Rock Engineering
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Lecture-07
Spherical Representation of Geological Data-02

Hello everyone. In the previous class we discussed about the spherical representation of the geological data. Then we saw that how we can use the earth, that is longitude and latitude to represent the geological data. Then we saw how the intersection of a plane and the sphere can be denoted in that spherical plot. So, today what we are going to do is, we will see that how we can get the intersection of a line and the sphere, followed by the discussion on equal area projection. And then we will see how to represent a plane with the help of a great circle and a pole on to the stereo net.

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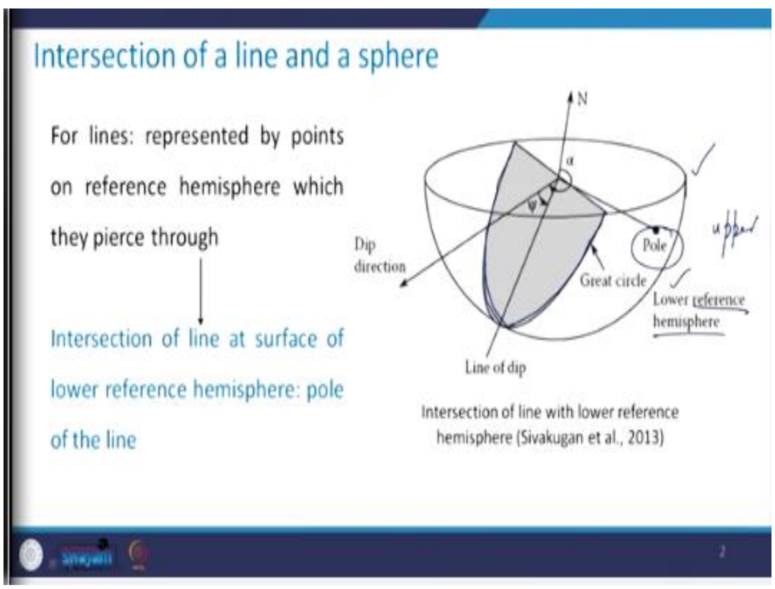

So, let us start with our discussion on intersection of a line and a sphere. So, as you can see and connected with our discussion on the previous class. This figure we had in the previous class where this plane, which is the shaded plane that is, this one is showing the great circle which we had that as a plane and its intersection with that sphere. And we saw in the previous class that both the hemisphere, lower as well as the upper hemisphere, they represent the same informations.

We will be having the reference as a lower reference hemisphere only. So, you see for lines, this is represented by the points on reference hemisphere which they pierce through. So, you just imagine a 3-D situation where you have a sphere and there is a line. So, how will its intersection will look like, it will not look like a plane but it will look like a point. So that is what we call as the pole of line. So, intersection of a line at the surface of lower hemisphere is the pole of the line.

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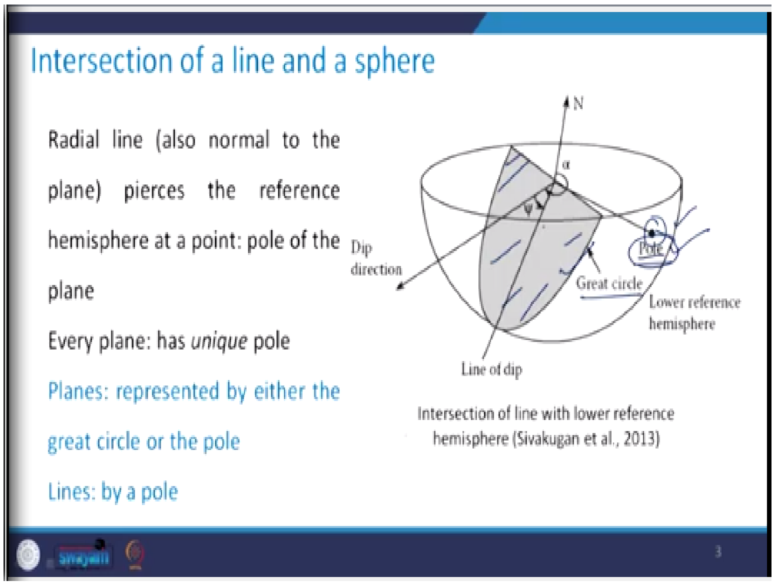

Now in other words, say this is the plane and when you have that line which is perpendicular to this plane, it intersects the hemisphere at a particular point which is called as pole. So, this is also called as the pole of a plane. So, remember every plane will have a unique pole because the normal to that will be one and its intersection with the sphere is going to be unique.

So, please remember that planes are represented by either the great circle, that is this or as pole and lines are represented by a pole. Please remember, once again planes are represented either by a great circle or a pole and lines by a pole. So, let us have a look on the concept of this equal area projection which is also known as Lambert or Schmidt projection. As it is name suggests, that means, we have to equate two areas, now what are those.

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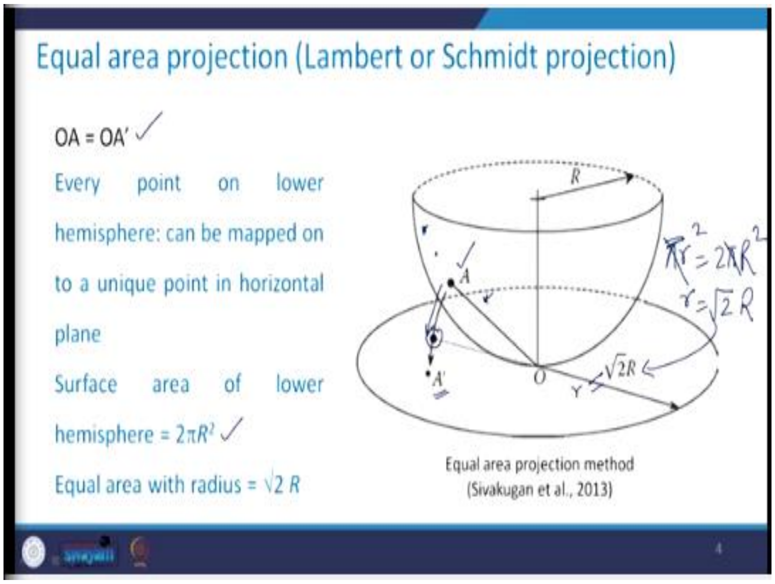

Take a look here, that any point on the hemisphere, let us say it is represented by a point A and this can be mapped uniquely on a horizontal plane, like let us say this is a point A' here. So, what we are doing is, any point A take an arc OA rotate it in this particular manner, such that OA equal to OA'. And therefore, any point B at this point, this point or anywhere on this sphere that can be mapped onto the horizontal plane in the unique manner.

Now this can be taken as an example that you have an orange take of it is peel and just spread it on a horizontal plane, so it is exactly the same thing. Now see the surface area of the lower hemisphere is $2\pi R^2$. And let us see if the radius of this circle on the horizontal plane is R, so what we do is, we equate the area of this horizontal circle to the surface area of the lower hemisphere.

So, see what that will be πr^2 that is going to be $2\pi R^2$, now this π and this π will get cancelled and small r will become equal to $\sqrt{2}R$. So, this is what has been given here, that is the equal area equivalent area which is equivalent to the surface area of the lower hemisphere will have a radius of square root two times the radius of the hemisphere. So, with this concept of equal area projection, we will use this for the representation of the geological data.

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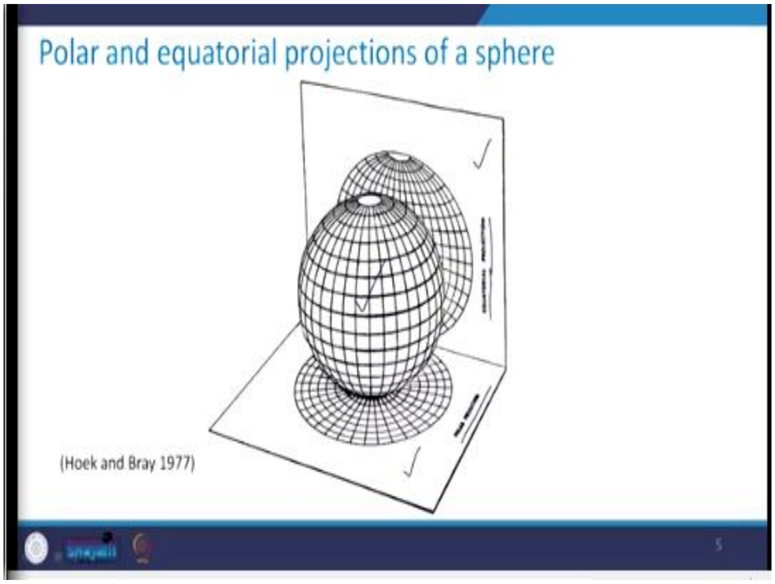

Now as we discussed in the previous class that think of a globe and its latitude and longitude to be used for the representation of the geological data. So, just see that you place the globe in the space and you have a vertical plane and you have a horizontal plane. This vertical plane is called as equatorial plane or the projection on the vertical plane that will be called as equatorial projection.

And when we have its projection on the horizontal plane, this is called as polar projection. So, polar and equatorial projections of a sphere, that means the projection of the sphere on the vertical plane is equatorial projection and that on the horizontal plane is polar projection. So, what we are going to learn here is now about the stereonet.

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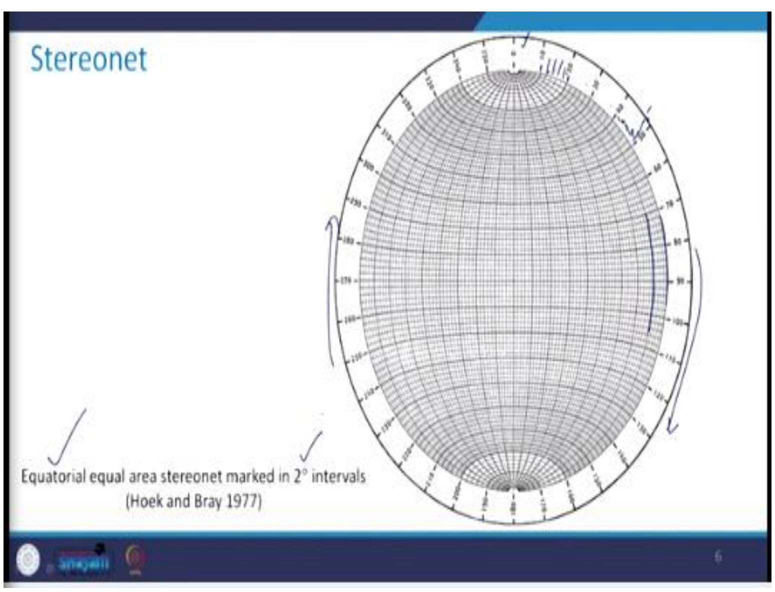

So, you see that this is equatorial equal area stereonet, what does that mean? That it is the projection on the vertical plane. So, when we look at it starting from 0° then all around it is circumference or the periphery you have up to 360°. So, you see 10, 20, 30, 40, so the periphery has been divided into these number of segments representing 10° each. Every 10° is further divided into 5, 1, 2, 3, 4 and 5, five parts that means it is marked at 2° interval.

So, that is why we are seeing here that this is showing the equatorial equal area stereonet, which is marked in 2° interval. So, not only in the peripheral direction but also if you see in the longitude direction also. So, you see in the latitude direction we saw that it is 1, 2, 3, 4 and then the fifth one, it is like this. And then when you see in the longitude direction, that here few lines are dark lines.

So, you see this is the first one, then the next longitude is this which is the dark one. So, this is representing 10° then again in between these two it has been divided into five intervals, each representing 2°. So, likewise when you use this stereonet which is having 2° of interval. So, using the information in the form of dip and dip direction, we should be able to use this stereonet for the representation of the geological data, how we will do that.

We will do it as a form of exercise today in the class only. Now similarly here we have polar equal area stereonet which is again marked in 2° interval. So, again you can see that it is the projection of that sphere on the horizontal plane. So, it is you see that it is varying from 0 to again here 360° here all around.

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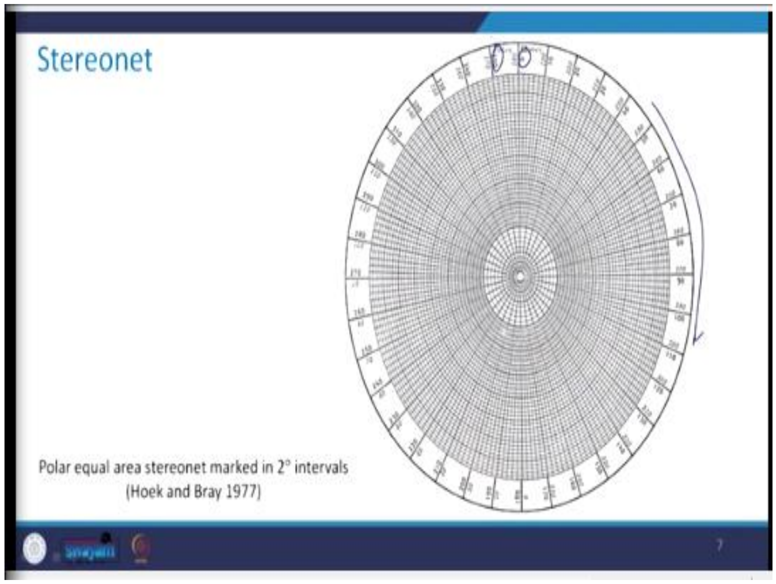

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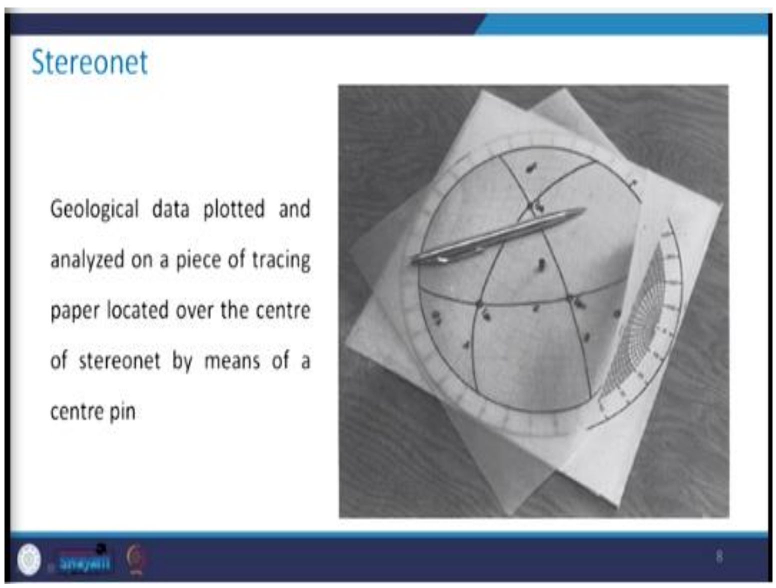

Now let us see how to make the use of this stereonet, you can take the printout of the stereo net as I mentioned to you, the printout is this. So, there 0° means, I will be representing that as not and accordingly I will fix all the other direction, that is north, south, east and west. Then on top of that we will place a tracing sheet, this is what is your tracing sheet. And we can pin that tracing sheet with that stereonet at the centre.

So, this point of tracing sheet as well as the stereonet that will be fixed. And then using the procedure that I will be explaining it to you just now. We can locate planes, lines and carryout any kind of analysis let us say that, there are two planes which are intersecting each other. Now their intersection is going to be represented by a line. So, how to represent that line of intersection of those two planes on this tracing sheet.

Second example can be let us say that, there are two lines which are they are maybe let us say two axes for the tunnel. Now I want to find out that what is the angle between those two, how to do that? So, all those things, we need to do graphically using this procedure. So, in this case, the geotechnical data is plotted and analyzed on a piece of this tracing sheet which is pinned at the centre of the stereonet and then you can just rotate and carryout the analysis.

So, we take an example of construction of a great circle and a pole which is representing a plane. Just now we discussed that a plane can be represented either by a great circle or by a pole, how? So, the answer to that how we are going to learn now. So, what I have done here is I have carried out that graphically using the tracing sheet on top of that stereonet. So, I will be simultaneously taking you through each and every step which is to be followed on the tracing sheet, let us see that one by one.

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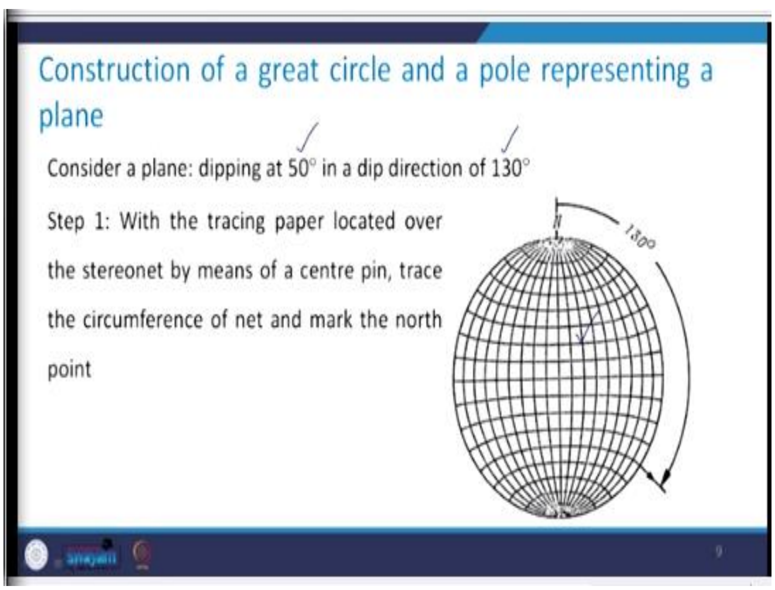

So, the plane has a dip of 50° and a dip direction of 130° and that is to be represented on a 2-D plane by means of a great circle and a pole, how to do that? So, the step 1 will be that we take the tracing sheet, say this is what is your stereonet. We put the tracing sheet on top of this and put a centre pin and what we do is, we trace the circumference of net and mark the point, north point.

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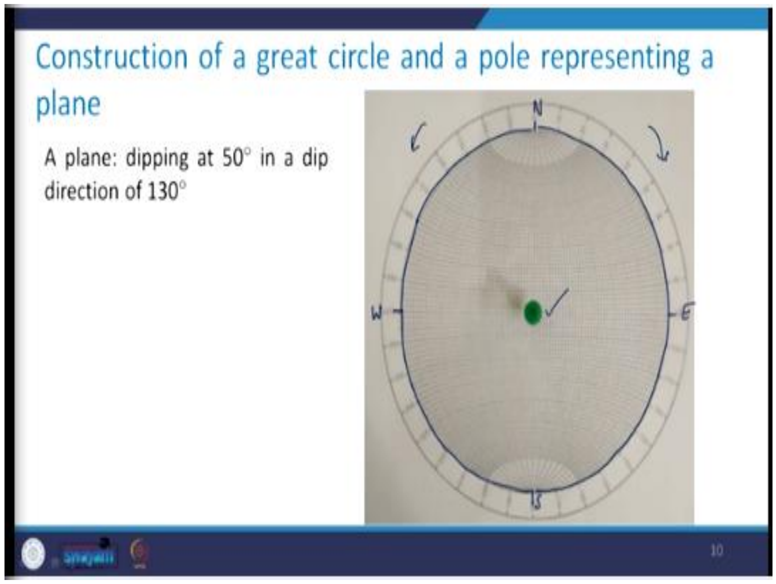

See this is how that we are going to do. So, here you see that that stereonet and on top of that I have placed the tracing sheet and this is where at the centre I have pinned it. So, I mark it here as this is north, this will be south, this is your east direction and this is West. Now what I do is, I mark this, I can trace, so this is how the sphere or its projection will look like. So, this is how that you have to do it, fine. Now see since this is pinned at here, so if we just rotate it either side or this side, this position will not be changed, so now what will be the next step.

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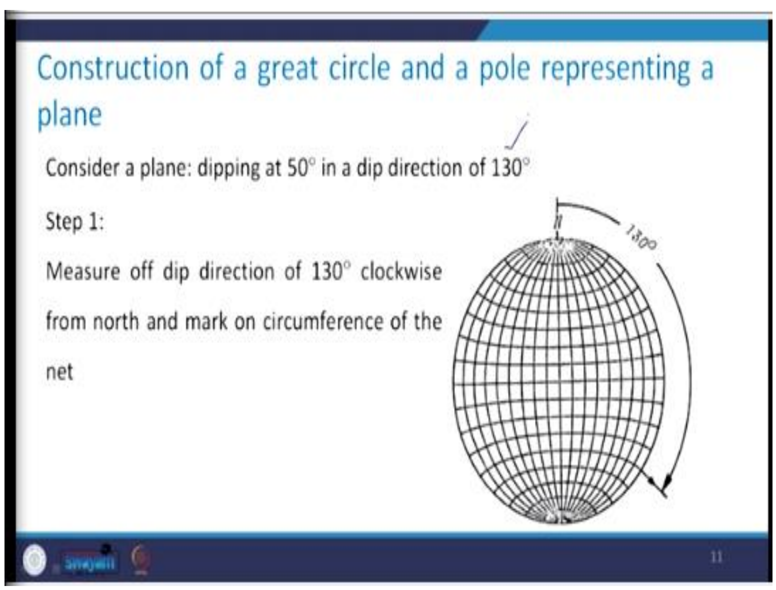

Next step I mean that is inclusive of this first step only that from this north we measure of the dip direction of 130°, because the plane has a dip direction of 130°, so how to do that?

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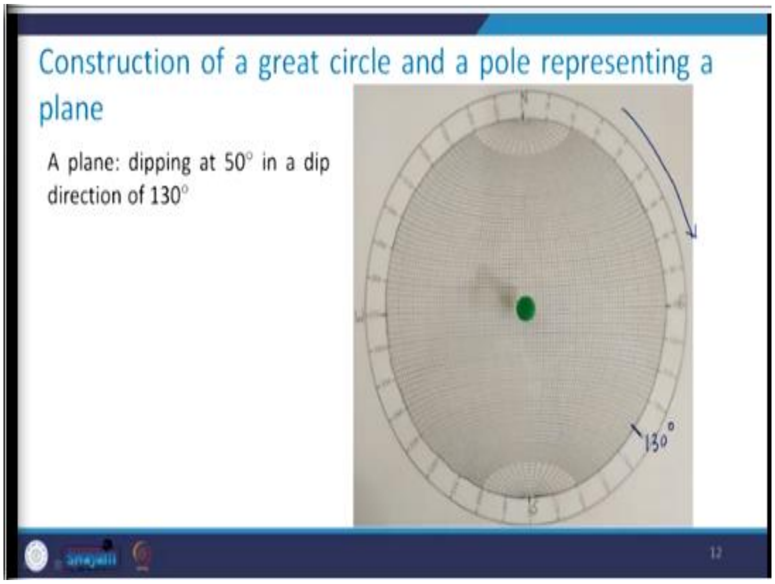

Look here, this is again I am back to this tracing sheet, so you see 10, 20, 30, 90. So, here this mark is 130°, this is what is 130°. So, from the north direction, I will mark along its periphery this 130°.

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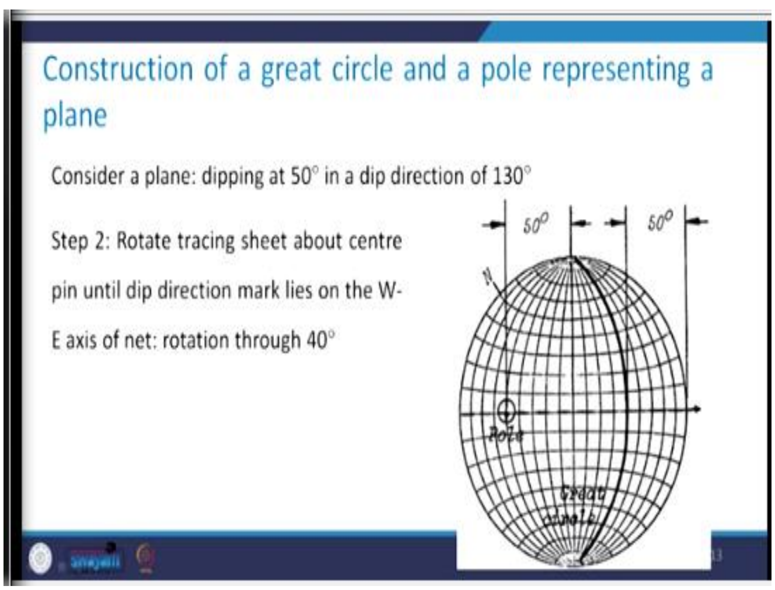

Now what is the next step is. We rotate the tracing sheet above the centre pin until that mark corresponding to dip direction of 130° lies on west east axis of the net.

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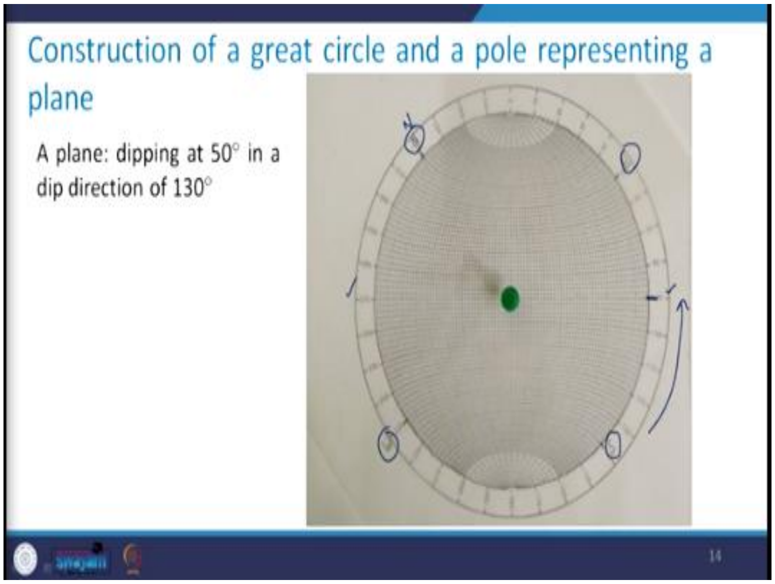

So, let us see how this is done, so you see that mark was earlier here, so I rotated it, this was the mark was here. So, you see this was the mark, so I have rotated, see this is 130°, so I have rotated it back. So, you see that, now the north has been shifted from this place to this place, now this is north, can you see the marking here which was the original marking this is north, south, east and west.

So, I have rotated it in such a manner that the 130° mark is now coinciding with this mark of 90°, 270°, that means it is lying on the west east axis.

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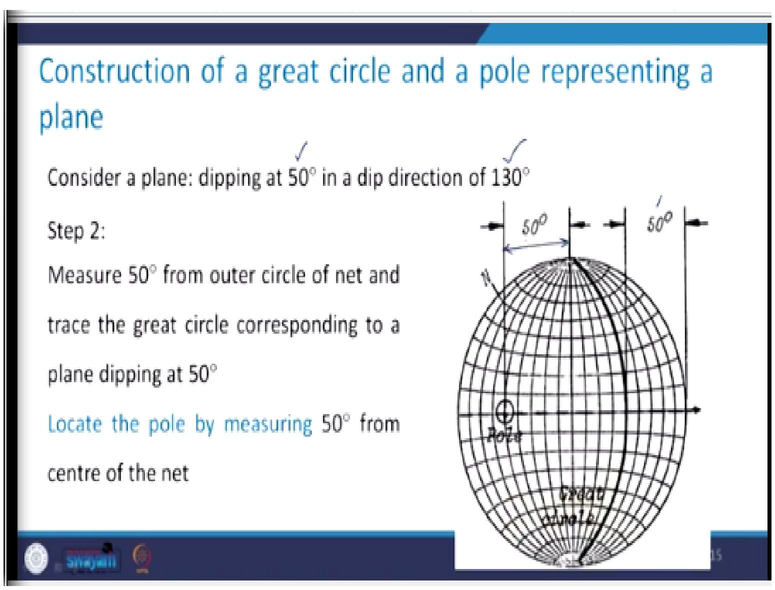

Now what is the next step? What we need to do is now? We have to measure 50° from this outer circle and whatever is the great circle corresponding to this point, that is going to give me the great circle corresponding to the plane which has a dip of 50° and a dip direction of 130°. And then the pole is located like for the dip you will take from the extreme point towards the centre. But for pole, to locate the pole you have to take it from the centre, that means this distance is 50°, let us see how this is done?

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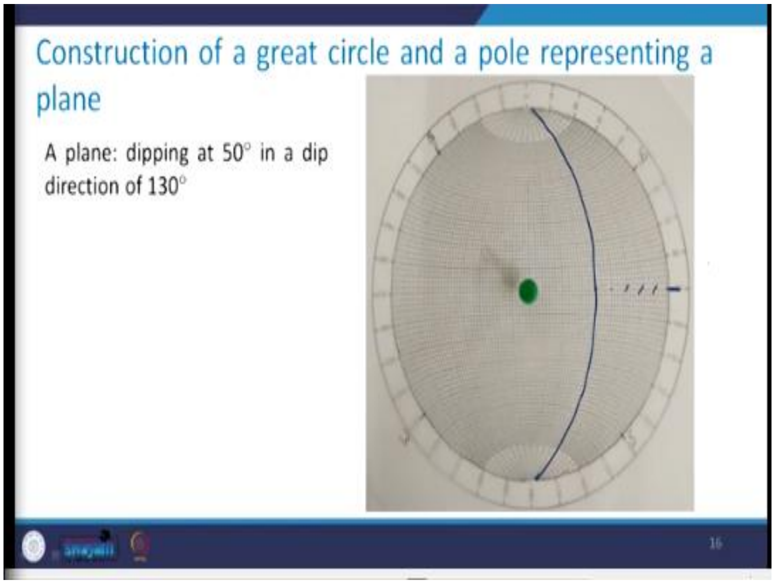

So, this was the mark which was corresponding to 130°, so from the outer plane see, I mark it as 10, 20, 30, 40 and then 50. So, this was the point, now corresponding to that point whatever is the great circle. So, you see this is what is going to be the traversing, like this. So, this is how one can get the great circle which is representing a plane that is dipping at 50° with a dip direction of 130°, now how to locate the pole.

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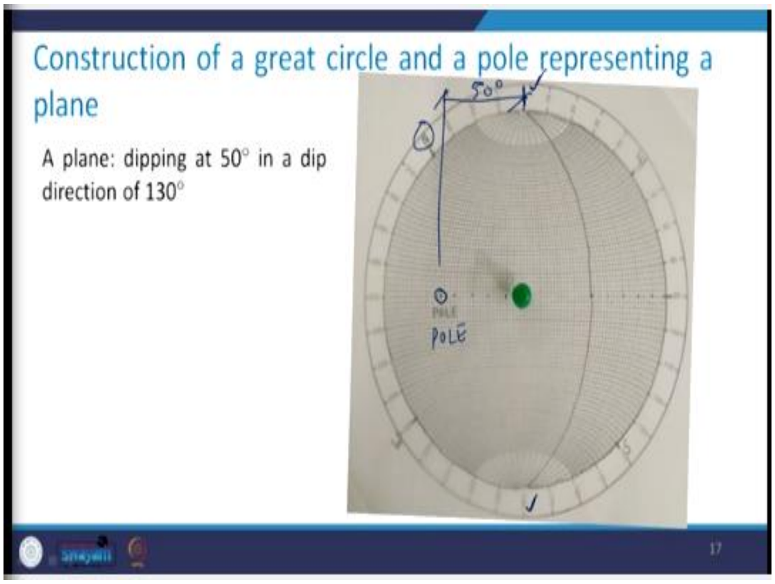

So, you see the next step in this case I took it to be say from here 1, 2, 3, 4 and 5 each are representing 10°, so 50°. Now in this case I will take it from the centre, so this is the pin centre, so 10, 20, 30, 40 and this is the 50 point. So, this point is going to give me the pole, that means what from this centre point to this which is from here to here, that is 50°, this I have to measure from the centre.

So, please remember larger is the dip, farther will be the pole from the center. Larger is the dip, closer will be the great circle towards the center. See the north is right now here, so I will rotate it back again to the original north position. I hope that you are able to understand that the bottom stereonet is not being rotated. That means for that wherever there is a 0° it remains as it is, wherever there is 180° it remains as it is, we are only rotating the tracing sheet in order to represent the data.

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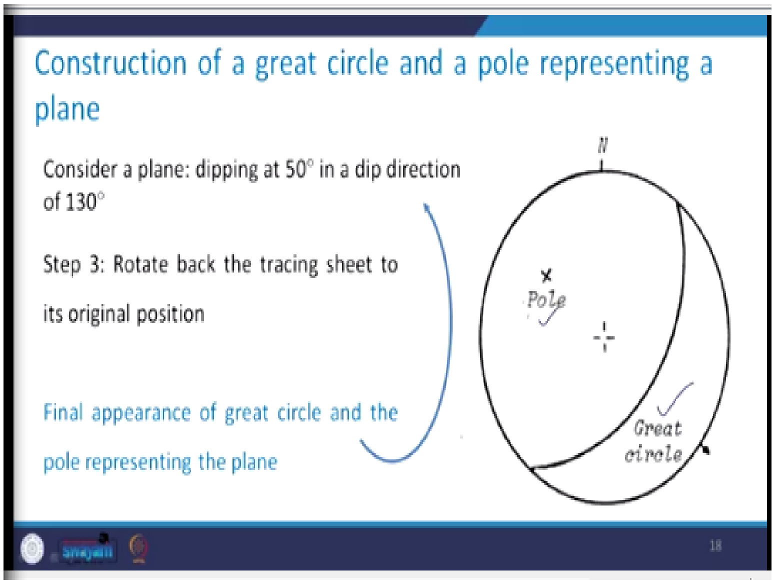

Now see the next step will comprise of that, rotate it back that is rotate the tracing sheet back to it is original position, so what does that mean? That north which is marked on the tracing sheet must coincide with the directions which are there in the stereo net, not only north but all the direction north, south, east, west. So, that the earlier one, that is the step 1, the first position of the tracing sheet is to be retained here.

So, when we rotate it back this is how the great circle and the position of pole will look like. So, this is going to give me the final appearance of the great circle and pole which is representing the plane which is dipping in 50° in a dip direction of 130°.

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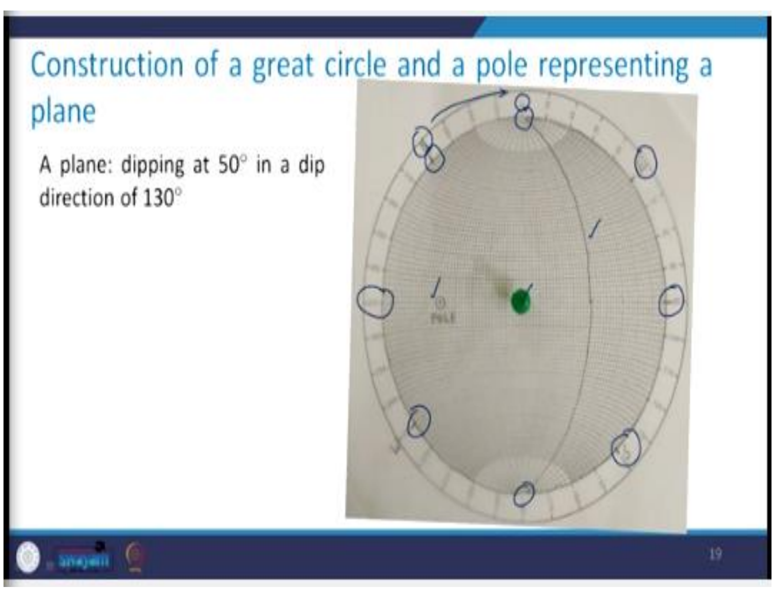

So, see how my tracing sheet looks like? So, this is what is the situation from the previous step. We have a great circle and we have a pole, you can see that here it is the 0° and this is the north here, which was there in the first step that we plotted on the tracing sheet. So, what we need to do is here? Again, we rotate it back in such a manner that this point coincides with this point and obviously since it is pinned at the centre. Automatically this east will coincide with this, this south will coincide with this and this west direction will coincide with this.

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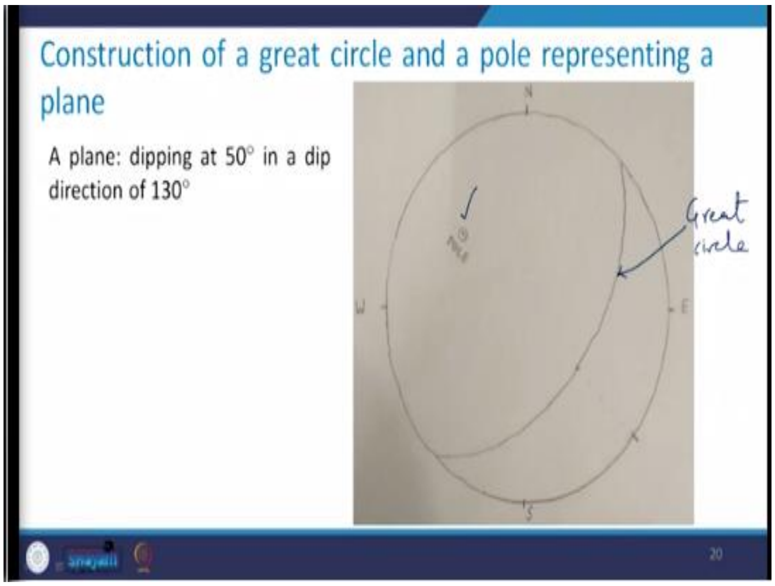

So, see this is how it looks like, so this is your great circle and of course this is going to be the pole. So, please remember that every plane can be represented either by a great circle or by a pole. This is how the construction of a great circle and a pole which is representing the plane, any plane is done. So, if I give you the dip and dip direction of any plane, you can follow this procedure to obtain the great circle and a pole representing the plane.

So, this is what that I wanted to discuss with you. So, what we discussed is that about the equal area projection, then how we can have the great circle and the pole representing a plane in 3-D and how we can present them in the form of a two-dimensional paper. Then using this procedure, we can represent any plane which maybe representative of a bedding plane or the slope anything. So, as we discussed in some of the earlier classes that you can have various geological structures and it is important for us to know that how to represent them graphically.

So, that the analysis can be carried out. So, this is how that we can represent the plane with the help of either the great circle or the pole. So, in the next class, we will learn about how to have the intersection of the two planes. How to obtain the angle between two lines? And then we will have some of the application areas. Thank you very much.