Structural Geology
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Lab Session
Paleostress Analysis from Fault Data

Hello all welcome to online NPTEL structural geology course. Today we will have a lab session on Stereographic problems related to faults. So, in this session we will determine the stress orientation when we have a fault plane.

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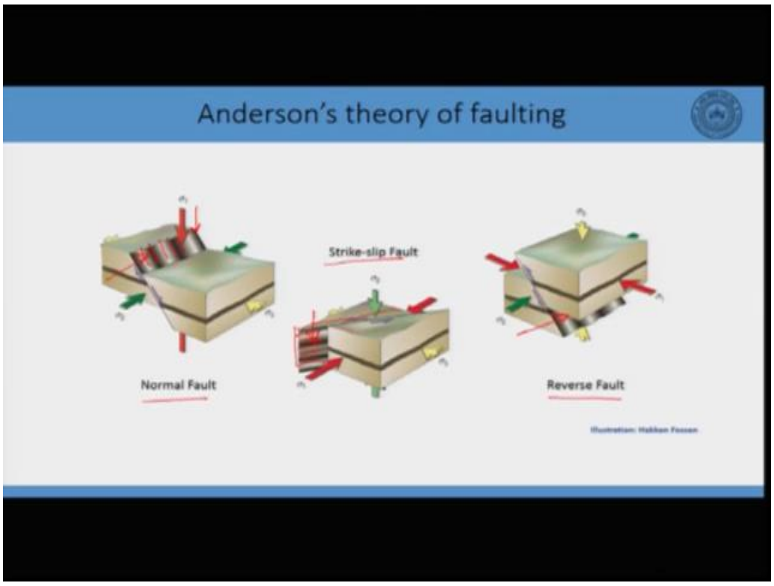

So, before going to the fault problems we will have a brief overview on the Anderson theory of faulting. Anderson classify the faults in 3 types, normal faults, strike slip fault and reverse fault. So, the assumption what he made to classify the fault is he argue that since there is no shear stress in the air, so air and earth surface interface can be considered as a principal plane of stress. Since the earth surface is principal plane of stress.

So, there will be one vertical stress that will be perpendicular to the earth surface and the other 2 will be horizontal. So, based on the stress orientation (())(01:12) axis of stress in space he classify the fault in 3 types. In normal fault we can see that the sigma 1 is vertical and in sigma 2 and sigma 3 is horizontal, so in that the maximum stresses is vertical which causes this hanging wall to move down word.

And when the hanging wall moves down word relative to the footwall it classify them as a normal fault. And when sigma 1 is horizontal and sigma 3 is vertical and the hanging wall moves up word relative to the footwall, so he called it as reverse fault. And when sigma 1 and sigma 3 is horizontal while sigma 2 is vertical and the blocks slide pass each other he called it as strikes slip fault.

So, what we see that in all 3 faults that sigma 2 is always lie on the fault plane, you can see that this is a fault plane and in that also sigma 2 is lying within the fault plane which is vertical. And also in normal fault and reverse faults sigma 2 is within in the plane. So, this is the Anderson theory of faulting.

And what we always see? When a fault forms there is always a striation that develop within the fault plane which is in this little fault it will be like this, while in the strike slip fault we will get striation like this. So, with the help of this striation in fault plane we determine the principal axis of stress in space. So, how we do this on the stereonet? We have some assumptions.

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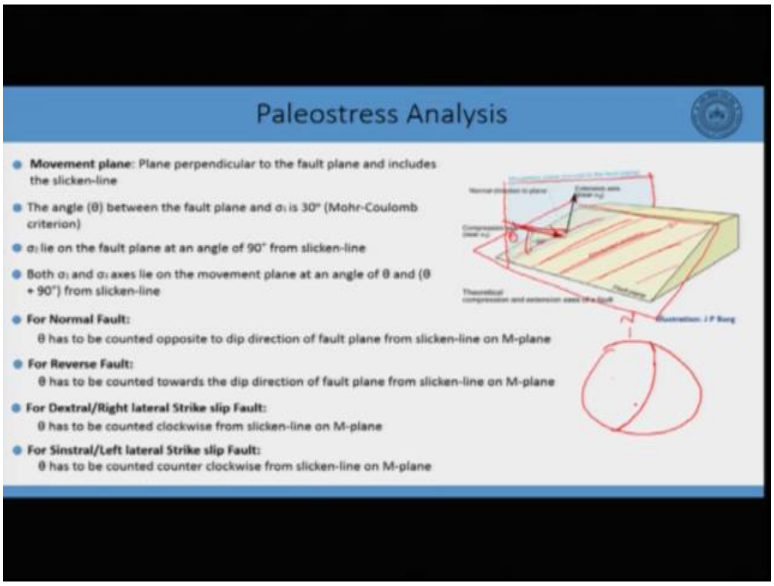

So, this is the illustration given by J B Burg, so in that we can see this is the fault plane, this one is the fault plane. And this is the striations this one. So, first what we will do? We will plot the fault plane in the stereonet and then we will draw a movement plane, this is the movement this light blue colour.

So, this we will also plot on this unit. How we will plot this movement plane on this stereonet? This movement planed is usually perpendicular to the fault plane and it includes the striation so suppose this is the stereonet and this is north and this is the fault plane. So, what we will do? We will take the pole to this fault plane and also if we have some striation on the fault plane, so we will bring this 2 striation and pole to the fault plane on the same great cycle and draw a line through this, then we will get a movement plane.

And also then we will consider a theta, theta is basically the angle between this fault plane and the sigma 1. So, this is 30 degree, this is theta and then we have seen that sigma 2 lie on the fault plane, so on stereonet we will plot sigma 2 at 90 degree from this slicken line on the fault plane, because we have seen in the previous illustration that sigma 2 always lie on the fault plane.

And sigma 1, sigma 3 is perpendicular to the sigma 2. So, we will then plot sigma 1 and sigma 3 on the movement plane at an angel theta and theta plus 90 degree from the slicken line and theta is 30 degree for sigma 1. Then for normal fault how we will calculate theta, for the normal fault? Since we know that the normal fault, so sigma 1 should be at high angle. So, what we will do? We will calculate theta opposite to the dip direction, on the movement plane at 30 degree from the slicken line.

And for the reverse fault we will count theta towards the dip direction from the slicken line on the M plane. And for the dextral or right lateral strike slip fault theta has to be counted clockwise form the slicken line on the M plane. And for sinistral or left lateral strike slip fault theta has to be counted counter-clockwise from slicken line on the M plane.

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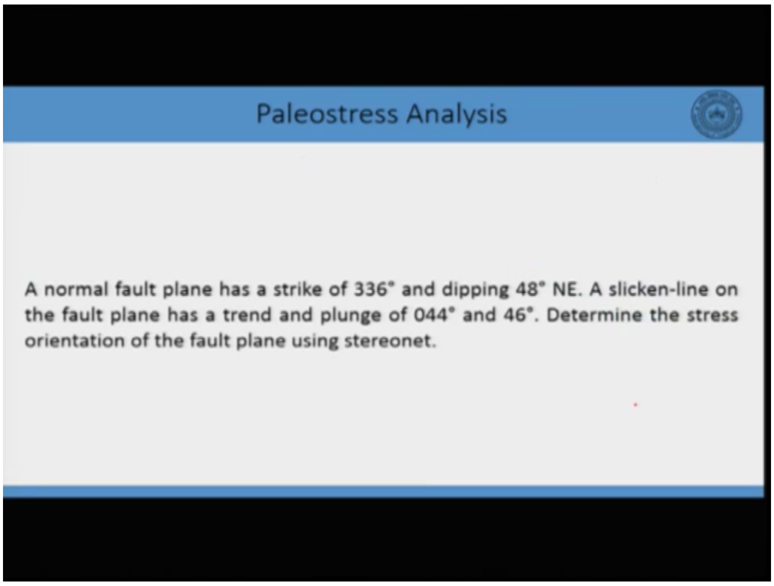

So, we will go to the question? So, the question is a normal fault plane as a strike of 336 degree and dipping 48 degree north east. A slicken line on the fault plane has a trend and plunge of 44 degree and 46 degree. Determine the stress orientation of the fault plane using stereonet. So, what we know? That the fault is normal, and the strike of the fault is 336 degree and it dips 48 degree towards north east.

And the slicken line or slicken slide on the fault plane as a trend of 44 degree and a plunge of 46 degree. So, we will use the stereonet to determine the stress orientation, basically the sigma 1, sigma 2 and sigma 3.

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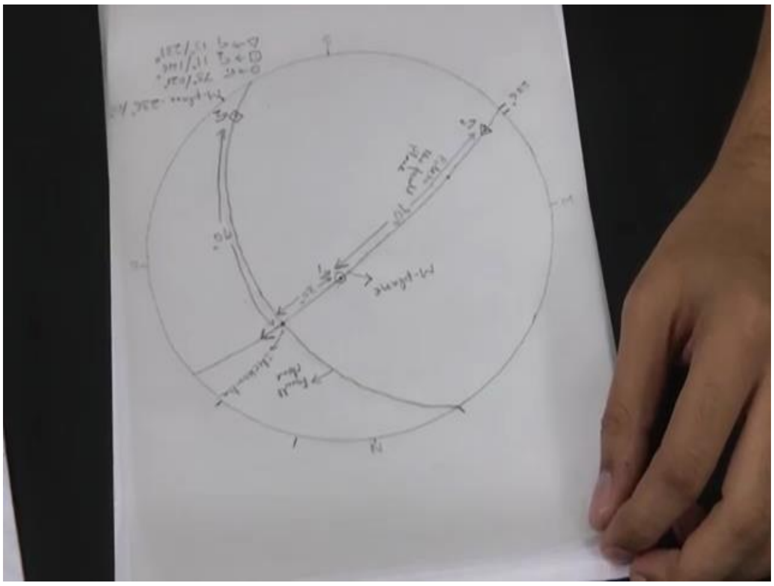

So, we will go to the stereonet and solved the problem. So, we know that the fault is normal fault, and the strike is 336 degree and dipping 48 degree north east, so first we will mark the strike. So, we know that this is 90 degree, this is 180 degree this is 270 degree, then 280, 290, 300, 10, 20, 30, 330, then 332, 334, 336, so this is 336.

So, we will bring this strike on the north and count the dip from the east, so the dip is 48 degree 10, 20, 30, 40, 42, 44, 46, 48, so this is 48, so now I will draw a great circle through this, so this represent the fault plane. And also, I will plot the pole to the fault plane. So, it will be 10, 20, 30, 40 and this is 48, so it represents the pole to the fault plane.

So, I can write this as 4 to the fault plane and this is the fault plane. Now, I will rotate this tracing paper and bring back to it is original position, so this is the fault plane. So, now I will mark the trend and plunge of this slicken line which is exposed on this fault plane on the stereonet.

Since it is on the fault plane, so it should lie within this great circle of this fault plane, so the trend is 44 degree of the slicken slide, so 10, 20, 30, 40, 42, 44, so this is 44 and now I will rotate this tracing paper and bring this trend on the east to west line. So, the plunge is 46 degree, so 10, 20, 30, 40, 42, 44, 46, so this so see this is lying on the fault plane.

So, this is the slicken, slicken line on the fault plane. And now what I will do for making the movement plane we have to bring this slicken line and pole to the fault plane on the common great circuit, so now I will rotate this tracing paper and bring these 2 points on the common great circuit.

Now, they are lying on the common great circle, so I will draw a great circle passing through these 2 points. And now I will rotate this tracing paper and bring back to its original position. So, this represent the M plane moving plane, so I will write it as M plane. So, now we have the fault plane which is this one and we have the moving plane, which is perpendicular to the fault plane, passing through the slicken line.

So, for the normal fault you draw the sigma 1, what we have the assumption that theta should be opposite to the dip direction of the fault plane at 30 degree from the slicken line. So, this is the fault plane, and it is dipping towards this side since this is in normal fault, so movement is towards the dip direction. So, for normal fault what we do?

We mark and arrow showing that movement is towards the dip direction. And to determine the stress axis principal stress axis the assumption is that sigma 1 is 30-degree opposite to the dip direction on the moving plane. So, we will determine the sigma 1, so sigma 1 is opposite to the dip direction, so we will count 30-degree opposite to the dip direction of the fault.

So, here this is 4 degree, then it is 14, then 24, this is 24 and 26, 28, 30, so this point will represent the sigma 1 and 90 degree from this sigma 1 will represent the sigma 3, so 90 degree we will count from the sigma 1, now this is 4, then 14, then 24, 34, 44, 54, 64, 74, 84 and 84 plus 6 will be the 90, then 86, 88, 90, so this point will represent the sigma 3, which I will mark as a open triangle.

Since sigma 2 has to be on the fault plane and the assumption is that you should be at 90 degree from the slicken line. So, we will count 90 degree from the slicken line, so this is again 4, then 14, 24, 34, 44, 54, 64, 74, 84, 84 and 86, 88, 90, so this will be the sigma 3 which I will mark as a open box.

So, again what I will do? I will again rotate this tracing paper to its original position and this open circle represent the sigma 1 and this triangle represent the sigma 3 and this open box represent the sigma 2. And what are the values of these sigma 1, sigma 2, sigma 3 and moving plane?

We know the values of faults plane slicken slide, so we will determine the values of M plane sigma 1, sigma 2 and sigma 3. So, first to determine the attitude of M plane we will mark this is so, so this strike is, this is 180, 90, 200, 210, 20, 30, 236, so this is 236 and the dip is, we will rotate this strike to the north and determine the dip and the dip is 80 degree.

So, the values of M plane is, 236, 80 degree. And what are the values of sigma 1, sigma 2 and sigma 3? Since this is the normal fault, so in normal fault we know that sigma 1 is vertical and sigma 2 and sigma 3 will be horizontal. So, it should be at higher angle, the plunge of the sigma 1 should be at higher angle and the plunge of sigma 2 and sigma 3 should be at should be lower.

So, in this plot we see that sigma 1 is at higher angle and sigma 2 and sigma 3 as a lower angle or most it is horizontal, so we will count its trend and plunge of this sigma 1, sigma 2 and sigma 3, so the trend is, we will bring this sigma 1 on the east west line and mark it trend and count the plunge trend 20, 30, 40, 50, 60, 70, 70, 72, 73, so plunge is 73 degree, plunge is 73 degree and trend is 10, 20, 21 degree.

So, sigma 1 I represent is as a open circle, so this open circle represent this sigma 1 and its plunge is 73 degree towards 21 degree. And now I will count the trend and plunge of sigma 2 which I represent it by the open box, sigma 2, so again I will bring this sigma 2 on the east west line and mark the trend and count the plunge to its 10 an 11 degree.

So, the plunge is 11 degree and the trend is and the trend is 100, 110, 130, 140, 42, 44, 46, 146 degree, 146 degree, so the plunge is 11 degree and trend is 146 degree. And for sigma 3 again I will bring this sigma 3 on the east west line and mark the trend and count the plunge, so plunge is 10, 12, 13 degree so it is 13 degree and so these traces represented by open triangle sigma 3 is 13 degree towards 180, 90, 200, 10, 20, 30, 230, 236, 238 sorry 238.

So, this is the complete solution of this fault plane and the stress orientation, which causes this normal fault plane to occur, so this is a normal fault, so the movement of fault plane should be in towards the dip direction and sigma 1 should be counted opposite to the dip direction at 30 degree from the fault plane and sigma 2 should be 90 degree, sigma 3 should be 90 degree from the sigma 1 on the M moving plane and sigma 2 should be 90 degree from this slicken line, this is slicken line or slicken slide, on the fault plane it should be 90 degree from slicken line the sigma 2.

So, through this process we can determine the paleostress of the fault plane. So, in field to determine the paleostress we take n number of data and plot it on the stereonet and in the field also we have to categories the fault plane based on our observation and the movement of this fault whether this normal fault, Reverse fault or strike slip fault and group them into different in categories and then determine this paleostress through this PT axis this method is called PT axis method or we have online software free available software through that also we can determine the paleostress.

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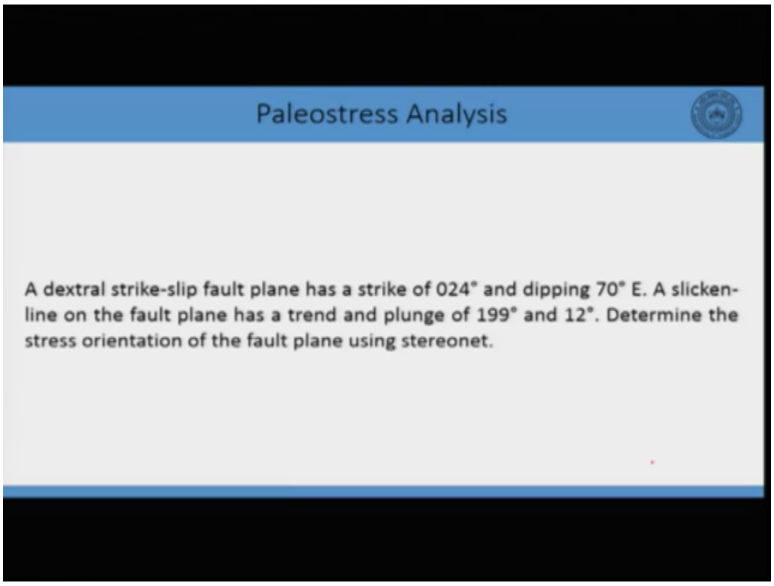

Now, we will go to the second question. The question is a dextral strike slip fault plane has a strike of 24 degree and dipping 70 degree east. A slicken line on the fault plane has a trend and plunge of 199 degree and 12 degree. Determine the stress orientation of the fault plane using stereonet.

So, we know that the fault is dextral strike slip fault and the strike is 24 degree, dipping 70 degree and the slicken line on the fault plane has a trend of 199 degree and plunge 12 degree. So, we will use stereonet to determine the stress orientation of this fault.

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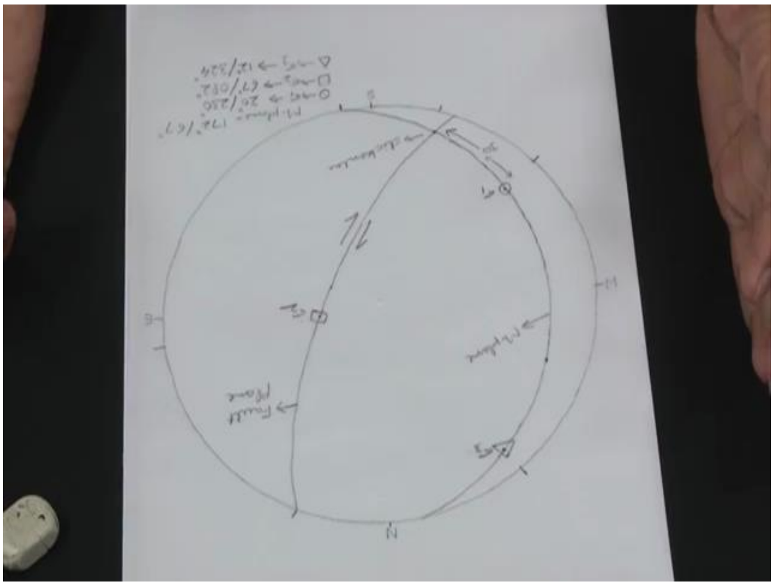

So, the strike of the fault is 24 degrees and dipping 70 degree, so we will mark the strike, the strike is 10, 20 and 24, now we will rotate this tracing paper and bring this strike on the north and count the dip, dip is 70 degree so 10, 20, 30, 40, 50, 60, 70, so this is 70 degree, so I will draw a great circuit through this point.

Now, I will plot the pull to the fault plane, so it should be, this is 20 then I will add 70, so just I will add 70 degree, 10, 20, 30, 40, 50, 60, so this is pole to the fault plane. And the trend and plunge of the slicken line on the fault plane is given which is trend is 199 degree and plunge is 12 degree.

So, I will mark the trend, so this is 180, 190, this is 199, now I will rotate this trancing paper and bring this trend on the east west line, so this is 10 or 12 degree, so this represent this point represent the slicken line on the fault plane. Since this is the strike slip fault, so the slickens movement will be in this direction along the strike and that is why this the value plunge of this slicken line is low.

And now I will draw a moving plane for which I will bring these 2 points on a common great circuit. So, now they are on the common great circuit, so I will draw a great circuit passing through these 2 points. So, now I will bring this tracing paper back to its original position, so this is the fault plane, and this is the M plane.

This is the slicken line in the fault, since this is the dextral fault, so it will be like this and to determine the 3 principal stress axis sigma1, sigma 2 and sigma 3, so for the dextral fault the assumption is that theta would be counted clockwise from the sheet out we counted clockwise from the slicken slide.

So, now we will count these 30 degrees from the slicken slide clockwise, so this is the clockwise direction and this will be the anti-clockwise direction. So, sigma 1 will be this is 10, 20 and 30, this point will represent the sigma 1 and 90 degree from the sigma 1 will represent the sigma 3.

So, 10, 20, 30, 40, 50, 60, 70, 80, 90, so this point will represent the sigma 3, this open circle. And to determine the sigma 2 we will count 90 degree from this slicken line on the fault plane. So, for the sigma 2 this is 8, 2, 4, 6, 8, then 18, 28, 38, 48, 58, 68, 78, 88 and 90, so this point will represent sigma 2.

Now, again I will bring this tracing paper back to its original position. So, this one is sigma 1 this sigma 3 and this is sigma 2. And what is the value of, so this strike and sip of this moving plane is dip is 10, 20, 30, 40, 50, 60, to 64 to 67 degree and the strike is strike is 172 degree, so M plane strike is 172 degree, dipping 67 degree.

And what are the value of sigma 1, sigma 2 and sigma 3? So, sigma 1 is represented by open circle, sigma 1 and the trend and the plunge of the sigma 1 is, I will bring this sigma 1 on the east west line and mark the trend and count the plunge, so plunge is 20 degree and the trend is trend is 200, 10, 20, 230, 230, so plunge is 20 degree towards 230 degree and for sigma 2, I will bring this again on the east west line and mark the trend on the plunge 10, 20, 30, 40, 50, 60, 62, 64, 66, 67, 67, so the plunge is 67 degree towards 82 degree.

And sigma 3, sigma 3 I will bring it to the east west line this sigma 3 mark the trend, this trend plunges 10, 12, 12-degree 12 degree and trend is 270, 80, 90, 300, 310, 320, 22, 24, 324, so this we can determine the stress orientation or the principal axis of stress which causes this fault plane.

Since this is the strike slip, this is the dextral strike slip fault, so we will count theta, we will count theta 30 degree clockwise. So, this is the complete plot, so this is the dextral strike, this is the dextral strike slip fault which was given in the question, the strike and dip has been given as well as this slicken slide the wealth trend and the slicken slide. So, what we did?

We them plot a M plane perpendicular to this fault plane passing through this slicken line and then for dextral strike slip fault we have to count theta which theta is the angle between this maximum stress sigma 1 and the slicken lines.

So, basically the fault lines the 30 degree between the sigma 1 and the fault plane, so which we take it from slickens line, which is 30 degree clockwise, so this is 30 degree clockwise for dextral strike slip fault, if the fault plane is sinistral so we will count a counter clockwise form this slicken slide, so it will come here some 30 degree for the sinistral strike slip faults.

Since this is extra so we count counter clockwise and this is 30 degree. And from sigma 1 we took 90 degree and plot sigma 3 on the moving plane and then for the sigma 2 we take 90 degree from the slicken line on the fault plane and plot sigma 2. So, these are these stress principal stress directions for this fault plane. So, in filed we take n number of data and plot it on the stereonet and take a best take the best one which represent for these faults.

And through that we can determine the paleostress for the faults. Also, there are online software through that also we can calculate the failure stress directions. Thank you again we will come with the lab session.