Earthquake Geology:A Tool For Seismic Hazard Assessment
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Lecture-35
Compressional Tectonic Environments And Related Landforms (Part I)

Welcome back. So now let us look at the new topic on compressional tectonic environment. And in previous lecture we discussed mainly on the what features we will see in extensional tectonic environment mainly related to the normal faulting and then we saw 2 examples of the paleoseismic studies also in normal folding environment. Now coming to the new topic that is here compressional tectonic environment.

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Now in compressional tectonic environment, we really will have the sigma 1 most normal to the fault plane and all that okay.

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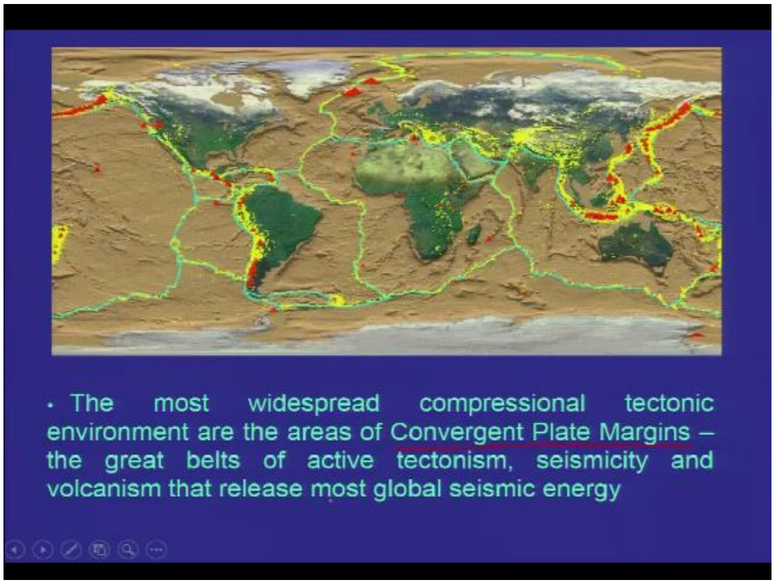

And the best example of so if we look at the locations of the compressional tectonic environments, then mostly we will find along the subduction zone and collision zone. So we have one here. This is the one of the best example of the compressional tectonic environment as well as we will also see the compressional tectonic environment along with that strike slip also in the subduction zone. So the one of the best example you can see is along this one, and then strikes that we will talk when we are talking about the transform faults ah between the Pacific and the North American plate.

Now, the most widespread compressional tectonic environment are the area of convergent plate boundaries. The great belt of activity tectonism, seismicity and volcanism that releases most global seismic energy. So if we take this then we have the maximum amount of energy seismic energy which is released will be along the subduction zones. Now this convergent plate boundaries and even this was earlier this is we say convergent and collision boundary. So, these are the locations where you will see the most the most of the global energy has been placed in this region.

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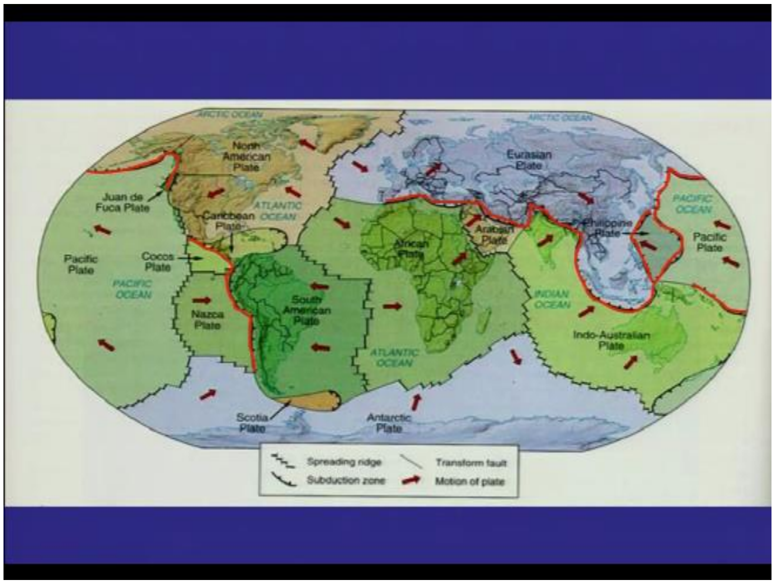

Now, as we were talking about the subduction plate boundaries, then we have the subduction plate boundaries over here which have been marked here or the collision plate boundary and over here, then it means somewhere in this portion also you can see here okay. So now let us look at the signatures what you will be able to see in terms of the surface manifestation because of the ongoing deformation in compressional tectonic environment.

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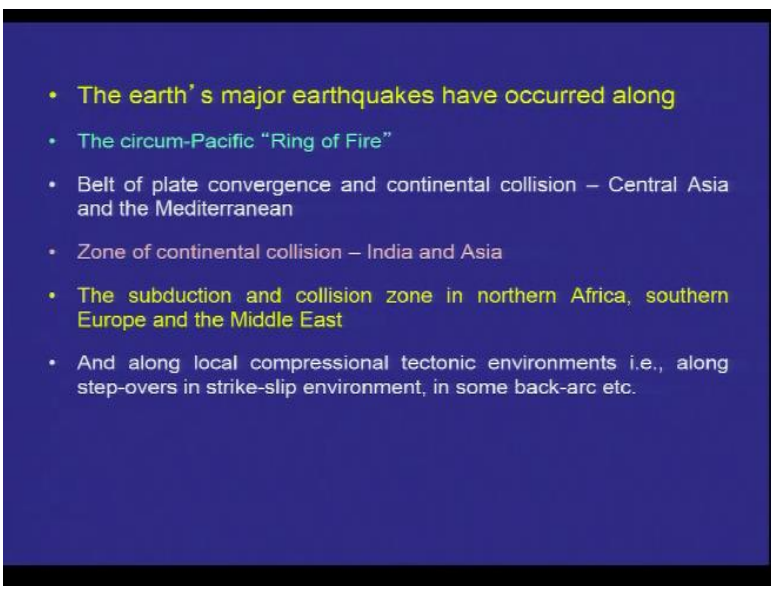

So, the earth's major earthquakes have occurred along the circum Pacific that is ring of fire, belt of plate convergence and collision, continental collision and the example is your central Asia and Mediterranean region, zone of continental collision, which we see in India between India and

Asia. So, these are the major location of where the main locations where the major earthquakes have occurred.

And then you are talking about the subduction zone and collision zone in North Africa, Southern Europe and Middle East and along local compressional tectonic environments that is along step-overs in strike-slip environment in some back arc regions etc. So, these are the major locations where you will have large magnitude or the earthquakes which have occurred and these are the location for that okay.

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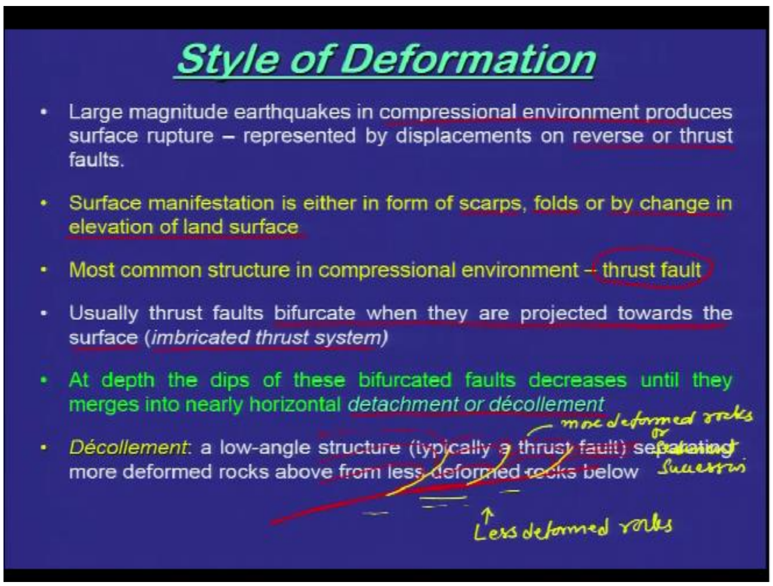

So style of deformation if we take them large magnitude earthquakes in compressional tectonic environment produces surface rupture represented by displacement on reverse or thrust faults okay. So, this part you will have to remember that in compressional tectonic environment mostly we are going to see the displacement along the reverse and thrust faults. Surface manifestation is either in the form of scarps, folds or by change in elevation of land surface.

That means we are talking about that either we will have a very definite surface scarp which had been developed or we will see just the folding. So, you have the displacement which is or you see, I showed often land level change and so just the change in the elevation and the formation of the scarps here of course after the erosion you will have, we will see something like that. So, these are the main forms which will come across in compressional tectonic environment.

And then their representation on the surface. So, this you now please remember that you have in compressional tectonic environment the manifestation will be on the surface along the reverse fault in form of scarps, fold, change in the elevation, most common structure in compressional environment will be your thrust faults, you will see most common and that what we have experienced and learn from the compressional tectonic environment in Himalayan region okay.

Usually thrust falls bifurcates when they are projected towards the surface and that what we call is the imbricated thrust system. So, you will have for example, if you are having low angle thrust faults and you will have the bifurcation of the faults which are taking place and you will see the formation along with this okay. See we will be able to see the bifurcation of the faults along the major one.

So, these are termed as imbricated faults and even we also say branching out faults. So usually this will be seen on the thrust faults or you can say low angle reverse faults. Then what do you see is at the depth, the depth of this bifurcated faults decreases until they merge into nearly horizontal plane, that is we term this as a detachment or decollement. So, if you have like the faults which are imbricated faults, they are coming in they are going to merge along the almost horizontal plane and that is here detachment.

So, this imbrications will get merge along the very low angle or almost horizontal and this plane that is termed as detachment and this is very common, what we see in Himalaya. So, the folding will be able to see it will be along this one and then you have the. So this is termed as yours detachment or we term this as an decollement. So at depth the bifurcated, what we see here, this one, okay, I may draw with the different color here.

So, see this part here, another one is this one and third one is this one. So they merge with the main horizontal plane that is termed as detachment. So, that decollement or the detachment usually what we term is a low angle structure typically a thrust fault separating more deformed rocks above from less deformed rocks. So, what it shows us that you will have the more deformed rocks will be.

So, basically it marks the contact between the mold formed rocks we will have this will be your having more deformed rocks or sediments form. So, you will have less deformed rocks over here. So, this is termed as here decollement.

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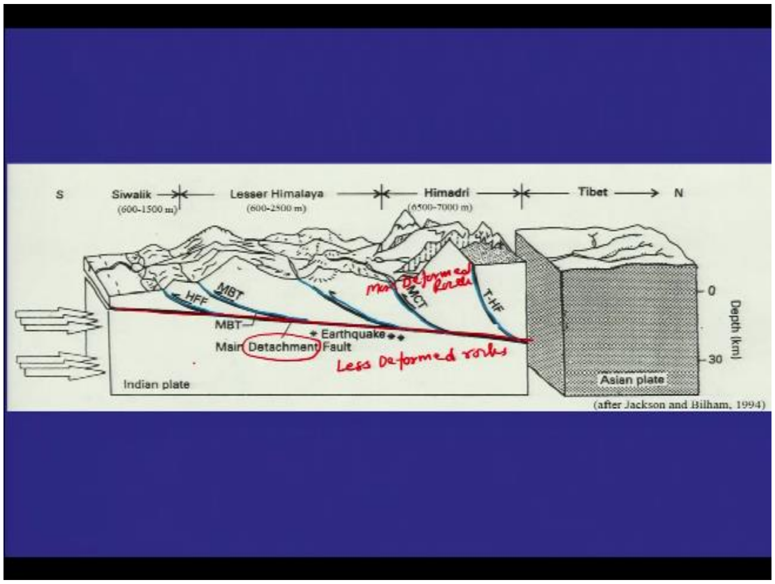

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Now if we look at the example from the Himalayan region, so what we have is that we have a very similar structure, we have the low angle contact between the less deformed rocks and then we have more deformed rocks and then we have along with that we have gained the similar features, I will take another color, this is not coming out well. So, maybe the blue one. So, we have this one here, we have another, then we have this one here.

So, what we have is not we along with the as an imbricated fault system, which we see along this one, this is your detachment and this is termed as main detachment fault or you can also say main Himalayan fault, okay. This also been termed as in literature you will find main Himalayan thrust, main Himalayan you can see. So, let us move ahead and we will discuss when we are talking about the in particularly for Himalayan.

So, on surface this what I have shown earlier also that on surface manifestation will be very similar to what you will see in the normal faulting typography okay. So, the typography here again you will have something like this okay the profile very much similar to or discard we were looking in the region of like a riparian fault or along the one of the faults from Bulgaria. So, this is an aerial photograph, which we took after 2001. And this is the one of the active fold in Kutch region.

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So, the ground photograph of this part here, this is a scarp here. So, you have the profile very much similar to what you will be looking at the normal faulting environment, but in this case, this will be your up throne block and this is your down throne block. So, this will be your foot wall and this will be your hanging wall. So that changes okay. So, in case of the normal faulting, even with this similar topographic profile, what do you see the fault runs somewhere here and this becomes your foot wall and this is your hanging wall.

But in this case the fault goes somewhere down here like this. So, as we did in the case of the normal faulting, so, we understand the fault runs along the base of the scarp here. And that was the part which we considered and we opened up the trench here. I will show in the next coming slides, what we will learn and partly I have already discussed why we click on the spot, but we will cover more from other study areas.

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So, after the identification of the scarp, we opened up the trench here.

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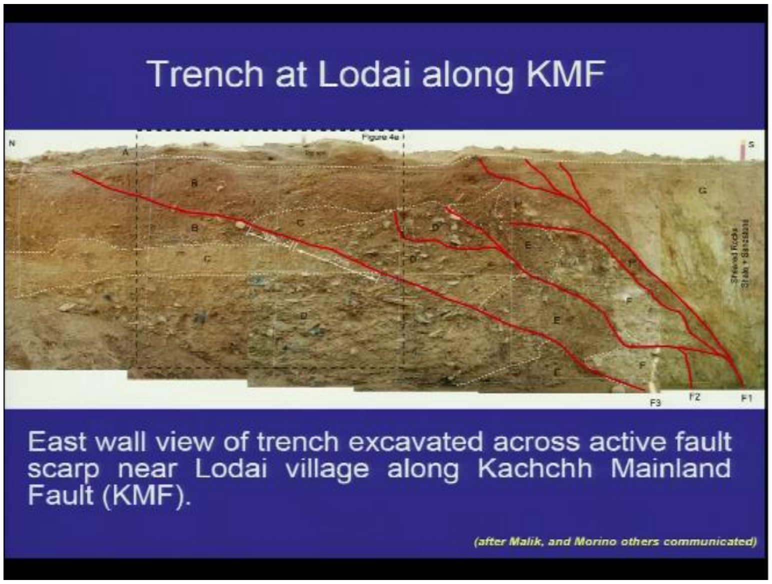

And this is the trench from Lodai. So this part I have already discussed. So I will just move ahead.

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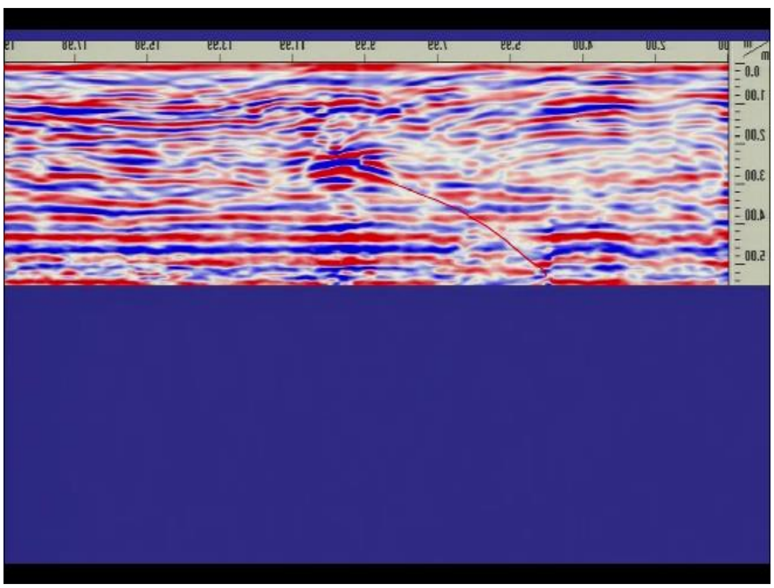

But I would like to show that the GPR profile which we collected the geophysical technique, but we will, I will talk and I will take in separate lecture on this showing that how we collect, we will talk about the principles of the GPR and what all parameters we considered to get the subsurface profile. Now, this profile is been flipped to actually show you the exact structure, what we see here.

So, we have the, the deformation which has been seen also in the GPR profile, which was collected before the opening of the trench. Now, here the trench is hardly 2 meters of depth here, but the profile goes if you just look at the inverted here numbers you go up to 5 meters or more than that and then faults trans somewhere over here like this and you can clearly see the deformation on the hanging wall side.

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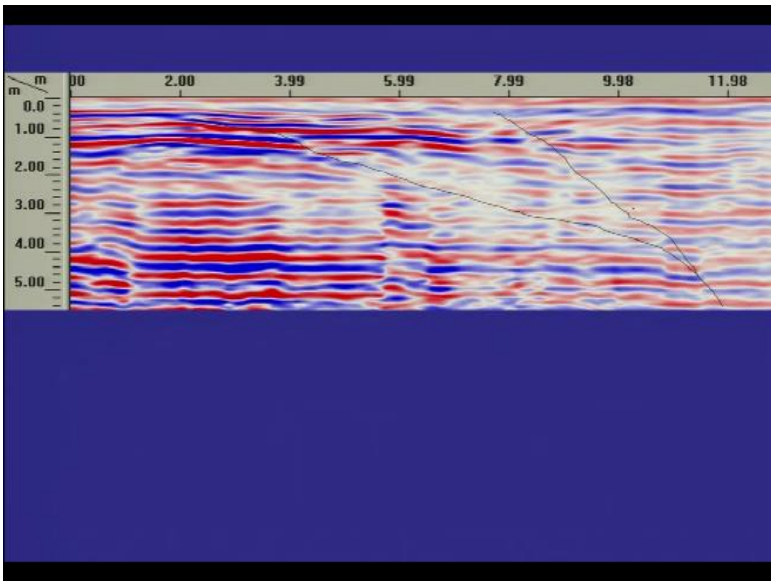

So, this was the interpretation of another profile which we took very much similar to what we found in the trench.

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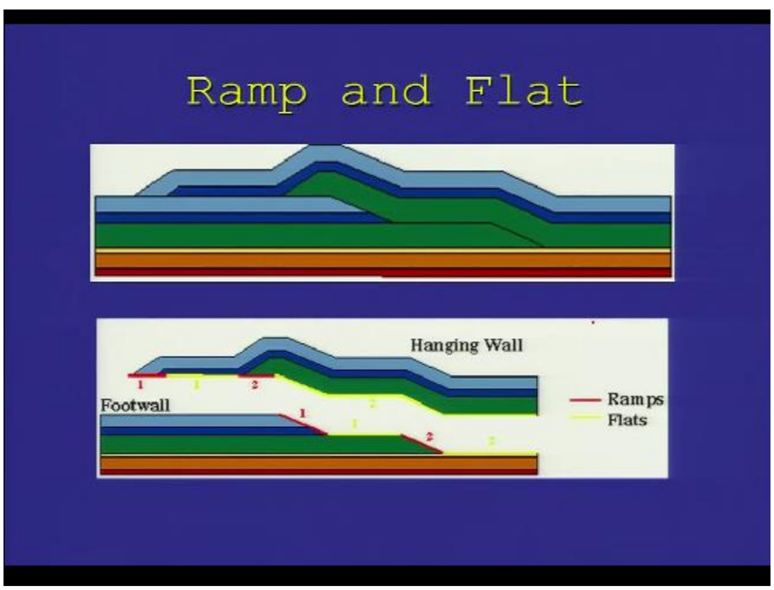

Now, usually what we see is the change in the depth of the main fault or the another fault these mind fault systems we will have typical of what we see fault a flat and ramps structure. So, wherever you have the flat which has been shown by yellow and then the red one has been marked by your ramp area. So, wherever you will see the ramp you will be able to see the folding here.

So, we have and then some look in the frontal part mostly what we see is the it will be almost horizontal, but it will result into the deformation which in terms of the fault, but this portion where we see the folding is the portion we marked as in ramp area, but mostly the ramp has been marked, what we see is the change in the depth. $so slightly higher up than those other ramp and you have the flat.

So, you will see also the flat deformation on this is not much deformation will be seen, but the long the ramp you will see maximum folding as it has been shown here okay. So, you have the flat here, then getting the ramp and then this part is also a portion of time because holding. So, ramp and flat structure will be one of the most common along in the compressional tectonic environment. **(Video Starts: 18:27)**

So, this is what has been shown here. So, you have the displacement which is taking place from this place, and then you have the ramp here. So, this is a flat, then you are having a ramp and then another ramp is developing over here, which results into the folding. So, this is typical of what we call fault bend faulting or you can say folding. So, associated folding you will be able to see because of the fault bend.

So the depth mainly what we see is the change in depth. Now, this one of course a cartoon which has been drawn taking into consideration way geometrically flat an inclined surface along the fault plane, whether we see similar features and field or not. Let us see a couple of examples from the recent survey which we did not very recent, but at least almost like 1 decade back okay. So let us see that what we are able to say thrust. **(Video Ends: 19:48)**

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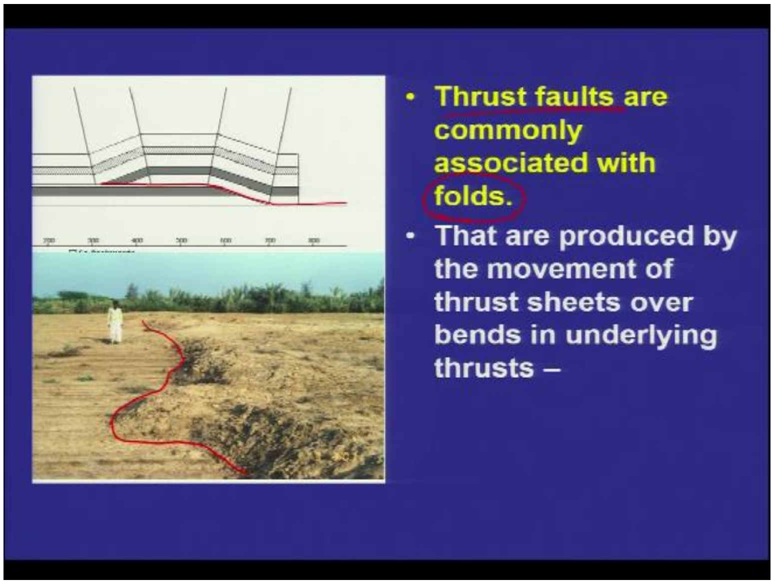

Faults are commonly associated with folds okay. So you will find the associated deformation will be a folding. So, you have the folding which has been taking place along the trust faults okay. So that are produced by the movement of thrush sheets over bends in underlying thrust okay. So, you have the overall you will put as in thrust only. So, this whole portion you will put as in thrust, but what we see is the force are developed along the bends okay.

So, this is one example from the of course, this was the secondary deformation but yes if you want to understand that what type of deformation you will expect along very low angle fault and compressional environment then this was the one of the best okay. Now, one thing which I would like to say that this example seen thing will happen during the major faulting and this deformation is resulted because of the 2001 Bhuj earthquake.

But was not the seismic one, but you can use this to understand the deformation on a larger scale okay. So, what we see here is the strike of the fault is not seen, changes over the along if you move along this one this strike okay, it is not just the straight line here like that, okay.

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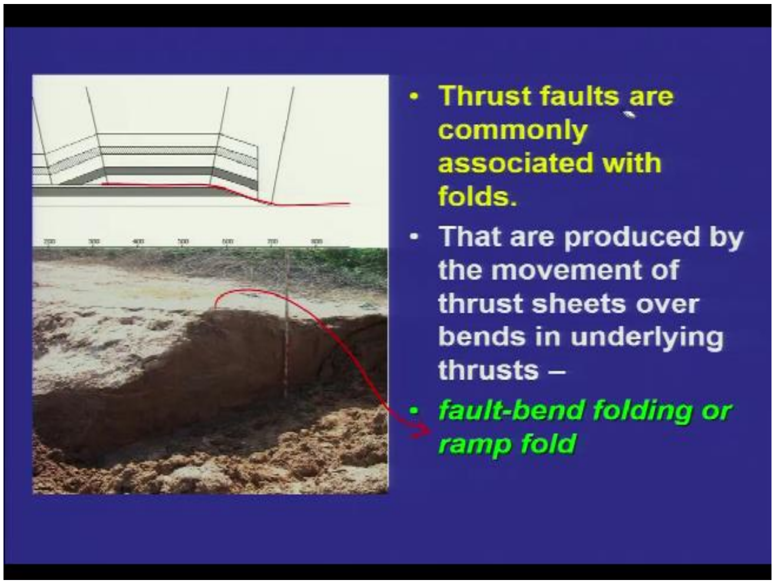

So when we open up the trench in across that scarp and what we found is what has been shown here. So, if you carefully look at the white line here, the white line which I am pointing out, now, this is very typical of what we were talking about. So, you have the ramp here, then you have an flat here and then again getting into the ramp here. So, if I just trace this one goes something like this okay and it goes up.

So this whitish portion is the contact of the between the overriding material and the underlying surface. So this marks this surface okay before the event I will just remove so that you can clearly see that, so you have the typical flat okay ramp flat and ramp structure okay. So, what we see is when you are having the ramp here, so you have the definitely it must be subsurface it must be something like that okay.

So we are coming out to be and flat and then again getting something like that okay. So this is termed as fault bent folding, okay. So this for what we see the fold which has been developed termed as fault bend folding or a ramp fault or ramp fold. So, this is typically deformation you will come across and compressional tectonic environment mainly along the thrust walls.

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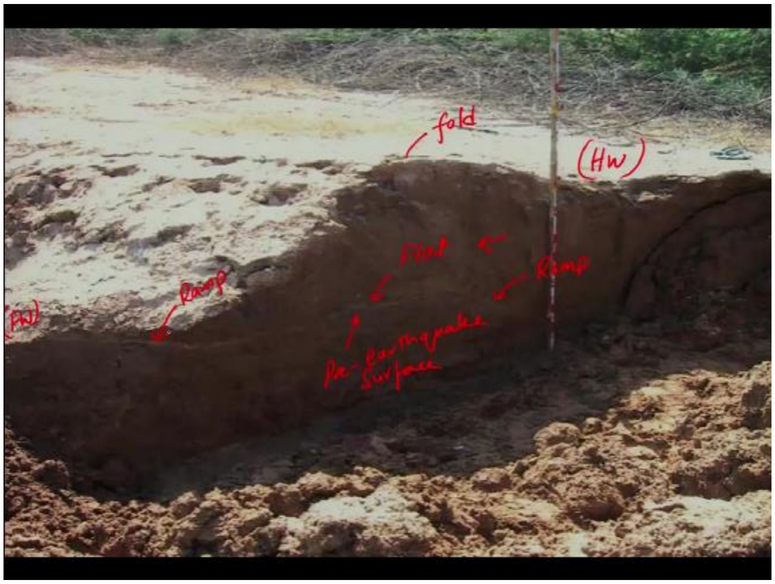

It is a close up of that, if you can now clearly is visible, this portion is your ramp, this is your flat, this is again ramp and this portion is your what we see fold and this plane which has been seen here, this one is the pre-earthquake surface. So this block has moved in this direction along this plane. So this will become your hanging wall and this will be your of course this side it will come will be foot wall okay. So let us see more examples from compressional tectonic environment.

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So there is another view of the same area.

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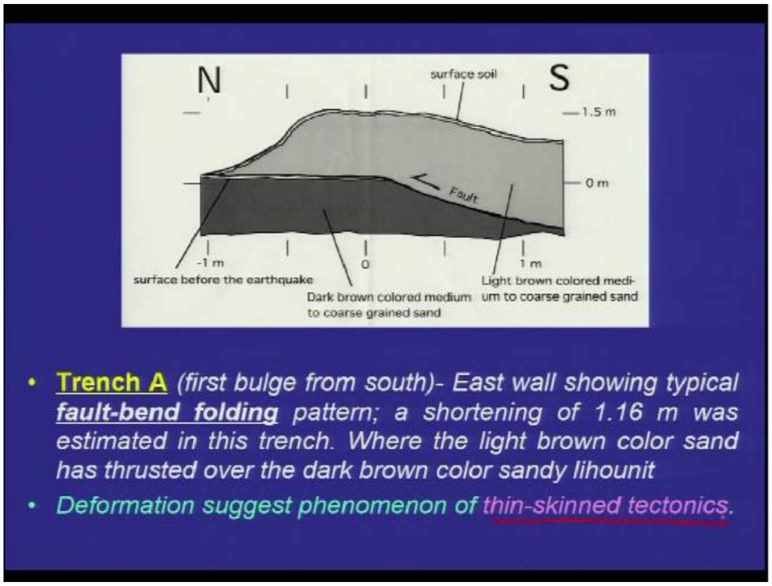

And this is a sketch here okay. So what we see is you have the is another ocean which we see is clear cut the ramp and then you have the flat. So what you see is a folding on the surface. So trench A first bulge from south east wall showing typical fault bend holding pattern, a shortening of 1.16 meter was estimated in this trench. So, we measured the displacement was or the shortening was around 1.16 meter.

Deformation suggests thin skinned tectonics. So, we have this deformation taking place in the upper part of the thrust. So, we can consider this as thin skinned tectonics.

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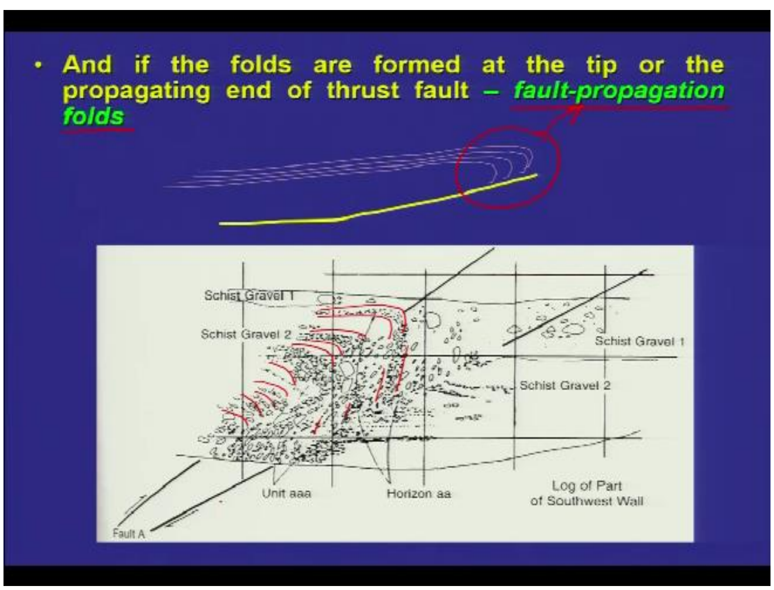

And if the folds are formed at the tip or the propagating end of the thrust fault. So, when we are talking about that if you are having the flattened end and if the folds are forming at the tip, okay like this and then those are termed as fault propagation folds okay. So, one is what we were looking at we have the fault bent folding and another one is at the tip of this one. So, they are termed as fault bend folding.

So, for example, if you have the low angle thrust fault and the fold is forming at the tip of this okay. So, we call this as fault propagation folding, an example from one of the trench log. So, you have the fault which is running here and the sediments and then you have the typical fabric of deformed fabric as you can mark here and then further it is going to impact. So you have typical of fault bend folding or fault propagation folding and the tip of that. So, I will stop here will continue in the next lecture.