Earth Sciences for Civil Engineering Part-2
Professor Javed N Malik
Department of Earth Sciences, Indian Institute of Technology Kanpur
Active faults and its related hazard in India (Part-6)
Module 2
Lecture No 9

Welcome back, so let us move ahead and see some ground photographs of strikes fault of how it looks like ok.

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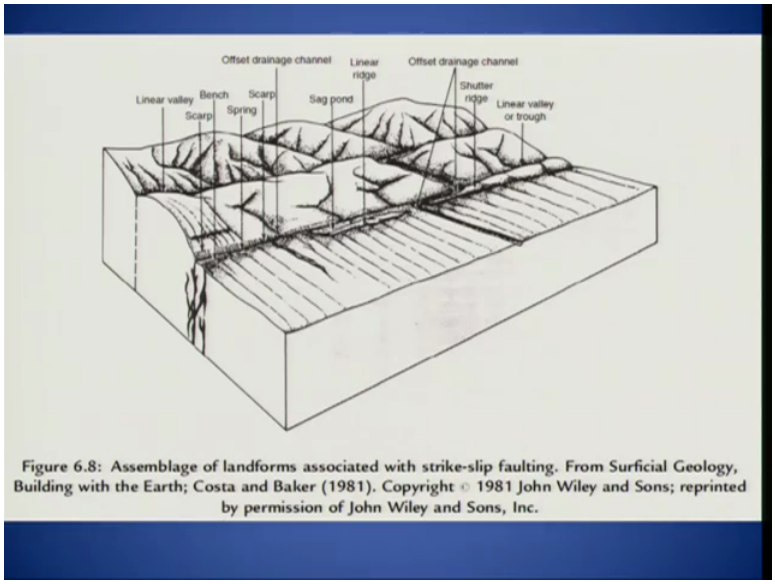

Figure 6.8: Assemblage of landforms associated with strike-slip faulting. From Surficial Geology, Building with the Earth; Costa and Baker (1981). Copyright © 1981 John Wiley and Sons; reprinted by permission of John Wiley and Sons, Inc.

So in previous lecture I was talking about one was the strikes fault what what features you will see on surface manifestation thrust fault and reverse fault, so let us see few more examples of that and how we classify it ok.

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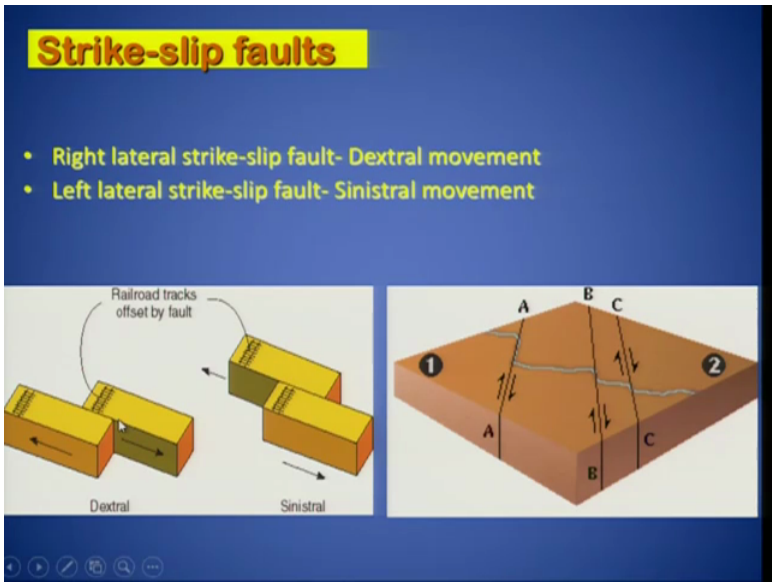

So mainly we talk about if there is a right lateral movement along the fault that is along the strike we also term that as a dextral movement and if there is a lateral, left lateral then we term that as an Senistral movement. So within small cartoon it has been explained here that if you are having the two blocks which are moving past each other ok and if they there is this block on the block which is moving towards us will be you the the motion ok you will take that as a motion ok.

So if you are standing here, if you are standing here and trying to view this one ok then this block is coming towards your side so that is a right lateral Dextral movement and if you are viewing this one from here then you are having again the left lateral movement here where the left block is coming towards you, so based on this we one one can classify that what will be the motion pattern of motion along the or the movement along the the strikes slip and as we discussed in the previous lecture that if whatever the the pattern of movement we will see on the surface, we will have these manifestation seen on the in form of the displaced land form.

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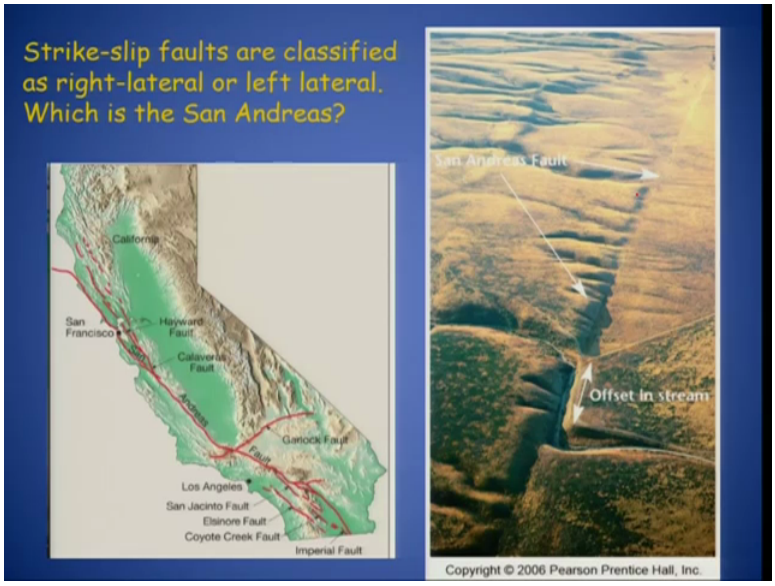

So this is an example again that what we we talked in the very beginning the offset of streams, so there is a stream which is coming here and getting offset along the fault and the fault runs over here, so we have the linear, very liner feature which is been seen on the surface and then we have the fault scarp also, this is the fault scrap here you can see here. So this is an example of the San Andreas fault system.

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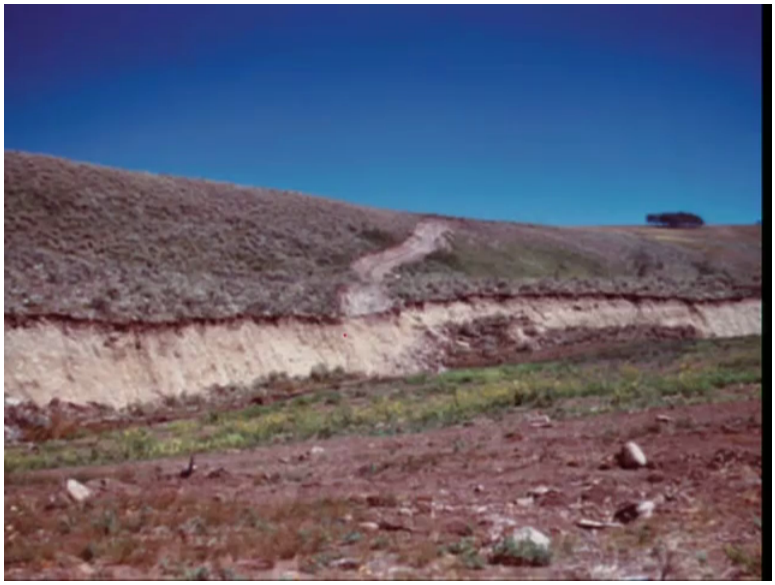

There is another example of the normal faulting ok where you can see the displacement over here.

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So what you see on the surface will be very sharp boundaries ok between the two land forms and this what is been shown here ok, already having very sharp mountain front. For example if you take this as an Himalaya and this is an Indo Gangetic plains we have a very sharp boundary which exists between the Himalayas and the Indo Gangetic plain.

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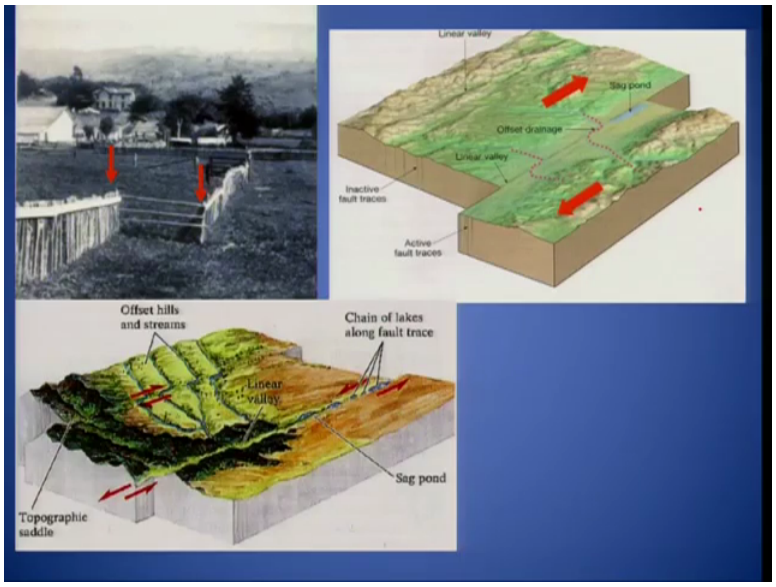

This again a very famous photograph which was been taken after 1960 San (An) San Francisco earthquake, so you will what you will see is the offset of the streams these are the most commonly seen features along the strikes that set ponds and offset of and liner valleys ok.

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Now in some part of US ok along the San Andreas fault, the fault is creeping ok, so it keeps on creeping every moment ok, so this is the the trace of that ok, so the fault goes from here and this

again an San Andreas fault system, part of the San Andreas fault system and you are having an the open drainage which is been the wall of that is in getting displaced ok.

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Few more examples of that so this fault is this one here fault which is creepy and this is a part of the San Andreas fault system. Now just very quick discussion here is that if you look at there are multiple fault lines ok, multiple fault lines here which are been shown in yellow lines ok and we have some numbers which is been written as three to four millimetres, 17 millimetres then 24 millimetre.

Now this is very important because this will give us an idea that which portion of the fault is having more displacement of accumulating more strain in that region ok and if you are having more strain and there is likelihood of having a large magnitude earthquake in near future increase ok, so the probability of earthquake in that particular region will increase, now that what we need to do in India.

So we need, we have multiple fault line in Himalayas like Himalayan frontal thrust then we are having main boundary fault or main boundary thrust and then we are having MCD and in between this fault systems we have many smaller (())(5:10) faults ok, so we need to have an idea of that how those faults are slipping and what are the rates of along that faults ok. So this will give us idea, for example here if we take the most having the higher slip or or the rate of

conversion is more here ok, so this area will have higher potential of triggering large magnitude earthquake in near future.

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Now coming to Hayward fault let us see couple if photographs, ground photographs of creeping ok. So people know that there is a fault here, so they settle before they came to know that there is a fault but now onwards after the after the understand that there is a fault here, no construction is been allowed but who so ever is staying here, they are, they have to live with the fault and they are ok, so fault runs somewhere here along the street and how they came to know that it is creeping because they used to face the the breakage in the utilities like water pipelines and drainage pipelines and all that ok.

So they they they reported this to the municipal office and then the survey, based on the survey and the details they did they came to know that there is a part of the San Andreas fault Hayward fault that it is creeping over the time ok.

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Close up of that one again, so you can if you can clearly look at the pedestrian path here, this corner is been displaced ok, so this is coming like this and like that ok, so fault runs over here. So they, they have the understanding ok.

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And then another photograph close up of that ok, so you can see here the cracks which are coming up on the on the road ok, so fault runs through here ok, goes here so this is the zone here ok and close up of this let us see close up of this one ok.

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Over here, so you have an displacement, you can see the displacement here also, so this pedestrian part, the boundary of that got displaced and this is because of the creeping ok.

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Again and there is a close up of this, this is an abundant rail track and this are the new one, so they know they understand that what is the amount of creep every year, so they keep on shifting the the rail tracks also, so minimize the the the accidents here ok.

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Close of this one you can see the offset of the of the train lines ok here, the railway lines. These are the new ones which they have created after this then they have abundant this one. So next when this will get deformed they will shift the rail lines here ok.

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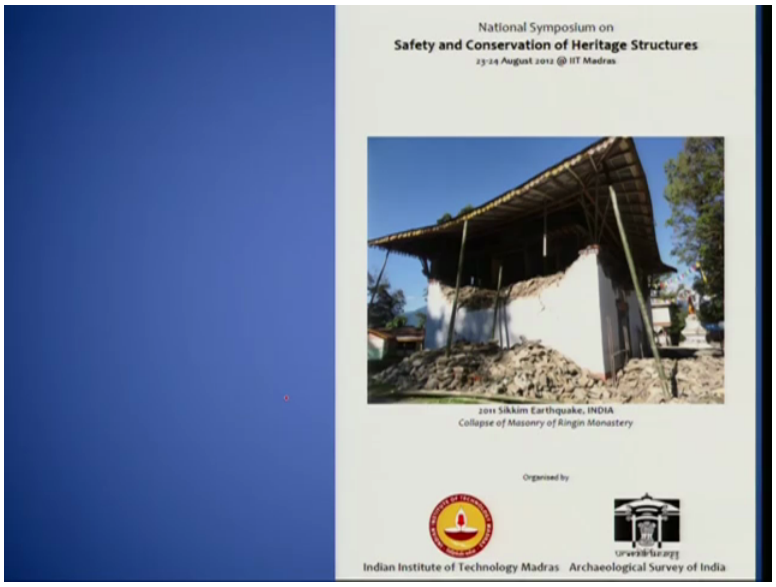

Now another important aspect which we have been looking at is the safety and conservation of the heritage structure ok, this I just wanted to put in because this is one of the most important part which many institutes have taken up ok and this I just wanted to project that there was a workshop which was been organised by IIT Madras and archaeological survey of India ok. so this talks about something on the the the conservation of the heritage structure because we have need to look at those also and then we need to look at what is the safety in terms of if there is an big earthquake in that region ok.

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Apart from this in in a European countries they have a major projects which are going on to look at the culture of heritage sites mainly in the Middle East ok, so it the project is the archeo-paleoseismology ok, so archaeology and the paleoseismology looking at the palue earthquakes ancient earthquakes for the protection of the cultural heritage. So I will show some examples of this project what they have been doing in Europe.

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So this study the leader of this project is Magroy, Professor Magroy from France and he has been studying this area ok where we have very prominent strike slip motion over here.

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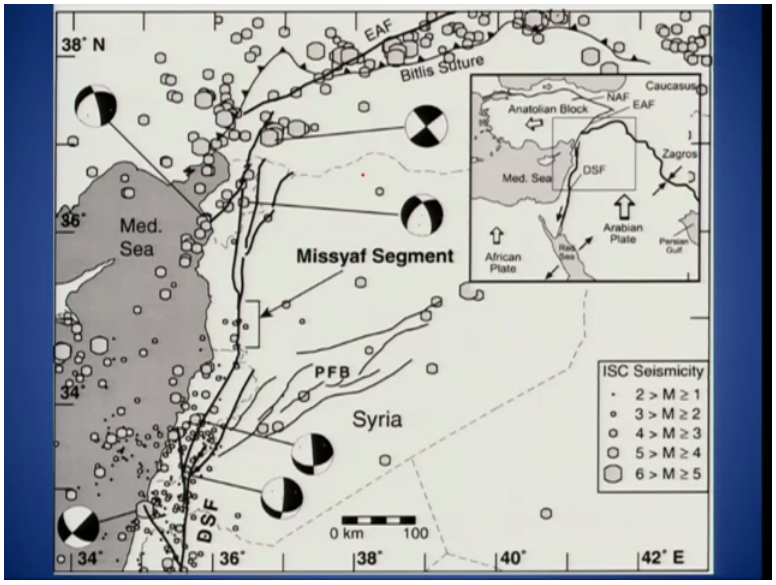

So this is what they have they call this as an dead sea fault ok where the dead sea faults run here and this is because of the extension which is going on between the the African plate and the Arabian plate ok. So this fault system is developed because of that and it shows the the strike slip motion.

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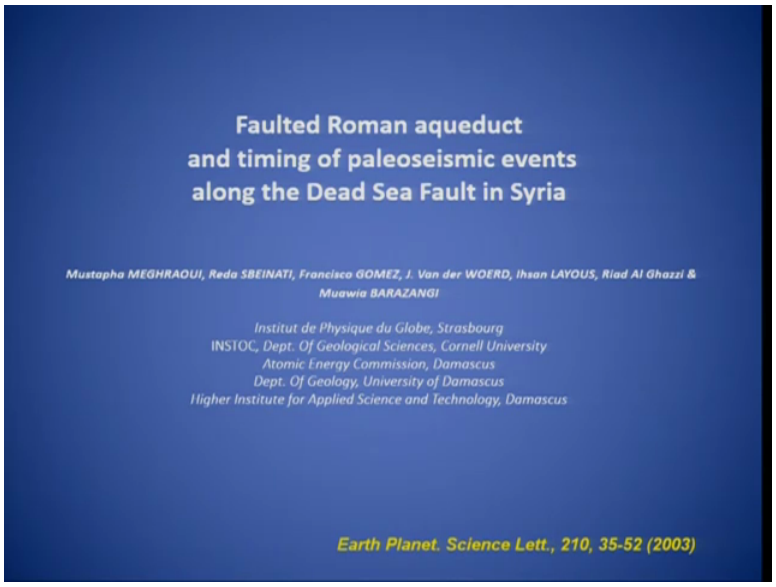

So this is their project and they were kind enough to give us the slides, so this is paleoseismic investigation along the Dead Sea fault in Seria.

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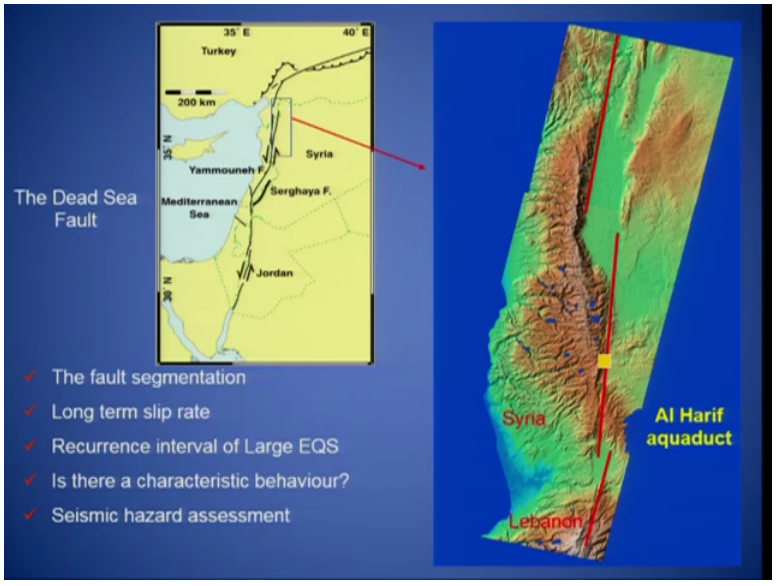

So very quickly we will look at what they have been looking at, so this is the the satellite data which shows the clear signature of the the Dead Sea fault here ok and this basin is also formed

because of the the displacement on the on the fault ok, this has an right (la) left lateral strike slip motion over here, so this is place of the fault which can be seen here also ok.

Now I will just talk about what the they found that was in we really exciting sample in which they wanted to highlight that how this earthquakes have been preserved ok. Now this is an ancient site ok where European aquada got displaced number of times during an earthquake and the people who occupied and reoccupied that place ok kept on reconstructing ok.

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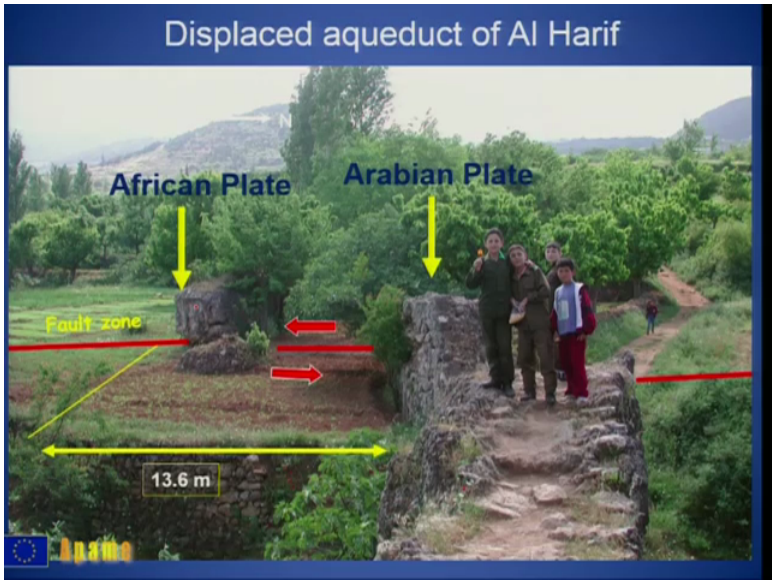

So if you look at the wall here which is been seen is been displaced here ok, so this is an left lateral motion here ok. So you have an the fault zone which passes through here and this moved left laterally and the total displacement which they have measured is almost like 13 metres or so ok. So one side you have the the the Arabian plate and another side is an African plate ok, the displacement is almost like 13.6 metres and this is not the single event, this is multiple event displacement ok.

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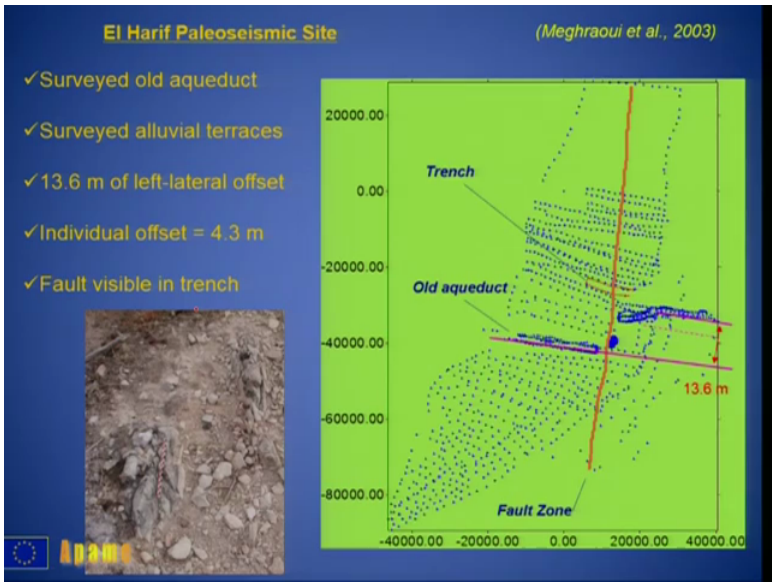

So the that what we do is, we do very detailed field mapping and try to understand that that how much displacement has been acquired by that particular fault, so if there is for example this is a fault line here than we are having the total amount of displacement which is been measured and the we try to look at the trenches also, so we see the section and try to look at that how many soil layers have been displaced in the past ok.

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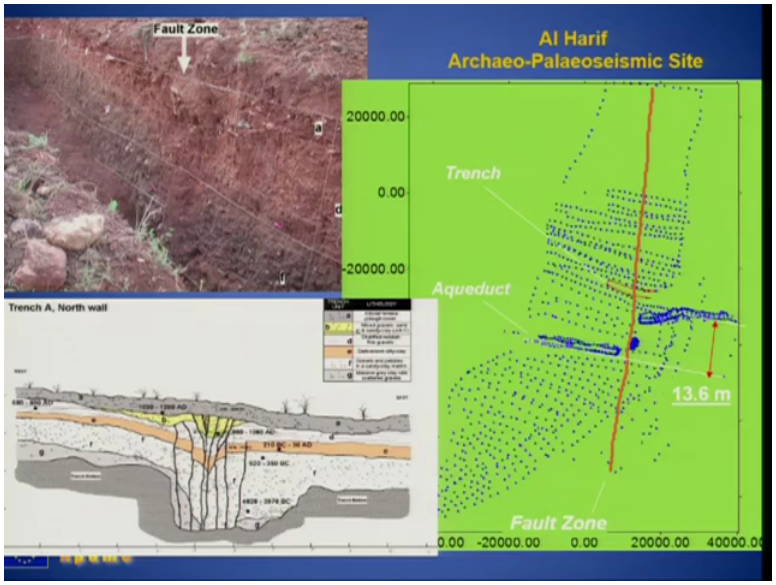

So this is the the way the trenching and mapping is been done if the if we open the section across the fault ok, so if you are having, this is what they have shown the trench, so this section is from the trench here ok, so they have marked multiple events, so this is the older event which stops here and then this are the younger events which goes right up to the surface ok.

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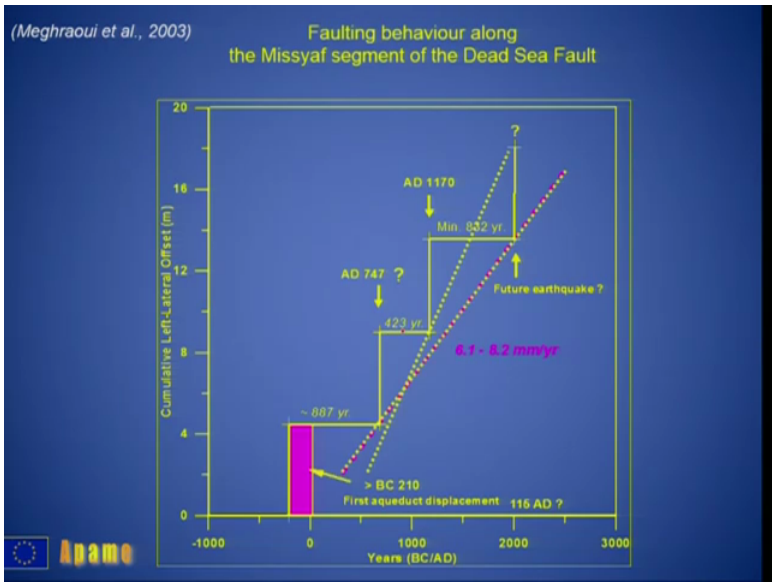

So based on this one can also predict an earthquake in future ok, if the earthquake are systematic if they are occurring in a very systematic manner in terms of the time then one can predict the the earthquake ok, so this is the if we it shows the linear relationship and the it is possible in terms of time and the so if you, if you look at here this is what they talk about cumulative displacement and then they are having the the years ok, so this much time it will take to trigger.

It took to trigger another one the next event with respect to this one, so this is earthquake here, so this much time was been time lagged between the two events and other one which occurred here and then it was in shorter period here then again it was on longer, so this is very much similar to this one here, so what they expect that either they have the another one here which will take similar time or maybe the shorter as compared to this one ok.

So at least they will be, they you can one can predict that when can be an next earthquake coming up in in that on that particular fault but what we have been experience that since we are not having an systematic time gap in between the two events, it is difficult to predict but I can

say that at least we can, we have the awareness and we we will be able to know that which fault we will be capable of triggering the magnitude that is the the earthquake of any particular magnitude ok, so that also is helpful and where the the fault passes through so we we should be aware of that.

So we can create a buffer zone and we avoid putting structures on those faults ok. So this is one interpretation which be taken up, this is another interpretation which can be taken up based on the shorter interval which is been seen here ok and this one is the third one ok, which you can like the same one you can take like maybe the next one will be here.

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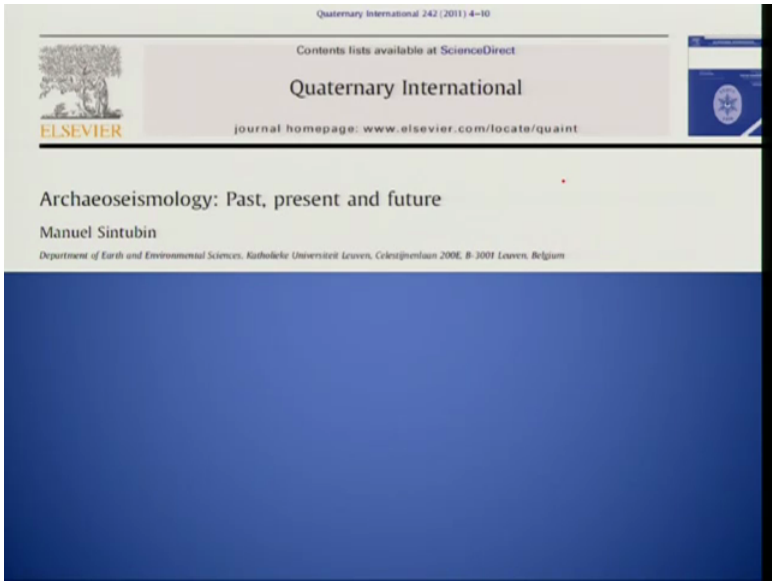

Now very quickly what another team is been doing in Europe that they have tried to look at the the the signature of the past earthquake preserved in the archaeological sites ok and they are trying to understand that what happened during that period and that an whether that can that information can be helpful in terms of the seismic hazardous assessment and in present day actually, so that is another one very important part which they have done ok.

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So the the older ancient structures there, they have tried to look at that what are the various signatures which can be taken as that this for example the falling pillars in one particular direction ok and the displacement of the of the block walls or the blocks within the wall and all that ok, so they have taken that as one of the examples for that ok.

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Now there is an another one which was been done, this is this was been published in bulletin of earthquake engineering which talks about the quantitative archaeological investigation, archaeo seismological investigation in Greece ok and this was the the great way to look at that ok that is a theatre.

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So this is an aerial photograph of that.

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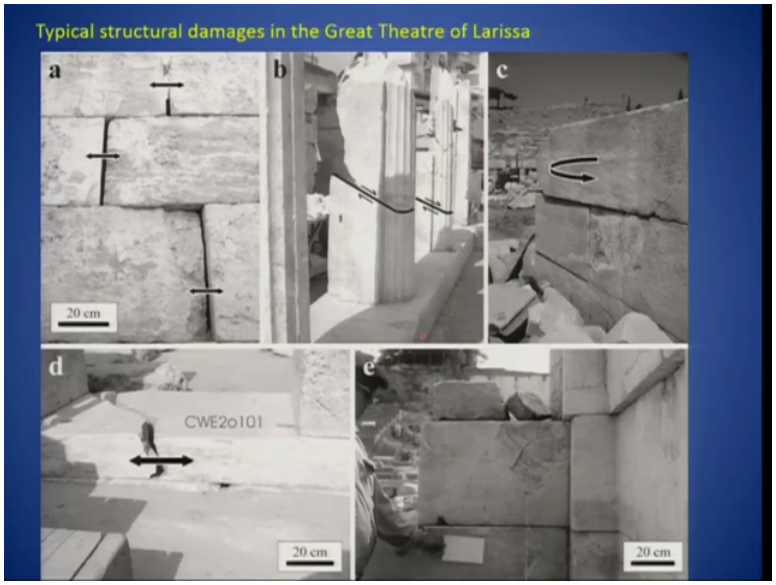

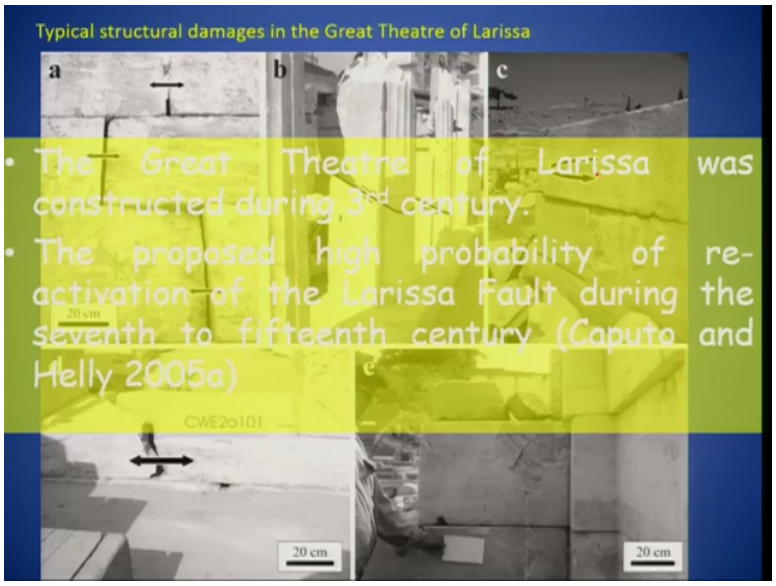

And what they looked at is the displacement, the pillars or the columns they have and then there was in displacement or the spreading out of the of the block ok and then forward and reverse displacement of the block and the rotation of the blocks ok, so this type of evidence or signatures they have taken into consideration to understand the past events ok.

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Now coming to the the part in India ok we have couple of good examples form the foothill zones of Himalaya and this is what we have been doing, I will quickly talk about that.

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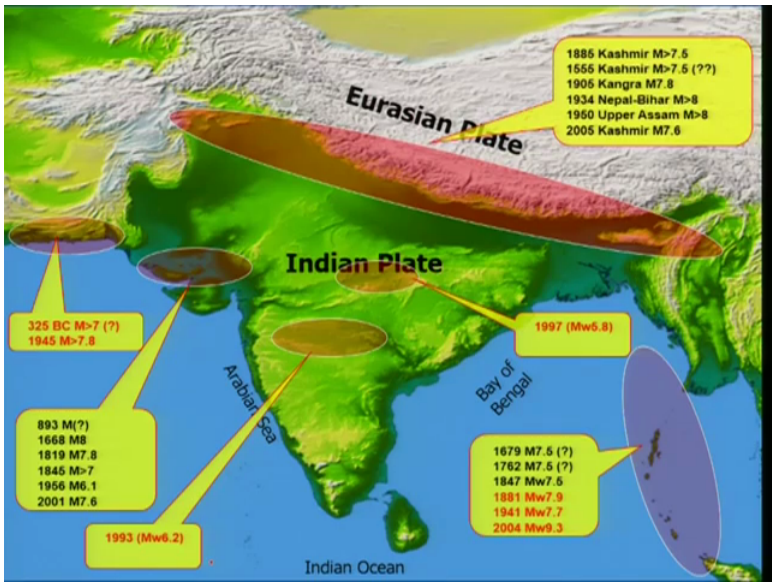

So we have discussed that we have a couple of large magnitude earthquakes in the Indian sub-continent in the past having different plate boundaries like subduction zone in the in the east and then we are having the subduction as well as collision zone in the in the north and then we are having a zone here which has triggered large magnitude earthquakes that is Kachchh and then we are having makrans ones here and this one is your Andaman subduction zone, Sumartra Andaman subduction zone and never the less, we have couple of events which have been triggered in within the plate and that what we termed as the earthquake triggered in stable continent regions ok.

Because we consider than this plate, we found the plate boundary is stable in terms of triggering earthquake but it is not so, we experienced 1993 earthquake of Latur, Khilari earthquake of magnitude of 6.2 and then even when we have another earthquake of which was not so large but it was, it also toddle the people here ok in 1997, this is the earthquake which took place, Jabalpur earthquake ok and then.

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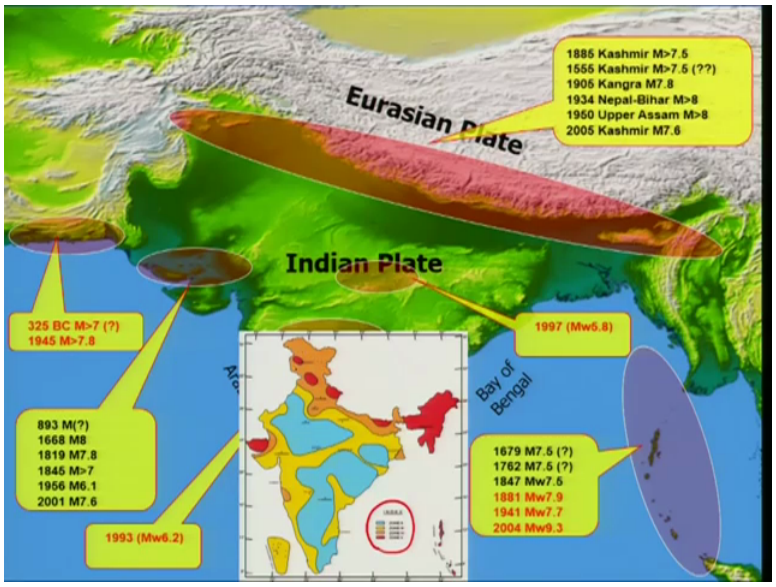

So based on this we have the the zonation map where we have the zones which is from like two to five ok, so we have zone two, this blue one and then we are having zone three and then we are having zone four which is this one here and then this are all in zone five. The whole Andaman is in zone five, Kachchh is in zone five and the some part of the Himalaya are been put in zone five and adjacent parts are in zone four.

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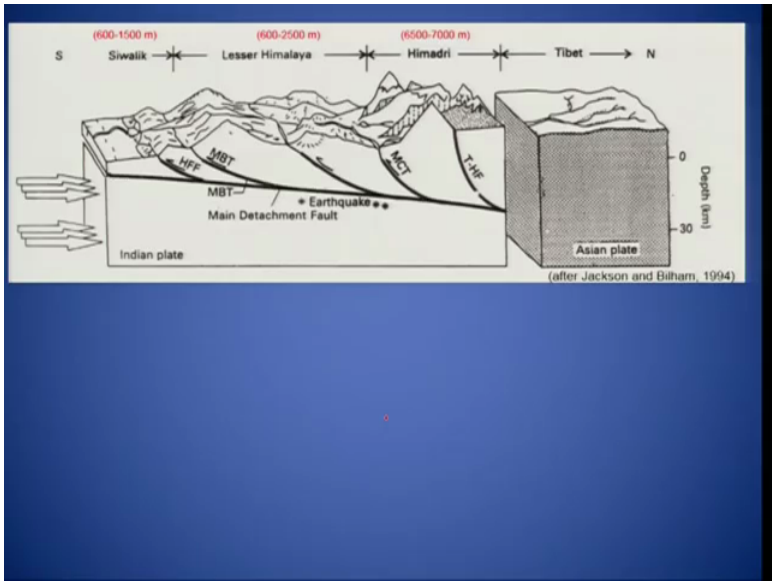

So zone five are the most vulnerable regions in the region ok like Himalayas and all.

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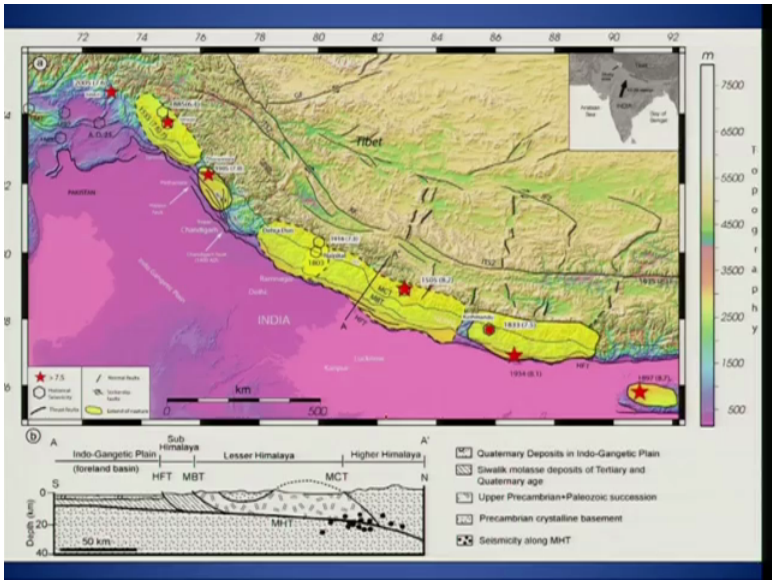

Now coming quickly to this one, I think we have discussed this one in the previous lectures also, coming to this area which is located over here ok in the foothill zone of the Himalaya where we have identified the most recent earthquake was around 1400 AD.

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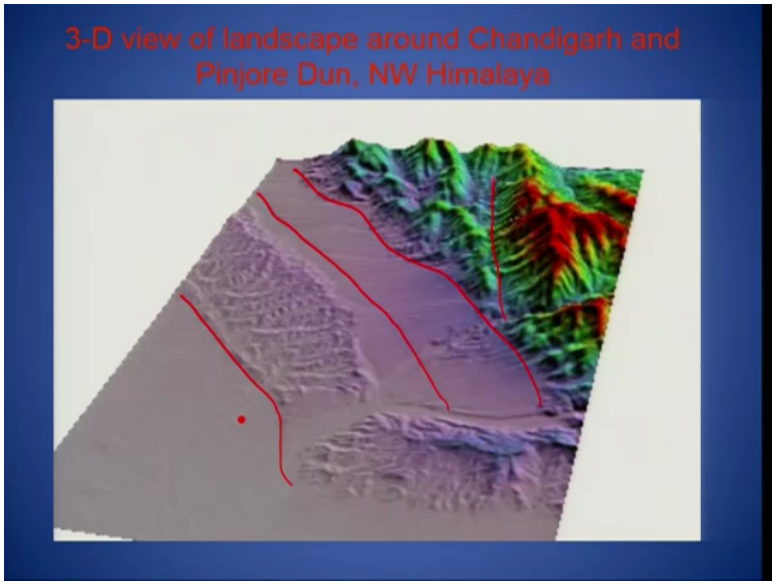

So you have an Himalayan front here so and and the will plant city we talked about is Chandigarh here ok and which is again having a very the active falls very sitting very close to it, so one fault which is Himalayan frontal thrust which goes here another fault crosses this valley, this is what we we have we we say Pinjore garden fault because it is within the Penjore valley and then we are having another fault which runs here and another one over here ok.

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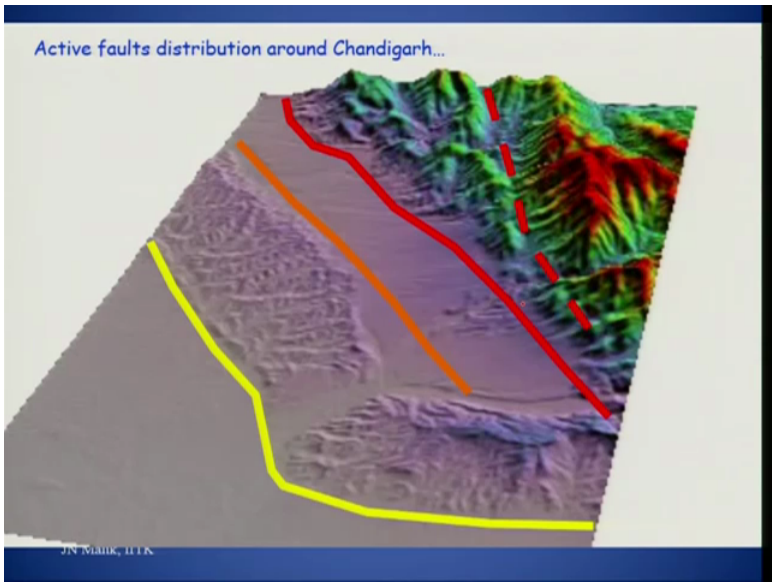

So if you look at that within distance of 25 to 50 kilometres we have having several active faults which are capable of triggering large magnitude earthquakes in near future. So one, two, three and four, so we are having four faults which are sitting close to Chandigarh region ok and not very far from the Indo Gangetic plain.

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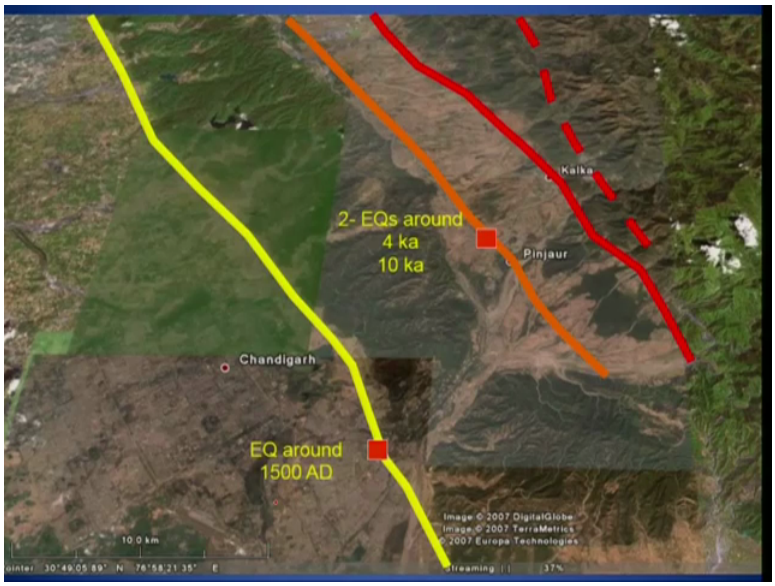

So we have this like the most recent earthquake as I told that it was around 1400 to 1500 AD from this one and the we have the signatures of earthquake which took place 4000 years and 10000 years back. Now based on the definition of active faults, this fault is categorizes under the active fault system because the earthquakes which we have marked here or identified from this region have occurred within 10000 years.

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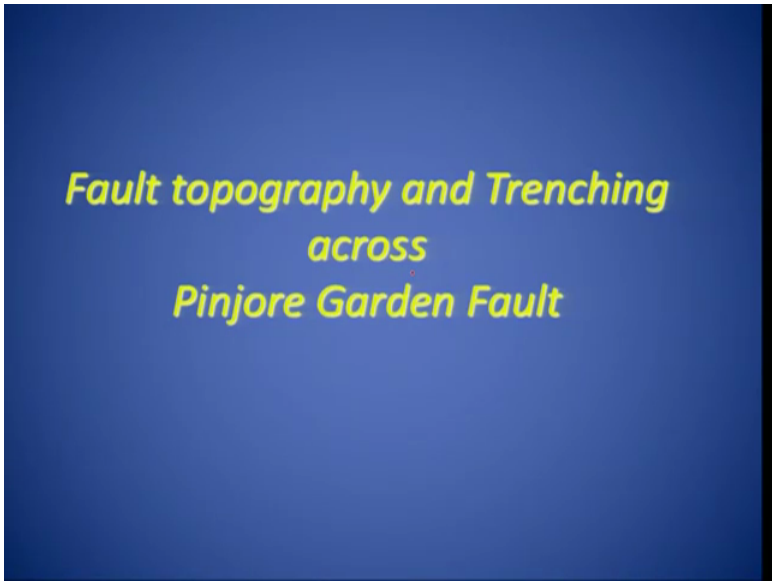

Now let us see the Pinjore garden faults signature in terms of the archaeo seismological part.

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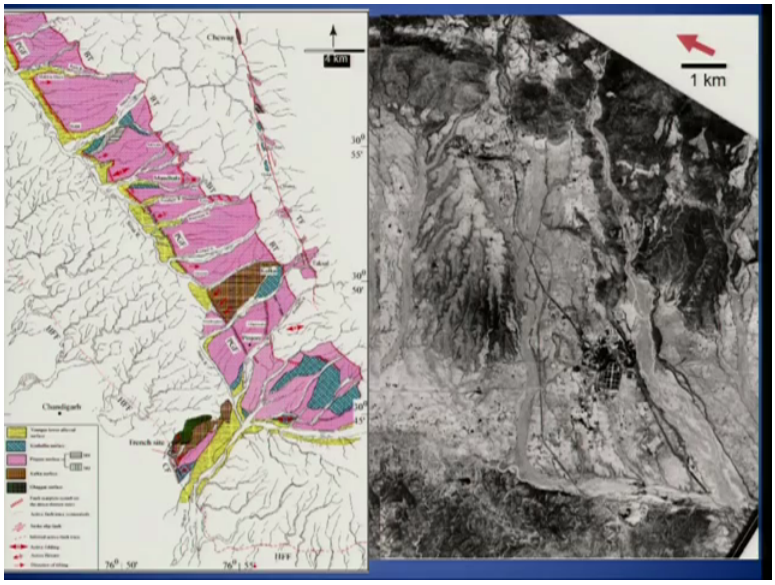

So these are the the fault map which usually we prepare this we call as an geomorphic as well as the the the fault distribution map and all the land forms have been marked here which you can see at displaced here in the caption where we have the older surface than we are having younger surface going up ok. So this fault which is the Himalayan frontal thrust ok which marks the present plate boundary between the Eurasian and the Indo Gangetic plane, Indian plate ok, is marked between, it marks the boundary between the Shivaliks, Shivalik hills or sub Himalayas and the Indo Gangetic plain, it has displaced all the surfaces here. This means that, that this remained active since its development and it has, it kept on displacing all the land forms right from the older to younger ok.

Similarly we have another fault which we have named as Pinjore garden fault another one is Barsar-thrust fault and then we are having a Taksal fault here ok. So this is a satellite, high resolution satellite photograph which is what we we used, so Corona satellite photo, so we have used and we have marked this the fault over here ok and let us see the close up of this area here ok.

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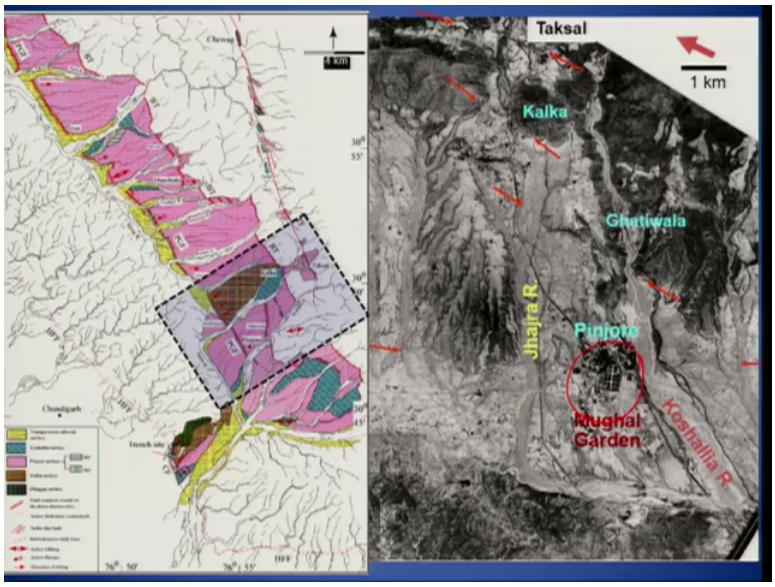

So we have number of the arrows which are been show here are showing the traces of the faults here ok.

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So this is a close (ma) Google earth picture which shows the fault trace, which goes over here ok. Now this is a beautiful structure which is most of the tourist are attracted with this ok, this is Mughal garden which is sitting right on the on the fault ok, so if you look at this one, this trace

here this part of the the garden is sitting right on the fault and what they did was because Mughals (())(24:41), if you look at ok, they were more keen in having the Mughals were more keen in having a path which which of a which can drain the water through and through in the centre of the garden ok and this what we have seen in most of the most of the gardens of ok of the Mughal gardens and the to create a flow ok, they used this scarp.

I will show you close up of this, so this scarp over here is almost 12 metres high ok, this side is the uplift uplifted part, this is the hanging wall and this side is the footwall ok, so they took this advantage of the land level variation ok and then they created the the flow over here, so they they wanted the haven gradient for the for having better flow.

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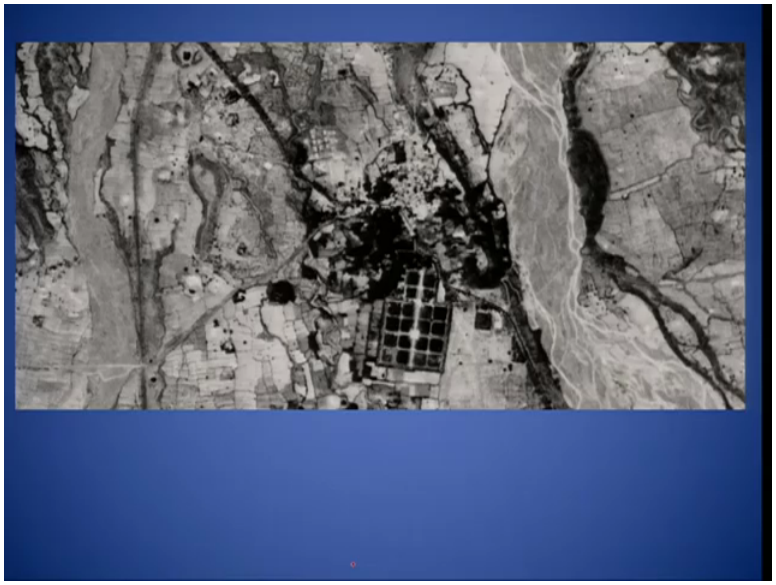

So close up of this again so they, this is the photograph which is been taken in 60's and between 60 and 65, so the fault raises over here ok.

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Again without having understanding this structure was been created or built on exactly on the fault, we can see the slide warping here and this is what is the fault scarp, this structure is sitting right on the fault scarp. So next event this structure will definitely go off ok.

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This photograph again was taken 1979 and this photograph we took in 2001 ok, so this road has been used number of times by local people but they are not aware that there is fault here ok. So this is the the garden which was been built in 17 century ok.

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So this is a fault scarp over here which was been used as an provide a gradient to this channel in the centre ok. So without having the understanding here ok. So we will stop here and we will continue in the next lecture and we will be quick to look at the examples from India ok, thank you so much.