Earth Sciences for Civil Engineering Part-2
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Active faults and its related hazard in India (Part-3)
Module 2
Lecture No 6

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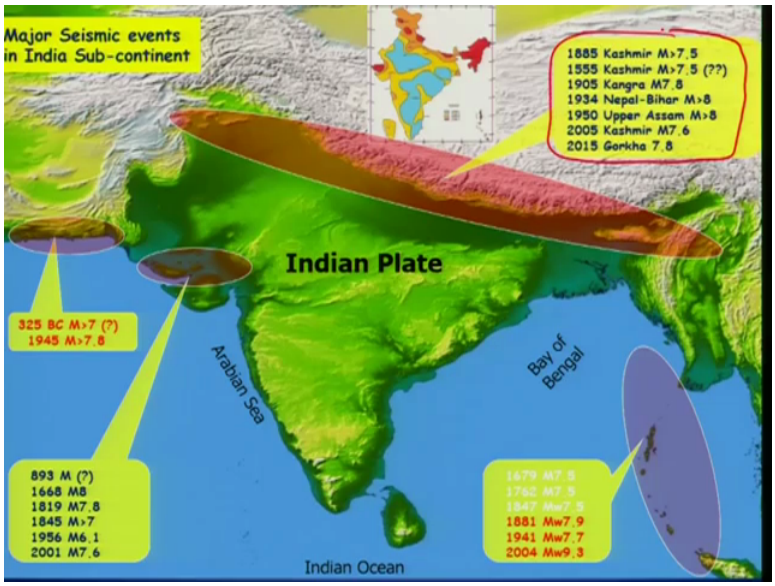

Hello welcome back in the previous lecture we discussed little bit about the the seismic zones around India and we talked about that how most of the parts of India either it is in the continental main land part or maybe around the costal line, coast line most of them are vulnerable to earth quake and tsunami and more precisely the Himalayan front or the the reach in joining the Himalayas and within Himalaya is extremely vulnerable to large magnitude earthquakes.

And that day we were talking about that we have couple of large magnitude earthquakes which we experienced in Himalayas starting from 1885 to 2015, Gorkha earthquake which was the recent one last year magnitude 7.8. Now before moving ahead , just briefly I would like to mention that whatever the records we see here ok, or the information we see here is not the complete one because we don't have umm the the complete historical records from this region and also what we are doing at IT Kanpur along with other teams in India that we are trying to identify the Palue earthquakes, signature of Palue earthquakes in Himalaya which are preserved within sediments and on the surface.

So the aim is to complete the catalogue of this umm ancient earthquakes which will eventually extremely helpful for proper seismic hazardous system of any region, so that is what we are doing over here . Now moving ahead when we talked about the earthquakes and all that based on the whatever the earthquake data is available from different parts of India, the zonation map has been prepared and this zonation map has been divided into four zones starting from two to five where the most of the red portions which you see here ok, are all in fall in zone five which are extremely vulnerable and will have very high seismic session during major earth quakes.

So if you look at, we have here that is the Andaman here and this portion whole is of the Himalaya and then we have the Kachchh here ok. And now Kutch comes here because of the earthquakes which have been listed here, so this is , these are the areas which are extremely vulnerable to earthquakes in future also ok.

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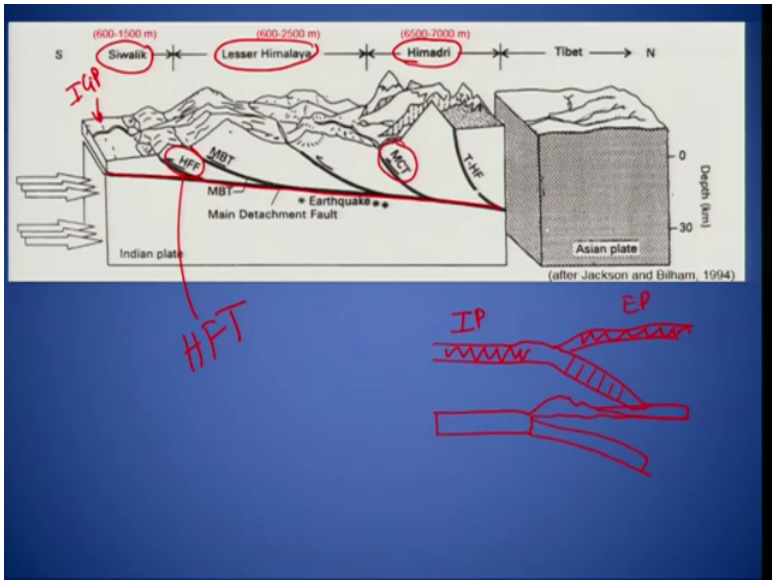

If you look at so I will briefly talk about some some falls in Himalayas, if you at in the Himalayan region mainly what we have is that the the initially and if you recall the previous course, we talked that the the the Indian plate subducted below the Eurasian plate and finally what are having that was between the the oceanic plate or the portion of the oceanic plate which was ahead of so if you look at here I will I will just put an sketch here ok.

So we had an the continental plate and we have the oceanic plate here which subducted below the continental plate of Eurasian, this is your Eurasian plate and this Indian plate we can say ok. So this subducted, so this is an oceanic plate and then we are having this one here continental plate but now what is happening when it it came close to the a continental plate of the European Eurasian side ok. So now what we have is just the collision which is going on ok and that is resulting into the formation of Himalaya.

So we have we are not more having the the oceanic plate going down but since it subducted below so we have still that contact exist ok and which is been shown here, so we are having what we call it is in the form of the detachment ok. So we have this detachment going on below the Eurasian plate and what we see is the the Himalayas are coming up. So Himalaya is now a single mountain but it is in chain of mountains, so we have the Hamadris, Hamadris or higher Himalayas then we are having lesser Himalayas and then we have Shivaliks that is the we call sub Himalayas at present.

So the elevation also if you look at, we have the elevation which reduces from 7000 meters the highest is about 8000 meters that is of the your Everest ok and then it reduces to 600 to 2500 meters and finally to umm 600 to 1500 meters ok. So this is what we see and then this all mountain chains are been separated or we can say bounded to their south by major falls ok. So one is what we call is the MCT, this is main central thrust and then we are having MBT.

Now MCT is separating the lesser Himalayas from the higher Himalayas and then we have MBT fall system which separates the lesser Himalayas from the sub Himalayas and finally we are having the HFF or we say HFT ok. This is your HFF or we say HFT Himalayan frontal thrust. This Himalayan frontal thrust mark the boundary between the lesser sorry sub Himalayas and the Indo Gangetic plane.

So this this portion is our Indo Gangetic Plane, so we have this one, the the Himalayan frontal thrust is the the present day plate boundary between the Eurasian plate and the Indian plate. So what it has been observed over the time now within the Himalayas that most of the earthquakes are occurring between the main boundary thrust and the main central thrust beneath the those two faults ok.

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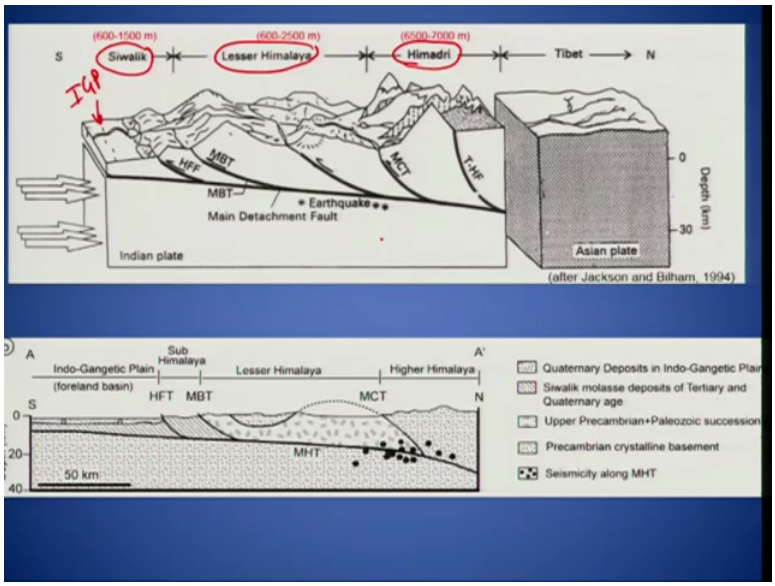

So we have the clustering of the earthquakes which are triggering mainly between main boundary thrust and MCT Main Central Thrust and then the formation is been taken up by the younger falls in the foreland side, this is what I was taking about the boundary between the Hindi Gangetic plane and the Himalayan frontal thrust, this is sub Himalayas and then we are having MBT boundary between the sub Himalayas and the lesser Himalayas and MCT is between the lesser Himalayas and the Higher Himalayas.

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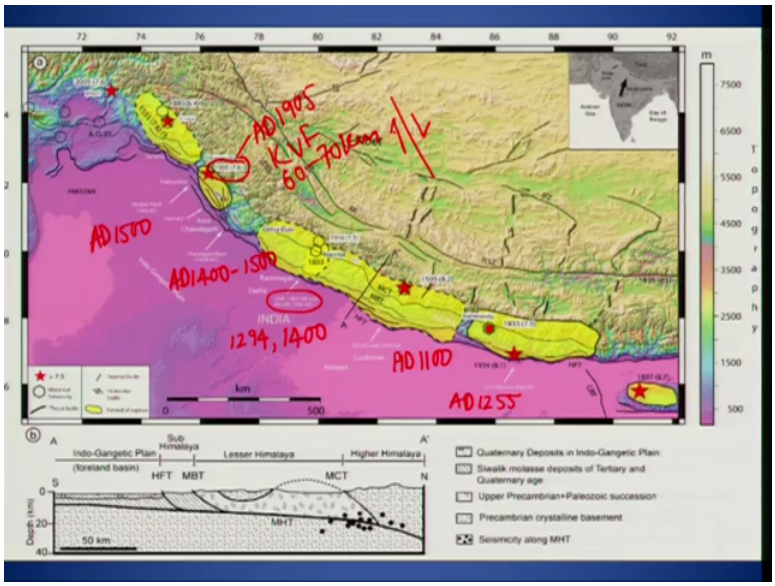

Now we have like some records of the historical events which have been experienced in Himalayas, so which starts right from AD 25, this was in Takshila earthquake and then we have couple of large magnitude earthquakes which are marked by the yellow areas now this yellow areas are the probable rupture areas ok where the rupture extended along the fall lines ok.

So this is one is 1555 is of Kashmir and then we are having 1905 of Kangra then we are having 1803 in Nainital region then we are having another one which extend quite a bit and which is 1505 earthquake and then we are having 1833 and then we are having 1934 and further this side if you towards Assam we are having 1950 which is not in this map ok.

So we have some records but this is again we can say that there is not in complete record along in from the Himalayan region. Some studies which maybe I will if I have time I will discuss it separately which have been conducted mainly based on the geological and geomorphological studies which has which which reveal that there are value earthquakes which have occurred like for example in 1255, this was major one Ad 1255 and the near Nepal.

There was another earthquake which was in the AD 1100 and then from the portion which is of the Himalaya in India we have couple of earthquakes which have occurred in like this is listed here which is not clear maybe we will try to put it on slide clearly, this is 1294 or so and then we

are having 1400 event ok. So there are couple earthquakes which have been listed again from Chandigarh area we have been able to identify the even around 1500 to 1400 to 1500 AD.

And then we are having again close to this Pathankot regions we are having again and the earthquake which occurred during 1500 AD. So and also our recent findings have suggested that this 1905 earthquake which was the major earthquake till almost like 20000 people at time in 1905 is again was to that within the valley.

So it the there was a fault which we have recently identified we named as Kangra valley fault which which was responsible for producing the 1905 earthquake ok and this falls run for almost like 60 to 70 kilometres and it is having a motion which we say cyclelateral stripes with motion, so again within thrust environment or the compression tectonic environment which we usually expect to have mainly thrust faults and reverse faults but at some places we are also seeing or we are also observing the stripe slip moment and this is mainly because of the oblique conversions in some regions ok within the the Himalayan domain.

So we have like coming up with lot of data from what we call based on the paleoseismic studies, so we have been able to locate and identify this signature of Paleo earthquakes ok. And let me share here one more thing that our recent investigation from this area particularly where we are having overlap of the 1803 and then we are having the the 1505 rupture ok.

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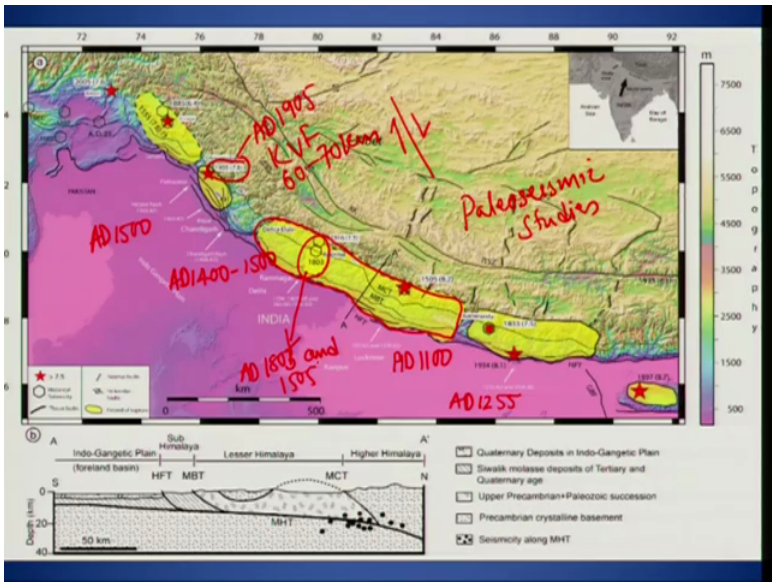

So from this region we have been able to pick up the signatures of AD 1803 and 1505 earthquake. This we recently published in one of the journal where we talk about that near Ram Nagar area, this is a famous area where most of the people go this area where we are having corporate park. So there we have been able to identify the signatures of this two earthquakes which occurred during 1803 and 1505.

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Let us move ahead and see what happened there was an deadly earthquake in 2010, this is what is the example of the destruction and photograph which is showing massive destruction and killing almost like 2 lakh more than 2 lakh people in that region ok. So Haiti earthquake of 2010.

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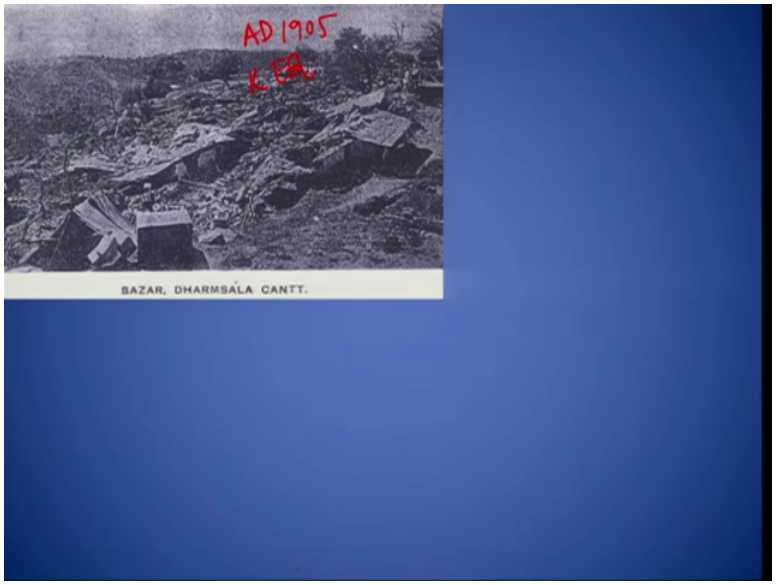


AD 1905
KEQ.


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Then these are some more pictures which have been taken from Dharamshala total damage resulted because of your 1905 Kangra earthquake, so this is an example of that, we have more massive damage in that area.

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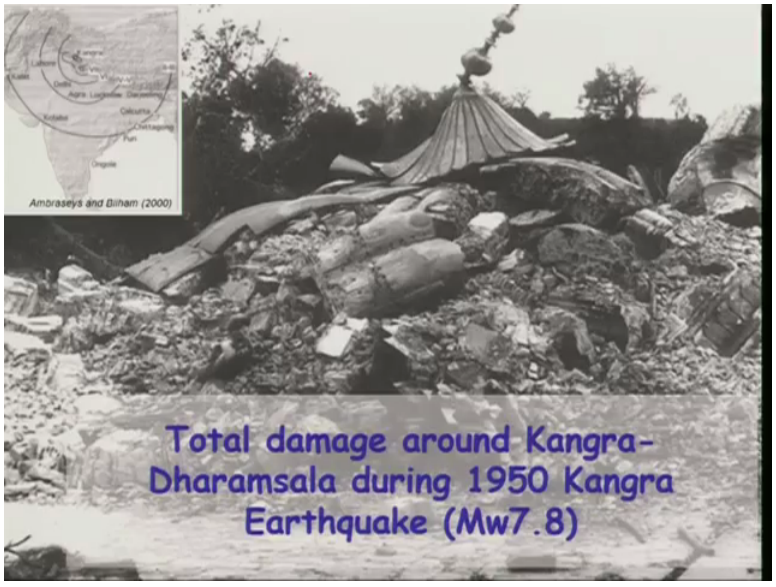

Now total damage , I am sorry this 1905 event of Kangra which was magnitude 7.8.

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This we have I think we have shown couple of pictures this is Bhuj 2001, Bhuj earthquake, this again from Bhuj.

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So we experienced total damage. Now what are earthquakes actually, let us have a very quick discussion on that part, what are earthquakes in in previous slides and lectures we have talked about that, it is an sudden release of the energy stored within the earth crust ok because of the ongoing tectonic deformation and the manifestation of those placements on the surface as termed as active faults and this is what is one of the famous fault line in US, America which is termed as San Andreas Fault System.

So this are the trace of that, if you see from here this is and then what what we are able to see here is that this fault has produced many earthquake in the past and there is a likelihood of having an earthquake in future also. So this is live fault or we can say the active fault which is having an motion of right lateral slip ok this is an right lateral strikes fault and this portion what you see here is the faults scarp and the streams which are flowing across this fault are getting offside, they are deflected along the motion of the fault.

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Another best example of the picture of that ok, so we have the strike slip motion here, right lateral, this is your fault scarp and the fault traces over here and if you carefully see, the the streams which are flowing from here are getting deflected along the fault ok. So this is one, this is another one, so if you look at how what is the best way to understand and to know that whether this fault has moved multiple times or not, if you look at this stream, this is showing larger displacement as compared to this one.

So this means that this stream was ofsetted, maybe during one or two earthquakes but this is showing a cumulative displacement in this particular potion of the fault ok. So that also gives an idea that this fault has been moving continuously over the time and resulted into many earthquakes in the past and has there is a likelihood of having an earthquake in future also.

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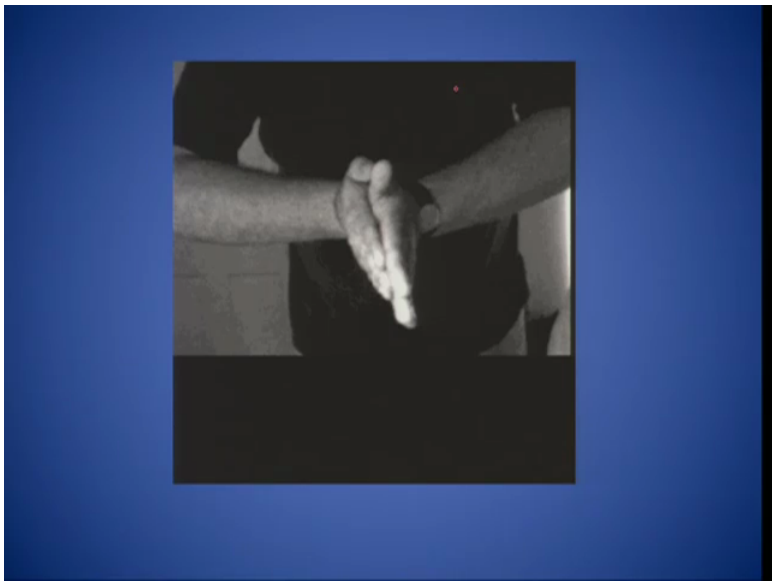

This is one of the very nice example which has been given by US geological survey where, what they explained is that you take up both the the hands and try to press it towards each other and try to move ok, so there is an friction which has been developed in between your two hands ok and when we were moving of course there you are putting lot of pressure on it and then trying to move ok and when it slips suddenly you will get a jerk over here ok or some vibrations will be there on your in your hand ok and that vibration is what we call the earthquake.

So similarly two rock masses are moving are under compression or maybe tectonic because of the tectonic forces ok and there are pressure or the strain is building up and when it moves or slip, it will reserve into the the vibrations.

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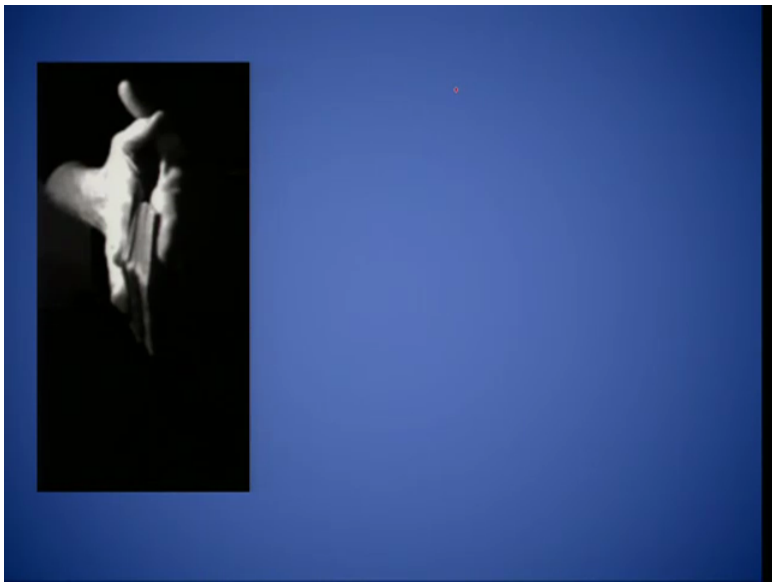

So sudden release of the energy which has been stored, so as we have been talking about that if you keep on increasing the stress, strain will develop and finally you will have the fractioning ok, so plastic deformation, ductile and then you are having the fractioning ok.

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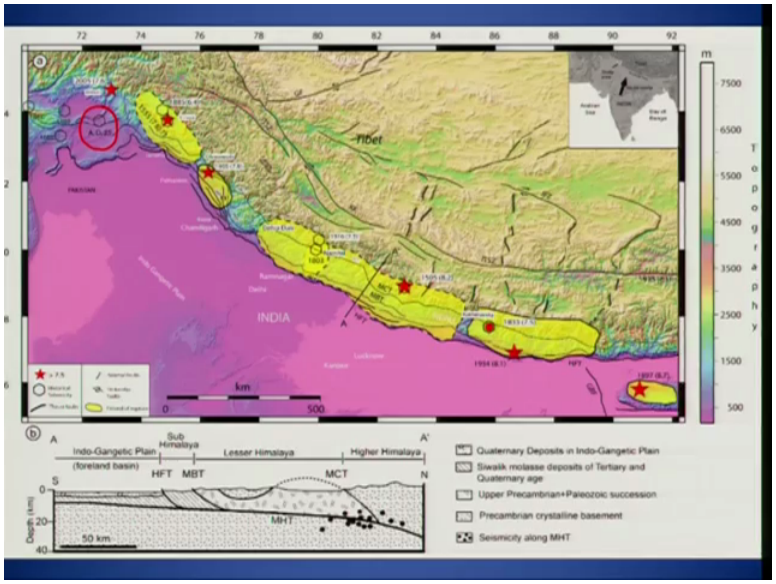

There is another example which has been given because on the earth surface we don't see only one single fault line, there are multiple fault lines ok, so if you look at like what we were talking

about the Himalayan frontal trust and all that ok, so if you look at this one here, we are having multiple fault lines, this all black lines which have been shown in Himalayas or mapped in Himalayas are the location of preliminary active faults ok. So we have multiple fault lines which you will come across in any tectonically deformed region.

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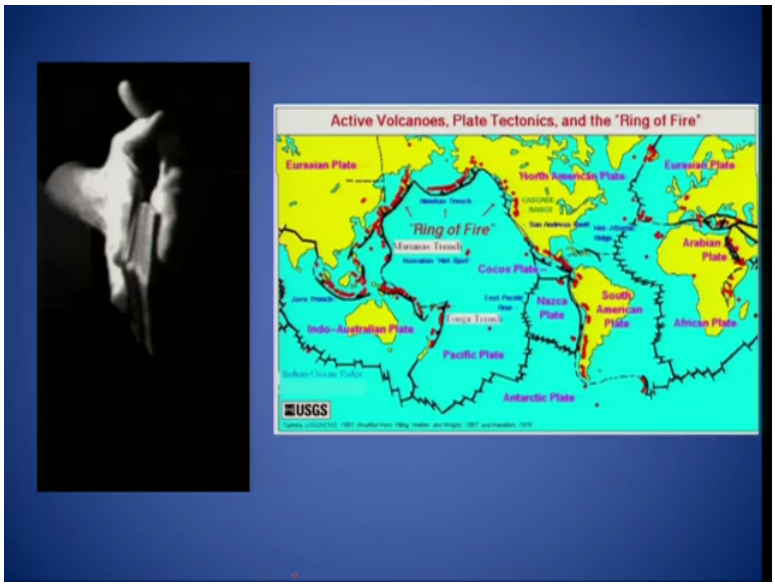

So this is an example which has been given that if you take a set of a plain card and try to press against each other and move in any particular direction ok than what will happen that the the plain cards, the contact between each plain cards you consider as an weak stones ok which will move at different rate, it will not move at the equal rate, it will move at the different rate and that is what we call the slip rate ok, slip rate is we measure or talk in terms of over here.

So slip rate of each fault or the contact between the each rock blocks will be different. So this it is important to know the slip rates that how this faults are slipping ok, if slip rate is higher than you are accumulating more strain that means you will have the recurrence of a earthquake will be very short, so you will have very quick earthquakes in terms of the time.

So this is extremely important and that is what we have been doing in Himalayas particularly that why did not we find that which fault, if those are active faults which fault out of them is moving faster that will tell us that what is the hazard posed by that particular fault in that region ok. So if

slip is faster, strain will be more in that area, so we need to identify the potential regions of the (())(21:52) areas where we are having higher strain accumulation.

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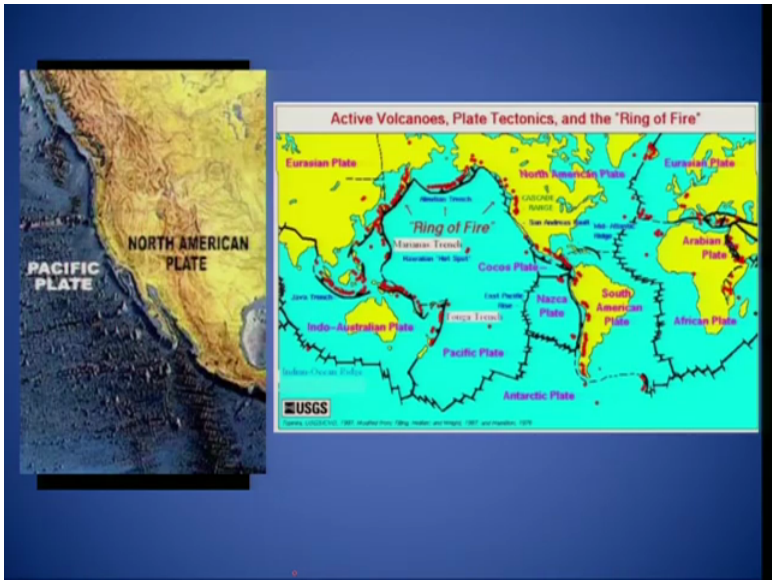

So this is an example where they suggested that if the pacific plate in the North American plate if they are moving ok, what will happen and they will have multiple fault lines over here ok. So this is the region where we are having in this particular part where we are having the pacific plate, this is the pacific plate and subdecting below or slipping along the North American plate.

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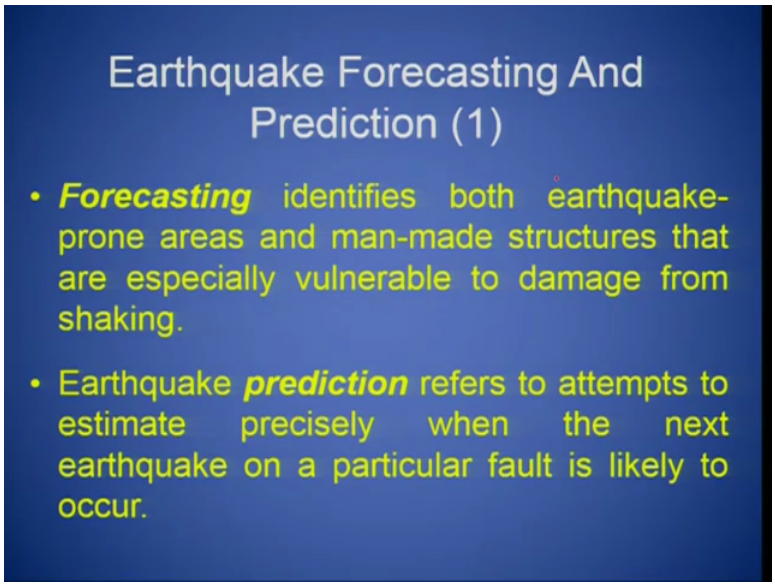

Now earthquake forecasting and prediction, as I told in the in the previous lecture that it is not very much possible to forecast the earthquake but people have tried looking at the precursor events and have predicted a few earthquakes, so forecasting identifies both earthquake prone areas and manmade structures that are especially vulnerable to damage from shaking ok.

Earthquake prediction refers to attempts to estimate precisely when the next earthquake on a particular fault is likely to occur. So this prediction is what I would say that is a part of the studies what we are doing Paleoseismic studies ok, so at least we will be able to talk about that when the next earthquake on what which particular fault it will occur ok, so this is very important.

So those the studies which we are doing is of course we are looking at the signature of earthquakes which took place in last 10000 years ok, but the recent development what we have, now we are doing is based on also based on the GPS measurements ok, so we have the permanent GPS stations across put across the faults and try to measure that because GPS 24/7 it will collect the coordinates ok and since we understand that there is an shift ok so since we we know that there is an there will be an shift there is an velocity at particular velocity the earth, the plates are moving so we can precisely monitor those those movements along within the earth crust ok.

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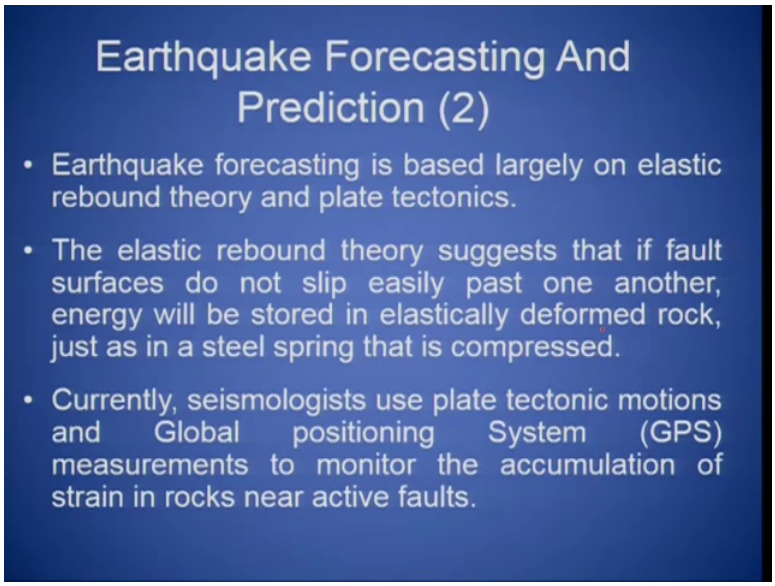

Now second part of the earthquake prediction if we take, ok earthquake forecasting is based largely on the elastical bond theory and plate tectonics ok. The elastical bond theory suggest that if fault surfaces do not slip easily past one another, so that means they are like locked ok and they are storing the the energy within them, so what happens, the energy will be stored in the elastically deformed rock ok, so this is what is happening along the fault line so it will not keep on slipping but it is, it is locked and it will keep on accumulating the the energy.

Since it will keep on accumulating the energy there will be some deformation which is what we call the elastic deformation will be there in the rocks ok and this can be captured or recorded by GPS measurements ok. So currently seismologist use plate tectonic motion and global positioning system GPS ok, measurements, so GPS measurements to monitor the accumulation of strain within the near the active fault.

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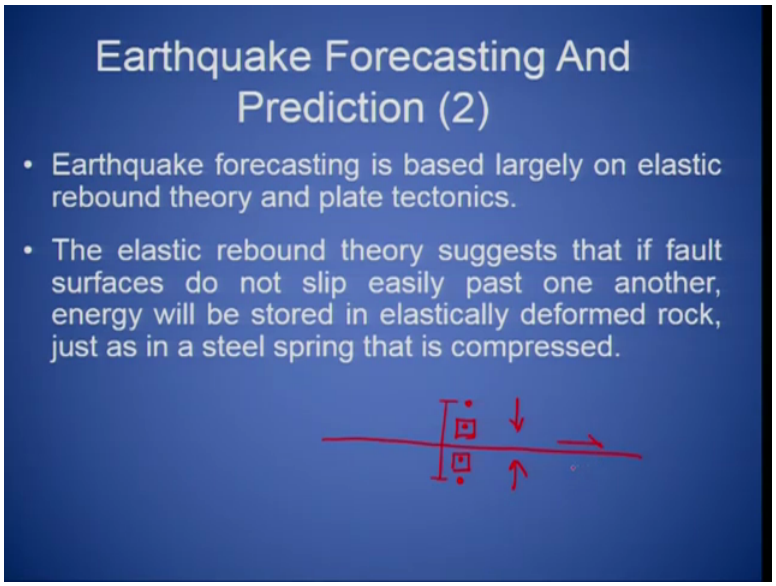

So for example if you are having an active fault which is running here ok, if I say that this is an active fault line then you will put a GPS here ok, this is what I am talking about permanent GPS and another GPS here ok, so this will keep on monitoring, so if the motion is like this ok, that is within, this is in compression than there will be movement which was been seen this, this coordinates of this two GPS will change ok and suppose if you are having, so this there will so over the time this for example one GPS is located over.

I will just put the point here and then say if you are having one GPS here another GPS here, so over the time what will happen, the GPS will move towards each other because this is under compression, so this will be another position, new position of the GPS, so there will be an relative motion which can be measured ok.

But suppose there is an strikes up motion ok, so one plate is moving or the fault side is moving like this or in the other direction than the GPS over here will move for example over here and then another one will be somewhere over here ok. So you can measure the movement of the along the fault line ok and then the formation can be measured. So this is extremely important that that in current situation with the advancement of science we have the GPS system which can measure the the ongoing deformation of the active faults, I will stop here and I will continue in the next lecture, thank you so much.