Earthquake Geology: A tool for Seismic Hazard Assessment
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Lecture No 4
Introduction to Earthquake Geology (Part-IV)

Welcome back, so in last lecture we were talking about not how the pattern of the earthquake that is in terms of the recurrence varies over the time because of the change in the rock strength and this is exactly what has happened in 2015 Gorkha Earthquake. So Gorkha Earthquake research carried out by different groups have revealed that not the complete stress was not released that is the incomplete stress release was took place.

And there is an expectation that in a short period that will be in major earthquake along the Himalayan frontal fault.

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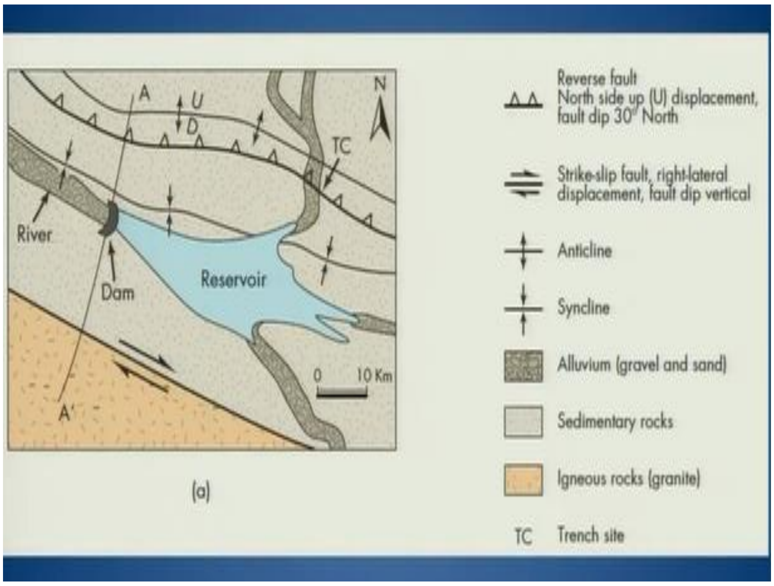

Moving ahead few more things which are important which we will be talking about in the previous two slides not is the site located from the sources important type of faulting is important and the overall tectonic framework is important and mainly this is related to the towards the reduction of the seismic hazard part.

So how far is my site located suppose for example the section which has been the plan view which has been shown here is the Dam and from that Dam how far is the faults, the active faults are located and what are the different type of faults yet. So for example; if you take this map it shows that there are two different types of faults which are located on either side and that is on the north and south of this dam. Okay?

So this one strike-slip fault whereas this is a thrust fault, so this what has been shown here the symbol is of your strike-slip fault and this one is the symbol which has been shown as the reverse fault. Okay?

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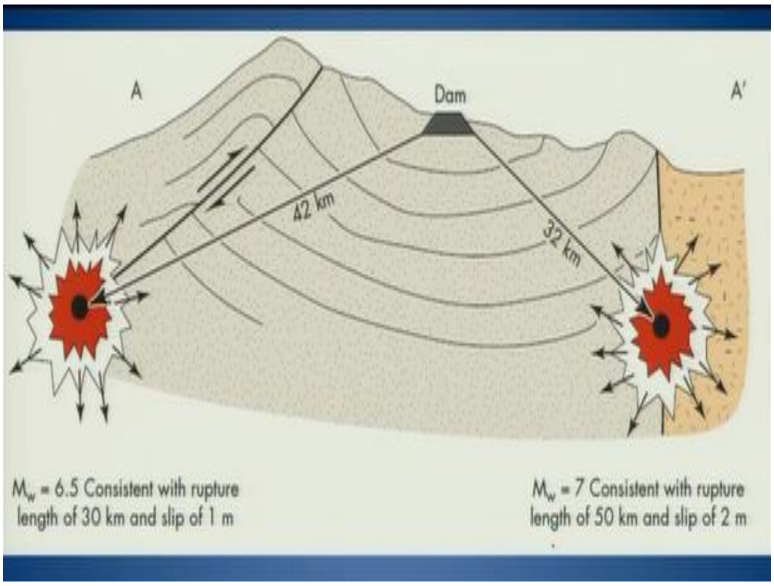

So, two different types of faults exist close to at a particular distance from the dam that is the site of interest. So here it says that around 42 kilometres and here it says that if the source is located here then it is 32 kilometres. Okay? And further another part is that even if you are having like the different mechanism it may trigger a different type of earthquakes and with different magnitude.

So 6.5 here consistent with the rupture length of 30 kilometres and slip of 1 meter whereas here and then in terms of the reverse fault what we have is and this is the section which has been shown A dash, Okay? So this you are having A dash here and this you are having A, so towards the A you are having trust fault and towards the A dash you are having in strike slip fault.

So this is what is mentioned here so you are having it strikes fault here you are having a thrust fault here a thrust fault is exposed at a particular distance and it strikes-slip fault. So a shallower earthquake and the magnitude is larger the length is larger now that so these are all important parameters which are required for the seismic hazard assessment. So what will be the slip at what depth it will take place and what will be the distance and what will be the magnitude.

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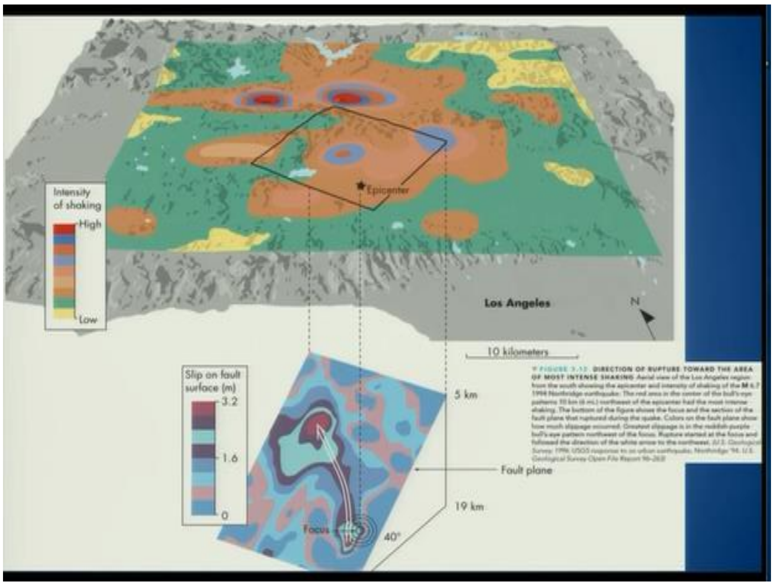

So this whole exercise has been done to understand the ground acceleration, okay? That is the intensity of shaking and so what will be the intensity of shaking at a particular location. So as I have been emphasizing that this will depend on the geology of the area. So the different material within the earth crust will have different ground acceleration, okay? So this is what has been shown here that you are having this red as over here.

So probably this is an aluminum here which is showing the high intensity of shaking and then set its shaking is lesser in the regions where they are having the harder rocks or maybe the material which is not so loose, okay? So then according to this also one can make out that which area will have high or higher ground shaking as compared to the nearby areas even though this whole area falls under the same city.

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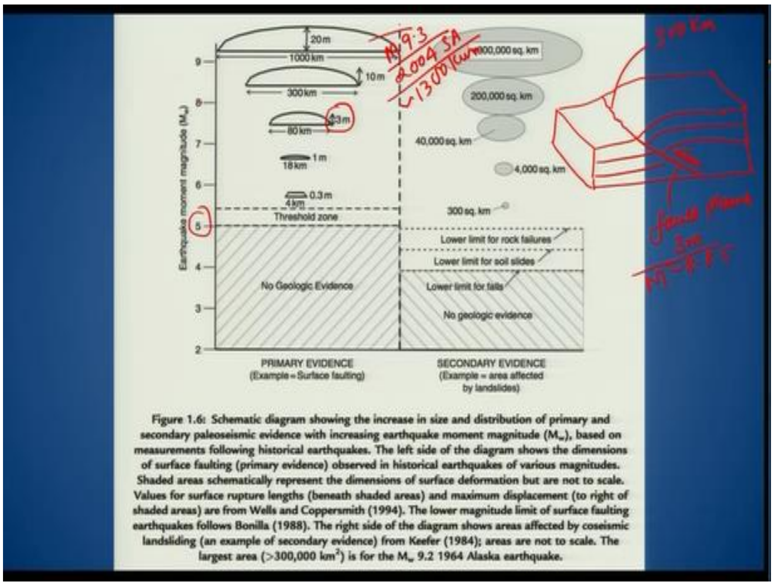

Now the rupture length is also having it is a relationship with respect to the earthquake but as I told that we are going to now look at the primary evidence and the secondary evidence. Okay? So primary evidence for example is your surface faulting on the fault or near the fault and the secondary evidence are the evidences or these natures where the area has been affected either by the landslide or liquefaction. Okay?

So even the far located areas will have secondary effects and the left-hand side of the figure it shows that depending on the magnitude there will be an length of the rupture length will increase okay so for example until 5 magnitude this is what we call the threshold limit. Okay? No geological evidence will be evident because of the moment. Okay? If but mostly no movement will take place if the earthquake of 5 magnitude is occurring in any particular region or on any particular fault, no displacement but as you move up 6, 7, 8 and 9.

Then for example 6 you can expect displacement along the fault up to 3 meters and up to 80 kilometres of rupture and if you move about like 8.5 or so then the rupture can extend up to 300 kilometres and the slip will be of 10 meters. So I will just put in sketch here, so what exactly they are talking about here is suppose you have a landform that is in fall scrap here on the surface there is an fault here.

So this slip along default is what has been talked here about that 3 meter, so slip worked the movement along the fault plane. So this is your fault plane will be around 3 meter if with the magnitude are round 8 to 8.5. So this is the magnitude and the rupture which we talk usually about along this line again. So this will be around the thing or 300 kilometres. So this is what has been attempt has been made based on the historical data as well as Paleo seismic data.

And if you move further up like around 9.5 the rupture may extend up 2000 kilometres and this was the case we had like 9.39 meters earthquake of 2004, Sumatra Andaman. The rupture length was almost like 1300 kilometres. So based on this also one can discuss out that what will be the amount of displacement one will we expect that is if you are having the magnitude and what will be the amount of or the length of the rupture along the fault on surface, so one is on fault and along default.

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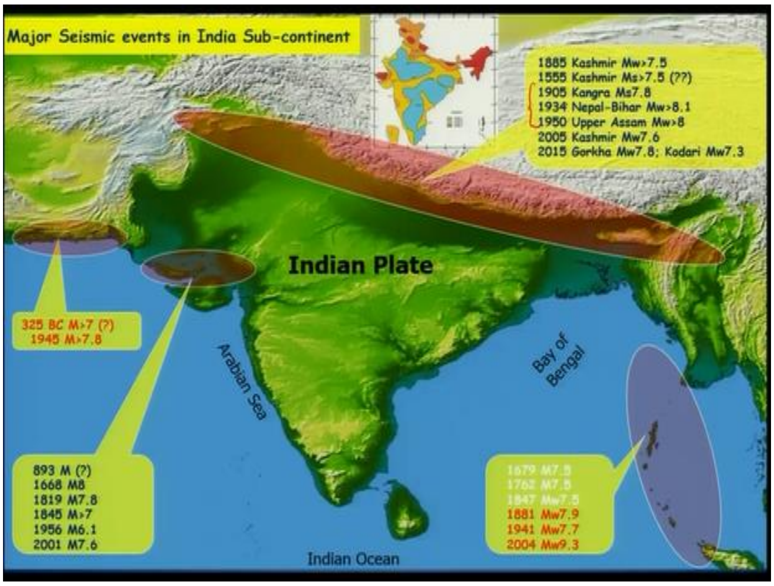

Now taking into consideration the Indian subcontinent, so we very well understand that the physiography of India is bounded from all sides mostly in the northern side and the eastern portion and the western portion here, we have major tectonic boundaries. so major seismic events in India or Indian subcontinent mainly so we have one as the main zone is in the northern side which has hosted several large magnitude earthquakes above 7.5.

This starts from whatever the data we have it of course it goes up to 25 AD, but we have or we do not have the data of in between, because of either the loss of the records because lot of foreign kind people have invaded us burn the records. So we do not have much of the information available likewise in other countries for example Japan, they have very consistent database in terms of such events. Okay?

Catastrophic events either it is tsunami or it is earthquake they have very good data and written historical chronicles. so in this we have the data for example; few examples I have been given here 1885 Kashmir earthquake, magnitude 7.5 in 1555 Kashmir earthquake, magnitude 7. 5 or greater the 1905 Kangra are these are all I was talking in the last lecture that in 20th century. We had almost three major earthquakes with greater magnitude of 8, 7.5. Okay?

And then we have the decent one is Kashmir and then 8, 2015 was Gorkha earthquake. So Gorkha earthquake in 2015 and in two months period we had two earthquakes, so one was the main shock and this is considered as an aftershock or a triggered earthquake because of the stress transfer. So the question comes now whether we have only above in those earthquakes which are been listed here have occurred in Himalayas?

The answer is no there ever many, many more which remain unrecorded or which were recorded but we do not have the data with us. Okay? So the Paleo seismology helps us in reconstructing those events which have occurred during historic time and prehistoric time all we can say up to last 10,000 years. Then apart from the northern belt of Himalaya one of the most seismically active zone, we have another one is Andaman Nicobar region.

Which has again revealed and they were these are all available in the records historical records. that will major events in 1679 magnitude 7.5, 1762 magnitude 7.6, 1847, 1881, 1941 and then the last one which we experienced was 2004 Sumatra Andaman earthquake. so can like this whole belt in the north coming down to the south is the most active zone in terms of the seismicity in the Indian subcontinent.

Apart from this if you move towards the west then we have the Makran subduction zone so this is Andaman - Sumatra Andaman subduction zone. There is an collision or we can say the subduction zone initially subduction took place but now we are having the collision zone between the two continental plates but here we are having oceanic plate subducting below the continental plate.

And this is a Makran subduction zone again telling us this story that it had triggered earthquakes and associated tsunamis in 325 BC and 1945. of course the tsunamis which were being generated along this zone must have affected this whole region not only this if you are having a mega tsunami similar to triggered by the and the magnitude similar to this one that is 2004.

Then we that those tsunamis must have affected the many countries joining the Indian Ocean and even away from that. Whereas this area would have affected the whole region and the west coast of India and then we have an under zone which is the most active a relative to what we see in Himalaya and Andaman is the Kutch region.

Which has hosted earthquakes during historical time one is 893, 1668, 1891, 1845, 1956 and the most recent one is your 2001 that in magnitude was 7.8 and nobody expected that there will be an earthquake in 2001 and so because we never did not complete or we never did studies in detail in that region. Very few groups from India we are working in this region but now what we see is that we may have much larger magnitude earthquake than what we have experienced here. Okay? Maybe around 8:00

So this is what, where one can talk or can give the input after having a proper highly seismic studies. Similarly, this goes for the Himalayan region where and we have whatever the information we are having is not complete and we are not even sure that which fault was responsible for triggering at the particular earthquake. Okay? for example we based on the Paleo seismic studies we have been able to tap or narrow down the 1905 earthquake.

It did not occur on the Himalayan frontal fault but it occur way behind 100 kilometres away behind on a new fault on Kangra Vally fault and then similarly these two events the groups our research groups have identified that they took place on the Himalayan frontal thrust. But we will have more discussion on this part when we are moving ahead in this course.

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Now coming down to the Paleoseismology part I what exactly we will do will slowly start learning and in this about the Paleoseismology and what techniques and what are the steps which we are going to adopt to get the best results how? Okay?

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TABLE 1.3
Terminology related to recovery of fault activity.

Geologic Age			Years Before Present	Fault Activity
Era	Period	Epoch		
Cenozoic	Quaternary	Historic (Calif.)	200	Active
		Holocene	10,000	
		Pleistocene	1,650,000	Potentially active
	Tertiary	Pre-Pleistocene	65,000,000	Inactive
Pre-Cenozoic time			4,500,000,000	
Age of the earth				

(After California State Mining and Geology Board Classification, 1973)

Now before we get into all this we it is important for us to understand few terminologies related to recovery or fault activity. So we have in broader sense we have the geological time scale which has been divided in era period in a Epoch. so we for example; we take this is the Cenozoic era is the most strongest era in the geological time scale and we are interested in Cenozoic part. Okay?

And even with the Cenozoic we are more interested in the Holocene epoch, so one is the one you have the era and then you have period and then he have epoch here and then this era is the Cenozoic and Cenozoic era comprises 2, one is the quaternary and tertiary and one tertiary because we the research tells us about that this was the period when the collision started that is collision between the Indian plate and the Euro-asian Plate.

So for on the regional scale or we cannot reason but on the global scale if you want to understand the tectonic framework then this period is important for us to be considered because this was the time or the initiation of the deformation that started along the Himalayan region or deformation of the Himalayan started.

Coming to the quaternary period of course a lot of climatic fluctuation will been observed during the Pleistocene epoch and then coming down to the Holocene epoch which is ranging up to 10,000 years and that period and during that period any activity has taken place along the fault then we termed that as an active fault and any activity which were recorded during the Pleistocene period or Pleistocene epoch are considered to be the potential active faults. Okay?

So this is what we have, we need to understand and probably the faults which were formed during tertiary or beyond that, that is Pre- Cenozoic time or further that is in terms of the age if you take that is before 1,650,000 years before then we consider those faults as an inactive fortunately. So this portion of the part is extremely important before we get into the real Paleoseismic domain.

So I will stop here and we will continue in the next picture talking more on paleo seismology, thank you so much.