Earthquake Geology: A Tool for Seismic Hazard Assessment

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Lecture – 06
Fundamentals Related to Paleoseismology (Part II)

So, welcome back so, in the previous lecture we discussed mostly about the different definitions and of paleoseismology and allied fields.

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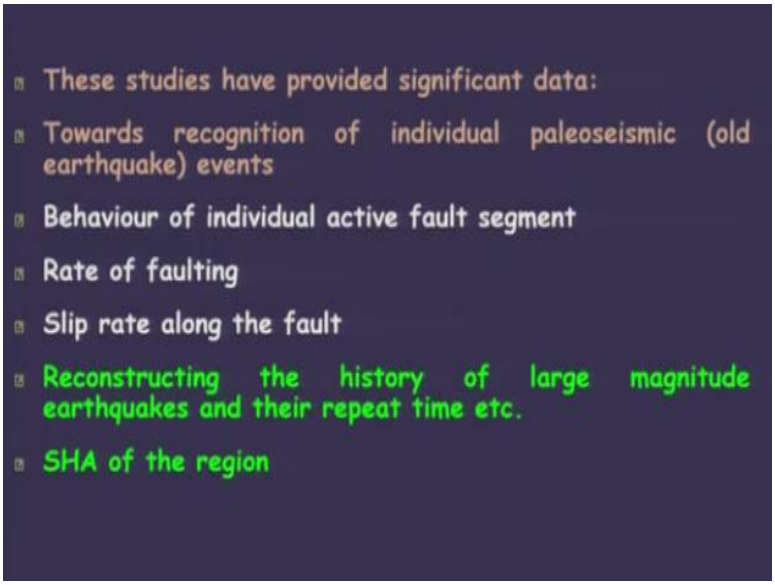

And the importance of the paleoseismology and also we talked about that the since it the onset of this feel like when it started way back in 80's and after that we have also started like in India on this part, the importance of the paleoseismology. Now, moving further as I was talking about this field requires like the knowledge of different light fields.

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So, for example, the paleoseismology itself is an interdisciplinary field which requires the knowledge of structural geology, geomorphology, sedimentology, photogrammetry, soil sciences; pedology and dating part. So, in short if we talk about we are covering almost all allied fields of our sciences or geology to understand the earthquake process. So, the structural geology part you need to know on the regional; global regional and local scale and the landforms which are been formed by tectonic activity.

And this will be like we will be able to achieve this aspect using photogrammetry or satellite data interpretation and then the sedimentology part is important because we are going to look into these sediments also, so signature preserved in sediment succession and we also should know about the soil types because this will also help us in interpreting the change in the environmental conditions because of the tectonic moment.

And finally, the dating part where we will be mostly dealing with the OSL and carbon-14 dating which help us in bracketing the events or reconstructing the earthquake history on an individual fault.

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So, before we will move to the details of the paleosiesmolgy field techniques and all that, we will also try to cover some basic parts which are fundamental parts and this and the plate tectonic we will discuss later on after the in this lecture but straightaway we will go to the part which is required for the initial understanding before we get into the details, okay. The plate tectonics will try to discuss later on.

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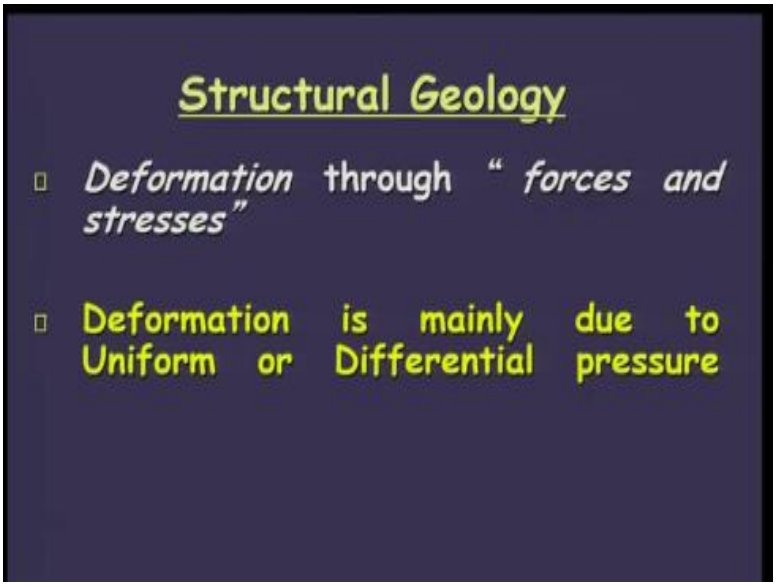

Coming to the structural geology part; the deformation through forces and stresses, so under different stress pattern, you will have different pattern of deformation, okay and mostly, if you are talking about the deformation on the surface, then we are talking about the differential stress and deformation basically, the structural geology can talk about the deformation due to uniform or differential pressure or differential stress.

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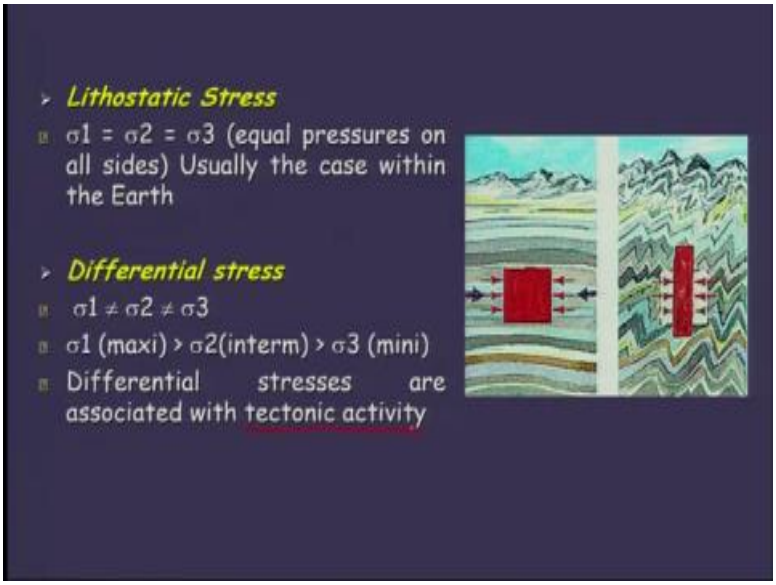

So, for example, if you have the, that what we call the thumb rule that all deposits were horizontally deposited you know, the sediments were deposited horizontally and but due to the differential stress, we see that a formation and then development of the topography. So, lithostatic stresses; sigma1, sigma2, sigma3 equal pressures on all the sides usually, the case within the earth, okay.

And further differential stress whereas are not the same and sigma 1, sigma 2 and sigma 3 are different, they are not same where sigma 1 is the maximum, sigma 2 is intermediate and sigma 3 is minimum. So, mostly the deformation which we see on the surface is because of the differential stress pattern, so differential stresses are associated with tectonic activity and whatever we are talking about the paleoseismology, we are talking about; we are going to deal with the tectonic activities.

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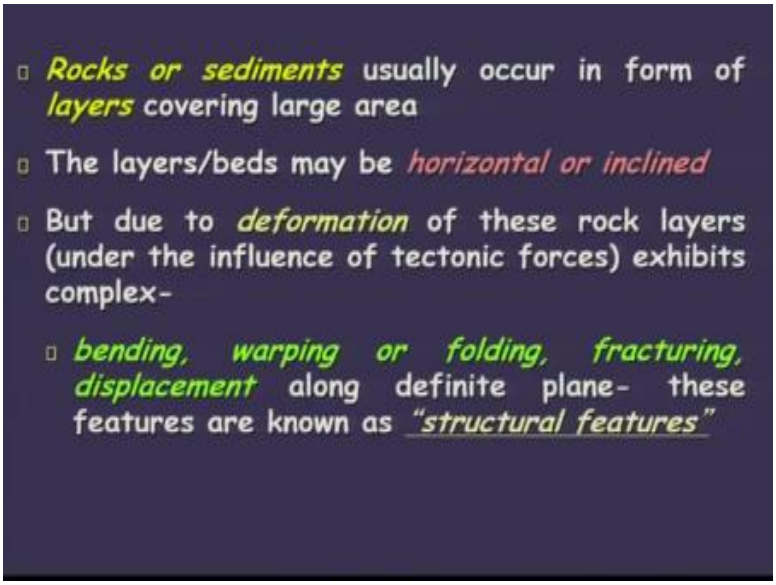

So, rocks or sediments usually occur in form of layers covering large area and this is because we are going to look at younger deposits, so for us, the younger sediments and the landforms are going to be an extremely useful portion. So, the layers or the beds may be horizontal or inclined, okay but due to deformation or the tectonic activity and as I was saying the differential stress, okay the layers are which were deposited horizontally or slightly inclined.

Or so, this rock layers or the sediment layers under the influence of the tectonic forces exhibits complex structure that is what you will see is either they are bend, warped or folded or finally, it will what we see is the fracture and further displacement along a definite plane, this features are known as the structural features. So, for us the part of the structural geology we will be interested in knowing that what type of deformation either, they are folded, we are just looking at the inclined beds or they are just warped or they are showing some displacement.

So, any fracture which is showing the displacement is will be termed as faults, okay so, these are all the basic structural features which we should know, okay.

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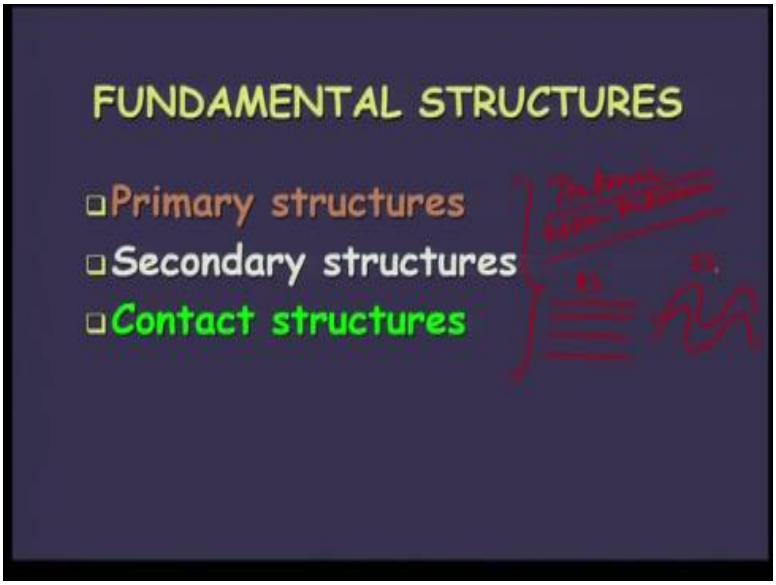

So, further and details if we get into the structural geology part, the fundamental structures you can have in a broader sense, you can have in 3 sub categories; one is your primary structure, secondary structures and contact structures because the to differentiate between the tectonic and non-tectonic origin of the structure will be important for us because we should not misunderstand the non-tectonic features.

For example, the contact structures could also mimic that they are formed because of the tectonic activity and of course, we also should know about the primary structures, okay. So, for example we are having horizontal beds or the layers of the sediments and so these are the primary structures and if you are having under the deformation, then you will see the folded ones, they are the secondary structures.

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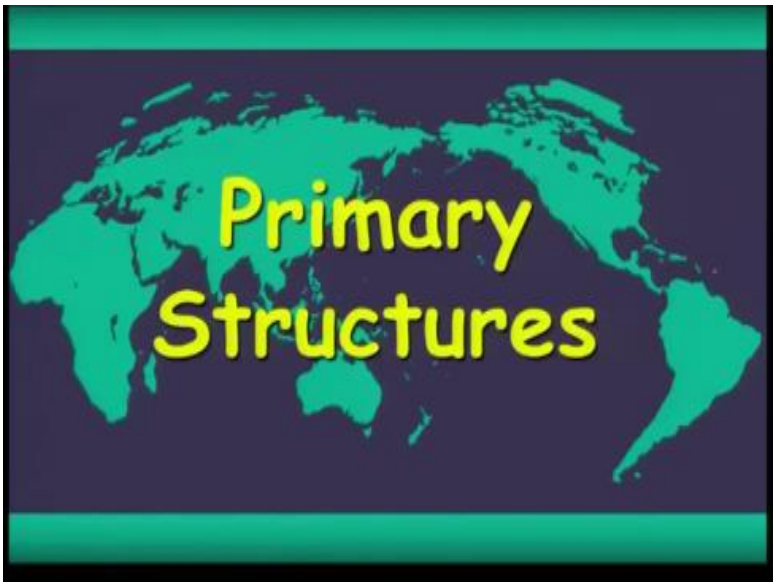

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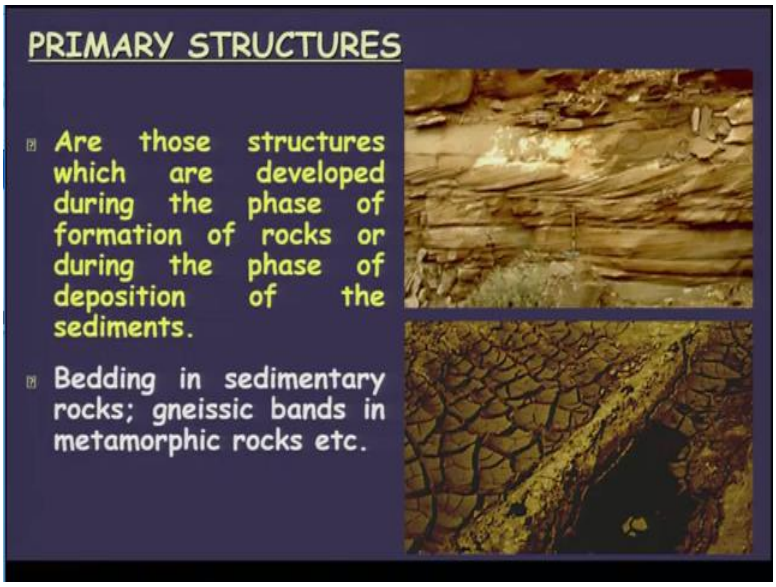

So, the primary structures if you take, then we have mostly, the sedimentary structures we take into consideration, so the primary structures are those structures which are developed during the phase of formation of rocks or during the phase of deposition of the sediments. So, what you see is the sedimentary structures, these are all primary structures or primary contacts. Bedding in sedimentary rocks; gneissic bands in metamorphic rocks are termed as the primary structures, even the mud cracks, okay are the primary structures.

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Now, this is one of the best example, which mostly, most of us will come across in terms of the sedimentary structures and can do mistakes in identifying or differentiating between the tectonic and non-tectonic structures. So, most of the time, what we say that the geologists

should try to look at the wider areas okay, instead of looking at the smaller portions of the exposed sections, okay.

Now, what we see here is that we have carefully, if you see on the left hand side, you have horizontally stratified sequence and then you have one boundary here, which goes right up to this here and then dyes out, so this trough feature is nothing but the channel; river channel. So, this is an old river channel which has incised those deposits okay, so you have a horizontal layer here.

And this contact is in erosional contact, now for example and in this also, the picture is not very clear but you can make out to some extent, you have some structures here, you have something over here, so these are all primary sedimentary structures. Now, what mistakes or without looking at the regional scale one can come across or can do the mistakes is that if you suppose, you look at this portion only.

I will just remove the rest of the part here and then, so we know that this is channel because we are able to see the whole area but suppose, we are looking at this portion, smaller area, this one, now if you want to sketch this, then what you will see is because usually, the faults which that in detail I will talk later on but suppose, you are having horizontal layers like this and if they are folded along this wall for example.

And what you will see is there is a displacement along this and you have this layers, so there is an abrupt termination somewhere along this line okay, so this is your fault plane, so this becomes your secondary structure. So, you have the sediments here which had been displaced it and now, if you sketch this portion then what you are able to see, I will just sketch in a smaller one here, then if you, so you have those layers here.

And then there is in contact which goes like that, then you have this, okay and then some layers are same here like this, okay, so again if you compare this with this one, okay it is more or less similar, more or less similar, you have what we call is the unconformity or you can say that the cross-cutting relationship between the layers are distinctly marked along this line and here also you can see that they are distinctly marked between this line which has been marked here, okay.

So, if you are just looking at this and then we are talking about something that whether it is in sedimentary feature or not you may say that this is related to tectonics because in faulting because this is under the compression the portion will break and it will move up and it will give very similar feature but if you look at on the regional scale and if you look this whole in one shot, okay then you will be able to trace this channel here.

And then you can say that this is the earlier deposited sediments which were been cut by the river channel or we because this is hanging along the cliff and so we also turned this as an paleo channel basically, this is in your sedimentary feature. So, differentiating between the primary this is; this will be sedimentary feature of course but this will be what we call the primary structure and this becomes the secondary one.

So, you can mimic easily between the tectonic and non-tectonic, so it is always better to look at on the larger scale and cover more area to understand and like you can at least come to the conclusion but whether this is tectonic or non-tectonic.

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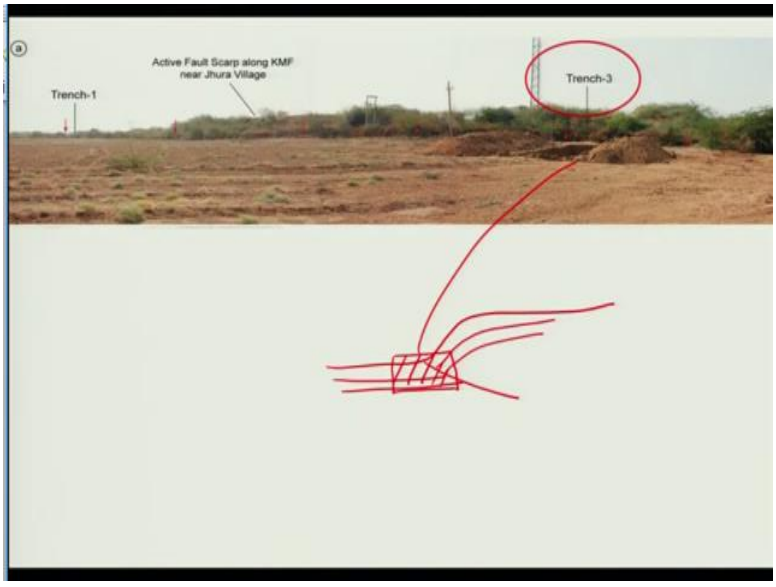

Further example, this we did in Kutch, where we so, Kutch is one of the another most active areas in the Indian subcontinent and has like produced our experience lot many in large magnitude earthquakes. So, this exercise we were doing in mapping the active fault and the elevated portion what you see here is the active fault scarp along Kutch mainland fault. See, if I just put the cross section across this for example and how it looks like is something like this, okay and it goes like that.

So, with the topography and the experience what we say that okay, find the fault is somewhere sitting somewhere here, so in the plain areas okay so, we have moved in the plain area and we dug the trench to see the section. So, what was expected is that there is a deformation here, so we will find something displaced sediments over here and we will be able, so we have, we dug the trench like this, okay.

So, this is the trench which is been shown here but we will see in the coming slides that what mistakes one can do if we are not trying to understand the overall contacts as well as the features okay, so differentiating between primary and secondary feature becomes extremely important.

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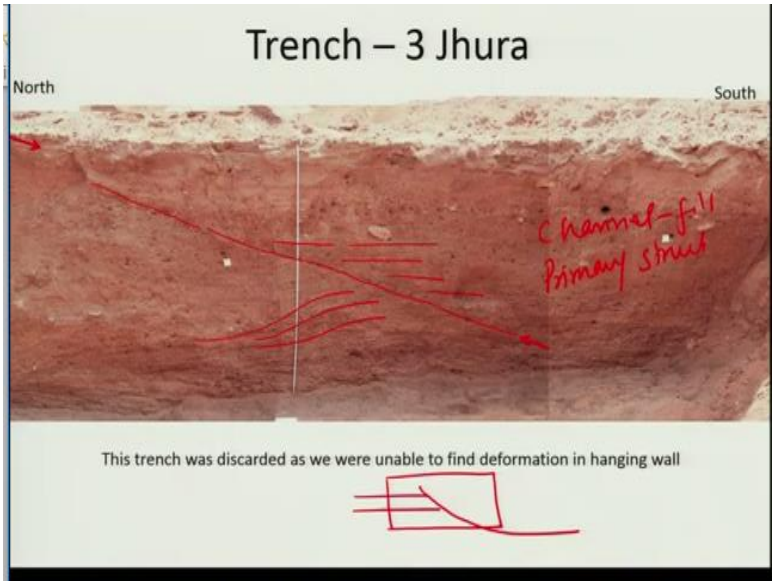

So, trench 3 if you look at, this is what we dug the trench, it is almost like 1.5 meters deep and this portion was the area of attraction in the sense because somewhere over here, I will show the close up, we were able to see the contact okay which could be a tectonic contact or a fault, so this is a close up here now again, as I did the trace the lines that is the sedimentary structures and one can easily make out this elementary structures like this over here and goes like this.

It tends somewhere along this one but along this line, so this is the line here, I will remove so that you will be able to see, which goes right up to this and then further on this side also, on the right side of the, of this line we see some prominent sedimentary structures. So, we could have easily say it that is an fault here, okay and this is your the faulted block and this is the stationary block here.

But what you are not able to see here as I have been drawing this sketch okay, the previous sketch if you take here, okay what I was showing here is that you will able to see some deformation along this line, okay. See and that we were unable to pick up here, so we did not see any deformation on this part, if we have to interpret like if you say that this is a deformation, then we must have seen something like this, okay but we did not see that.

We are still having a very straight and prominent layers, which (()) (20:25), so this is nothing but a channel fill deposit, similar to what we which looking at but you are having this layers here and this some channel has cut, so we are again looking at and very small portion over here, so this is not a tectonic feature, this is in a part of primary structure.

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Few more slides; so what we did was that we were not satisfied with the features which we identified here, we opened up another trench and which was the trench 1, okay and we definitely were satisfied that what we were looking at in this trench; trench 3, we were looking at primary structure and in trench 1, we were able to see the secondary one, so this is the close-up of that.

And the displacement of the layers can be seen clearly along this line, so this layer is sitting somewhere here and there is an clear-cut displacement and then what I was talking about that you will be able to see some short of warping okay or the folding along the plane and that we were able to pick up here.

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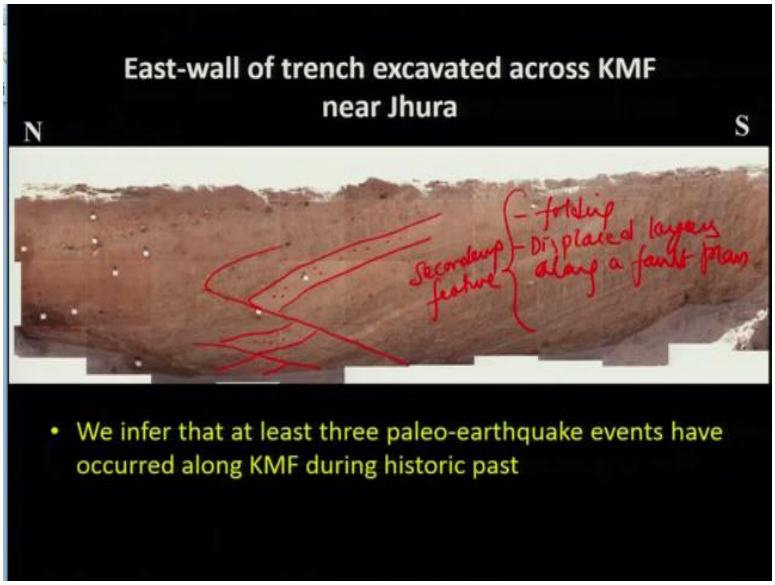

This is a close-up of that so, you can easily make out the displacement now, I will just put the cursor here, you can see this line along this sharp line, this is your fault plane and you are having this layer is sitting here which is displaced along this one, so this is a fault here which goes which has moved and brought this sediments on top of this one, so you have like if I just put the boundary here of this one and goes something like this.

And this layer is sitting over here, there is another line here which is, so only this unit if I put it, then there is something here and then you have this fault, which goes here, so there is a clear cut displacement along this as well as what we see is a warping. So, what we see here is the folding displaced sediment layers along a fault plane and based on this, we straight away we can say that this is your secondary feature.

So, the differentiation between the primary and the secondary feature or the structure is going to be an important part in this course, okay. So, here the knowledge of sedimentology is extremely important because you cannot do mistakes and identifying the primary and or you should not do mistakes in differentiating between the tectonic and non-tectonic feature, this is the most important one.

So, I am removing all this, so that you can easily make out what I was talking about in terms of the deformation features, few more slides I will show on this, so that you are aware and of course, we will keep on discussing when we are talking about the trenching part okay, so this is what we have done the trenches and the squares which you see here are the grids, okay because we need to map each and every layer.

This we will talk in detail when we are talking about the field techniques and all that so, we have almost 3 faults here, one is here, another one is here and third one is here again.

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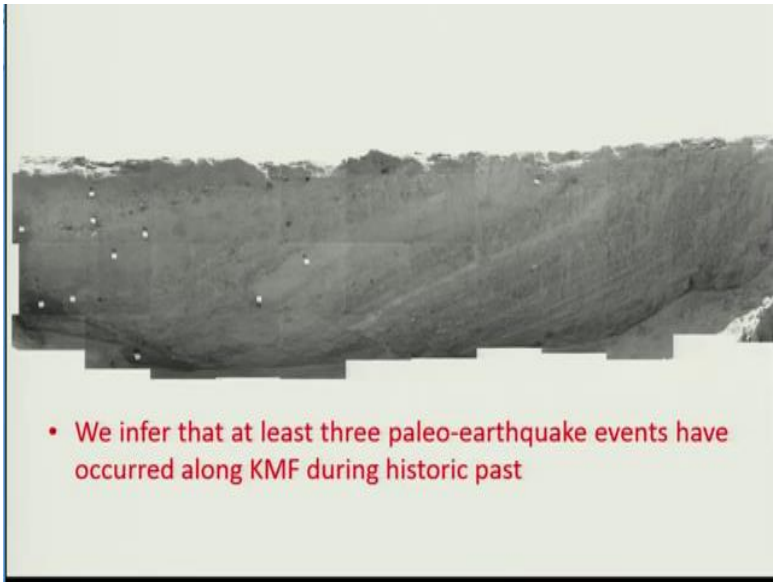

So, close up of one of this if you see, then this is in black and white which also enhance and you can play with the colours and try to identify the features, you can see this deformation along this one and this very sharp line here along with the deformation is there and the third one which goes here.

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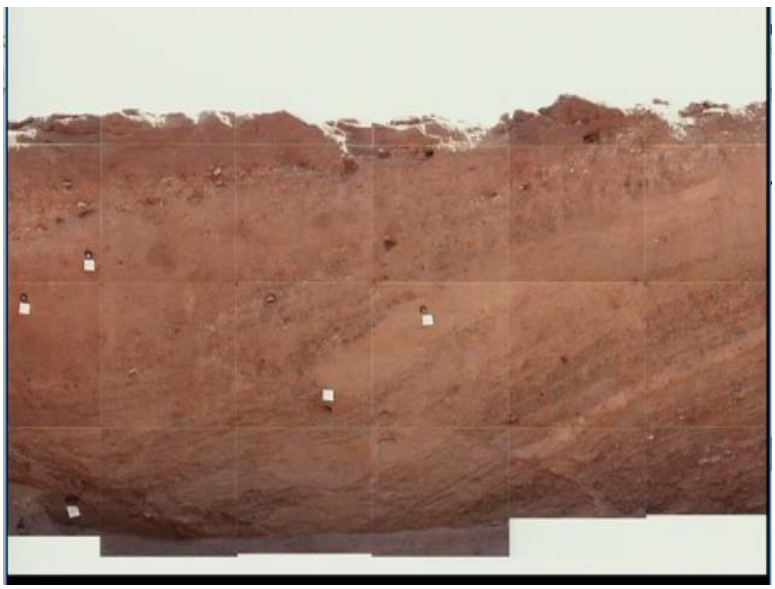

Close up of that; now, I hope it is more clear to you so, you have the line here and the beautiful part if you see here is this layer, okay. This layers goes here and then get into this and then folded okay and this one also is getting folded over here, so this layer is sitting here

and this again is for here, so along this one this is faulted, along this one it is faulted and in terms of the primary one, what we were able to see was something like this, okay.

So, there is no deformation but here we see so, the contact is more or less similar, this contact is more or less similar to what we see here but yes of course, it is not so curved what is been was been observed in the primary structures.

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Another close-up of the default which was been seen towards the south that is in this portion here now, close up of that okay, you can see the folding on this one and the fault goes like this here. So, these are few of course, the basic things which we should keep in mind when we are moving into the field either it is in terms of the landforms because there are many land forms which will mimic not there probably, the product of tectonic activity but they might not be; they might be simply erosional features, okay. So, we will talk more in detail in the next lecture, thank you so much.