In, which way it has behaving either it is coming in the loop dealer there either it is coming in a channel with this opaque feature? if, by joining this opaque features are there looking any geological objects is are resembling any geological object. So, that means, if it is looking that means, we are able to further going we can go further interpretation which type of geological feature is looking either is looking at channel wise it is looking a fault it is looking a fold.

It is looking unconformity like so, that means, first we make it opaque and this opaque material, how it is arrangement is there how geologically it is resembling that will lead to further exploration further interpretation. So, once an FLT is defined it becomes the focus of further detailed analysis that we have already discussed in the horizontal slicing in vertical slicing and many others. So, in different support we are getting so, for example, here we are getting a channel like objects here.

And we will get in so that means this channel like object, we have to make it slices that means one time slice, another time slice and a third time slice forth time slice and then looking vertically into looking vertical that means to what extent the channel is confined to up to what depth to what depth is channel is confined, whether there is an evolution of this channel. And similarly, if we are looking for cutting a slice, we are looking horizontally also, we are looking horizontally from which distance to which distance this channel is migrating.

So, that means in a flood plain geometry, vertically the channel geometry, this involvement of the evolution of this channel, the evolution the flood plain that can be interpreted from this type of materials.

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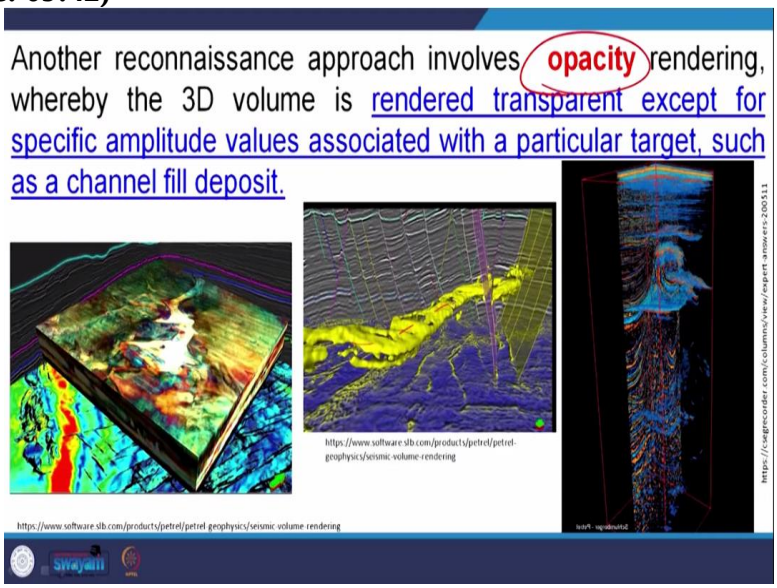

Another reconnaissance approach involves opacity that is rendering whether by this 3D volume is rendered transparent except for a specific amplitude or volume values associated with particular targets such as the channel filled deposits. So, that means here if you see, this is this channel filled up deposits and here, everything is making everything is opaque except this one. So once we are making it this so that means how a particular geologically looking object a particularly geologically looking feature, how it is behaving, it is lengthwise, it is depth wise, it is a lateral behaviour that can how it is behaving that can be interpreted very easily.

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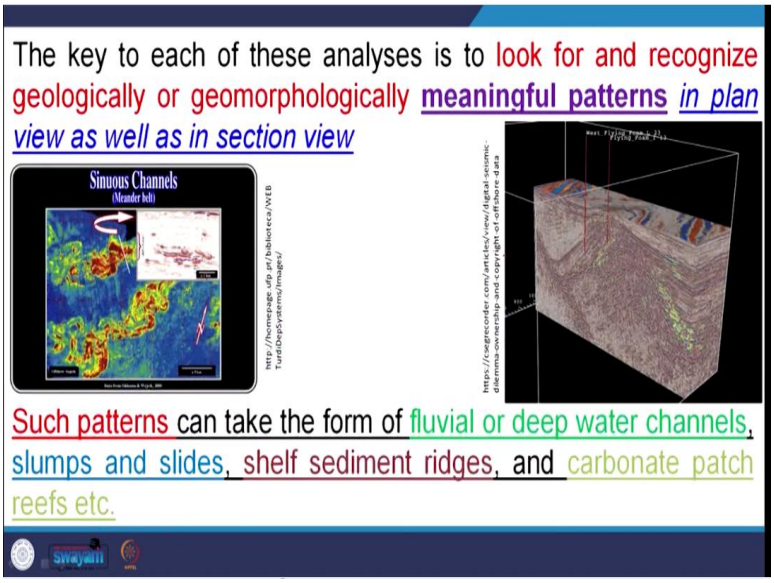

The key to each of this analysis is to look for and recognize geologically or geomorphologically meaningful patterns. This is very important only getting an opaque object is not enough how geologically and geomorphological it is making any meaningful pattern in plan view as well as a section view. So, as we have discussed it in a section how, from what depth to what depth it is continue. And what is this behaviour whether this suppose it is depth wise continue whether the channel width remain same throughout the depth or it is decreasing or increasing.

The valley width to depth ratio is increasing or it is decreasing. Similarly, here at this plan view whether the valley width is increasing in a particular slice or the value in this this subsequent slices whether this valley width is decreasing or increasing. Similarly, the flood plain depth flood plain width is increasing or decreasing so, that means in meaningful geomorphological interpretations would come out otherwise getting in opaque object opaque FLT is not enough.

So, how geological we are correlating how geological we are interpreting this thing that is meaningful. Such patterns can take the form of fluvial or deep water channels, slumps and slides shelf sediment ridges and carbonate patches and reefs it is that means these patterns this whatever they FLT you are getting out how geological were interpreting it, that is meaningful.

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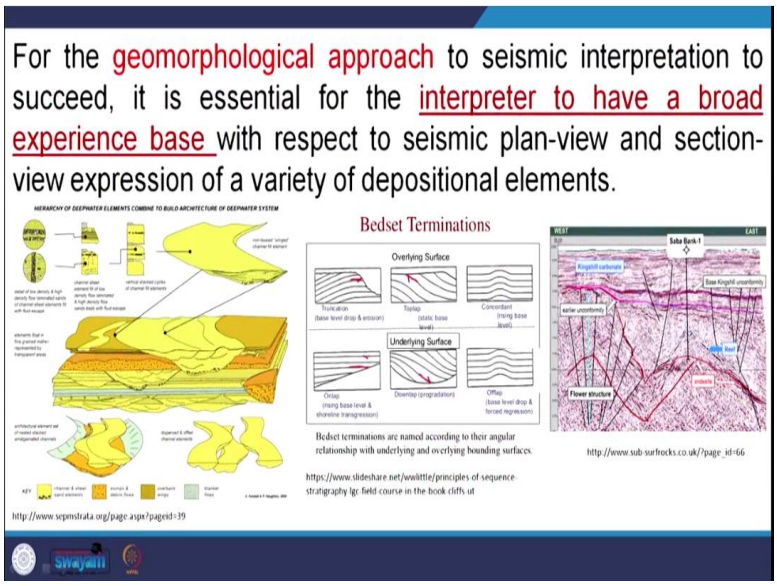

For the geomorphological approach, the seismic interpretation to succeed, it is essential for this interpreter to have broad experience base with respect to seismic plan view and section view expressions of variety of depositional elements. So, until unless we have sound knowledge about the geology, with the geomorphology with the depositional of features with the tectonic features, that means, we are missing or we are not competent enough to interpret this as seismic section.

So until unless we interpreted properly that been really meaningful things meaningful objects, we can miss or out misinterpret to something that is some type x. For example, here, it is contour arising base level. So here that means we can misinterpreted fold, which is looking like a fold you can misinterpret similarly here, there is overlying surfaces there are truncation is there that is onlap it is downlap, the truncation.

Similarly, we have depositional element environment we have fluvial depositional environment we have marine depositional environment lacustrine depositional environment because each of these depositional environment each geomorphic process they have a unique pattern of deposition, unique pattern of formation of land forms. So, once we are not able to interpret these processes and we are misinterpreted or we misinterpret these processes, that means, we are not doing nothing.

So, that means, we should have proper or sound geological knowledge and sound geological knowledge of correlating these things, these patterns to a particular geomorphic process particular depositional process that is important until unless we have that interpretation to capability or in that means correlation capability. We are not doing it properly. So, that means a seismic interpreters must have sound knowledge about this geomorphic as well as depositional processes.

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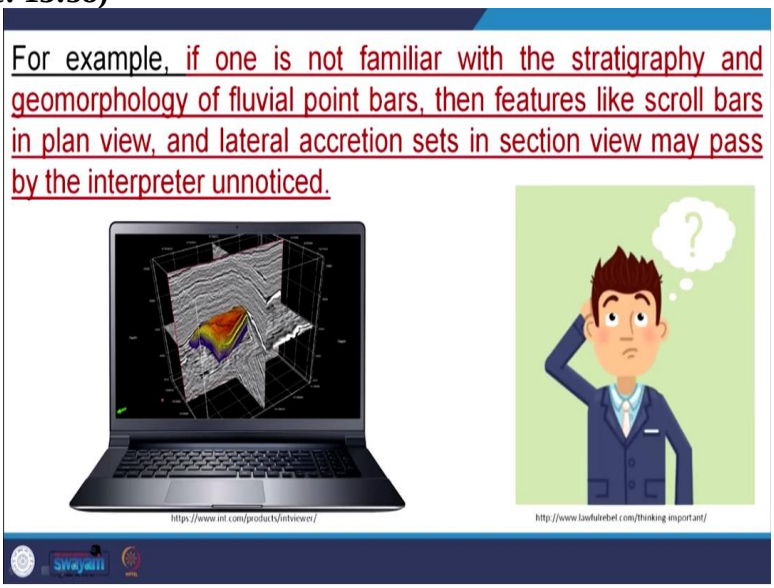

For example, if one is not familiar with the stratigraphy and the geomorphology of fluvial point bars, then features like scroll bars in plan view and lateral accretion in the section view may pass by the interpreter or interpreters unnoticed. So that means, if we do not have knowledge enough may misinterpret or even if we do not interpret it, we may neglect it. We may ignore these things.

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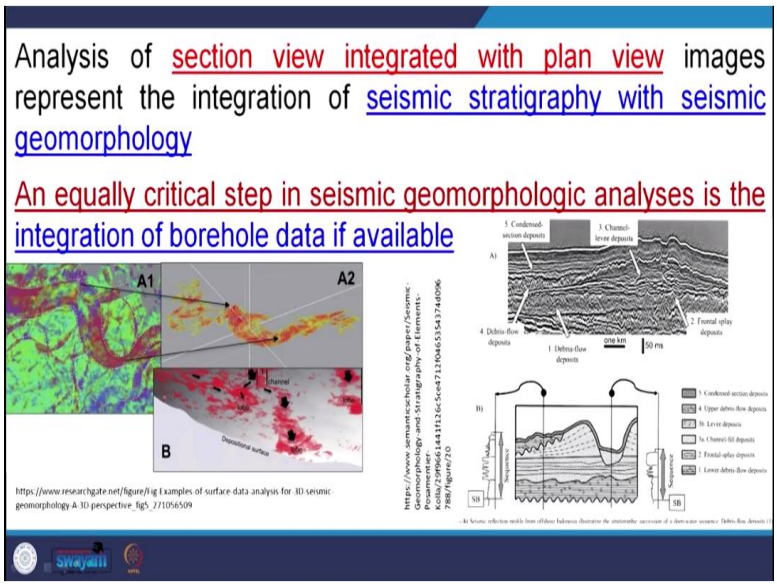

Analysis of section view, integrated with plan view. Images represent the integration of seismic stratigraphy with seismic geomorphology. So seismic geomorphology and seismic stratigraphy, they are interlinked because seismic stratigraphy is a product, but seismic geomorphology is a process. Similarly geomorphology is a process and depositional system is a product is not it an equally critical step in seismic geomorphological analysis is the integration of borehole data, if available.

To validate it because whatever this seismic whatever the GPR we are going we are doing the indirect method because we are not able to see what is happening in the subsurface. But if we have that not necessarily but if we have this borehole data that means this borehole data can be correlate to validate our systems will validate our interpretations.

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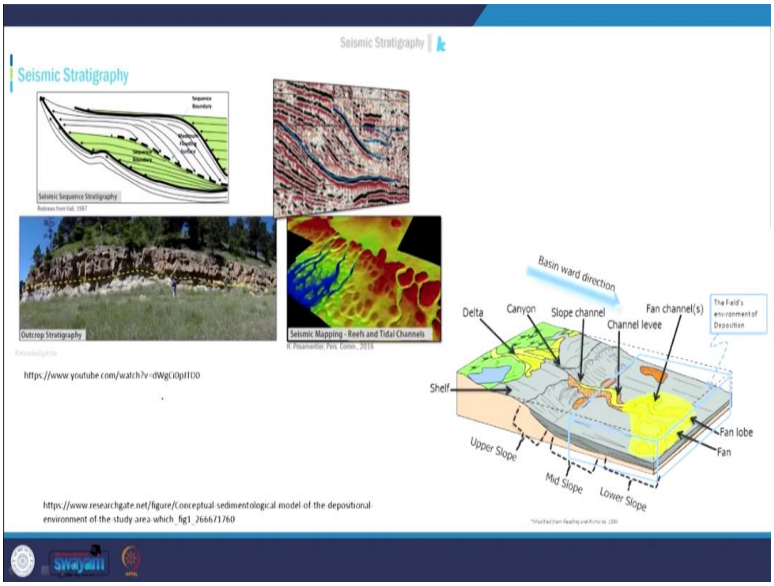

So, here are some of these examples. So, how this seismic geomorphologies system stratigraphy is involved when it is there, so, here is the product it is in front of us and these are this product it is from depth from the depth it is in seismic profile and this is the interpretation and here these are the geomorphic processes that are responsible for this formation of this type of depositional pattern.

So, that means now we have this one and we have through our seismic profiles, we have a seismic study, we have we are getting this one we are interpreting this one and we are correlating with the geomorphic processes. So, this is a complete cycle, how geomorphic or seismic profile can be interpreted and we can be correlated with the corresponding geomorphic process.

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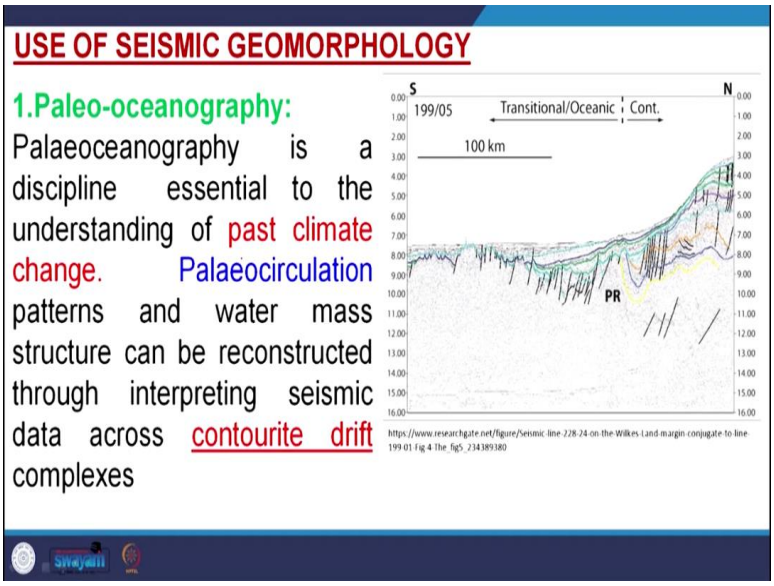

What is it use it should have used something. So, the use of seismic geomorphology use first is the paleo oceanography, paleo oceanography means it is oceanic circulation that is exposure of continental self, is not it? So that means what his involvement is there in what is how this marine geomorphic process, they change with time. There is the paleo oceanography so paleo oceanography is a discipline, essential to the understanding of past climate change, paleo circulation pattern and water mass structure can be constructed through interpreting seismic data.

Across the contourite drift complexes. So, we have seismic data from the seismic data we can interpret this contourite drift, this exposure of self, this migration of this change of sea level, this migration of coastline, all those in that means all these processes involved in the in the oceanographic that means it is the ocean or the coastal geomorphology or the nears that means, whatever the geomorphic processes involved in this formation of these depositional structures that can be interpreted from this value that can be interpreted from this seismic profile.

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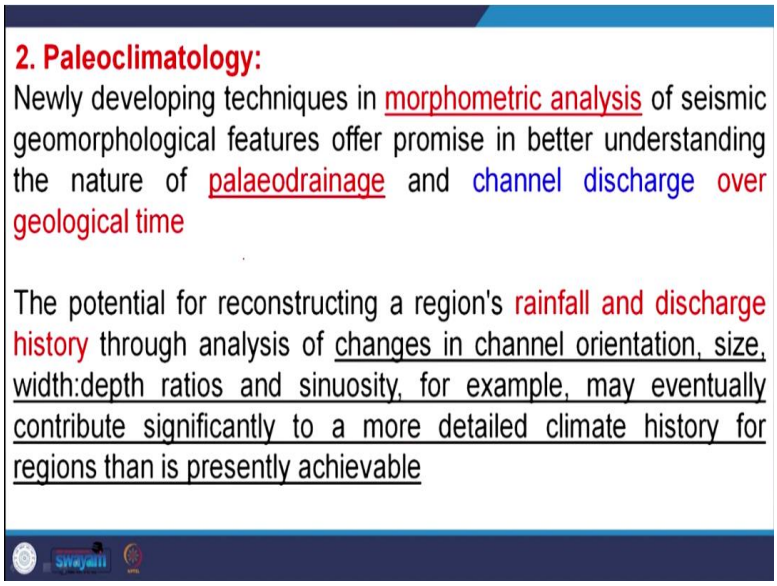

Then, second is the paleoclimatology newly developing techniques in morphometric analysis from seismic profile or seismic geomorphological features offer promise in better understanding in the nature of paleo drainage and channel changes or channel discharges over geological time. That is, suppose for example, we have a 3D seismic data, take an example, in 3D seismic data, we have a channel, which is here the channel width is this much and depth is that much and with the time we are getting this channel is divided here number of channels here.

And the channel width and depth it is gradually reducing. So, that means, it is the interpretation of climate change. Similarly, suppose depth width ratio is some what different and it is increasing here. So, that means it is indicating there is a larger discharge so that means larger discharged in the same channel, how it can happen, it is due to climate change due to the human increasing rainfall.

So, that means by in a vertical scale that means, in the down depth we are going so, if whatever the changes we are recording in a channel pattern from some depth to some depth, so, that means within that within that time unit, so how this climate changes there how this channel pattern is behaving with that, to that climate change that can be interpreted from here the potential for reconstructing a regions rainfall and the discharge history through analysis of changes of channel orientation, size width depth ratios and sinuosity.

For example may eventually that contribute significantly to a more detailed climatic history for regions that is presently achievable that means in the past geological history, how this channel was behaving with the change to climate that can be recorded and that can be interpreted from seismic profile.

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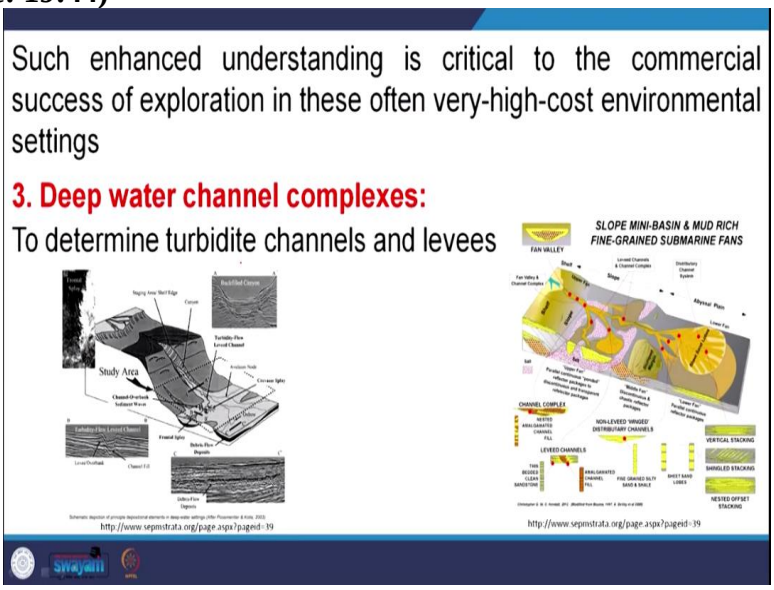

Such enhanced understanding is critical to the commercial success of exploration of this very high cost environmental setting because why we are doing so the fluvial environment in marine environment in deltaic environment we are in we are doing it due to for our interest in hydrocarbon exploration. So, that means environmental interpretation particularly the geomorphic and depositional environment interpretation is must going for any hydrocarbon explorations.

So, we are spending crores of rupees millions of dollars. So, until unless we interpret it properly, we do not correlate it properly to particular geomorphic processes that means, we are lacking something. So, that means, it is very much important to in to interpret these geological objects with geomorphic processes. Then, third is the deep water channel complex deep water channel complex we know we are getting deep water channel complex here, mostly this continental slopes.

And if you remember our last class when we are talking about this oilfield geomorphology these 67% of petroleum hydrocarbon it is coming from this hinge zone. So, that means here we have

deep water channel complex we have turbidites formation of tubidites here and the turbidite is deposited somewhere here. So, that means, those environments are commercially important and commercially important means we are spending crores of rupees or millions of dollars there.

So, that means proper investigation in these regions depth wise as well as laterally as well as time wise, it is very much important for this interpreter. So, that means, these areas are commercially very much important and this processes are very much important to interpret the past geological history as well as that is related to our hydrocarbon exploration purpose.

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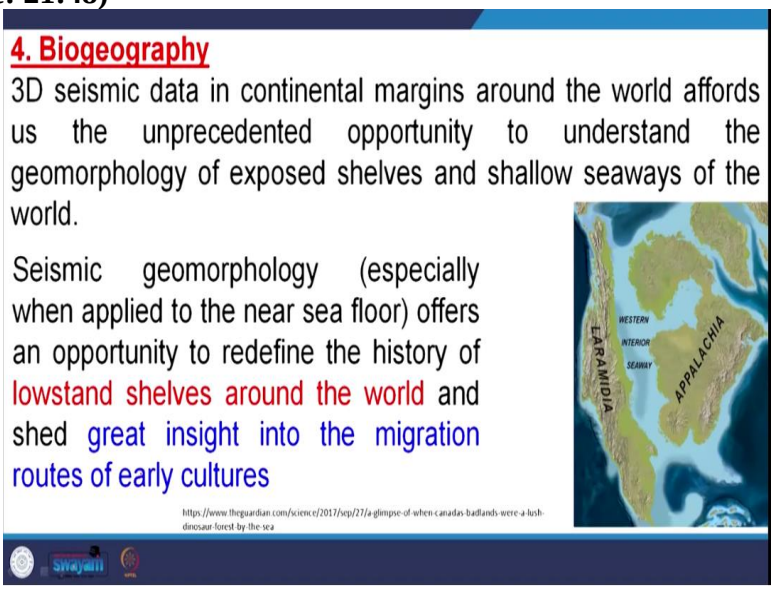

Then, biogeography biogeography in a 3D seismic data in continental margin around the world affords us to the unprecedented opportunity to understand the geomorphology of exposed self and the shallow seaways of the world. You see, in the past climate change when we are talking about the initial classes, many times the sea level fluctuation is there. And even in the last glaciation time, the sea level or this present day, coastline, it was 100 meters or so.

Below the present one or even kilometer one kilometer below the present one. So, that means, it is significant. So, if you go to that geological time, so, here the whatever this the connecting route through sea shelf that are much below the present one, so, that means, that can be interpreted by biogeographically how, what was the past a connecting route from one continent to another within the continent from one site to another site that can be interpreted from seismic data.

Seismic geomorphology offers an opportunity to redefine the history of lowstand shelves around the world and said great insight into the migration route of the early culture, it is important migration route of the early culture it means, what is this early civilization time how these who are migrating from one part of this continent to another part of this continent through sea level near to the sea that can be interpreted from the seismic data.

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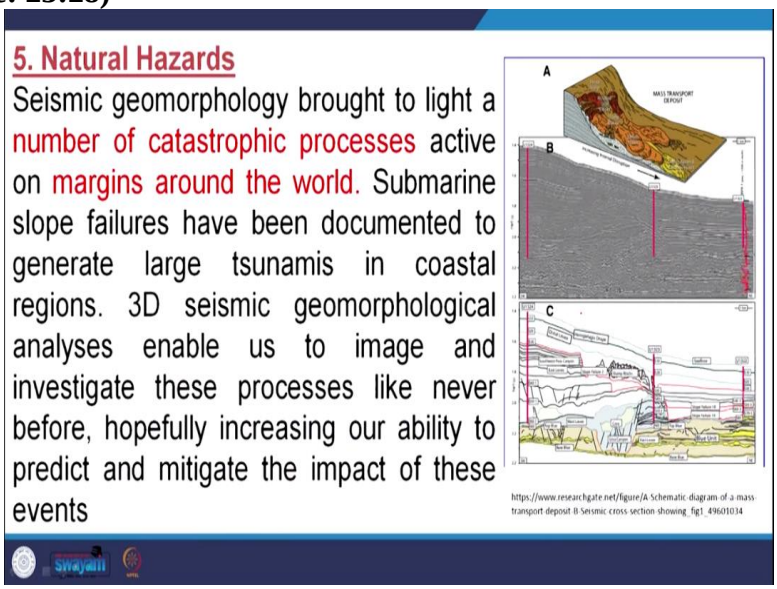

And this most important one is natural hazard, natural hazard means tsunami deposit if you know that in the past, in the last class we are talking and depending upon the reflection pattern, we can interpret what type of geomorphological process involvement is there. So, that means, if you remember we are talking about the chaotic pattern. There is a Chaotic pattern when there is no proper orientation, no proper management of a depositional system.

That is the tsunami deposit the catastrophic deposit the landslide deposit similarly seismic geomorphology brought to light a number of catastrophic process active on margins around the world submarine slope failure. That is submarine landslides have been documented to generate large tsunamis in the coastal regions, 3D seismic geomorphological analysis enable us to imagine, imagine investigate these processes like never before, hopefully increasing our ability to predict and mitigate the impact of this event.

So, that means these interpretations, it is socially useful, it is commercially useful, it is research wise useful. So, that means, this seismic geomorphology is nothing, we are retrieving the geomorphological information from the seismic profile, either 2D or 3D and we are correlating with the geomorphic process and we are correlating how the geomorphic processes changes with time with vertical scale at a lateral and longitudinal scale.

So, this is nothing, this we have sufficient we have sound knowledge of geomorphology that when we can, we can correlate the products with the process. So, here we can say that the seismic geomorphology is nothing but the retrieving the geo morphological information from the seismic key data either a 3D cube or a 2D profile. So, this data we are retrieving, we are correlating with these corresponding geomorphic processes.

That means, product is there and it is buried in the subsurface. We are using this seismic technique to retrieve it in a profile form. And whatever these changes are they are in a vertical scale. These changes the lateral scale, the longitudinal scale, whatever these changes are they are these changes we are retrieving it and those changes are correlating with the associated geomorphological process, is not it?

So, this is the utility of these seismic geomorphology and mostly this seismic geomorphology we are using our exploration purpose mostly the oil exploration and it is very much interesting to know that without a proper interpretation of the geomorphic process, if you are going for this oil exploration or hydrocarbon exploration, that means we are spending millions of dollar without any meaning. So I think this seismic geomorphology very much useful for you to interpret the past to geomorphic processes that are fossilized and are recorded in seismic profile. Thank you very much. Thank you again.