Earth Sciences for Civil Engineering
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Module 4
Lecture No 19
Geological structures (Part-3)

Ok, welcome back. So last lecture, we were talking about the plunging fold.

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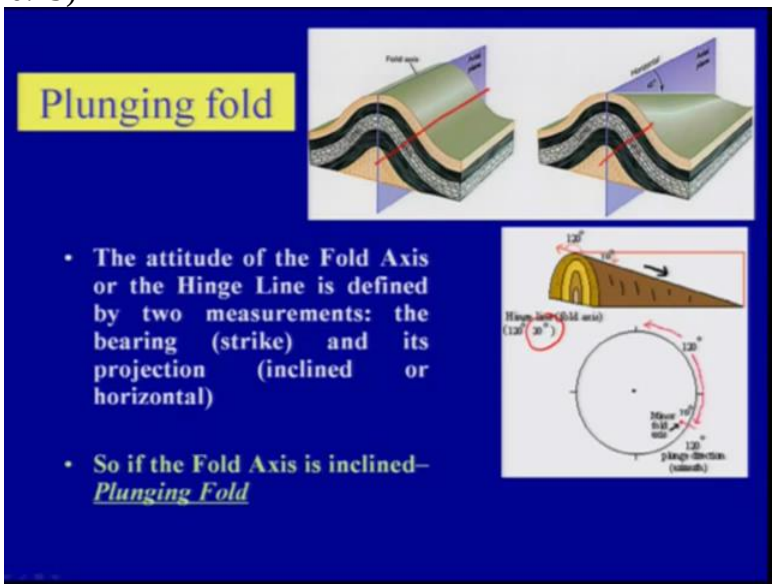

Now the importance here is the fold axis okay. If the fold axis is inclined, then we will call this as a plunging fold and if the fold axis is horizontal, we will say non-plunging fold okay. And this is extremely important because we need to know that where to put tunnel. And if suppose you are planning to put tunnel here, then the tunnel will go through across this bed here okay.

But if you are coming across the plunging fold then your tunnel will last up to this only where here you can go across this one okay. So that is very important in civil engineering. Also for us in geology or the earth sciences, it is extremely important because we need to understand the evolution of the fold. So this is very important for us also okay.

So the attitude of the fold axis or the hinge line is defined by 2 measurements, that is the bearing, the strike what you call and its projection, the incline or it is horizontal okay. So this we will talk about very quickly. So if the fold axis is inclined, then we will term that as an plunging fold. So

this is been represented like this and can be plotted on a steel unit, that we will see very quickly in the next one.

So here what we are adding is we are adding more attitude. Earlier we just had an strike of the axial plane or the fold axis but now we are having also the inclination. So this has been added here and if you have this inclination with respect to the horizontal, then you term that as an plunging fold.

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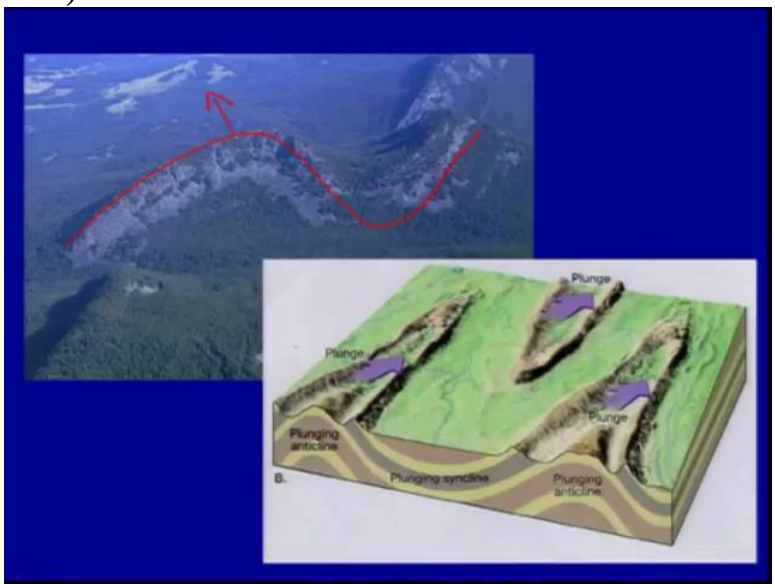

So here is an example of the plunging fold where you can see that there is an fold here. So from the front, you can make out that there is an fold but if you go further dip in this direction, then you see that it is dying out okay. So this is an example on the on the section if you look at, the plunging folds will die out at a distance if you travel okay. They will not extend further.

So accordingly, you can check. But on this face or the section you see a very beautiful folds which have been developed. So you may get confused okay. But one can sort out very easily if you are having the dip and strike of the beds or the limbs you are having that can help you in identifying the weather this is a plunging fold or not okay.

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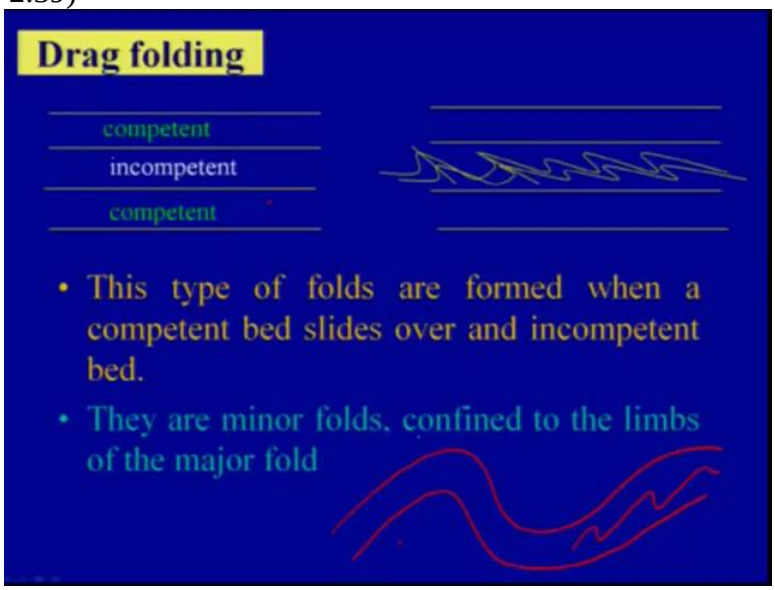

This is another important part where we talk about the difference in the strength of the layers or their strata or the beds where we have like incompetent beds, 2 incompetent beds and in between squeezed is your incompetent bed, then during the folding, this incompetent bed will slip okay. And that is extremely dangerous because you may say that the competent beds no no folding will take place and no slippage will occur but the incompetent beds or the layers will have problems okay.

They will slip and they will result into the displacement of the layers okay. So this type of folds are formed when competent bed slides over the incompetent one okay. So they are minor folds confined to the limbs of the major folds okay. So you not will not be able to see this type of fold on a very large-scale but they are within the folded layers okay. So you are having and they will slip like this okay. So you will have that what we call the drag folds okay. So these are the drag folds.

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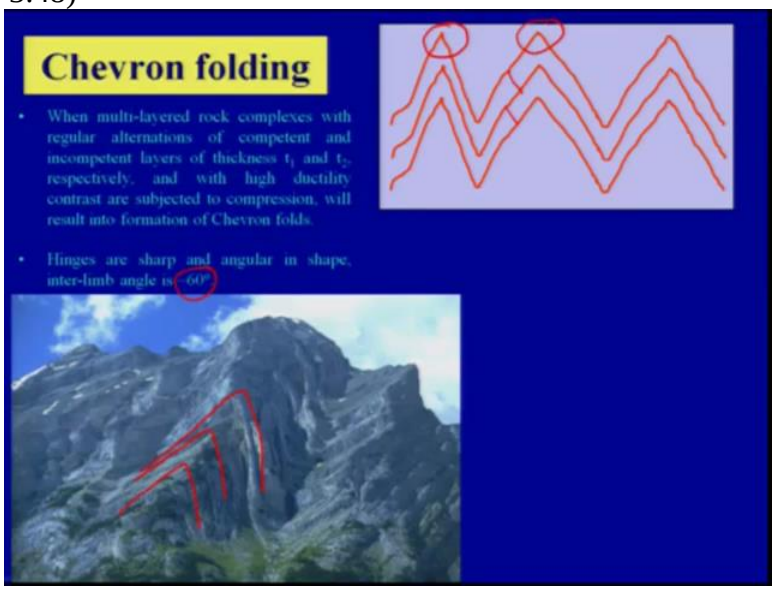

Then, Chevron folds. They are again multilayered you will see in the multilayered rocks okay, complexes, regular alteration of competent and incompetent layers again of the thickness T1 and T2 respectively if you take the thickness of these beds here and then with the high ductility in the compression region, they will result into the formation of chevron folds.

And they will have the tip that is very very sharp okay. So these are the hinge what we call the hinge okay. The upper crust or the hinge lines or the hinges are very sharp and angular in shape or it is or it goes up to the angle of around 60 degree. So this is an example of the chevron folds. You can see these hinge lines are very sharp here okay.

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This is another example and here you can see there is a slightly bending in the axial plane okay. And then there is an there is some slight of displacement over here what we call as an fault okay. So this is an this is an example of chevron fold and previous one was drag folding.

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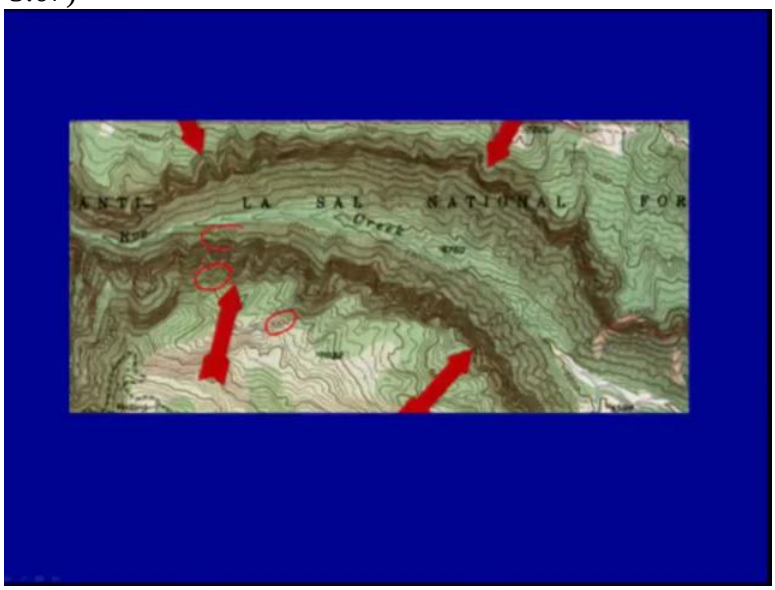

Now in the on the topographic maps also, you can easily make out that how the landforms, the folded areas can be looked at okay. So if you if you look carefully the contour values and all that and then spacing also between the different contours, one can make out that what is whether this is an so this here they are very closely spaced. Whereas here, they are slightly widely spaced okay.

So these are the escarpment or the limb of the fold and this is either the top or the basing part okay. But you can if you can see here, this is around 70,000 feet or either meter. And then there you are having, this is 6800, this goes to 6000. So the height is higher here. And then it reduces further down okay. So this could be like the stipling limb of one of the fold okay.

And then again you are having 5900 here. Then you are having 6000. And then you are having 7000 okay. So what we see here? If you look at the cross-section here, we have 7000. Then you are having the lesser one. Then you are having again lesser one. Then again slowly you are increasing okay. So this is what you are having the sync line here.

So these 2 points are 7000 here what we see in the cross-section. And then somewhere near a 5900 and then again you are getting up into 6000 okay. 6000 you got here also okay. So this is what we can say that this is an syncline. But this part is quite steep here okay. So this is this side is an anticline and another site, this one is your syncline or Valley okay.

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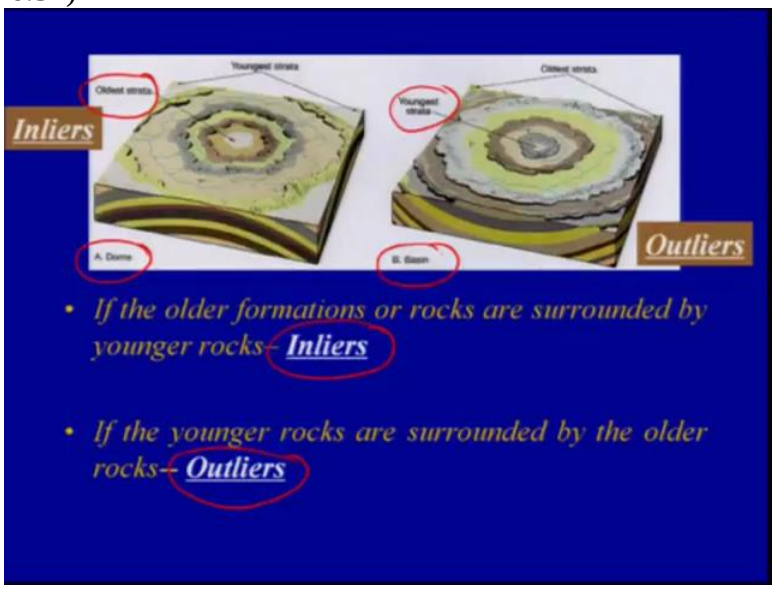

Again these are the few very important structures which are related to the anticline and syncline. So if you are having anticline structures here and if they are eroded on the surface then what you see is the drainages are are flowing away from the centre okay. Whereas here if you are having the basin or the syncline, then the drainage is moving towards the centre. And the dip if you see is been shown here okay with this smaller one.

So dips are like this, this is the strike and this is the dip direction. This is the strike and this is the dip direction. So they are dipping towards each other. So you are having the sync line here. Whereas here similarly, you were having the anticline which are dipping outside okay. So these are termed as, these landforms which are associated with this where you are having the older strata at the centre okay.

Older strata is at the centre when the younger stratas are surrounding the older one. Whereas here, what you see is that you are having the jungle stratas in and the older stratas out okay. So this is an, this is what is the difference between these 2 okay. So these are been termed as basin okay and this is these are termed as the domes okay. Further this is another term which has been given as inlier and outlier.

So if the older formations or the rocks are surrounded by the younger rocks, then they are termed as inliers okay. So older rocks surrounded by younger rocks. So this is your domal part which you are having the inliers okay. Whereas this one, is the younger rocks, we are having younger rocks are surrounded by the older rocks. So older rocks are on the outside here, periphery. Then what we say? This is an old outlier okay.

So we are having inliers an outliers which are associated with the anticline and syncline or we can say with the domes and basins okay. So these are inliers and these are outliers okay. So this also again, you can you should remember about that okay. And one can identify this based on the drainage also okay.

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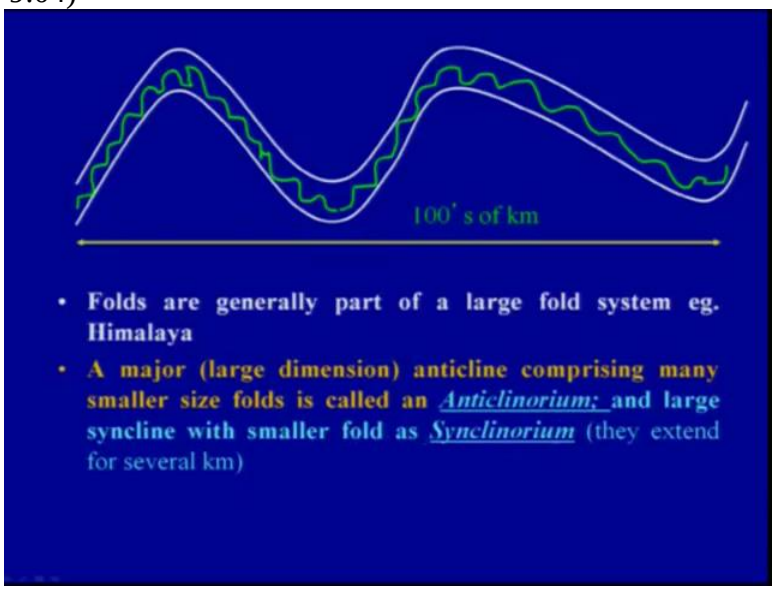

So this is another feature which is mostly associatedt with the larger folds what we call the mega folds. So these folds are generally a part of the large fold, that is we term that as an Anticlonorium or Synclonorium and they are been seen, associated along the within the limb of the major folds okay. So they are the smaller folds where again these are being termed as anticlines and synclines.

That we are having but they are termed as Anticlonorium and Synclonorium okay. And they extend for several kilometres okay around the major large fold okay. So folds are generally part of the large fold system. Example, this is a mega fold system, Himalaya. And major system anticline comprises many smaller size folds called Anticlonorium and the large synclines and the smaller folds associated with the they are termed as Synclonorium okay.

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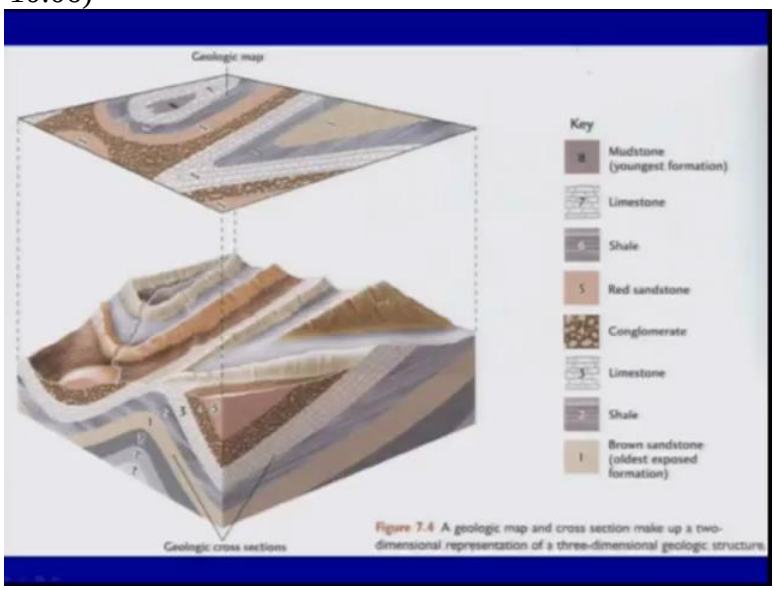

This is an example of that how they these folded sections are been represented on the on the geological maps. So these are the folded beds which are been shown here. So if you add here with the dip direction and the strike direction, you can easily make out or you can draw the sections also in this okay.

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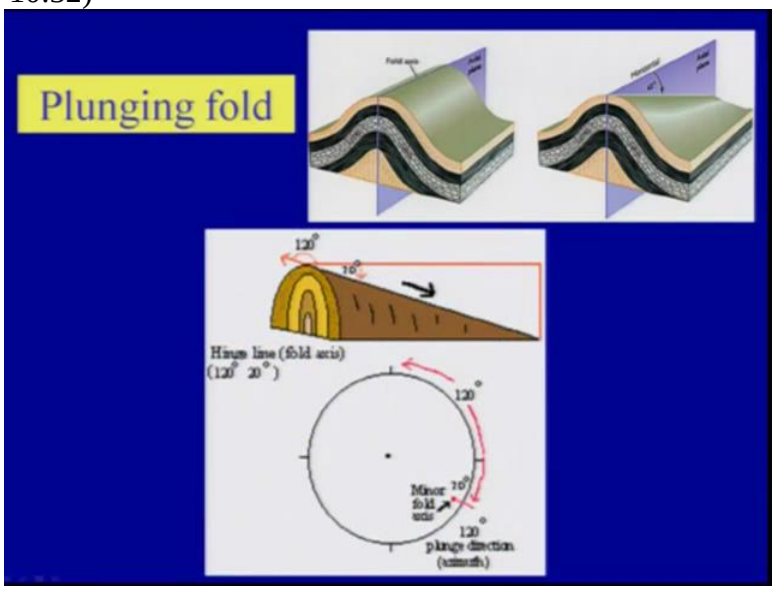

So plunging fold again coming back. So we were talking about that how we can plot this and know whether it is in plunging or not. So we will just go ahead with that.

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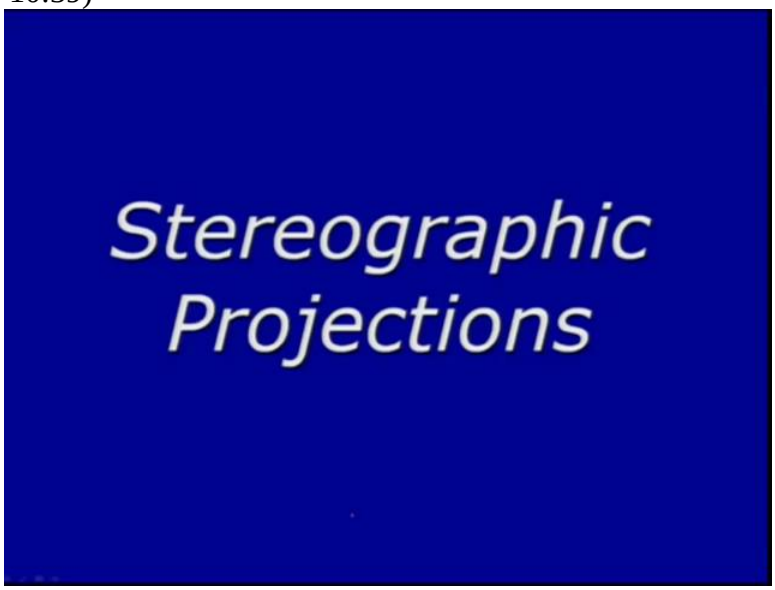

So this is what we use is these stereographic projection. Nothing but this is an knob like like stereographic projection which has been given and which is again representing the your coordinates okay or coordinate system that is the latitude and longitude. And that is how they are been given.

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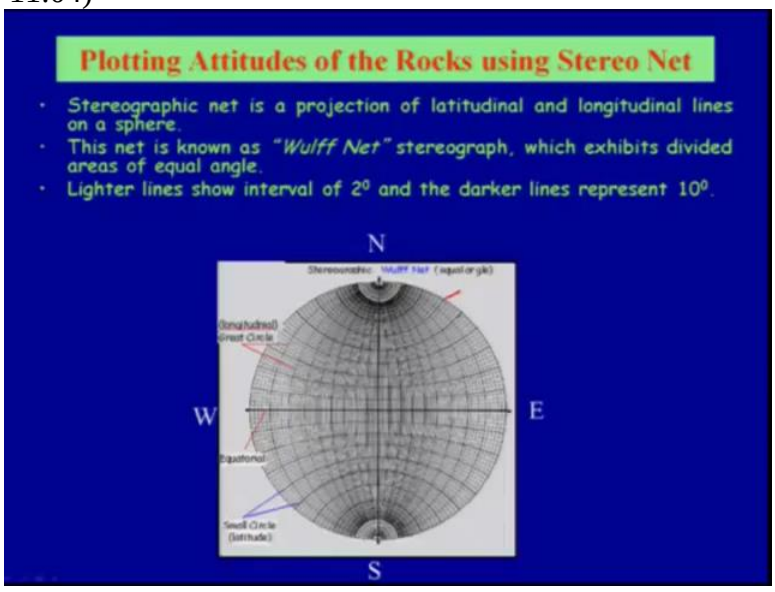

So this is what we call is the Wolf net at we are having okay. So this is the Wolf net which is again equal areas. Now you are having different lines along on the Circle okay. So you are having one is the what we call the darker lines here and then we are having the lighter ones here okay. So we are having those lines here.

And then we are having few lines which are been seen crosscutting like it is running east to west. Whereas they are running north to south okay. So north to south are they are representing the great circles. They are representing your longitudes and then smaller circles here over here they are representing the latitudes here okay. And the centre is the East West is your equator.

So this is the representation of that. So what we see here, the plotting of the attitudes of the rocks okay. So we have the strike and we have the dip. So we can plot that on the stereo net and try to understand that what type of fold those limbs are associated with okay. So stereogeographic net is a projection of latitudinal and longitudinal lines on a sphere okay. This net is known as a Wolf net okay.

Stereograph, Wolf net stereograph which exhibits divided area of equal angles okay. So this all are representing angle okay. So this is 0 and this is 90 degrees here and this is your 180 and this is your 270. Back to your here or you can say it is 360. So this is what you are having the representation of the of the equal angles and this all are like equal angles.

So we are having this as an like this is 90 here, 80, then 70 and so on. Now, why this is important and how we can make out whether the fold is plunging or not okay. Let us see. So the lighter lines what we are having inside is equal to 2 degrees whereas the darkers are representing 10 degree okay. So these all are 10 degrees here, this one. This one is 10 degree whereas the inner one, the lighter lines are all your 2 degrees okay.

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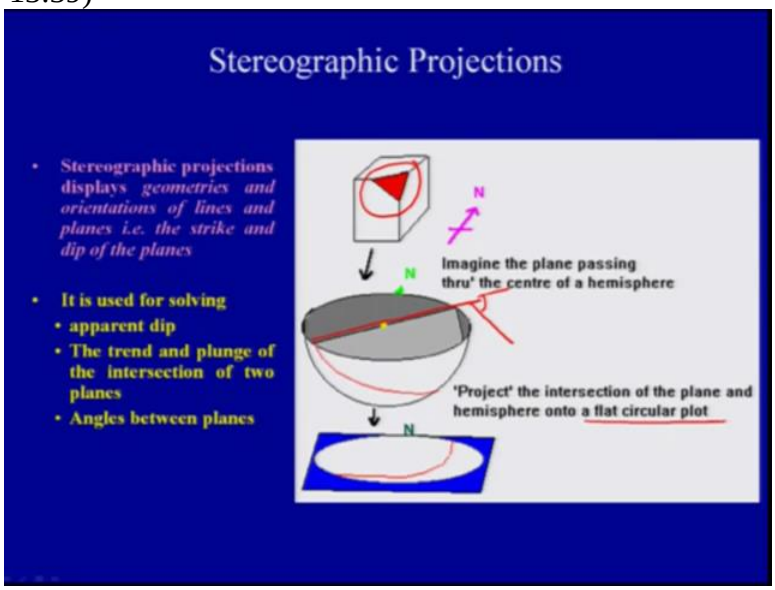

So we have like for example we will collect the information from the field and then we can plot it on the stereo net okay. So stereographic projections displays geometries and the orientation of the lines and planes okay. So that is the strike and dip of the planes. And it is used for solving apparent dip. So if you are having apparent dip, you can you can easily make out and try to identify the true dip also of that area okay.

Then, trends and plunge of the intersecting plane with the help of that you can make out whether it is in plunging fold or non-plunging fold. Sorry. So what we will look at okay? So suppose we are having an incline up here and that need to be projected on the stage graphic projection, then what you will do is that you will you will project on this is what we call the plane or the centre of the hemisphere.

So we are having a plain area and this has been projected on the on the flat or the flat surface. That is what we call the stereographic projection okay. So imagine that the plane passing through this one or this plane what we see here is passing through the centre of this and the hemisphere then how they will be it will be projected on the flat circular plot okay.

So this will be representing your this is your the plane or the Circle here okay. So this plane is like this is your strike here and this is your dip what you are having of the plane okay. So with respect to, so this is an angle here. So that what we have projected on the flat circular plot okay.

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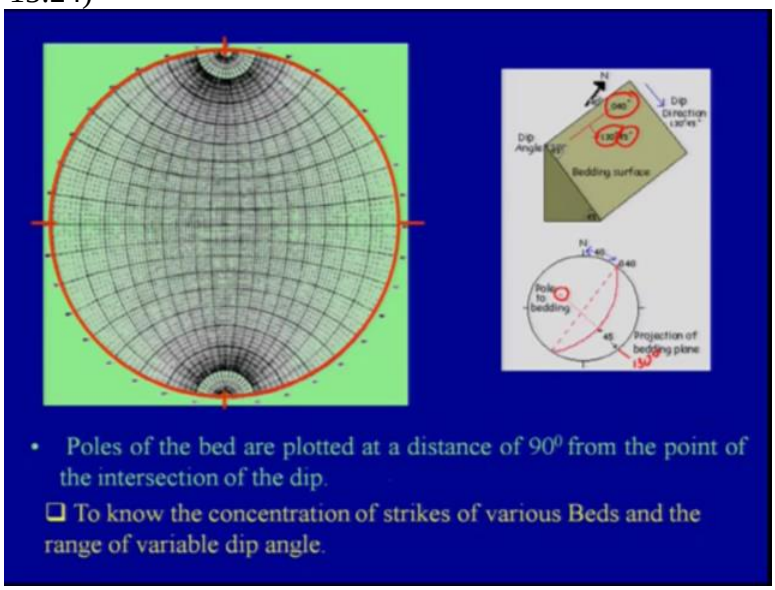

Now taking this, very quickly, we will look at and you can do, one of the exercises will be given to you see. Now we are having the latitude of the one plane okay. For example, we are having here. So what we have is the we have this is your strike, that is 40 degree. And then we are having the dip direction and then we are having amount of dip. Amount of dip is 45 degrees and then we are having the dip direction is 130 with respect to North okay.

And we are having this one, 40 degree. So what we need to plot is that we need to plot is that we respect to North, this is your 40 degrees which is coming here okay. So with respect to North, we are moving. So this will be your strike which is passing through the centre of the flat plot or the projection okay. And then amount of dip your having again it is it is dipping in like towards 130.

So this will be your 130 and then you are having your dip is amount is almost 40 degree. So that is be measured from the from the outer circles towards the centre here okay. So let us see how we can project this on this one okay on the stereograph, the new projection. So pole this is what is been and then if you take this point 90 degrees so you can you can take this 90 degrees, that will be your pole which you represent on the intersecting part okay.

So that is the that will give you all information about the planes and all that okay. So to know the concentration of the strike in various beds, so if you just plot the pole, that will also help you in knowing the strike and dip of the beds okay.

So in most of the stereographic projections what is being done is that you have the poles which are plotted and the concentration of the pole will tell you whether what are the maximum strike or the concentration of the strike of the beds or the direction of the beds and the what is the inclination of the beds here?

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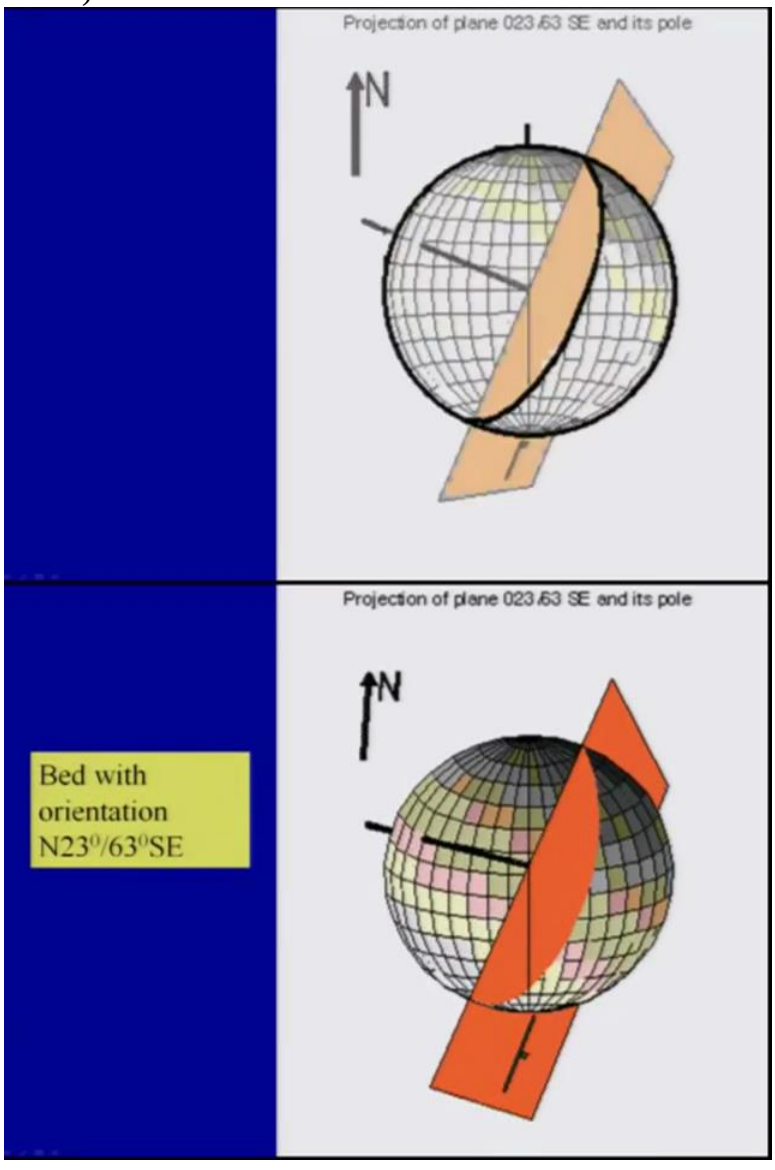

So coming to this, if you see carefully this one, this will explain you that how it is been projected. This is the how the hole is been projected. So you are having the inclined plane here and that is from that point you are taking 90 degrees and then you are putting that pole here okay. So that is the point.

The pole is representing the point and complete data of strike and dip here okay. So the next part we will see that how if you are having 2 beds, how you are plotting those okay.

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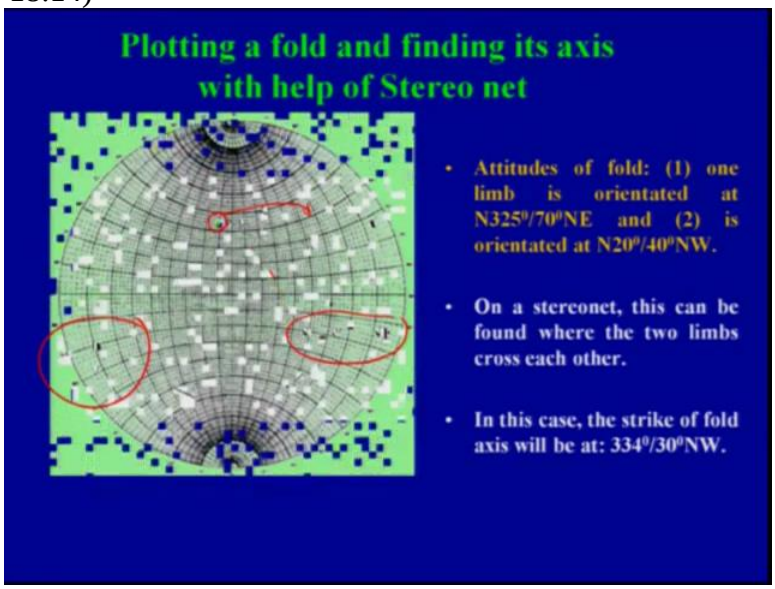

So for example, we are having the fold and we have 2 beds which are having attitudes, that is having strike and the dip okay. So one is like we have 340 34 degrees (334 degrees) and then we have so this is your strike. This is your amount of dip and this is your dip direction okay. And similarly the other one is you are having is around this one okay. So let us see how we can plot this one okay very clearly.

So attitude of beds, one limb is oriented in this one that is 325 degrees,70 degrees north-east and another one we can also say this one is North 20 degrees and 40 degrees you are having north-west okay. So this is again another another plate fear having. So in this case, the strike of the fold axis will be at 334 okay. So this is the sort this and what has been given is the is the strike of the fold. So this is the strike of the fold. So we are having 2 beds here, one is the blue line and this is the red Line here.

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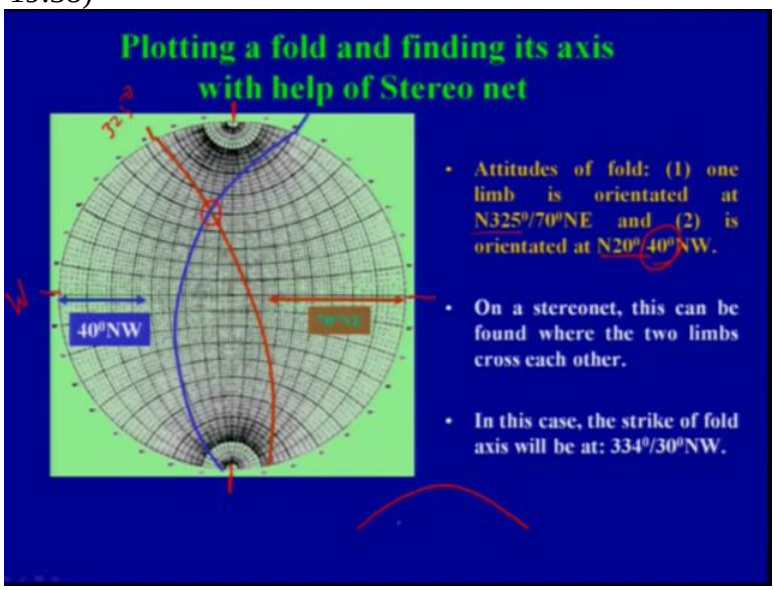

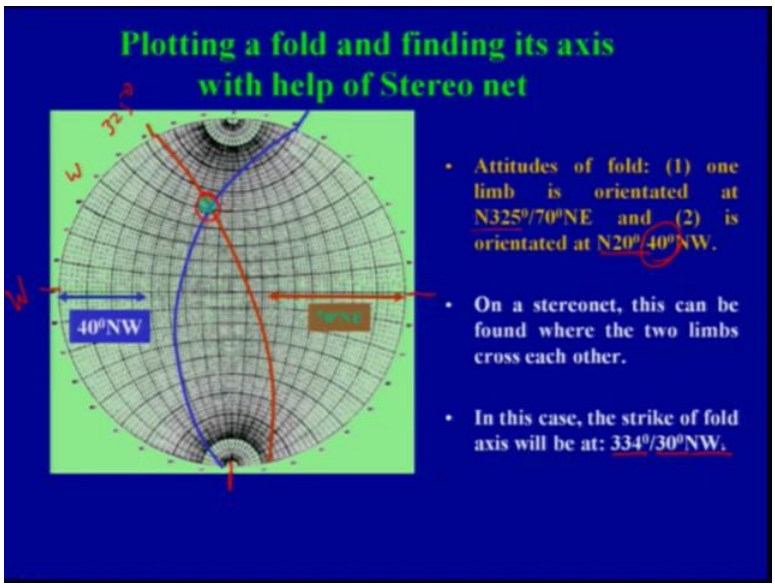

So let us see how we can plot this one okay. So we can remove this one quickly and then we can select. So we have one that is what we have marked is North 20 degrees okay. Sorry, this one we can take 1st, that is the 325 okay. So this we have taken, this is 325 degrees okay we have taken the mark. And then what people do is we will try to measure the depth okay.

And since this is our east quadrant, so we will move this mark parallel to this one okay. That is to North okay. So what we have done and we will measure this one so. So we have moved this parallel to the north and then we have marked the outer line that says this one. This is 70 degree

north-east. This we have marked from here. So we will start from, this is the North East. So North.

From the east we will go in this direction, so that will give you, that plane will give you the plane of your fold okay. And if you mark this, so this will be your strike. This will be your strike here. So then you move back and this will will be left out with you. So this will go off okay. So this you are having the one playing you got okay.

That is with 70 degrees okay. And then another one, you have you are marking that is 20 degree, so North 20 degree. So we have 10 and 20 here. Again, you are having this amount of dip is 40 degree which is north-west okay. So you have to go in this quadrant. So this is your west. And again you have taken 10, 20, 30 and 40 here okay. So you have taken this. Again you will move this towards north and then bring it parallel to this one here okay.

This one here and that will give you the plane here okay. So you are getting this plane. So again you are getting another one, that is the blue plane you are getting and you will get this the information here. So again you move back in the same fashion, bring your North which was being initially marked. So when you start this, it is better to mark the north, south, and east west okay.

So that will help you in bringing back the your tracing at this has been done on the tracing sheets. So you will put the stereonet and you can do this on the tracing sheet. So you can bring it back and then what what you have is that you see that the 2 limbs which you have drawn are not intersecting along the outer circle okay. They are intersecting within that. This means that it has some sort of an attitude okay.

So this is an fold axis because when we were talking about the intersection, this is what we have drawn is the intersection of the 2 planes okay. So this is your fold axis. Now either the fold axis is vertical or the fold axis is inclined okay. Or it is plunging or not plunging. With that, you can make out easily. So what you got is that if you if you's again bring this at the Centre here and then again you measure okay.

So this will be your the direction is this is your fold axis here you got and then amount of dip you can measure from here when bring it on the centre okay. That will give you the amount of dip.

So when you bring this whole part here, because you have the Centre here, then you can measure from the Centre here that how much is the amount. So that gave just 30 degree and since you are again putting back, so this is in the western side so you will say this is dipping towards north west okay. So that is what we have done here okay.

So you are able to measure with the help of 2 limbs okay. And the intersection not along the outer circle and you have named the you have you have calculated the strike. You got the strike, you got the amount of dip and then you got the direction of dip of the fold axis here. So this is your fold axis.

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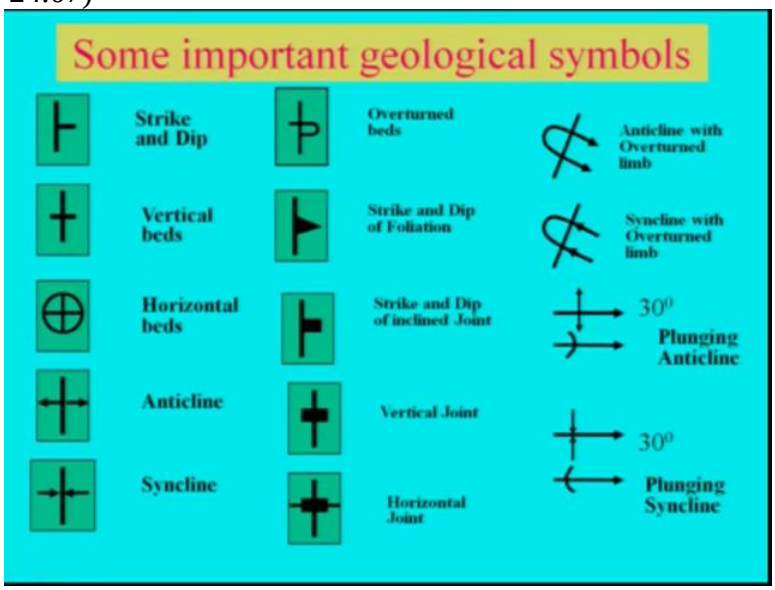

So there are some symbols which you can go through which indicates the strike and dip and mostly you will find these type of symbols on your geological maps okay. So you are having horizontal, you are having incline, you are having syncline, you have overturned folds, you are having strike and dip of these foliations, this is related to the metamorphic rocks which we were talking about, foliated and non-foliated rocks.

Then you are having the strike and if of the syncline joints. And then you are having vertical joint. And then you are having horizontal joints. Then you are having anticline with overturned folds. Then syncline with overturned folds okay. And then you are having the plunging anticlines okay. So if you are having these symbols which are been given, then you can easily make out

that what is the plunge amount and what is the plunge axis and in which direction it is plunging okay.

So these are some of the symbols which are been given which you can study from the slides okay. And I will stop here and I would like to start a new topic. Hopefully we have enough time to complete that also. So we will talk about the faults okay. So we have been talking about the folds and we talked about the different type of folds.

But now the important part which is there which we talked about the faults okay. So please remember, the different type of folds which we have talked about, about the anticlines, synclines, about the plunging folds, non-plunging folds, how to measure it using the stereographic projections and then you can talk about or this stack-based on the slides and the notes you learn about the symmetrical folds, aymmetrical folds, and then overturned folds, recumbent folds, Chevron folds and then you can talk about, you can learn about the back folds and also the isoclinal folds also or monoclinal folds. So these are the different type of folds.

So based, everything is dependent on the fold axis or you can say in which direction the limbs are dipping and it what angle okay. As we have talked about the open folds, closed folds, tight folds also so you can learn all this okay. I will stop here. Thank you so much.