Natural Hazards
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Lecture – 16
Earthquake and related hazard Part I

Welcome back. Now the earthquake related hazard is growing day by day in our country also and we had experienced couple of earthquakes in last 20 to 30 years which were relatively quite damaging.

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So, if you look at, there is the main reason why we would like to understand the periodicity of the earthquake and what is the likelihood of the large magnitude or damaging earthquake in near future in our country. So, we discuss little bit about the Himalayan seismic zone, and the reason why the worry is too much, because we have very thick alluvium which is in the indo Gangetic plain area, which will result in; like if there is an earthquake in Himalaya it will result into major damage.

These are few examples which I will just quickly browse through which talks about or tells you about the damage pattern in 1994 Los Angeles earthquake.

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Then you have Mexican city earthquake of 1985 then 1995 earthquake of Kobe in Japan.

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Now here I would like to just explain that what we were talking about the false graphs, this is what will happen during an earthquake. So, the rupture of 1995 the Kobe earthquake, they have preserved in a form of an museum. And in this museum people can come and see that what happened in 1995 Kobe earthquake.

So, this one is your fault plain and the surface manifestation which you see here, is your surface rupture. So, if you look at this section here then what we see is that this is the

surface which has been displaced along this fault here. So, the fault moved like that, but the movement here was oblique. In one of my lecture I was explaining that we can have the dip slip movement, as well as the strike slip movement. So, the movement along the, during the Kobe earthquake along this fault was oblique.

So, this block which is your hanging wall and this is your foot wall. So, hanging wall moved up, as well as it moved in the right lateral direction. So, but here we do not see that right lateral movement, but somewhere over here if you, have some photographs may be later I can show you, which shows the clear cut right lateral displacement. So, this is how you will see the first crack on the surface and the displacement during an major earthquake.

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So, 1995 Kobe was one of the major earthquakes in Japan. Then we have 2001 Bhuj earthquake with the damage was extensive. And most of the villages in Kutch were damaged, because of the 7.6 magnitude earthquake of Bhuj.

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Then 2005 again there was in Kashmir earthquake then in, which also partly effected the Indian territory.

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Then 2015 Gorkha earthquake in Nepal. These are the few photographs from that area.

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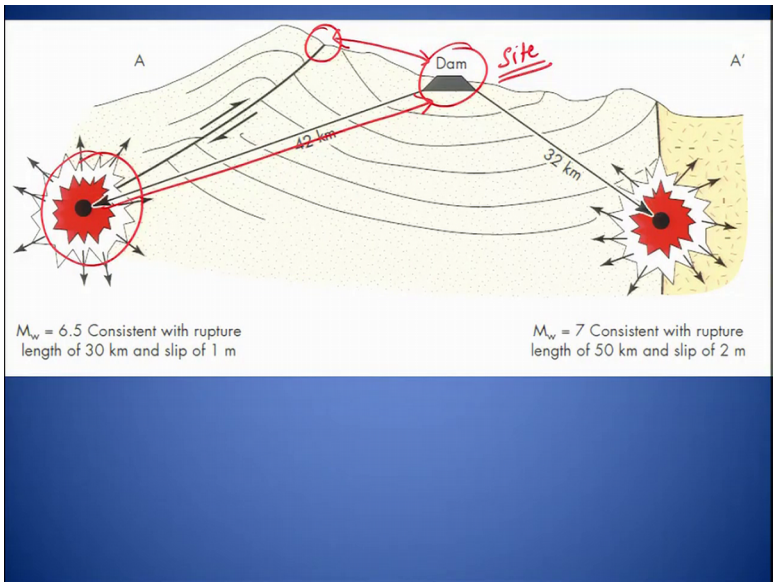

. So, the most important part which we would like to understand from the this that, where is the source of the earthquake is, one is the fault, where it is exposed on the surface and second is at what depth the earthquake will occur, and how far we are sitting from the earthquake. So, this is for example, here it is been shown as the dam, but any site you are interested in about the settlement that we will take into consideration. Of course, along with that we also take into consideration that what will be the distance between and the site of our interest

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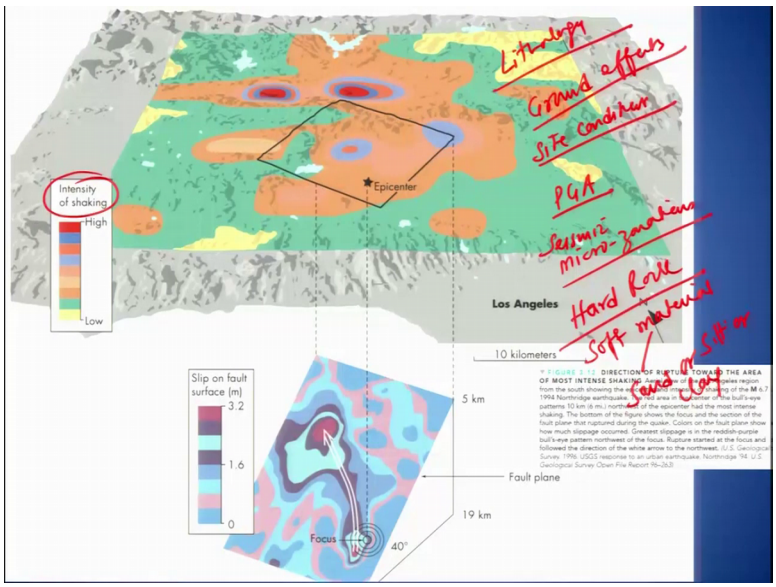

Other than that we go for Seismic Microzonation. So, Seismic Microzonation is extremely important, because not all areas within a region will behave in a similar fashion and that will be in terms of the peak ground acceleration; that is P G A, and this will depend upon the material or the site condition.

This we will talk more in detail when we are talking about the ground deformation or ground effects. This will be in the next following lectures; we will try to talk about the this. So, interest here is, what will be the slip on the fault, because slip will again, will have an direct relation with the ground shaking or the energy released, and what will be the amount of the intensity of shaking which one can expect at a particular point. So, this figure is from the area from Los Angeles which talks about that the intensity of shaking will be high at few points.

So, irrespective of the region in material will play an important role; that is what we call the lithology. I will just briefly say tell here is that if you having for example, hard rocks, then the ground shaking will be different. And if you having soft material, either it is sand or silt or you can say clay layers, the intensity of ground shaking will vary in the same earthquake or during the same earthquake. So, these are few things which are very much important, but at the same time we also need to understand that how far is our source from the particular site.

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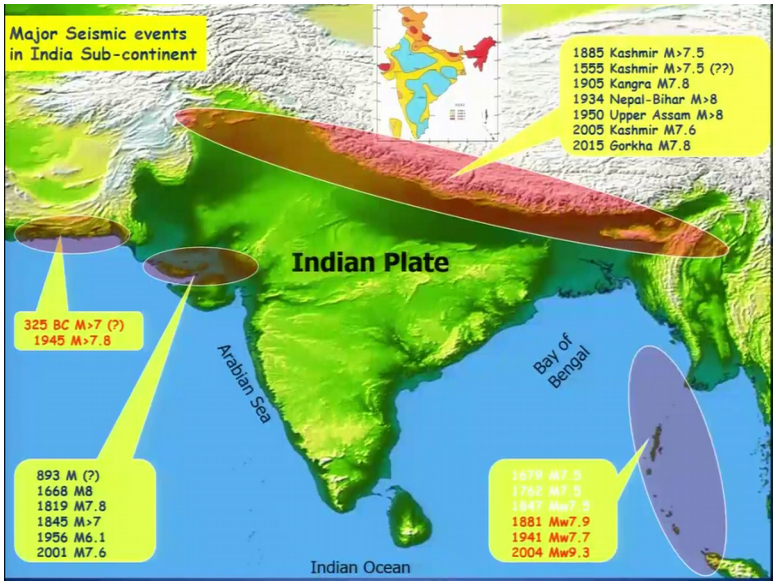

Now, coming to India, if you look at the complete Indian plate, I would say that not an single place is been left out, where we say that this place is safer to stay in terms of the earthquake hazard. We will talk more about the Himalayan zone here. If you look at the past historical data, we have earthquakes in 1885, 1555, 1905, 1934, 1950, 2005 and 2015. These are all earthquakes which are greater than 7.5.

We have not listed any earthquake which is less than 7 in this list, but these are few earthquakes which were recorded or described in historical chronicles, but there are many before 1800 which are not listed in the historical chronicle. There are few of course, from Nepal; like 1833 and then from the Indian side close to Nepal; that is Kumaon Himalaya we have 83. They are not been listed here, but they were also damaging earthquakes.

Now, based on this historical and present earthquake data what understanding we can immediately have is, that this region; that is the Himalayan collision zone, is vulnerable to the region, because it can host large magnitude earthquakes which are going to be damaging earthquake.

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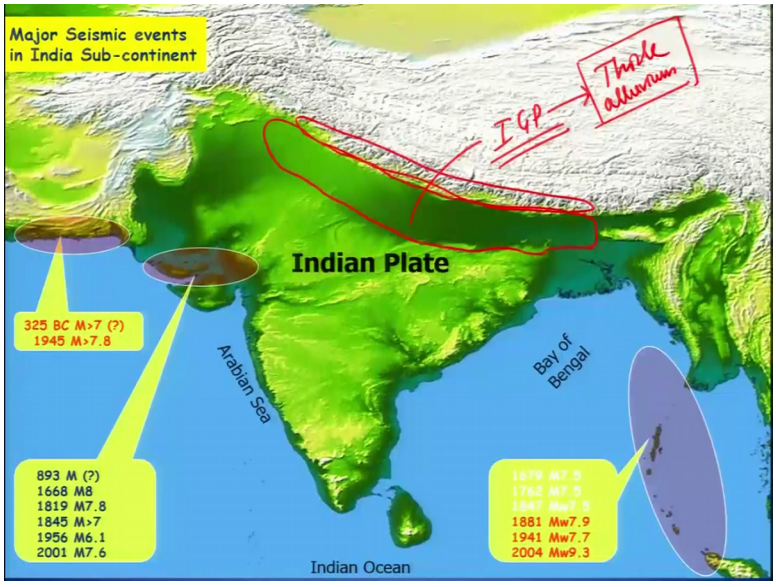

And as I was talking in my previous slide, this zone; that is you indo Gangetic plain area is extremely vulnerable to ground shaking, so this is your indo Gangetic plain. Nevertheless the region along the Himalayan zone will also be effected by the large magnitude earthquakes which are triggered along the plate boundary. So, this area

comprises a thick alluvium. Hence we, the worry is always remains that this area is going to have more amplification during an earthquake.

So, with this list we will see what exactly with, in what way this can be helpful in interpretation. So, based on this earthquakes, the Himalayan zone is been categorized in seismic zone 5, which is the most vulnerable region in terms of experiencing a large magnitude earthquakes. So, we now this, but the only point is that which area is going to host next earthquake in near future. That is another important point which we would like to know and which are the sources which are available in this region.

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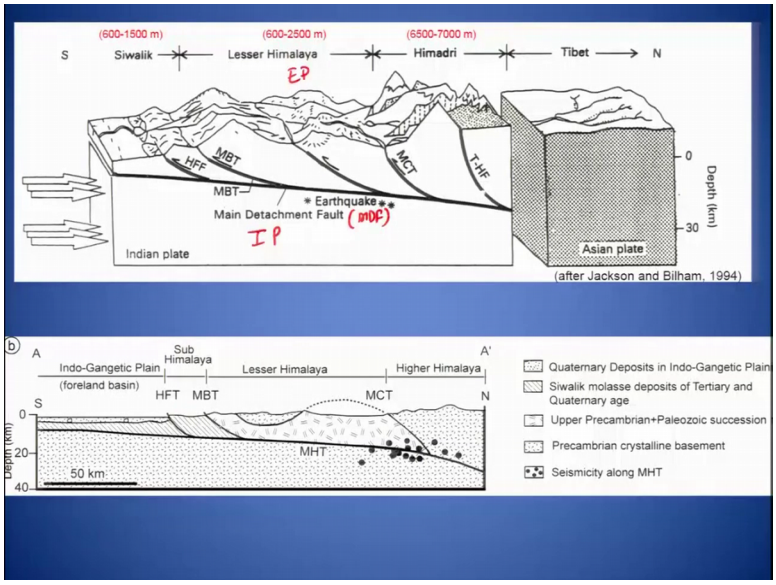

So, if you look at the cross section across the Himalaya, taking into consideration some part of the indo Gangetic plain. Now this cartoon try to explain that this the contact between the two plates where the Indian plate, the part of the Indian plate is subjecting below the Eurasian plate. And this contact is either termed as the detachment, mean the detachment fault or it is also being termed as main Himalayan thrust ok, or main Himalayan fault.

So, this is one very important contact between the two plates and it has branched out what we called imbrications, different faults which have been termed as in M C T Main Central Thrust or M B T Main Boundary Thrust and Himalayan Frontal Thrust. I will not go in to the detail of this the part, but the most important part which we would like to

emphasise here is, that between that M C T and M B T the present seismic zone lies actually.

the present seismicity is concentrated between the two major fault system, but periodically what we see, is that the strain which is been developed between the two plates, because of the compression or one plates subjected below the other one or the collision which is taking place between the Indian plate and the Eurasian plate, the strain is developed and then that strain is periodically released along the H F T Himalayan Frontal Thrust or M B T. So, this is, this is been identified based on the active faults which have been mapped in this particular region.

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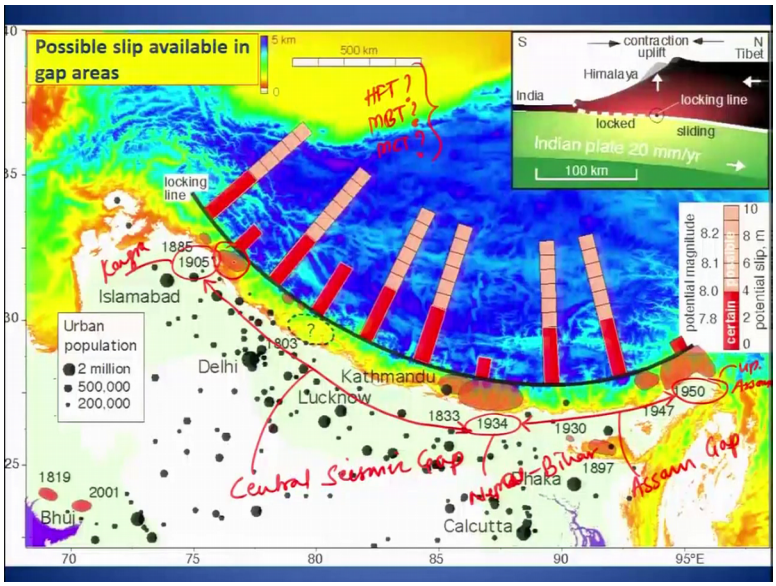

Now, based on the past earthquakes, historical earthquakes, this was the hypothesis which came up, was that the amount of strain or the slip which is available here in the potential slip which is certain, is same all along the Himalayan arc, because of the ongoing collision between our partial subjection between the Eurasian plate and the Indian plate. And during major earthquakes like 1905, 1934, 1950, the available strain or the potential slip was consumed, but in some areas which are falling in between this two earthquakes. For example, 1905 and 1934, the areas still is capable of hosting a large magnitude earthquake.

So, a term has been given here is that this area which exist between the 1905 and 1934 is been termed as Central Seismic Gap. There is another gap which is been suggested is in

between 1934 and 1950, either you can call this as Assam Gap. And then further there is one more gap which has been suggested between 9, 1555 earthquake in Kashmir and 1905 earthquake of Kangra. So, this is your Kangra earthquake, this is your Nepal, Bihar event and this is your upper Assam earthquake, but the question which remains is, that which fault line was responsible for triggering this earthquake, whether it was H F T, whether it was M B T or it was M C T. So, these are the questions which we usually ask ourselves that what was exactly happened. Now based on our research which we carried out in the Kangra region, it suggests. That the 94 19, 1905 Kangra earthquake was triggered in the hinterland side, it was not along with Himalayan frontal thrust. My pointer which I am showing here is the location of the Himalayan frontal thrust. Whereas, the Kangra earthquake was triggered along a newly identified fault in which we have reported in one of our paper is termed as Kangra valley fault, K V F.

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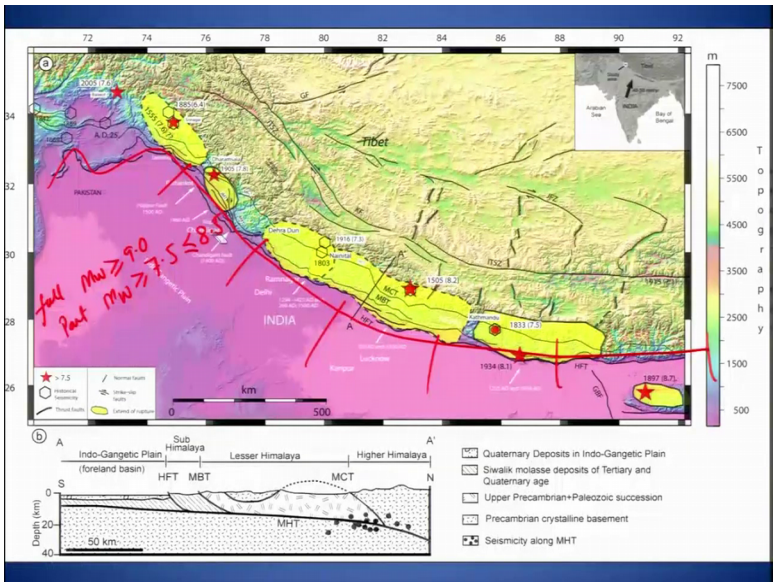

So, this fault was not been identified earlier, so there is an totally a new fault line which was marked over here. Now the question which we asked in the previous slide that whether these earthquakes been triggered along the Himalayan frontal thrust or they were triggered along some other faults ok. So, what we have suggested is that the 1905 earthquake of Kangra with magnitude 7.8 was triggered along K V F. Hence the energy or the potential slip which is available in this region is still available, partially is still available along the frontal part. So, the next event can be triggered along H F T.

Hence the gap which we were talking about between 1905 and 1934 will extend, it will not be between 1905 and 1934. Because 1934 as per the recent research suggest clearly that the, the earthquake was hosted by Himalayan frontal thrust or the slip came right up to the Himalayan frontal thrust. Whereas, in the case of 1905 Kangra it was triggered along with the K V F. So, this type of research or the investigations are extremely important to understand the future scenario in terms of the earthquake hazard.

These are few investigations or the results which we have put here, but I would give you a special talk on this where we have compiled all the information which is available based on the; that is geological investigations or Paleoseismic investigation we would say. Then along the Himalayan front along H F T Himalayan frontal thrust and what we infer out of that ok. Whether the Himalaya is going to rupture in one go from right from here to the east or it will rupture in part.

Now if you say that it is going to rupture in one single go, then we are looking at the earthquake with magnitude greater then equal to 9. Or if it ruptures, this is this is the complete full rupture full rupture ok, but in part then it may have the earthquake with magnitude which will be between; like greater than equal to 7.5 and less than equal to 8.5 or so

So, this is what we have inferred from one of our, in one of our paper where we have compiled the complete geological data which was, which is available from the research in the recent investigations. So, these are few important things which also plays an important role towards the seismic hazard assessment.

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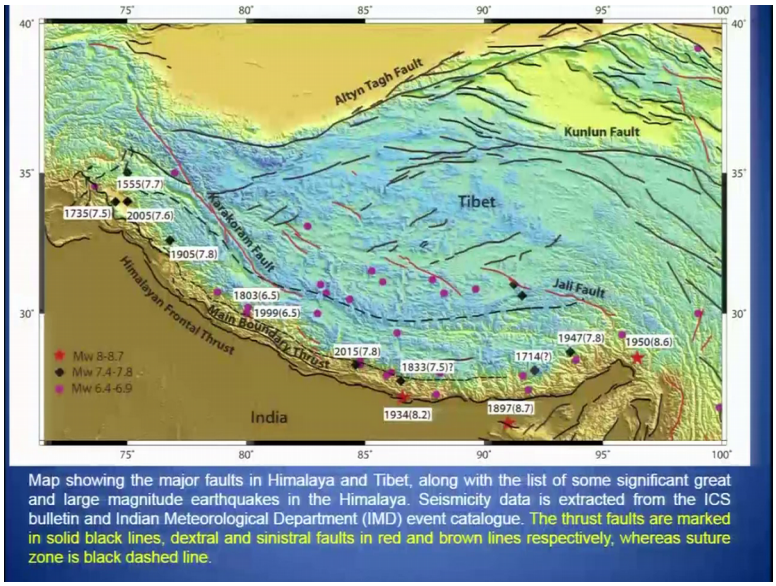

Map showing the major faults in Himalaya and Tibet, along with the list of some significant great and large magnitude earthquakes in the Himalaya. Seismicity data is extracted from the ICS bulletin and Indian Meteorological Department (IMD) event catalogue. The thrust faults are marked in solid black lines, dextral and sinistral faults in red and brown lines respectively, whereas suture zone is black dashed line.

Now, if you look at the this map which again have most of the historical, as well as the recent earthquakes, starting from the west side we have 7 1735, 1555 and the recent earthquake of Kashmir earthquake or Muzaffarabad earthquake of magnitudes 7.6, 2005, 1905, 1803 and then you are having 1999. These all are with magnitude 6.5.

This is an again question whether this earthquake was of 6.5 or not ok. Then we are having 2015 Gorkha earthquake. There was another one here, in the same in after couple of months, again 2015, then 1833. This is what I was talking about and this is the information and this is an the information historical event, and 1934 and so on.

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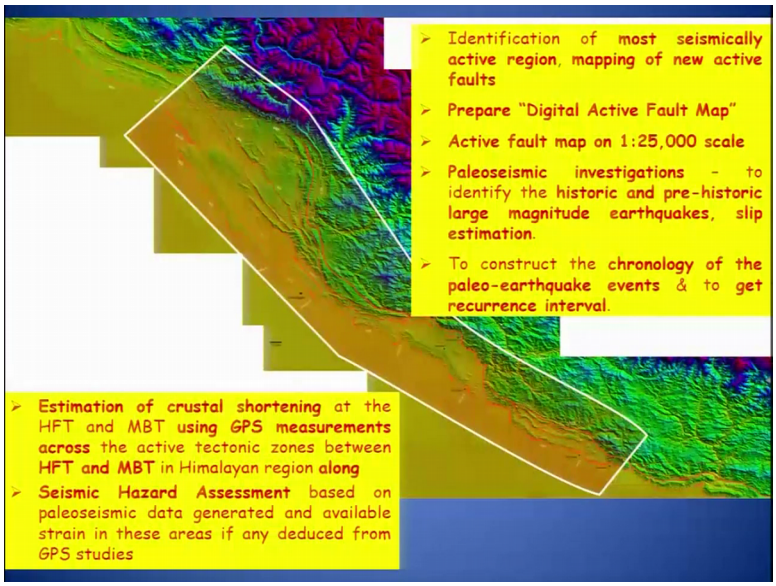

So, now what we are doing at I T Kanpur along with some other institution in India, that we have taken up the whole area with a name to identify the active fault traces and try to come up with an digital active fault map.

So, this is a area between Nepal which goes right up to Jammu in north west. So, the idea is to study the active faults, Paleoseismic and crustal deformation in north west and central Himalaya, with an integrated approach towards seismic hazard assessment. So, what we are doing is, that we are trying to identify the active fault in the regions; that is the central and north western portion of the Himalaya, to prepare a digital active fault map. And we would like to emphasise to prepare the map at the scale of 1 is to 25000. So, high resolution map and then the other part which is important that we would like to identify the historic as well as prehistoric large magnitude earthquakes and also go for slip estimation.

And finally, we would like to reconstruct the chronology of the ancient earthquakes or the Paleo earthquake events and to get the recurrence interval, so that can help that when will be the next one ok. So, for this what we are doing is, that we are doing geological investigations which we call as Paleoseismic investigations. Along with that we are trying to put and few of them are already installed in the north west Himalaya that we are putting G P S, permanent G P S stations across the Himalaya or here. So, we are taking few one transit here, another one here, third one here and so on ok.

So, that we know that in which pocket of this region in there are, there are chances of having a next earthquake ok. So, this will be an important data which will be collected to understand and to have proper evaluation of seismic hazard assessment. So, I will stop here and continue with the central Himalaya in the next lecture.

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