Rock Mechanics and Tunneling
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Lecture No. 03
Discontinuities in rock (Continued) and classification of rock

Hello everyone, I welcome all of you to this third lecture on rock mechanics and tunneling.

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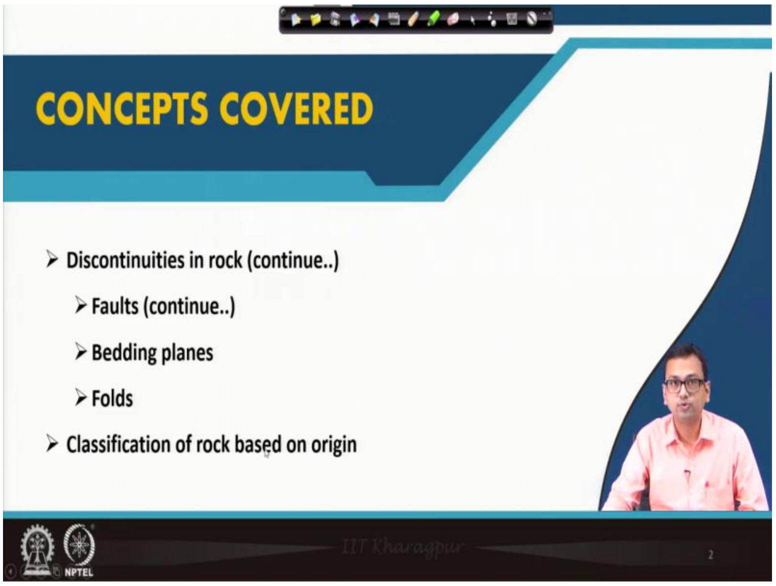

So, in our previous class, we have started discussing the discontinuities in rock. We shall continue with that. So, we were in the middle of 'Faults' actually. And when we are discussing faults, I have introduced three terms like strike, dip, and dip directions. So, we will recapitulate that part once again and after that, we will again start discussing faults, then we will discuss bedding planes, then folds, and then I will start discussing the classification of rock based on its origin.

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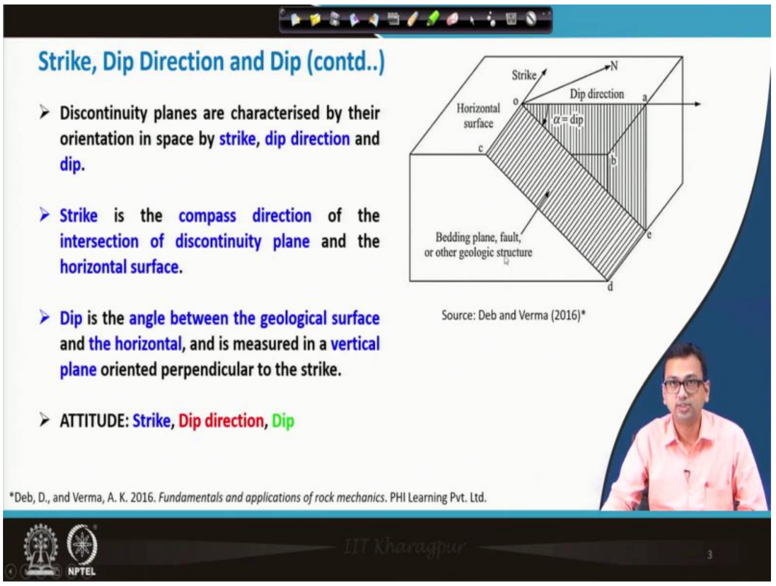

So, what we have learned in our previous class is that the discontinuity planes can be characterized by their orientation in space by strike, dip direction, and dip. And what we can see in this diagram is also that this is a horizontal surface and this is the discontinuity plane. Then what is the strike? What we have discussed is that the strike is the compass direction of the intersection of the discontinuity plane and the horizontal surface.

If it is the north direction, then using a compass, we can measure this angle, why this angle? Because you see the oc line, this is the line where this horizontal surface and the discontinuity plane are intersecting. The orientation of this line can be measured with the help of a compass and that will give us the strike.

Then dip, the dip is the angle between the geological surface and the horizontal and is measured in a vertical plane oriented perpendicular to the strike. So, you see the vertical plane oae, in this vertical plane we have to measure this angle α, this will give us the dip and this dip needs a direction. So, that is called the dip direction and the relationship between strike and dip direction is that they are 90o apart.

So, this is the strike, this is the dip direction, they are 90o apart and in this vertical plane, we are measuring dip. So, together with the strike, dip direction, and dip are called the attitude of the discontinuity.

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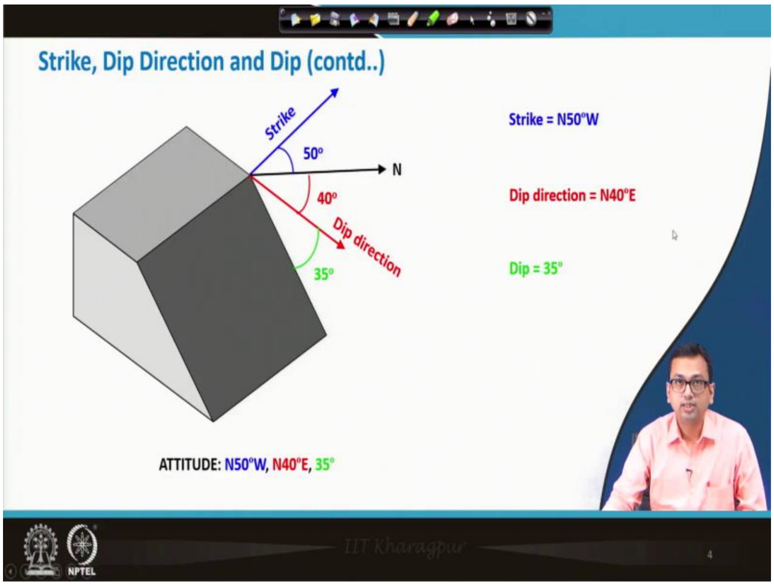

Just to make it even a little bit clearer, we will see a smaller animation. Suppose, in this block here, some discontinuity is present. This is the horizontal surface and here this discontinuity plane is intersecting with the horizontal. So, accordingly, if I consider the 'Attitude' as N50^{o}W, N40^{o}E and 35^{o} that mean the strike, dip direction, and dip are given here.

So, in this diagram, if I want to see what these numbers are trying to say that we will understand very easily. So, if we consider this is the north direction, and then the extension of this line will give us the strike. It is written that N50^{o}W, so this angle is 50^{o} and it is the West side of the North, so N50^{o}W, this is the strike.

Now, what is dip direction? So, the dip direction is the one which is 90^{o} apart from this strike. So, this angle must be 40^{o}. So, this is the dip direction, N40^{o}E. Now the dip i.e. the vertical angle we have to measure. So, this angle is 35^{o}. So, finally, we can say that the dip is 35^{o}. So, if the attitude is provided, you should be able to visualize this picture.

As I have told you, this is very important. So, you should remember this because in the future also we will refer to these terms very frequently.

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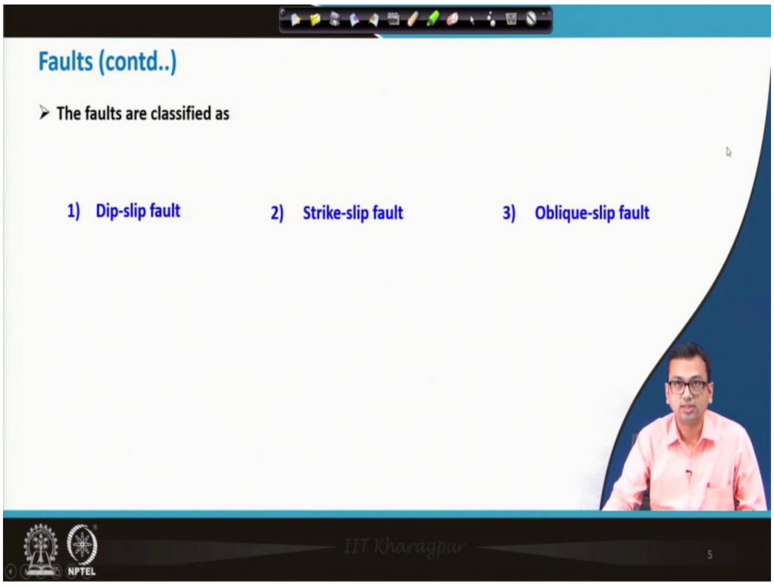

Next, let us again continue our discussion about the faults. So, faults are again classified in different categories like Dip-slip fault, Strike-slip fault, and Oblique fault. So, again each of these individual categories has subcategories. So, we will understand them.

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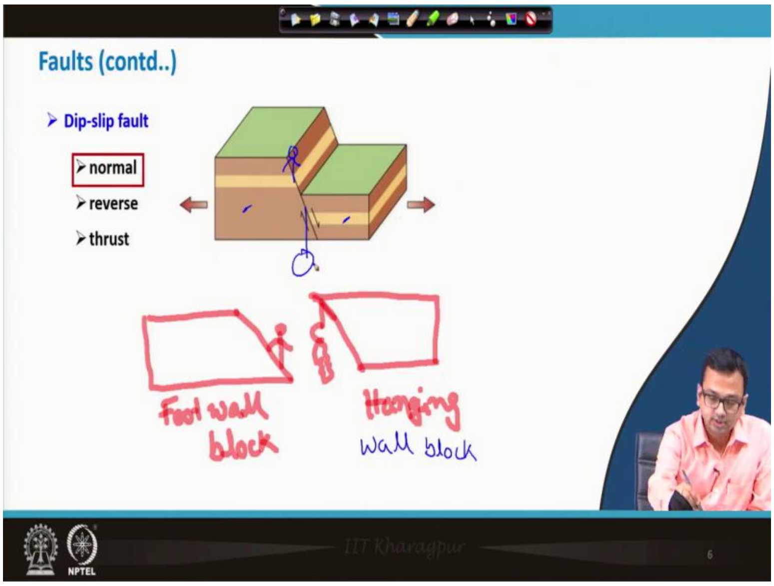

First, let us discuss the dip-slip fault. Under that actually, there are broadly two categories, normal dip-slip fault and reverse dip-slip fault and an especial type of reverse dip-slip fault is called the thrust fault. So, let us see all those things. It is the normal fault. The force is tensile and because of that, this block is coming down.

Now, there are some names of this block and this block. This block is called the footwall block and this block is called the hanging wall block. So, let us try to understand why it is like that so that you should not forget. So, suppose this is a block and its counterpart is this one. Now, if a person wants to stand over here i.e. in this discontinuity line over this plane, the person can only stand over here.

Suppose, I am standing over here, but I cannot stand over here, what I can do that I can hang something from here. So, that is why this is our footwall block. So, this block is our footwall block and this is the hanging wall block. So, it is very clear that you can stand over this inclined surface, so it is the footwall block. From here you can hang something, so it is the hanging wall block.

So, likewise accordingly what we can say this one is the footwall block, this is the hanging wall block because here you can stand but you can hang something from here. So, this is the footwall block and this is my hanging wall block. Now again, let us get back to our discussion.

So, what we can see if the tensile force acts, the hanging wall is coming down. So, this type of dip-slip fault is called the normal fault. And you can see that from here only we can measure the dip angle. So, the dip-slip fault under tension is known as the normal dip-slip fault.

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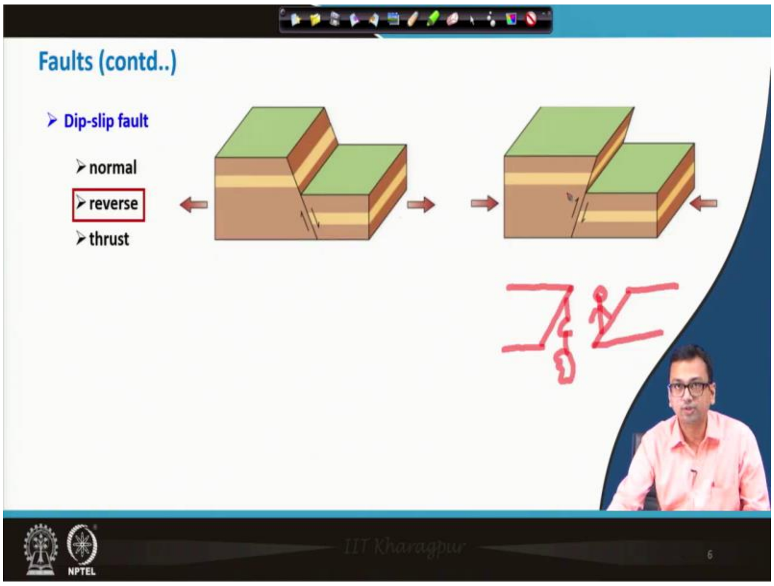

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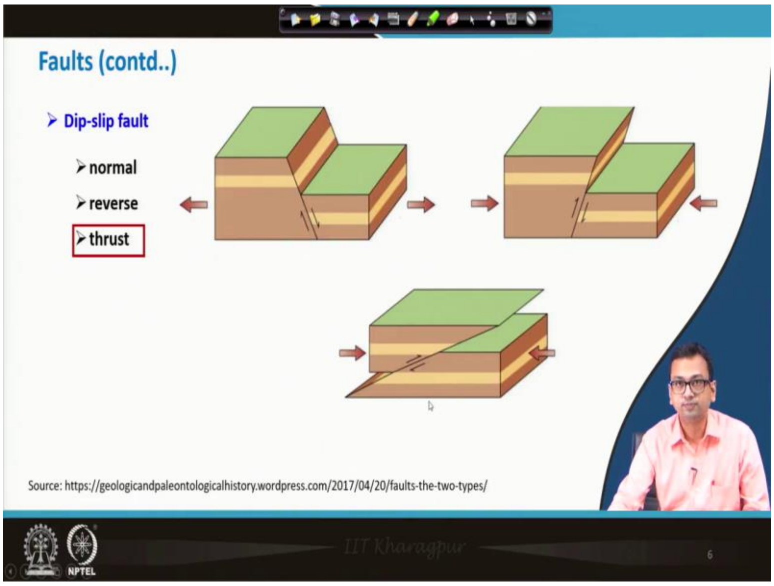
The next one is the reverse fault. So, in reverse fault, the nature of this force is compressive. And here this one is the footwall block, you can see the inclination, this is the footwall block and this is the hanging wall block.

So, this is the hanging wall as you can understand something is hanging and this one is the footwall block, so a person can stand over here. So, now, what we can see over here is that under the compressive loading, this block will go up. So, this is called the reverse dip-slip fault. Now, one special type of reverse dip-slip fault is called the thrust fault.



So, first, let us see the picture. You can clearly see that the nature of the force is compressive and this is the footwall block, this is the hanging wall block. So, the hanging wall block is going up very similar to the reverse dip-slip fault, the only difference is when this angle i.e. the dip is less than 45^{o}, then this reverse dip-slip fault is known as the thrust fault.

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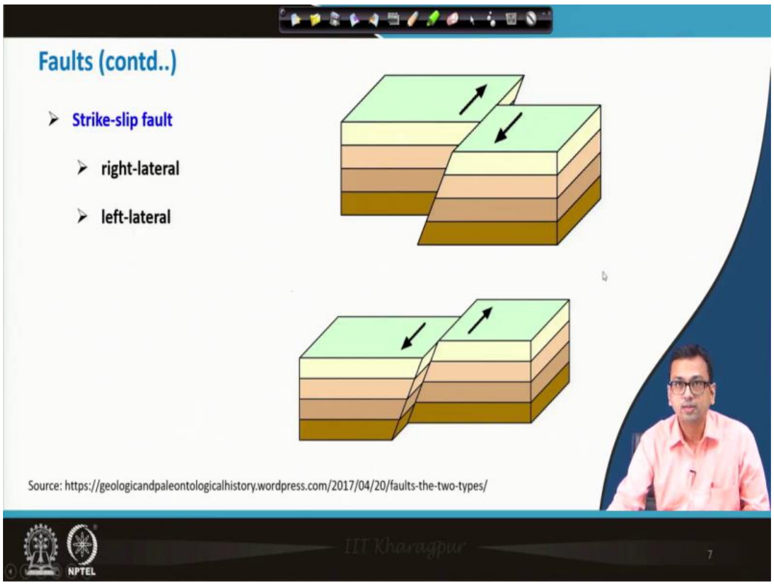

Now, we will discuss about the strike-slip fault and the first one is the right-lateral. So, we have seen in the previous case that the forces were either tensile or compressive in nature. Here, the forces are neither tensile nor compressive. Here, we can see that the shear force is acting and the lateral movement is happening along this line.

Now, this line is nothing but the intersection line between the horizontal surface and the discontinuity plane. So, orientation of this line gives us the strike. So, from here you can think that the name ‘strike-slip fault’ has come and the lateral movement is happening over here.

And now why is it called right-lateral or how to identify that? The idea is that if you stand over the inclined plane i.e. you are standing over the footwall block. So, you stand over here and see the movement of another block (i.e. the hanging wall block) which is in the right hand side direction. That is why it is the right-lateral strike-slip fault.

Similarly, just the opposite one, if you stand over here and look towards the hanging wall block, you will see that the block is moving in the left with respect to footwall block because of the shear force. So, it is called the left-lateral strike-slip fault.

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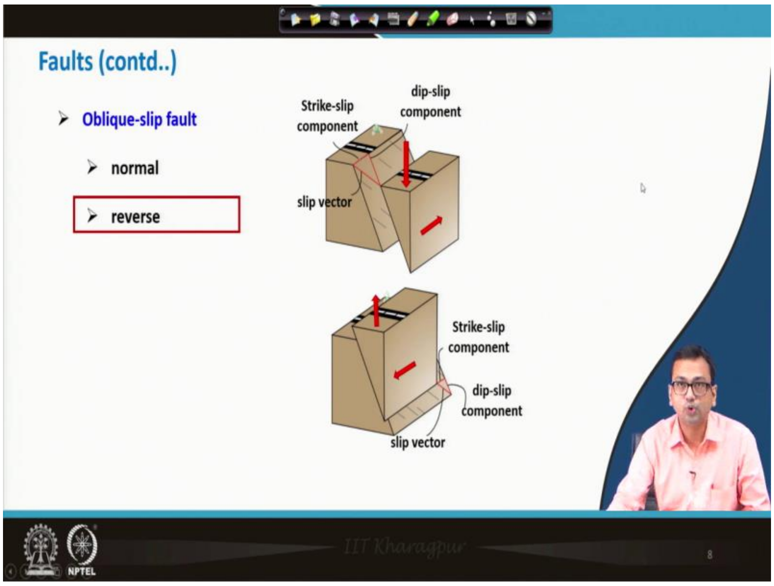

Next, another one is oblique-slip fault. There also you can see normal and reverse two divisions, primarily, what are they? First normal, this is a normal oblique-slip fault. What is happening? You can see that the hanging wall block which was initially with the footwall block, has moved here and the movement is in the downward direction vertically. Now, along with this downward movement, there is a movement in horizontal direction also i.e. in the direction of strike.

So, a small triangle is drawn over here where you see this component, this side of the triangle is nothing but the dip-slip component as you can understand, just now we have discussed dip-slip fault. So, this movement is what we see in case of dip-slip fault. So, dip-slip components similarly, this lateral movement is strike-slip component and this is moving in this direction.

So, this is nothing but the slip vector. So, it is normal for because the hanging block is actually coming down and this is also moving laterally in the left if you stand over the footwall block. Similarly, reverse-fault what will happen here, the diagram, it is like these now, these red arrows are showing the direction of movements.

So, there is lateral movement and there is some movement in upward direction also. So, upward movement we see when the nature of force is also compressive and the lateral movement has occurred because of the shear force. Anyway, this type of movement if we see, then this type of oblique-slip fault is called the reverse type.

Now, you can see the strike-slip component because of the lateral movement. This is my dip-slip component i.e. the vertical upward movement, which you see in case of reverse dip-slip fault and this is the slip vector. So, together it forms the reverse oblique-slip fault. So, these are some of the things that we should know.

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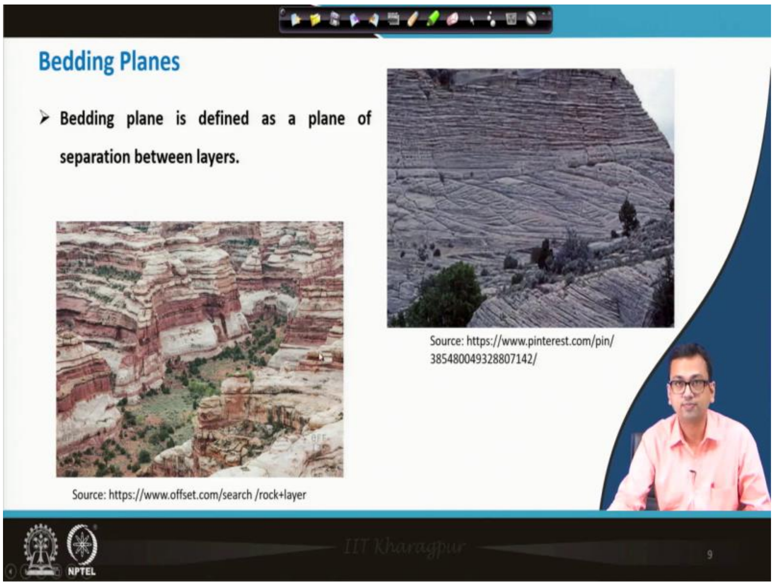

Now, now, another type of discontinuity is the bedding plane and all of us must have seen this type of discontinuity. So, what is bedding plane? Bedding plane is defined as a plane of separation between layers. Now, pictorially if we see, there are several layers, maybe the next picture will give you a better idea because the color contrast is there, you see this is a bedding plane, this is a bedding plane.

So, what it says that the bedding plane is defined as a plane of separation between layers. So, this is a layer and this layer and you see the plane of separation is here, this is the bedding plane, and it is a particular plane. So, you can see here one bedding plane and again here also, you can see another bedding plane distinctly.

Similarly here also you can see the bedding plane. So, the bedding plane is defined as a plane of separation between layers. So, it is very much clear here as we can clearly see a plane of separation.

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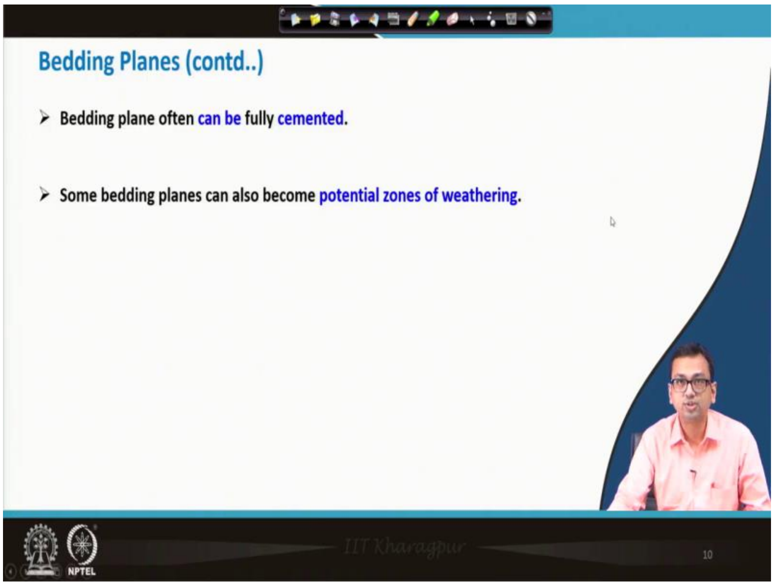

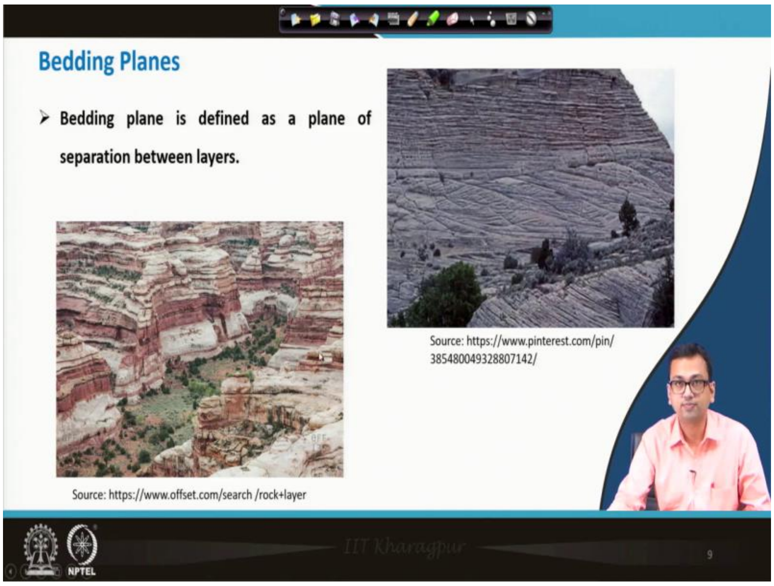

Now, regarding bedding plane, we can say that bedding planes often can be fully cemented. So, if that is fully cemented, then it is very good obviously, and also another problem we may see that is some bedding planes can become the potential zone of weathering, why I am telling this because if we go back to this figure, it may happen that maybe between two layers, there is a soil layer, which is not so strong.

So, as a result of that, it is very much susceptible to weathering, so what may happen between two layers some because of erosion, this portions may get eroded and ultimately that will affect the bedding plane in those regions. So, that is why it is stated here over here that some bedding planes can also become potential zones of weathering.

So, because of the nature of the material present if it is susceptible to erosion, then this may happen.

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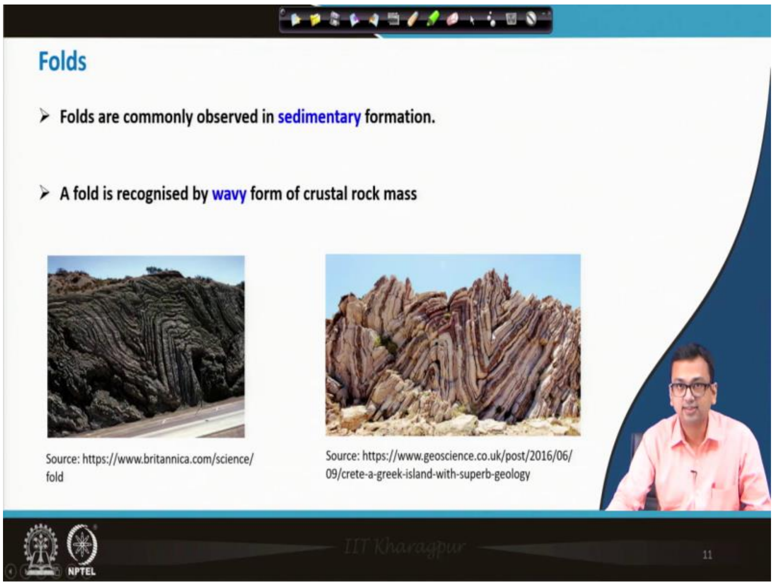

Now, next category of discontinuity is folds. Folds are commonly observed in sedimentary formation. So, how is it? You see the wavy pattern in the pictures. So, that is why, I have written over here that a fold is recognized by wavy form of crustal rock mass.

If you see this kind of natural formation obviously, we feel good as this is very nice, but obviously constructing anything over here from the engineering perspective that may be very difficult because full of discontinuities are there.

So, these are the folds and constructing anything over here is definitely difficult. Now, we will have a little discussion on the patterns of folds.

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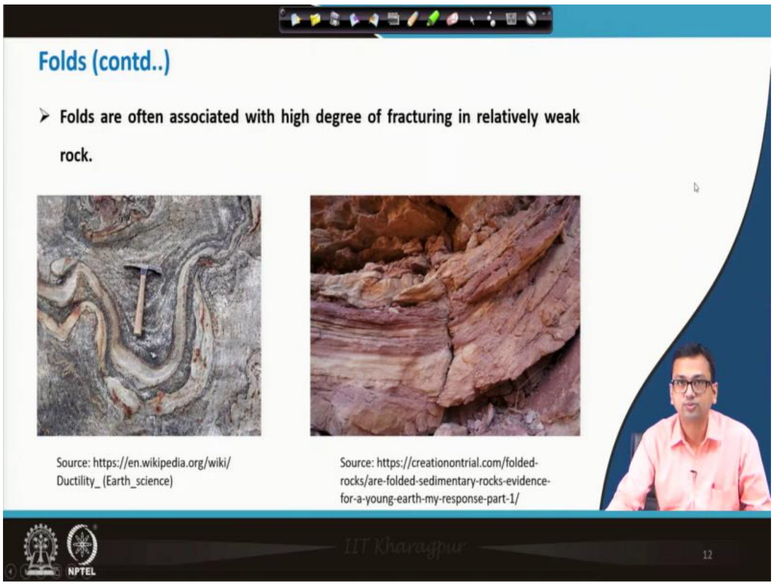

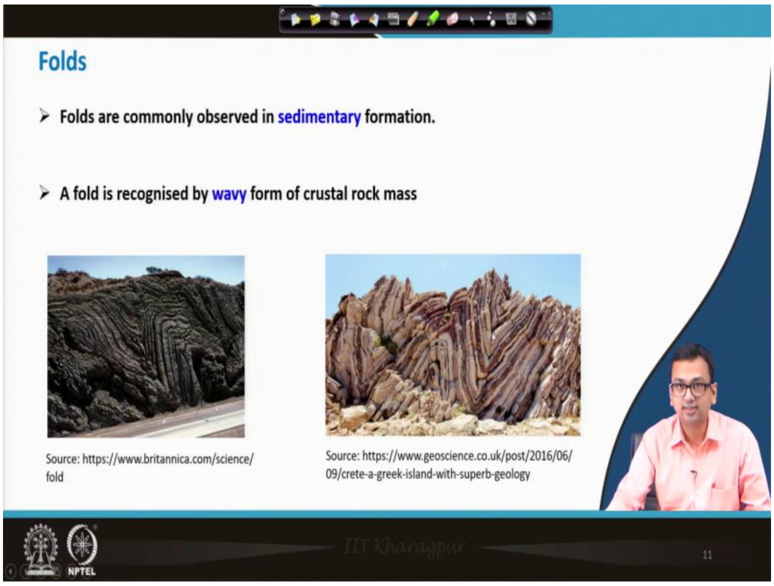

Before that, maybe we can say one point that is the folds are often associated with high degree of fracturing in relatively weak rock. Obviously, if the rock is weak, and if you see that this type of formation is developing, then obviously, there is a chance of developing cracks. So, you can see that the fracture is developing. So, folds are often associated with high degree of fracturing in relatively weak rock.

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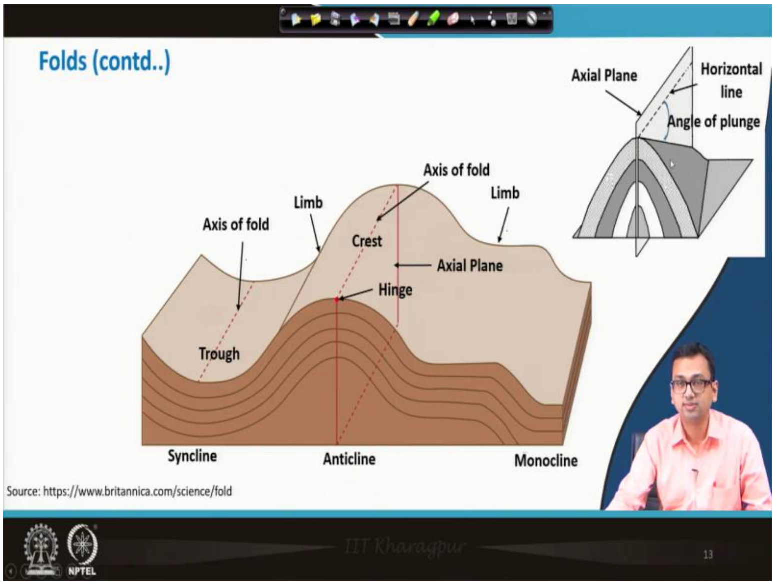

So, next is that we will discuss about the different components of a fold. So, if it is a typical diagram of a fold, so you can see this plane is called as the ‘Axial Plane’. This line is called the ‘Axis’ of the fold. Likewise, it is also the ‘Axis’ of the fold. For this pattern, the folds is concave upward; this is concave downward button for that. This is the ‘Axis’ of fold; this is also the ‘Axis’ of fold.

This is called the ‘Hinge’ of the fold, this is called the ‘Crest’ of the fold, this is the ‘Trough’ of the fold, and these are the ‘Limbs’ of the fold Now, this is called ‘Anticline’, when we see the pattern is like this where the folds are concave downward, this type of folds are called ‘Anticline’ and the opposite one when these patterns are like concave upward, then it is called a ‘Syncline’ and another one is the ‘Monocline’ where the folds are placed almost parallel.

Now few more things like from this diagram, you can see that if this is at some inclination, then this angle is called the ‘Angle of plunge’. Otherwise, these two are same, this is the horizontal line, this is the axis of the plane, but new thing is the ‘Angle of plunge’. So, this is another thing that we are seeing over here.

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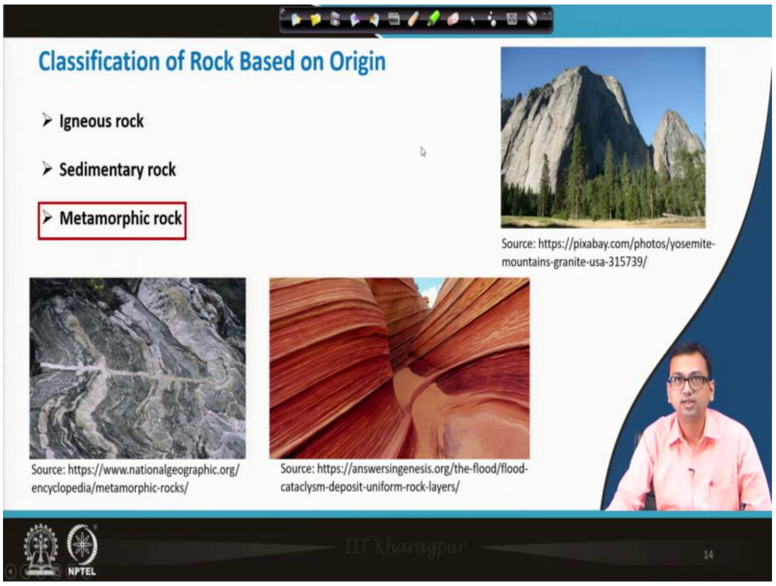

Now, with this we have finished our discussion related to this discontinuity, but truly speaking not finished. In the fifth lecture, I will again discuss about the discontinuities, we will discuss about a separate topic, which is very much related to discontinuities that we will do in our fifth lecture. So, today we are in the third lecture.

Now, we will spend some time on the classification of rock based on origin. So, that is known to you to some extent. So, rock can be classified in three categories based on its origin. What are they? They are igneous rock, sedimentary rock, and metamorphic rock. So, the igneous rock, this is the big mountain, very old mountain.

Then maybe the sedimentary rock like this kind of rock where you can see some of the deposition over there and it has become rock because of cementation. And this is the typical diagram of sedimentary rock. And, similarly this is a typical diagram of metamorphic rock. Now we will discuss these things in detail and try to explore it.

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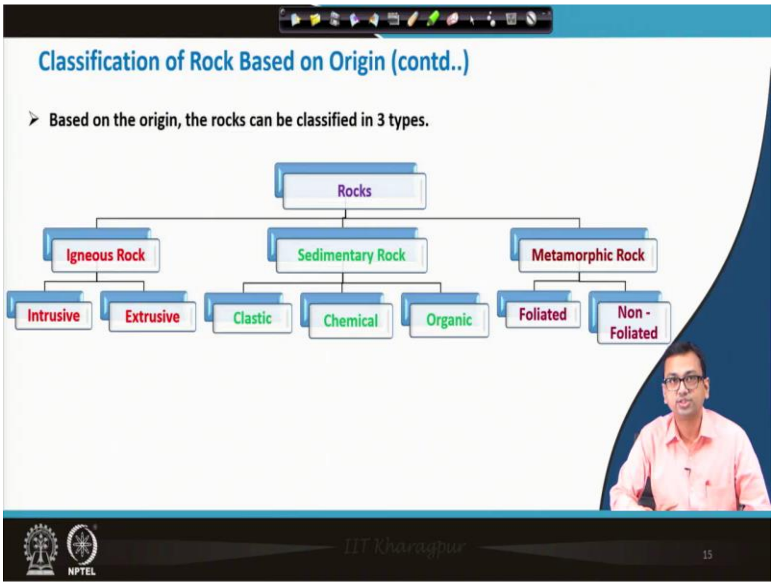

So, first is based on origin. Again same thing but what we will see over here that the igneous rock can be again divided into 2 categories; Intrusive and Extrusive. Similarly, sedimentary rock can also be divided into 3 categories; Clastic type, Chemical type, an Organic or Biological type sedimentary rock.

Similarly, metamorphic rock can have 2 categories; Foliated and Non-Foliated. So, I think with this let us stop here, we will continue our discussion in our next lecture that is in the lecture 4, with this detailed discussion about this classification of rock based on origin. Thank you.