Structural Geology
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Lecture No. 25
Boundinage & Pinch and Swell Structure - I

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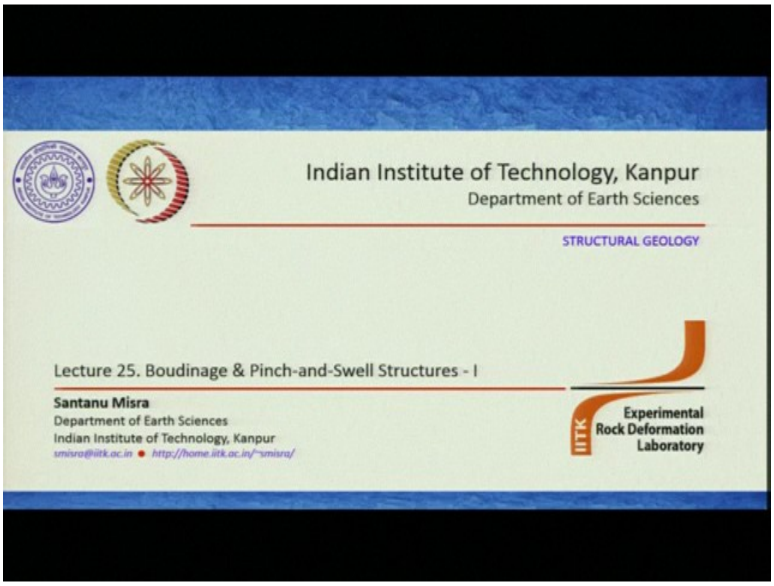

Hello everyone, welcome back again to these online structural geology NPTEL course. We are in our lecture number 25 and we are actually in the week of boudinage and related structures. However, this is the second lecture of this week, in the first week, we learned something related to called porphyroblast, where we looked at deformation at different stages and how it happens in microstructures and then how we can relate these sort of things to a large-scale deformation and at the same time metamorphisms and so on. I hope you will like that lecture. In this lecture you we will start actually the topic of this week, which is boudinage and related structures and today we will focus on boudinage and pinch and swell structures which is the part 1 of this lecture series.

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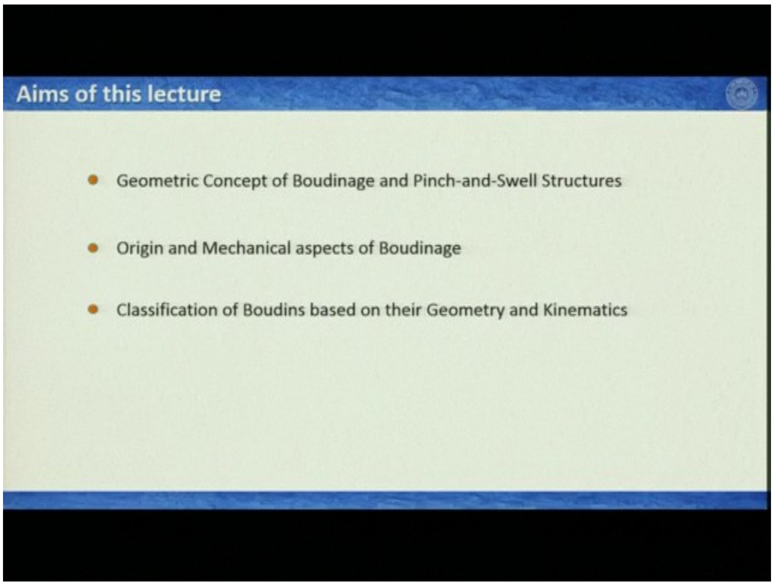

Now what we are going to learn in this lecture, the geometric concept of boudinage and pinch and swell structures. Then we look at that how do this boudinage structures actually do form in nature, will see a series of experiments as well and then we will try to classify the boudins based on their geometry and kinematics. Now you see that most of the times when we deal with a particular structure, particularly delta with foliation or planet fabrics, then lineation, then we learned fold and now this time boudinage.

These all these topics of structural geology actually include a lot of terminologies and these terminologies also take a significant part in describing or in defining the classification schemes of these structures. So boudins also not an exclusion of this topics, so will also see a lot of names, will see lot of different geometries and so on. Because with these we actually go to the field, try to identify and describe them and this is very common for all structures and also applicable for boudinage structures.

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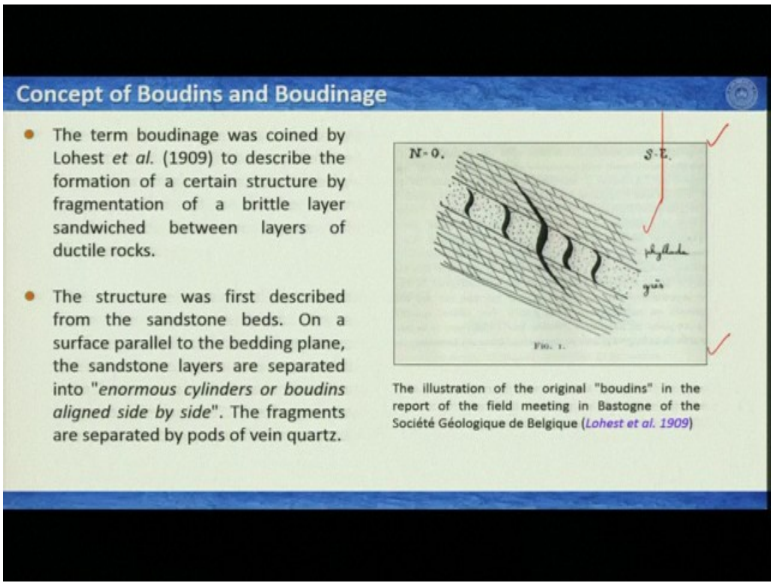

Now, so the term boudinage actually was coined by Lohest 1909 to describe the process of formation of a certain type of structures by fragmentation of a sheet of brittle rock, which is sandwiched between layers of ductile rocks and the structure Lohest first figured out and described from a sandstone bed in the Bastogne region of Belgium. I do not know if I have pronounced the area, name of the area properly but it is spelled as Bastogne. So could be Bastogne or something like that. So in plain view, let us come to the topic that is on the surface, and a parallel to the stratification plane if you look at then he described it this way that the sandstone beds are separated into enormous cylinders or boudins aligned side-by-side. And the fragments are separated by pods of vein quartz.

Now boudins is a French term that generally describes the sausage to be very specific blood sausages if you have seen it. So we will see the structures very soon and interestingly in transverse section the fragments are barrel shaped. So in the, if you look at from the top surfaces, it appears like long enormous cylinders. But on the transverse section the fragments are barrel shaped and are aligned in a row.

The individual fragments are called boudins as we have described already. And the process itself is called boudinage. The term boudin means sausage as we have described and in making this analogy Lohest emphasise the plan view of the cylindrical boudins. However, to some people the analogy meant the similarity of cross-sectional view of a row of boudins to a chain of sausages tied one end to another end. Now most of the time in the field we see boudinage structures, particularly on transverse section, we hardly see them on the horizontal surfaces.

So we mostly would actually describe most of the boudinage structures in this lecture and the next lecture, mostly seeing them on the transverse section. What is interesting, this image here in this slide, this is actually the presentation. So the illustration of the original boudins in the report of the field meeting that happened again in Bastogne of the Societe Geologique de Belgique. So it happened in Bulgaria and this work, he presented in 1909. So this is his drawing and we will see, actually these, this typical we figure that type we are seeing here we will see this later as well. And this is known as gash boudinage or something like that we will learn it soon.

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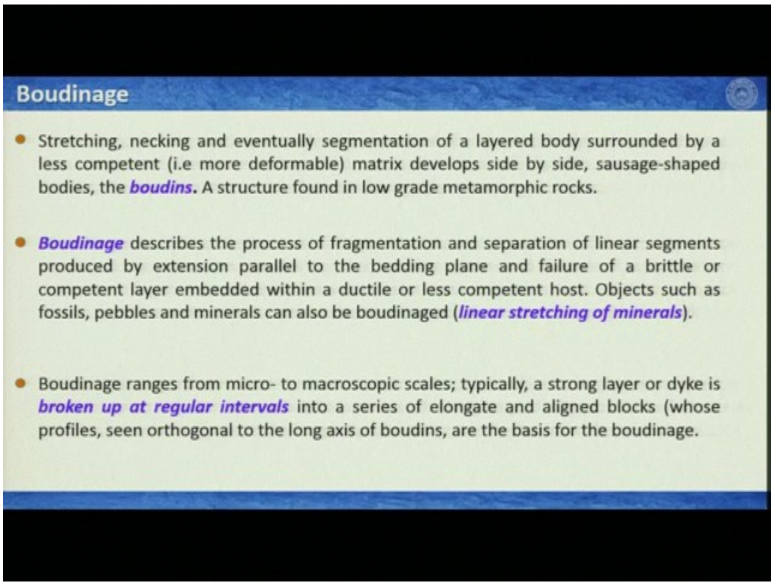

So here are some descriptions that we have just learned. So stretching, necking and eventually segmentation of a layered body surrounded by a less competent or more deformable matrix develop side-by-side, sausage shaped bodies and these are known as boudins. And this is a structure the boudins it generally expects in low-grade metamorphic rocks or boudins generally to form during low-grade metamorphism of the rocks.

Now boudinage as we have understood so far that this describes the processes of fragmentation and separation of the linear segments produced by extension parallel to the bedding plane and the failure of a brittle or competent layer which is embedded with a ductile or less competent host. Objects such as fossils, pebbles and minerals can also be boudinaged. So in other ways you can think that you need a strong layer which should be sandwiched by relatively weaker layers.

And this is actually included the study of boudinage, you will see in few textbooks and also in some study materials that they are included within the topic of lineations. Because we see them in a, as a linear feature in the rock, we will see or learn more about it later. However, boudinage is just not I would say a lineation like we have learned, it is not just, it is not a typical lineation it has some interesting characteristics within its structures, so within its geometry and shapes. So therefore it demands a special attention and therefore we have dedicated a week to learn boudins and pinch and swell structures.

Now boudinage it can range from micro to macroscopic scales. So you can see them in large scales in the filled, sometimes on the road sections or some mountains and you also see them under microscopes. So typically you need a strong layer or a dyke is broken up at regular intervals into a series of elongate and aligned blocks. So whose profiles, seen orthogonal to the axis of the boudins, are the basis for the boudinage.

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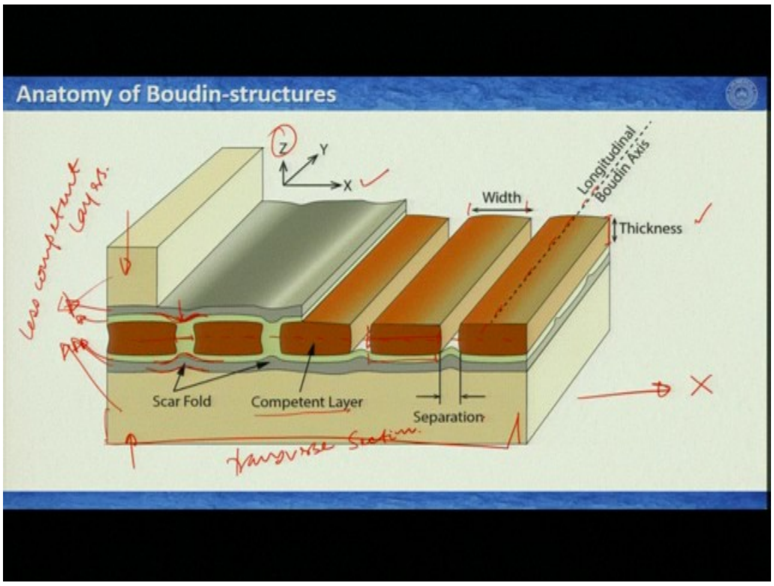

Now here is the anatomy of the boudinage. I will first describe the image and then we will talk about the different parts of it. So what do we see here? So this is slightly yellowish blocks here, these are actually less competent layers and also these, these grey and then yellow and so on. And then this dark layer, this darker layer, this brown layer is actually your competent layer, we will see soon how did it form but this is how it looks like.

So this section you are looking at, this particular section is your transverse section and this is, this is what you are looking at from the top, where you have. Now you see this large cylinders that Lohest has described. So this typical direction is known as the longitudinal boudin axis. Then the layer which is undergoing boudinage process is the thickness of this layer, we call it thickness. The individual width of this boudins in the transverse section are actually the width of the boudins.

And interestingly when you have the boudins, you have separations when these layers are separated, then the layers which actually sandwiched the boudinage, they come in to fill the gaps. So this gap is known as scar or separation or sometimes nodes and because this is an empty space, we will see it soon. Then these things try to fill up or occupy this space, and therefore it forms a fold like features. But this is not a buckling type of fold, this is kind of bending fold.

Now as we can see it, you can also relate it because this is the deformation related feature. So you can relate it with the overall strain ellipsoids. So if I considered this certainly this was my stretching direction. So this was the X and then Y. I can align it along the longitudinal boudin axis and this is the compression direction and then I can refer to it as Z. So we will see it later. Also in the next lecture that how boudinage or boudinage processes are directly related to strain and strain features.

So the boudinage structure, the fragments occur in a row. So that you can figure out or you cannot question the fact that about the continuity of a layer before the boudinage occurred. So what I mean by this that these separated blocks that you see now they must be once upon a time was continuous layer. So it in certain areas, we find sometimes irregular isolated fragments of a competent rock within an incompetent host.

Now the fragments are occasionally folded, although they are derived from one or more layers. So the general continuity of a layer therefore cannot be deciphered with certain T by joining this fragments. So this is a very special case, I am talking about and these are not typically known as boudinage, but they are called tectonic inclusions or fish rather than boudinage.

So to more about this slides so geometry of boudinage as we have seen of boudinage structures may be described in terms of the series of structural elements. So one is we learned the length of the boudin, so, which is measured along its longest direction and the direction is the boudin access we have seen it. The width of a boudin is measured in a section transverse to the boudin access and along a direction parallel to the layering. So is this one as you have learned little before.

The thickness of the boudin is the thickness of the layer which has suffered boudinage. The distance between two adjacent boudin's inner transverse section is called separation or we have seen we can call it gap or scar or node and in general way the gap between two boudins may be described as the scar, sometimes also known as node or gap or separation zone as we have already described all these features. Now there is one very important part we should remember. So when we have seen this in an illustration.

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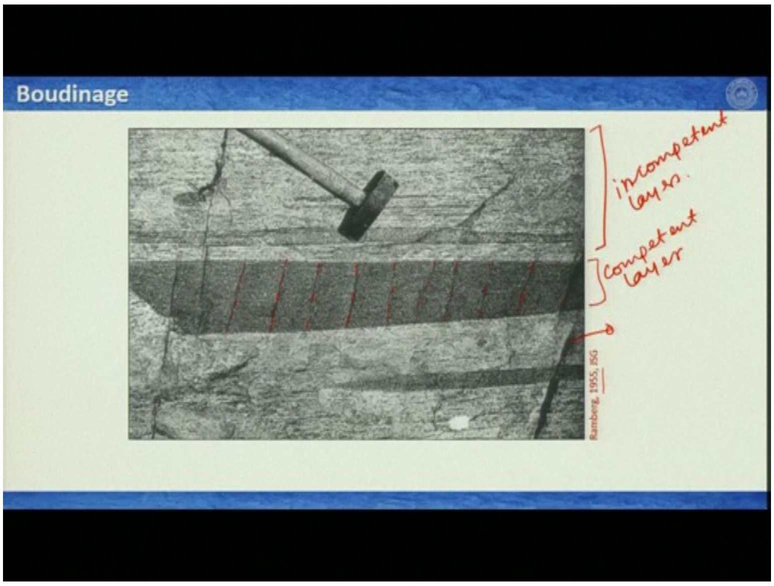

Let us have a look of some real photographs of boudinage structures. This is one of the classic images as you can see the date is 1955, is a photograph from a paper by Hans Ramberg. When you see that this, the black layer is the competent layer and these are incompetent layers and this as well. So you can clearly see that these fractures are concentrated only in the black layers. Now these are not separated yet, they are yet to be separated, but this is very initial stage of the boudinage process.

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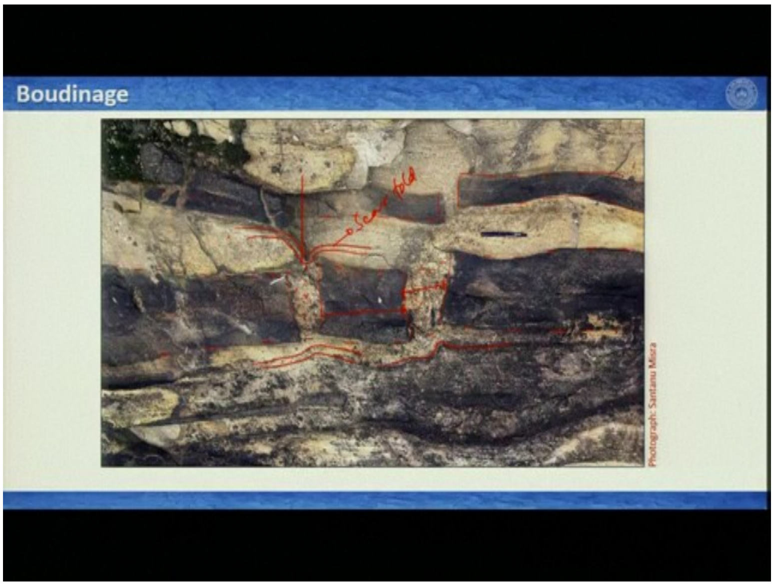

Now we see here that this is a photograph from ChotaNagpur nics complex and here you clearly see that this must be a continuous layer is not it, this black layer if you consider, this was be a continuous layer and now they are broken in parts, you can also see it here in the top layer and it also broken in parts, it got folded a little bit, but we will talk it about later. But this is how you see the boudinage in the transverse section. So this is your, what you call scaror separation or gap and this is the width of the boudin.

And you can see here that this is somehow going in you see here, this layer which is less competent is trying to flow inside a layer, will also see here, it is trying to flow inside the layer, inside the gap that is being created. So these are known as your scar folds as we have seen in the illustration and these are actually the bending folds and these places are actually initially open places and later this places are filled by mostly some fibres and this could be quartz or calcite or some other minerals and these are mostly characterised by larger grain size than the grain size you have in the matrix.

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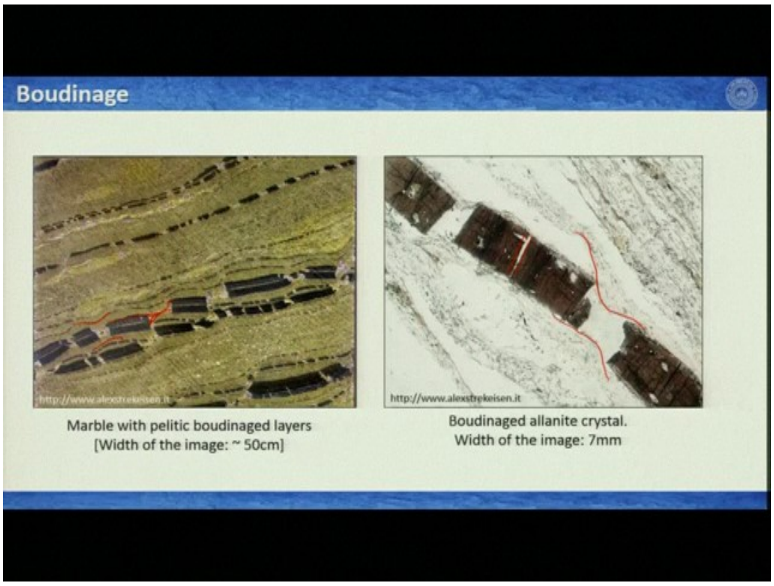

Okay, this is another image, you see that a series of layers are good boudinage, here, this host rock or the matrix is a marble and then it had some competent layers of pelitic rocks and what is interesting you see that here these layers got also a little bit also a rotation here. So if I try to follow the trend of this, it does not match here. So there is a little separation, will talk about this, these are known as asymmetric boudinage, this is not fill typical asymmetric boudinage. But yes this as a, this is on the verge of formation of a symmetric boudinage, we will see about it.

But this is an example of boudinage structure and this is allanite crystal, this one, these dark things and you see here again thus this is a microscopic image, the width of the images 7 millimetres and here you see this allanite crystal is somehow, at least from this image we see they got fractured along its length and we see the separations here, we see another separation is happening here, the separation is here as well. The also see in this scale that this scar folds are happening here as well. And we see this scar folds here as well, things are trying to go in. So this is how you describe the difference you see in the field or under the microscope, this boudinage layers.

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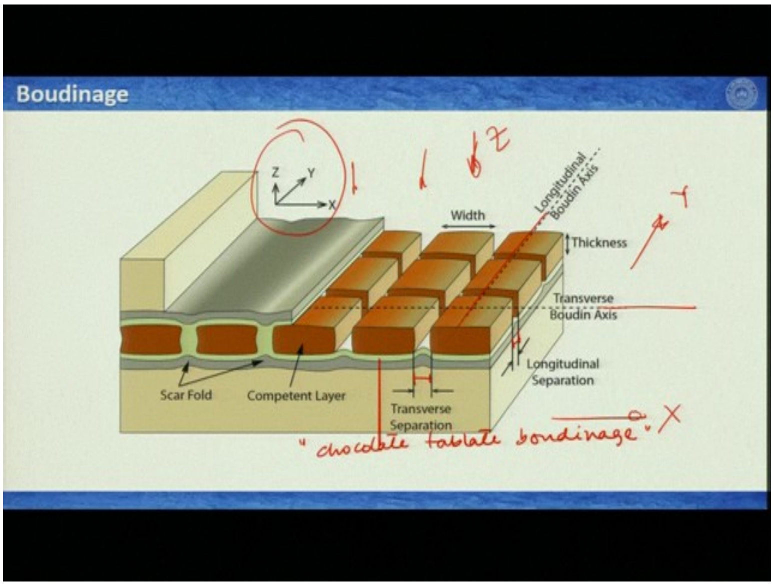

Now there could be another possibility, as we see in this slide that if you have extension in both directions. So you are compressing along the Z direction, but X and Y, both are in the extensional field. That means you are having more or less a flattening type of strains. So if that happens. That means if the boudinage takes place in two directions. The individual boudins in plain view may either be equidimensional or more commonly in equidimensional as you can see here in this illustration, this is mostly equidimensional.

So if you compress it from the top, then it flows in this direction along the Y direction, it also flows along the X direction. So and these compression direction is your Z, as it is reveal here. So it would certainly fracture along the X direction or for boudins along the X direction and it would also form boudin along the Y direction. So now it is very important that if the individual boudins are equidimensional. The longer direction you can call as boudin access.

But if they are equal in dimensional, equidimensional then it is little difficult. But if necessary, it is possible to distinguish between the longitudinal boudin access, which we have defined in this case, this one and then the other one would be your transverse boudin access. And in a similar way, you can also distinguish transverse separation or scar this way and you can also figure out what is your longitudinal separation along the longitudinal boudin access.

So this is how we see the boudinage which is happening in two different directions under the flattening conditions and difficult types of boudins are known as chocolate tablet boudinage. We will learn more about it in the next lecture and will see how with different structural features, particularly with buckle folding we can have or we can form the chocolate tablet boudinage at particular conditions.

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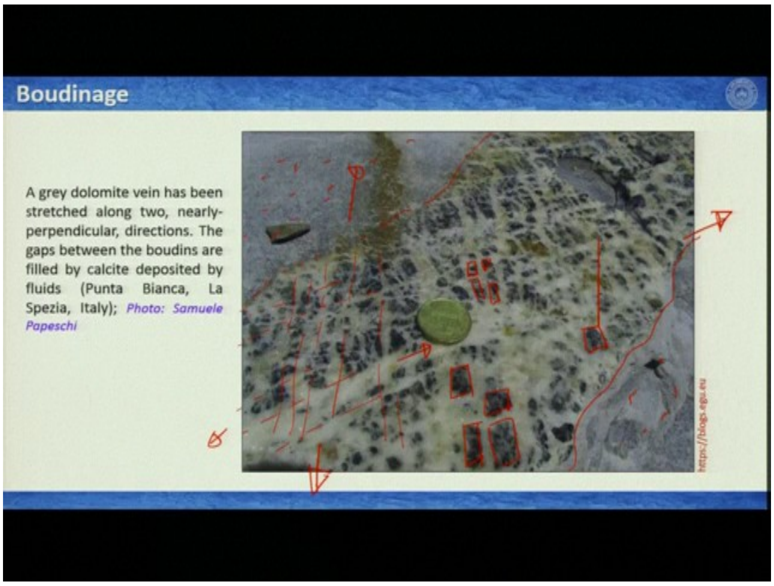

Now this is an example of a field photograph of chocolate tablet boudinage. I took it from EGU blogs. So what do we see here the matrix as you can see here, these are the matrix, this matrix is actually calcitic or marble. And then you had a dyke of dolomite or dolomite vein or dyke and then it got fractured, you can clearly see the trends. So one trend is like this, as you can see here and another trend you can figure out is like this.

So almost orthogonally they got separated and as a result, you get this blocky shape. So this is a very typical or you can figure it out here the chocolate tablet boudinage. So that means it got extension along this direction and also along this direction, you can put it here. So it would look in that photograph. So we will see the mechanics of chocolate tablet boudinage in a different way later but to give you an impression how they look like in the field, this is how it is, you can also search in your search engines on the internet and you can find many more photographs.

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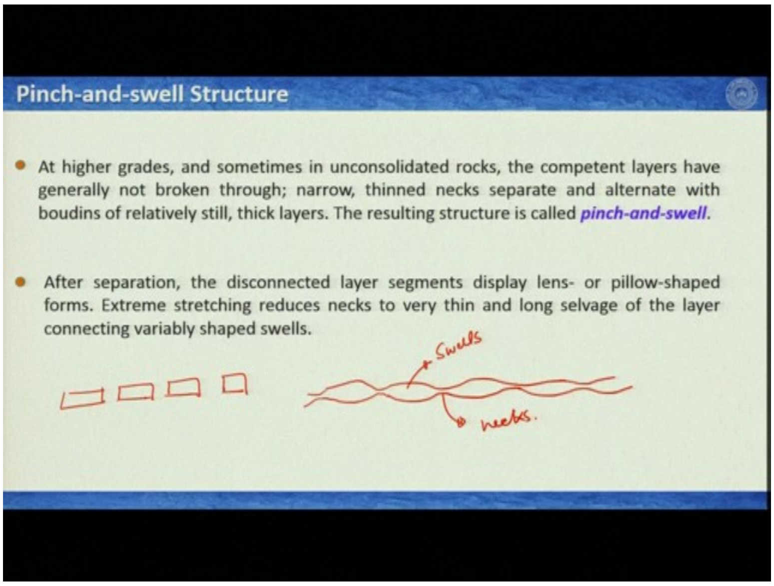

Now in a very similar way when we talk about boudinage then another type of structures to appear in the field and these are known as pinch and swell structures and as I said that boudinage we find mostly in lower grade metamorphic rocks. But pinch and swell structures are generally observed in higher grade metamorphic rocks. So in higher grades, sometimes also in unconsolidated rocks, what I mean by saying this is that the competent contrast is less between the layer which would be undergoing boudinage or pinch and swell and the sandwich materials.

So the competent layers have generally not broken through. So narrow, thinned necks separate and alternate with boudins of relatively still, thick layers. The resulting structure is called pinch and swell, we will see it soon. After separation, the disconnected layer segment display lens or pillow shaped forms. Extremely stretching reduces necks to very thin and long selvage of the layer connecting variably shaped swells.

Now in boudin we saw that it occurs like this, so you have real blocks. But in pinch and swell instead of this block they actually don't get separated. What it happens that they forms some sort of necks in between. This you can experiment by yourself by using a straw that you use to generally drink cold drinks and so on. So these are known as swells and these are known as necks or you will see in the next slide actually.

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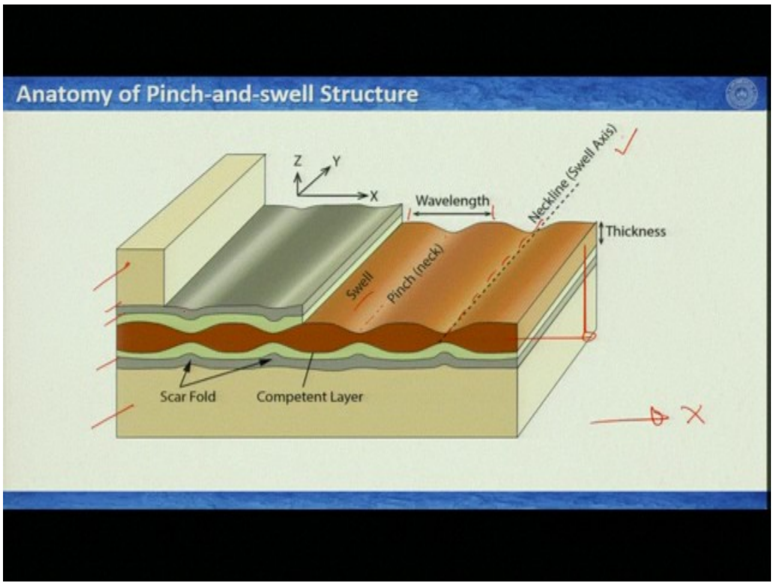

So yes, this is how it is again, it is the same configuration we have incompetent layer, incompetent layer, incompetent layer, incompetent layer, incompetent layer and we have a competent layer here. However, the competents contrast between this, incompetent layers and the competent layer in this case is less than what we have seen before. So if that happens then again, this is your stretching direction X and instead of fragmenting the competent layer it forms the pinch and swell structure.

So pinch we have understood that this is the pinch and the swollen part is known as swell. Then instead of width we generate describe it is as wavelength and then this alignment of the neck is known as neck line or swell access. So this is how it looks like, you also develop the scar folds along the necks of this pinch and swell structures.

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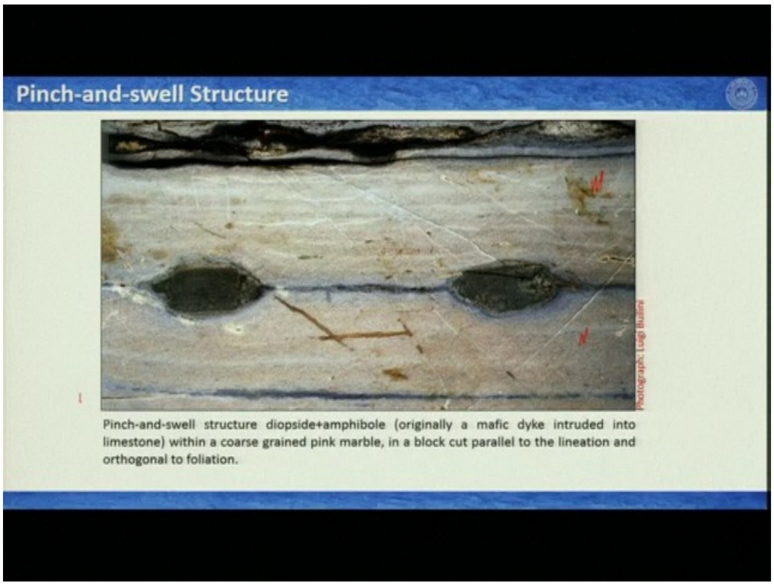

Now this is an example of pinch and swell structure. It is a diopside amphibolite layer that you can see here, this dark layer and then material matrix is a marble. But this is how the pinch and swell structure looks like in the field.

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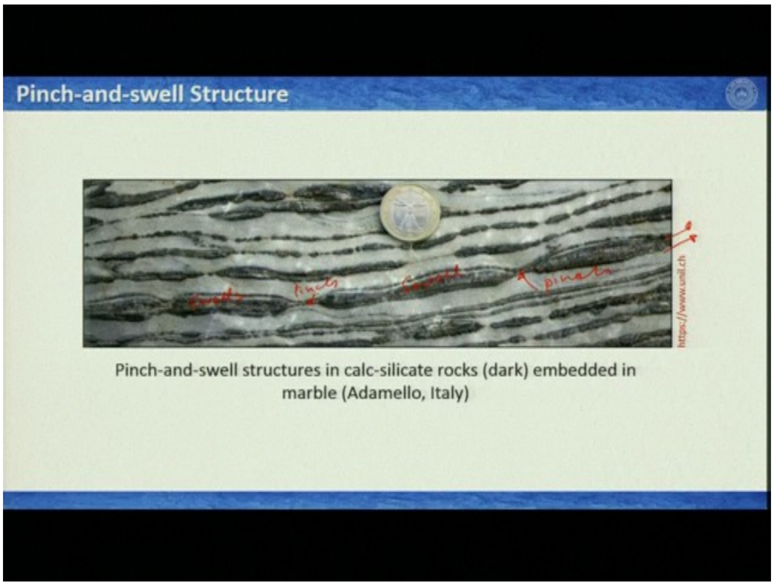

And this is another one and you see that it is not fragmented as we have seen before. It has this swells here and then pinch here right, then again as well. So this is alternate calc silicate rocks. So these are the silicate part and this is the calcitic part and of course silicates are stronger than the calcite at I grades at some temperatures and therefore the silicates are undergoing pinch and swell whether calcite is working as less competent material or matrix to produce the pinch and swell structure.

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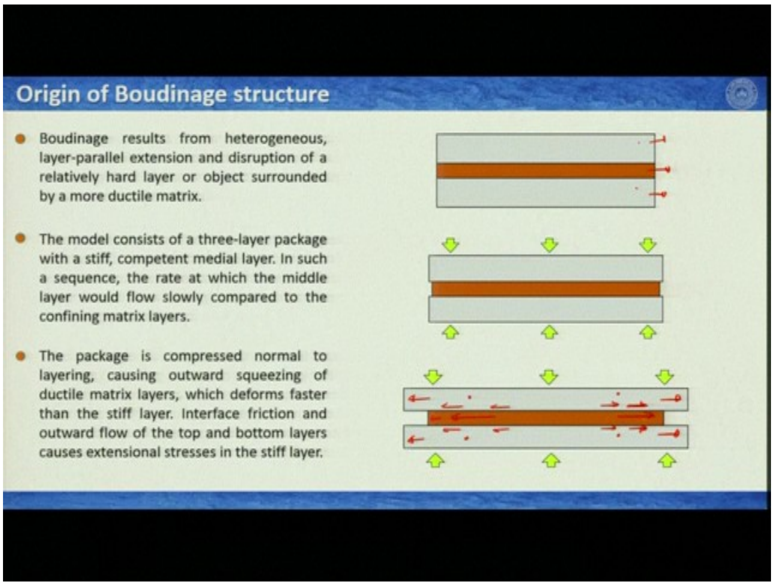

Now how do they form? What is the origin of this boudinage structure? Now people mostly figure out the boudinage structure or most of the structures that we see in nature by experiments. So that also happened with the boudinage. So boudinage mostly results from heterogeneous layer parallel extension and destruction of a relatively hard layer or objects surrounded by a more ductile matrix.

So these we have been talking several times, but this is how the boudinage do form. So you can imagine that if I consider a model, then I have a model that model essentially needs to have a three layer package. So the middle layer as you talking about is a competent layer and the upper and lower layers must be less competent layers. Now the sequence is made such a way that the rate at which the middle layer would flow slowly compared to the confining matrix layers.

So that means we see it next soon that, if I apply a layer normal compression as you can see here. Then these top and bottom layers would flow faster than the layer in between. So what is happening if that happens? So if this layer is flowing faster the rate of strain accumulation in this layer, if it is faster than the layer in the middle it generates an enormous amount of friction at the boundary. So whether this red layer here is trying to deform, trying to flow horizontally but this grey layer at the top and the bottom is also trying to pull it away from each other. So therefore with a particular condition, at a particular condition we will see that this interfere friction and then the outward flow would produce an extensional stress in the stiff layers. So therefore you have some sort of stress going on in this direction.

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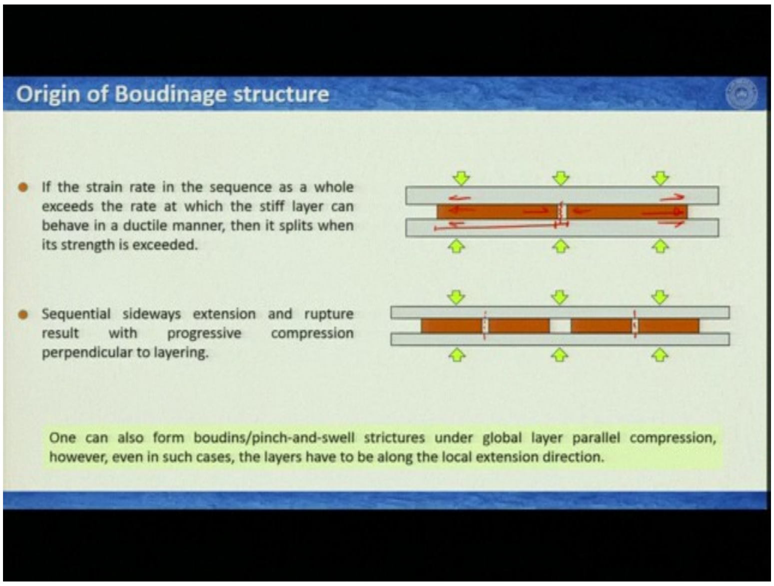

And if that continues, so if the strain rate in the sequence as a whole exceeds the rate at which the stiff layer can behave in a ductile manner, then it splits when its strength is exceeded. What I mean by this that we have generated in the previous slide, a significant amount of tensile stress or extensional stress, along the layer. So therefore it has to break at the middle and then the force is still there. So you still have friction continued and then this separation increases. However, that is not the case that would run forever.

What I mean by this, that if this deformation continues then this block behaves separately and again, this block also has developed an extensional stress within itself and therefore it produces another fracture and the same happens here. So this is how it multiplies and the boudinage processes go on. Now, one can also form boudins or pinch and swells structures as you have seen here that you need a layer normal compression.

But when you have the global stress in a compression mode, you also can form a boudinage structure, we will see later that folds and boudinage are sometime close associated if there are certain conditions but even in that case we will see that even the global stress is compressive but the layers that is undergoing in boudinage processes have to have a local extension direction along the layer, will see about it later.

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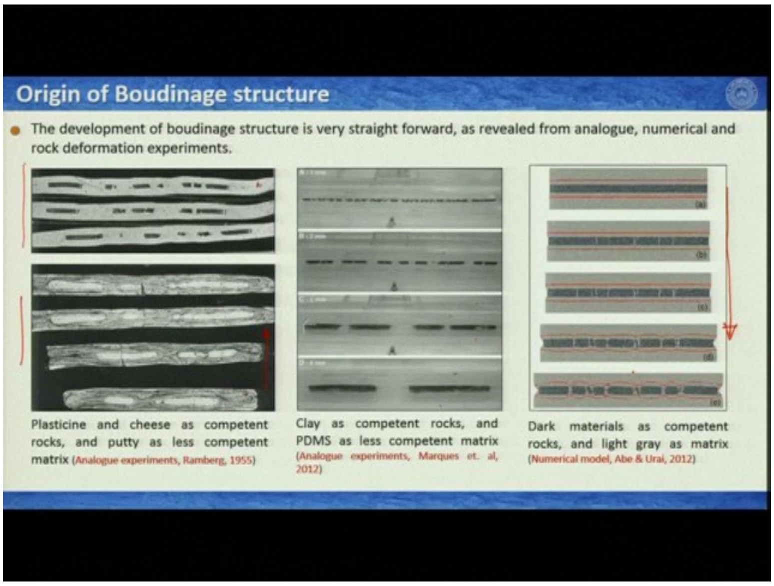

Now, as I said that the boudinage structure that we have learned the origin and so on. These we mostly derived from experiments and here I would like to show you some of the experiments. So the again the first one is one of the very classic ones from 1955 Ramberg paper. He used a plasticine as the competent material in the first panel and you can see that this is how he is developing with the flow, how is developing this boudinage.

And the second panel these white things are is stiff layers and these are cheese and the outside materials in both cases are putty. So you can also see here that how with this when the compression went on he produced the boudinage structure nicely. Now this is another experiment from Marque settle, where you see these are, these four are four different experiments, He changed the layer thickness and then deformed it.

So here the layers are actually clay and the matrix, the less competent matrix is PDMS is a kind of polymer is known as polydimethylsiloxane and here also produce as you can see that boudinage structure. People have also produce boudinage structure numerically once you know the rheology and so on, we can produce it with some numerical codes and this is an work of Abe and Urai published in 2012 as you can see here.

This black is a competent rock and the light grey is matrix which is incompetent and here the sequence is like this. So you can see that as I was talking about, you just do not stop with 1 or 2 boudinage, you continue multiplying the numbers and at the end you arrive somewhere like this. The red line here is just a marker and you see these red lines are here and here developing the scar folds.

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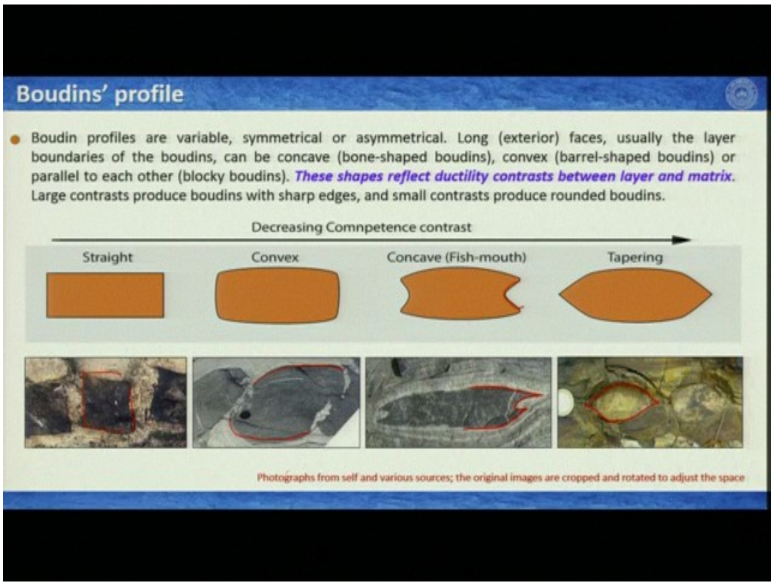

Now the boudins in the profile as we have seen in few cases that we have pinch and swell structures in one hand. So it is like lensoid shape and in few cases in fill, fill photographs we have seen the boudins are really strip. So the boudin profiles variable as you can imagine and we will see later that it can be symmetrical or asymmetrical. The long or exterior faces usually, the layer boundaries of the boudins, can be concave or you can call it bone shaped boudins, it can be convex, it can call it barrel shaped boudins or parallel to each other, then you call it blocky boudins.

All these terminologies have their own meanings and significances, we will learn about it later. But when you have this concave, convex or parallel boudins. They actually indicate some sort of rheological consequences. The shapes reflect the ductility and contrast the between layer and matrix. So large contrasts generally tend to produce sharp edges, and small or less contrasts produce rounded boudins.

So here is an example, as you can see here. I just gave four, examples will see more later. So this is straight, this is convex, this is concave, sometimes it is known as fish mouth as you can see from this particular shape here, it is like a fish mouth and then tapering where the age is tapering here I have given some examples. So as you can see here, these faces are pretty much straight also this, so these are straight faces. These are convex as you can see here. Then concave or fish mouth, you can see here, this is the shape of the boudin so on, and then tapering, you can see here it is exactly like this and also the next one. Now these photographs I took from a large image, so I have cropped it. I also rotated them to adjust the shape.

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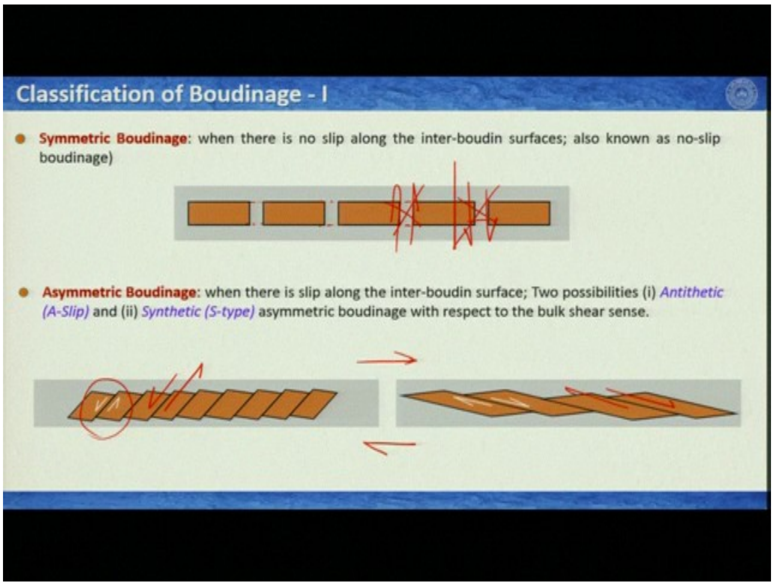

Now classification of boudinage is something that we have to do, which is one of the aims of this lecture, there many classification schemes of boudinage and again many classification schemes are there and in a very similar way no classification is complete, but they are classified based on either geometry or kinematics and so on. So what I will do in this lecture, I will just give you a tour of this with some logical explanations of this classification scheme.

The first classification you will learn is symmetric and asymmetric boudinage. A symmetric boudinage is when there is no slip along the inter-boudin surfaces. So the scar or the separation of these boudin spaces did not undergo any slip in between. So what you see here in this image, that these are pretty much straight. So there was no slip along this or any way. So these things were absent. So therefore these are known as symmetric boudinage and sometimes will also call them no slip boudinage.

Asymmetric boudinage is exactly the opposite when you have a slip along the inter-boudin surfaces. And there could be 2 possibilities, one is antithetic or a slip type of boudinage and synthetic or S type asymmetric boudinage and this is with respect to the bulk shear sense. So in both cases these two illustrations the shear was something like that.

And as you can see here, within this intra-boudinage spaces. The shear direction, it went this way, and this, and this way so here the shear sense is dextral but here it is senistral. So it is not matching with the global or bulk shear strength. So therefore this is anti, so this is antithetic slip and then in this case, you see that this is the shear sense which is very similar to the global shear sense and therefore this is synthetic type of asymmetric boudinage.

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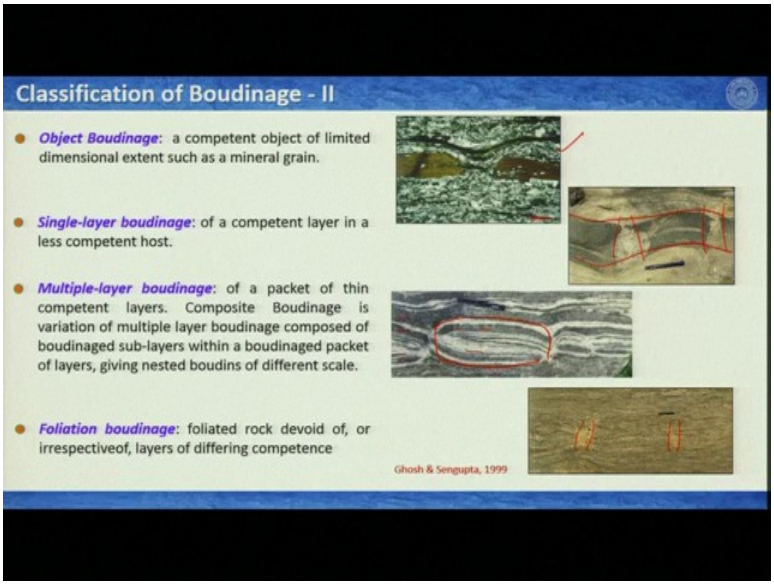

Now there is another classification scheme, which is given by Ghosh and Sengupta in 1999 and they classify the boudinage in four ways. One is object boudinage, then single layer boudinage, multiple layer boudinage and foliation boudinage. Now object boudinage are some sort of competent object, but of limited dimensional extent. So you can think of a mineral grain or something like that, very small competent material undergoing boudinage processes, so here you can see an example here. So this is the scale about 1 millimetre and you see here, this is a mica grain which undergone some sort of boudinage processes.

Now single layer boudinage is generally you see a competent layer. A single competent layer which is embedded within a less competent host, as you can see here. As a single competent layer undergoing boudinage processes here and here. Now multiple layer boudinage is very interesting one is some sort of a packet of thin competent layers, as you can see here, so these are some thin competent layers and they actually get boudinage together and sometimes they also call composite boudinage. So composite boudinage is sometimes a variation of multiple layer boudinage composed of boudinaged sublayers within a boudinaged packet of layers giving nested of boudins of different scales, as you can see here that this you can consider as a boudin but it has many other individual boudins.

So therefore this is a competent boudinage and then there is foliation boudinage. So sometimes foliated rocks do show boudinage process, as you can see here, that here we have this boudinage and this happens apparently with no competence contrast. So foliation boudinage at one point of time was extremely important for researchers. Now people have understood why do foliation boudinage happened but this foliation boudinage a spectacular to see in the field as well, along with the other types of boudinage. So these are the classifications four types, object boudinage, single layer boudinage, multiple layer boudinage and foliation boudinage.

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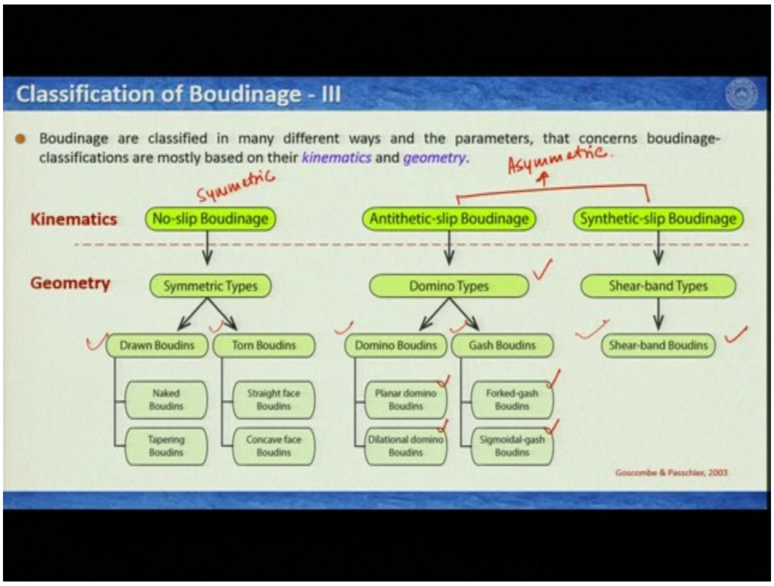

Let's see another classification scheme. So this classification scheme is given by Goscombe & Passchier in 2003 and here they considered both kinematics and geometry. So kinematics means that how do these boudins form with respect to their displacements and so on and we have learned about it. When we were learning the symmetric and asymmetric boudinage. So they define it as no slip boudinage or symmetric boudinage.

Then antithetic slip boudinage and synthetic slip boudinage. So it can figure out that this is a symmetric type, as it is written here. And these two are actually asymmetric jump to the geometry from the kinematics. Then we see that no slip boudinage are of course symmetric types, antithetic slip boudinage domino types and synthetic slip is the large shear band types.

Now let us focus on the symmetric types. In symmetric types we have two classes, one is drawn boudins, another is torn boudins what these are we will see the next slide. Within the drawn boudins we have naked boudins and tapering boudins. And within the torn boudins we have straight face boudins and concave face boudins.

In the domino types domain we have domino boudins and gash boudins. Then, within the domino boudins we have planar domino boudins and dilational domino boudins. Within the gash boudins we have forked gash boudins and sigmoidal gash boudins. The shear band boudins remain as shear band boudins, it does not have any further grant applications within this. Now let us have a look that what do we mean by all this terms, this drawn boudins, this torn boudins, domino boudins, gash boudins and shear band boudins.

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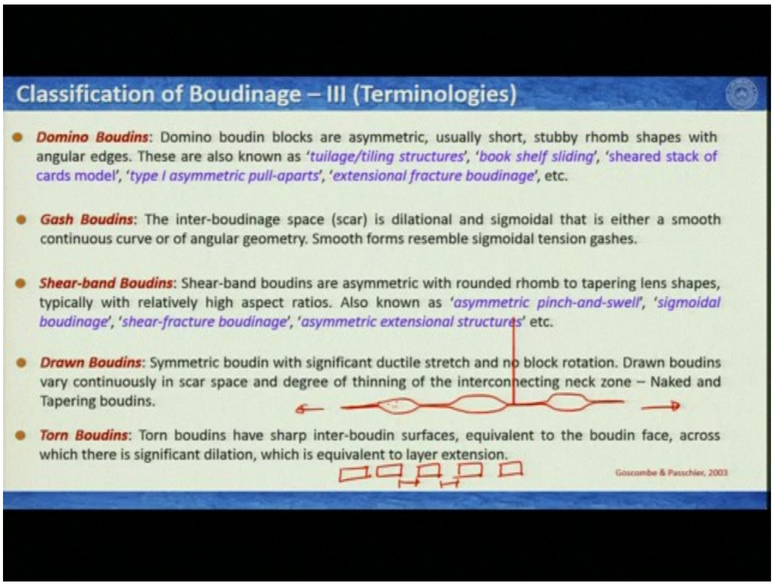

So let us start with the domino boudins, domino boudins are some sort of blocks of asymmetric, usually short, stubby rhomb shapes with angular edges. Now the domino boudins is now people use it, but it has legacy of many names and I have listed here are few. So these are also known as tilling structures, bookshelf sliding, sheared stack of cards model, type I asymmetric pull aparts, extensional fraction boudinage and so on.

The gash boudins are when the inter boudinage or the scar is dilational and sigmoidal and it could be either smooth or continuous curved or angular geometry. Now sometimes these dilational spaces are filled by some other minerals and these are known as so some, it is some sort of tensile gashes and therefore it is known as gash boudins, will see examples soon. Shear band boudins are asymmetric with bounded rhomb or tapering lens shapes, typically with relatively high aspect ratio. And these are also known as asymmetric pinch and swell, sigmoidal boudinage, share fracture boudinage and asymmetric extensional structures.

Now drawn and torn boudinage or boudins they are little different from this. So these three the domino gash and shear band. These are mostly their shapes and geometry together with their kinematics, but drawn and torn these are essentially kinematic things. So drawn boudins are symmetric boudins with significant ductile stretch and no blog rotation. Drawn boudins vary continuously in scar space and degree of thinning of the interconnecting neck zone, you define in two classes. One is naked and another is tapering boudins. What you have learned, so someone is drawing it, so that means it is like this, then, you form it this way. So you see this, what I have drawn here tapering boudins. So it is a kind of pinch and swells structure. But someone is drawing this layer from both ends and therefore you see the features like this.

And torn boudin have the sharp inter boudin surfaces, so it is like this and equivalent to the boudin's face, across which there is a significant dilation. So this is the dilations you can talk about which is also equivalent to layer extensions. Now for strain measurements torn boudins are much better than drawn boudins. So we have learned the strain measurements from boudins. But now you can figure out the torn boudins because their layer extension is equivalent to the dilation. So these are much more useful for strain measurement.

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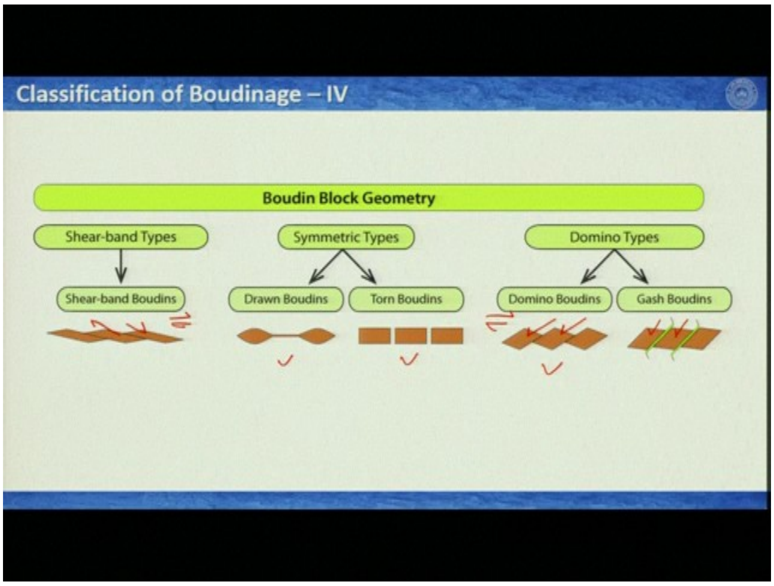

Now here, we can see better that this boudin block geometry. So shear band type, it is like this, so here the shear sense is again like this and this is the sheer sense and this is the shear sense in the intra-boudinage spaces. These are drawn boudins as we have drawn, these are torn boudins, these are domino boudins, again the shear sense here is like this and this is deforming this way, this is slipping this way and these are the gash boudins where you see this asymmetric veins are inside the boudins where the shear sense is somehow like this inside the intra-boudinage spaces.

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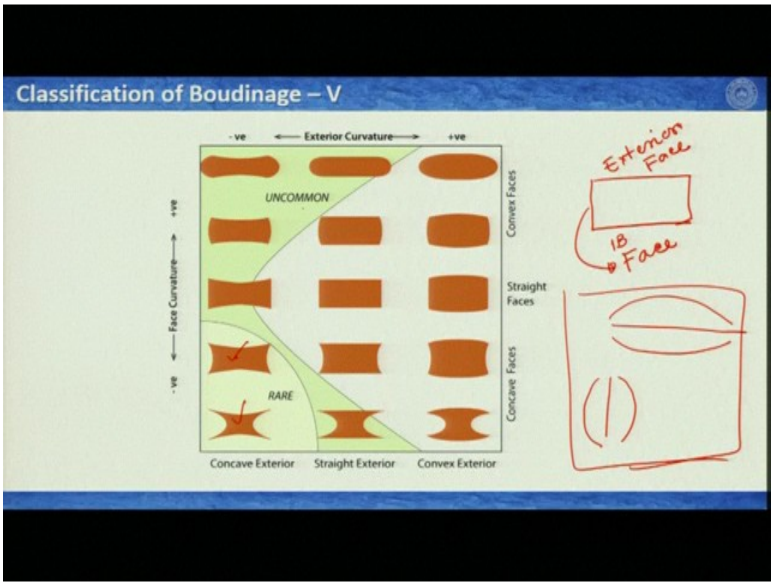

You can further classify in a different way. So this is another one that you can have the face. So what we defined here, that if I have a boudin here like this, then this is known as exterior face and this is known as face, intra-boudinage face only or intra-boudinage face, you can call it. Now based on the curvature of this faces, so whether it is like this or like this, or a straight, whether IB face or intra-boudinage face is straight or like this or like this. So based on this, it is possible to classify the boudins in a different way, based on their exterior curvature and face curvature. Now what do we see here that theoretically you of course, many possibilities are there. But these two shapes, this one and this one are rare and what is under this light yellow area is defined by uncommon.

These are also not so much visible in the field but these which is under the white field, this we see frequently, this fish mouth and so on we see them commonly. So it is actually based on the how do your exterior face and interior face or inter boudinage face, whether it is curved or straight and if it is curved then whether it is concave or convex. So based on that people also do classify the boudinage in this way.

Now with this I finish this lecture. In the next lecture we will continue this and we will see that how we can relate boudinage structures. So what is importance of boudinage structure when you try to interpret some other structures? For example, fold and so on. So thank you very much. I will see you in the next lecture.