Structural Geology
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Lecture 23
Folds and Folding: Superposed Folding

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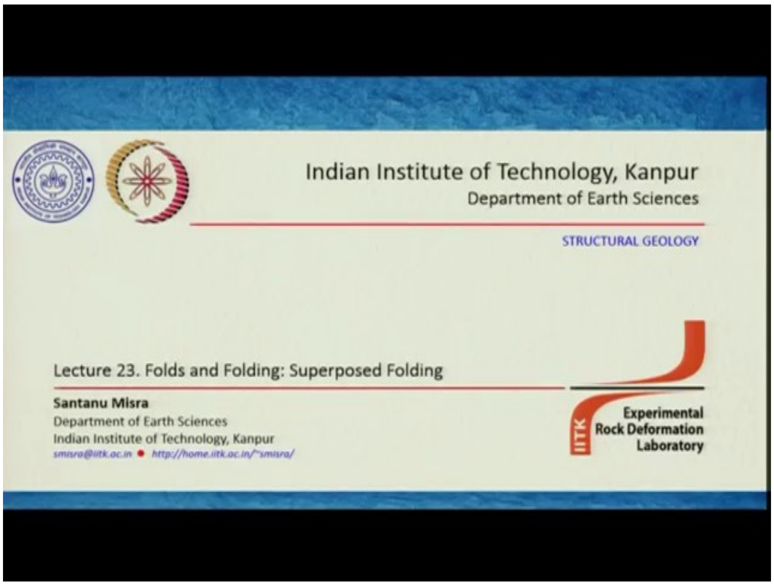

Hello everyone welcome back again to this online NPTEL structural geologic course and in this week we are learning folds and foldings and in this particular lecture we will learn a superposed deformation of folds so, this week is little long for you because we have 4 lectures of quite long hours, but this is how it is fold is one of the spectacular features as we have discussed in previously.

So, we decided to spend quite a lot of time learning folds and different features but a good news, this is the last lecture on folds and as I said today we will be learning a superposed deformation of folds and we have in lecture number 23.

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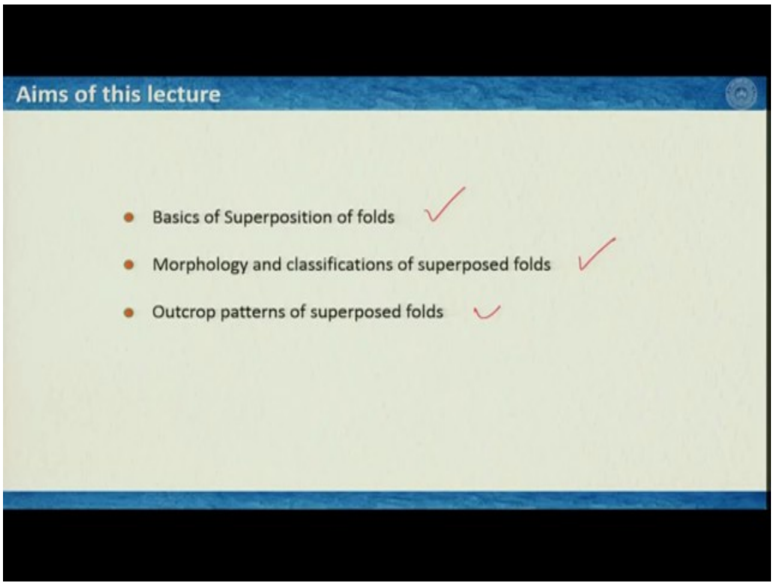

So, the things we will learn in this lecture the first one is the basics of superposition of folds then we will try to a figure out the different morphology and the classification of superposed folds and finally we will see what are the different outcrop patterns of the superposed folds. So we will take one after another with a lot of descriptions, illustrations and also some field examples.

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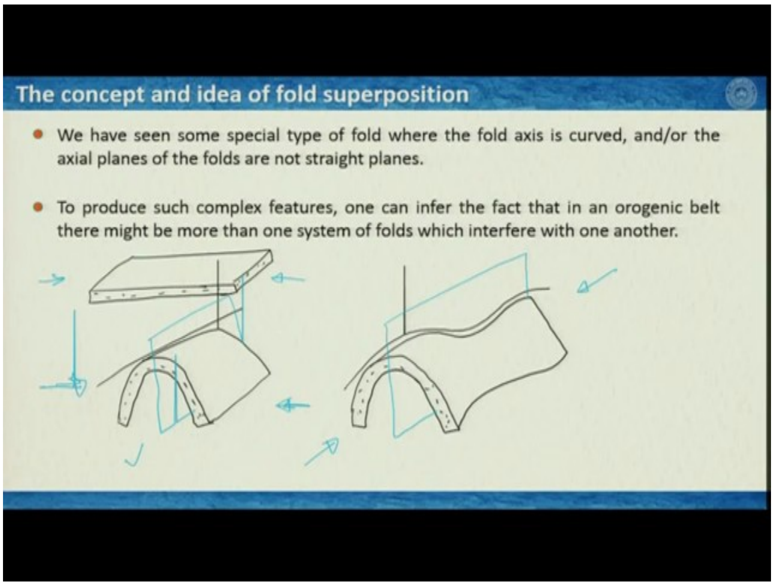

So let us first understand that what is the superposition of fold or get the basic idea what it is now, if you remember in the previous lectures, we have seen some folds where the fold axis is curved or the axial plane is not a very much a straight plane. Now, to give you an example of this for example, so you can consider that you had this initial straight layer something like that and then it got folded to form the shape like this so this is an anti-form it is one up right fold and so on okay.

Now what we see here, the fold axis is this one which is straight the axial plane if you can consider, is also straight now, in this second we see that there is only one deformation that has happened so, the deformation came from this side to this side to make this fold but we have seen folds which are non-cylindrical for example we have seen shape of a fold something like this where the fold axis is not straight but, curved and interestingly the axial plane is straight and this we have identified has a non-cylindrical fold.

So, to form this it is very much clear to us if we understand the stress lecture that to form this kind of curves in a straight layer we need a deformation layer parallel shortening layer parallel compression so, after that, after this structure has formed this particular one, you must have to have another deformation almost perpendicular to the previous one, the compression that could curve this fold axis which was initially straight. And this is the basic concept of superposition.

So, you have formed the structure and then you modify the structure with a second or third of fourth deformation which may be similar to the previous one or may be different to the previous one, and this is the basic concept. So to produce this complex structures you can infer the fact that in an orogenic belt there might be more than one system of folds which will interfere with one another. We will learn about more on this kind of structures and features throughout this lecture.

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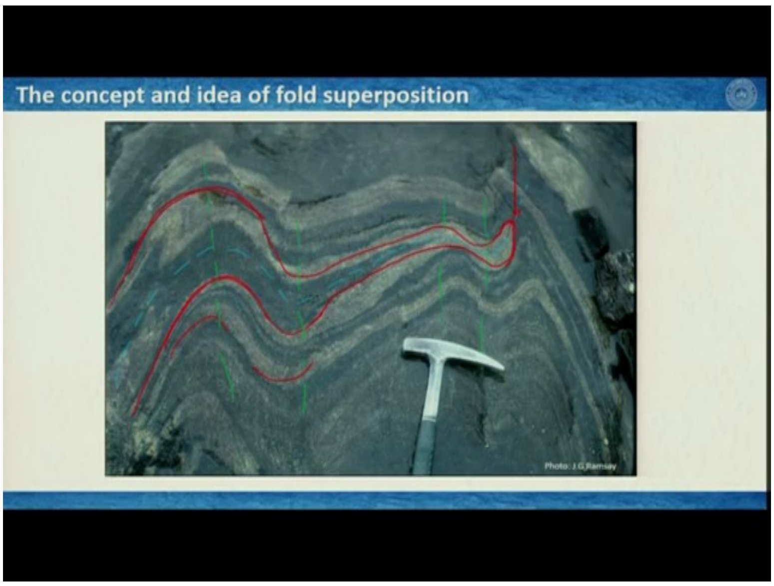

Now here is an example just to orient you, as you can see here that this is an outcrop, this is a photograph from John Ramsay and you see if I just first try to understand the fold closer then I see certainly we have a closer like this so it is closing in this side and then we have series of closers which is closing up ward forming anti forms and then series of closers this way forming synforms and this happened in the single layer. Now if I try to draw the axial traces and if I consider that this is the profile plane of this fold, profile section of this fold, then if I consider this is the folded layer, then certainly the axial trace would be something like that.

And interestingly the axial trace is not a straight line, so therefore the axial trace got curved and how did it get curved, it got curved because you have another fold which I see the axial trace of which are like this and in this case the axial trace are very much straight. So, one the axial trace which is curved one the axial trace which is straight or common intuition says at least looking at it that, the blue one must have formed initially and then it got refolded with this green one.

So this is how we look at and interpret things now, we will learn these things in more detail with different other kinds of structures and features but, this is something an example of the superposition of folding.

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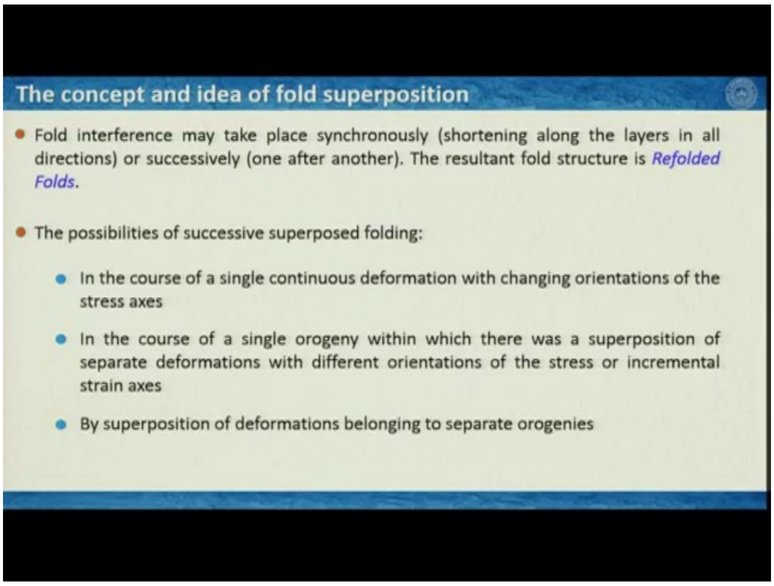

Now how it can happen now, fold interference may take place either synchronously that means you can have shortening along the layers in all directions so, not a particularly oriented direction but all sigma1, sigma2 and sigma3 if you consider in on a plane so, sigma 1 and sigma 2 you can consider that these two stresses, these two principal axis of stresses are equal or it can happen successively that means one after another which was the example I sighted at the very beginning that we have compression along this direction so, you made a fold then you have compression along this direction then, you curve the fold axis. So, this is how it occurs.

Now, this successiveness that one after another deformation can happen in 3 different ways so it can happen when a single continuous deformation is going on but the orientation of the stress axis are continuously changing that can happen in an orogenic belt. Now, it can also happen in the course of a single orogeny which there could be some sort of superposition of separate faces of deformations with different orientation of the stress and at the same time incremental strain axes and you can have superposition of deformations that can belong to different or separate orogenies.

So, there could be many possibilities and we will look at each of them but, first we will see the first kind of a features where it can deform synchronously that means you do not need two stages of deformations or one after another successive deformation so in one single event you can produce superposition of folds. Whatever be the case you have your initial structure and then you get your final structure by superposition, so the second one is known as refolded folds.

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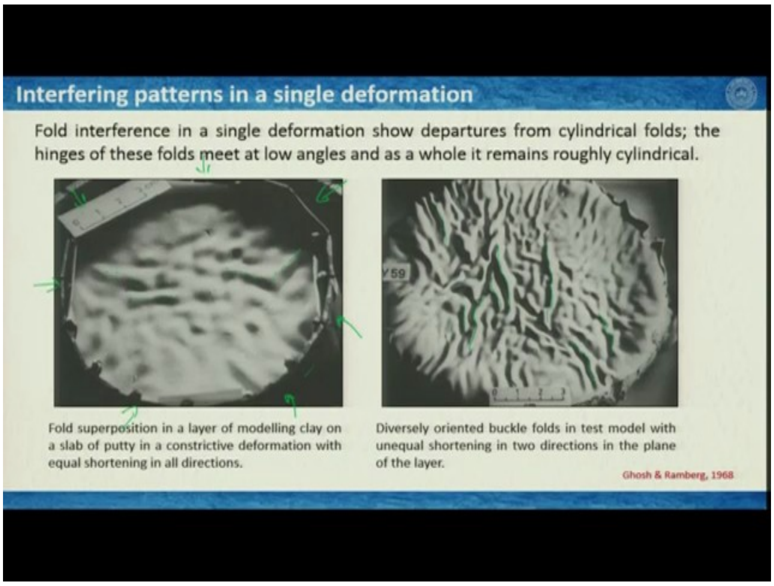

So here is an example of interfering patterns in a single deformation so this is, these two what you see an experiment the first one it was a circular canister or something like that you can consider and the stress axis it got compressed. From all directions equally and then it was a modeling clay and then you can see here, that these are your fold axis and they are not necessarily oriented equally and also from the shades you can figure out that fold axes are not straight.

In this case the second example you see the buckling is happening you can understand by the shapes of this shadow and things like that, so these are fold axis and you can clearly visualize that these are not straight. They are some sort of getting branched and so on and in this case the deformation was directed mostly due to shortening in two directions. So, this is what can happen in a single deformation but this kind of feature we see in the field but not very common so we will not focus in this particular type of deformations a lot.

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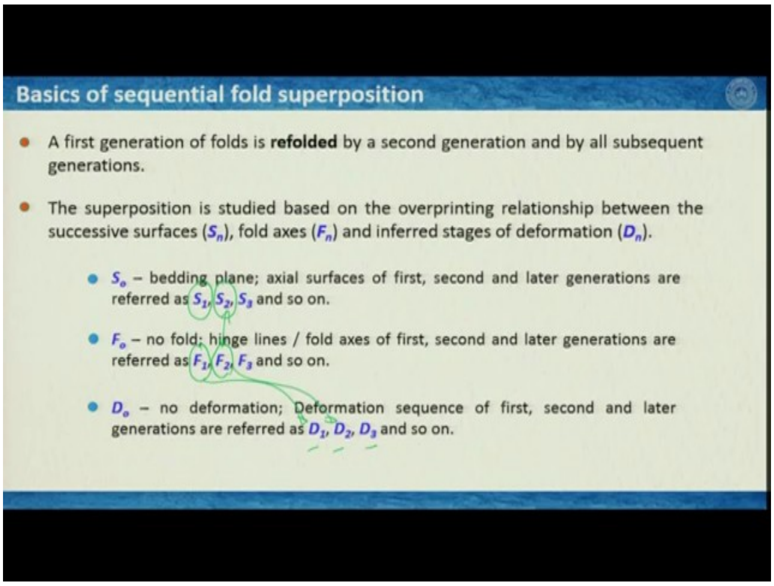

But we will figure out how, we can see these things in different stages of deformation and the first generation of folds generally is refolded by the second generation and by all subsequent generations. We have a first generation fold then it can get refolded by second generation it can get refolded by third generation and so on.

Now, you can imagine the fact that the features particularly the fold axes and axial plane which are developing in the first generation of fold can get modified in the second generation of fold at the same time the second generation of fold can also produce a different fold axes and the different axial planes and so on. So it is important in the field we identify which one is what. And also coordinate them with the deformation.

So generally we studied mostly based on over printing relationships, that is how was your first fold axis then how it got modified by the second deformation and what was the orientation of the fold axis of the second deformation and so on and also we consider this with the axial planes. So one is the direction there is a plane and then we co-relate them with deformation.

So, we have 3 terminologies one is surfaces that we have producing successively then we have fold axes which we are producing successively and they correspond to the deformation. So surfaces are defined as S if I denote as S 0 where 0 is on the index position. So, S 0 or S Naught means that there was no deformation so this was generally considered as sedimentary surfaces or bedding plane.

Then you generate your first axial surface, second axial surface, third axial surface and so on and these are assigned as S1 S2 S3 and so on. Similarly, F0 is hardly used because that means there is no fold but, then you produce successively fold axes like hinge lines or fold axes on first, second and later generations and then you refer them as F1 F2 and F3 and so on and these S1 S2 S3, F1 F2 F3 should be correlated with the deformation. So, D0 means no deformation and then deformation sequences you can go with D1 D2 and D3.

So enough a S1 should have F1 and that should be correlated with D1 S2 should modify S1 and produce F2 and that deformation should be correlated with D2 and so on. So this is how we learn in the field how we identify the structures in the field and also interpret them successively.

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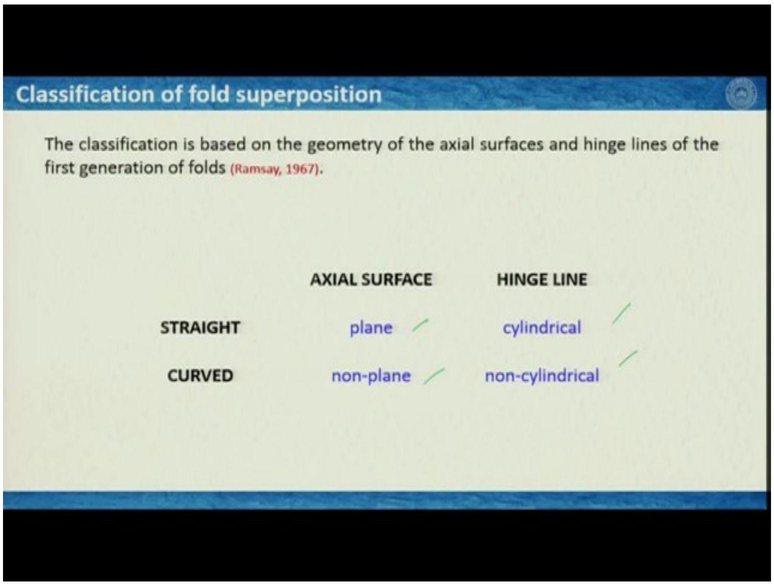

Now, as I talked about that the classification of fold superposition is based on mostly the geometry of the axial surfaces and hinge lines or fold axes of the first generation fold and in that case we can have 4 possibilities 2 for the axial surfaces and 2 for the hinge lines. So, axial surfaces could be either plane or non-plane and hinge lines could be either cylindrical or non-cylindrical. So combination of these 4 would give you the classification of superposition of folds which is in the next slide.

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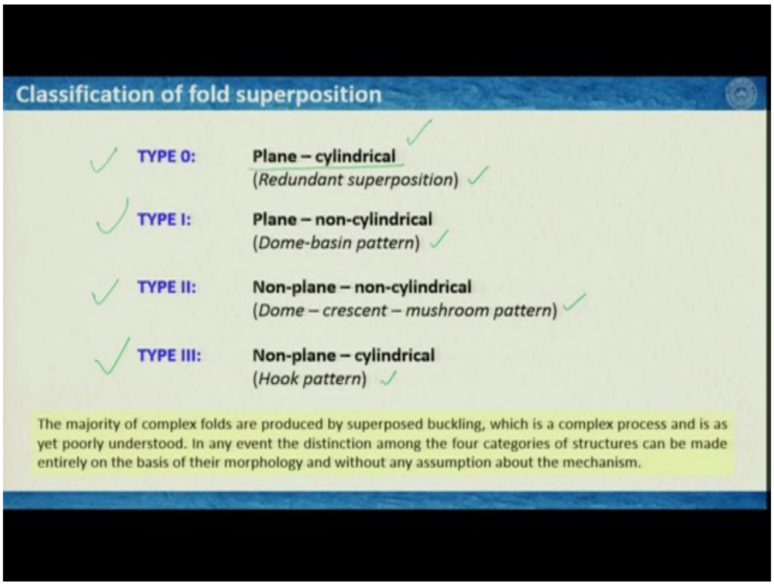

So, the first classification is type 0 which is known as plane cylindrical that means the fold axis is straight, therefore it is cylindrical and axial plane is also not curved it is straight, so therefore it is plane cylindrical. Type 1-fold superposition is plane, non-cylindrical axial plane is straight fold axis is curved. Type 3 is non-plane, non-cylindrical both axial planes and fold axes are not straight they are curved. And in type 3 what is remaining it is, non plane cylindrical axial planes are curved but fold axes is very much straight.

What is written within the parentheses here, that redundant superposition or dome basin pattern, dome crescent mushroom pattern, or hook pattern these are the structures or superposition outcrop features that you see in the field we will learn about it later after we classify or we see them through some geometric considerations and then we will go how we form this dome basin crescent mushroom and hook patterns.

Now, the majority of this complex folds are mostly produced by superposition of buckling deformation so you do not get it by bending and so on. So it happens mostly due to the buckling fold mechanism which essentially is a very complex process and people still work on it because it is not very well understood and it is a very hot topic in the structural geology research community.

So in any event the distinction among the 4 categories of this superposition can be made entirely on the basis of their morphology and without considering their mechanisms and so on, but people generally try to coordinate with the mechanisms but, in the field you mostly identify by their mutual relationship and so on, so, we will learn about it soon.

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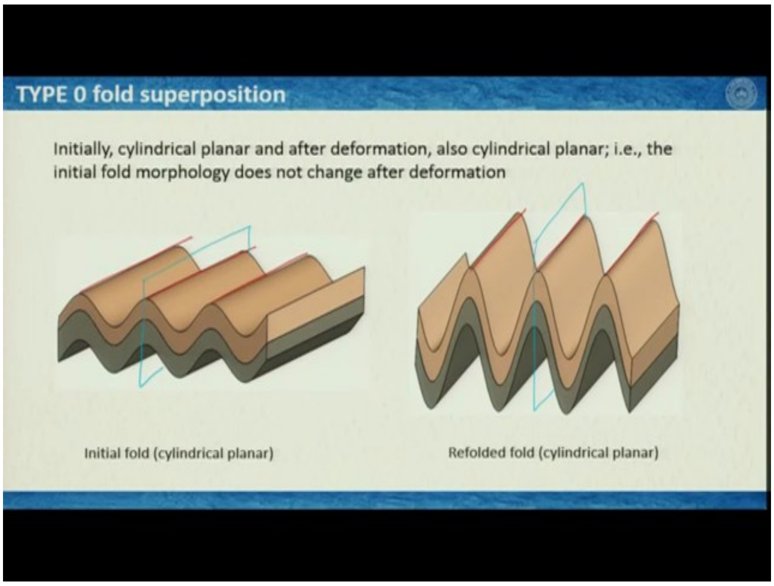

Let us focus on type 0-fold superposition so initially cylindrical planar and after deformation it is also cylindrical and planar that is the initial fold morphology does not change after the deformation it may get tightened only. So, what you see here this is your initial fold we can see the fold axis is straight, here and in the refolded fold that simply tighten base fold the fold axis are also straight here, so it is cylindrical before and after deformation, if I consider the axial planes I just draw one here this is the axial plane of this fold it was straight plane and here it is also very much straight. So therefore, this is plane cylindrical superposition and this is type 0-fold superposition.

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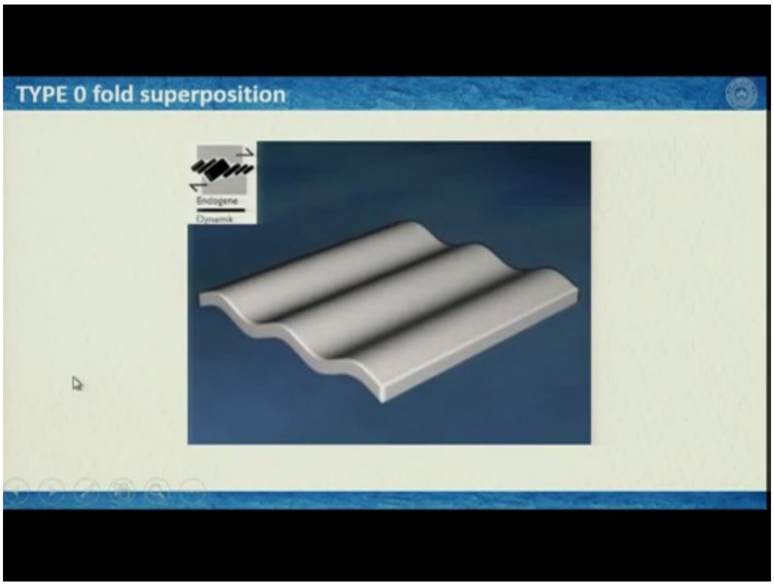

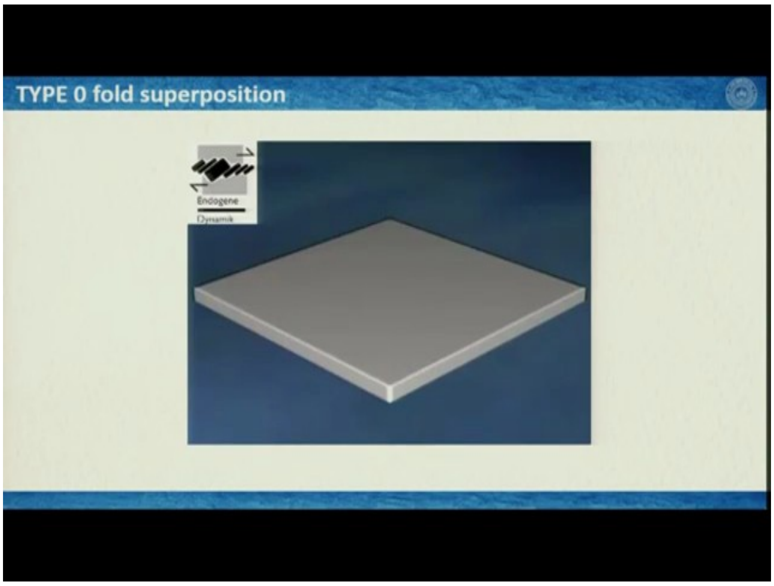

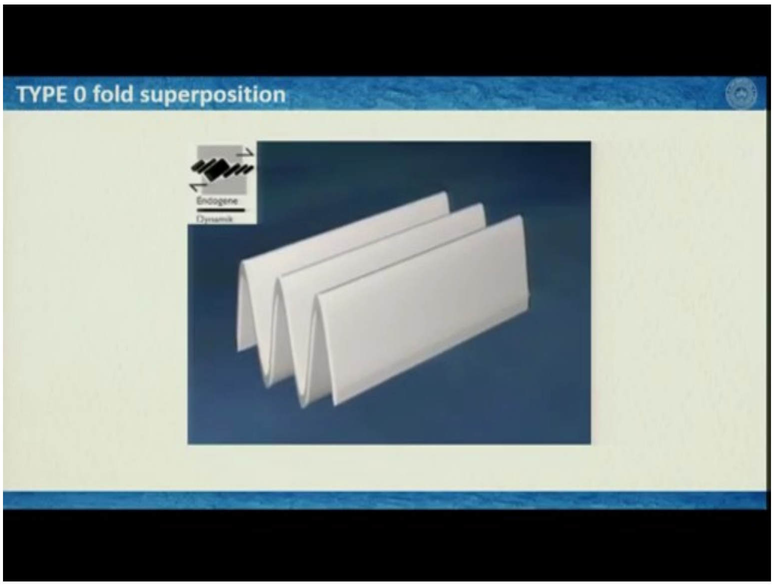

Now here is a movie short movie you can see how does it work, so you see here it just the fold gets tighten and tighten and tighten but, it can happen episodically that means the deformation can stop and then it can start again but, without changing the orientation of the principle axes of stresses. Or the direction of layer parallel compression.

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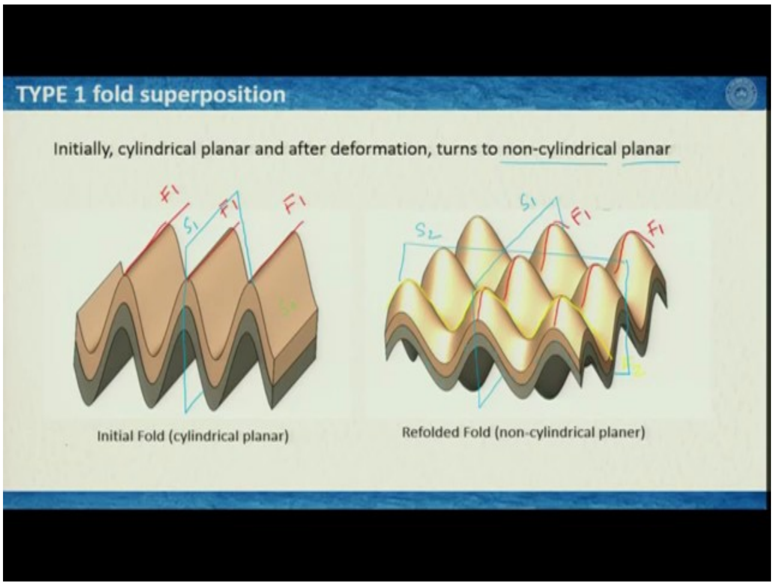

Now, let us the look what is type 1 superposition as we have defined so, initially cylindrical planar and after deformation, it turns to non-cylindrical and planar so, here again if I consider the fold axis in this initial fold is very much straight and here, we will assign this as F1 so that means these are the folds of the first generation fold axes of the first generation and axial planes if we draw only one is like this and this we assigned as S1 because this is something which is being developed on a surface which we can consider as S0. So, this is your S0 that is your formed surface or initial bedding plane and so on.

Now after the deformation if we try to trace the fold axis F1 we see that F1 now is very much curved then it went inside then it is coming that again here, it went on the other side and so on. So, F1 is clearly folded so this is your F1 this is also your F1 and so on. Now who is folding the F1 or who is refolding the F1, is something a different fold which is appearing here, that you can figure out from this, so this is your F2. The S0 is again here the form surface which is this brownish layer.

Now, if I try to consider what happened with the S1 we can clearly see that S1 is still very much straight though it deformed in this direction but, the axial plane is still very much straight so this was your S1 and that did not become curved due to the second stage of deformation. What is also important that if I try to draw the S2, then S2 probably would appear if I just, this section actually this section you are looking at, this section is parallel to S2. However, if I try to draw the S2 would appear something like that.

So, I have F1, I have F2, I have S1 and S2 in both cases we see that S1 and S2 they remain plane planar so it is planar deformation but F1 and F2 both are curved therefore the fold is not cylindrical and therefore it is non cylindrical planar superposition or type 1-fold superposition.

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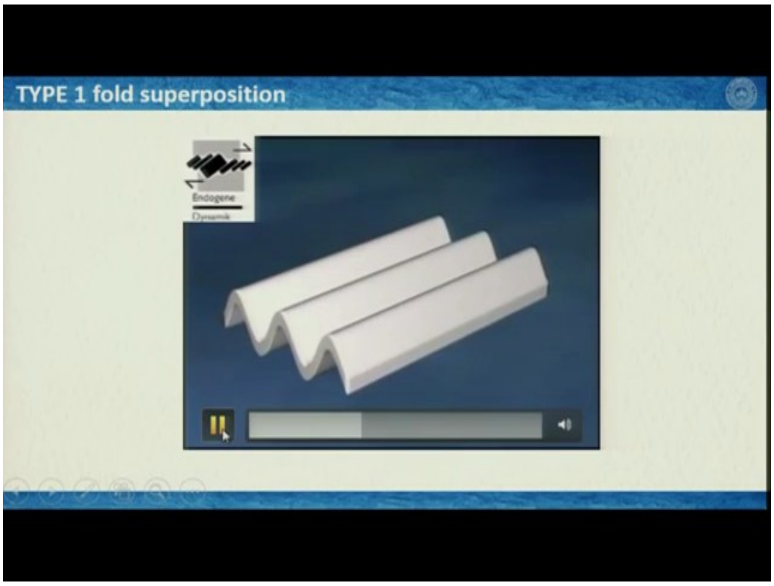

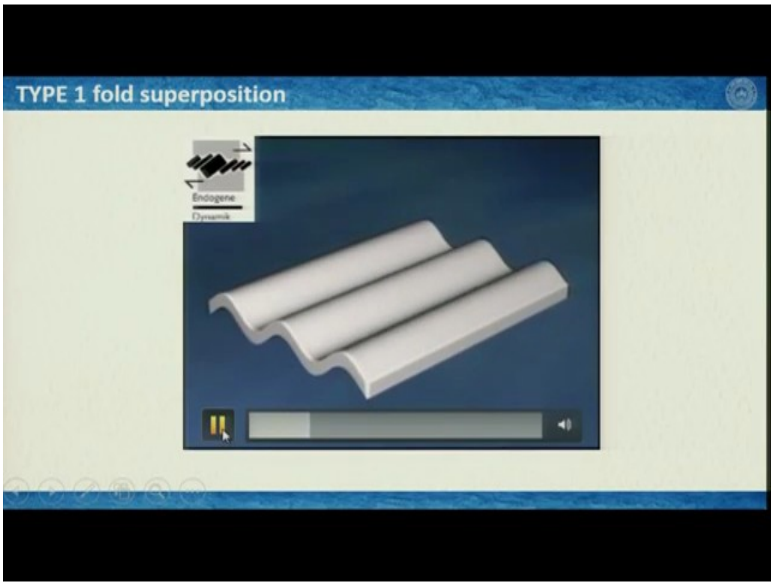

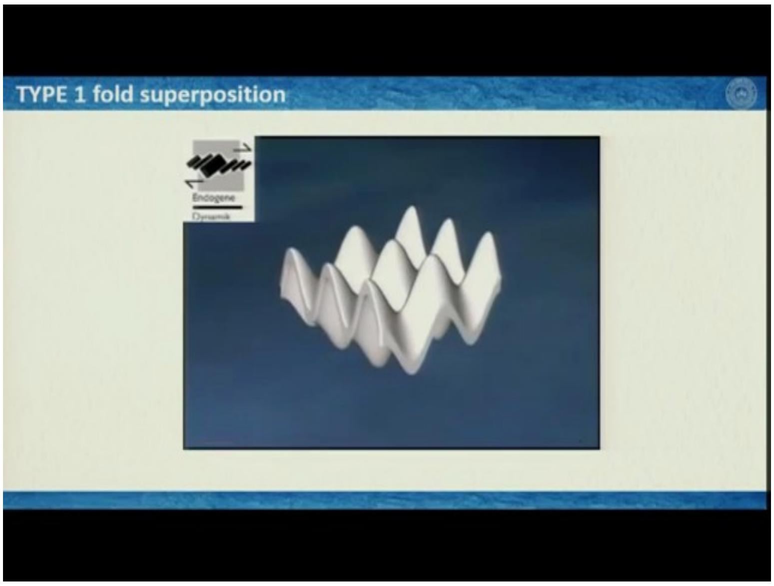

We have again a movie for this. Let us have a look, and now the superposition started you see how F1 is getting folded by F2.

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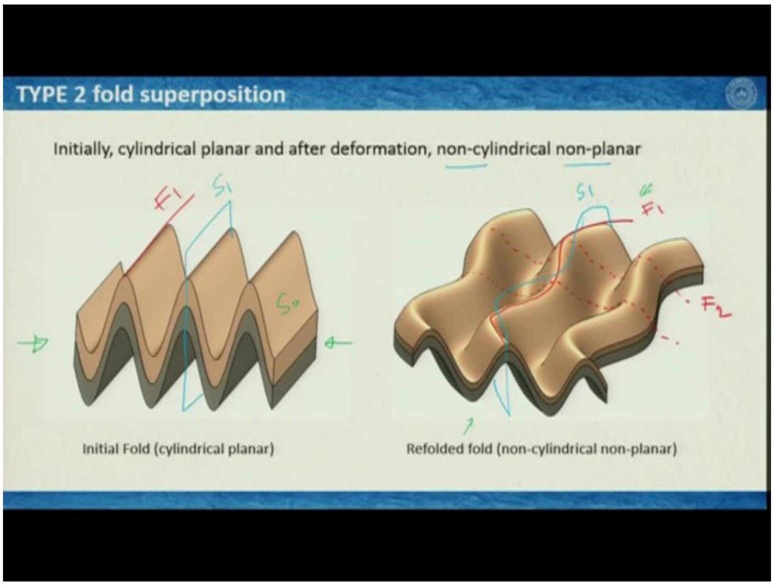

Let us consider the type 2 fold superposition so, initially as we have defined a cylindrical planar fold would turn to a non-cylindrical and non-planar fold. So again this is your initial fold I again defined all these features this is your F1 and this is your S1 where, this is S0 as a form surface. And that happened in D1. In this case I just draw to the same color the stress came from the layer parallel shortening happened in this direction. Now, if you deform it from this side after that you may have a shape like this let see, what happened with the F1, after the deformation, you can clearly see that F1 is now, running like this so F1 is not straight any more.

Therefore, initial fold axis F1 is non cylindrical what happened with the S1 we choose this one we can also see I draw it here, the S1 is also curved as it is going here, because it is intersecting the plane in a curvy way so S2 is also, sorry, this is S1, so S1 is also curved so F1 is non cylindrical we have established and S1 is not planar any more so this is non planar, non-cylindrical non planar fold we have developed due to fold superposition and this is type 2 fold superposition.

What happens with F2 in this image and you can see that this fold axis this red line here is getting folded by of course F2 so, F2 is coming this way. So this is another fold axis of F2. And if this is F2, then you can guess that what would be your S2, now I am now drawing it, it is up to you, you figure it out how this S2 would look like in this image. We will see this later in many many cases. So this is type 2 superposition where we developed non-cylindrical non planar refolded folds.

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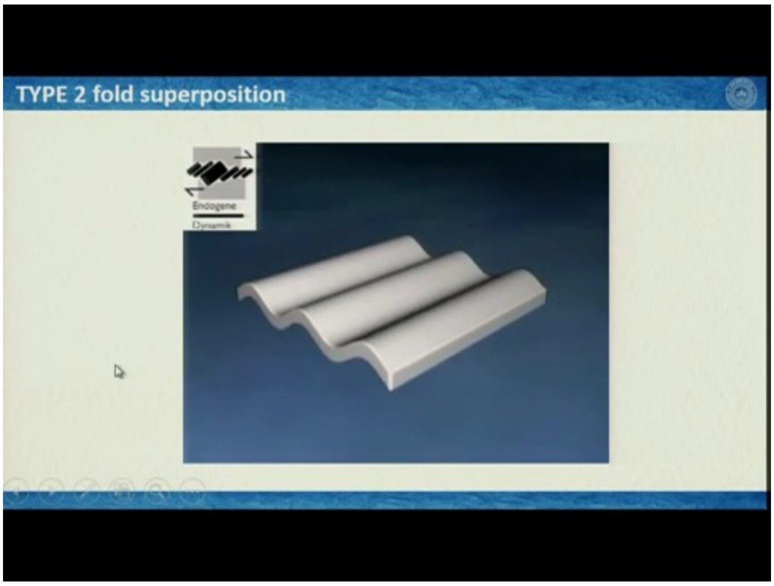

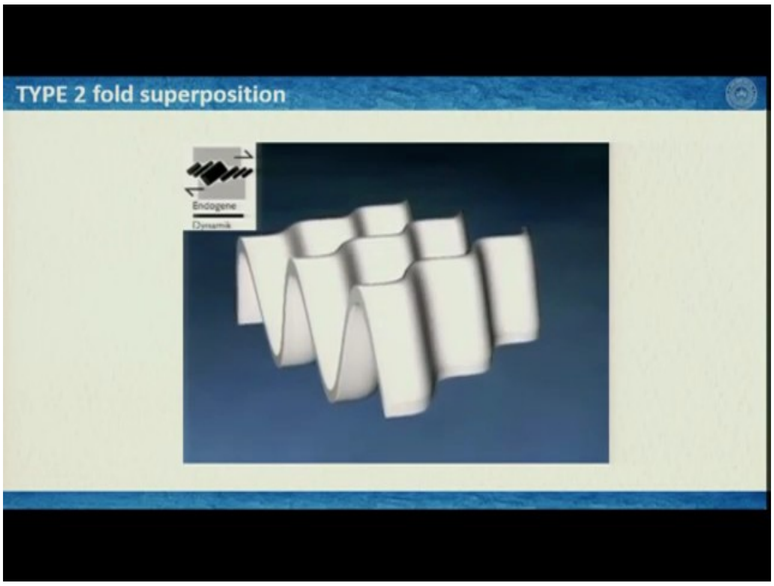

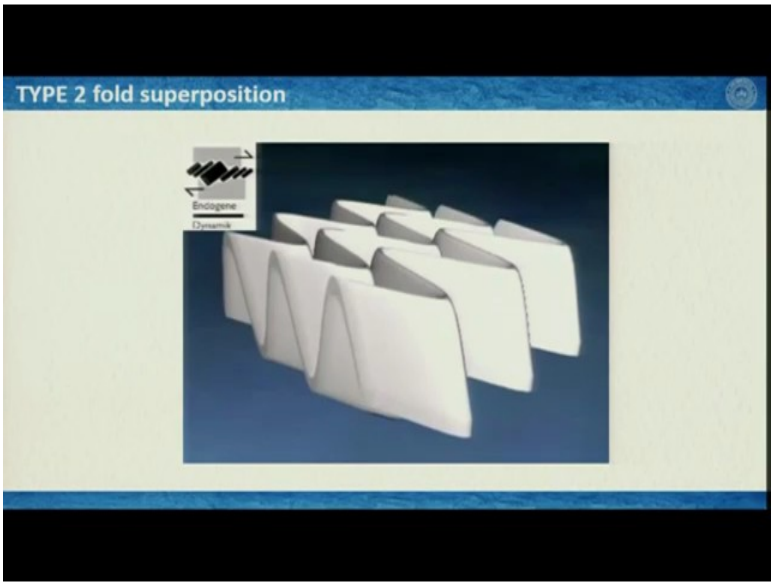

And finally, we have this movie so we see how does it develop, is this clear to you? I believe.

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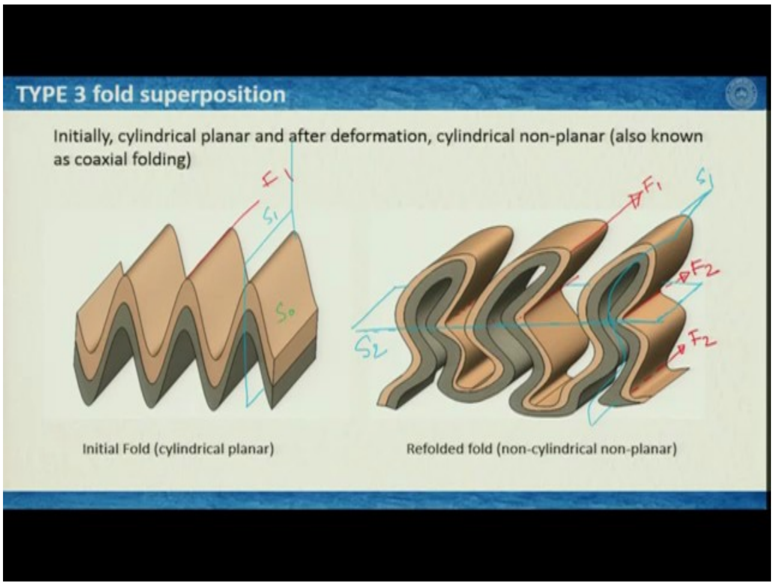

Now we will look at type 3-fold superposition where, as we have defined initially cylindrical planar and after deformation, it becomes cylindrical and non-planar. And this is also known as coaxial folding and we will see why, so again we do the same process as we have been doing with the other superposition so, this is your F1 this is your S1 and again the form surface is S0.

Now, what is happening with the F1, after deformation we see that F1 is straight, it did not get curved or it did not change its orientation but, S1 interestingly if you try to look at this plane it is now, extremely curved and it is going like this, is not it so, if I try to do the axial stress it would be something like that so, S1 here is very much curved now, who is curving the S1, of course it is happening due to the deformation. So, where is the F2, F2 is seating somewhere here.

So all these secondary curvatures that is see here here, and so on, these are your F2. Now it clearly sees the orientation of F1 and F2 are parallel to each other and because they are parallel to each other these are known as coaxial folding, where the fold axes are oriented very similarly. Now where is the S2 here, you can figure out from this fold that S2 is lying something like this and in this case S2 is very much straight.

So this is how we developed the type 3-fold superposition which is known as coaxial folding or cylindrical non planar folds.

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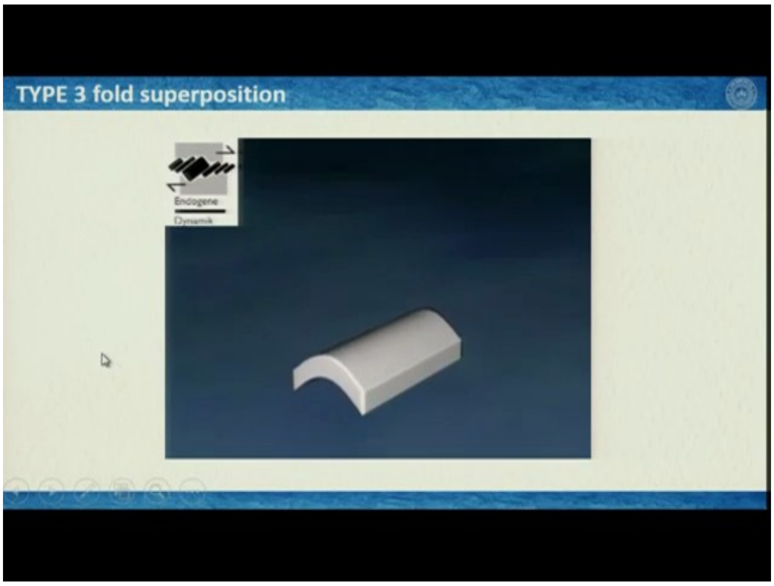

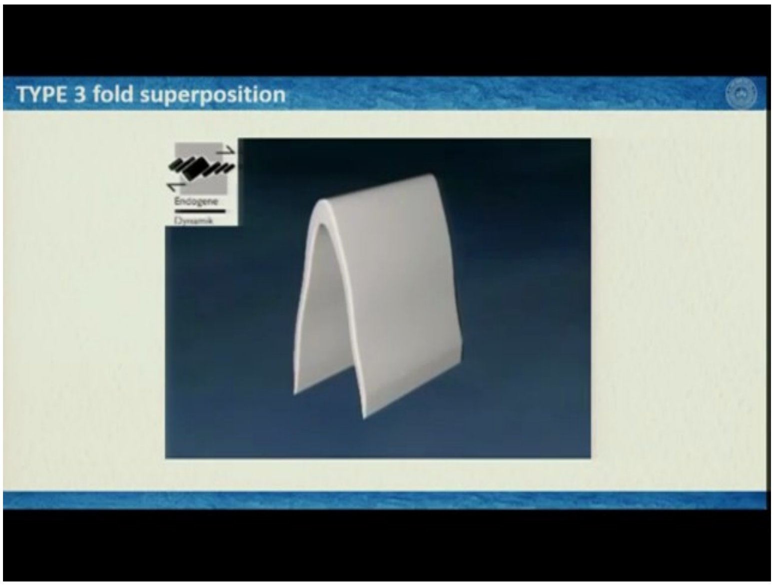

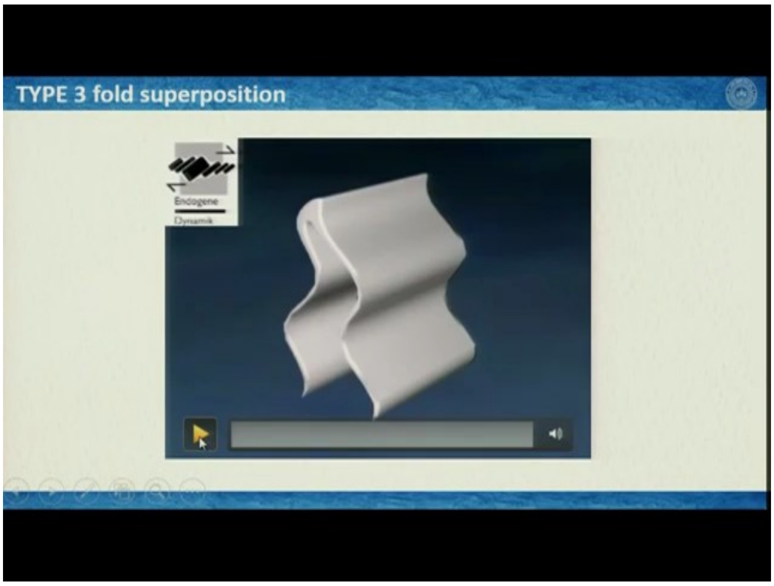

And here, is the movie again, for this type 3-fold superposition, brilliant so this how you develop type 3 superposition of fold now, we have a very clear understanding of how to define or how to classify this type 0, type 1, type 2 and type 3 superposition as given by professor Ramsay. There are some other classifications professor Ghosh has come up with another classification which is based on more sub superposed deformation we are not going to learn this, but you certainly can refer the book of professor Ghosh that I have recommend at the very beginning of this lecture and this is also very interesting to look at.

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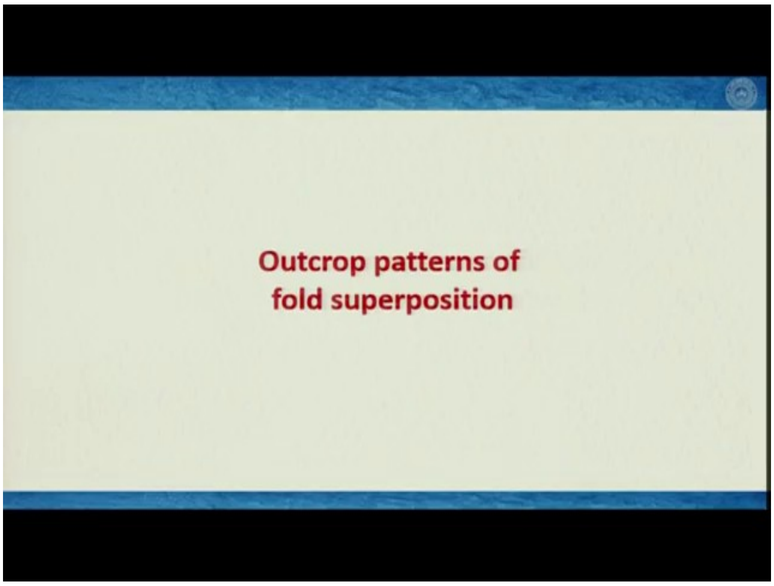

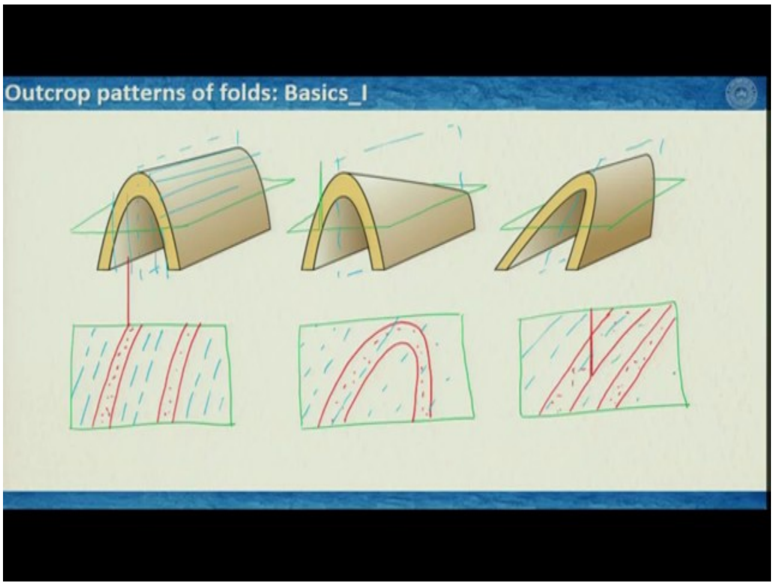

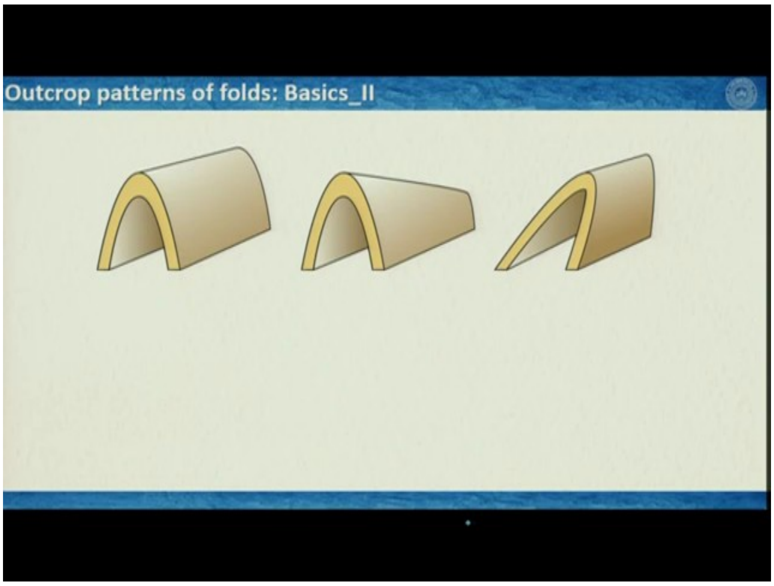

Now, let us talk about the outcrop patterns of fold superposition but before we jump in to the actual topic let us understand what do we mean by outcrop patterns. Now we have seen all this kinds of folds actually we have seen many different geometries so in all these 3 folds that we see here, in this slide, these are all anti forms and this is an upright fold the fold axes in all cases are very much straight and so on. So what do we mean by outcrop patterns that, we just have seen the geometries but, they can appear on the surface in different ways because, the non-necessarily will appear the way we see them, or we draw them.

What I mean by this that this fold after they are formed they can break or we can see them in any sections and these are their appearance on the outcrop scale what do I mean by that if I make a horizontal section like this, here then the fold will appear I have to use a different color because I do not have this color here, so if try to trace them on the horizontal surface on this green surface, and if I plot this green surface hare, then the two limbs would appear on this surface something like that.

In a very similar way if I try to with the next one, the plunging fold and if I take a section along this, you see that it has to cut on this side so it probably would look like on the surface something like that and if I do the same on the third one, I am sorry it will be opposite, this would be thinner and this would be thicker. So these are the outcrop patterns of this fold, these 3 folds what we have drawn here.

Now can we draw the axial trace the answer is yes, so in this case the actual trace would be something like that. Again it is here, like this and here this are the actual cleaner cleavages that would form successively. Like this, like this, like this and so on. So if I try to draw the traces they will appear here, as the traces of this axial planes on this surface for actual cleaner cleavages. Ohh sorry, and here as well it would appear something like that.

So these are outcrop patterns now you can imagine that I can draw a series of sections on this folds, oriented differently and we can get different kind of outcrop patterns. It can be a vertical section, it can be a horizontal section, it can be an incline section and so on. So the best possible way when you have a single fold is the, if you see, through the perpendicular section of the fold axis but, if we have a superposed deformation than it is not very easy to figure out that which fold axis I should take, to have the profile section number 1, number 2 if the fold axis is curved, then how to get the successive profile planes and so on, but in the field there is no control.

So they do appear in many different ways and therefore the superposition also appeared in the field in many different ways and this is exactly what we have going to learn that what would be the typical outcrop patterns of this 4 types of superposed deformation that we have just seen.

Now in this image, these 3 are given here in the previous slide we have seen different kinds of outcrop patterns of these 3 very simple folds, so what we can do, you can take these 3 images and you can make them sections in different ways and see what kind of outcrop patterns you get out of it. You can also use all other kinds of folds. It can be inclined, it can be tied, it can be open and so on.

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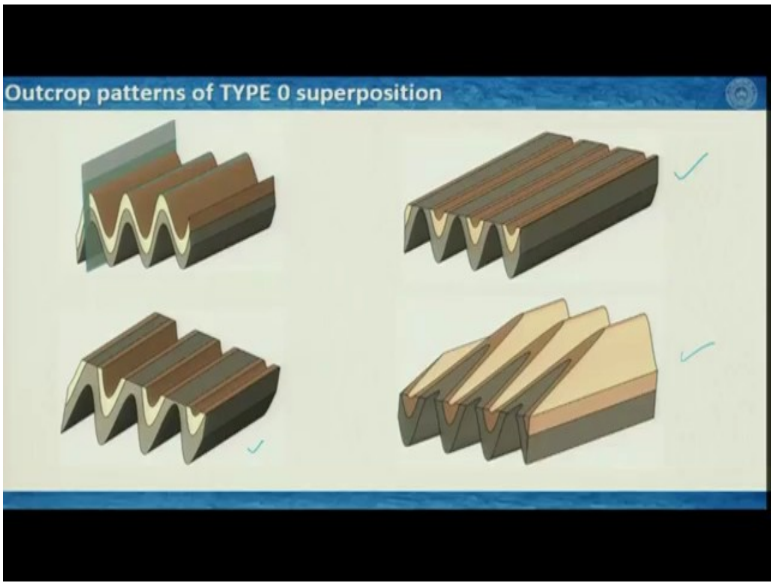

Now, let us the look, how do we get the superposition patterns of type 0 as I have told in the very beginning that the superposition is redundant in type 0, so what we see here, that F1 and F2 these are parallel to each other in type 0, because it just getting folded in a very similar way so, therefore S1 and S2 as well parallel to each other. So, the outcrop patterns if you cut it along a horizontal plane it would show up like this if it is an inclined it would show up like this but, this is somehow this section is as we can see it cuts both F1 and F2 and if you cut this in a different angle which is here, then it may show up as a folded structure but, this is something we really cannot interpret looking at it, whether it is type 0 superposition or it is a single type of fold. So, this is how it is with the type 0 type of superposition.

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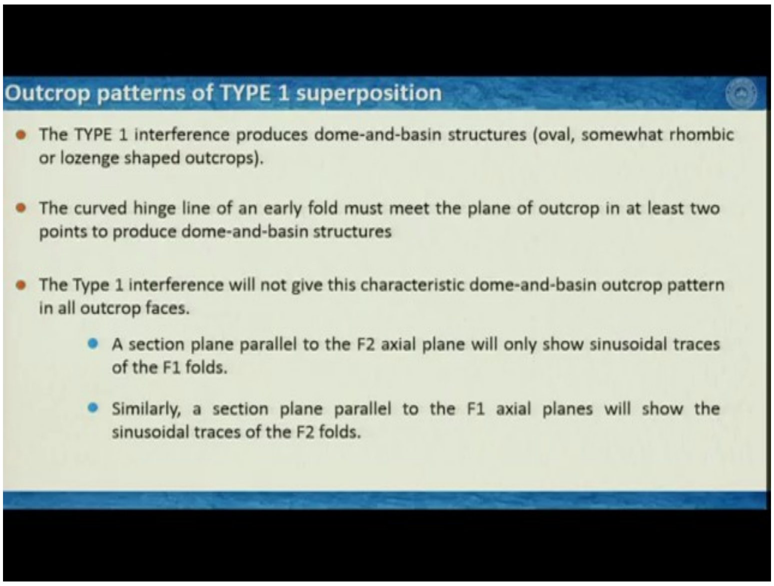

Now, outcrop pattern of type 1 is very interesting and it produces mostly what we call dome and basin structure or in other ways oval or somewhat rhombic or lozenges shaped outcrops. Now the curved hinge line of an early fold that is F1 must meet the plane of outcrop at least 2 times to produce dome and basin structures, we will see this how it happens and the type 1 interferons will not give however the characteristic dome and basin outcrop patterns in all outcrop faces.

For example, if you see it along the F2 axial planes then what you will get, the sinusoidal pattern of F1 fold and vice versa is also true. If you see it along the F1 axial plane you will see the sinusoidal, you will see the sinus pattern of the F2 folds we will see it soon.

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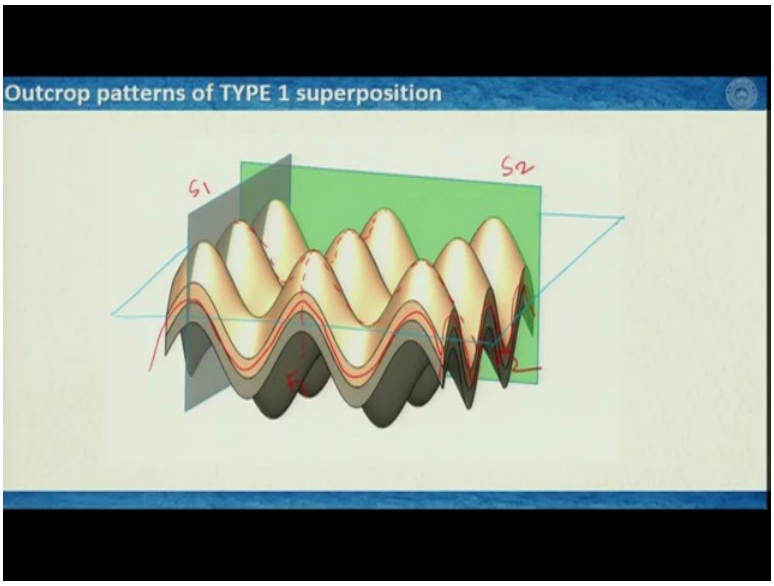

So what we see here, in this so this is as we can imagine here, that we discussed about it so, this is how, F1 is going like this, and this how your F2 was moving, so this is your F2 and this is your F1 now, this section is your S2 the green one and this is your S1. So this S2 is actually the section of here this one as we can see, so this is showing up a sinusoidal pattern on S2 you see this and S1 if you see this way then you see also the sinusoidal pattern and you may not figure out that this is a product of superposed deformation.

However, if you cut it, along this plane then you see something very interesting and which we are going to see in the next slide.

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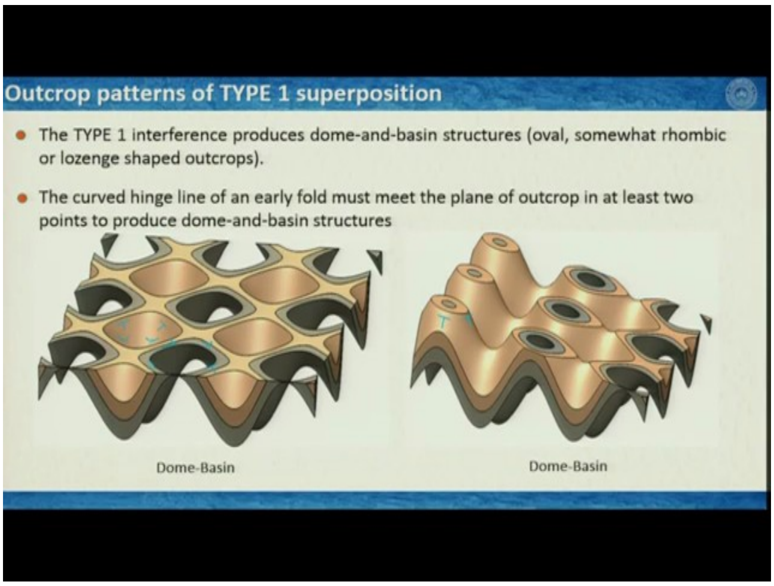

So, these are known as dome and basin structure the type 1 interference produces dome and basin structure as we talked about oval or somewhat rhombic or lozenges shaped so we can see here, that these are your basins so that means it is like a boll and these sections as you can see here, these are like a domal structure. So these things if we can talk about they are dipping towards the center of this basin and this layer if I talk about they are dipping away from the top of the fold you can actually figure it out here, so they are dipping this side and therefore, it is producing a dome and basin structures.

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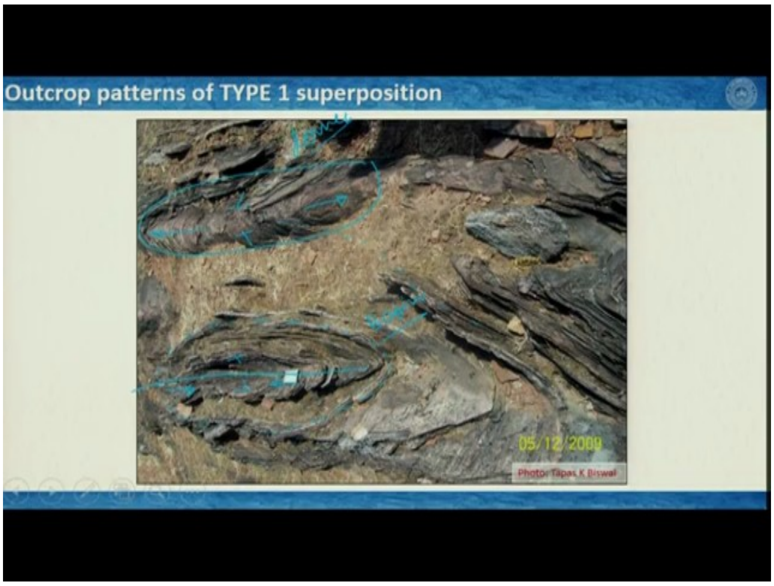

Do we see them in the field, yes we see them in the field, as we can see here, that you have this, you can figure out that these are your some sort of folds going on here, and here you have a closer where, the fold axis is going something like that, and this here the fold axis is plunging towards this side and here, fold axis is plunging towards this side so, they are converging here, and the beds are dipping also towards the center so, this is a basin.

On the other hand, if I consider this particular area you see here, the fold axis is plunging to this side, here the fold axis is plunging to this side, the beds or the form surface is in this side dipping here, and in this side dipping here, so, this is a dome and this is the basin. And this is how we produce alternatively dome and basin structures.

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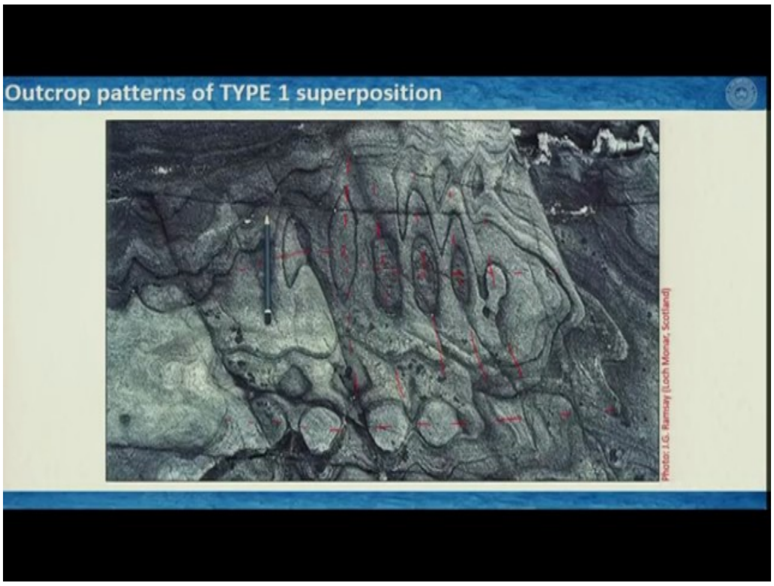

There is another example here, we can see this is again a very classical photograph from professor John Ramsay so we can see this is your one set of axial traces of course you do not see in three dimensions and another one is going like this. Here it is going like this so this is the interaction between F1 and F2 producing the dome and basin structures in type 1 superposition.

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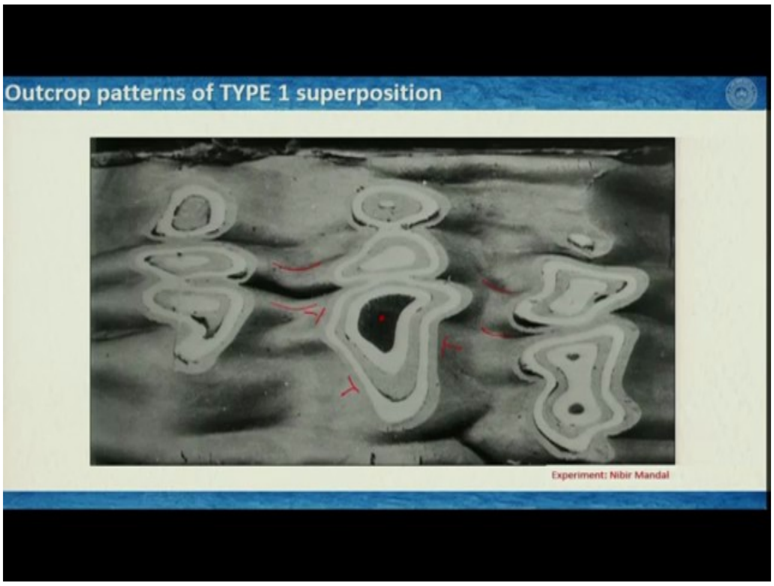

This is an experiment again performed by professor Nibir Mandal and you see here, that these are your basins these are curved here and here and these are your domes because when you cut the section the domes are out and then you see them exposed in this way and you see these are all dipping away from the hinge zone which is somewhere here. The fold superposition you can study the best if you do, some sort of experiments and people have done it since long time and this is just an example.

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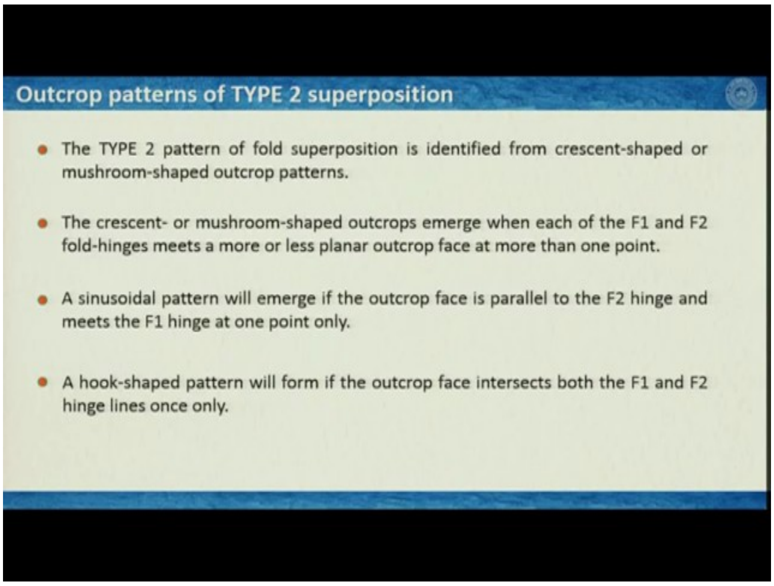

Let us have a look, what happens with type 2 superposition in terms of their outcrop patterns. The type 2 pattern of fold superposition is generally identified by crescent shaped or mushroom shaped outcrop patterns. Now you do not see them again in all sections so for crescent or mushroom shaped outcrop patterns you can only see when, F1 and F2 fold hinges meet more or less a planar outcrop faces at least more than one point so, that means F1 has to pass through the plane at least 2 times and same for the F2.

Now, also in other sections you can get a sinusoidal pattern when you see the F2 hinge meets the F1 hinge at one point only and you can also get a hook type pattern and we will see how does it work.

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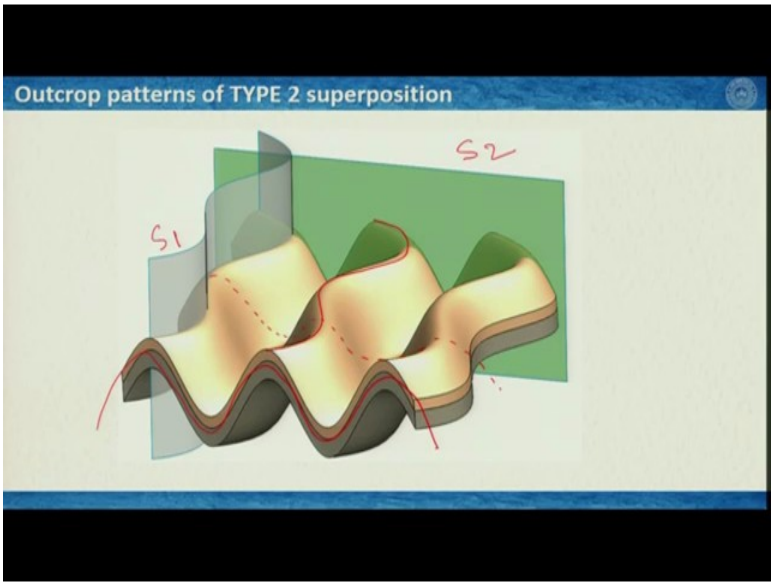

So again this is what we have drawn this is your F1 going like this your F2 is going like that and this is your S1 and this is your S2 so clearly, on the S2 surface which is this one you see the fold patterns of S1 only and you cannot figure out whether this is a superposed deformation or not.

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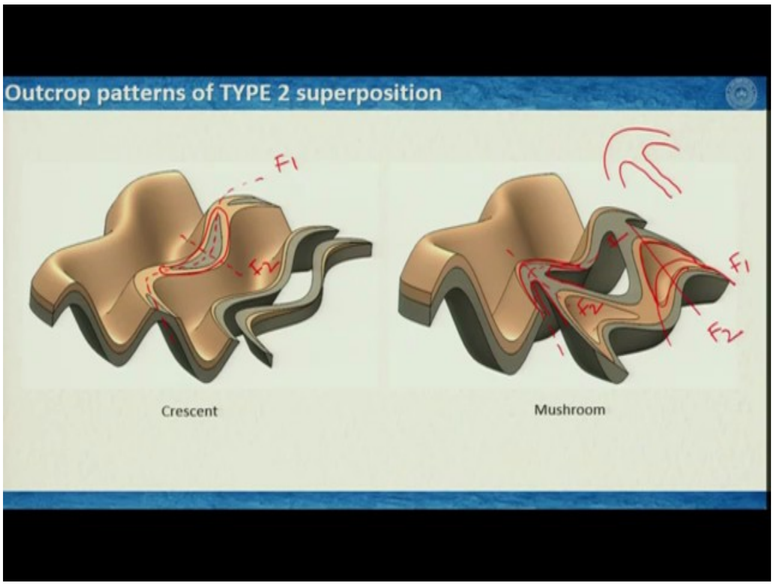

However, we can see some excellent features when you make sections in different ways so this is typically a crescent shaped outcrop where you can see the F1 is going like this and F2 is going like this and this one is known as mushroom as you can see from this typical shape. So it is like this, isn't it. So this is like a mushroom and this is known as mushroom type of exposers and again we see their F1 is going like that here, and F2 is like this. The crescents are also here, as you can see here F1 is like this and F2 is coming like that.

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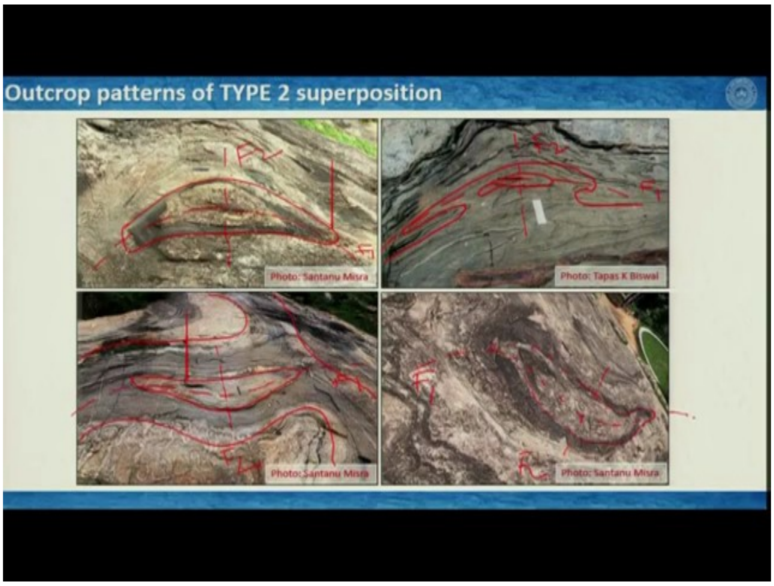

This is a crescent as we can see so F1 is something like that, this is a first fold axis and this is your F2. In this example you can also see it is going like this so, gain this is your F1 and this is your F2 here, it is a tilted outcrop but, you still can figure out the shape of the crescent this is your F1 and this is your F2 in this image, this image you can also see how this is folding here. And the same layer is coming up here like this, so this is a very complex pattern but, if you understand the geometry of superposition you can figure it out.

In this image which I received from professor Biswal we can clearly see that at the center we have a crescent but we have an excellent mushroom on this side so the best is if you do a geometric analysis and you figure out. So again you see this is your F1 and this is how it got the entire 4 that you see here, this is because of the second deformation and the trace of the F2 going on along this side.

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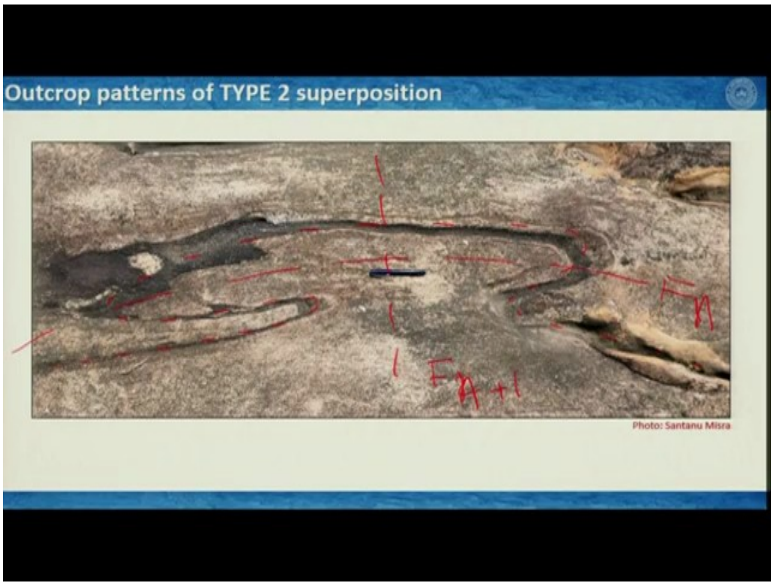

This is an excellent mushroom as well you can see here this is the outcrop pattern, so clearly, you can figure out this is your F1 here and this is your F2. So this is how it works but, by the way this is not the first fold we see here, this is a highly deformed terrain, so could be a many second generation fold we can define it particularly for this, so if this is a N, then this is N plus 1. So the N is the number of deformations we are looking at.

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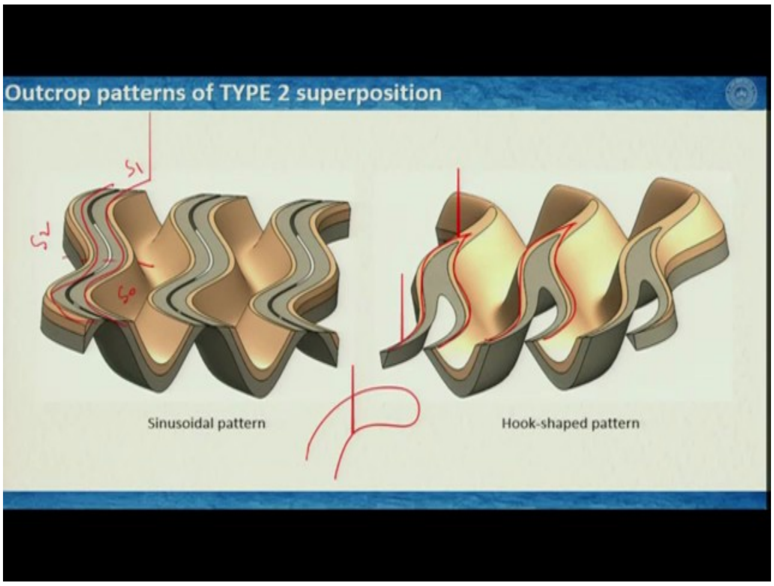

Now, we can also see a sinusoidal pattern if we cut it flat so, in this section you see the traces of this S0 here, and on this surface which is horizontal surface here, so these are your S0, the form surface and you see the traces of your S1 folds on this case and you also see the S2 folds in way. You can also see the hook shaped pattern something like that, it is coming like this and this is known as hook because it is coming something like that so these hooks are also possible in type 2 on superposition of folds.

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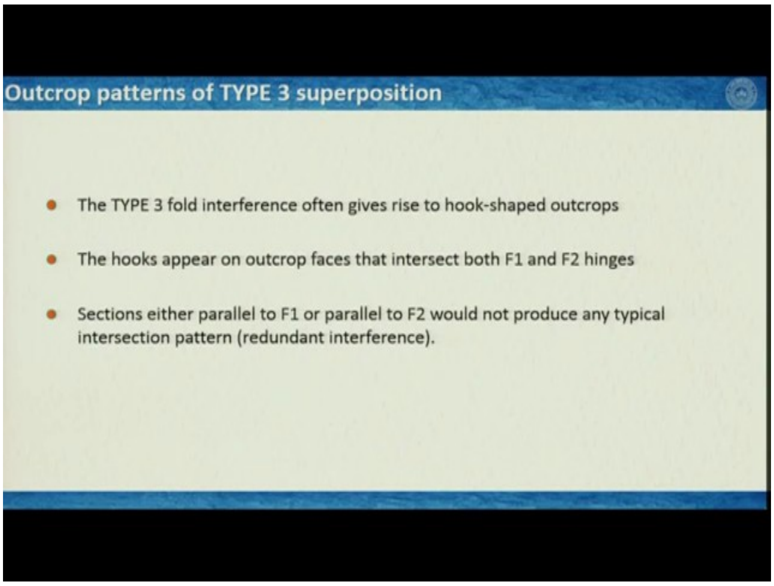

Now, let us talk about what happens with the type 3 superposition, now type 3 fold interferons is essentially characterized by hook shaped outcrop. So, you also get them in type 2 deformation so you have to look from other, look in some other surfaces, if you can also get hook shaped outcrops, or not or crescent or something like that, but they generally are very complex so, you have to be very careful to identify that which type of superposition is actually what.

Now the hook appears in the outcropped faces that intersect both F1 and F2 hinges now, sections again either parallel to F1 or parallel to F2 would not produce any typical intersection pattern or it would be a redundant interferon.

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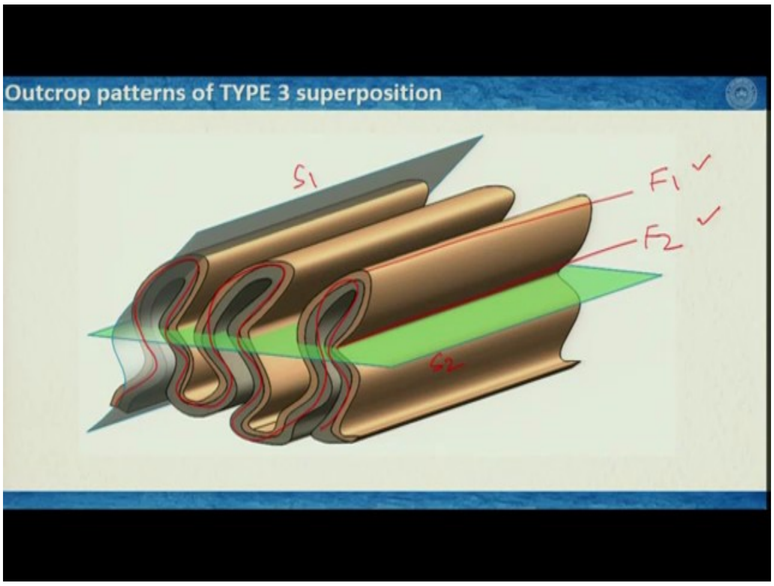

So what we see here again, as we have learned in these previous slides that this is your F1, this is your F2, this is your S1 and the green one is your S2. So S1 is curved that is why it is non-planar but it is cylindrical because neither F1 nor F2 are curved. So they are straight.

Now, you can clearly see in this section we see this hook shape okay so sections particular to F1 and F2 would give you a hook shape or if the outcrop pattern cuts at an angle F1 and F2 you would see essentially a hook shaped pattern like here.

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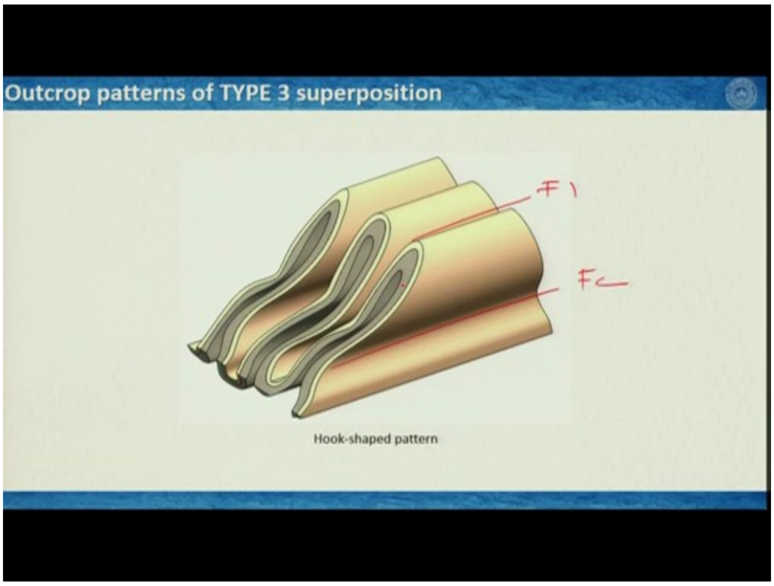

So, we cut at an angle so, this was your F1 and this one is F2 so this is the plane, this outcrop pattern that is cutting both F1 and F2 at an angle and producing this hook shaped outcrop.

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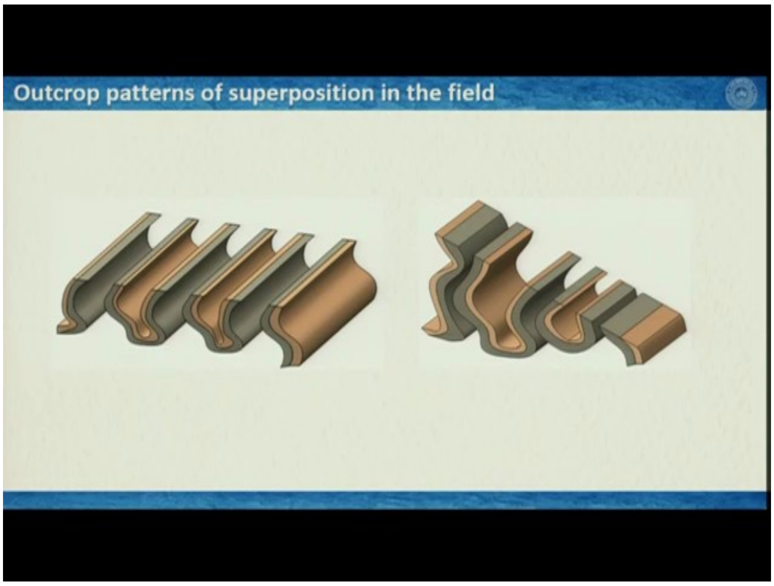

But, if they are parallel to F1 and F2 then you can have an outcrop pattern as you see in this slide and these are some sort of redundant superposition.

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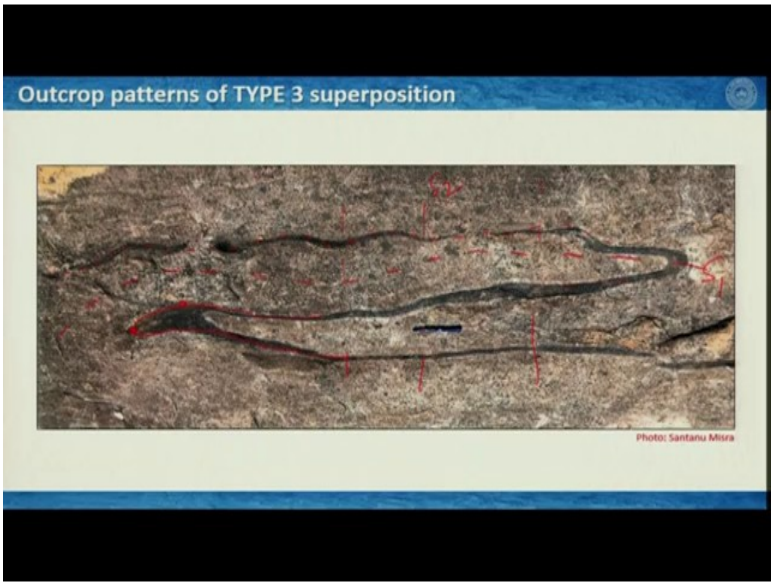

Now do we see them in the field, the answer is, yes. First have a look here, we see that this thin layer is folded something like that to thick layer is straight and then here, we see a very faint hook formation. Okay, so this is again your F1, this is your F2, they are aligned almost perpendicular to this projection plane and these are your traces of the actual planes and this is another one. So we can figure out this must be your S1 and this must be your S2.

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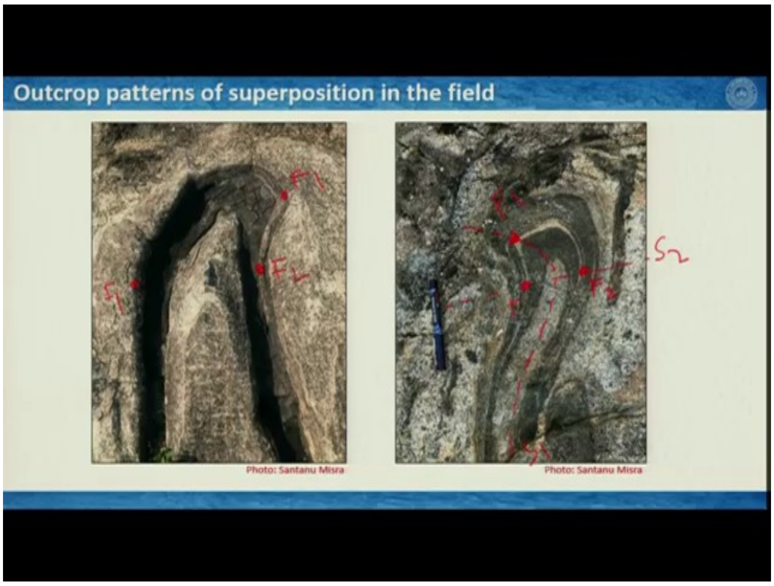

But we can see them in a much much detailed and better way. So this is again one hook as we can see this is one-fold axis and this could be another fold axis where this one is certainly F1 and these are F2 fold axes they are parallel to each other and in this section that you are looking at they are approximately perpendicular to the plane of view and here as well we see this is, this must be your F1 and then these two fold axes are where it got maximum curve. This is the trace of S2, this is the trace of S1 in this case and these are your F2.

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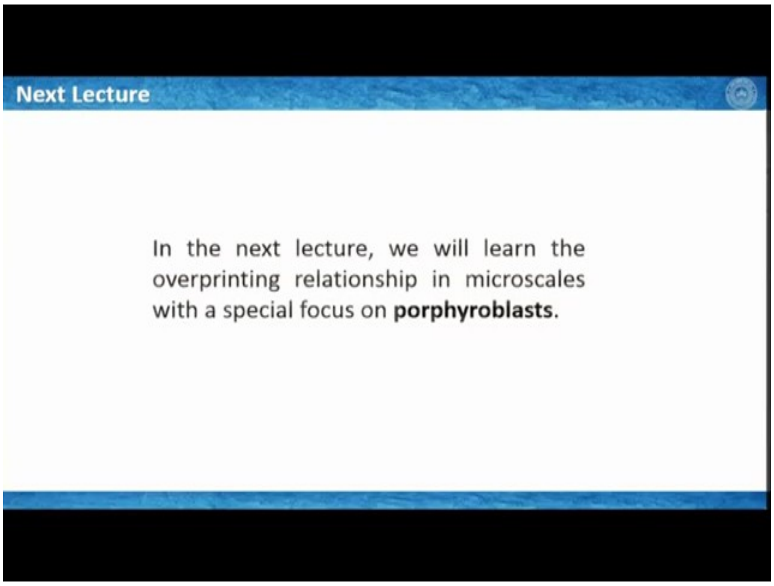

So I conclude this lecture of fold superposition and also the conclusion of this week's lecture so I repeat it was again a long week, I am sorry for that for, that you have to spend time in front of your computers or something for quite a long time this week, but I believe this is something we should understand and learned as an undergraduate students of structural geology and in the next lecture we will actually continue this superposition but we will see them in a different way.

The next week is assigned for boothins but I would like to spill part of it to the next lecture and we will look at things in microscale and we see how this different kinds of planar fabrics appeared in the field so what are their mutual relationships what are the overprinting relationships together with the metamorphism because during metamorphism we form some new minerals and the new minerals grow during deformation and while they grow they include or they produce some characteristic micro structures.

And these micro structures are very very crucial and important to identify when and how the deformation had happened. So stay tuned. I will see you next week. Thank you very much.