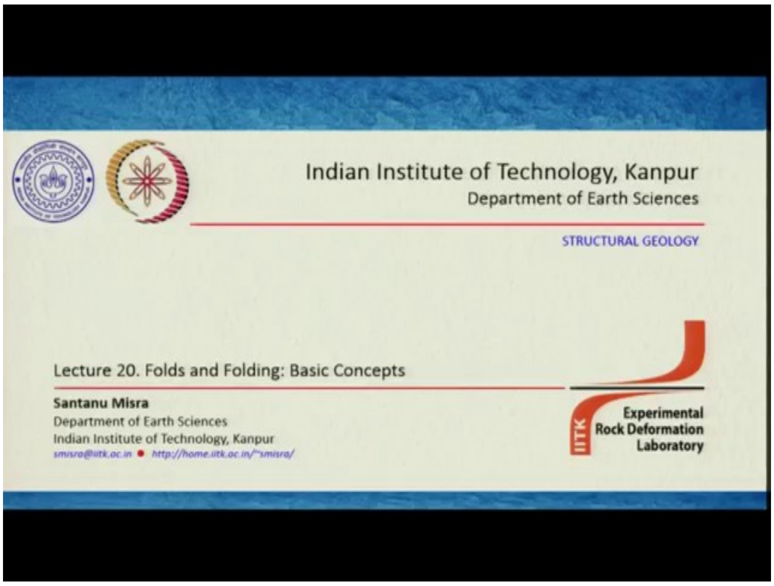
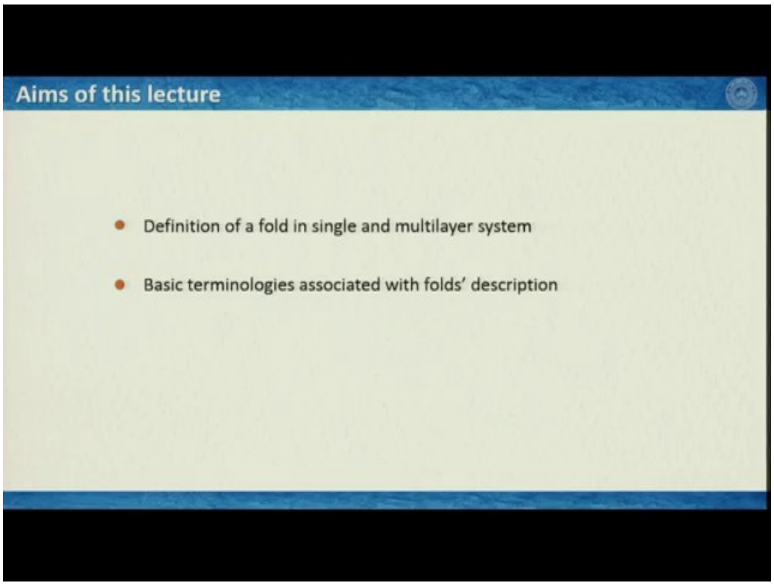
Structural Geology
Professor Santanu Misra
Department of Earth Sciences
Indian Institute of Technology, Kanpur
Lecture 20 - Fold and Folding: Basic Concept

(Refer Slide Time: 00:30)



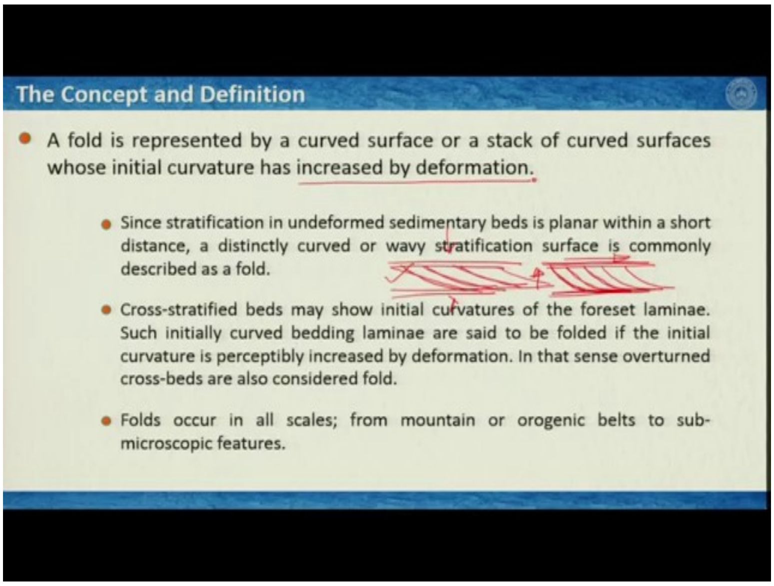
Hello everyone, hope you are doing welcome back again to another lecture on this structural geology in NPTEL online course. We are also in a new week and we are on our lecture number 20 and in this week will be learning folds and folding. So this particular lecture we will focus on the basic concepts of folds. The next lecture would mostly we will see the classification of folds and the final lecture will dedicate to understand the different mechanisms, the way the folds form in nature and at the same time we learn after that, how different folds interfere each other or we call it superposed folding or superposed deformation.

(Refer Slide Time: 1:20)



So in this lecture we will mostly focus as I said the basic concepts of folds and folding and we will cover first we will define the fold in single and multi-layered systems and then we will look at or try to understand some basic terminologies associated with folds description. Now at this point before we go to this defining fold, I would like to remind you that this lecture and the next lecture as well would consist of a lot of new terminologies that we generally use to describe the folded structure and these terminologies are very very important and essential, not only to understand the folded structure but also to communicate your ideas or your understanding to someone else. So, you may figure out that it is little boring because it would include lots of terminologies, their definitions and so on, but I request you to keep patients and listen to this lecture carefully and try to understand the terminologies, their physical significance and meaning.

(Refer Slide Time: 2:35)



So first let us try to define that what is fold? So the concept and definition of fold. Now as it is written here in this slide, fold is represented by a curved surface or a stack of curved surfaces whose initial curvature has increased by deformation. Now, apparently this sentence looks very simple, but it has some very important words which we need to remember in defining or in understanding the fold. The first and 4 most important term or phrase of words is increased by deformation. In many notes or texts, you may find that fold is defined in such a way that a fold is undulations on earth's surfaces.

Well this definition is not wrong, but essentially it does not describe the fold that we try to understand in the subject structural geology. Any curvature is not necessarily any undulation is not necessarily a fold. The curvature or undulation whatever word you use this has to be produced by deformation. So that means that if I have an initial curvature, that may not be produced by deformation and by application of deformation if that curvature got increased, then we term this structure as a folded structure or simply a fold. So deformation is very very important in defining fold. Without deformation if you have any curvature that is not at all a fold.

Now in this context, you can imagine the fact that the stratification of sedimentary layers in undeformed sedimentary beds is generally planar within a very short distance. So, within that short distance, if you can develop wavy or curved surfaces or wavy or curved stratification, then it is a fold provided, I repeat this curvature or waviness has produced by deformation. Now in this context, there are also some a very typical sedimentary structures where you may find that it is curved, but you have to inspect whether this curvature has produced just by sedimentation or during the sedimentary processes, in that case it is not a fold but if that curvature got increased due to deformation, then it is essentially a folded structure.

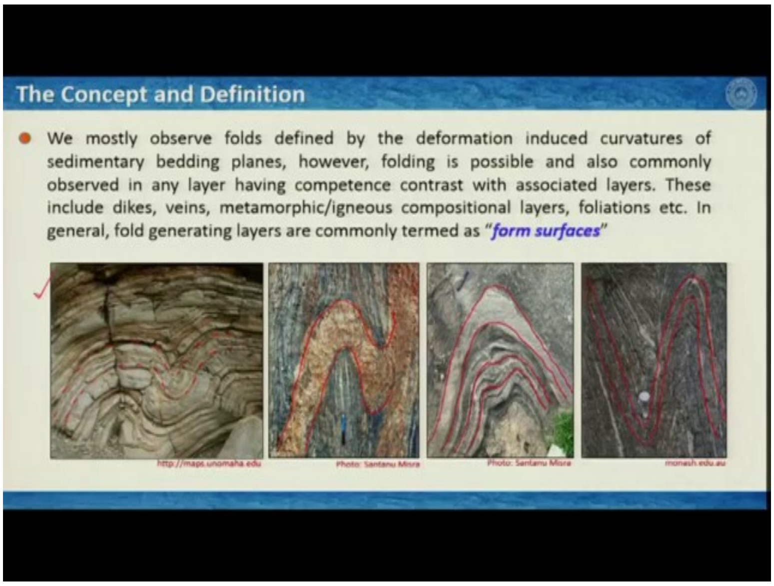
So, in that sense you can think of the cross-stratified beds, as it is written here, the cross-stratifications as you know, this is a structure like this. So, you have sedimentary layers and in between you may have a very typical structure sedimentary structure like this or this has a lot of information. First of all, it tells you the younging direction of the sedimentary deposit. It also tells you the flow direction, paleo flow direction and so on.

Now, essentially we see within this two layers, this sandwiched structure. Now, there is some sort of curvature as you can see in this illustration. Now, is this a fold? You have to inspect or you have to understand by some processes that whether this curvature you see here is due to deformation or it is just the depositional feature. Now, you can also deposit layers something like that, whether the curvature is very very less and then during compaction, you may develop a curvature here in this layer and this is then a fold.

So, while you define a fold then you always remember, I am repeating it that you must see or you must have to find some sort of perceptible deformation feature within this structure or within this curvature. Then you name it as a fold or understand it or recognize it as a folded structure. Now, a fold as we have seen in one of our first lectures can be of various scales. This indicates that the fold mechanism or the way the fold forms is a very constant process, but their scales could be different. You can see folds in an orogenic scale and you can also see folds under microscope, even under transmission electron microscopes, whether the length of a fold is in nanometre scale.

So with this, we try to understand that what defines a fold in this particular slide. Now, so far we have learnt about structural geology or so on or with some sort of information from other subjects that most of the time we think or we perceived the fact that folds are defined by sedimentary layers and I tell you, this is very much true. However, as per the definition any layer can produce a fold provided it has competence contrast with its surrounding.

(Refer Slide Time: 8:28)



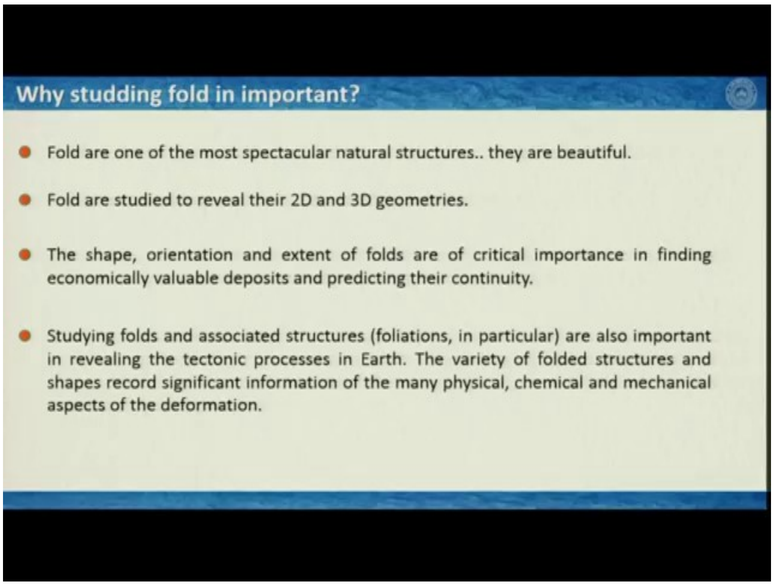
So as it is written here we mostly observed folds defined by the deformation induced curvatures of sedimentary bedding planes, however, folding is possible and also commonly observed in any layer having competence contrast with associated layers and these layers you can think they can include dike, veins, metamorphic or igneous compositional layers, foliations and so on.

So, to distinguish between the sedimentary layers and all these other layers or all these other planar features that is listed here in this slide. We generally term them as form surfaces. So form surfaces are nothing but along which a fold can develop or a surface that has a potential to develop a fold. So you can see here are 4 images. The first one is this folded structure is defined by sedimentary layers. Here, you see this is a dike that got intruded at one point of time and then it got folded.

This one is a metamorphic layer compositional banding in a migmatite migmatitic rock alternate dark and white bands and this also got some sort of deformation and that is why it generated the curvature, and here you can see this, we can understand from our previous lecture, that this is a continuous foliations as there is this fold, so this foliations certainly got folded. So initially it was planar of course foliations do develop in a planar manner and then by deformation this foliations got curved and that is why it has now a folded structure.

So doesn't matter whether it is a sedimentary layer or a dike or a metamorphic compositional layer or some foliations. It can generate folded structures provided there are feasible conditions and these conditions are mostly included whether this layers or surrounding materials of these layers have enough competence contrast with the layer that we are expected to be folded. So, the obvious question comes now that, why we should study fold? Why it is important in studying fold and related features?

(Refer Slide Time: 11:15)



First and foremost, folds are one of the most spectacular natural structures that you see in the field, they are really beautiful. I personally got excited by seeing the folds in the field. If I get time I sit there, take out my field notebook and try to sketch it and if I do not have time, then I just take a photograph and leave that place, but it excites me a lot of folded structure in the field. Apart from this, folds are studied to reveal their 2 and 3 dimensional geometries, as we talked about that fold can be of any scale, so you can think of a fold of orogenic scale you not necessarily are going to see the entire folded structure.

So therefore, if you see a part of this fold in different places, different parts of this fold, it is very important that you construct their first 2 dimensional and then 3 dimensional geometries and it is not only the field work you have to collect the data like dip, strike, trend, plunge of belated structures and then you have to plot it on the stereonet, and then you can construct the 2d and 3d geometries. This you must learn from your field studies.

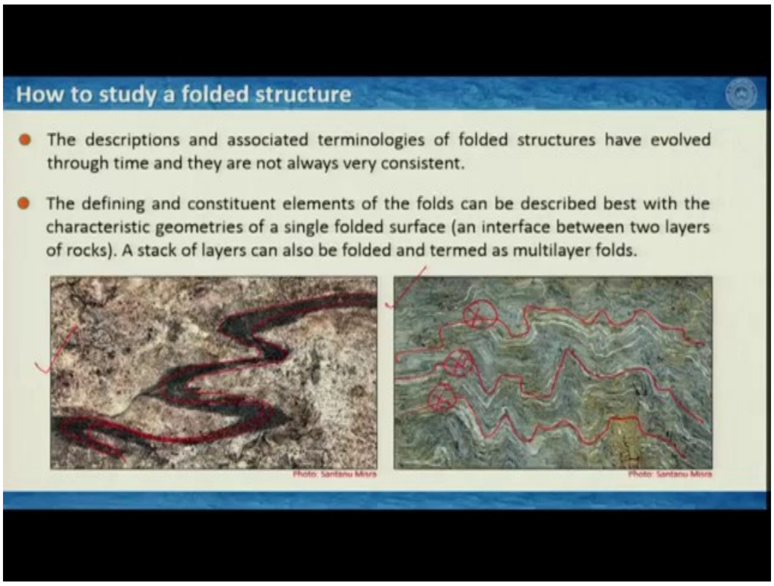
Apart from this, the shape orientation and extend of the folds are of very much importance in finding economically valuable deposits and predicting their continuity. You probably know from your petroleum or hydrocarbons geology lectures that hydrocarbons particularly oils, these are generally found at the top of the folded structure. We will define it later that these are antiforms, but generally at the top of this folded structure, you find hydrocarbons.

Sometimes some old deposits are confined along a particular sedimentary layer or along a particular dike or vein and so on.

Now, if the sedimentary layer and dikes are extremely folded, then it is very challenging for a mining engineer to plan the mine, because the layers do not have a constant strike and dip and so on. So, the mining engineer cannot just drive the mine along a single direction, so there a structural geologist can guide him or suggest him that "hey, this is the folded structure, the mineral of importance is confined within the folded structure, so plan your mining like this." So, this is how the folded structures are also important in finding economic or economical valuable deposits and so on.

Now the final and most importantly, the folds do carry a lot of information regarding the tectonic activities. So, folds and their associated structures like foliations are very very important in revealing the tectonic processes in earth, particularly dip earth processes. The variety of folded structures and shapes record significant information of the many physical, chemical and mechanical aspects of deformation. So folds, the layers, the form surfaces, their relation with the foliations, and so on, do carry a lot of information and it is a challenge for a structural geologist to study this information to reveal finally, the overall tectonic deformation of that particular region that you are studying.

(Refer Slide Time: 15:19)



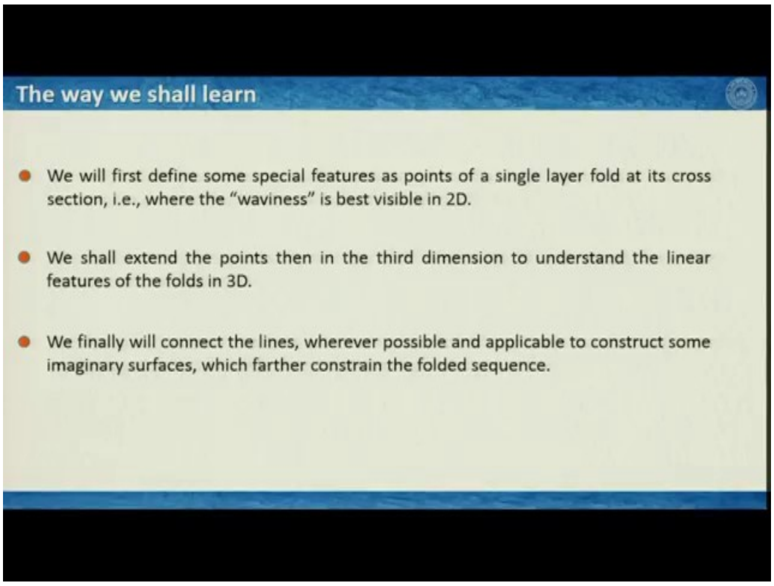
Now, how to study a folded structure so if you see a fold, not necessarily you can study, there are many ways you can study the folded structure. But as we discussed with foliations, the descriptions and associated terminologies of folded structures also have evolved through time and sometimes the terminologies or their descriptions are not always very consistent. However, with recent days, these terminologies and their descriptions became very very strong and mostly globally people are using the very similar terminologies. So, life is a little easier now, in terms of describing folded structures.

So, to define a folded structure you can think off in two different ways. The first one is you can describe if you consider a single layer or an interface between two layers and then we call it a single folded surface. So, if you have two layers, then you can think of their interface that how this interface is defining the fold or you can consider a very thin layer of the rock and how it is defining the fold. This is the example.

The example is given in this photograph. You can see that in this gravity matrix, we have a black layer, which is defining the fold, the other sides we do not have any other layers to interfere this fold, so if we study this folded layer, then we can figure out the deformation of this area. But that is not always the case, sometimes you find a stack of layers that can also be folded and in that case, we term them as multilayer folds, which is the second image, we see here.

You see here this is alternate bands of metamorphic foliations and you see these layer got folded, like this, then this layer got folded like this, the layer in between it got folded like this. So if you study a single layer and you can see that the fold pattern of this particular layer is significantly different from this particular layer and this particular layer. So in multilayers, they can produce fold in a very similar fashion or in a very different fashion, we will learn about it later, but the concept is you can study the folded structure in single layer or also in multilayer and they do have their own pros and cons. So, how will you proceed in this lecture? I wanted to give you this slide that we will proceed this lecture in a very very structured manner and how will you do that it is written in this slide.

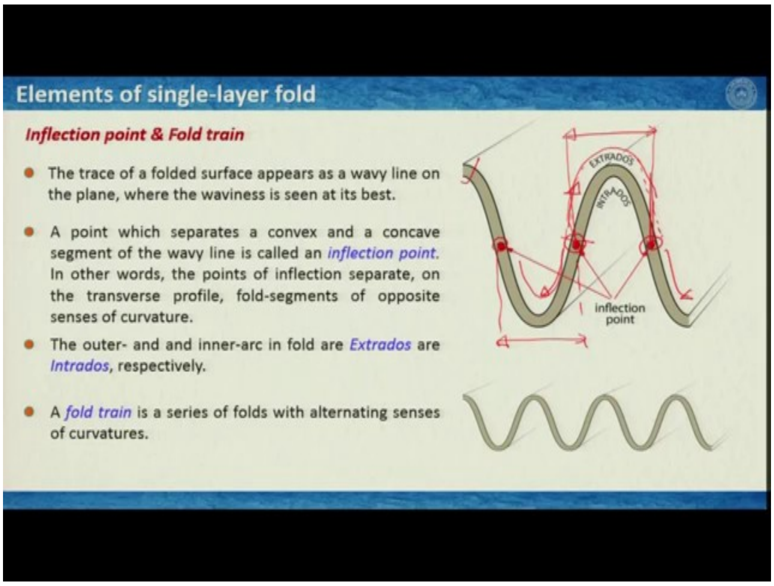
(Refer Slide Time: 18:05)



We will first define some spatial features as points on a single layer fold at its cross-section. So, what we mean by cross-section at this stage of our understanding of folded structure is where the "waviness" is best visible in 2d. So, if I have a folded layer, then I have to see it in 2d and I will see it on a section where this waviness is best visible.

Then we will extend these points to the third dimension. That means we will draw some lines along successive and similar points and will try to understand the features of the fold in three dimensions and finally, we will connect the lines, wherever possible and applicable to construct some imaginary surfaces, which further constrain the folded sequence and define the folded structure. So, with this concept let us start with our first definition.

(Refer Slide Time: 19:20)

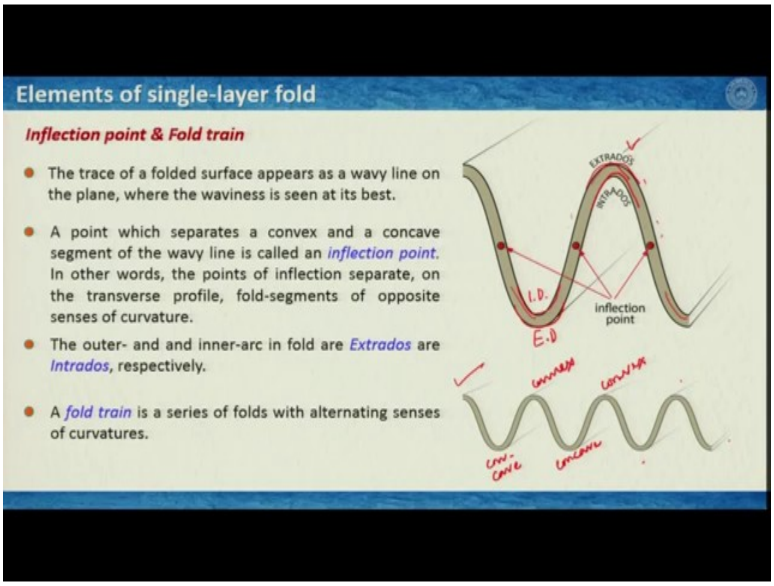


The first thing we learned is inflection point and fold train. So these are the elements of a single layer fold, we will see more terminologies in the next slides, but let us focus on the inflection point and fold train. Now as we talked about the trace of a folded surface appears as wavy line on the plane, when the waviness is seen at its best. Let us take this example, so this is a folded layer, as you can see here, this particular layer, this light brown layer that got folded and we are seeing this along a section where this waviness is best visible.

Now you see this wave has a very typical point, if I consider this point here or the best this point here, this point is a very important point because it separates the curvature of the fold or in other way, the nature of the curvature of the folds. So if I go this way from this fold then it generates a convex pattern and if I go this way, it generates a concave pattern. Similarly this convexity at one point here, it terminates and then it goes again to the concave side.

So when we define a single fold, we take this point and this point, so this distance or this particular curvature is defined as a single fold and in a very similar way here to here, it is defined as a single fold and this particular points at each and every wavy surface or each and every wavy line, you can define this point as a point which is separating the fold segments of opposite sense of curvatures. So here, it is convex and here it is concave and this point is separating this convex and concave side of this fold and this point is known as inflection point.

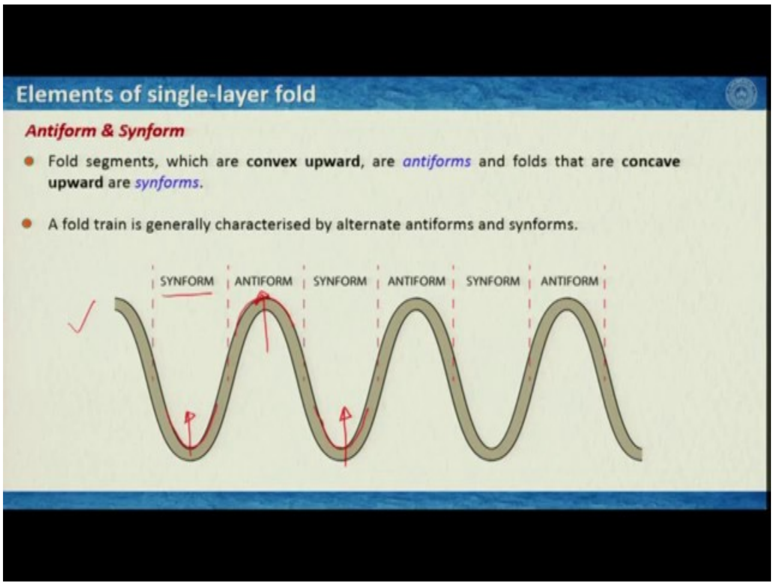
(Refer Slide Time: 21.59)



At the same time, we learn another term, which is called extrados and intrados. This is a relatively easier term to understand the outer and inner arc in the fold are extrados and intrados respectively. As it is written here, so this is the outer arc, so this is known as extrados. This is inner arc, this is known as intrados. The fold core is also towards the intrados side. Now, if we come here so this would be your intrados and this would be your extrados, so this side the outer arc here is extrados and this inner side is your intrados.

Now, if you have a series of folds with alternating sensors of curvatures, like you have series of convex, sorry concave and convex and then again concave and convex layers, they move on from one point to another point as it is shown here in this illustration, then it is known as a fold train. So fold train is a series of folds with alternating senses of curvature. So, here it is concave, here it is convex, here it is again concave, here it is convex and so on. So, this alternation when it happens then we call a fold train in a single layer fold. Now in this concept of inflection point, fold train, extrados and intrados let us move to the next element.

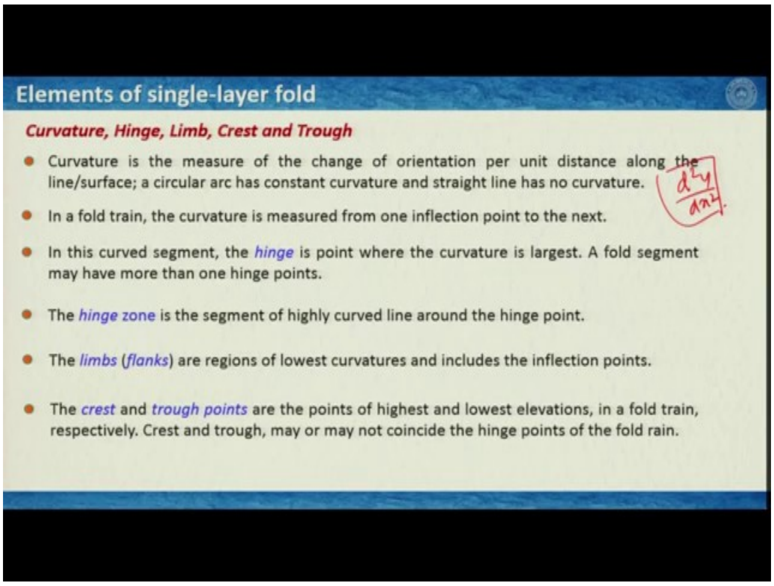
(Refer Slide Time: 23:51)



What we learned here is 2 very important terminologies related to fold geometry and fold description is antiform and synform. Fold segments, which are convex upward are antiform and the folds that are concave upward are synform. So, a fold train is generally characterized by alternate antiform and synform, so now we define the fold train with the help of antiform and synform.

So, as you can see in this illustration here, this is a concave side and this concavity is upward. So, as by definition, this is synform. Here, this is convex and the convexity is upward. This is antiform. Here, again this is concave, concavity it is upward. This is synform and so on. So, a synform is where the fold closes downwards, you can say it that way as well and an antiform is something where the fold closes upwards. So, upward closing folds are antiform and downward closing folds are synform, we will talk about more with antiform and synform in the next lecture, particularly when you talk about the classification of the folding.

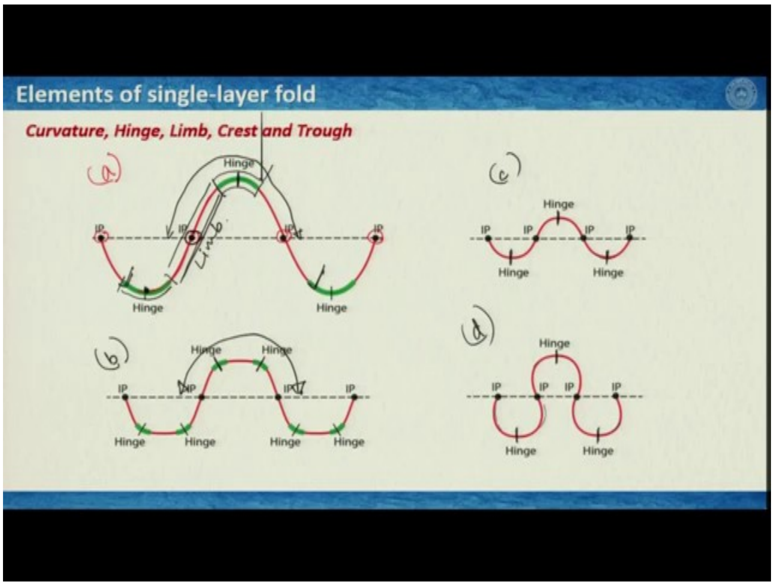
(Refer Slide Time: 25:29)



Now, 5 more very very important terminologies as well we are going to learn in this slide. First, we will define these, and in the next slide, we will see them in the form of illustrations. These are curvature, hinge, limb, crest and trough. Now we start first with the curvature, we know that curvature is the measure of the change of orientation per unit distance along the line or surface. That means that a circular arc, so if I draw a circle, then the curvature is continuously changing and the change of curvature is constant. Mathematically, it is defined as a curvature d2y by dx2 okay? Now, a straight line, when if you consider, then the curvature does not change because, at any, any segment of this line, the orientation of this line does not change if you proceed along the line. So in that sense, within a fold train, we can figure out that it changes it curvature from the synform to antiform and so on, keeping the inflection point at the middle.

So if I consider a curved segment of a fold, then we define a typical point at this (curv) curved segment, which is known as hinge, which is a point for the curvature is maximum. Now, not necessarily in a folded segment, you will have or a typical curve segment single curved segment, you will have a single hinge, you may have more than one hinge points. The hinge zone is the segment of highly curved line around the hinge point. It also includes the hinge point as well. Then it comes the limbs or flanks, which are the regions of lowest curvatures and includes the inflection points. Then comes the crest and trough. These are the points of highest and lowest elevations, in a folded train or in a fold train, respectively. The crest and trough sometimes they coincide with the hinge points and sometimes they do not coincide with the hinge points. We will see this in the illustrations.

(Refer Slide Time: 28:05)

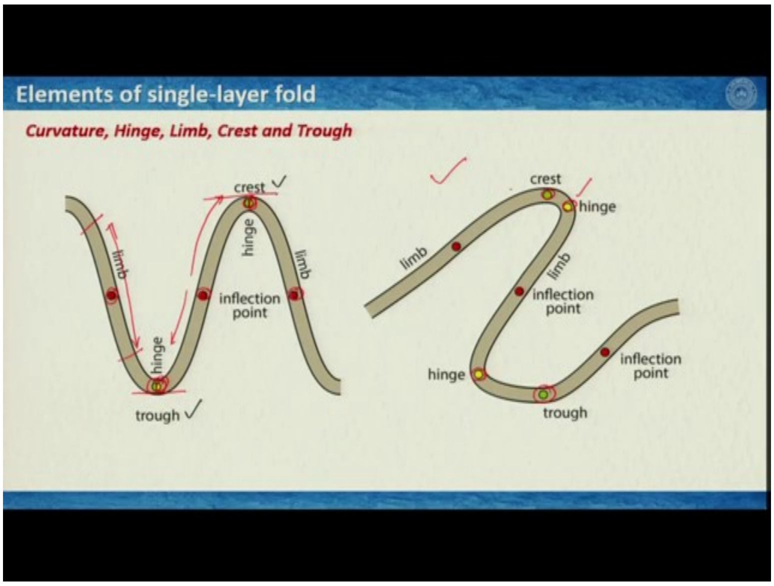


So, here we have defined this hinge, inflection point, limb and so on. Hinge zone in this very typical illustration of a folded structure, particularly with the concept of curvature. As you can see here this first illustration this one let us define this as, a. What we see here, this is certainly an inflection point, which is separating this folded segment to the other side of the folded segment right! So this is here, this is convex and this is here, this is concave. So, I have alternate or continuous inflection points. Now, if I consider this segment from here to here, of this fold, then I see that there is a particular point where the curvature is maximum and this point is known as the hinge point and around this hinge point, we have a small segment of this fold, where the line is mostly curved and this green area here, here, here. The green areas here, here, and here are known as hinge zones.

Whatever is left hinge and hinge zones; this is the limb of the fold. So as we have defined in the previous slide, limb must include the inflection point and hinge zone. Also, I am sorry hinge zone should include the hinge point. So, we have defined in this illustration, A, the hinge, hinge zone, again inflection point and the limb of the fold. Now let us have a look of this second illustration, as B. What do you see here, a very similar feature, but in this segment if I consider this particular segment, we see that it has two points where the curvature is maximum. So this particular folded segment has 2 hinge points, this one and this one. Therefore, 2 hinge zones as well.

In these 2 illustrations C and D, if we define it like this, then typically, we see that from here, if we start from here, inflection point and then we travel along this folded train. The curvature is more or less constant and it is very similar in the illustration, D as well. The curvature is constant, but inflection points is there because it separates sensors of opposite curvatures. So in that case, if I have constant curvatures all along the folded trains, then it is the hinge point is defined the middle point between two successive inflection points. So this is the hinge point here, this is the hinge point here, this is the hinge point here. Similarly, in illustration D, these 3 are the hinge points that you can consider. Let us have a look of the same similar illustration in a different way.

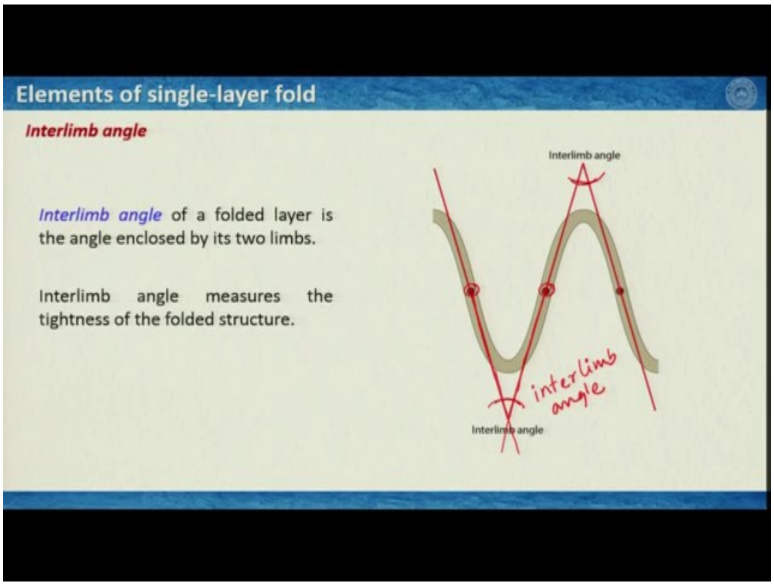
(Refer Slide Time: 31:50)



As you can see here, we have also defined the crest and trough. But before that, let us quickly summarize what we have learned. So hinge is where we have maximum curvature here and here. Inflection points are these 3 points that separates the convex side to the concave side of this folded structure. Now crest, at least in this image, as we have defined is the maximum elevation you can achieve in a folded train and in this case, this is coinciding with the hinge point and similarly the trough as well, which is the lowest point, you can achieve in a folded train and this is here as well, coinciding with the hinge point. The limb is this entire region from the hinge zone to the next hinge zone in that segment.

If I look at this image, I see that the maximum curvature is here. But this is not the highest elevation point. So therefore, crest is defined here, hinge is defined here. Similarly, this is the maximum curvature of this concave side. So hinge is here, but this is the lowest point of this entire fold train. So this is the trough. So, we have understood now that hinge may or may not coincide with the crest and trough points.

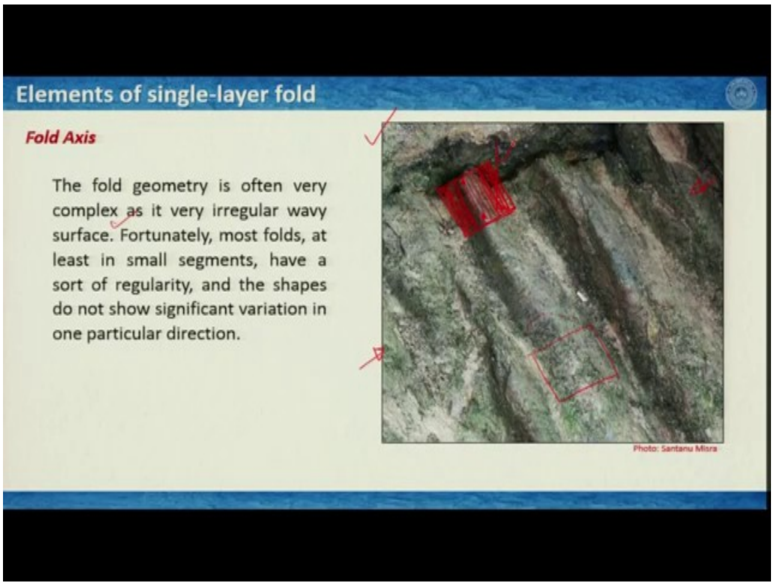
(Refer Slide Time: 33:35)

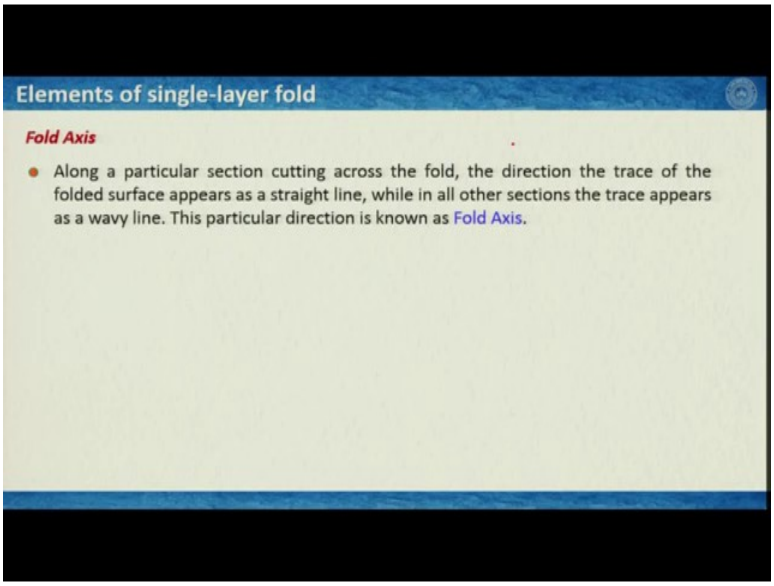


We have another very important term, that we are going to learn now is interlimb angle. Now, interlimb angle of a folded layer is the angle enclosed by its 2 limbs. The way it is constructed or the way it is measured that you first figured out the 2 successive inflection points. So in this case, I can consider this one and this one and then, from these inflection points I draw a tangent, which for example, is this red line and for example here, this red line. They will intersect somewhere and the angle they make is interlimb angle.

Similarly, I can also draw an interlimb angle on this convex side and this is again your interlimb angle. Now in a fold train this interlimb angle may vary from one curve to another curve or it may remain constant, we learn about it later. But interlimb angle tells us or it measures the tightness of the folded structure, the lower the interlimb angle, the tighter is the fold, we learn about it later and we classify the fold also based on the interlimb angles, the fold is mostly defined by a term or by a parameter is known as fold axis.

(Refer Slide Time: 35:35)



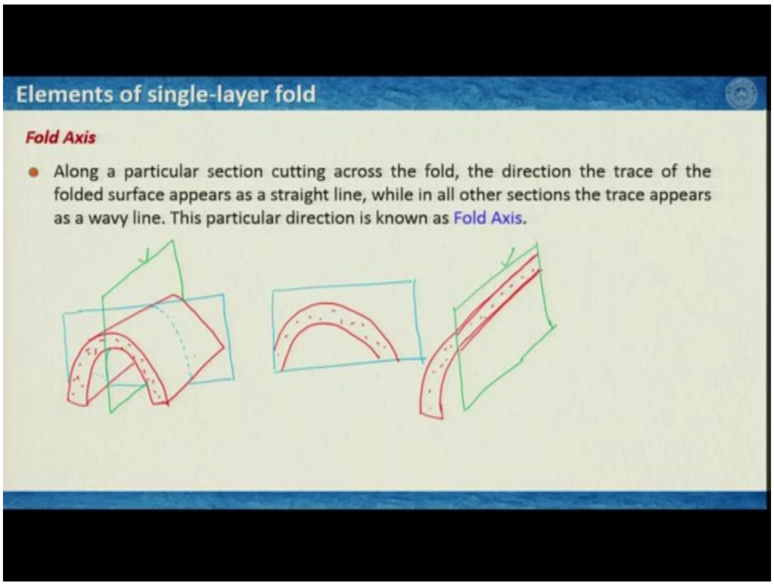


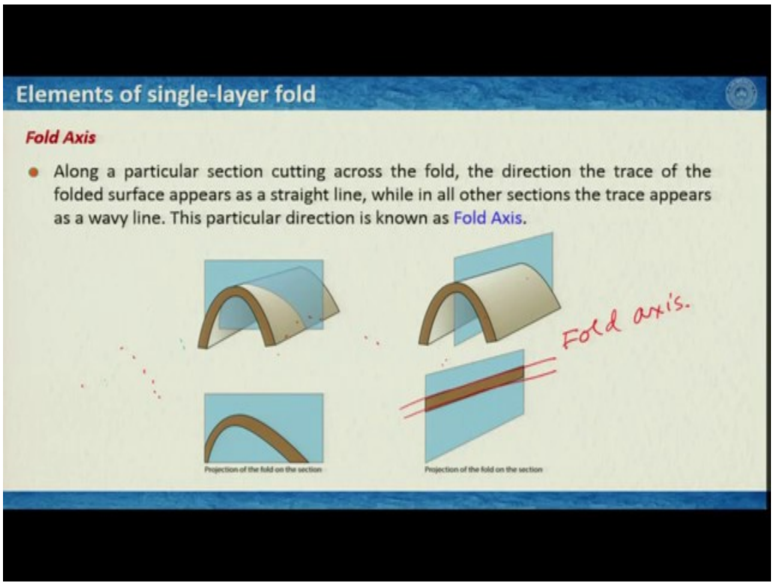
Now, fold axis is something that is initially not so easy to understand or to conceive, but I will try to give you the ideas or how different ways you can understand the fold axis and this is because the fold geometry is often very complex and it is very irregular wavy surface. It is just not a very typical sine curve that you can think of, which is consistent on its third dimension and this photograph; we see here is an excellent example of such irregularity. Now what we see here, we see the form surface, the folded surface itself with the shadows. You can figure out that this layer, which was horizontal at one point of time, it has a compression, it had a compression from these two sides and then this layer got wrinkled or folded.

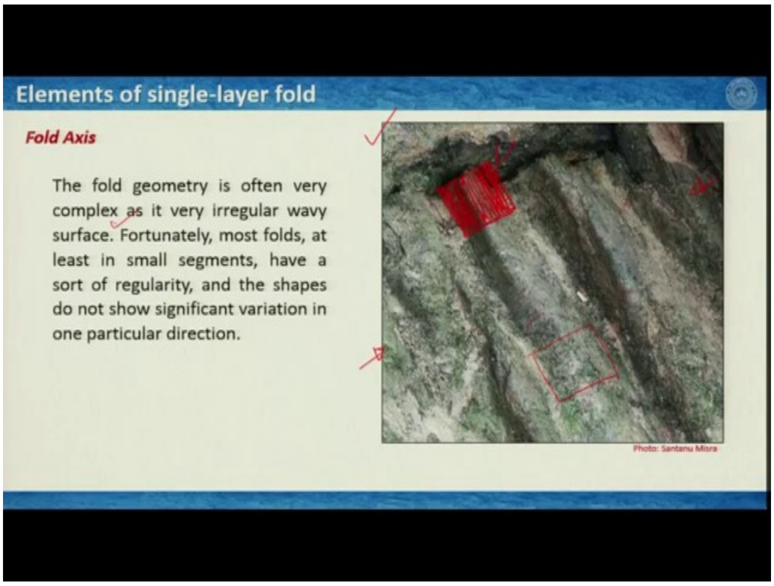
Now, you see that if I talk about the interlimb angle that we just have learned. If we can measure this interlimb angle here and if we can measure the interlimb angle here, these two would be very, very different. So, on a single folded surface, the interlimb angle is changing. We can also figure out that the overall geometry. So here I have a very distinct fold and here the fold has almost disappeared. So it is extremely heterogeneous, thus as we have learned does not matter how heterogeneous is your structure is? There is always a small segment of the structure where you can find some sort of homogeneity. So, this is what it is written here. Fortunately, most folds, at least in small segments have a sort of regularity and the shapes. Do not show significant variation in one particular direction. So if I again concentrate on this little box that we have drawn here and if we try to figure out what is going on, then we can at least can conclude or can convince ourselves that here the deformation is more or less homogeneous.

The interlimb angle, if I measured here, if I measure here are very much consistent and so on. So this is how we try to define or in the next slide will try to define the fold axes, based on this segment. So what is that, I see that if I have a series of lines like this that I can draw on this folded surface, which is curved. Remember, this I am drawing on the plane, so it is appearing like this, but these are actually curved folded right! So it is somehow like this and I am drawing individual lines around the folded surface. Now in this case, the direction of all these lines are parallel to each other, okay?

(Refer Slide Time: 38:46)







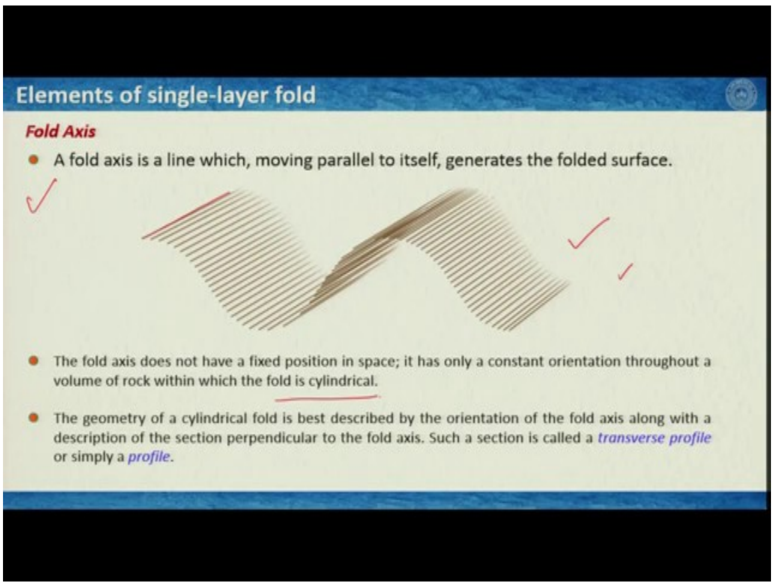
So, we can define the fold axis, that way that along a particular section or we can define the fold axis. So we can define the fold axis in this manner, but we will learn it later. But before that, we see how we can conceive this fold axis in a different way. Now, if I have a folded layer, then along a particular section cutting across the fold, the direction of the trace of the folded surface appears as a straight line, while in all other sections the trace appears as a wavy line and this particular direction is known as fold axis. What does it mean? You can consider that you have a fold like this okay! and then, you may pass a plane through the folded structure, something like that, okay? So you did got somewhere here, something like, something like that. I am sorry, it may not look like this and so on. I can also draw this one a little better way for your better understanding.

Now, what we see here that if I now take off or slice of the fold along this plane, then I would see that on this plane, the folded layer would appear. Something like that. On this plane or in other words, this is curved. I can also draw any, any other plans or I can also construct any other planes, which is cutting across the folded surface, but in each and every surfaces, will always see that the trace of this folded surface on this plane would be always curved. However, there would be a particular plane along which this folded structure would appear as a linear structure and this would be in this particular case may be this plane.

So, if I pass this plane this way, then I would see the folded structure, so it is like this then this green plane is this one and I would see the fold here. The trace of the fold on the surface, something like that. So in any section, you can rotate this blue plane in any direction in any axis, you will always get a curved trace of this fold on this surface, but this green surface is the unique one, whether you would get this trace, a straight line and this straight line or the direction of this straight line is known as fold axis.

Now I have 2 drawings for you. So what we see here, a very similar drawing that we have made. So, this blue layer is, is this passing through the folded structure and this is the trace of this fold and there is this, again the blue plane passing through the folded structure and you have a straight trace of the folded structure on this blue plane and this is your fold axis. This direction is fold axis. Now if we go back to the photograph that you have seen, this one. So, now you see that these are the straight lines, right? So, these straight lines can move parallel to them and can form the fold surface. How does it work?

(Refer Slide Time: 43:49)

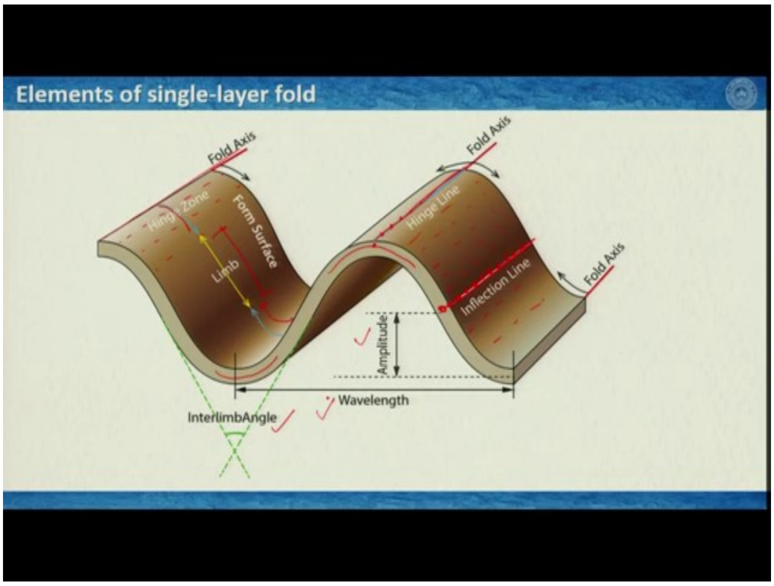


The illustration is here. So series of parallel lines that you can see here, they can move parallel to each other and define a fold. So fold axis is defined in other ways, a fold axis is a line, which moving parallel to itself generates the folded surface as it has done here. Now, from this illustration or whatever we have discussed about the fold axis, I hope you can understand the fact that fold axis is not a material line or it is not a fixed position in the space.

It is a direction with constant orientation and this is important for a particular type of fold or this is valid for a particular type of fold, the fold is known as cylindrical. If that does not hold, then the fold is non cylindrical, we will learn about it, but for a small segment of a very very regular or systematic geometry of a folded structure, we can define fold axis as it is written here, a fold axis is a line, which moving parallel to itself generates the folded surface.

Now, the geometry of this cylindrical fold that we talked about or any fold is best described by the orientation of the fold axis, of course, because this fold axis is defining the folded surface or the fold axis, actually can form the form surface and at the same time, a section perpendicular to the fold axes. So in other ways, the geometry of a cylindrical fold is best described by the orientation of the fold axis along with the description of a section, perpendicular to the fold axis. Now this particular section or this particular plane is known as transverse profile or simply a profile or a cross-section of a fold. We will see later that if we vary this if we cut the fold in different sections, but the transfers profile, the appearance of the fold, would change drastically.

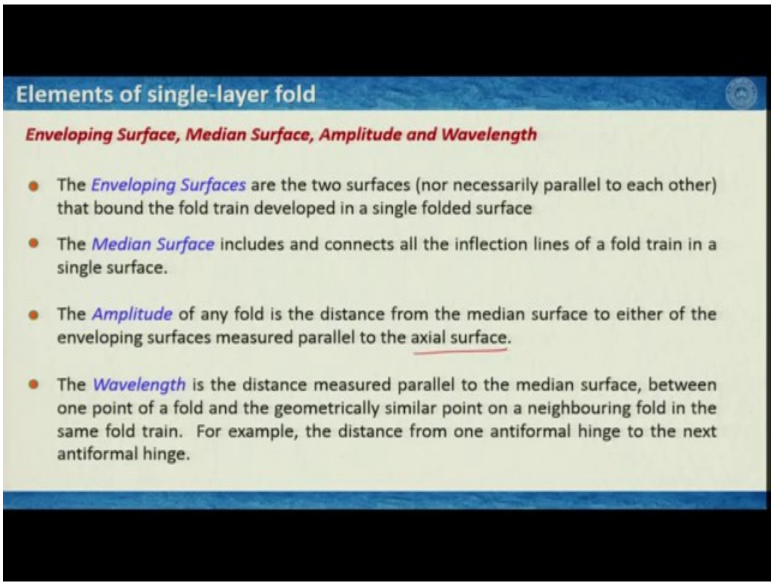
(Refer Slide Time: 46:18)



Now we will see this fold in 3 dimension, when we have defined the fold axis properly. So, what do you see here, we see the fold axis? That should go like this and interestingly, in this case, the fold axis is also parallel to the hinge line. Something to note here hinge line is a material line and what is hinge line? If you have a hinge point and if you connect the successive hinge points, then you generate a line and this line is hinge line. Hinge line is most of the cases parallel to the fold axis, but not necessarily fold axis is the hinge line. Any line that defines the trans parallel to this folded surface can define you or can give you the fold axis.

So, this is your interlimb angle defined with this green lines. This is your hinge zone. This is your limb. This is your hinge zone. This is your concave side. This one and this one is your convex side and this was the inflection point. So if you similarly like the hinge points if you connect successive inflection points on this surface, then you get inflection lines. So this is how you construct the 3d geometry of the fold. So we learned fold axis. We learned hinge line, we learned inflection line and we also have seen the interlimb angle. 2 terminologies are written here amplitude and wavelength will learn it in the next slide.

(Refer Slide Time: 48.06)

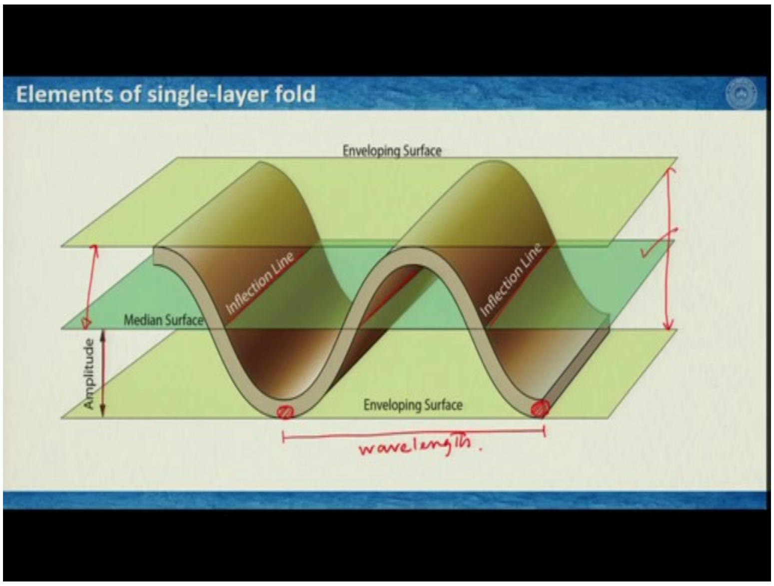


So, once we have, as I said in the very beginning, the way the lecture would proceed. We first learned points, then we connected the points, we got hinge line, we got inflection line and now we try to see if we can connect the lines in a way to define the folds geometry in a much better way. So here comes 4 terminologies enveloping surface, median surface, amplitude and wavelength.

The enveloping surfaces are the two surfaces and they are not necessarily parallel to each other that bound the fold train developed in a single folded surface. We will see the illustration in the next slide. The median surface includes and connects all the inflection lines of a folded train in a single surface. The amplitude of any fold is the distance from the median surface to either of the enveloping surface measured parallel to the axial surface. Now, we learn axial surface in one of the next slide soon.

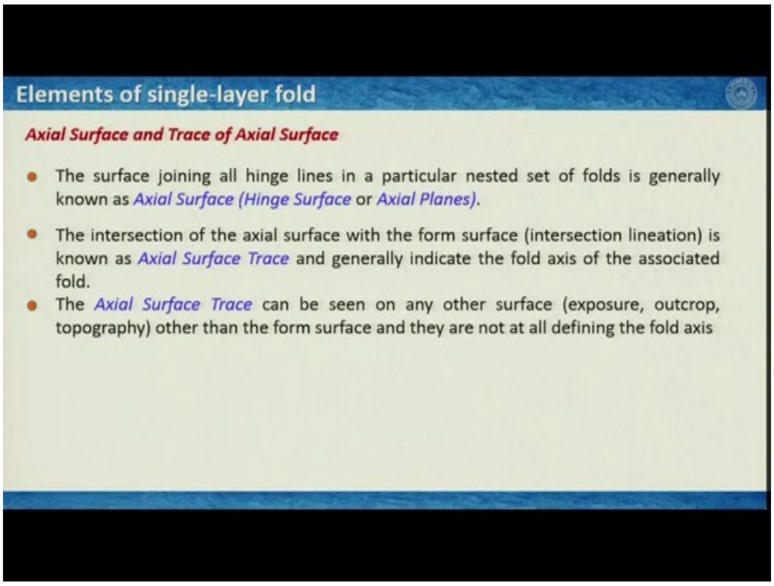
The wavelength is the distance measured parallel to the median surface, between one point of a fold and geometrically similar point on the neighbouring fold in the same fold train. So, if I take the hinge point in an antiformal hinge. Then I have to take the hinge point of another antiformal hinge, which is next to the hinge we have selected. So the distance between these two is wavelength. Let us have a look in a better way

(Refer Slide Time: 49:58)



So again, this is the fold. The enveloping surface, which is covering the fold or that envelops the fold this from distance from the here is known as fold height. The median surface is the green one that connects the inflection lines, successive inflection lines and generates the median surface. So the distance from one of the enveloping surface to the median surface, this one or this one is the amplitude. The wavelength is, if I consider this as the hinge point of this antiform, then this is the next antiform and this is the next hinge point. So distance from here to here is wavelength. So, we have now learned in enveloping surface, median surface, amplitude and wavelength of the fold. Now, these planes are imaginary planes.

(Refer Slide Time: 51:20)

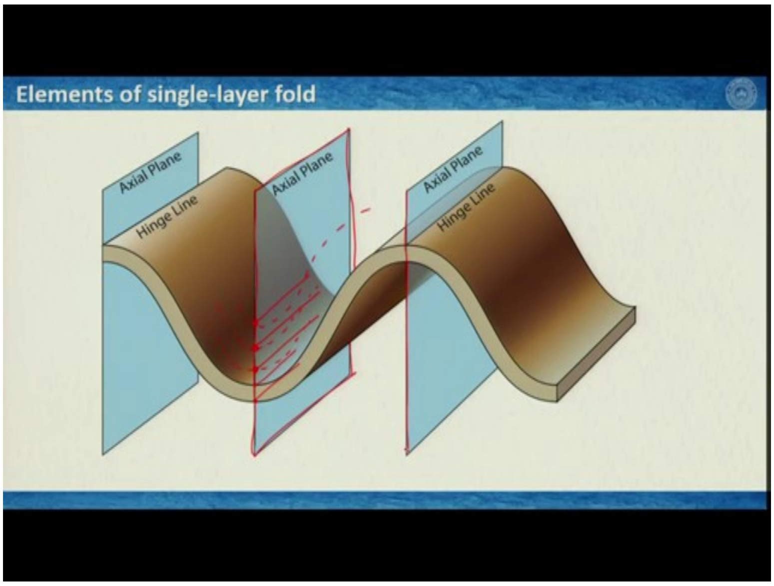


But there is another plane that is considered as imaginary plane, but along this plane, we form a very typical structure and this is known as axial surface and we will also learn at the same time, trace of the axial surface. Now again, we will first describe these with these texts, I will read it and then in the next slides we will see them as illustrations. The surface, joining all hinge lines in a particular nested set of folds is generally known as axial surface. It is also termed as hinge surface or axial planes.

Now, the intersection of the axial surface with the form surface, so it is a kind of intersection lineation because you have axial surface and the form surface. So 2 planes are intersecting each other. So that will produce a line and we learned from our lineation lecture, that this is an intersection lineation. So that particular lineation on the folded surface is known as axial surface stress and it generally indicates the fold axis of the associated fold, we will see this in the illustration.

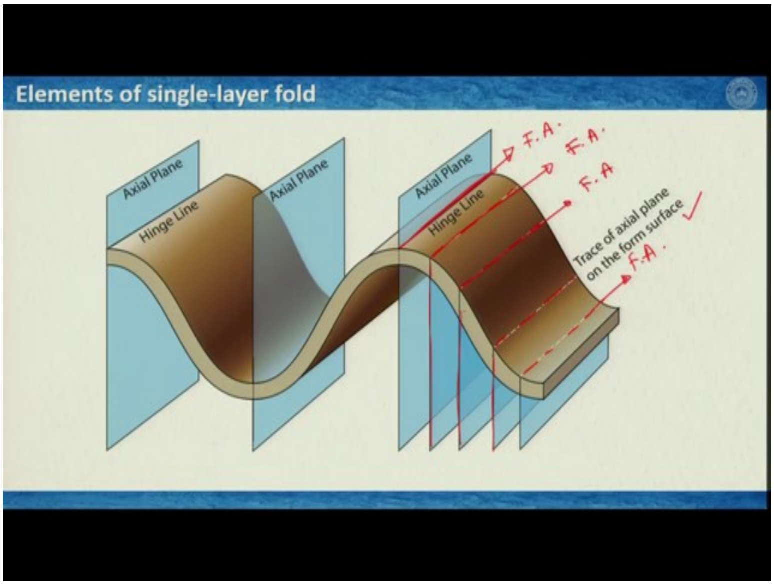
The axial surface trace can be seen on any other surfaces, so this is something very very important and therefore, if you can see it in exposure so you can see in outcrops or in typography and so on other than the form surface. So if you see them any of the surfaces, then the form surfaces, they actually do not define the fold axes and this is how it works.

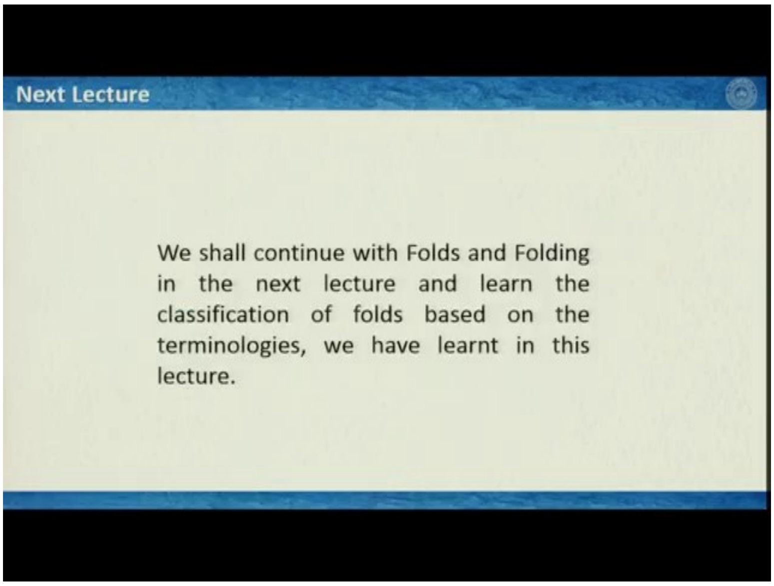
(Refer Slide Time: 52:53)



Now, this is the illustration showing what is axial plane. So, this is one hinge point. This is another hinge point and if you can imagine. We have series of folds here in the multilayer goes like this. Then you can always find series of hinge points and their corresponding hinge lines. So if you connect all these lines together, then you generate a surface. The surface is known as axial surface or axial plane that essentially has to pass through the hinge line.

(Refer Slide Time: 53:39)





Now, you can construct a series of planes parallel to the axial plane. So this is your hinge line and this parallel axial planes would intersect on the fold surface. So you can see this axial plane and the hinge line is essentially passing through the hinge line, of course this is how it has to be. This also defines the fold axis. Now this parallel planes of axial plane, when it intersects this form surface, they are intersection lineation or you can call it as trace of axial plane on the form surface and they also define the fold axis of this folded structure. We learn more about it and we will see how we can use them in analyzing the folded structure in a complex funded structure and so on. But with this, I conclude this lecture, but we will continue with folds and folding in the next lecture and learn the classification of folds, based on the terminologies, we just learned in this lecture. Thank you very much. I will see you in the next lecture.