**Natural Hazards**
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**Lecture - 23**
**Monitoring Seismic Activity Part I**

Welcome back.

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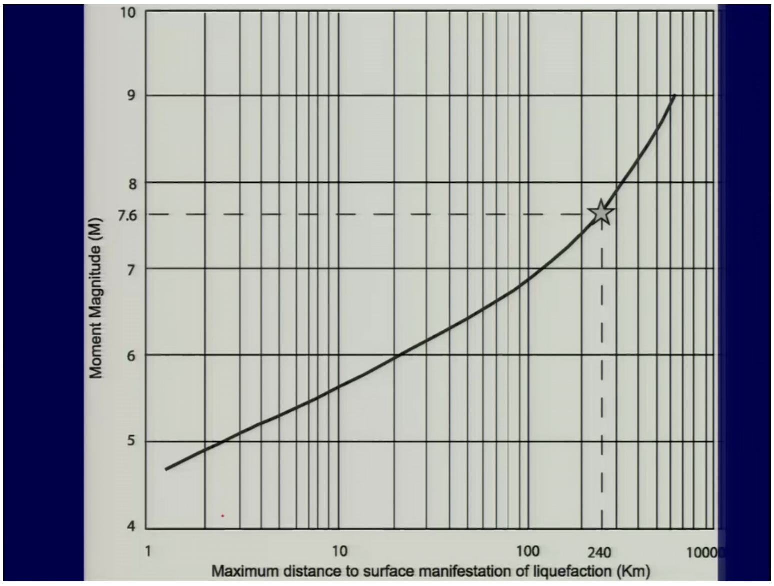


So, last lecture we discussed about that what is the relationship between the magnitude and the farthest liquefaction manifestation from the epicenter. So, and we discuss in that about the farthest recorded liquefaction feature during Muzaffarabad earthquake of magnitude or Kashmir earthquake of magnitude 7.6 which occurred in 2015. Now apart from the liquefaction features what one can do to understand the ground effect is.

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And the probability of having the event in near future and this is purely where we are talking about the geological signatures and geophysical signatures what we can do. So, monitoring seismic activity can also help us an understanding or knowing that this area we will experience an earthquake in near future.

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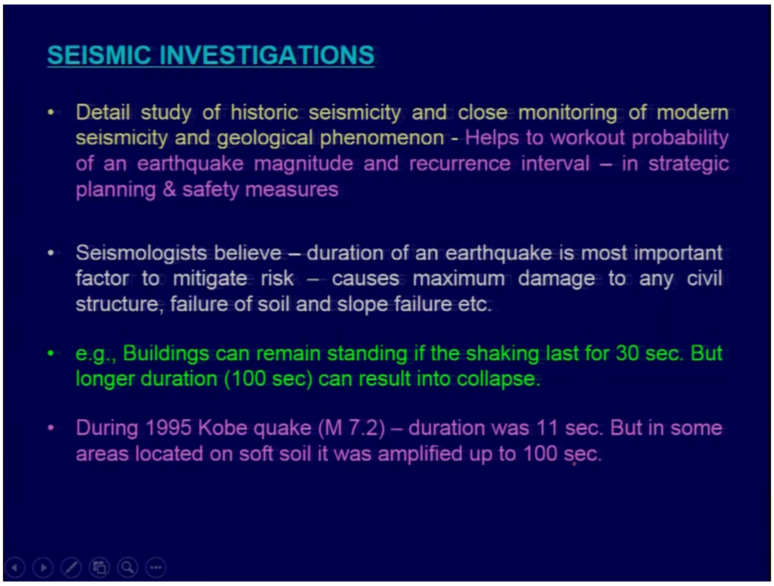


So, there are lot of studies which have been carried out talking about the seismic investigations. So, initially what we do is we try to look at the historical seismicity, because this helps us in understanding that what happened in the past or the recent past and how the area in particular the epicentral area or if you are having the area which is located as we were looking in the previous section of liquefaction that it can affect if magnitude about 7 or 7.5. Then it can affect the area due to liquefaction up to 240 and 250 kilometers or more.

So, historical seismicity is important, but yes the question comes that whether they were the earthquakes were recorded as we are recording using the modern instruments, but at that time no such instruments were available. So, what usually we rely on is the data available in historical chronicles.

So, if we browse through those informations which are available in historical chronicles at least we know that what happened in the past. So, the detailed study of historical seismicity and close monitoring of modern seismicity as well as geological phenomena.

Now this helps us to work out probability of earthquake magnitude and recurrence interval in strategic planning and taking safety measures. Now the probability of course, they were other 2 ways also people have been doing either deterministic hazard analysis or probability hazard analysis, which has been done which will talk about that at that what will be the scenario at a particular site of interest in terms of the peak ground acceleration.

If you know the source and what will be the return time of the earthquake in that area, but here what we basically look for is, mostly the geological signatures and the seismologist they look for the past and present ongoing seismicity. So, seismologists believe that the duration of an earthquake is most important factor to mitigate risk which causes maximum damage to the civil structures failure of soil and slow failure.

So, these are all be related to your geological phenomena of course, if you are having the duration as we have discussed in one of the example from Mexico that the duration of even the area which was sitting far away from the epicentral zone experience more duration of crown shaking, this was because of the amplification of the and the seismic waves in un consulated loose sediments.

And the secondary effects mostly what we see is yes, soil losing it is shear strength as we were talking about the liquefaction and of course, the slow failures. And if the civil structures the buildings if they are not constructed considering the proper building codes of course, the poor construction if it is there then you will experience maximum damage.

Now example building can remain standing if the shaking last for about 30 seconds, but longer durations say around 100 seconds can result in into collapse. Even now people have started taking into consideration the buildings by using base isolations and all that which can protect your building and absorb all ground shaking.

Now this is an example what during 1995 Kobe earthquake magnitude was 7.2 duration was 11 second. But in same areas located on soft soil it was amplified up to 100 seconds and this areas where they were having soft soil mostly where the reclaimed areas because Japan does not have much of the land which is available. So, what usually you have and they have done is that, they have reclaimed most of the regions around the coastal zones and that has resulted or cause the amplification. So, this amplification of the soft soil that is something into the seismic shaking which lasted for almost 100 seconds.

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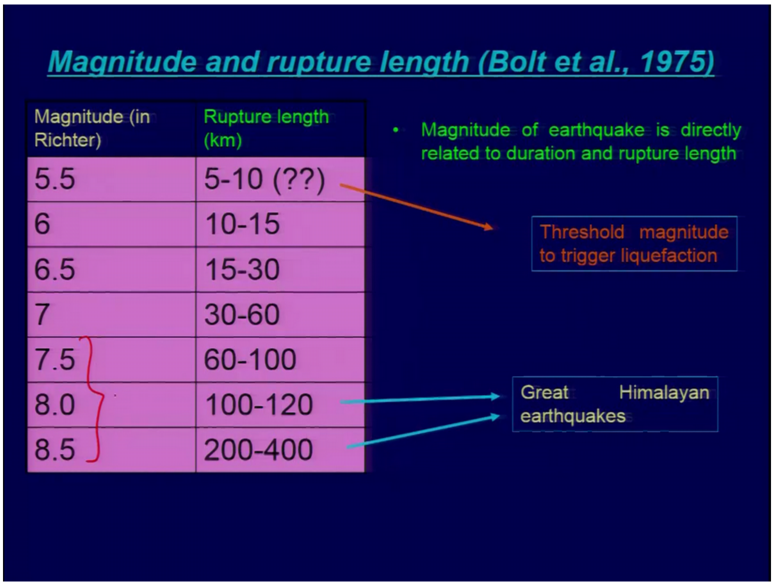


A magnitude and rupture length can also be taken into consideration and this information can be used from the recent earthquakes as well as from the paleoseismic investigation. Paleoseismic investigations we try to look for the paleoruptures and that can help us in understanding that how large was the rupture in terms of the length. So, if you compare the magnitude then magnitude inductor on Richter scale if you take an rupture length has been given in this table. So, 5.5 can rupture provided it is having an ideal condition to 5 to 10 kilometers and this is not what we say the threshold limit to trigger liquefaction.

So, around 5.5 magnitude earthquake if you experienced and if the conditions are ideal saying that you are having near surface saturated sediments cohesive less then you can trigger the liquefaction. Then for 6 magnitude the rupture length could be around 10 to 15 kilometers 6. 5 15 to 30 and so on.

So, now, if we are looking for the rupture length for this magnitudes 7.5, 8 and 8.5 now why I am pointing out this here is because we have experienced this magnitude earthquakes in Himalaya and as well as in Kutch. Of course, in Himalaya mostly we see above 7.5 and which can go up to say 8-8.5 magnitude.

Now, if this magnitudes this magnitude earthquake occurs in Himalaya then it can go up to the rupture length of 60 to 100, 100 to 120 and up to 400 or more kilometers the area will be ruptured. So, this is what we call is an great Himalayan earthquakes namely above 8 or close to 8. So, this is the part which is worry some for all of us.

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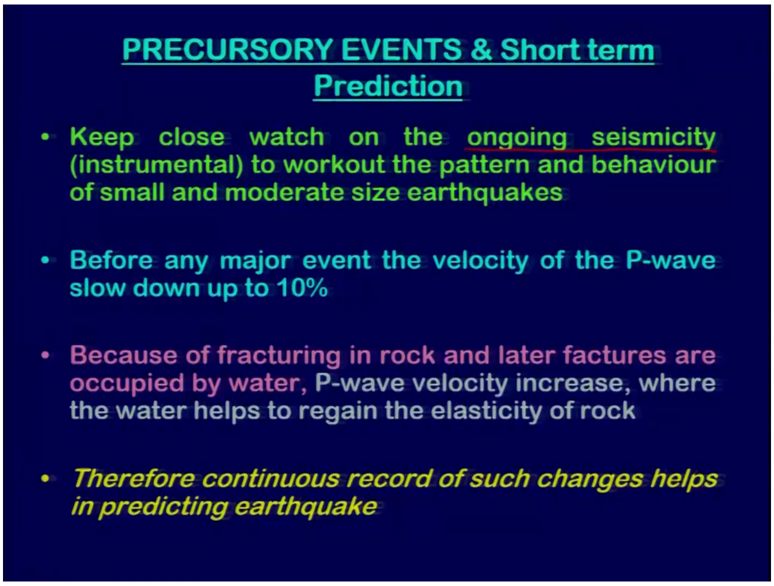


Now, precursor events and short term predictions have been done in the past and few successes we have been achieved. However, it is bit difficult to clearly pinpoint when and at which are the earthquake will occur it is still we have not achieved of we have not reached up to that mark to predict the earthquake very precisely.

But keeping close watch on the ongoing seismicity based on the instrumental data to work of the pattern and behavior of small and moderate sized earthquake is extremely helpful. Now before any major event the velocity of P - waves slows down up to 10 percent, now this will happen only if you are keeping a very close watch on the ongoing seismicity because that this will be very important.

Now this P- waves velocity will slow down this is because of fracturing in rock and later the fractures are occupied by water. So, P- wave velocity increases where the water helps to regain the elasticity of the rock. Now, if you remember the seismic wave propagation and then it is velocities getting affected because of the medium through which it passes this exactly is what will be experienced ok.

So, if you fracture the rock then there are open space which will be available and that will result into the change in the medium which will result into the slowing down of the of the P- wave. As soon as those fractures or the cracks are filled up by the available fluid then it will the P- wave will regain, it is the velocity and that is because of the change in medium again, therefore continuous record of such changes helps in predicting the earthquake. So, this phenomena will happen because what we say is that the crustal deformation will is ongoing interest deformation so, the rocks within the crust will fracture.

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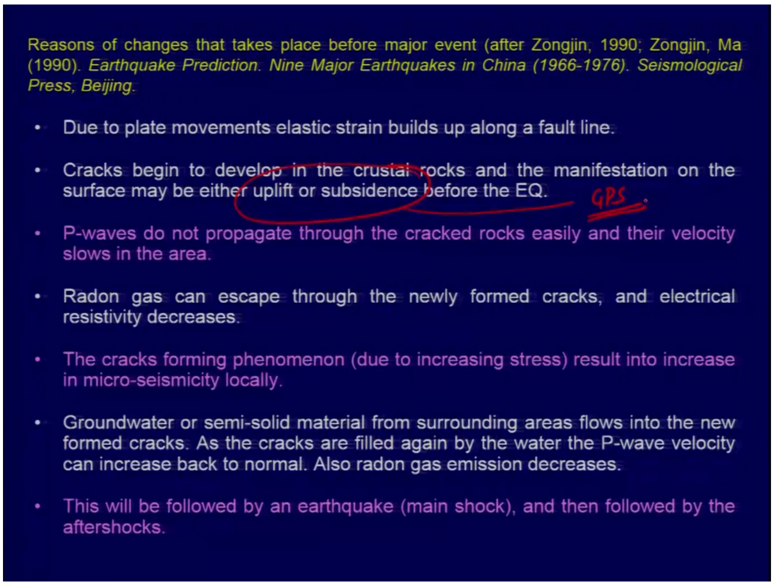

The reason of changes that takes place before major events and this has been given and published in seismological letters what it says is, due to the plate movement elastic strain builds along the fault. Cracks being begin to develop in the crustal rocks and the manifestation on the surface may be either the uplift or subsidence before the earthquake.

So, land level change will occur in this such cases, now this land level change either the uplift of subsidence can also be complimented by using a dense network of GPS provided you know where is the fault line. So, this identification of fault line and knowing that the region prone to earthquakes is very much important.

So, first if you know this then you can deploy more of seismogram and more of the GPS, close network of GPS can help in identifying the change of the P- wave velocity as well as you can make out the change of land level that is either uplift or subsidence this can be well recorded before a major event.

So, P- wave do not propagates through the crack through the cracked rock easily and their velocity slows down in the area. Radon gas can escape through the newly formed cracks and the electrical resistivity also decreases. So, these are very crucial or important parameters which one can look for identifying whether you are going to expect big earthquake in near future or not.

Now, the cracks forming phenomena due to increasing stress because this is because of the ongoing deformation the results into increase in micro seismicity. So, ongoing deformation cracks are forming and this cracking phenomena will trigger some earthquakes, but they will be micro earthquakes. So, the activity of the micro earthquakes will increase slow downing of your P- wave velocity will also take place and you may also see the uplift or the area is subsiding.

The groundwater or semi solid material from surrounding areas this is the phenomena after cracking around the areas flows into the newly formed cracks. As the cracks are filled again by the water the P- wave velocity can increase back to normal. So, this change and also the radon gas emission decreases because the radon gas will only escape at the time when the new cracks are formed. So, when the new cracks are formed radon gas is emitted, but as soon as the cracks are filled by water or the semi solid material which is available in the surrounding areas within the crust the P- wave velocity increases back because it regains the fractured area and at that time it will not allow the radon gas to escape.

So, this the emission of the radon gas decreases and this will be followed by an main shock. So, main shock if the is recorded then the micro seismicity whatever is been was been observed or noticed will be here for 4 shocks. So, these are the 4 shocks and after even after the main shock we will have the aftershocks. So, you please remember few things here one is the P- wave velocity reduction in the velocity of the P- wave and then and because of the fracturing of the of the rocks or the crust and because of the fracturing the medium changes and it will not allow the P- wave to pass through as it used to propagate through the solid medium.

And as soon as this gap the cracks are filled up by the water or the semi solid material available in the surrounding it will regain the velocity. At the same time you will have more of micro seismicity as well as because of the newly formed cracks the radon gas will be emitted, but as soon as the red the cracks are filled up there the emission of the radon gas will decrease and will be followed by an major earthquake. Apart from that one can also observe the area getting uplifted or subsided and this as I was talking about this can be done or observed using thermal GPS stations.

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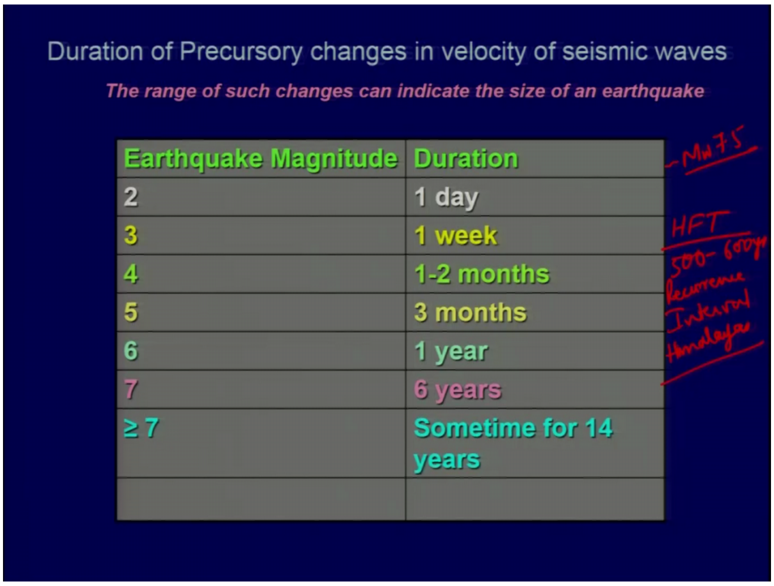


| Earthquake Magnitude | Duration |
|---|---|
| 2 | 1 day |
| 3 | 1 week |
| 4 | 1-2 months |
| 5 | 3 months |
| 6 | 1 year |
| 7 | 6 years |
| ≥ 7 | Sometime for 14 years |
| | |

Now, duration of precursory changes in velocity of seismic waves, the range of such changes can indicate the size of an earthquake. Now range in the sense the duration we are talking about so for example, the duration could be 1 day, 1 week depending on the magnitude what it will be, but if you are having the magnitude around 7 then this phenomena can last for almost 6 years and if you are having the magnitude greater than 7 then sometime the duration of such phenomena can last for more than 14 years or 15 years.

So, of course, the time is large here this time span, but yes the strain which is require of 2 triggers such large magnitude earthquake is also very large like for an example in Himalaya along Himalayan frontal thrust what are the polytechnic study suggests that the recurrences most around 500 to 600 years ok. So, this is the recurrence interval along HFT in Himalayas. So, once the earthquake has been triggered of say magnitude 7.5 or so, then the next earthquake on the same fault may reoccur after 500 to 600 years. So, the time which we are talking here is too short again, but this is an short term predictions which we one can do for predicting and occurrence of an earthquake.

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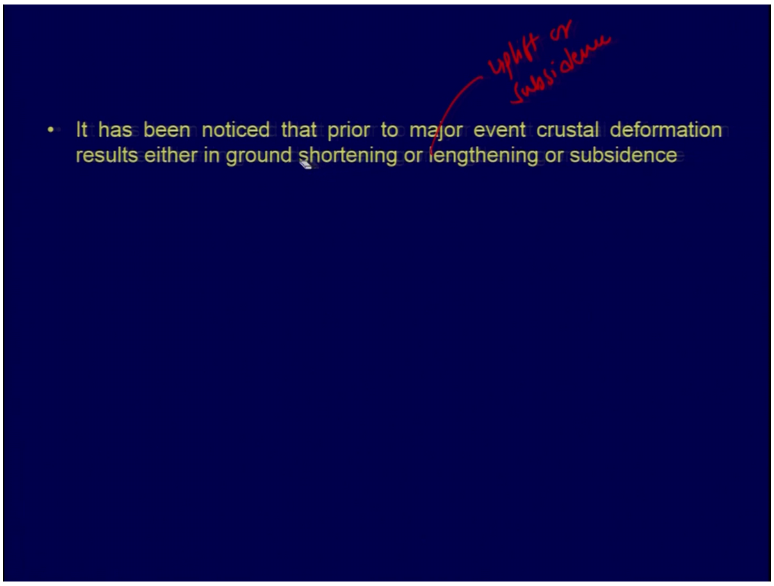


So, it has been noticed that prior to major event crustal deformation results either in ground shortening or lengthening. So, this is what we were talking about the uplift or subsidence.

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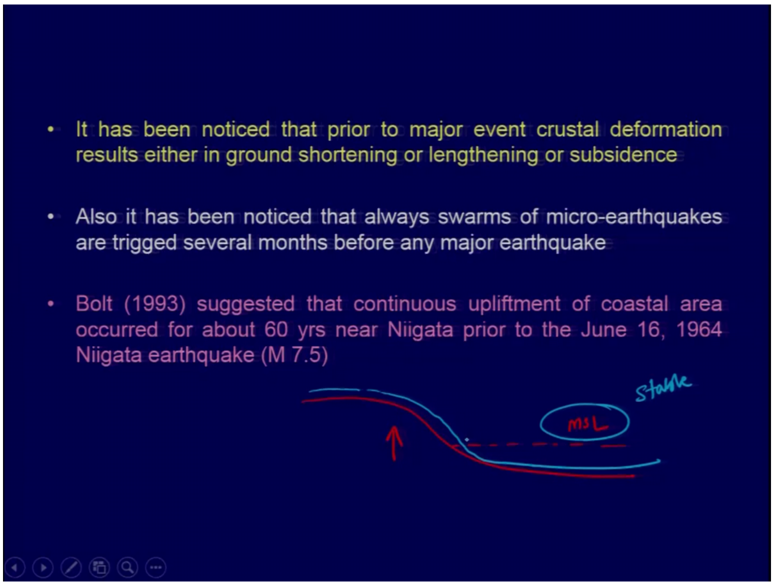


Also it has been noticed that always swam of micro earthquakes are triggered several months before any major event. Bolt in 1993 suggested that continuous upliftment this is very important ok, continuous upliftment of coastal area took place for about 60 years this took place for 60 years near Niigata prior to Niigata earthquake which was in 1964 the magnitude was 7.5. So, the point which we were talking about 14 years, but the deformation was going on since last 60 years in Niigata and the magnitude was 7.5.

So, this continuous uplift we have been noticed in the coastal areas and yes of course, you can notice because there is no fluctuation for example, I am just putting in sketch here suppose you are having in water level over here this is your MSL. Now, if you are putting the area getting up here then what you are going to observe is your uplifting the area. So, the new profile which is coming here will be something like this ok.

So, what has happened is that, your area has gone up the, but the mean sea level has remain as it is, because we know that since last we come like 1000 years or more and maybe 3000 years we do not have any major fluctuation of the sea level, sea level is stable. So, the change in the water level here is not because of the change in the mean sea level, but it is because of the uplift.

So, one can notice because the landforms will emerge along the coastline. So, this observation in such region coastal areas will be extremely beneficial, but the process is so slow that most of the time people ignore it, but the GPS if you have put cannot ignore this change.

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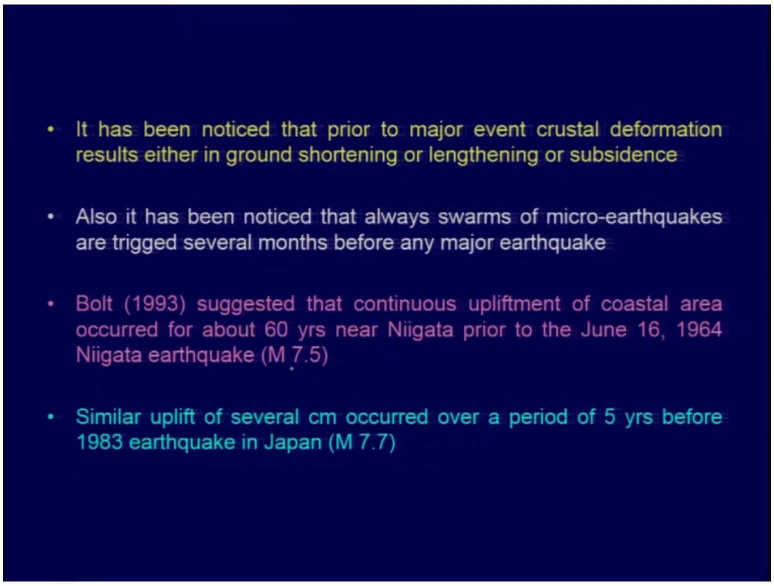


Similar uplift of several centimeters occurred be over a period of 5 years before 1983 earthquake in Japan, magnitude was 7.7. Now since this region is prone to earthquakes and the deformation is pretty fast as compared to the other regions, around the world people have been very much particular in observing such phenomena. So, I will stop here and then we will continue in the next lecture.

Thank you so, much.