Earthquake Geology: A Tool for Seismic Hazard Assessment
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Lecture - 23
Fundamentals Related to Active Faults (Part II)

Welcome back so let us see quickly what are the different faults which we have been talking about the reverse fault, thrust fault, a normal fault and strike slip fault and then see how far the surface manifestation have been seen on the surface.

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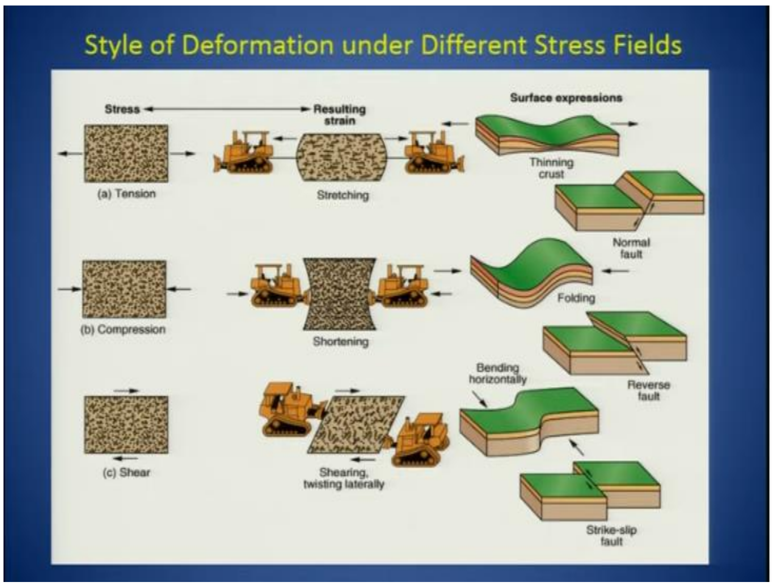

So style of deformation this we already discussed that we have 3 type of deformation usually has been seen on the globe this one is in extensional tectonic environment compressional and share and respective and deformation pattern or the surface expression has been given here and even half the one block is moving down with respect to another. In this case the reverse and the block moves up with respect to the another block and then the block is displaced horizontally along the strike.

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So this shows clearly that you have the initial and just play it again. So you have the movement which is taking place along almost a vertical fault and resulting it to the strikes the one. So the feature which has been shown here has been displaced so this was aligned earlier but now after the movement along this one you see that they are sitting apart away from and this is the man-made structure which has been shown here so if this type of movement has been seen then we mostly classify this as an strike-slip fault okay. So strike-slip fault not accumulate is horizontal slip between the adjacent block.

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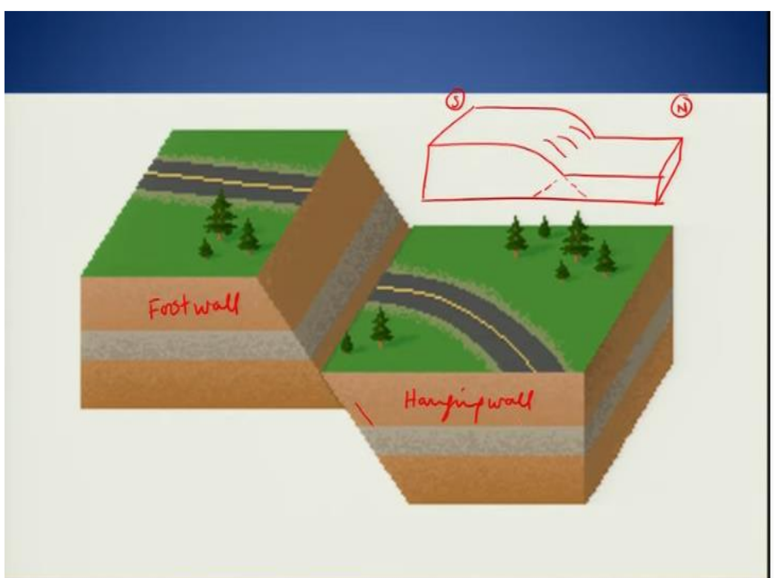

So in another case in extensional tectonic environment what we see is the one block is moving down and another block is the stationary block. So you will have you can easily make out that which block has moved down if you have exposed the section here otherwise as I was talking on the in one of the lecture that if you have the surface expression something like what you have because after the erosion what you will see over here is and just an warped surface okay.

So you may look at and the surface expression something like this. Now the question remains not how which type of faulting was responsible for this scarp okay it may be this dipping if you say so let us say this is north and this is south here, and it may be due to the north dipping fault or it may be due to south dipping fault. But in this case if it will be a normal fault in this case it will be in reverse fault.

So on the surface both the scarp the both defaults will show a very similar topography. So this we will more clarity we will get when we are looking at the field signatures of such features like related to the normal fault and the reverse fault, but in this case what you have in this this is your hanging wall, and this is a foot wall. So foot wall is usually what we say is the stationary ball and the movement is been experienced by the hanging wall and the movement has taken place to move in this block has more town with respect to this one. So this is in case of the normal fault.

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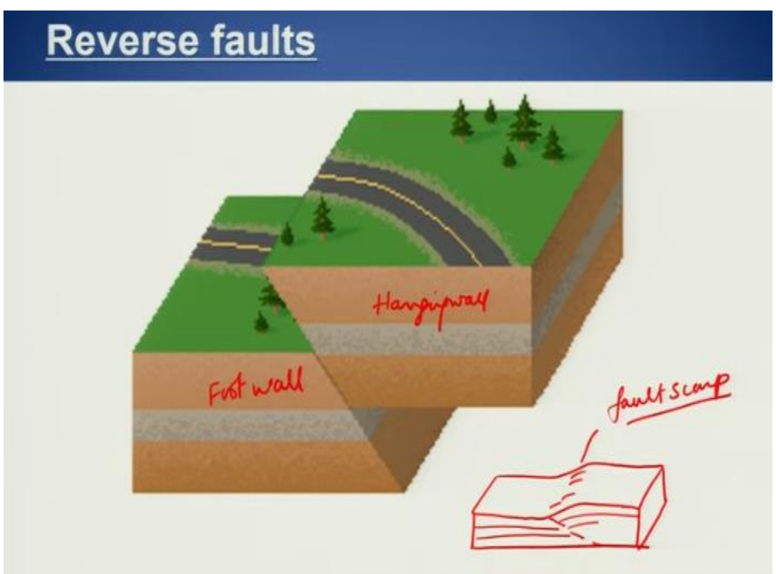

And then if you look at in the reverse fault is exactly the opposite. So you have this one is the hanging body and this remains the foot wall this again so in previous one what we see if suppose we consider that this was the this scarp or the feature which was been formed at the surface after the erosion you will see something like this and in the next one again if you look at then what you will be able to make out clearly is very much similar to what we have seen in the previous slide.

So the point is that in both the cases the feature on the surface that is your fault scarp will be very much similar in both the cases okay. So if you are having reverse fault or the strike-slip fault the faults graph will be very much similar. So for detailed study for classification or characterization whether it is because of the normal fault or the reverse fault then you need to see the dissection. So, steady graphic section will be important to finally justify that whether this fault scarp is related to a normal fault scarp or a reverse fault scarp or the reverse fault.

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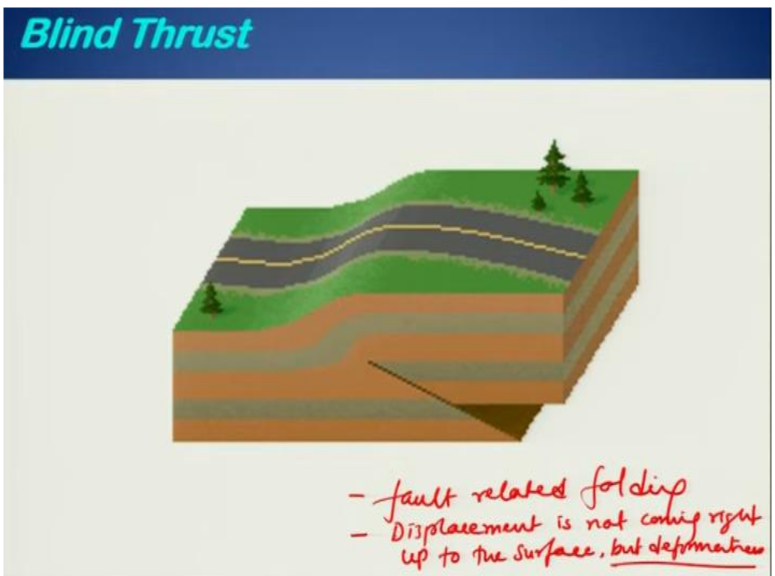

Now this is another one which shows so clearly that is there is a displacement at the greater dip but near the surface and this deformation is been seen but there is no displacement. So fault has never has not seen the surface and this type of deformation what we call is just the folding. So this has also been turned as fault related folding and since the displacement is not coming right up to the surface should remember that there is displacement is not coming right up to the surface, but deformation do.

So we see deformation which is coming right up to the surface the flat surface has been deformed along a reverse fault, but no displacement has been seen here and such type of faulting has been termed as or the deformation is termed as either along the blind reverse fault or a thrust fault.

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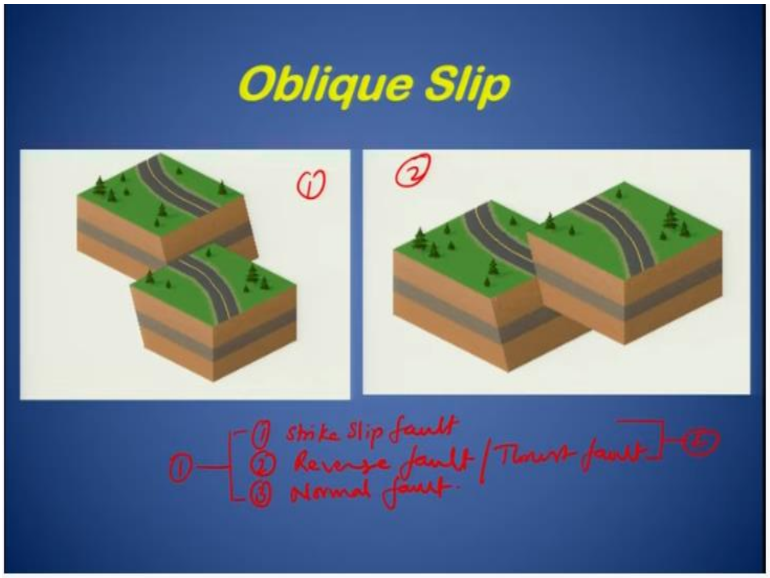

Now there will be in combination of both so the initially what we have looked at is one is your strike-slip fault and another one is reverse, or you can say thrust fault. So these are the 2 different type of faulting you can see and then the combination or the third one is your normal fault I mean in this to figure if you see one and two then what you are able to see is the combination of the first one is the combination of this one this is your one and then second one is the combination of the strike slip and reverse fault.

So the block has moved along this strike as well as along the dip and block has moved along the strike here the block has moved down and along the strike of the fault so lateral movement as well as dip slip movement is there here also there is a lateral movement as well as the dip script movement. But here the block has moved up and in such cases what we characterized this type of fault are termed as your obliques slip fault.

So slip has occurred obliquely now one thing which you should remember that the direction of the dip at the dip plane if you see is in the cases either it is that this is of course the normal step is also there along the strike-slip but if you just consider the normal slip and the dip of the fault is in this direction and in the reverse dip slip the dip of the fault is in this direction. So any block sitting on the top of the inclined plane there will be your hanging wall this even have to remember.

So further what we see we have the displacement in this direction and in this case the displacement is, so we have lateral as well as dip slip movement along this strike and along the dip of the fault. So basically if you consider all this 3 type of fault, strikes fault, reverse fault and normal fault and what you see is the oblique slip also. So this clearly suggests that we have and very complex phenomena or the process which is taking place in nature and the part which we discussed in the beginning that we look at the global tectonics and then we come down to the regional and the site-specific.

Now to some extent the global tectonics and the regional tectonics will help us in at least having a preliminary interpretation or inference that what type of deformation we will see in a particular region. So in case of extensional tectonic environment we will see of course the 2 plates are moving away from one another so we have mostly the normal faulting you will be able to see but in case of the transform deformation of deformation along the transform fault or the transform fault boundaries we will see that 2 plates are just passing each other.

And in in case of the compression electronic environment we will see mostly the reverse and thrust fault but nevertheless you will come across at many locations the oblique slip depending on the orientation of your maximum stress axis. So you will find mostly in the even in the compressional electronic environment mostly you will find the reverse and thrust faults but along with that he will also come across the oblique slip faults.

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Now this part we have already discussed in the beginning is that.

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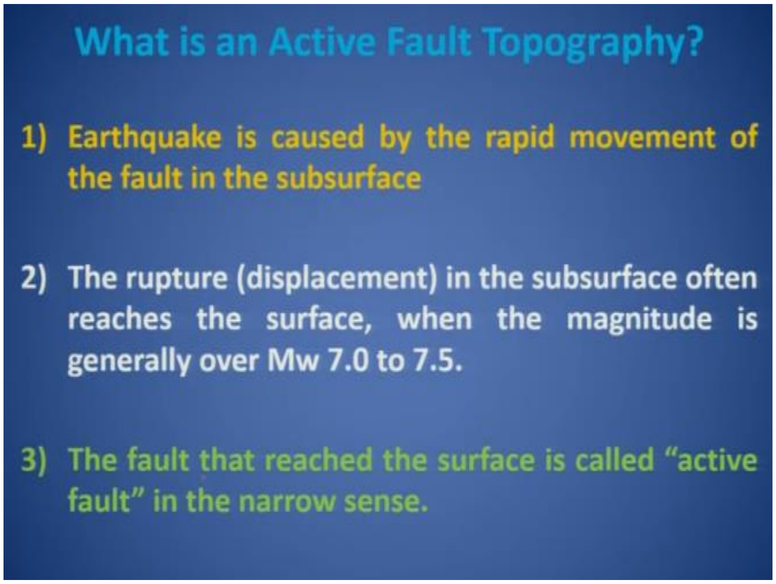

Whenever there is an faulting you will have earthquakes and further the earthquakes usually, we are tagging them to the active faults located in seismically active regions. Now knowing the or mapping the active fault we should understand that what is the surface expression of those active faults and related deformational features okay. So basically what we say is the active fault topography.

So as we have discussed in the previous lecture that we have the earthquakes we are relating the earthquakes with the active faults and the active faults are the locations or the weak zones which are likely to produce the earthquake large magnitude earthquake in near future and we also talked about the whether they are the whether we can classify that as an active that depends on us active potential or capable.

Now whatever the deformation will occur along this type of faulting either it is in strike-slip environment or reverse compressional tectonic environment or normal they it will be seen on the topography. So for us the active fault or understanding of after your active fault topography will be extremely significant. So earthquake is caused by rapid movement of faults in subsurface and the surface manifestation what we call rupture that is a displacement in the subsurface often it reaches the surface when the earthquake magnitude is around 7 or greater than 7.

So what does this indicate clearly that are the earthquake with movement magnitude less than 7 mean not result in to the surface object but this postulation is not exactly correct because in some cases we have seen that even the displacement has not reached right up to the surface but we had and big earthquake like large magnitude earthquake and the best example if we see is magnitude 7.6 Kutch earthquake the deformation reached the surface but this displacement it not.

So again such blind earthquakes are there around the world which have occurred in recent past and that has resulted into a sort of a challenging job to identify the active fault. Now usually what we take is the topography okay that is what we are talking about the surface expression so when there is a fault that reached surface not is due to the displacement we will categorize that as an active fault but this is a narrow sense okay.

But we can see as I was showing in one of this slide that you have the displacement remain sub surface but the deformation reached right of the surface so within understanding and knowledge of though those features we can also classify that whether this is related to the active fault or not you may not able to see the displacement in section also but at least fold relief of fault related folding which is coming or the deformation coming into the in form of folding at the surface should also be taken into consideration and the associated landforms will clearly tell us whether there is a deformation in that area or not.

So in strict sense if we if we say that we will consider the faults as an active fault only if we see the surface topography or the display surface then that may not be completely true. So in narrow sense we can say that okay fine whatever the displacement which is reaching right of the surface along the faults are termed as active fault.

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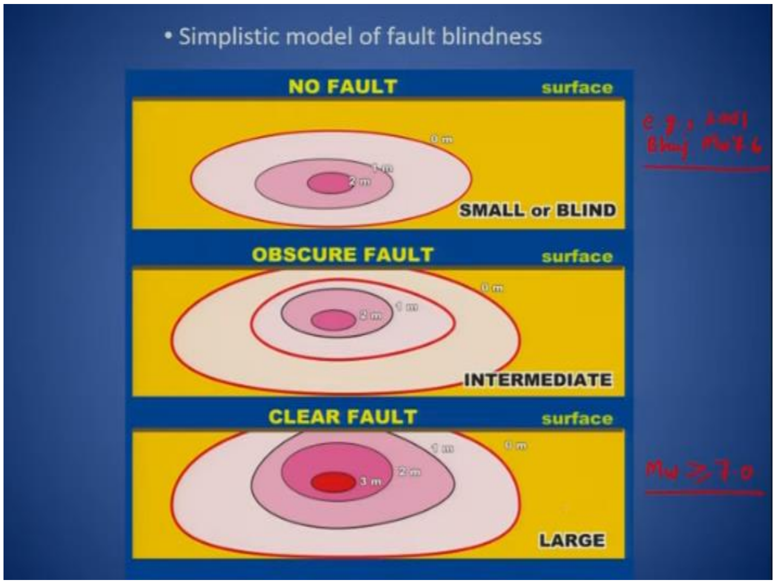

So this is basically the idea behind what we were talking about that we have like medium magnitude earthquake or large magnitude earthquakes or we can see moderate and large magnitude earthquakes. So everything depends on the amount of energy and at what depth those earthquakes have occurred. So these are the 3 examples which have been given that you have surface ruptures in case of the small magnitude intermit magnitude and large magnitude earthquakes.

So and again as I told that this depends on the energy released and the displacement at what dip they this type of earthquakes are occurring. So in case of the small earthquake mostly the surface rupture will not be seen no fault on the surface will be seen hence it remains blind. So you may say that the earthquake which took place as I told the example of 2001 which was magnitude 7.6. So even it was a large magnitude earthquake then why it did not reach the surface the reason could be that the energy was not sufficient enough to displace the material in that region okay that may be one of the reason.

But here we basically considered as 3 that is small intermediate and large then in case of intermediate, we will see some deform or displacement which is coming like a good surface. So obscure fault topography will be seen but in case of the large earthquake that what we were talking in the previous slide that if you are having the magnitude MW greater than equal to 7 then you will have the surface rupture.

So in this case you will have clear surface rupture now what it has been shown here that we will even with that you will have the larger radius area which will be covered in terms of the rupture area because the rupture area will include the length as well as the in the depth okay. So the whole area along the along only on the fault plane so intermediate you will have less portion which is getting displaced but in case of the large you will have large area which has been covered.

So this again put us in a challenging situation to identify the active fault in the region but nevertheless with the help of a detailed topographic interpretations or the morphological studies of the landforms we can easily make out that which area is active and where are the active faults located.

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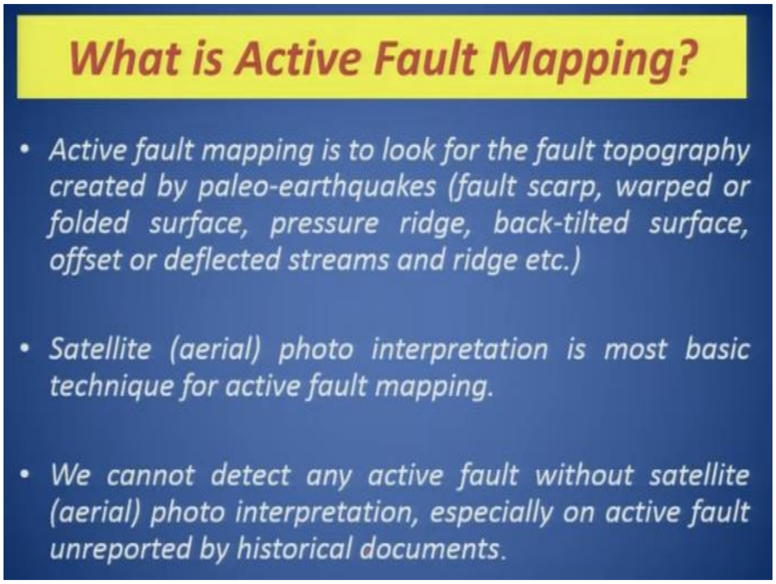

Now what is active fault mapping. So active fault mapping is to look for fault topography created by ancient earthquakes like fault scarps, warped, folded surfaces, pressure, edges and back tilted surfaces, offset and deflected streams and ridges this all forms the part of the geomorphology and further as we will move into the respective domains like compressional electronic environment or strike-slip faulting environment and normal faulting environment.

We will learn more about the individual fault topography developed with respect to the different tectonic regimes like strike-slip compressional and tectonic and normal or extension electronic environment. So in general we what we will do is we will in this lecture we will try to quickly look at few of the examples just for the introductory purpose that what exactly is the fault topography we are talking about.

So mapping usually we take into consideration the first step is the aerial photo interpretation. So if you are having the high-resolution aerial photographs or you are having the high-resolution aerial satellite data that can be used for interpretation and most is the most basic for the technique for the active fault mapping. So this is the first step but as I told that we will also look at that what are the different landforms tectonically formed landforms in different environment this we will slowly learn in coming lectures.

So we cannot detect any active force without satellite aerial photographs or high-resolution satellite data especially on active faults unreported by historical documents. So if this this suggests that not if we know that these are the active fault region then you will be easily able to pick up the active fault but if there is absolutely no evidence reported evidence might be on occurring or lying on the surface.

But if there is no report of an active fault in any region then it will be difficult, he eventually just locating going in the field. So the aerial or the satellite photo interpretations or the satellite data interpretation is extremely important.

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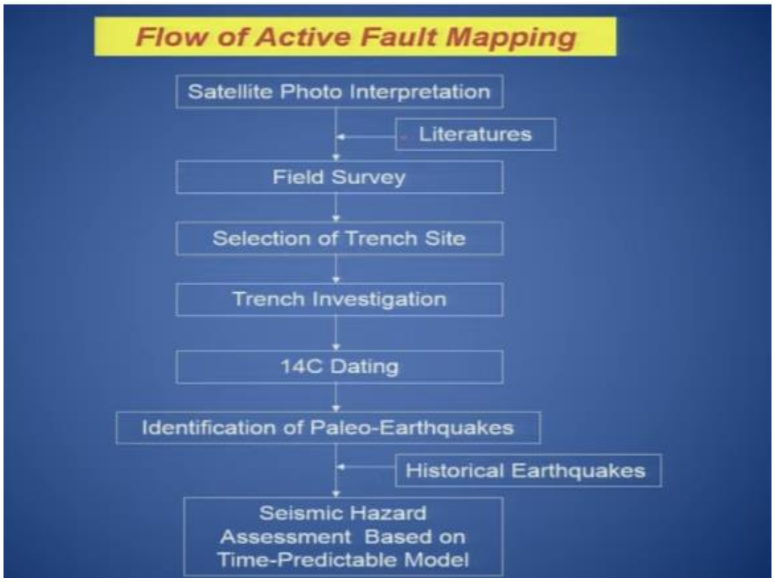

So in particularly for active fault topographic mapping or active fault mapping we use satellite photo interpretations we also take into consideration the literature and this literature mostly will be related to your ancient or historical chronicles and that will help us at least to some extent to know that which area hosted large magnitude earthquakes. Then we do field surveys selection of the trench sites, trenching investigation.

Then collecting the dating material identification of paleo earthquakes then comparing those paleo earthquakes which identified from the trench investigations will be compared with the historical data available and finally this course is one of the component for seismic hazard assessment bates based on the time predictable model.

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So we saw in one of the slide that one block is moving up and another block is remaining stationary with this you can easily make out but if there is a displacement there will be a development of the topography. So even if the displacement does not reach right up to the surface you will be able to see the topography which has been developed. So this is there is a fault here, so you are looking at the section and you are looking at the topography also.

So you have the deformation which has occurred along this fault there is the fault plane here and a net displacement if you want to measure you can easily measure this I have already discussed in one of my slide before so you have this is your net displacement and what you see is the topography which was been deserted because of this one here. So I will stop here, and we will continue in the next lecture. Thank you so much.