Earthquake Geology: A Tool for Seismic Hazard Assessment
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Lecture – 27
Lab & Field Techniques in Active Mapping and Paleo Seismic Studies (Part - II)

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Welcome back. So this was last slide and we were discussing about that we usually use very high resolution satellite data to identify the tectonically formed landforms. Now this photograph is this is a corona satellite photograph which was collected by the U.S. spy satellite long back almost 30-35 years back. And this is this data is available in stereo vision with an stereo vision capability. This portion is from the foothill zones of Himalaya in Northwest region.

And the city you can see here well planned is here the Chandigarh city. So if broadly if you classify this landscape then what you have is you have the Indo-Gangetic plain sitting down here and the contact between the Indo-Gangetic plain and the upper Siwalik or we can say the sub-Himalaya is the current plate boundary between the Indian and the Eurasian plate on the side. Then we have Intermountain Valley which is located between the 2 hill ranges you are having lesser Himalayas here and that you are having sub-Himalayas.

So this is an intermountain valley very much similar to you must have heard the name of Dehra Dun and similar to that you have Kota Dun and then you have Soan Dun and even you have the Kathmandu valley. So these are the Intermountain Valley very much similar to what we see along the Himalayan range. So further detail have just this was when done based on the very tip prominent tonal variation and as well as the morphology of the terrain.

You can see that this portion is very like dissected by small streams we have ridges here. But with this just looking at the 2D view you will be able to identify the major features geomorphic features but details you would not be able to pick up here. For example, if I am asking you to identify the active fault in this region then you would not be able to trace out just to you will put an line here in contact.

But the precise location of active fault in this region or in this region or anywhere in this I will show couple of close ups of this where we have picked up new faults new active faults which had not been mapped earlier and that was done based on the of course this data with the resolution of around 2.5 to 3 meters. But this that was been done using the stereo vision capabilities.

So further so major classification you can do with any satellite data either it is Lancet or even the panchromatic data. But precise location of active faults I would emphasize here is can be done only if you are able to see the terrain in 3 dimension.

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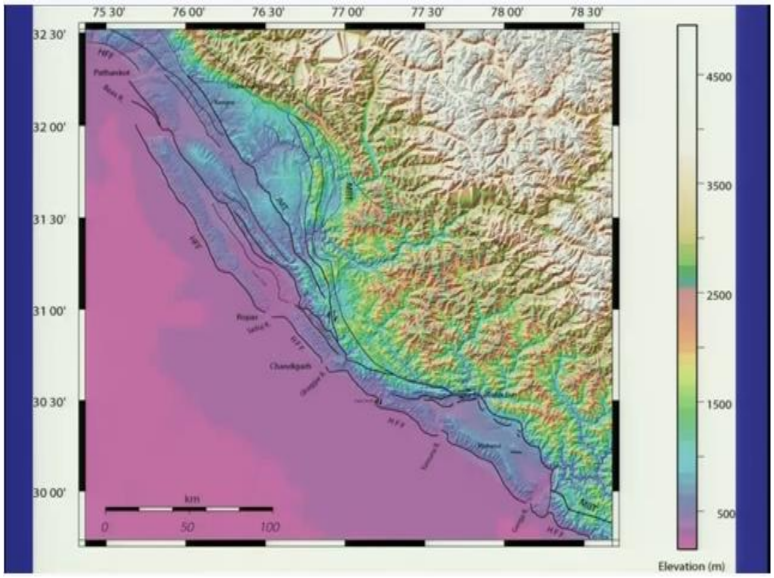

Now you can also use other data like satellite topographic mission data and idea here is that you will get an digital elevation model and this map is your shaded relief map which shows the variation in the elevation which has been shown here. So you can see like from 0 you are moving ahead into almost like the height of 4500 and more here towards the higher Himalayas. So you can have digital elevation model and this also helps us again to identify the landforms on macro scale.

But on micro scale you need to have an high resolution satellite data with stereo vision capability. So of course you can you will with this you will be able to put some lines that is the contact between the 2 prominent geomorphic features on the larger scale. But to the site specific you need to have the high-resolution satellite data with stereo vision. So mainly our team has worked in this region. So we will be highlighting and showing you what research we have done and what the new findings we have come across during our investigation from Northwest Himalayan region.

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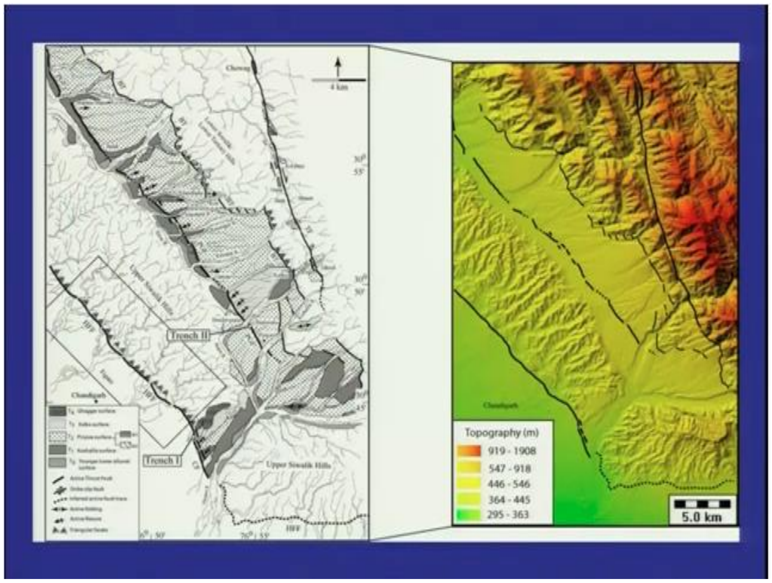

So with the previous slide which I was showing that we can have the regional on the regional scale you can trace out the features or the structures and with the help of further detail like high resolution satellite data you can have further detailed mapping of active fault. So usually what we do is we use the digital elevation model for this and based on that we can we prepare high resolution geomorphic map.

This I am talking about high resolution because we have we will be able to put the precise location of active fault. So this bold lines which you see here is the precise location of active faults and this line is again we are looking we are showing the plan view but this is related to the features which we are going to learn that what are the all features which helps us in identifying and putting those line as an active fault.

So we have like here lot of symbols are been given like triangular facets. So you will learn about what do you mean by triangular facet. Active flexures, active folding, inferred faults. So those locations where we are not having an prominent exposure on the surface of the active fault trace or the landforms with the help of which we can demarcate the fault line then we put dash line here or discontinuous line saying that those are the inferred faults.

And then the map also shows that the sense of movement so mostly this faults which we have marked are thrust faults. So now it should be clear to you that what when I am talking when I am saying the thrust fault then it should immediately come in your mind that this is an low angle reverse fault and which are developed during in compression tectonic environment. And then another symbol which shows the very much similar to what we were talking about the transform fault so this strike-slip fault.

So this is your strike-slip fault which is occurring here and then the sense of movement has been shown here. So this becomes your right lateral strike-slip fault and again with the help of what we have discussed in the previous lecture that with the help of offset of streams formation of linear valleys, location of the sag points and all that or shutter edges we can demarcate or characterize this fault in terms of its sense of movement.

Whereas these are the faults which are all thrust faults with this block is up and this is down here. So and along with that what we have included here is different surfaces. So what we learn in the previous and discussed in the previous lecture that we need to analogy of the landforms that is the quaternary landscape and this is exactly what it shows here. So you have T0 is the terrace. So what are the terraces and all that?

You will learn quickly in coming lectures. But in short quick I will briefly I will explain that if you have not section here for example then what you will be able to see that we are having almost like 1, 2, 3, 4 and 5. So you have something like this okay 1, 2, 3, 4 and 5 terraces and then it goes like up here okay. So you have this is your youngest one T0, this is your T1, this is your T2, T3, T4 and then further one more is your T5.

So you have but here we see is mainly the up to T4. So we have these are the terraces or the steps which are developed along the river but on one of the bank here. And other side we do not have the terraces. But usually we may come across mostly but we have the paved terraces. So we will have the terraces on other side also. So T0, T1, T2, T3 and T4. So T0 is the youngest one here. So this part I will discuss later that why this is younger? And why this is older?

But this is the youngest one which is sitting close to the riverbed. So you have this 4 terraces sorry 5 terraces including the T0 are all displaced hence this is also an important part which one has to identify and the best location for trenching is also important when we see the youngest displacement on the surface. So youngest landform if it is displaced then those areas are the potential site for trenching.

So this includes a detailed geomorphic map with the landforms here we have which have been marked here with different symbols as well as the fault lines. So this will easily help in understanding that whether the fault has remained active since past or not. Because this is one of the basic interpretation or you can say that you can take up this as an the first step before you go in field and start mapping the active tectonic related landforms.

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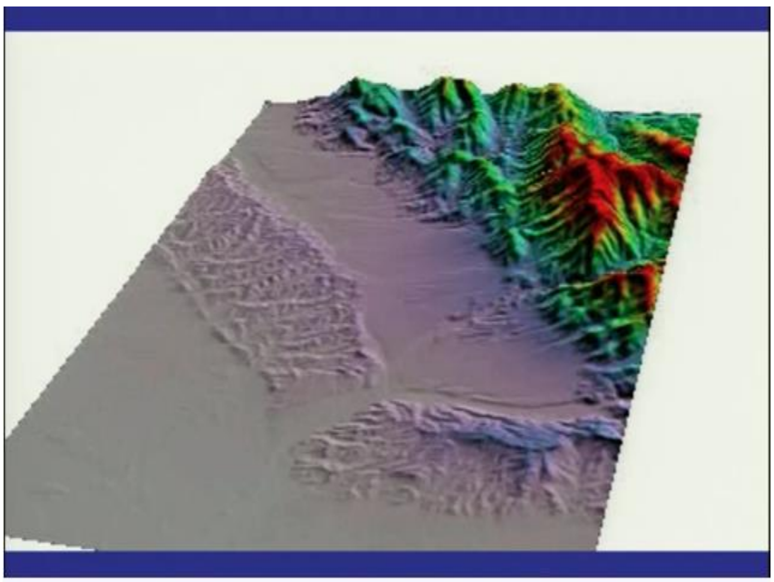

Now further you can also play with the data you can generate the digital elevation model and with the help of certain data so what we have done here that we used SRTM data and we generated shaded relief map and with the help of again the DEM we have draped this DEM on the top of the or on DEM we have draped the shaded relief map to get the topography. And in this topography you can see clearly this is the same location which I was showing in the previous slide.

So you have this portion as well as this one and this these are the Himalayan rocks which we or the hills which are been exposed. So the next slide is exactly on this area which I am showing. So you can have an 3D perspective view of this. So you have the flat area and then flat area is getting abetted. So roughly it at first instance you can easily mark that this is some boundary which could be active could not be inactive also okay.

But the other information which will come in with the help of these satellite data interpretation and the landforms which you will demark it you can fix up that with that this is an active fault or not. Now you can even create an fly through this which can help you in understanding the landscape. So you have 1 fault here another is passing through this valley here and third one is going here.

And this is what I was talking about the reformation of the linear valley and all that okay. So this of course the resolution is not so high. But to some extent you will be able to pick up very easily on a larger scale. Even this is the part which is from here the strike-slip fault which we picked up and we the close-up of that if we look at then the strike-slip fault run somewhere over here. Let us see what the movie is telling us okay.

So you have the thrust faults over here and then you have the strike-slip fault which is sitting along here in this line okay. And then these are the offset of streams you can see these are the offset of streams here you can see and the linear valley which has been formed here okay. So you can do lot of thing and you can have lot of fun using the satellite data and with the help of the softwares which are available with us.

But of course if they are available in your labs at your university or institutions you can use those software's and try to build up such maps or the images. So this again as I told that we will give will be we are planning to give exclusive 1 or 2 lectures particularly on this that how you will develop? How you can rate this data and then play with the data using different software's okay.

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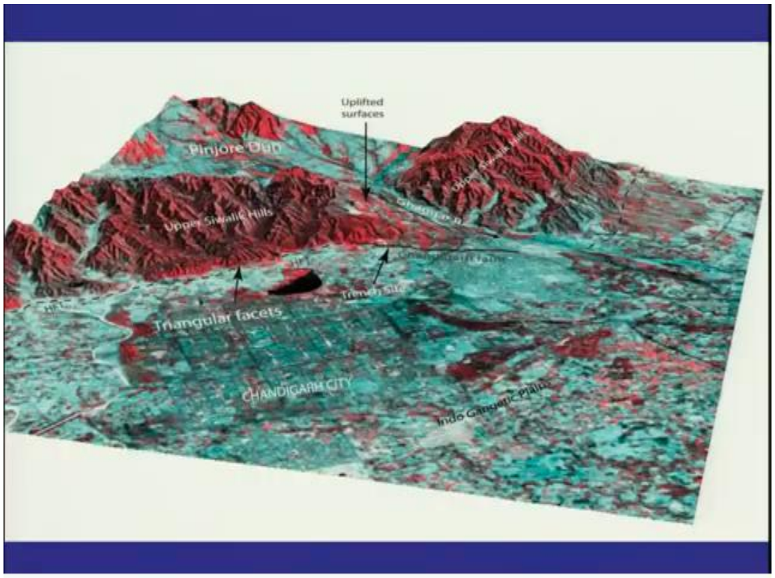

So another data from but this data is a Landsat data draped on the satellite radar topographic mission data that is your SRTM data which has again helped us in putting and preparing some detailed maps okay. So this portion we have marked is in bold line. So this is your active fault but this portion we are not sure. So these are all inferred because this the contact between the 2 that is your the Indo-Gangetic plain and the upper Siwalik hills or sub-Himalaya is the plate boundary. Hence this is definitely in active but the to know the ancient earthquakes okay it will be difficult to precisely dig along this line because the portion is erosion.

Because the reason for the erosion is the dynamic nature of the system here you have very dynamic fluvial system which exists in this region. So it keeps on eroding but some places they are well preserved. So we usually try to pick up the well preserved portion and try to put the trenches and to see the section and the deformation preserved in the sediments mainly. So one is the landforms we have identified and then we want to go into the go back into the history and see that how many earthquakes have been triggered along this fault line?

So we have the triangular facet here which are being marked. So you can imagine that not the what so called very well planned city of Chandigarh is sitting just exactly almost few kilometres hardly 2 to 3 kilometres from the most one of the most active zone in India.

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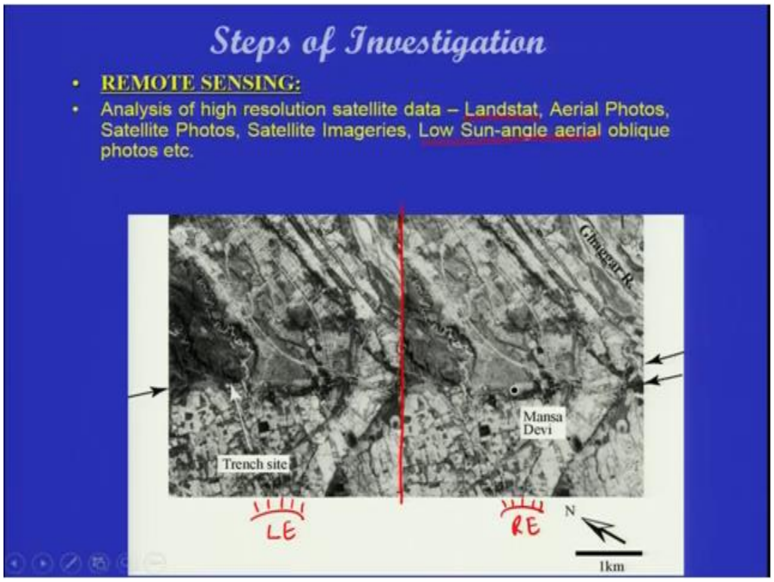

So this is what we usually use okay we have the 2 images of the same area okay. But taken by different from different angle by the same aircraft okay. So this this when you view using stereo scope you will be able to see the whole terrain in 3 dimension okay and that is what we called the stereo vision capabilities okay. So remote sensing is one of the basic step towards getting into the detail mapping and all that okay.

So analysis of high-resolution satellite data either you are using Landsat, aerial photos, satellite photos, satellite images, Low Sun-angle aerial oblique photos, etc you can use. But as I told that the Landsat you do not have with the stereo vision. So mostly if you are having the Low Sun-angle aerial oblique photographs then that can also help you in identifying the features. But this is going to be a very expensive process or expensive affair.

But you can have the satellite photos or satellite images high resolution with stereo vision. So what you see the common here is that you have this drainage here, this drainage is the same this portion of the land is here is the same and that based on that you can identify and the arrows which are been marked here are showing the trace of the active fault. So even if you are having the capability of using with the naked eye you can do that.

So what best you can do you can place your 1 photograph here, another photograph here and separate this portion using a cardboard. So that your left eye okay so you are viewing this image with your left eye and this image by your right eye okay. If you can do that you will be generating a pseudo 3D image in your brain and that will give you the stereo vision okay.

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This is another one photograph of the Pinjore region which shows the locations of the active fault here. Actually this is 1 here which is been seen on this side also. But again all these are the stereo photographs.

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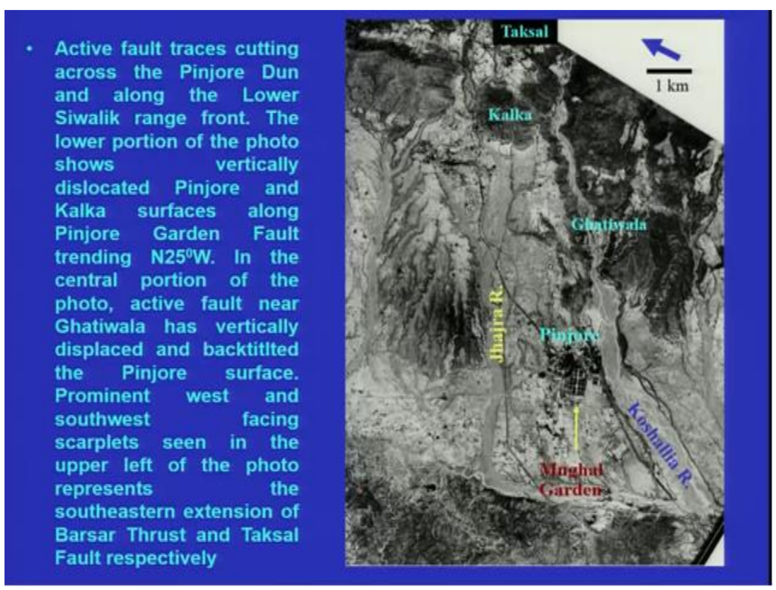

Now with the help of that several features which we very been able to pick up likewise here one is this one, another one is which goes here but with this of course because now when I am showing you may agree you may not agree with me but this is the fault line. But when you see that this landform because you will say no I do not agree. Because this the tone of this surface land surface is same as almost like this okay.

But it has been broken here or displaced along this line. Because I know this I have seen this terrain in 3 dimension. So I can confidently say that this is up and this is down okay. And there is an fault line which goes somewhere over here. And similarly for the case of here this one there is an beautiful squarish building here you have a smaller square here and then you have a larger one and there is a fault here which runs across this one okay.

But you will not you may say that no this is almost same but when you see this in 3 dimension that what I am trying to emphasize that if you see this terrain in 3 dimension then only you will be able to identify the displaced surfaces okay. So this portion is up here, this is again down. This is another fault another one which runs somewhere over here and third one in this area here okay. So the arrows which I have been shown here which shows the location of this fault.

So these are the location of the city here and then you have Jhajra river which is flowing this side and then you are having Koshallia river and this portion is your famous Mughal garden which is sitting almost around 2025 kilometres from Chandigarh and which was constructed on the active fault without having proper understanding okay.

So this mistake was done way back in 17th century but similar mistakes have been done in recent years also. So these are the location of the towns you have and the location of the active fault traces okay. So many here. So you have those arrows are indicating the fault lines here.

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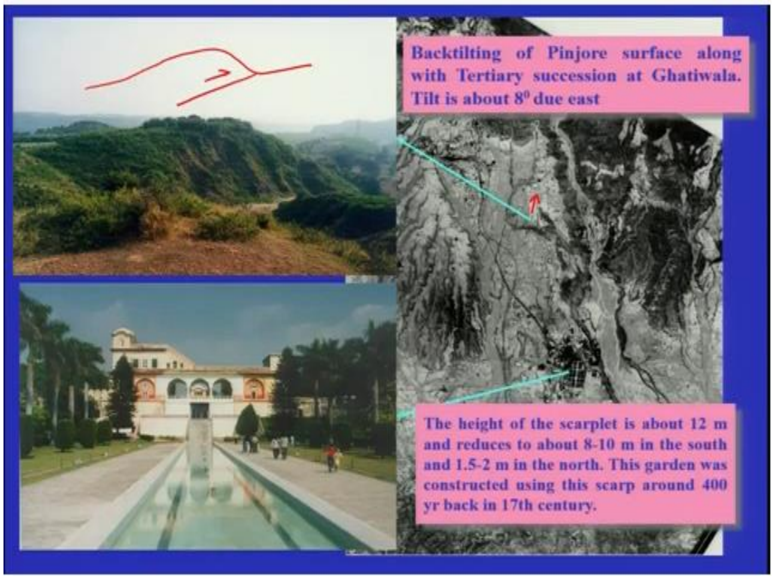

Now the features which you will be learning slowly in other lectures also. But this is one very prominent because this portion what you see here is the scarp the darker face here is the scarp. This side is having the escarpment and you are having this side is it down this is up and this is back tilted. This is back tilted in this direction. So photograph which was been taken from here you can see this one.

So this portion where I put the arrow is this surface okay. So this is back tilted and the fault runs somewhere here in the front of that okay. And this is typical of thrust fault. So you have the fault line. This is the fault line on this surface and fault may be somewhere deeper in this side okay. So if you have to you have to draw the section here then you will see something topography like this okay.

So you have an fault here okay. So this is an typical of thrust fault. So back tilting of Pinjore surface along the tertiary succession at Ghatiwala village which is tilted almost like 8 degree due east and then you have this portion which I was talking you can see that they have this side is up. So the photograph has been taken from here this point view in this side. So you can see the big step what has been turned as and this is the fault line which runs here.

So I will come maybe I am having these slides later on I will talk about this. But usually the Mughals were having like they usually have the fascination to put water pathway in the centre portion of the gardens which those gardens which they constructed even if you go in Kashmir or in Delhi you will find such features which are extremely common.

So they will have an pathway so to give a flow to this water pathway the higher elevation in this region was been selected and this higher elevation was the fault scarp and which exist now which is still there as an fault scarp okay. So height of the scarplet is around 12 meters and reduces to about 8 to 10 meters in the south and 1.52 meters in the north. This garden was constructed using this high scrap around 400 years back in 17th century.

So fault here runs somewhere at the base and they never had an idea that they have constructed this garden structure on exactly on the fault scarp.

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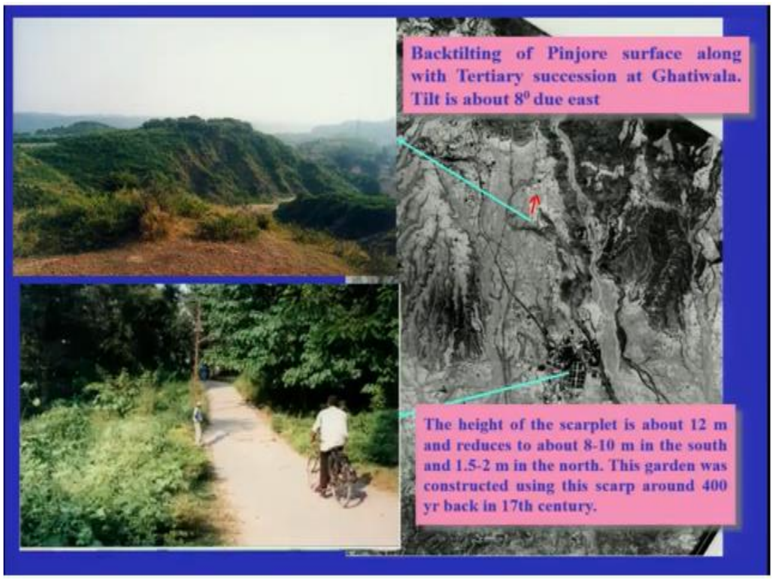

And this is outside the garden somewhere over here where people keep on just passing through this area but never had an understanding that what exactly is this undulation or the warp which has been seen but they just go through and local people never does not know about that this is an active fault scarp. Even this was not known like a few decades back okay.

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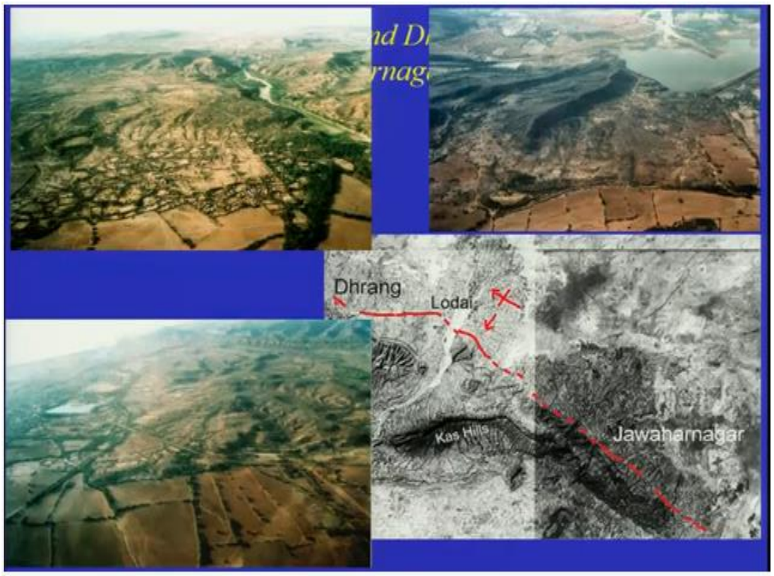

Now another technique what we use other than using the high-resolution satellite photographs we use aerial photographs and this is the fault traces which have been marked. This area is from Gujarat Kutch region. So initially we mark the landforms and the active fault traces using corona satellite photographs in this region and this exercise was done way back in 2000 before 2001 earthquake of Bhuj**.**

And we did aerial survey during 2000 that is after 2001 Bhuj earthquake and we wanted to map the features which we marked as an active fault. But fortunately this fault did not move the earthquake was blind and this fault did not move. So still this region has an potential of triggering large magnitude earthquake in near future. So this the photograph which has been seen here is an oblique aerial photograph.

And photograph was taken from here. Our flight was in this direction we were moving and what you see is this ridge has been sitting here, this one and then another one is this one here. And the dam which has been seen here you do not see the dam here because this photograph was taken before the construction of dam. So sometime using all photographs is extremely helpful in identifying the landform.

Because over the time the areas are modified you can just say in the timeline of 10 years or 20 years there will be lot of like area will be encroached by the development and may be modified because of the erosion also. So old photographs can help you in locating the features which were intact at that time okay. So this is one advantage using old photographs. So this area does not show location of this dam.

But the landforms are definitely preserved here. So this portion is here. So this scarp is false scarp runs over here this portion. Then another one is from this side here this part which has been shown here and what you see is this portion okay. This portion of the contact between the ridge and the flat area is backdrop here okay. So you can see those ridges over here. So this hill that is the Kutch mainland region has been seen here okay.

And then flat area which is dissected and abetting along the further low lying alluvial plain is this one. So this sharp contact is your active fault scarp. So again this road you do not see here it was constructed later on. So similar things you can use another photograph from this part. This is Jawaharnagar where you can see the flat surface getting abetted again the low line alluvial plain. So I will stop here and I will continue in the next lecture. Thank you so much.