Structural Geology
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Lecture 21- Fold and Folding: Classifications

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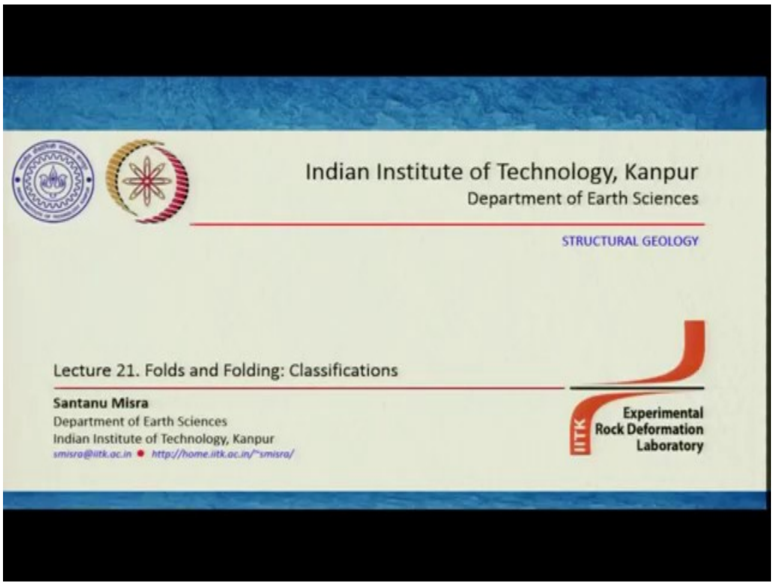

Hello everyone. Welcome back again to this online structural geology NPTEL course. In this week we are learning folds and folding and we are lecture number 21 and we learn in this lecture, this is the second lecture of this week, we learn classifications of folding. In the previous lectures, we learned a series of terminologies to describe a folded structure or a folded layer and these ranged from a point related structures a line related structures and also a plane related structures and these include hinge, hinge line, fold axis, inflection points, inflection line, median surfaces, enveloping surface, then we also learnt interlimb angles, we learnt crests, we learnt trough, we learnt limb we learnt hinge zone and so on.

So, there are so many terminologies we learnt in our last lecture. I hope you went through these and you understood all these terminologies, their physical significance and their actual meaning. In this lecture what we will do we will use most of these terminologies to describe a folded structure and to understand that which fold is what and in other way or in other words we will be classifying the folded structures.

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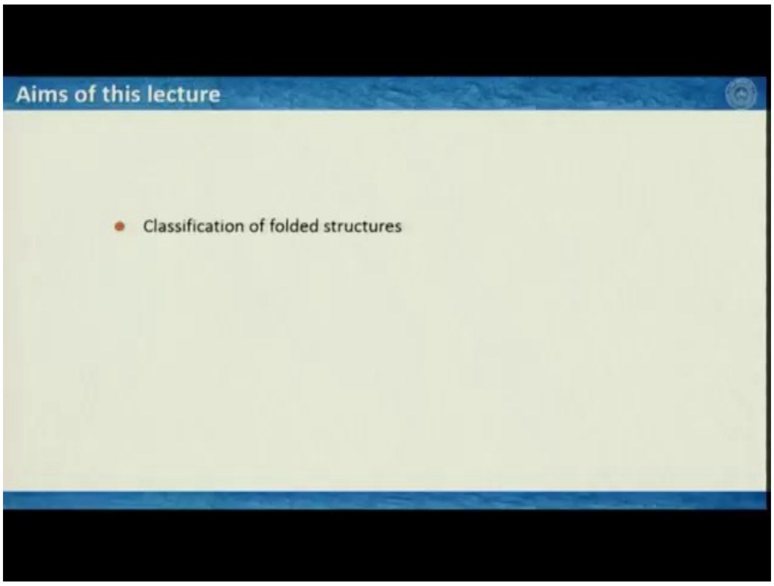

So yes, there is only one aim in the structure and that is classification of folded structure. Now, as you have understood from the previous lecture because we had to use a lot of terminologies to describe a folded geometry. So, it is not very easy to quantitatively or accurately describe the geometry of a fold and it is difficult and at the same time it is time consuming. Also, it is not very easy to communicate the other people that, yes, I have seen this kind of fold in the field in a quantitative manner, of course.

So most of the time what structural geologists do, they try to describe the folded structure in qualitative manner and while doing so, the structural geologists do use a combination of certain terminologies. We have learnt few in the previous lecture and in this lecture, we learn a few more. And all these descriptions, these qualitative descriptions, sort of provide us a rough idea of the shape of a fold and at the same time the orientation of the structural elements which are associated with folded structure. Just for example if I use a terminology that this is X type of fold, then a visualisation appears that okay the fold is like this if I say no, this is Y type of fold then another visualisation appears. So, in this lecture we will sort of cover all this kind of features and will try to again classify the features that we have learnt in the previous lecture and few of these we learn in this lecture

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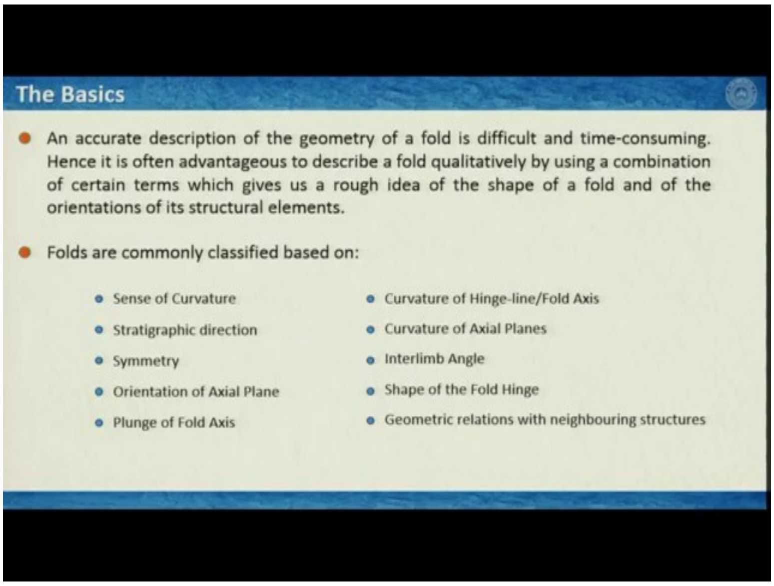

So folds are commonly classified based on series of parameters and here I listed a few which I will cover in this lecture and these include sense of curvature of this fold, or form surface of this fold, when stratigraphic direction will consider that as well that whether the fold core is representing younging layers or older layers. Then folds also do have symmetry because it is some sort of (sine verse). So whether the fold is symmetric or asymmetric will also test that. How the actual plane is oriented that is also parameter to classify the folds. Plunge of fold axis because fold axis is a linear feature so it must have a trend and plunge and we take the plunge to classify the folds.

The curvature of hinge line and fold axis is also major parameter that whether the fold axis is straight or curved and we will see how do we classify folds based on that. Then curvature of the axial plane as well a plane not necessarily is a straight plane, it can be curved and we will classify folded structures based on that as well. The interlimb angles the angles can be widened or wider or shorter. So we will also check that in classifying the folds. Then shape of the fold hinge is also an important parameter. And finally we will classify the folds based on how it is related with the neighbouring structures.

And while we will study all these things, I have restricted all these things to illustrations or in other ways that I did not use in this presentation any image or photograph. You can check all these images and photographs if you would like to in your search engine. You just typed the name of the fold and you will see it. So I did not want to sort of populate or crowd this presentation, but tried to give some easily understandable illustrations to better identify and better comprehend the classification of folds. However, if requires in the next lecture, I will try to add some photographs which are very key features where you will see some key features of a folded structure.

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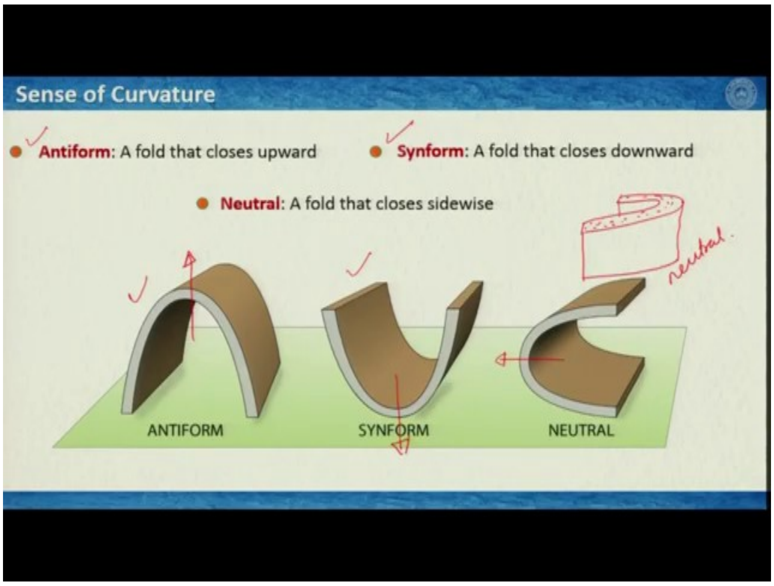

So let us start first with the sense of curvature and these two terms, we have learnt already in the previous lecture one is antiform and another is synform and they are given in these two illustrations. So we learnt in the previous lecture antiform is a fold that closes upward so as we can see here, this fold is closing upward so this is an antiform this fold is a synform because it is closing downward. But there could be a series of possibilities where the fold is not closing upward or downward but sidewise in that case we call it neutral fold where the closure is not upward not downward but sidewise. We can also consider a fold something like that. This fold has a special name we will learn it later but as you can see this fold is also not closing upward or downward so this is also a kind of neutral fold. So any fold which is not closing downward or upward you can classify them or you can group them as a neutral fold that closes sidewise.

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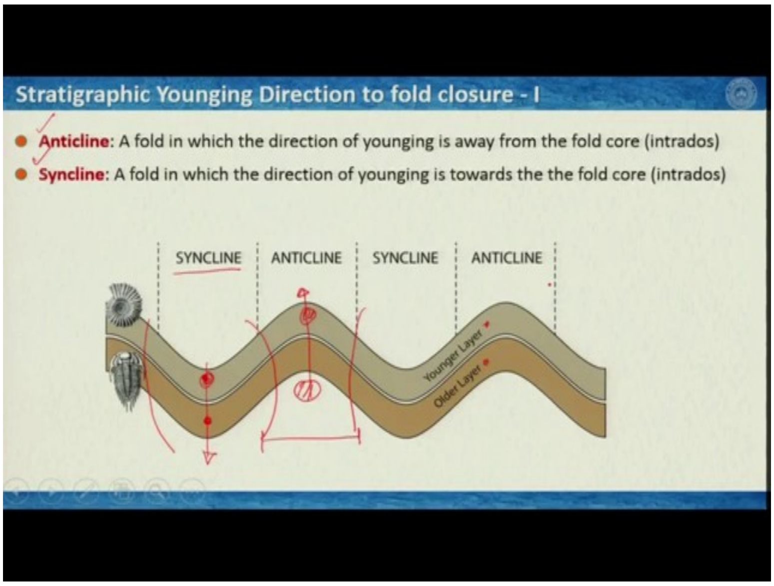

Now stratigraphic younging direction of the fold closure. Here we have two primary terminologies to classify or to take into account the stratigraphy of the folded strata. So this, these two terms that those are written here anticline and syncline these are only restricted to the form surfaces, defined by sedimentary layers because in other stratigraphic in other form surfaces like veins or foliations and so on these are not really included in describing anticline and synclines.

So let us have their definitions first as it is written here an anticline is a fold in which the direction of younging is away from the fold core. And a syncline is a fold in which the direction of younging is towards the fold core. Let us first look at this image, so as you can see that in the top layer which is written here this is younging layer and the bottom layer is older layer say in the top layer you find the fossils ammonite and in the bottom layer you find the fossil of trilobite so therefore top layer is of Mesozoic age and the bottom layer is of Palaeozoic age. Now what do you see in this in this first fold if I consider this one. Then this is a synform as we have learnt from the previous lecture and it is closing downwards. So this is essentially a synform.

Now in this synform the younging direction or the younger layer is towards the fold core. So this is the younging layer and this is the older layer. Now younging layer if it is towards the fold core then we call it syncline. But in the next wave if we considered this one this particular wave what we see here that it closing upward so this is an antiform and in this antiform the younging layer is away from the fold core so this is your fold core and the younging layer is away from the fold core therefore we as per definition we term it as anticline. So syncline anticline, syncline anticline this is how it progresses in a folded stratum. So I repeat synform and antiform are geometry-based terminologies and anticline and syncline are also geometry-based terminologies but they also include the stratigraphic younging direction.

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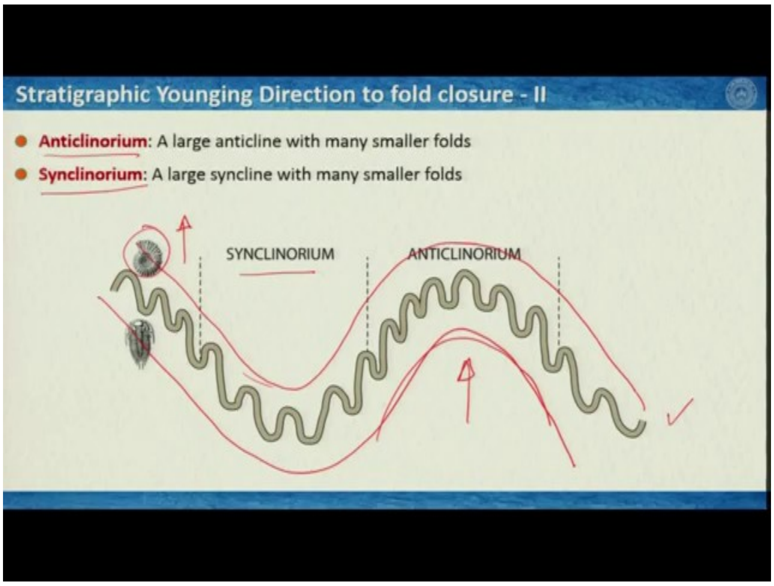

So if we have a large anticline with many smaller folds then we term it anticlinorium and if we have a large syncline with many smaller folds then we term it as synclinorium. So as you can see this is a packet of folds or we can actually make a large fold like this and it is defined by many small folds as you can see here in this illustration. Now in all these folds the top part is defined by the fossil ammonite that so that means this is the younging direction. So this is a synform and this synform contains many smaller folds so this is a synclinorium and in a similar way this is an antiform because it is closing upward and younging direction is also away from the core so this is an anticlinorium as it is consisting of make smaller folds. So we learnt syncline anticline and now we learnt anticlinorium and synclinorium. The picture becomes a little complicated when this stratigraphic younging direction reverses and we will see this in the next slide.

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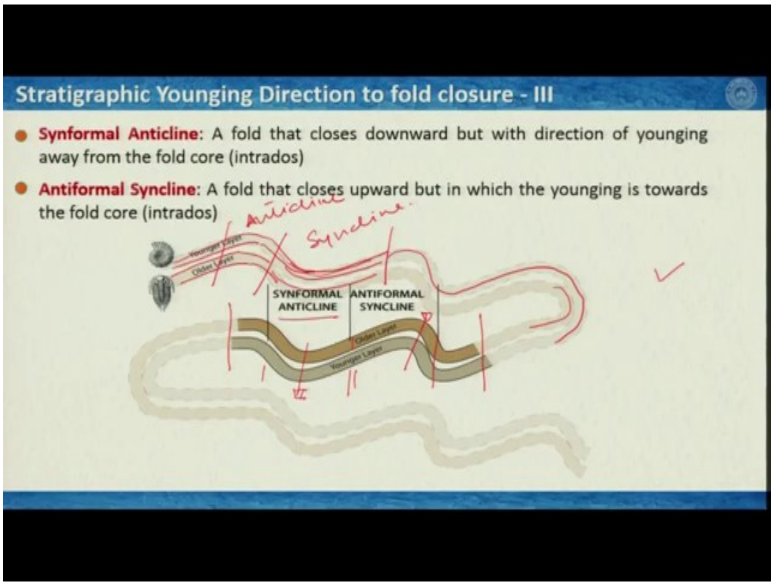

The first one we will take is synformal anticline and then we will take antiformal syncline. Now an anticline is we learnt in the previous lecture when the younging direction is away from the fold core in an antiformal structure. But in this case in a synformal anticline a fold that closes downward but the direction of younging is away from the fold core and the reverse happened when you have antiformal syncline. A fold that closes upward but the younging direction is towards the fold core. The folds generally produce this kind of structures like synformal anticline or antiformal syncline is little complicated but we will understand it with this illustration given here.

So you can imagine the fact that this is your younging layer here, going here defined by this ammonite fossil and this is the older layer. So if I see in this section which is little faded. So clearly this is an anticline. And the next segment the younging layer is at the core older layer is away from the core and this form is a synform so this is syncline. No problem. But if the folded strata is curved and got a turn in this side then interestingly you see that this brighter area here which is not faded the younging layer comes at the bottom of the stratigraphy and the older layer is at the top of the stratigraphy.

In that case this structure is a synform because this is closing downwards. Its closing this way. The structure next to this the folded structure is an antiform because it is closing upward. However we see that in this synform the young layer is away from the fold core. So this is actually anticline. So therefore we name it a synformal anticline and similarly in this antiform the younging layer is towards the fold core so this is antiformal syncline. So we learnt a series of terminologies related to fold geometry and their stratigraphic younging directions. Synform antiform, syncline anticline, synformal anticline, antiformal syncline and anticlinorium and synclinorium. Let us talk about the symmetry of the fold. So you can understand this fact that a fold can be symmetric or asymmetric.

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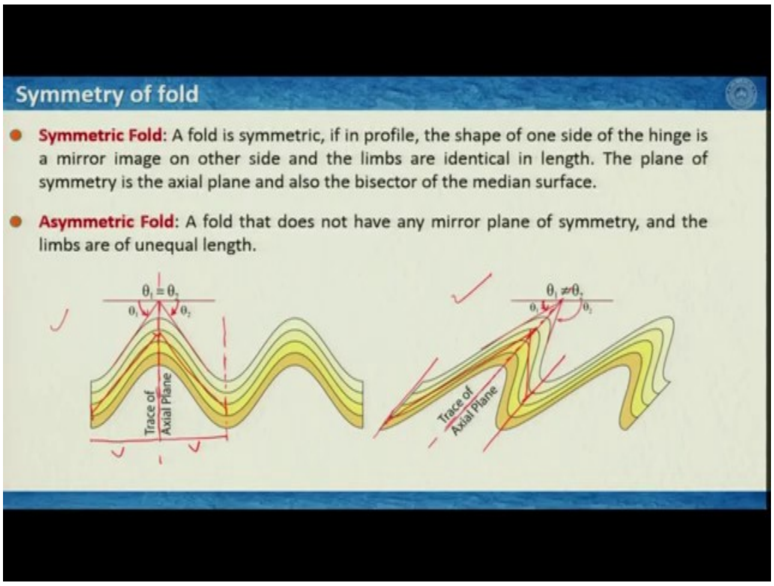

A symmetric fold is if in a profile section that means a section perpendicular to the fold axis the shape of one side of the hinge is a mirror image on the other side and the limbs are of identical length. The plane of symmetry therefore is the axial plane and is also the bisector of the median surface. An asymmetric is where all these conditions do not hold or in other ways, a fold that does not have any mirror plane of symmetry and the limbs are of unequal length. Let us concentrate on these two Illustrations in this slide. The first one is an illustration of a symmetric fold.

As you can see here, that if I bisect the fold, with this red line here then this part of the fold and this particular part of the fold, which is also the next plane of symmetry, mirror plane of symmetry so this part and this part they are very similar to each other or they are mirror image to each other. So therefore this folded structure as per definition is symmetric fold. Also the length of the limb if I can consider from here to here or here to here considering it has no hinge zone then they are also similar to each other. Also this layer as it is mirror symmetry if I consider this angle theta one and if you consider this angle as theta two in a symmetric fold theta one should be equal to theta two and this plane of symmetry is the tress of the axial plane. We will learn it later that this is also axial planar cleavage.

In contrary in asymmetric fold there is no plane of symmetry or there is no plane of mirror image so you can see that if I consider this segment of this fold and this line if I consider or any other line you cannot have a… you cannot produce a mirror image of the other side. So therefore this fold is asymmetric. You can also see the length of this limb is longer than length of this other limb considering it does not have any hinge zone. This angle if you measured, this angle is theta one this angle is theta two and in this case theta one is not equal to theta two. So this is how we define the symmetric fold and asymmetric fold.

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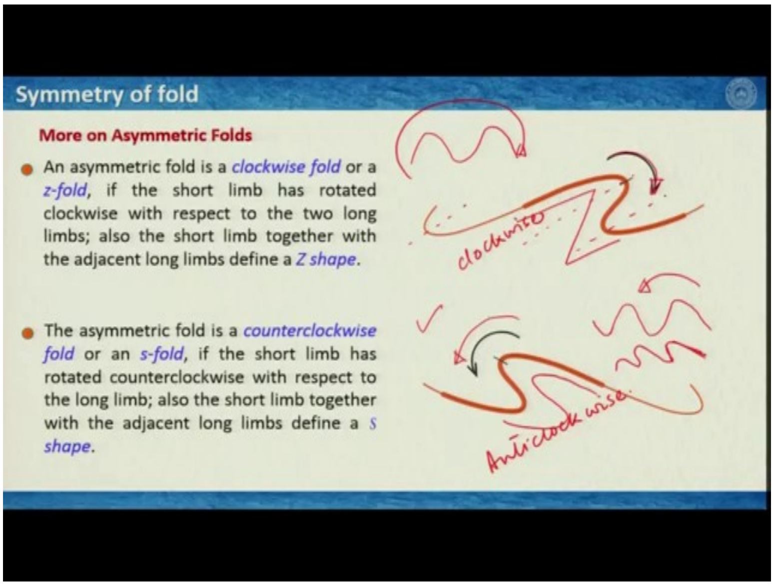

The asymmetric fold is the counter clock wise fold or an S fold if that short limb has rotated counter clockwise with respect to the long limb. Also the short limb together with the adjacent long limbs define an S shape. Now we now focus on this illustration again if I consider that there was a symmetric force something like that and then if I rotate it counter clockwise then it may a take a shape like this. Where this is the short limb and this is the long limb and the resultant structure is here so it rotated counter clockwise, the short limb. Also you see that this short limb together with the adjacent two other limbs, it defines the English letter S. So this is clockwise. And this is anticlockwise. Asymmetric fold. Now in a single straight or in a single layer we can have this clockwise or anti clockwise folds or in other ways we can figure out Z and S shaped folds.

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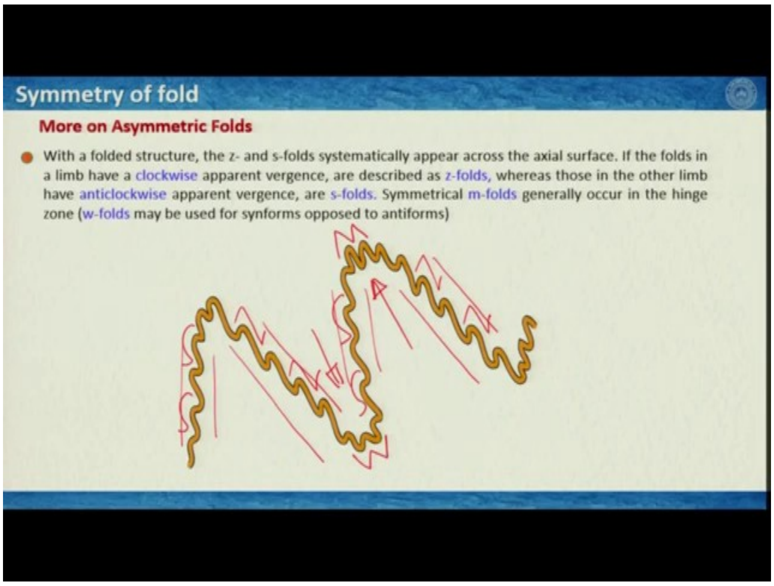

So here, so with folded structure the Z and S folds systematically appear across the actual, the axial surface so in a single fold you can see them. Now if the folds in a limb have a clockwise apparent versions are described as Z folds. So let us have a look here you can see in this limb particularly if you consider this one and this one. Okay? So here you see these are Z. On the other hand those on the other limb have anticlockwise apparent versions. Here, here these are S shaped. Now in between these Z and S you may find symmetric M fold if it is an antiform as you can see here it is closing upward if it is synform instead of M you may find a W type of fold. So in the field we sometimes describe this as S fold Z fold W fold or M fold. So if your teacher, colleague or if your friend tells you that, okay, in the field I have seen a Z fold then now you can immediately relate what he or she is talking about.

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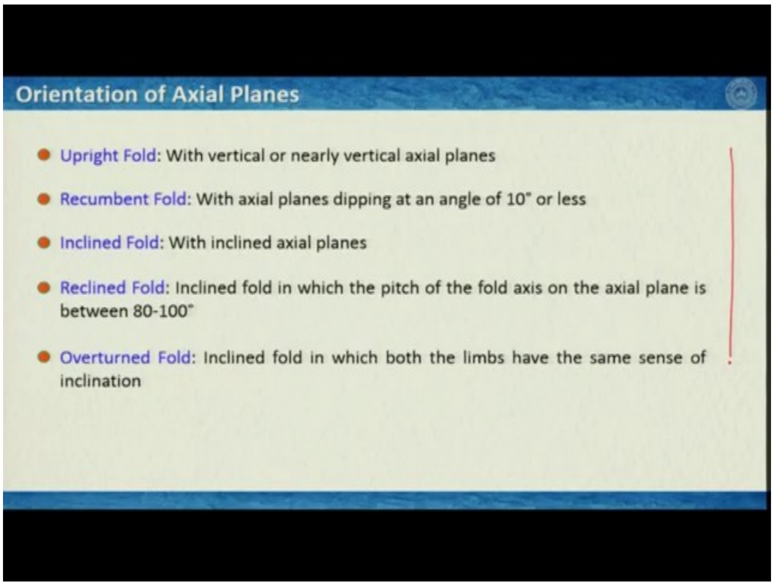

Now let us have a look how we classify the folds based on the orientation of axial planes. A number of terminologies we will be using here. The first one is upright fold with vertical or nearly vertical axial planes. The second one is recumbent fold with axial planes dipping at an angle of 10 degrees or less or you can consider the axial plane is somehow sub-horizontal or horizontal. The inclined fold is anything in between upright and recumbent fold that means the fold axial planes are inclined.

The reclined fold is a very special type of inclined fold in which the pitch of the fold axis on the axial plane is vertical or is, is orthogonal is, is about 80 to 100 degrees. An overturned fold is also a kind of inclined fold in which both of the limbs have the same sense of inclination. So based on the orientation of axial planes we define folds or we classify folds as upright folds, recumbent folds, inclined folds, reclined folds, and overturned folds. The definitions are given here and now we will see them in the form of illustrations. And here they are.

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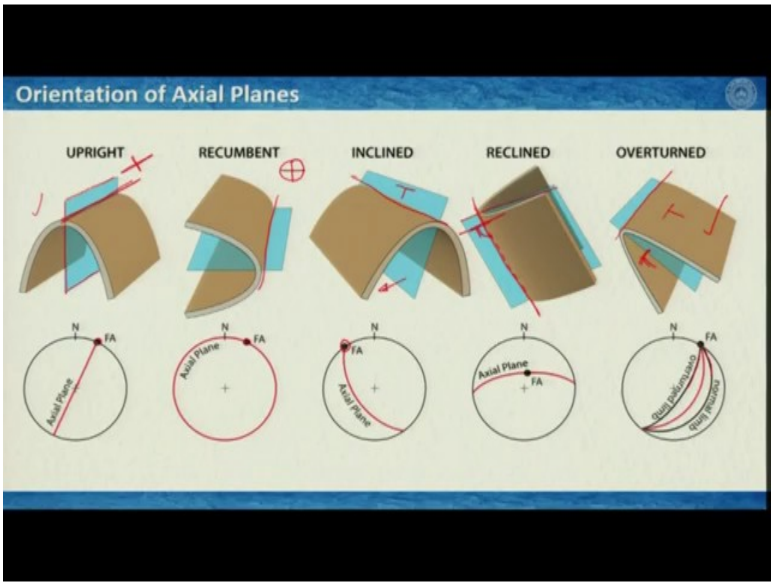

In all these illustrations the blue shaped rectangles are the axial planes. What do you see in this first illustration? Which is an example of upright fold. We see that this is the folded strata folded layer and this axial plane is, this one and the axial plane is almost vertical. In the second one we see that this is a recumbent fold so in the field if you figure it out you will write it like this. Or you can orient it like this in this way so if you have to map it, you can plot it like this where this long line is the strike of this axial plane and this defines that this is vertical we learnt it in our dip strike lecture. In the recumbent fold you see this is the folded strata and here this is your axial plane which is horizontal and we call it recumbent. So in the map you will define it something like that.

Now inclined fold we clearly see that this axial plane this blue plane is inclined. It is dipping towards this side. So axial plane is neither vertical nor horizontal, it is inclined. Reclined fold as I said it is very interesting fold where the pitch of the fold axis is almost 90 degrees or it ranges from 80 to 100 degrees with the strike of the axial plane. So if this is the axial plane then you can consider the strike could be something like that. And this is the dip. Now the fold axis is like this so the pitch of the fold axis with a strike of this bed is at high angle and therefore we term it as a reclined fold.

The overturned fold is something that has both limbs dipping in the same direction. So this one you see is dipping this direction and this one is also dipping in a same direction but with different dip angle. You can also see them in the stereonets and stereonets are the best way to visualize if you plot the axial planes in the stereonet and you can clearly identify whether your fold is upright, recumbent, inclined, reclined or overturned together with the fold axis.

Just come back in this upright fold, this is the fold axis, here this is the fold axis, here this is the fold axis, here we have defined already this is the fold axis and in this overturned fold this one is the fold axis.

Now for the first one if we take the upright folds, clearly the axial plane is vertical so that plot of the axial plane would be the redline the fold axis as you can see this is horizontal so it would come somewhere on the primitive circle. On the recumbent fold it does not have any strike because it is a horizontal bed so the entire primitive circle is actually the plot of your axial plane. And the fold axis we can plot if you measure, if you can measure it, it is somewhere here and this is also horizontal. In the inclined fold as we have seen here it is dipping in this direction so it should be an inclined plane that is why the plot is curved not a straight line. And this is the fold axis.

The reclined fold as we talked about that the axial plane here is also inclined so we see the red circle here as a curved circle. And the fold axis should be somewhere in the middle of this axial plane. In the overturned fold we call this one as normal limb which has the lowest dip amount so this is the normal limb and then this one is the overturned limb that means it got turned towards the normal limb and giving rise the same dip direction but with different dip angle and this is therefore overturned limb and the axial plane should pass through the middle of this normal limb and overturned limbs. Now all these things we have to see under or all these we have to see in profiles sections otherwise there could be some little error in plotting your data.

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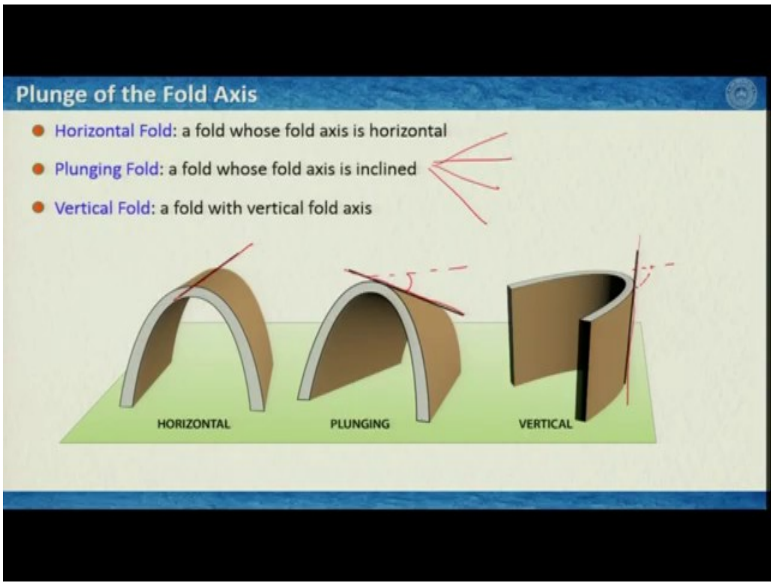

Now we will see how to classify the folds based on the plunge of the fold axis and in this section we have three different types of folds. One is a horizontal fold, another is plunging fold and third one is vertical fold. As the name suggests a fold is horizontal if the fold axis is horizontal that means it doesn't have any plunge,so plunge is close to zero. A vertical fold I am taking the third one after that is where fold axis is vertical or it is closed to 90 degrees and anything between horizontal and vertical fold is known as a plunging fold or a fold whose fold axis is inclined. As you can see in this illustration here. This is a horizontal fold because the fold axis is horizontal here.

This is a plunging fold because the fold axis has a plunge if you consider this is your horizontal line on this plane. So this would be the plunge of this fold axis and if you consider this one the vertical one then this is your fold axis and of course the angle is quite high or close to vertical. So therefore we have based on the plunge of the fold axis we have horizontal fold, plunging fold and vertical fold. In some text books this plunging force are also classified in so many different categories based on zero to 10, 10 to 20 and so on. So highly plunging, moderately plunging, gently plunging and so on. We are not going into that part but anything in between horizontal to vertical is plunging fold. This is what we are going to consider for the lecture.

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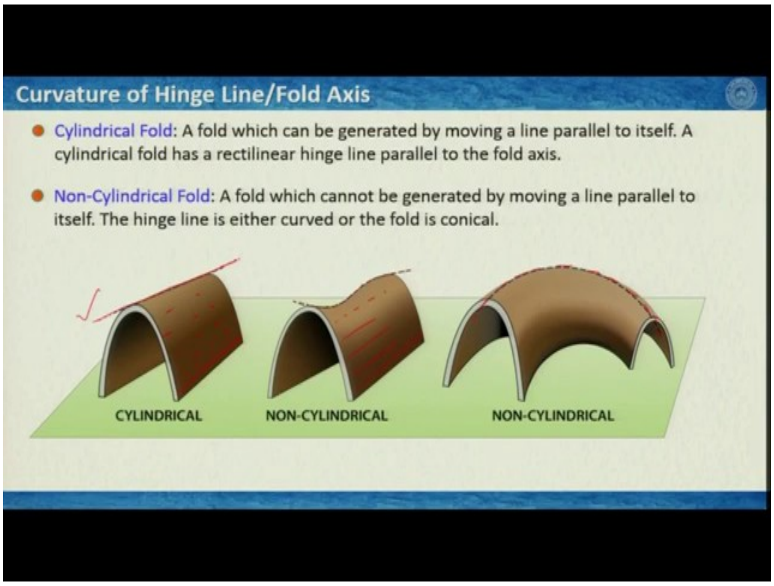

Now we are going to take over that on the fold axis whether now we are we are going to see if the fold axis is straight or curved. So far all these illustrations we have seen we have seen the fold axis was straight. Now if the fold axis is straight then we call it cylindrical fold. Or in other way the way or in other words the way we defined the fold axis in the previous lecture a fold which can be generated by moving a line parallel to itself and this line this particular line is your fold axis and if you can do that the produced fold the fold you will produce out of it is a cylindrical fold because the fold axis the direction of the fold axis is not changing in this case.

So a cylindrical fold therefore has a rectilinear hinge line parallel to the fold axis and if the fold axis does not have a straight hinge line or straight fold axis then this is non-cylindrical fold. So a fold which cannot be generated by moving a line parallel to itself and the hinge line is either curved or the fold is conical. Here is one example of cylindrical fold we are little bit bored now but seeing the similar image or similar illustrations so here we see we particularly focus on the orientation of fold axis this dotted black line is the fold axis here. And you see the orientation of this black line does not change so it is straight therefore it is a cylindrical fold. However in this case we see that the variation of fold axis.

The orientation is changing along the hinge line and the hinge line as well so this is a non-cylindrical fold. Here you can have a line and with this line if you place it you can produce the fold completely. But here if you have a line you cannot produce the fold completely because at this stage you will have some sort of gaps and so on. This is also a different kind of non-cylindrical fold so here we have the depression along the hinge line and here the entire hinge line is folded in a different direction. But the bottom line is that fold axis here is also not straight. It is curved and therefore this is also a type of non-cylindrical fold. Now we will see how we can classify the folds based on the curvature of the axial plane. Again so far all these illustrations we have defined axial planes or axial surfaces. All of them were straight. And this time we are going to see if the axial planes could be curved or not.

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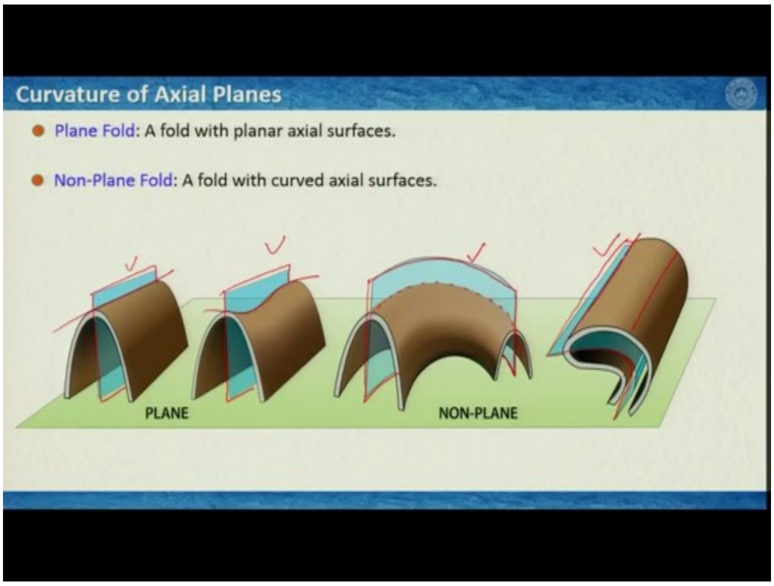

So if the axial plane is straight or axial surface is planar then we term it as plane fold and if the axial surfaces are curved then we term it as non-plane fold . And here are four illustrations for you. The first two are examples of plane folds so and it is not a function as I have drawn these two Illustrations to convey the message that orientation of the fold axis not necessarily indicate or not necessarily justify whether the fold would be plane fold or non-plane fold. So here we see we have learnt in the previous slide. This is a cylindrical fold and this one is a non-cylindrical fold. In both cases the axial surface or axial plane is straight this blue plane.

So these are therefore plane fold and it is indifferent whether the fold axis is straight or curved or in other words whether the fold is cylindrical or non-cylindrical. The same logic applies to the non-plane fold. The fold could be cylindrical or non-cylindrical in producing non-plane fold what we see here that here the fold axis we have seen it in the last slide so this is your fold axis which is curved the axial plane is also curved so this is a non-plane fold but here the fold axis you can see it here you can see it here or even here these are straight. But axial plane as you can see here this blue plane which is driving the fold or bisecting the fold curvature here is curved as well. So here it is curved here it is curved therefore both are examples of non-plane fold however in this case the fold axis is not straight here fold axis is straight.

So we learnt that plane fold and non-plane fold is simply defined by whether the axial surface is planar or curved it does not have any relation with the orientation of fold axis or whether the fold is cylindrical or non-cylindrical. However we will use this plane fold non-plane fold cylindrical and non-cylindrical fold when we learn more the superposition of deformation and we will see and come back to all these kind of illustrations so I request you to understand this part very very clearly.

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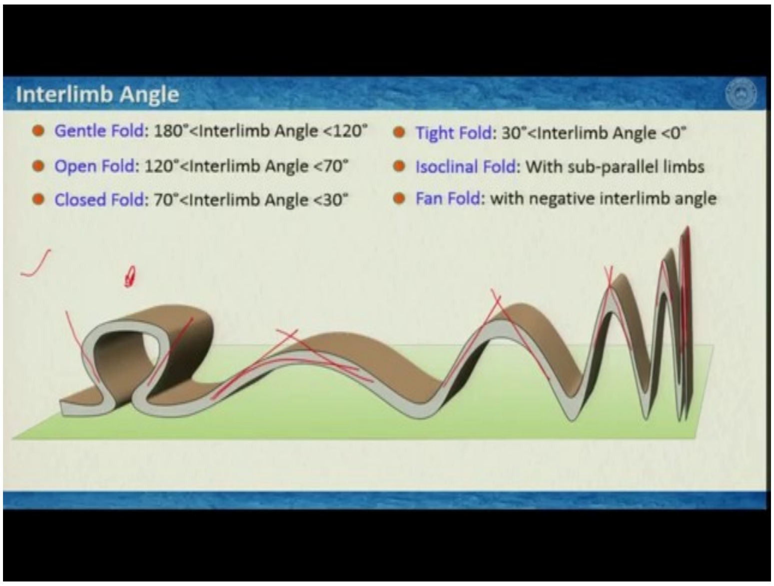

Now based on interlimb angle we classify the folds as gentle fold, open fold, closed fold, tight fold, isoclinal fold and fan fold. It is essentially based on the difference or the classification is based on that how much the interlimb angle is. If interlimb angle is from 80 degrees to 120 degrees then it is gentle fold. If it is between 120 degrees to 70 degrees then it is open fold. We assign a fold as a closed fold if the interlimb angle is between 70 degrees to 30 degrees.

A tight fold is where the interlimb angle is 30 degrees to 0 degrees or sub-zero. The isoclinal where you cannot define an interlimb angle that means the two limbs are sub parallel to each other and the fan fold is something where we have negative interlimb angle. So this is an illustration you hardly see these kind of folds in a single layer but this I have drawn to sort of accommodate all these classified folds under interlimb angle. So this is fan fold. As you can see that here and here we the interlimb angle you cannot measure in this side this is therefore a negative interlimb angle and we call it a fan fold. In some texts fan folds are also given a term called elastica.

If you hear it then you just remember that it is related to fan fold but elastica is something completely different in terms of waves and other descriptions. So we are not going into that part but fan fold sometimes you can see in some text books that are termed as elastica. Now of course this is a gentle fold this one, the interlimb angle is pretty wide. This is an open fold, this is a closed fold. This one is a tight fold and here you see the two limbs are running almost parallel to each other and therefore this is an isoclinal fold. So this is how we define folds based on their interlimb angle. Gentle fold, open fold, closed fold, tight fold and isoclinal fold together with fan fold.

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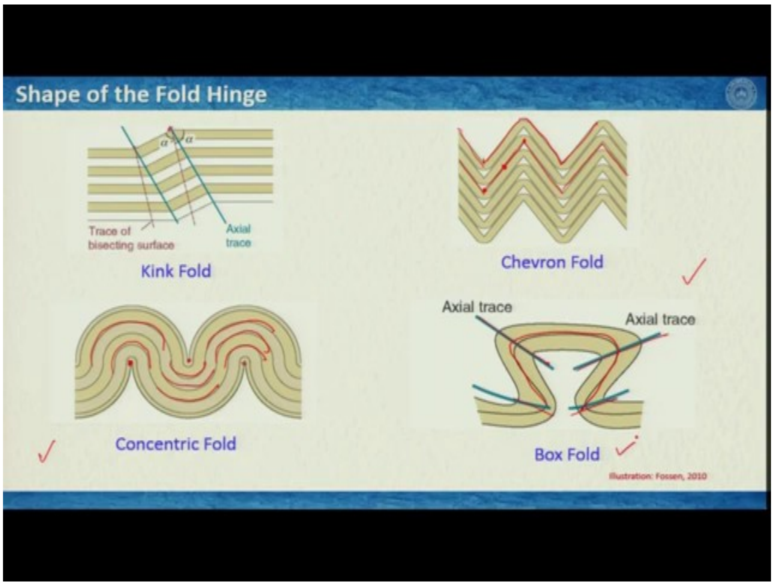

Now shape of the hinge is also one of the very important parameters to describe folded structure and here I have shown only four end members you can think of so these are kink fold, chevron fold, concentric fold and box fold. What do you see here that this kink fold and chevron fold both of them have sharp hinges? Like this. And in terms of fold geometry that you have learnt in the previous lecture let us have this profile or this line we try to do it. You see when you encounter a chevron fold in the field it is very difficult or it is impossible to define the inflection point. Right?

So it is somewhere here right? But the sense of curvature actually is changing at the hinge points. So this point you do not change the sense of curvature so typically this cannot be inflection points and this is why I am repeating the fact that these terminologies that we use to define the geometry of the fold are very much qualitative and they vary from one kind of geometries to another kind of geometries. So keep this always in your mind that not necessarily in each type of folds or each type of geometry you can define each and every terminologies that we are learning so far.

The concentric fold is something like this where along this point the folds generate here along this point you can see the folds are generate that means it has some sort of a centre along this centre the folds are generating this is known as concentric fold and if so here we see this in multilayer but sometimes we call it cuspate lobate fold as well. So cusps and lobes, these are forming alternatively in this kind of fold. Now box fold or double hinge fold is something like this where we have seen it before we have in one segment of the fold we have two hinge points and therefore the axial stress you can see here they are some sort of converging towards the fold core. And these are known as box folds and sometimes we see this kind of folds when we deform the multi thin multi layers of contrasting competence contrast. So based on the shape of fold hinge we define it as kink fold or we just say kink fold chevron fold concentric fold and box fold and they are mostly identified or they are classified based on their appearance and geometry of the hinge.

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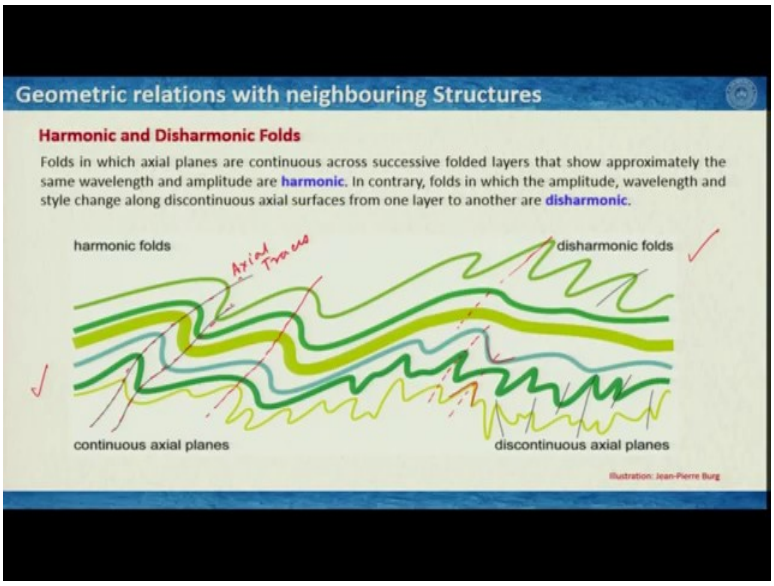

Now we are on the last part of this classification which is geometric relations with the neighbouring structures and here we learn the series of terminologies as well to define how one folded layer or stack of folded layer is related to the neighbouring features and the first on we will take over is harmonic and then disharmonic folds. Now folds in which axial planes are continuous across successive folded layers that show approximately the same wavelength and amplitude are called harmonic folds.

So as you can see here in this part on the left side of this illustration, you can connect the actual tresses of all these successive layers. Okay? Here you can also connect all these successive layers so these are your axial traces. Okay? So when that happens that is folds are in a harmony these are known as harmonic folds. However in contrary folds in which the amplitude, wavelength and style of this folded layer do change along this continuous axial surfaces from one layer to another are disharmonic folds as you can see here on the right side of this illustration.

You cannot connect so you can connect there three but then it is here. So there is a discontinuity there is a disharmony here for example you see an antiform and if you connect try to connect to you arrive to a synform so here all these things are little jumbled up and therefore they do not have any harmony in this folded layer and we call them therefore disharmonic folds so we learnt what is harmonic and what is disharmonic fold.

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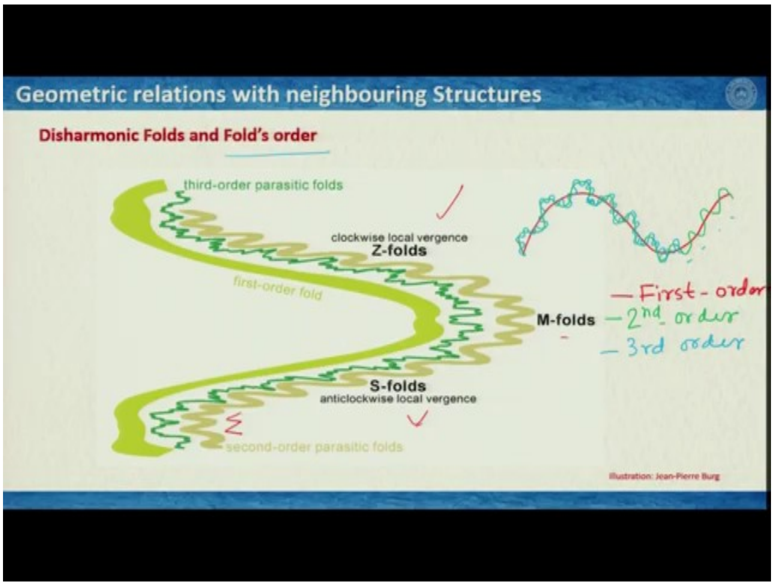

Now harmonic and disharmonic folds also related to some sort of ordering of the fold. As you can see here if I consider this that this is some sort of what we learnt there that Z fold M fold S fold and so on clockwise local vergence, anticlockwise local vergence and so on. Here you also develop this W folds and so on. Now what is the message I try to convey here that you can have a large fold like this and then this large fold may be defined, something like that. And then this small folds also, can be defined by smaller folds and so on. So the red on we call it first order fold.

The green one is the second order, I write it this way for better space and the blue one is third order fold and this first order second order third order so on this folds can be of harmony or can be of disharmony. That is, this is how they appear but this is where in this light we learn the orders of the fold. So large fold wavelengths are generally lower order and small wavelengths are generally of higher orders of folds. Okay.

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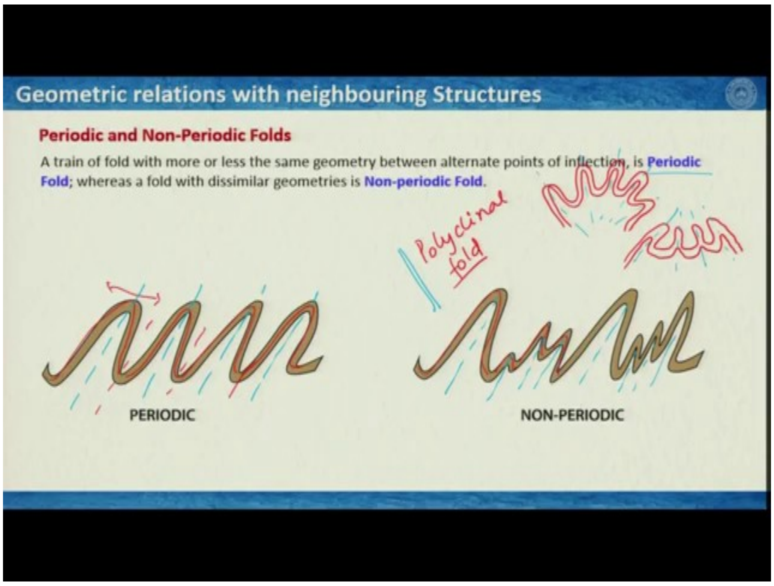

Then there is something called periodic and non-periodic folds. Now if within a train of folds you have series of synforms and antiforms and so on. So with more or less same geometry between alternate points of inflection if you, if you see that then this is known as periodic fold or in other ways other words folds look very very similar they are they are similar to each other. So one set of fold here the next set of fold here and they appear in a similar way and these are known as periodic fold that is the same structure appears periodically and if that does not happen that they have a dissimilar geometry then this is non-periodic fold.

So as you can see here in a very rough sketch, that this structure is appearing here as well appearing here as well, here as well and therefore this is, this particular structure is getting a periodicity in the next structure. However in this we do not see this. So first one is like this, second one is something like that third one is like this and so on so this is a non-periodic fold. Now non-periodic folds there is a special kind of non-periodic fold which is known as polyclinal fold. What do you see here in all these cases I use this typical colour for actual planes.

The trace of actual planes does not matter whether the fold is periodic or non-periodic. The trace of actual plane are more or less constant right? But in polyclinal folds you may have folds like this, or you may also have folds like this. This is not very common. Where there where you see the in the first case the axial planes are converging towards the core and here axial planes are converging away from the core. So these are known as polyclinal fold where axial planes in successive layers are different to each other the orientation of the axial planes to be specific.

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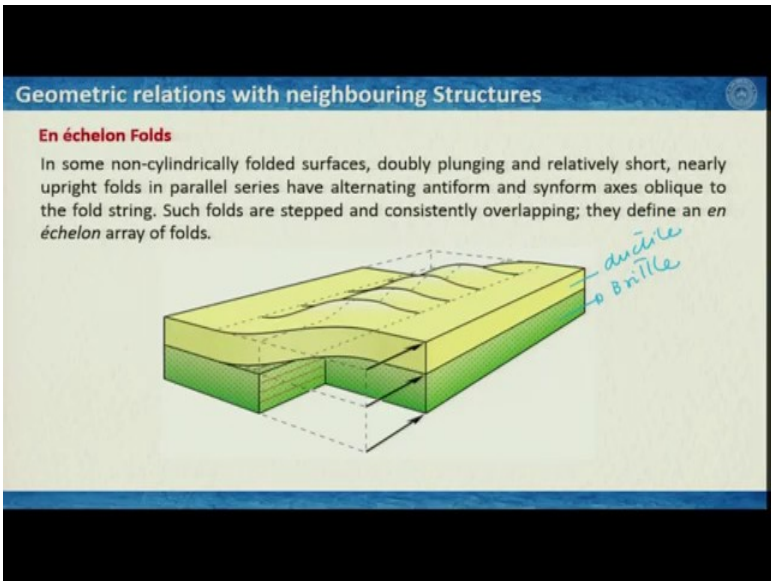

Now then there is another type of fold which is known as en échelon fold or enéchelon fold this is a French word I. I do not know how to pronounce it properly but most likely en échelon fold. So it is a very special type of folds in some non-cylindrically folded surfaces or doubly plunging, relatively short nearly upright folds. In these see, in a parallel series they have alternating antiform and synform axes oblique to the fold string and these folds are stepped and consistently overlapping to each other they define an en échelon array of folds know as en échelon fold.

So this is an illustration as you can see here so if you have some sort of a ductile layer on the top this yellow one so this is little ductile and if you have a strong layer which is brittle and if you generate a fault a strike slip fault we will learn it soon in the one of the next lectures when we talk about fault. So if this block slips the past the other block then it drags the top ductile layer and then that happens then you form series of folds in an array and these folds together known as en échelon folds.

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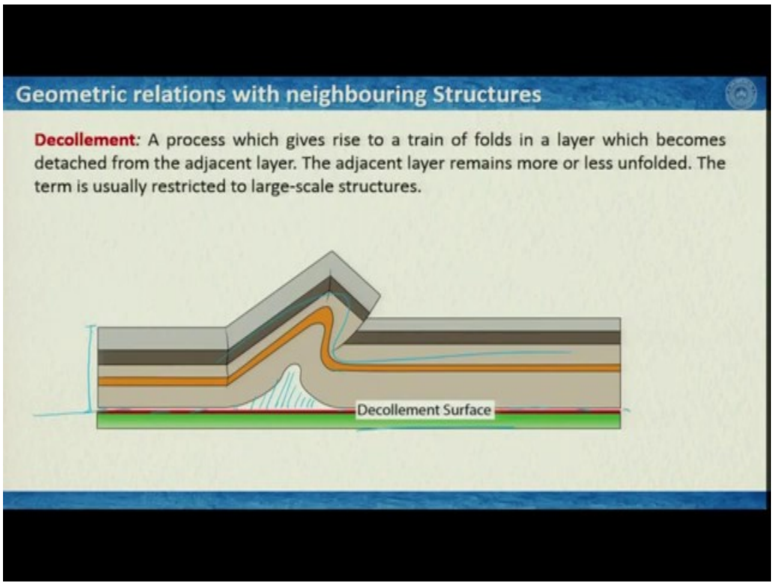

Now there is also another important terminology related to the geometric relations with neighbouring structures and this called decollement or decollema. A process, a decollema is a process which gives rise to a train of folds in a layer which becomes detached from the adjacent layer either at the bottom or at the top so the adjacent layer therefore does not suffer or enjoy any deformation so it is almost unfolded or undeformed and these kind of decollema these kind of features is generally seen in large scale origins.

So what do you see here this series of layers these are getting folder so it got folded like this however here so here is a fold it got detached from the surface so this is the opening due to detachment and this is kind of slip surface and this is known as decollema or decolomous surface and I repeat these things you hardly see in small scale feature but you mostly see these kind of features when you go to or when you map a large scale structures then you see these kind of decollemas. The final one we will see is called intrafolial fold. So folia means leaves so intrafolial means a fold between the leaves in our case a fold between some layers or fine layers.

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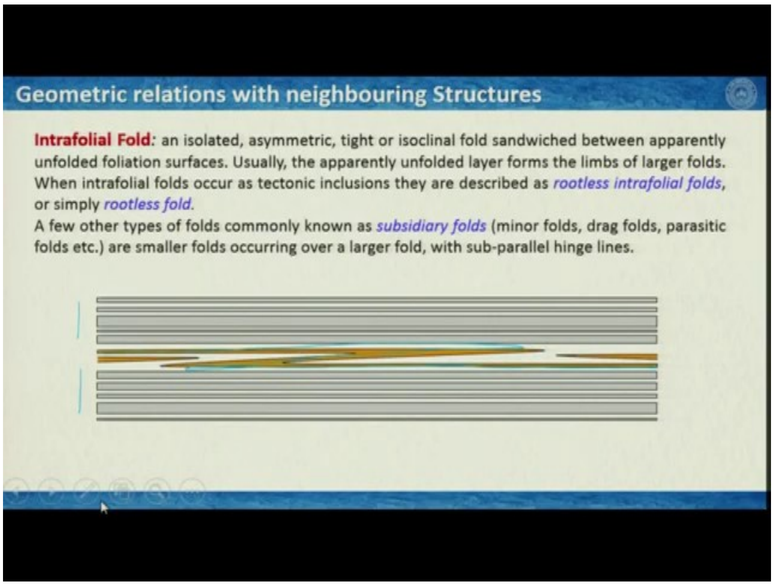

So this is defined as an isolated asymmetric type or isoclinal fold sandwiched between apparently unfolded foliation surfaces. Usually the apparently unfolded layer forms the limbs of the larger folds when intrafolial folds occur as tectonic inclusions they are described as rootless intrafolial fold or we simply define it as rootless fold. And in this context there are few other types of folds so we generally term them as subsidiary folds like minor folds, drag folds, parasitic folds etc, etc. these are kind of smaller folds and they occur over a large fold with sub parallel hinge lines.

So let us look at the intrafolial fold here. So you see you have a straight strata with apparently no deformation at least in this section and in between you have a layer which is strongly asymmetric very tight fold in between or which is sandwiched between almost partially undeformed layer at least in this section and these are known as intrafolial folds. Folds within finely laminated layers.

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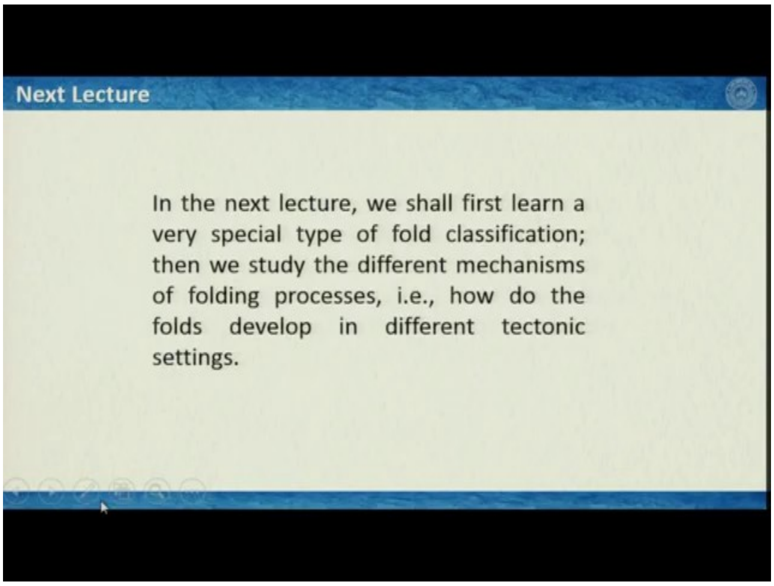

So with this I conclude my lecture. In the next lecture we will first learn a very special type of fold classification is given by professor Ramsay is called dip isogons and then we study the different mechanisms of folding processes that is how the folds do form differently in different tectonic settings and so on. Thank you very much. See you in the next lecture.