Natural Hazards
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Lecture – 14
Active fault and Paleoseismology

So, welcome back as I told that will be talking about ah, the active faults, and how we identify the active faults and what are the importance to do this type of studies, in any seismically active area.

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As I told, I have talked in detail in my previous course, but very quickly we will see some very different examples from India in this particular course.

Now, if you look at the collage here, what it shows us that we are having the very beautiful landscape here of Kangra Valley which of course, is a very fascinating in terms of looking at the natural beauty, but at the same time this was the area where 19 of 5 earthquake was triggered, but the magnitude of 7.8 and it was quite devastating and at that point of time in 19 of 5, it killed almost like 2 20000 people.

So, what we do is I will just quickly explain here is that, we use high resolution satellite data's to identify the deformation which is preserved on the surface where the crust, the uppermost part of the crust when it breaks it leaves some signatures on the surface and the topography which got, which develops, because of this displacement constant displacements we try to map those.

Now, why earthquakes are so important for us, because whenever there is an event, we experienced a massive damage and basically, the buildings which collapse, it kills many people. Now, this is the example from 2005, Muzaffarabad earthquake, which also resulted into the massive damage and another figure which you show, see on the on the right-hand side is 2015, Gorkha earthquake of Nepal.

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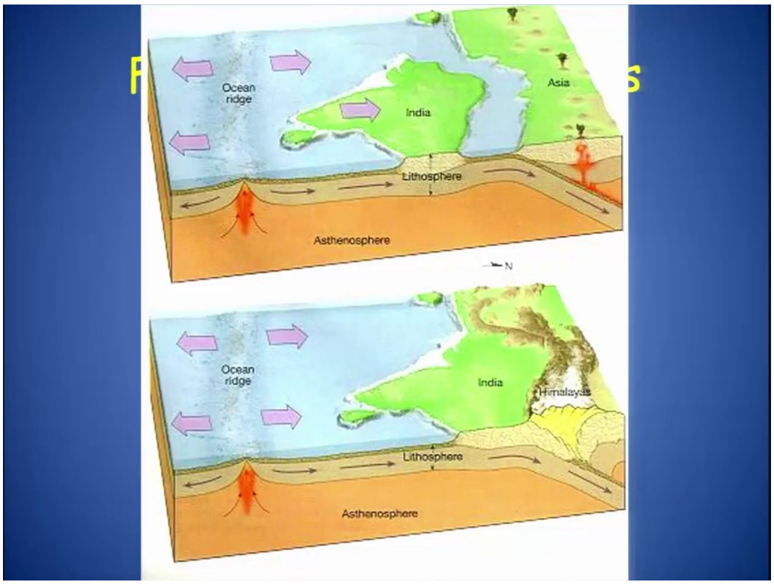

So, let us start with the formation of Himalaya. This we have discussed in previous slides also.

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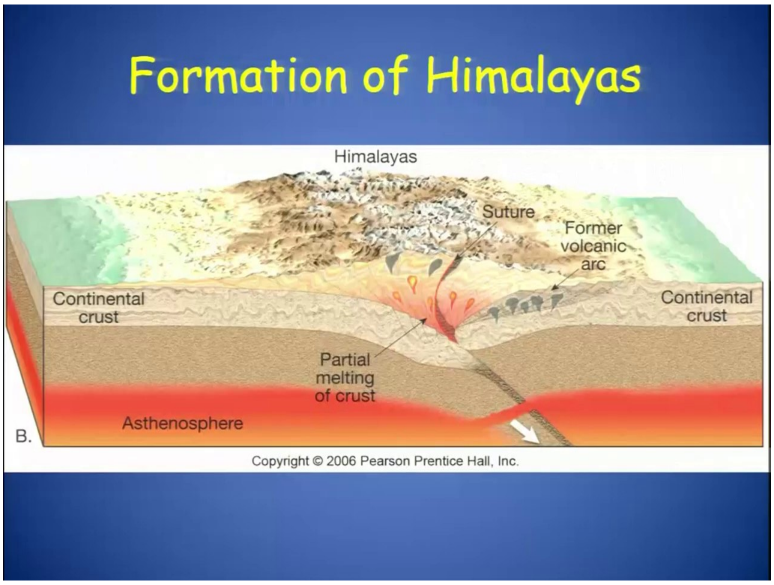

So, most of the material which is been push by this two plate, because of the continental, continental convergence is under gate strain and as I told in one of the previous lecture, that the energy which is getting stored, because of the ongoing collision how the convergence between the two continental plates have crumpled and resulted into the buckling up of the material and the material from the Tibetan side is coming over or over the Indian plate.

So, these rocks are getting folded and time will come, this will get fractured.

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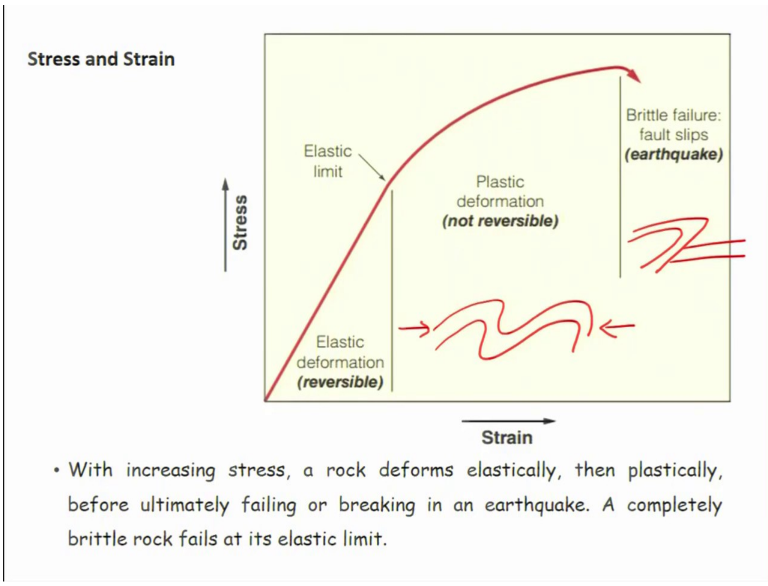

So, if we take a simple stress strain diagram and then what we see is that the material, the earths material has an are elastic in nature and to some extent, if you keep on deforming it. So, you increase the stress you increase the strain here and after the elastic limit of that particular material, it will start deforming into the plastic state. Whereas, if it is an elastic state then there is in possibility that you can reverse the deformation and of course, this happens after the earthquake, because of the elastic rebound ah, which we have made, based on the material

So, some readjustment we will always take place after the major earthquake when these are these strains which is available is released, but if you deform more of course, there will be in rupture or fracturing, but it will never come back. So, this is a plastic deformation and further if you keep deforming, it will, there will be in brittle deformation and that is what is the failure. So, finally, fracturing will take place if you cross the threshold limit of the material. So, what we usually see on the surface is the brittle deformation. Of course, we see some deformation in terms of like folding and finally, if you keep deforming this further, then you will have a fracturing.

So, you will have the material which is fractured here. So, this point of time when this brittle failure there will be in slip along the plane, which is termed as a fault plane. And this gets preserved on the surface and if there are repeated earthquakes along the same fault over the time then you will have the very prominent land form which will develop, because of this events.

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So, this another basic example, which we see usually that if you are having, rock cylinder if you take it will behave differently at different in different environment.

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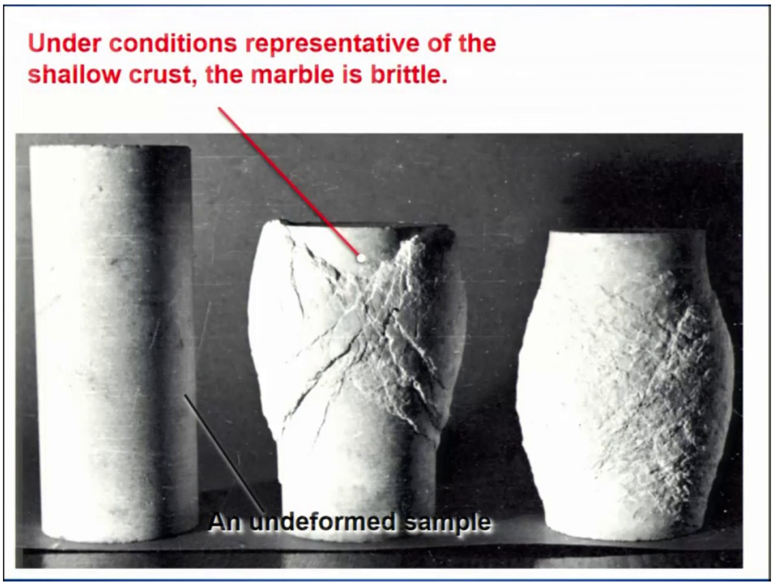

So, for example you have under the conditions which represent shallow crust. So, if you are having shallow crust you will have, a brittle deformation. So, you will see the fractures which are developed and same thing happens during the earthquake.

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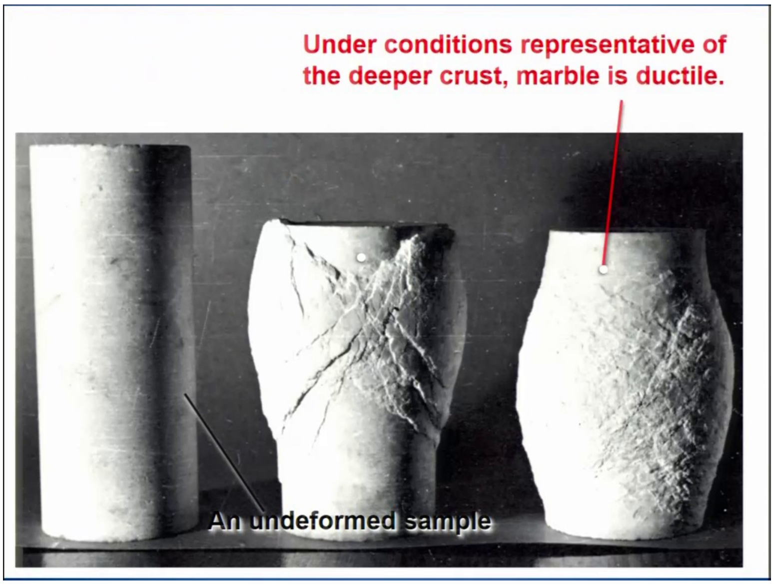

So, we have fracture which will be, and under the ductile condition, you will just deform the material. So, this will this represent the deeper part of the crust. So, what we see is the shallower part mostly and the earthquakes, what we experienced are, because of the fracturing or the displacement or the slip in the shallower part of the crust.

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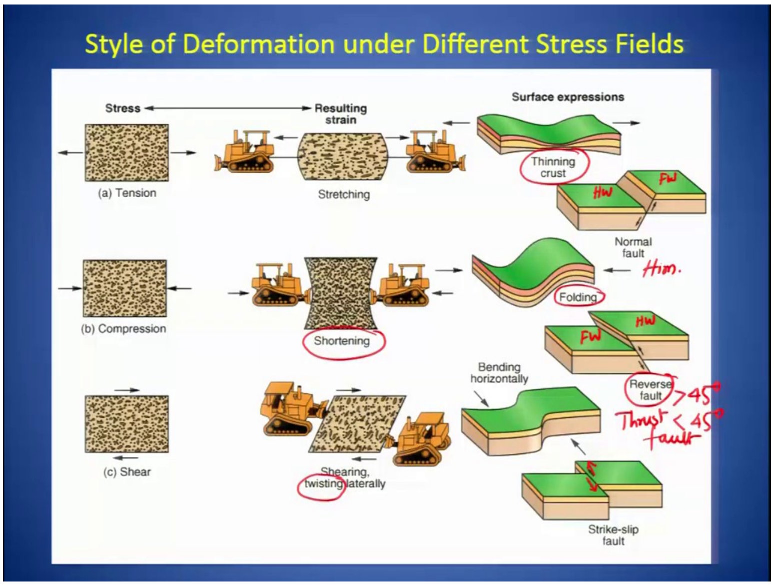

So, in total if you take the style of deformation, then we can classify quickly into three; the tension, compression and shear. And these three patterns of deformation you will result into different type of what we call faulting. So, we have normal faulting where we have tension, where two like plates are or the block of the rocks are moving apart, from one another. So, we have stretching and we see a normal faulting where we have like they again in the hanging wall and the foot wall. So, foot wall remains stationary whereas, the hanging wall will move down.

Now, here what will happen is the thinning of the crust will take place. The second is the shortening. So, shortening will occur when you compress any material. So, compression will result into folding and this is an example of the Himalayan Mountain. So, Himalaya is a product of the folded mountain theme and in compressional Tectonic region. So, what we see mostly here is the reverse fault, where the, this one is the hanging wall and this one is the foot wall. So, hanging wall will move up and in case of the normal faults, the hanging wall moves down and here we have shortening of the crust. Now, third situation or the scenario would be the shear.

So, when you shear the material or the block rock blocks then it, it kept twisted. So, twisting will result into what we call the bending moment and finally, when it fractures, it will, there will be a movement along most mostly the you have vertical plane whereas, here we have an inclined plane, here also we are having the inclined plane. I will come to this again, but looking to this the sense of moment can vary. Here, what we see is that one block is moving in this direction, another block is moving in this direction. So, the block which is moving towards us based on that we can classify that what is the sense of movement. So, we can see here the left lateral moment. I will put some sketches in the next slide and try to explained you.

So, the reverse faults again are in product of compressive tectonic environment, but based on the angle, it has been classified as that if you are having the fault angle greater than 45 degrees then you classify that as in reverse fault, but if you are having the fault angle less than 45 degrees, then you would say thrust fault.

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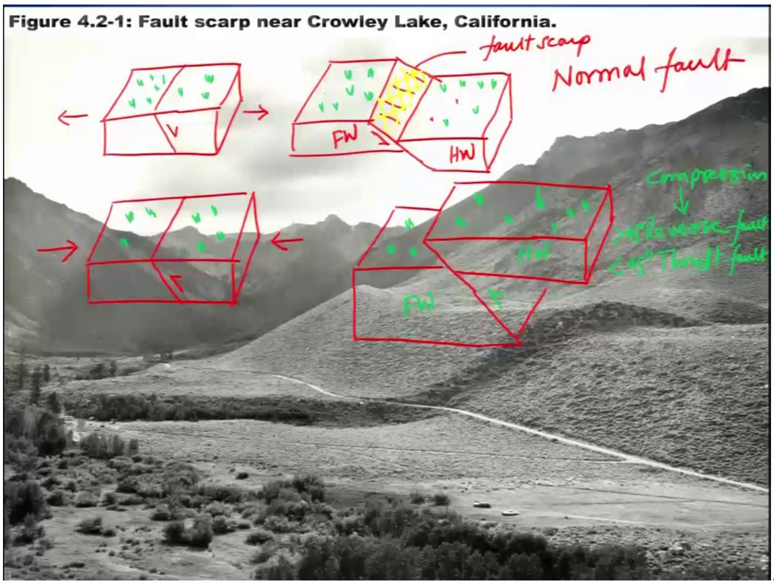

So, let me put very quickly few sketches before coming down to this one. I will just put on the screen itself. So, one what we have seen is that, we have ah the block here and then we see there is a fault, we have moved like that.

So, if this is moving down and what we see in the next is, so here, this is the feature which is developed and the both blocks have been stretched away from one another. This feature on the surface we will call as a fault scrap. Now, the movement has taken place like, this is your, I will just take another. So, this was the ground previously which was almost horizontal, but it moved down. So, the portion which you see here, this one this is your fault scrap of the expression, which you see on the surface and since the block has moved down, this is your hanging wall and this is your foot wall. So, this is moved like that ok. So, this has been termed as normal fault.

Now, another example, same here, but what we see is that we have a block here. You have a fault like that call I am just putting in a missionary line and this block is moving up and this is the situation where we are having in compression. So, what we see is and we will have, we can put a little bit like that ok, so it will easier. Now, what has happened here is that here again, I will just put the surface, this is your surface here. So, this surface has moved up. So, this block has moved up. So, this is your hanging wall and this is your foot wall. So, now, this happens then we say this is under compression and the fault name is here reverse fault.

So, if it is the angle is greater than 45 then reverse fault, less than 45 then you are having thrust. Now, the third one is your strike slip. I will come to that after explaining this part here ok. Now, what you see in the backdrop.

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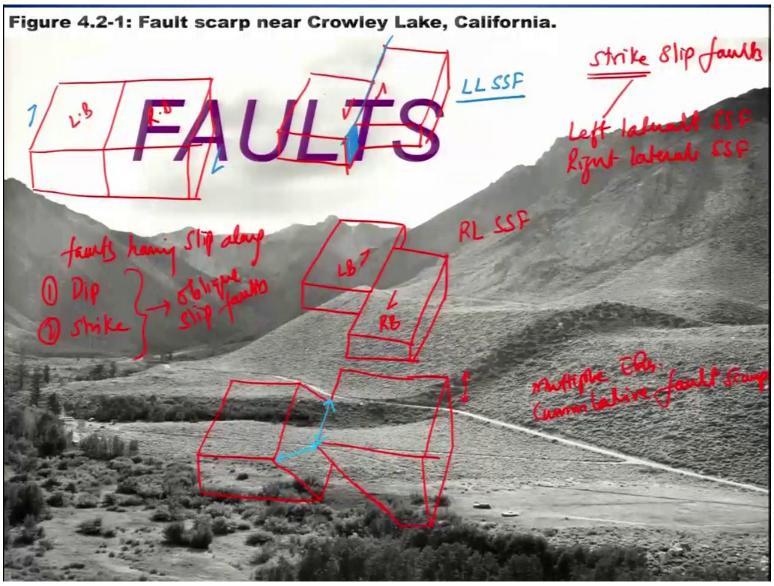

So, this is an example of the fault scrap which developed in one of the earthquake in California, where the, a same surface which you see here is been displaced by several meters. So, this is the fault scarp. So, this type of signatures, you will see on the surface when there is an earthquake. And if you keep on having the earthquakes or experiencing earthquake around the same fault then it will keep on developing, that is what we call the cumulative fault scarp and one can easily judge based on the very small, if you see here I am circling the motorcars which have been parked that how large is this fault scarp. So, this has not developed this fault scarp in one earthquake, but it shows that this got developed in a multiple earthquake. And what we see here is the cumulative fault scarp. Now, another the type of faulting, which we have seen about the shearing.

So, mostly that occurs along this, we say strike slip faults. So, please refer what is strike and from my previous lectures, but here I can this quickly put that what does the what are the strikes, different type of strikes default. So, we categorize this as in the as in left lateral strike slip fault and right lateral strike slip faults. So, how it looks like and what basically we take. So, one is, take for example, you are having in a block like that and then you are having a moment, I am just putting in horizontal plane say; if there is a moment shearing. So, one is like that and another is like this.

So, if you are deforming, you can like this, if you are deforming like that then what you are doing is that one block is moving towards you. So, I am having the right block which is coming towards me, but in this case what I have drawn is that the right block, this is my right block and this is my left block. So, my left block is moving towards me. So, what I will see on the surface, I will draw here again. So, if you have this and then this block has moved this side, this has moved and that this is one.

So, what I have is in form of the and the plane is this one here, this. So, this is my fault plane and then since, it is moved along the strike we term this as a strike slip fault. So, slip along the strike and the previous two, where slip along the depth of the fault. So, this is one. So, this is your left lateral strike slip fault, another one same situation, but the sense of movement changes here. So, this block is now, moving towards us and this block is moving away from earth. So, we have another situation here, is that your right block is moving towards your side. So, now, if I put this on sketch then what I will get is; this moved towards me, that is my right block and this is your left block and this is been termed as right lateral strike slip fault.

So, just keep this in mind. So, we have in short what we have discussed now is that, one is the dip the faults having slip, along dip and another is along the strike and we can have combination of this two. And if you are having combination of this two the movement, which takes place along the strike as well as along the dip then we say there is as an oblique slip faults. So, I will try to sketch this if possible, let me check. So, if you are having a combination of both then how you can look at this one.

So, what you have, you see here is, that you have the combination of two, where you are having this slip which has occurred like that and also in this direction. So, you have an oblique slip which is taken place.

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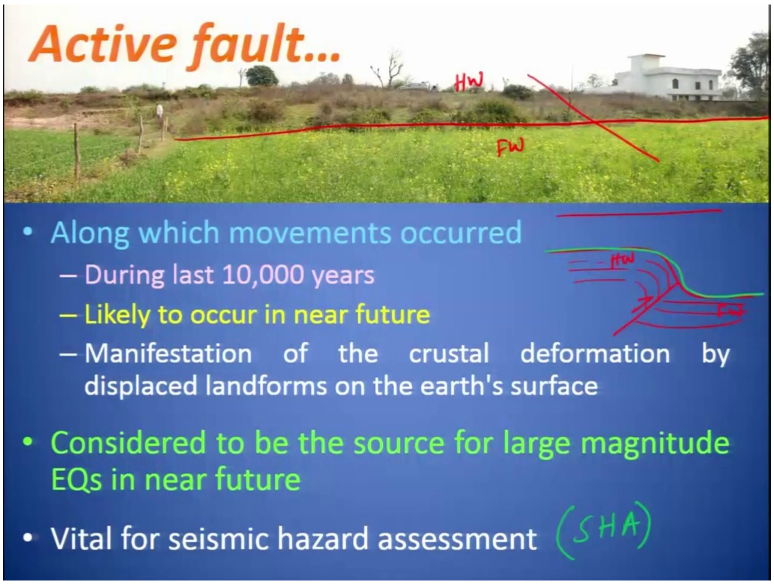

So, the importance of the active faults, as I was talking about that why we need to identify this. So, I explained, I have explained this figure in my previous lectures also and this is a very one of the beautiful fault scraps which we have come across in Himalaya. So, it shows this side is up. So, this is your hanging wall and this is your foot wall side and the fault runs somewhere over here, that is the fault line on the surface.

So, if I have to mark the fault trace on the surface, then on the satellite data, well mark this is in fault line. So, of course, this house which is sitting here is not the appropriate site for the construction. Now, the importance's that the active faults are the fault along which movements have occurred in the past and the moments have occurred in last 10000 years. So, this is in last 10000 years if we come across that any displacement is been recorded on such features or such faults then we consider that as an active fault. These faults are likely to trigger the earthquakes in near future and the active fault is the manifestation of crustal deformation by displaced landforms on the earth surface. So, if I put the cross section here, then what you will see? For example, I have taken the cross section here and you will see a feature like yes.

And so, this earlier this was in flat surface, but, because of the deformation and the movement along this, our fault the inclined fault. Why I am putting very confidently, because we know that this is a reverse fault where this is a hanging wall and this one is the foot wall. So, the hanging wall has moved up and then also we see some short of a deformation. I will show couple of photographs, if possible which show the deformation patterns were like that. So, this is in the trench sections, which we have seen.

So, this is the manifestation on the surface. So, what we see this is your surface here and we understand that this will move in future also, because there is an ongoing convergence between the two plate and lot of strain is getting developed. And these are the locations, which are considered to be the source for large magnitude earthquake. So, when we say that the fault moved and there was on displacement or the slip on the fault then, it requires lot of energy. So, the amount of energy is required we talk in terms of the magnitude. So, larger the magnitude, more will be the displacement, more area will get ruptured.

However, the large magnitude earthquakes which we are talking here in Himalaya can range from greater than 7.5 and less than equal to 8.5 or so. So, this will, this earthquake is the fault under the category of large and great Himalayan earthquake. So, these earthquakes are dangerous and the features which we have mapped on the surface, which we call the active faults are important to understand the hazard part in this particular area. So, this is very common practice in most of the countries, but in India we are slowly doing our job and hopefully in few years, will be having incomplete active fault map of the regions which are seismically active.

So, as I was talking about that this is very important for the hazard assessment. So, mainly this plays an important role as in one of the parameter, where we talk about the seismic hazard assessment of any tectonically active or seismically active region.

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So, this part I will try to cover in the next lecture, where we will come up with some case studies, which we have done from Himalaya as well as from the other part of the India that is mainly, I will talk about the Kutch part and we will learn more about the faults and earthquakes.

Thank you so much.