Photogeology in Terrain Evaluation (Part 2)
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Lecture - 05
Identification of Fault Topography

Welcome back. So yesterday we had discussion on the active fault and in particular the strike slip faulting where I explained that how the movement will be seen on the surface and what are the manifestation that we should look for identifying this strike slip faults.

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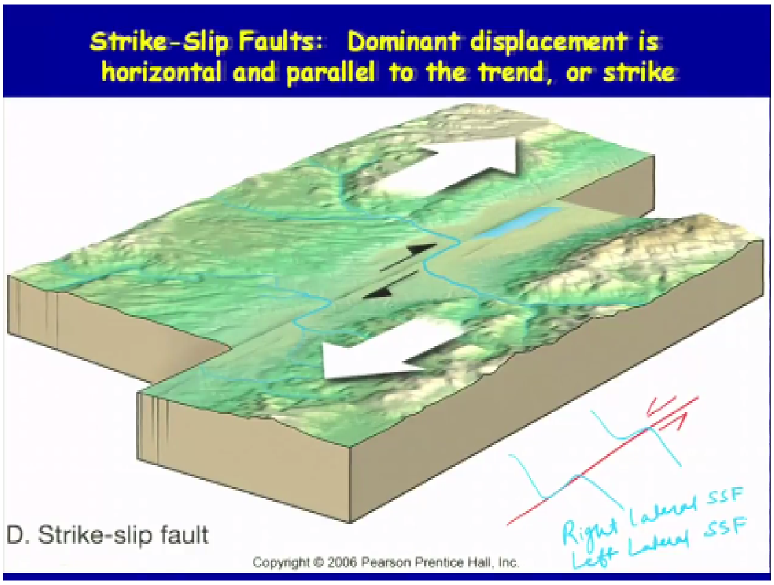

Now this is again a sketch which shows that 2 blocks have passed each other along a line here this is what we call the fault line on the surface and if you see the section which is sometimes difficult, but you can try and feel. But since we are talking about the photo interpretation or the photo geology part we will be looking mostly on the surface. So based on the surface manifestation how we will identify we will see couple of slides.

But here I can tell you about that whatever deformation is taking sub surface will be reflected on the surface and the landforms or the features which exist on the surface will get modified and what is a simple way which has been shown here in this sketch that the streams which are flowing and crossing the fault will also get deflected because of the movement taking place between these 2 blocks.

And this is what we call it the stream is coming like this and then following the fault and then keep start flowing like that. So if you look at the drainage which was initially flowing like that. So these are the streams which were flowing without having any influence of the fault, but when the fault came up and then displacement took place. For example, the movement has taken place like that then what you will see is the streams which were coming like this will get deflected. So the present configuration of the stream will be this one along the fault.

So this is one very commonly seen or observed feature which you will try to identify when you are doing photo interpretation to mark the active fault which is having strike slip motion. Along with that we have few more features which we will talk later, but this is the most common which you will see. Now suppose the movement is in the opposite direction. So if you have the movement which is taking place like that then what will happen?

It will be exactly opposite. So this streams which were flowing straight here like this, but because of this movement along the fault it will change again in a similar way but now it will be something like this. So this based on the movement or the pattern of displacement we can say either it is right lateral, strike slip fault or left lateral strike slip fault.

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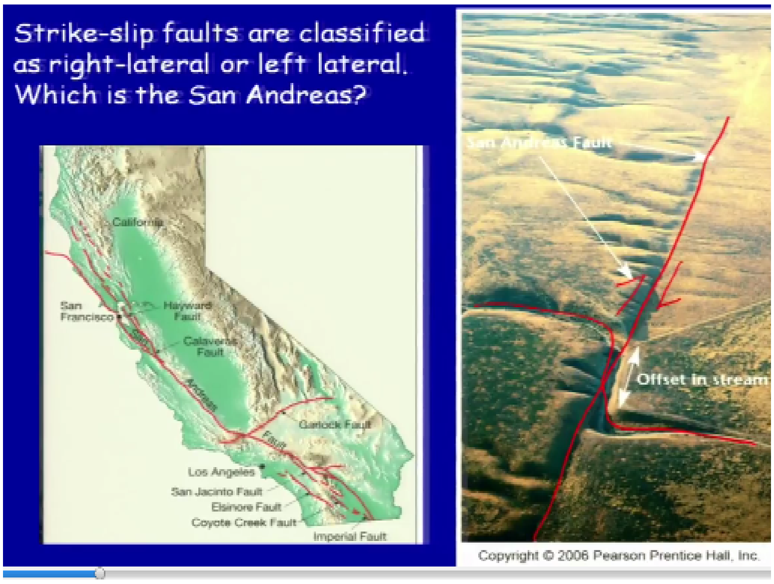

It is one of the best examples which you will find in most of the textbooks and in literature is of San Andreas Fault System. So what do you see in this aerial oblique photograph that you have the fault trace along with that you have a very prominent scarps, a fault scarps which are developed and along with that you have an offset of streams here. So fault runs here and then offset of stream has been seen like that.

So this is typical of strike slip fault and this motion here if you look at is something like that. And we can say this is right lateral strike slip fault.

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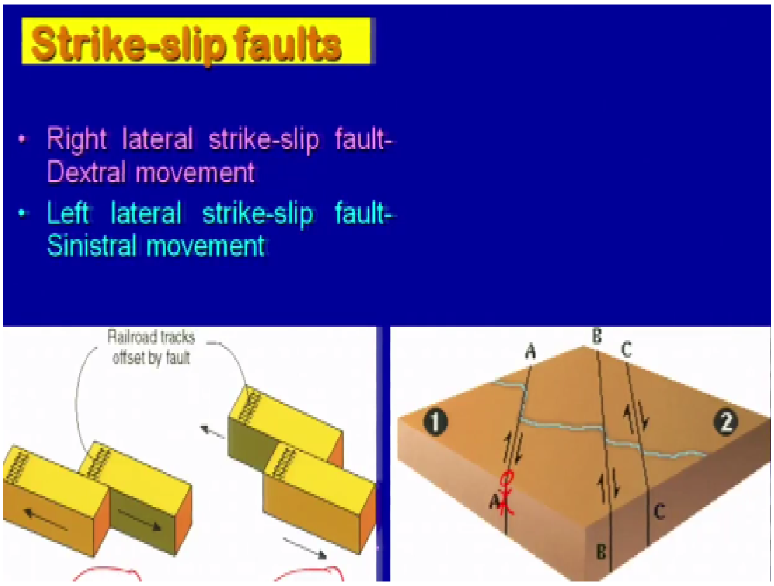

So just giving in brief idea about the right lateral Strike-slip fault and left lateral strike slip fault which is also termed as dextral that is for right lateral and left lateral strike slip fault we say Sinistral movement. So here it has been again shown the similar pattern, but if you are having the right block moving towards your side irrespective of where you are standing if you are looking from this place then also it will be right lateral.

If you are looking from this place, then also it will be right lateral. So whichever block is moving towards us based on that we will say it is a right lateral or a left lateral. So here all this faults A, B, C which have been shown are all right lateral strike slip faults. Another example which has been given to understand this where the 2 rail tracks has been displaced which are showing Sinistral left lateral moment and dextral right lateral movement.

So where this block is moving towards our side whereas if you stand here and see the left blocks is moving towards your side so that you can identify easily based on that.

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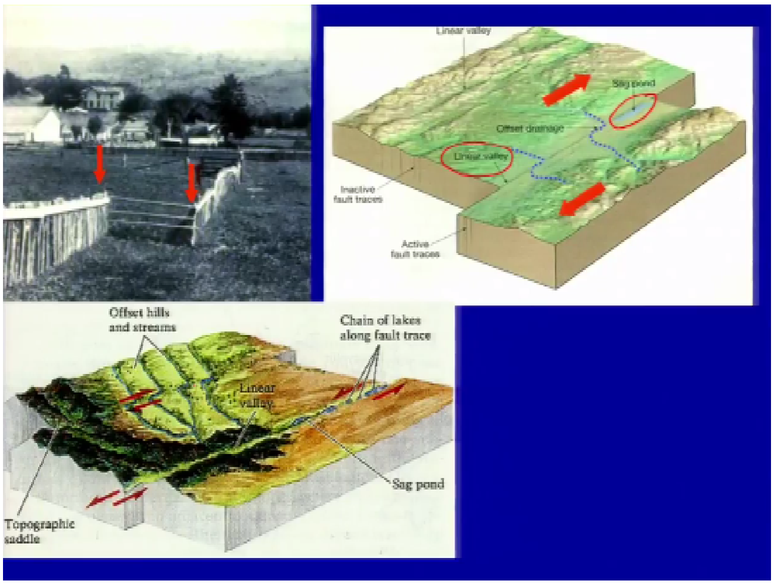

This was example of a manmade structure which was displaced during San Francisco earthquake and another one has been shown where I was talking about that along with the offset of streams or deflections of the streams which have been shown here what another feature you will see is deformation of the sag ponds and you will also see a very linear value which has been formed along such faults.

So (()) (07:39) similar examples we are having formation of the sag ponds and the displacement which has created a very linear feature on the earth surface. Now as we see that okay fine the landforms or the features which will exist on the surface where the drainage is there we will also have some hilly regions or the hills or the ridges they will also get offset. So you will also see the offset of hill ranges as well as this streams on the surface.

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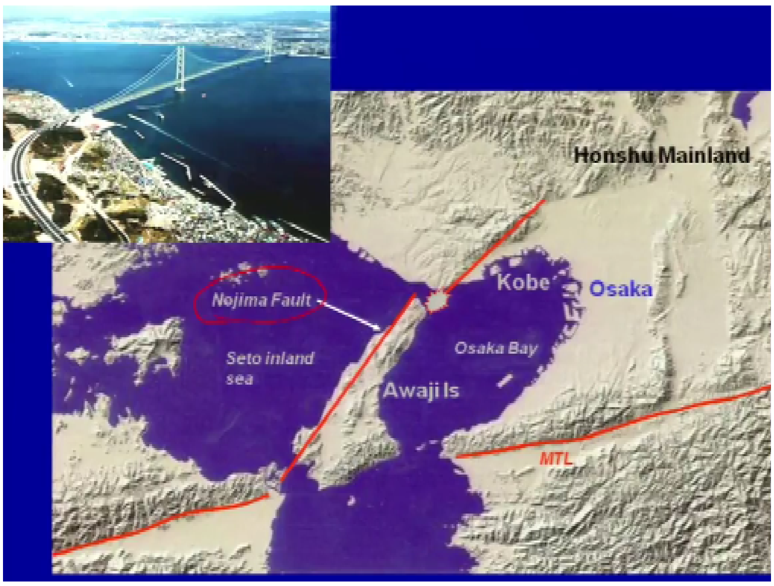

Now this is a very good example again from Japan where 90, 95 Kobe earthquake took place. So this is a main island that is what they called Honshu and Kobe was the city which was destroyed or we can say that it experienced extensive damage and the fault which runs it runs through the Awaji. So this is a main fault strength what they call as Median Tectonic Line MTL and the earthquake of 1995 Kobe occurred over this place.

This was the epicenter and then fault which run through or ruptured the surface was through the Awaji Island. And I will show couple of field photograph which they took after the event how it looks like and also the aerial photograph which they took after the event. So this fault which structured in 1995 is Nojima fault and this was one of the damaging event in Japan. So since the earthquake epicenter was between the 2 islands here which is connected by the bridge here, the suspension bridge.

This also experience some shift because of the displacement and again the displacement was around the strike of the fault that is what we call the strike slip fault. So what type of movement it was whether it was right lateral or left lateral we will see in the coming slide.

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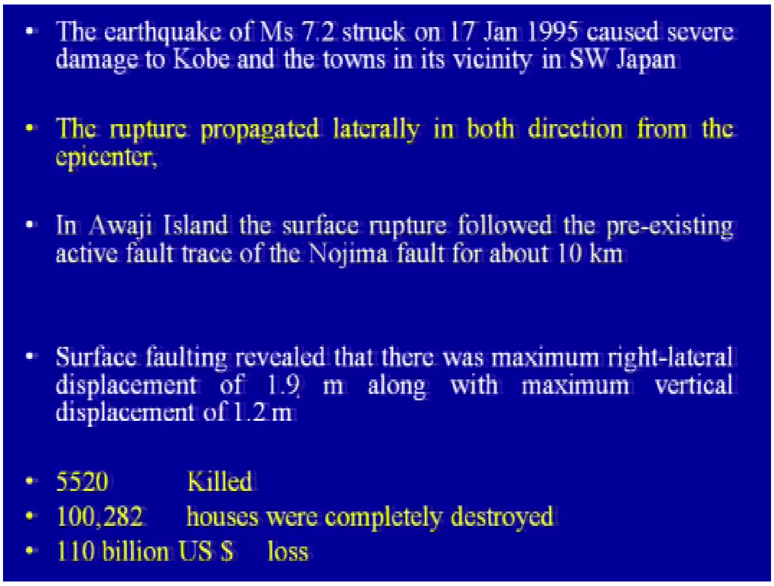

So the Kobe earthquake the magnitude was around 7.2 struck on 7 Jan 1995 cause severe damage. The rupture propagated laterally in both directions as I was showing in the previous slide from the epicenter. It moved towards north as well as towards south and it cut through the Awaji Island and the fault name was Nojima fault and the rupture extended almost for 10 kilometers.

Now what they observed was the surface faulting resulted into maximum right lateral displacement of 1.9 meters. This was the displacement laterally as well as it also accompanied a vertical displacement and that what I was talking in my previous lecture that you will may come across in combination of both that is right lateral displacement that is the fault has move laterally as well as oblique.

So I will show here if you look at what exactly happened was that you had this movement, but along with this you had a movement where one of the blocks moved up something like this. So you have a lateral movement and at the same time you are having the oblique slip. So vertical displacement which was observed was 1.2 meters. So I will not go into this detail, but you can look at many people were been killed.

Now after this at least if we consider that what they have done in terms of saving the people or providing safer environment to the society. They have extensively mapped all such faults that exist in Japan and that similar thing we need to do in India also because as we were talking about the infrastructure development is exponentially throwing.

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So surface rupture this is what they observed after the Kobe earthquake and you can see this is an aerial photograph which has been taken. So rupture was seen here where you can see that some portion of the land has been uplifted here as well as right lateral movement. Now ground photograph of that. So you are having one block which has moved up. So this is what we call thrust fault and we have also strike slip movement, so both were combined in this.

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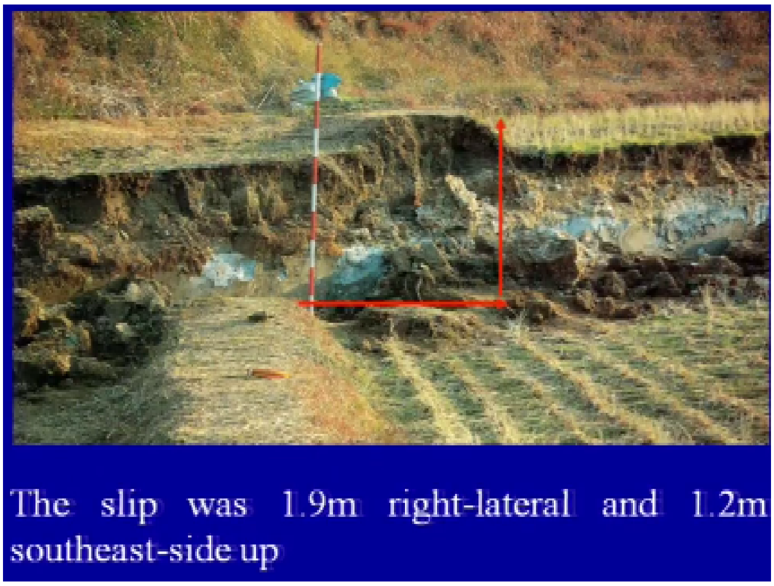

Close up of that. So this photograph is from this location same photograph has been seen in the ground photograph in the aerial view. So what has been seen here is that these are 2 piercing points this one and this one. So this 2 were together before the displacement took place. So the movement occurred was something like 1.9 meters it moved laterally and 1.2 meter and it moved vertically.

Now let us have a few questions here that why this identification of such faults are important. Suppose you construct some structure on the top of this when there was no fault trace identified and if earthquake comes and which is very much likely because these are all active faults. So in future if the structure is sitting on the top of this fault line it will experience severe damage. So we need to avoid such location from constructing the civil structure.

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So this is another aerial view of the fault of 1995 Kobe earthquake which moved laterally. So we had right lateral movement as well as we had thrust movement along with this. So this is a very beautiful trace which they finally preserved and converted this whole area into a museum. So what was the idea behind this that why they wanted to preserve it. They wanted to show the local people or the citizen of Japan.

That such things will happen in future and we should be aware of this. So you get support from the local people also as well as from the government to provide the safer environment. Now if you see here this house was just very narrowly escape the damage. I will show the close up of this. So the trace goes like this here and between these 2 arrows.

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Another aerial view of this so trace is over here you can clearly see that. Road got deformed and the agricultural field also and it crossed. This house had a very narrow escape from that. However, the displacement they resulted into the lateral shift of the compound walls you can see here. You can see a very clear offset over here also. So this also they have preserved.

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Close up of that again an aerial view you can see that the land has moved up. Hence you see the breaking here. This part has gone down because this was straight before the displacement took place as well as it moved laterally. Another view you can easily trace out this. So like stream offset of the man-made structures which are sitting on the top of the fault will also experience a damage.

Suppose this fault was few meters over here then you can imagine that what would have happened. Another view of that house.

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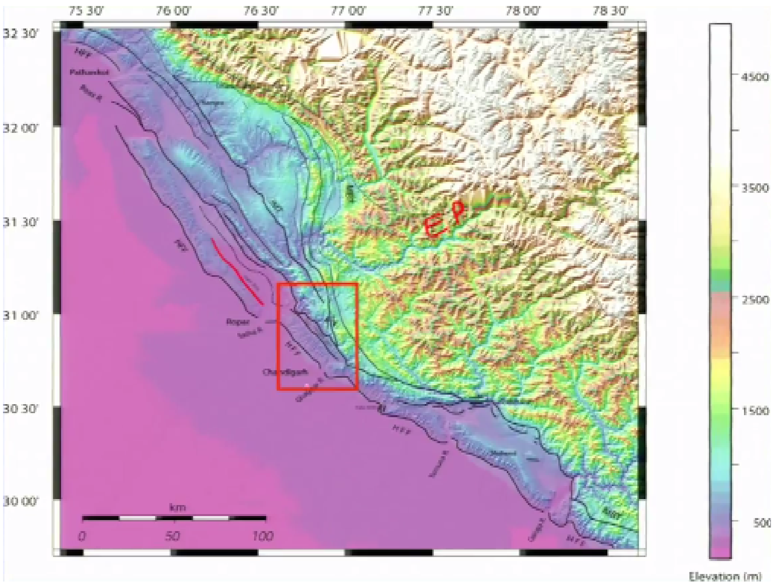

Now coming to the Indian scenario this is a shaded relief map of northwest Himalaya and just to make you comfortable that where exactly this lies. This is one of the well built city of Chandigarh this area is close to that. So this side which you see is your Indo-Gangetic Plain and the boundary between the rugged terrain in your plate boundary the (()) (18:34) boundary between the Indian plate and this is your Eurasian plate.

So this marks the Himalayan frontal thrust and we have several chains of mountains or you can say that the folded ranges. One is here another one is here third one is here and so on. All this folded ranges are bounded to the south as well as in some places to the north also by active fault. So let us see what we will able to identify in terms of the strike slip fault because we have (()) (19:21) strike slip fault and later we will talk about the thrust fault also from the Indian examples.

So this area we took and we have been doing studies in this area since last 10 years and we have picked up and marked several new faults which were not mapped earlier and which is extremely important for the hazardous assessment in this region.

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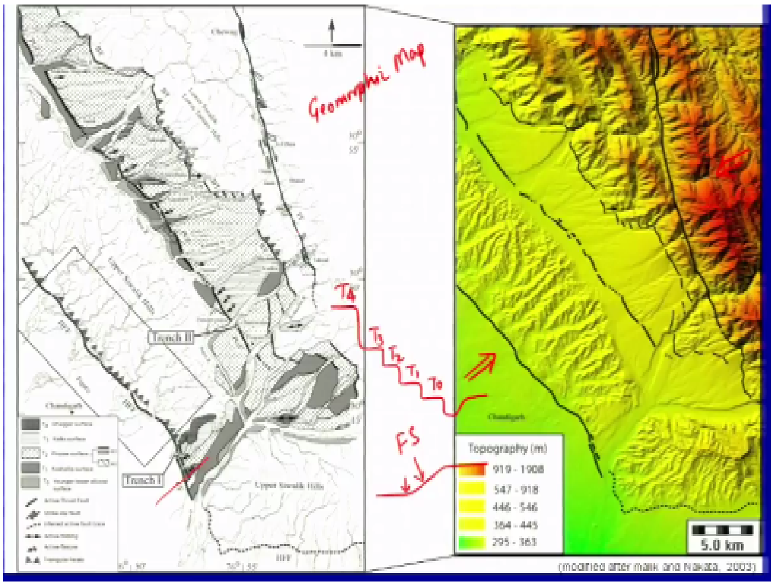

So what we do is again there is a part of the remote sensing or photo geology and photo interpretation you can use different data which is available either in a free domain or you can purchase from national remote sensing agency Hyderabad. Now we are doing and buying the data from (()) (20:22) Hyderabad which provides us very high resolution satellite data Cartosat data mainly.

So this is just to see the elevation variations and all that this was been prepared using Satellite Radar Topographic Mission data SRTM. So this is again initiated relief map which clearly shows the variation in the topography in this region and these are all black line which are been marked are the traces of active faults which we have. This active traces have been marked based on the features which we picked up on the satellite data.

And what is required is that this information has been extracted in the form of what we call the geomorphic map. What we do is in geomorphic map this exercise you will be doing we also mark the different surfaces because as time goes you will have deposition in the area because you are eroding it that means you are depositing. So the rivers or the stream which are flowing across these regions will also deposit as well as erode.

So erosion and deposition and that will result into the development or the formation of different landforms what we call river terraces or you will have alluvial fans and all that. So these are all fluvial surfaces which are been marked with this different symbols which have been given here and we have classified this as a younger terrace T1, T0, T1, T2, T3 and T4. So T4 is the oldest.

So if you take the cross-section here then what you will see is something like strip like features. So if you put this as T0 this is T1, T2, T3 and then T4. So this terraces were developed in last more than 10,000 years and what we found was this all terraces at some locations were displaced. If you see here this all terraces are displaced. So they are vertically displaced.

And if you take a cross section here across one of the terrace then the topography you will come across will be something like this okay. So this is what the step along this strike whereas across if you move then you will have this configuration of the terrace and this is what we call the fault scarp and fault line will be somewhere here. So this information is extremely important because this will go as a map which will be important for the uses.

And who are the users for this are the town planner mainly the civil engineers, the structural engineers. So they will take care of this that while selecting the side we will avoid putting any structure on top of it. So we will keep a sort of buffer zone avoiding this fault line. Now the point is that when it was not known before so what we did. So without having any awareness about that where the fault line is passing through what we did.

We avoided putting structures on the top of it we will see couple of examples of that okay.

Another point here which I would like to emphasize that based on the topography which will develop by different faults or the displacement coming right up to the surface we have marked this fault for example this is mark here as thrust fault, this one again is a thrust fault these are all thrust fault. So the deformation is something like that.

But this point here this line is showing a right lateral so there is a variation in deformation in a very short distance. So hardly if you take this in 4 kilometers so may be this is covering hardly 20, 25 kilometers or 30 kilometers across this. So in a stretch of 30 kilometers we have faults 1, 2, 3 and 4 faults and this all 4 faults as per our research suggest that they will move in future.

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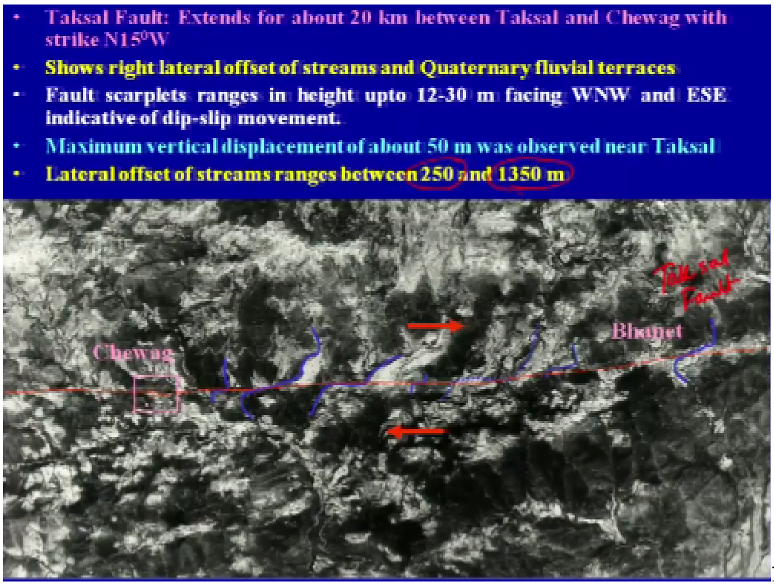

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Now let us see what we see on the surface and how we identify. This is a high resolution again the Corona satellite photograph when you will do the lab we will provide all the details of this which is again available on you can buy through internet because this is declassified images or the photograph taken by US by satellite and it was declassified in 1995 or so and we use this the reason were because from 65 or so.

Because the data is they started collecting this information for military purposes and all that in 64 or 65 when the development or the construction was not so high in India and definitely if you go back about 40 years, 50 years you will see that the erosion is also not much at that time. So we see a very fresh landform which were not modified by the erosion as well as not modified by the human intervention.

So the fault passes through this part here and this was identified which was a new fault and we name this as an Taksal fault. So Taksal fault there is a town named as Taksal near somewhere here and based on that we name this as an Taksal fault. So if you look at the fault rays there is location name few Bhanet and Chewag where we found that the fault extends for about 20 kilometers which is quite good enough for the deformation or triggering of the large magnitude earthquake in this region which shows right lateral offset of streams as well as quarternary fluvial terraces.

Fault scarplets ranges in height up to 12 to 30 meters facing West Northwest and East Southeast which indicates that this displacement which was experienced was right lateral as well as dip slip movement also. The maximum vertical displacement at one location which was identified was about 50 meters. A lateral offset of the streams which were identified was between 250 to 1350 meters.

So this also indicates that the variation which we are able to see here is because of this stream is showing a sort of cumulative displacement and this stream is showing very young displacement. So let us see how many streams we were able to pick up here the blue lines are showing all streams which are coming up on your screen. So this were the offset we picked up and also at one location we were able to pick up the sag pond here.

So movement is right lateral close up of this and this part if at all I am having let us see.

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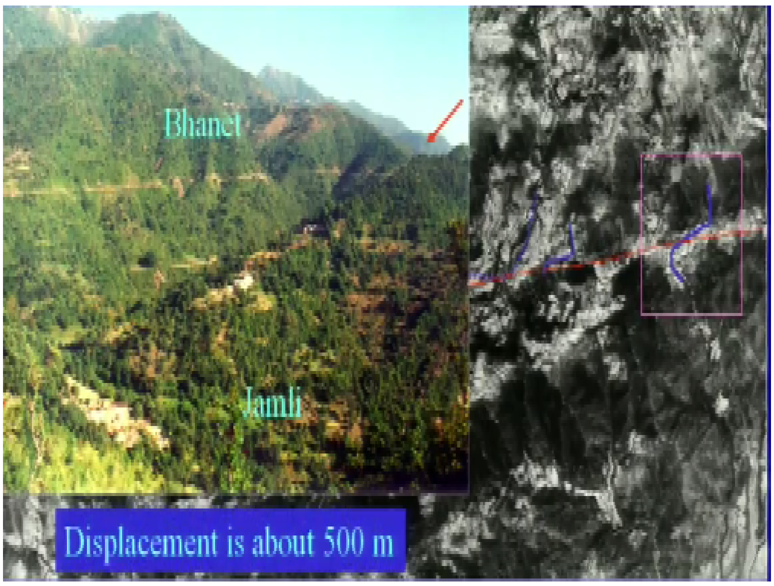

So the offset which runs here is the stream flowing through this area and then getting offset and start flowing like that. So fault runs over here and the offset which was measured was almost around 500 meters. So I will stop here and we will continue in the next lecture. Thank you so much.