Earthquake Geology: A tool for Seismic Hazard Assessment
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Lecture – 42
Strike Slip Tectonic Environments and Related Landforms (Part- I)

Welcome back. So in previous lectures we looked at mostly the deformation and compressional tectonic environment and we saw a couple of surface expressions of faulting along the low angle reverse fault or we can say thrust faults. Now one of the major topics which is left out is your strike-slip faulting environment.

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So the major sites if we take in terms of the plate boundary where we see the strike-slip motion or transform plate boundaries. So they are located for example here in the Mediterranean part region you have close to Algeria and then we have the transform plate boundary over here and that is between the along the Himalayas and this part is your German fault system we also have this strike the ridges taking place here.

These are the major one and the one of the most prominent we see between the Pacific plate and North American plate.

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That is your San Andreas Fault system. So mostly what we see the displacement is accommodated along the typical strikes default if it is not oblique then we will just see that this slip has taken place horizontally this place in the landforms is where the sediment situation here. So geomorphic markers associated with strike-slip environment will see couple of features that is fault topography now we see on the surface and then we will talk about later again in a similar way the trenching part.

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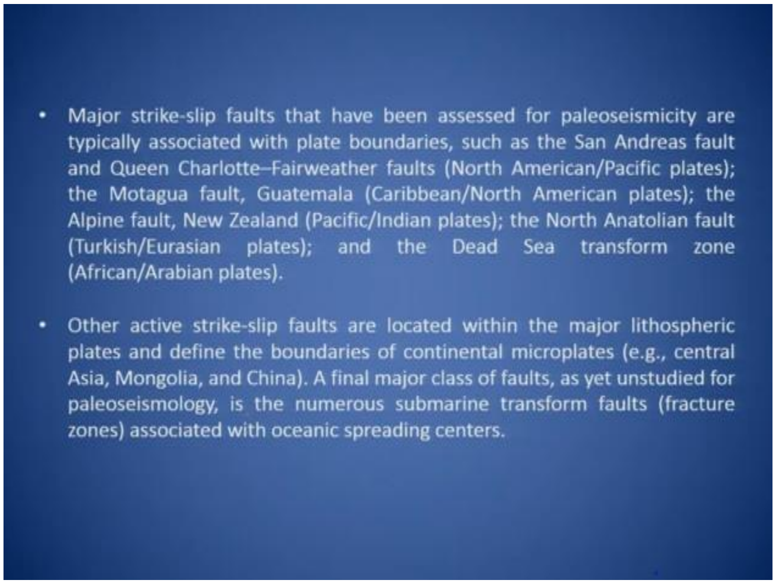

So major strikes the faults that have been assessed for paleoseismicity are typically associated with plate boundaries and some of the most important that what I was mentioning is between your North American and the Pacific plate. You have the San Andreas fault system and few more in the Alpine fault system you have in and in New Zealand that is between the Pacific and the Indian plates.

Northern Anatolian fault between the Turkish and Eurasian Plate and the Dead Sea for faults between Africa, African and the Arabian plate and other active strikes the faults are located within major lithospheric plates and define the boundary of continental microplates like central Asia, Mongolia and China. The final major class of false as yet unstudied for Paleoseismology is the numerous submarines transform faults and that what we see along the spreading centers.

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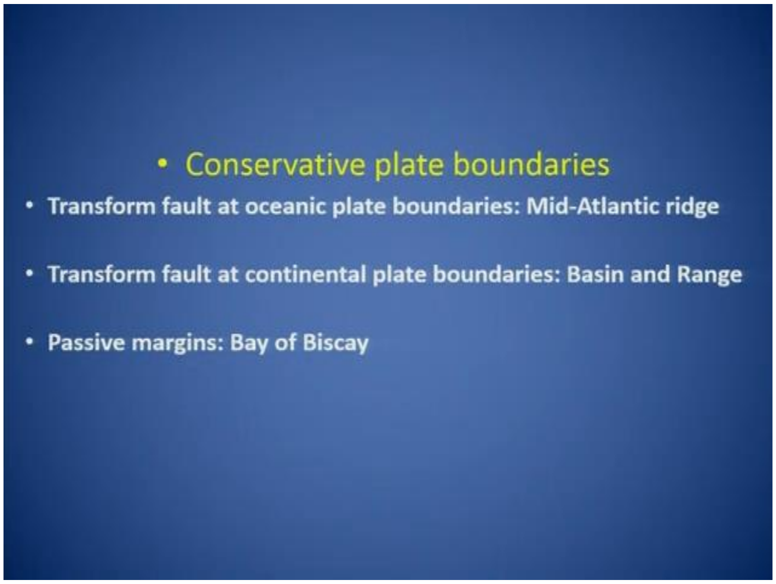

So, conservative plate boundaries transform fault at oceanic plate boundaries we have the major one mid-oceanic or Mid-Atlantic ridge transform fault at continental plate boundaries. We will see mostly in the basin and the ranges and along the passive margins like for example Bay of Biscay.

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Destructive plate boundaries with oblique convergence. So those were the conservative plate boundaries. And now we are having the strike-slip environment along the destructive plate boundaries with oblique convergence. We see a transpression at continental plates boundaries like New Zealand, California, Sumatra-Andaman so we see this as then oblique convergence along this one.

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And then we have the constructive plate boundaries within oblique extension. So we have the back-arc basins where also we will see they strike slip motion and one is the Kuril archipelago and then in the intra-plate strike slip, like intra-plate regions we will see mainly in Asia. That is your the northern side of the Indian plate or we can say in the in the Eurasian Plate we have the tectonic escape. And trans-tension in the Mid-Atlantic ridge area.

So these are the few examples where you will be coming across mainly the strike-slip motion;

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Of major and minor faults okay. So, transform zones mostly you will see the strikes the motion or the deformation in the mid ocean or spreading centers or the Mid-Atlantic ridge which is marked here.

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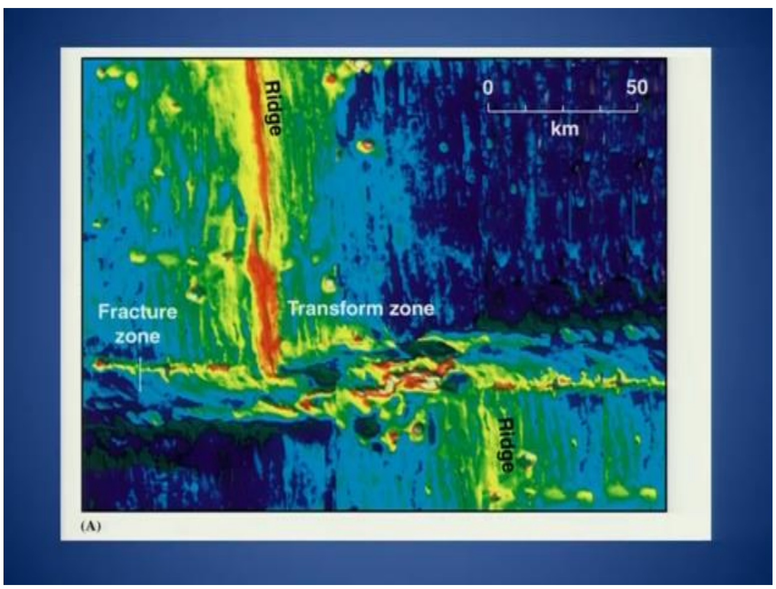

And we see also like this is what has been shown same you have the strike-slip motion along the fracture zone here.

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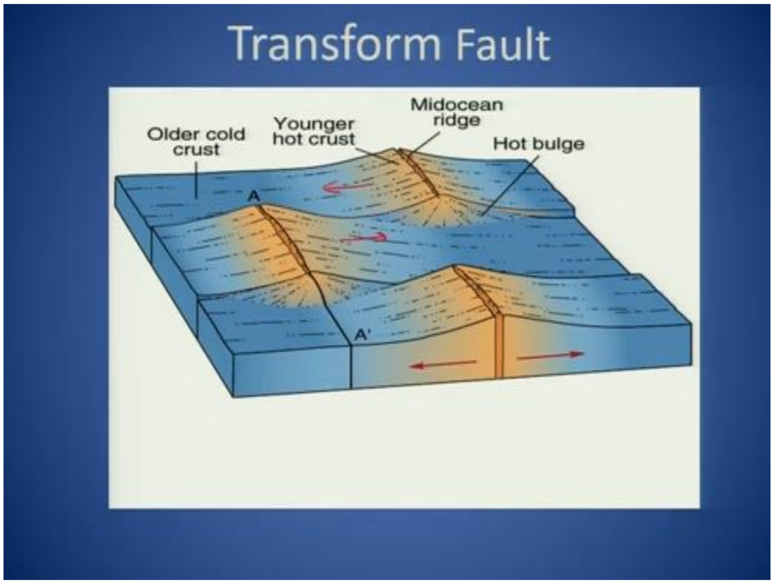

So you have the Mid-oceanic ridge over here so this both the plates are moving like in this direction here and then this is moving away so the motion is taking place along this one.

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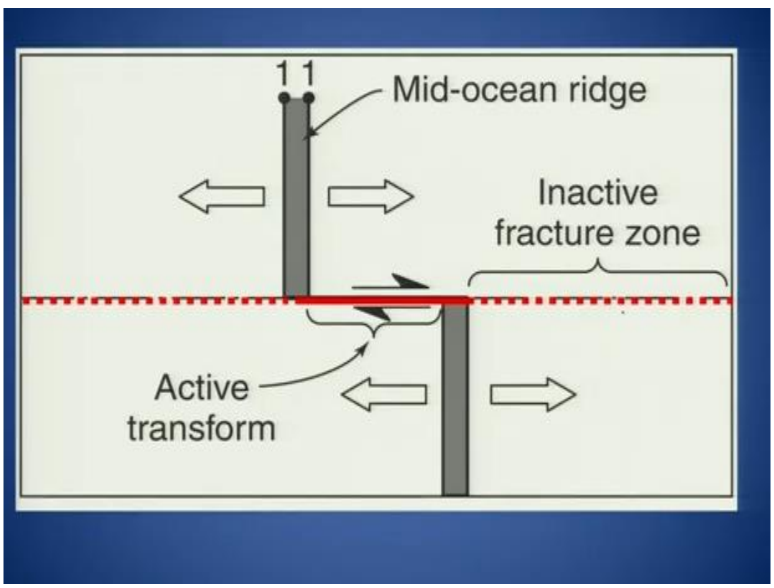

So, Mid-oceanic ridge this portion is basically an inactive one and this one is the active okay? So, if we take this portion as a marker then we see that this part of the plate is moving away from because this is the spreading center. So this portion if we take as an alone then we clearly say this is an extensional which is taking place so this part is moving away from one another. So you have this portion which marks the active transform fault.

Because this portion is moving away in this direction and this is moving in this direction here. So this portion is an inactive fracture.

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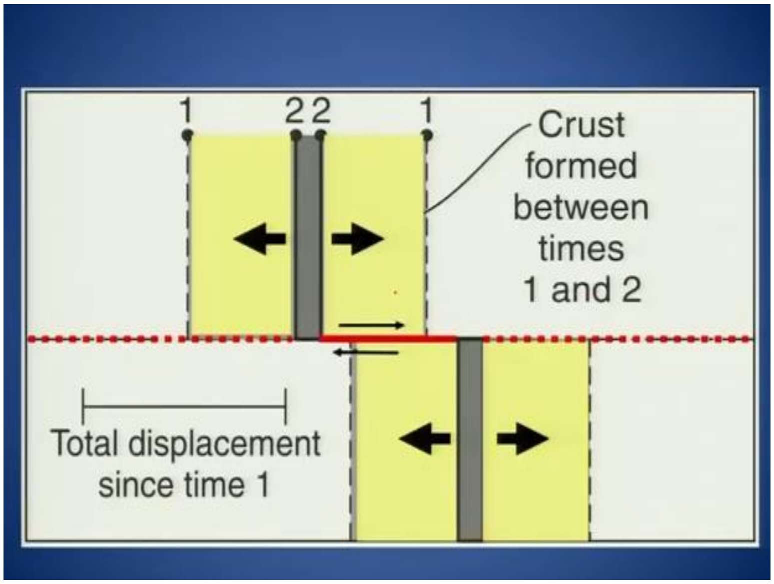

But this is an active where the two plates are passing by each other.

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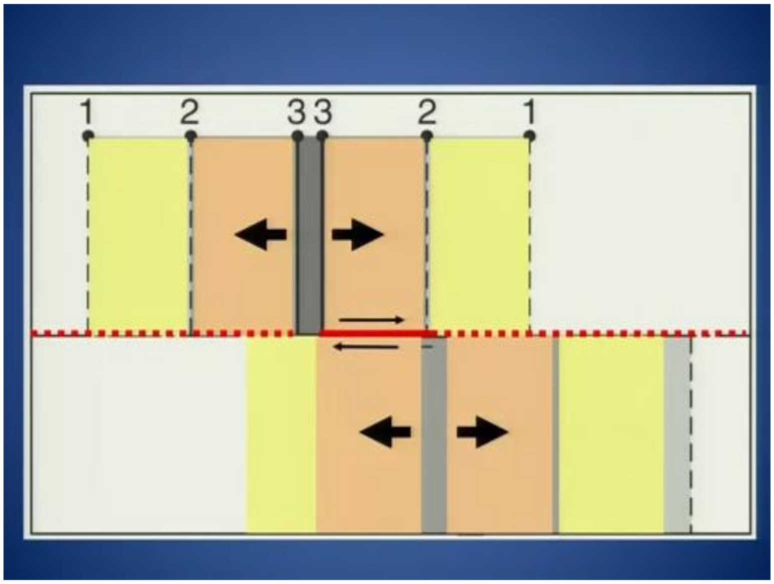

Or with respect to each other.

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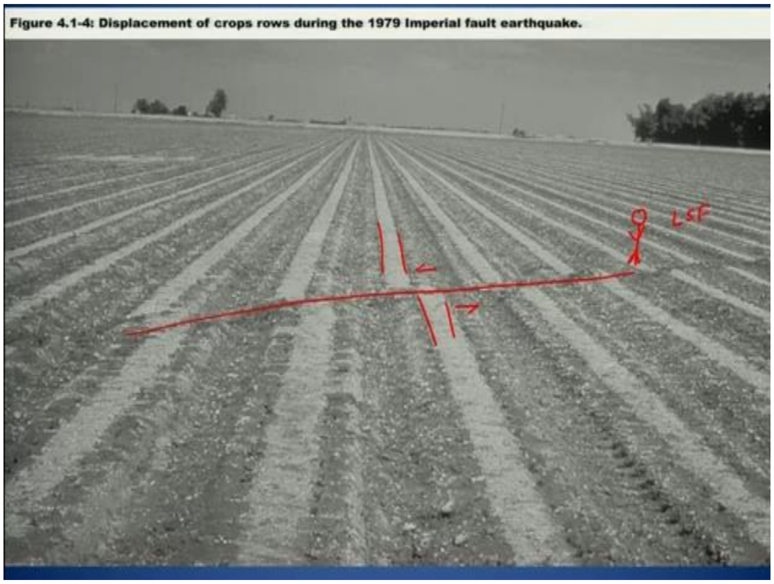

So this photograph which I have shown earlier also which clearly shows the displacement on the surface and if you take this boundaries as a marker here then this portion has moved like that and this portion has moved in this direction. So if you are standing here then you will mark this as an left-lateral strike-slip fault.

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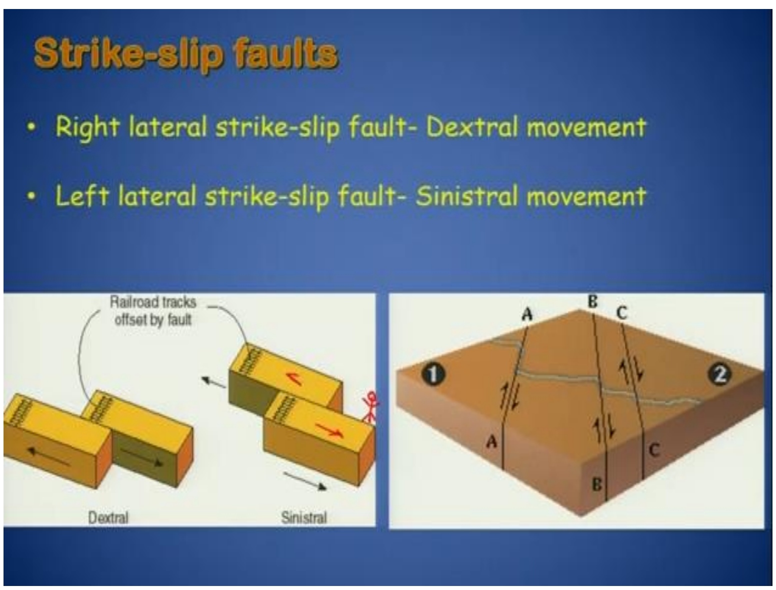

So, two types of motions we have already discussed. So i will just quickly move to the slides further ahead. So, we have like we see the Dextral movement which we mark as and right-lateral strike-slip, Sinistral movement we say that is an left-lateral strike-slip and that what we see here.

So, we have the sinistral one you have the left lateral. So, the left block is moving towards you if you are standing here.

And trying to view this is left lateral and this is moving away whereas this is right lateral dextral which is moving towards your side. So, right block is moving towards your side.

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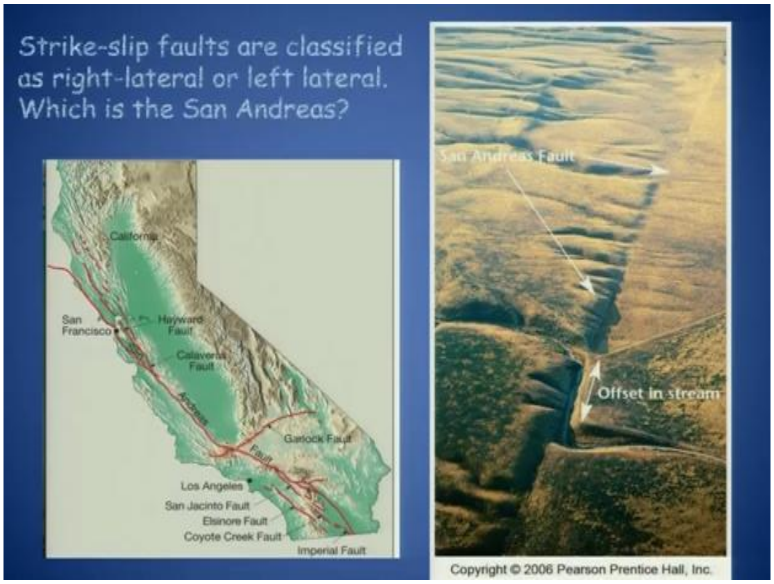

So, the surface manifestation already we have discussed the most prominent one which we will see the offset of streams, formation of linear valleys and if you are having an oblique component you will also see the formation of faults scarps. So, this is one of the most prominent strike-slip systems on earth with between the Pacific plate and the North American plate that is your San Andreas Fault system.

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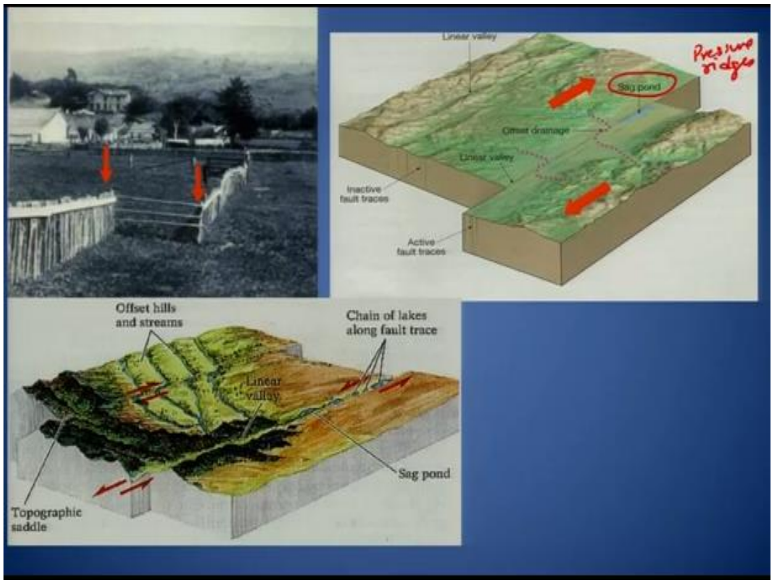

So this was during 1960, San Francisco earthquake and the features which you will come across will be formation of sag ponds, linear valleys and offset of streams. So, now as we will move further in this lecture we will talk about how we are going to use the offset upstreams and in what condition you will be able to see the formation of Sag ponds and third one what we need to cause the pressure ridges.

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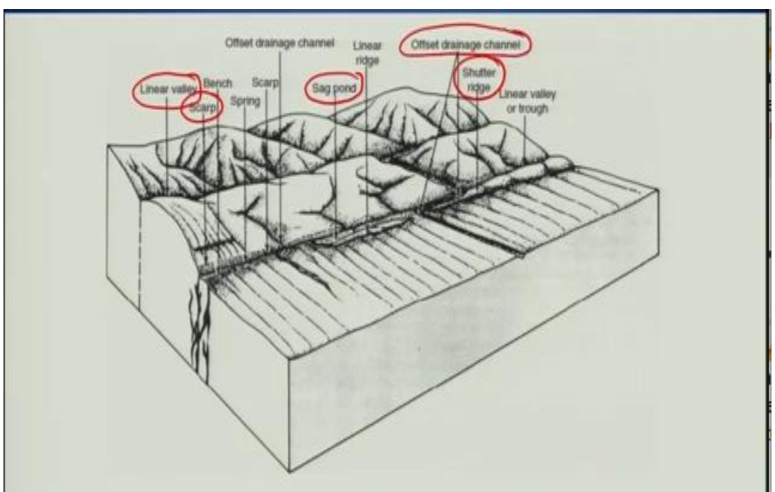

Figure 6.8: Assemblage of landforms associated with strike-slip faulting. From Surficial Geology, Building with the Earth; Costa and Baker (1981). Copyright © 1981 John Wiley and Sons; reprinted by permission of John Wiley and Sons, Inc.

This part we have already covered so I will just move but you can refresh this keeping in mind that we will be looking at the sag ponds then formation of the linear valleys. Okay, and if you are having the oblique then step then you will have scarps for mission and we will also see the pressure ridges or shatter ridges here and the most prominent one will be the offset of drainage.

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So, this is an example of the Hayward Fault which shows creeping here. So this portion has moved here and this one is over here is fault and somewhere here. So, this portion is your typical right lateral if you stand here, all are stand here and view then it will be the same motion.

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So you have right lateral strike-slip faulting along this fault. So, as I discussed not we have we will come across like number of faults not a single fault line and that forms the total.

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It will form the fault system.

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And this is for this San Andreas Fault system.

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So I will just quickly move this part already we have covered.

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But of course this is in the next slide we will talk about the shear fractures how they are developed with respect to the default which runs across this one. So, usually in the fault zone we will be able to see the formation of the riddle structure on the surface. Okay? If the general moment if we take like that okay, so we will talk about this in the coming slides

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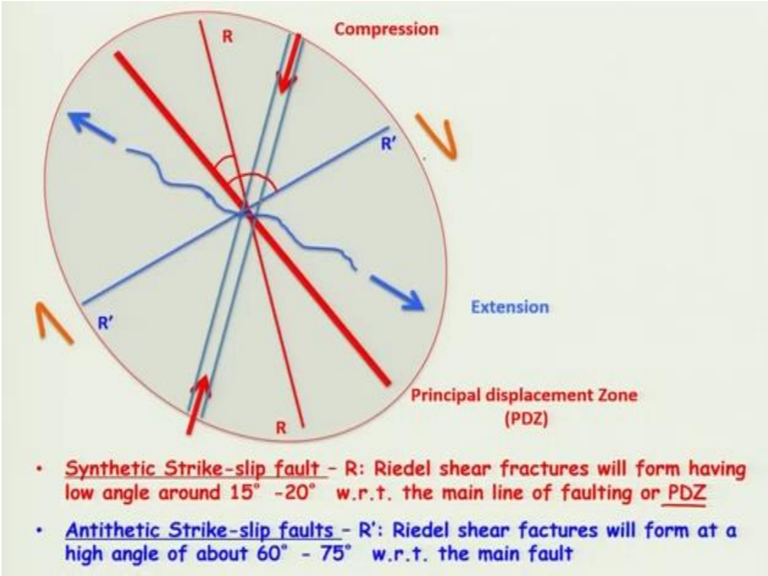

That you have the deformation zone. And you take the principal displacement zone that is your fault and if it shows the right lateral movement then two definite type of deformation you will come across here. One is compression and other is extension and two different sets of fractures will form and they will have typical angle with respect to one another. That is with respect to the main fault zone or the displacement zone.

One is it will be at low angle. Another will be at high angle and so you have the compression in one direction an extension taking place in another direction. So this zone is marked by compression so you will have synthetic strike- slip faults are there little fractures which will develop having a low angle around ranging from 15 to 20 degrees with respect to your principal deformation zone and another one will be your Antithetic Strike-slip faults.

So small fractures or shear fractures will form and then this will be at high angle which will be ranging from like 60 to 75 degrees with respect to the main fault zone. So this what we were able to pick up where the deformation is going on in a strike-slip pattern and in along.

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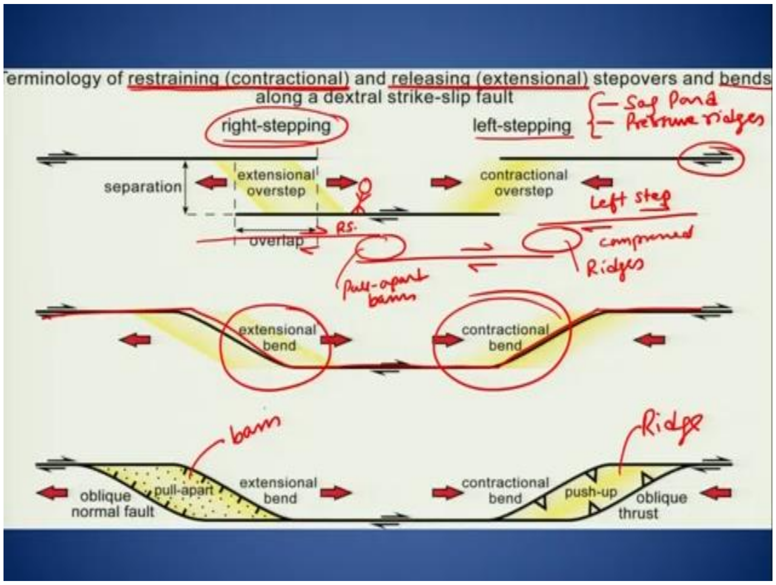

The Hayward fault that I will try to explain. So, now if we look at the different deformational features prominent one usually will come across the formation of sag ponds and formation of pressure ridges. Now this will be two prominent landforms which you will see in a strike-slip environment. Now how they are formed actually? So they if you have the step overs, okay right stepping or left stepping. So if you have the defaults which are getting step over it will result into the formation of either the restraining bend.

You will have the releasing bend and restraining will be your contractual compression and releasing is your extension. So suppose if you take this example which has been given here very clearly but let us draw it and then see what exactly. So you take this as a principle fault here and then step over to your left. So you are standing somewhere here and looking to the fault. So you have a fault running like that and then stepping to your left.

So left stepping and you have the movement which is taking place over here like that. Okay. So you have the right lateral movement, so right side is coming towards you this is also moving away. So this portion is getting compressed. Hence, what you will see the formation of ridges. Similarly here if you have the portion which is stepping to right so right step over this was left and this is the right step over.

So, this portion again you are having this part portion is moving in this direction this will move away from this like that. So then you will have the overlap portion you will have the land form which will be formed will be here pull- upwards and the same has been explained here so you have the overlapping zone where this step over is taking place. You will have different form of deformation and different landforms associated with same type of movement. Okay?

So this step over will result in to different a pattern of deformation either it will be like if you are having right step over, then you will have extension step over, you will have compression here. So this again explained here with the bend. So you are having the fault coming here then stepping to your left then you are getting this one here and then if you are having the right step over then you are able to see the extension in this one.

So you have extension you have contraction here. So this is what has been shown here. So you will have push up that is your ridge and this side you will have a basin. So if you have for example the left lateral then the things will be exactly the same but not the deformation will change. So first if you change the deformation just remember this that the portion moving towards each other will result into compression the poor portion moving away from each other will result into the formation of basin. So you have extensional and contractional features.

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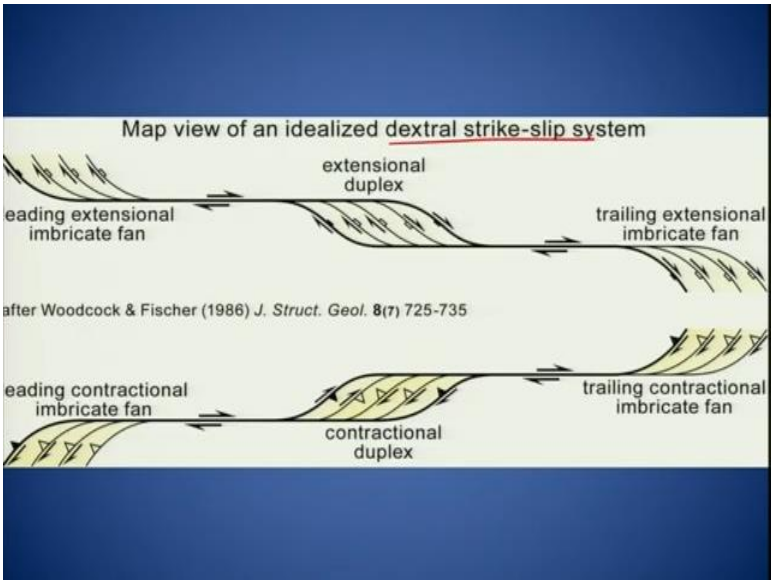

Similarly it is been shown here, so you will have this is the right lateral. So you will have the step over here will result in to different deformation pattern typical of dextral slip.

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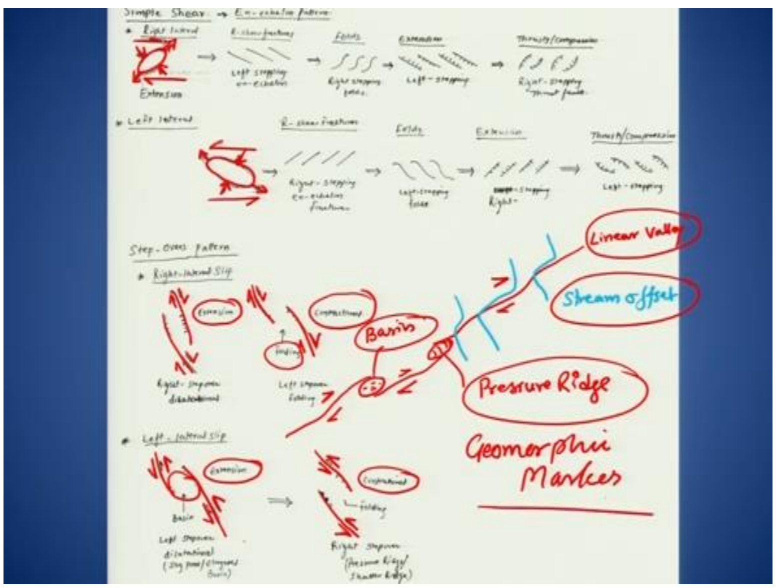

Now, this portion we were talking about now in case of first we will talk this and then we will get back to this one here on the top. So in case of right lateral so what is being shown here so suppose you have the fault here and then you have the right stepping. So again we mark the arrows here, that shows the. So both the arrows are moving away from one another. So the overlapping zone will have extension and that what we have discussed.

And similarly if you are having this fault here and you have the portion here overlapping will have conduction. So we will see folding and this is your left step over this is your right step over. Similarly in case of the left lateral step okay so this is we were looking at the right lateral. Now in similar case if you are having left lateral and you have the left step over then what you are going to see.

So, you have the fault here and then this step over is to towards your left. Okay? So again we will put the arrows here and this is your left lateral, so the left block is moving towards your side. So again this is in your direction. So this portion will have extension that is the formation of sag ponds and even have elongated patients. Similarly here, so you have the fault this one and then it is right stepping.

So again the movement is left lateral here on both defaults. So what we see the right stepping so this portion is moving keep this side and opposite to this. So this will result in to contraction. So we will see folding here and this is in case of the right step over. So, if you compare this and if you are having left lateral right step then you will see folding right lateral a right step you will have extension and exactly opposite what you will see here.

So now if you look at the shear fractures with respect to the right lateral movement and the left lateral movement and if you consider the ellipse then you will have extension over like that and the contraction in this direction. So the movement what we see is a right lateral movement and the shear fracture or real fractures will be able to see in terms of what we were talking about the high angle and low angle with respect to the principle deformation zone.

So if you are having that is your synthetic one is your low angle and the antithetic fractures will be at high angle. So what you are having is the left stepping you will see in case of your right lateral movement and the folds you will be able to see in fractures of right stepping. So this if you recall the chart you will be able to understand it better. So in case of your left lateral so again we will have the ellipse here so you will have extension in this direction and contraction in this direction.

And exactly opposite you will be able to see you will have the right stepping and a extrusion fractures where is the contraction you will see what you were looking at the right stepping here you will have left stepping here and similarly what do you see the related features the folds or the thrust faults or the extensional normal faults. So these are few important aspects which you should remember when we are talking about the signatures of strikes faulting.

So, one thing what we were talking about is the formation of Linear Valley. Then we were talking about, I will just use another pen so it is clear so Stream offsets. Then we are talking about for example so this we are taking in right lateral. Then what you will see here because this is your fault you are having left stepping. So this portion is here moving here and this portion is again like that. So you will see the formation of Pressure Ridge.

Then suppose the fault is going like that, then again you have the deformation like this and you will have formation of Basin here. So these are a few important landform indicators which will help you in the demarcating the strike-slip fault on the surface. So we can say this as in your Geomorphic Markers.

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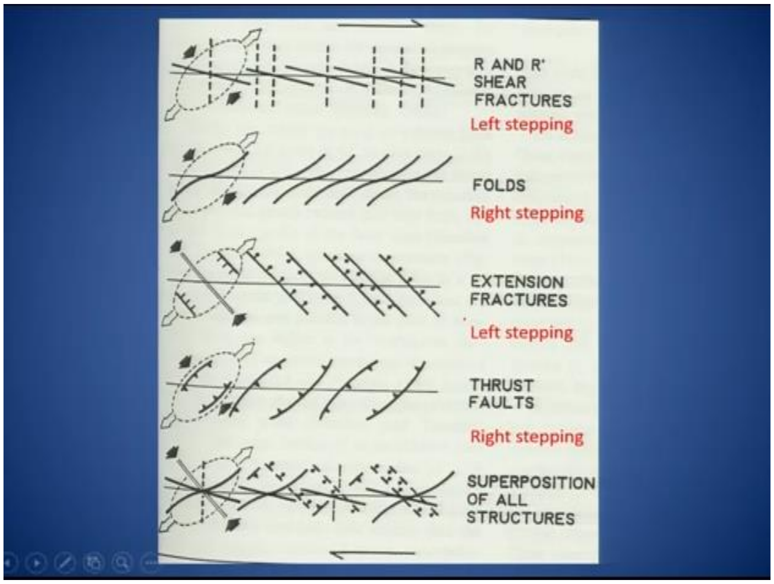

This is the same thing which we were talking about the shear fractures. So you have right lateral again. So you will see the faults. So you will have Folds Right Stepping and this will be your left stepping again the Thrust Faults you will see right stepping and if you overlap then you are having the faults which are right stepping here and then you have the extensional one is your left stepping.

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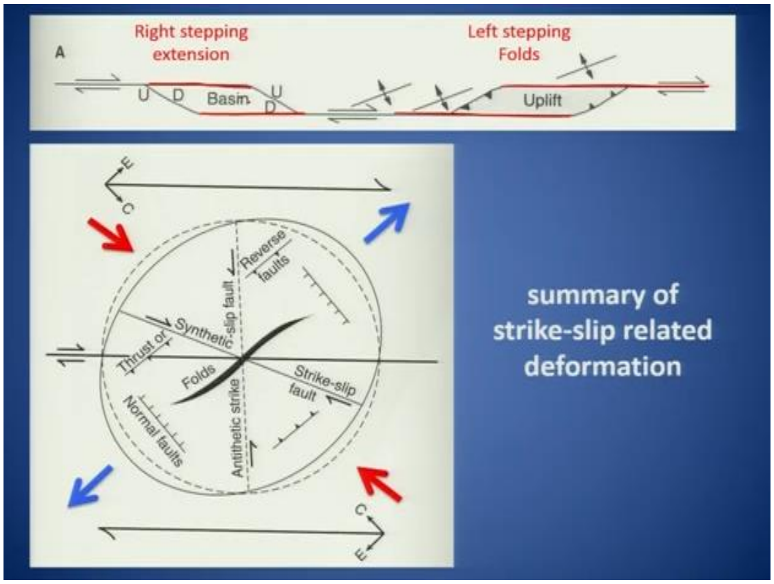

So, similar thing together, so if you have the right lateral and then what you will see is the pop up or push up here. So you have the formation of pressure ridge whereas if you are having so this will be your left stepping this will be a right stepping. So you will have the formation of the basin here and similarly which has been explained here that you will have the formation of synthetic faults.

And even have formation of antithetic faults here and then this is what we are having so if you take this we have the synthetic faults. So we have compression in this direction we have extension in this direction and which will result in the formation of the extensional faults and the thrust faults exactly perpendicular to that. Okay? And if you look at this one again the similar configuration we have the right lateral strike-slip.

And if you have left step over so you have fault running here and then jumping on this side then you have the uplift or the pop up. And if you are having default jumping to your left then you have the extension that is formation of the basin.

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Now if you look at this one the fault runs over here. And we have the cracks or the shear fractures which are developed here. So we have the extensional crack over here which is a tied angle and then we have the compressional cracks which are there were fractures which are developed almost at low angle with respect to the principal deformation zone or fault.

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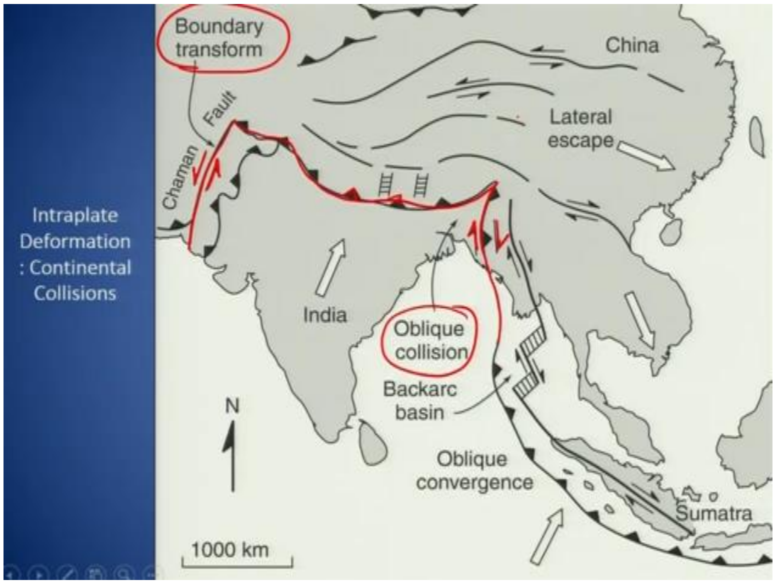

So, now coming to the other part here, what we see is not a clear deformation boundary in terms of Indian plate and the Eurasian Plate. So not only we will be able to see all in the compressional tectonic environment we will be able to see the thrust faults or the diverse faults. But also if you are having oblique collision or convergence then you are going to see the deformation of the strike-slip faults or transform fault boundaries.

So we have prominent transform fault boundary over here in the eastern side of the Indian plate how it shows your right lateral motion and on the left that is your western side you have German fault system which shows left lateral fault system and this location we have that is this shows all thrust faulting and this is because of the Indian plate is just protruding or banging with respect to your Eurasian plate here.

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So, this it shows along with that.

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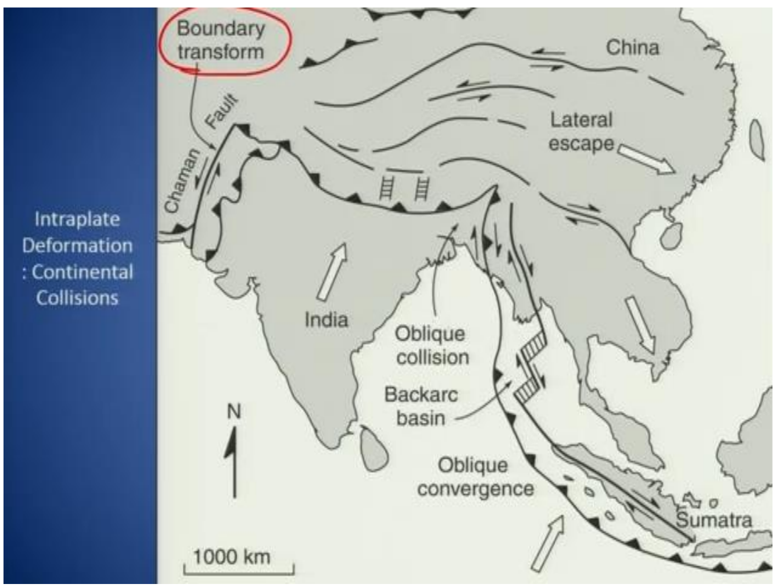

What we have this one here this is another fault system which is right lateral zero Karakorum fault system and many more in the Tibetan side of the Eurasian plate because of the Lateral escape of this plate here. So in total if you take the right lateral and left laterals strike-slip faults. So we have any. This is a southern faults system. So we have this plate boundary here we have on the western side and then few further north in the china side. So these are all because of the oblique convergence with respect to the different plates.

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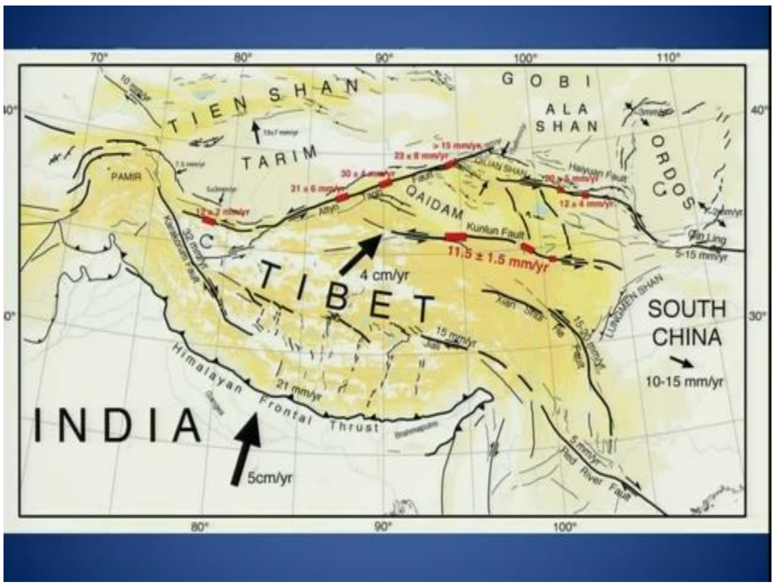

So you have the same one here which we were talking about. They have this southern faults system here then the Karakoram one and this is your Atlyn fault in Tibetan side and Kunlun fault again. It is having this is left lateral this one is again your left lateral here and this one is right lateral and then what we were looking at here is German faults system and this southern faults. So southern faults system is your right lateral and German fault is here the left lateral.

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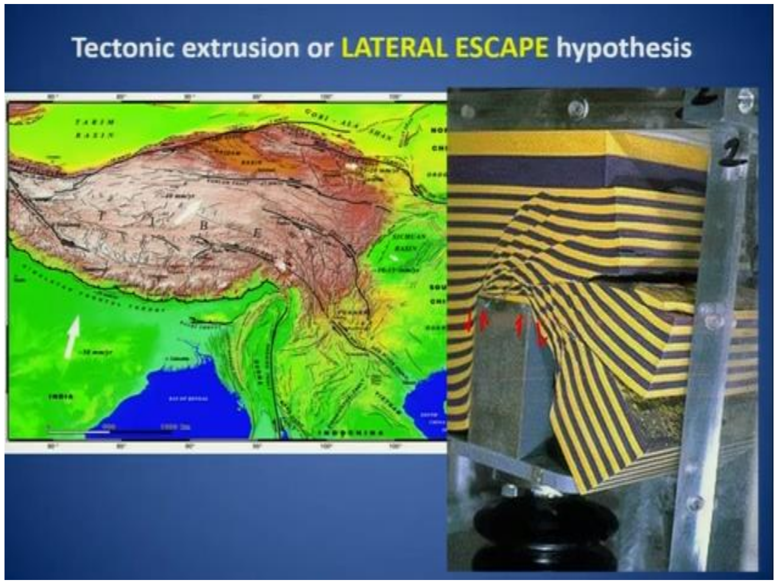

So, this is how it has been explained that why, what is the reason for the formation of this faults system here has in right lateral and this side that is on the western side is your left lateral. So suppose you take this portion as an Indian plate which is just banging into the Eurasian Plate or the Tibetan plate then this portion is what we see is escaping or has been pushed out towards south-east.

And because of this contact here since this portion is moving like that and this is coming out, so this is giving rise to your right lateral and this portion is moving like that and this is coming out this is remain being raised to your left lateral and then the other faulting which we see here as in Kunlun fault or Altyn fault. So the tectonic extrusion or little escape hypothesis is when explained with this, I will stop here, Thank you so much.