Surface Mining Technology
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Lecture No. 01
Rocks Mineral and Ore

Let me welcome you to the first lecture of Surface Mining Technology. In this lecture, our lecture title is Rocks, Minerals, and Ore, which is basically a part of the introduction to surface mining. In our first week, we will cover the introduction to the surface mining part. In this, the first lecture is related to rocks, minerals, and ore, and this is basically related to the background. We have already introduced you to the subject.

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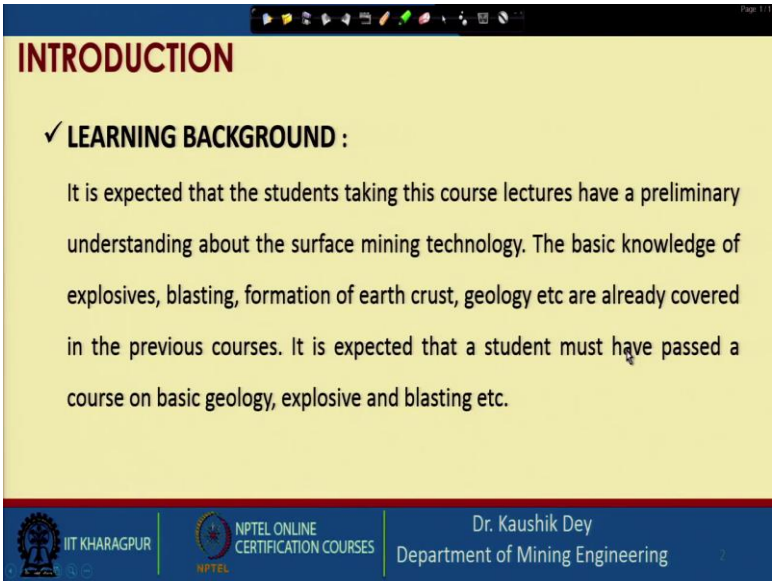

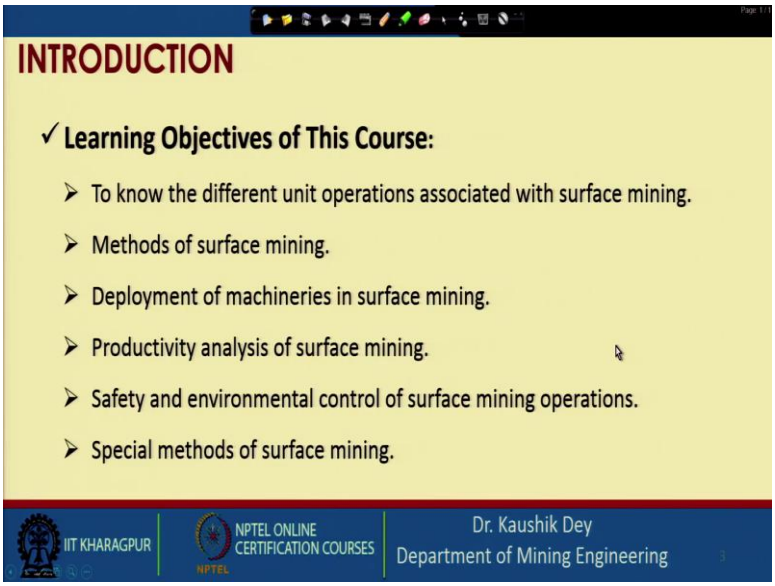

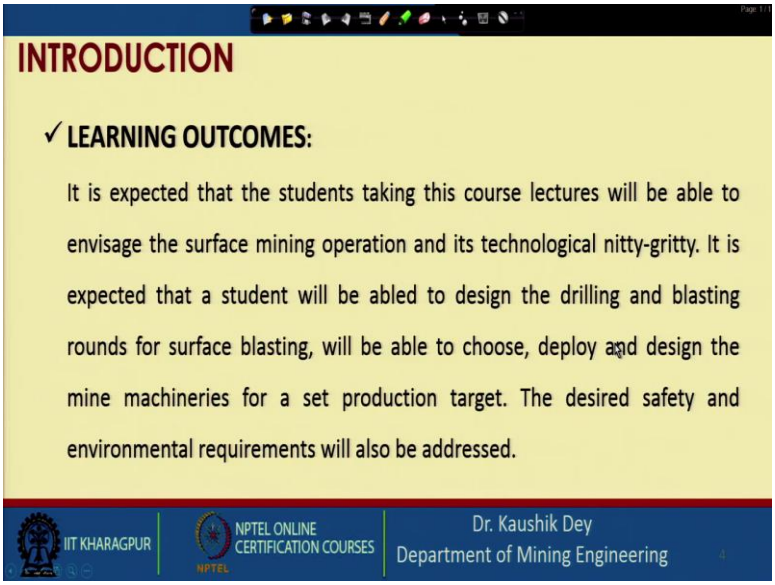

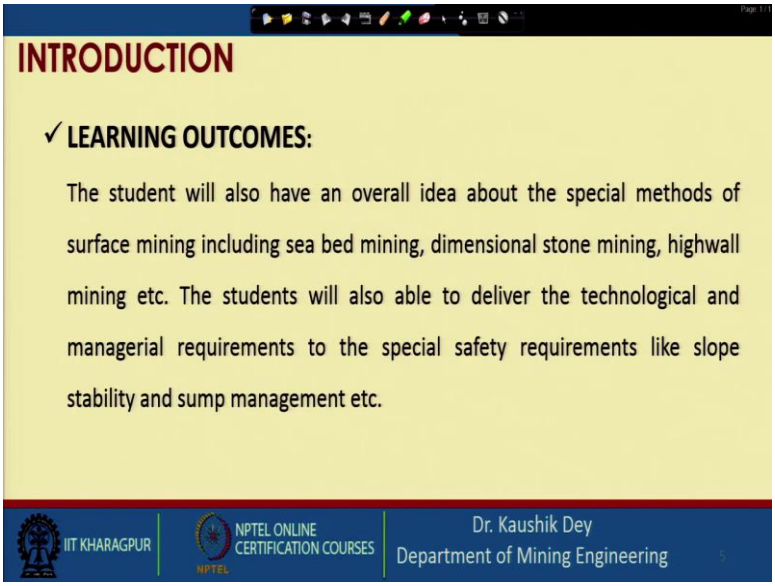

So, let us directly go to the objective of this lecture, this learning background for the course, learning objective of the course, learning outcomes of the course; these are already have discussed.

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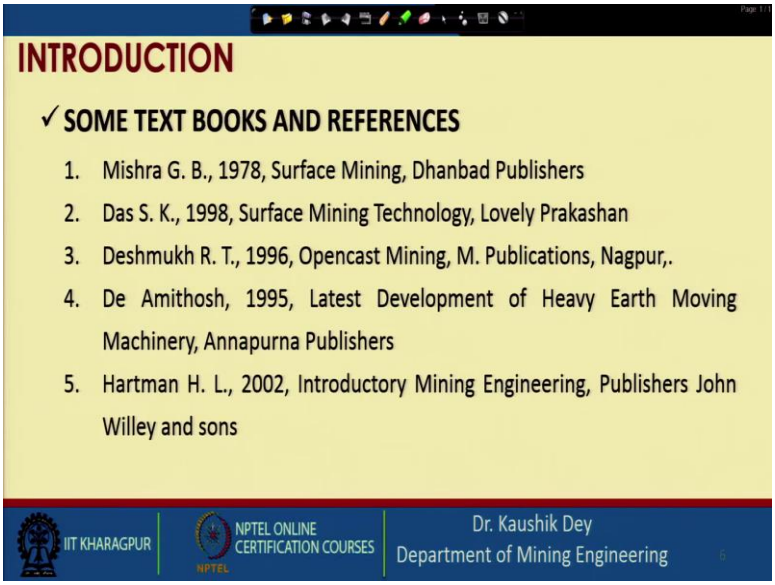

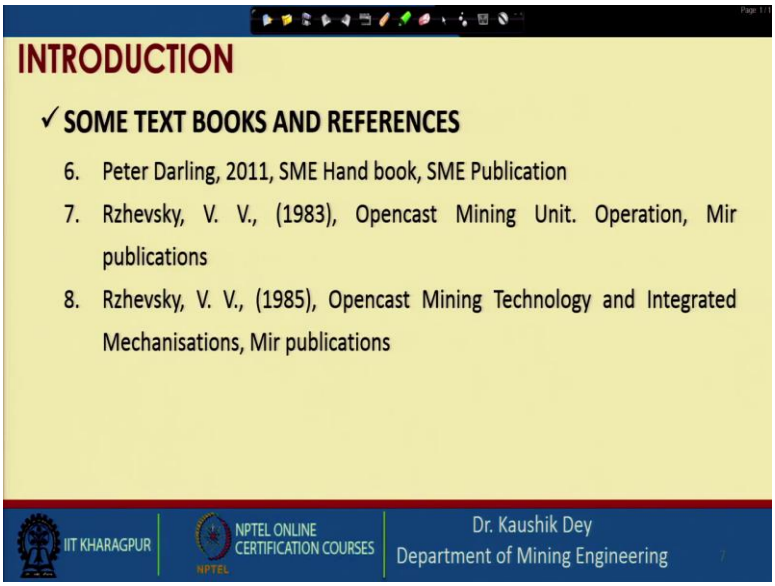

The textbooks and reference books are also discussed.

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And the learning objective of this lecture is to understand rock and rock mass discontinuity. In this case, let me give you the idea for a mining engineer, our rock and rock mass is basically the medium. So, the medium which we are trying to excavate is the rock and rock mass.

So, our perception related to rock and rock mass is different from the geologist. Geology people are interested to know the rock and rock mass for its other uses, but for the mining engineers, rock and rock mass is nothing but the medium and we are interested in the different properties of the medium and based on that we will decide how to excavate that one and what is its economic benefit.

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So, first is that mining is defined as the process of obtaining or excavating minerals or rocks or other valuable materials, either solid or in liquid form. So far, we have not discussed the gaseous form of mining, but it may be in the future that may come. So, petroleum excavation can be termed oil mining, and in some cases also water mining is also possible. In fact, there are few instances where water is considered as a very, very precious and valuable material and has significant economic value.

But otherwise, mining is mainly related to the solid excavation system, excavation of the solids, and obviously, you remember that mining is carried out for a business purpose. So, we will carry out mining if it is profitable only. So, mining with a profit is a very, very important aspect. If profit is not there, mining should not be carried out. There are some cases where strategic mining is carried out, like, say atomic minerals etcetera which is required for other cases but does not have any commercial value.

In those cases, strategic mining is also carried out, but otherwise, mining is carried out for having some profit. In some other cases, excavation is carried out related to civil projects, etcetera. The method of excavation remains the same, or you can say similar with the mining system, but the purpose is different in those cases. In fact, we have more than 4000 naturally occurring minerals. These minerals are basically inorganic solids that have characteristics, chemical compositions, and specific crystal structures, and these minerals are found naturally in the earth's crust.

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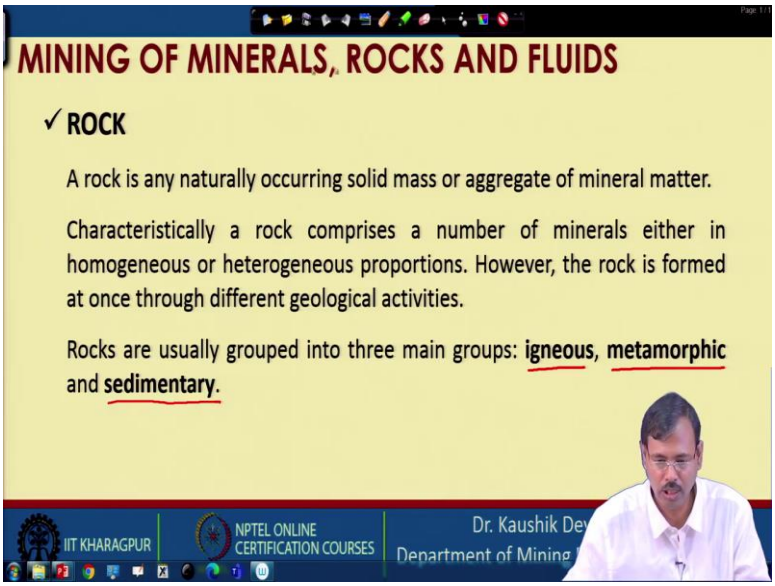

And you can define a rock as any naturally occurring solid mass or aggregate of mineral matters. So basically, the earth is formed by the rock, and rock has naturally occurred. It is a

solid, and rock comprises a number of mineral matter. Characteristically a rock comprises a number of minerals, either in homogeneous or in heterogeneous proportion. However, rock is formed at once through different geological activities.

So, the rock is understood as the occurrence of the rock occurred at once, and different rocks may have different occurrences, or there may be the simultaneous occurrence of the different rocks are also possible. Rocks are commonly having ingredients that are basically mineral matters and mineral matters are having their definite chemical compositions.

Rocks are usually grouped into three main groups depending on its, depending on its origin, one is igneous, another is metamorphic, and another is sedimentary. In our next slide, we will understand how this process is going on.

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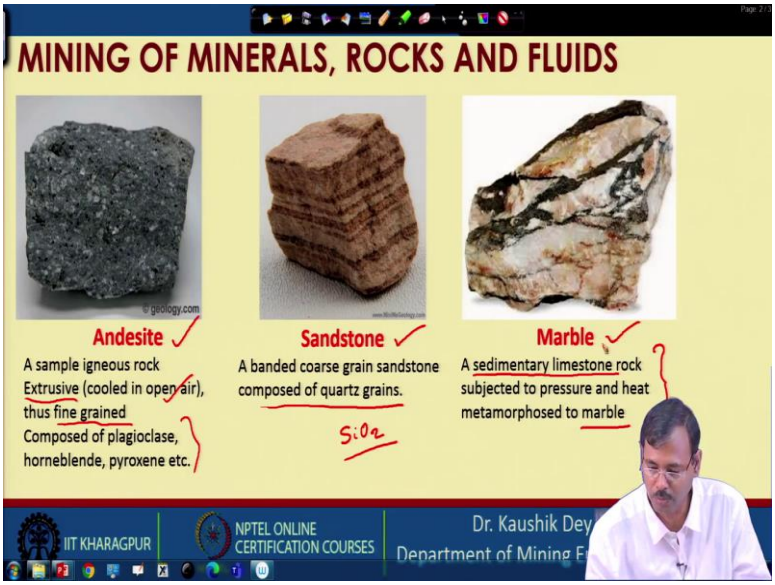

So, first, let us have the example of three types of these rocks. One is, first one is the andesite is an example of the igneous rock, and you understand that igneous rocks are basically the volcanic products. When the volcanic magma or lava is coming out, and it is cooled down, and formed rock is called igneous rock.

And this happens in the extrusive condition where it is cooled in the open air, and if it is cooled in the open air, it becomes fine-grained, and this is the composition of this particular rock. In the case of sedimentary rock, which is basically formed from the igneous or metamorphic rock on their erosion and then the compaction under pressure is formed, whether the sedimentary rock. So, this is the sandstone rock. This sandstone rock is a sedimentary rock and basically composed of quartz grain which is nothing but silicon oxide.

And marble is considered a metamorphic rock. Metamorphic rocks are basically the sedimentary or igneous rock, further subjected to heat or pressure or maybe some magnetic contact and by that pressure, heat because of these activities, their chemical compositions are changed, often the crystal structures are changed, and in those cases, it is called metamorphic rock and marble is basically a metaphor for sedimentary limestone which is metamorphosed to become the marble.

So, the composition of the limestone and marble is more or less the same, but the crystal structure is different, and that is why marble is characterized as a different material.

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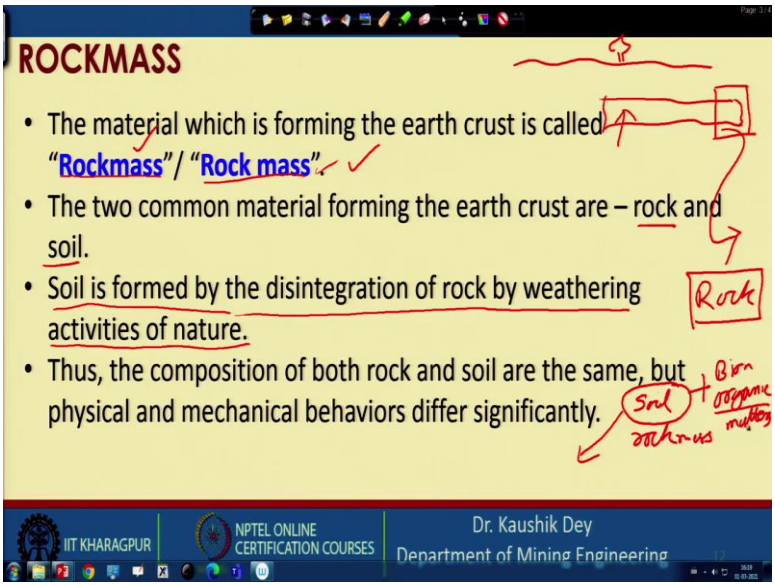

Now, let us have some idea about the rock mass. We have already discussed rock; the difference between rock and rock mass is that rock mass is considered when the rock is under in-situ condition. So, suppose this is the earth's surface, and there is a rock layer here. So, if this rock layer is here and you have taken a cut piece, you have taken out this cut piece, and you are now considering its properties, then it is called rock.

But when the rock is inside the earth, it is called rock mass that means when the material which is forming the earth's crust is basically rock mass. I have mentioned the two letters here, often rock mass is shown as a single letter and often a single word, and often it can be shown as a double word.

So, the two common materials forming the earth's crust are rock and soil, and when the rock is inside the earth's crust, it is called rock mass. Soil is basically formed by the disintegration of the rock by weathering activities of nature. Thus, the composition of the soil and rock

remains the same, but as the soil is allowing the growth of the vegetations, so most of the time, the soil is added with the different biomass or the organic matters, biomass or the organic matters.

So, these are the characteristics of the soil. Otherwise, rock is situated in the earth's crust as a rock mass. When it is located in the earth's crust, it is associated with different types of discontinuities.

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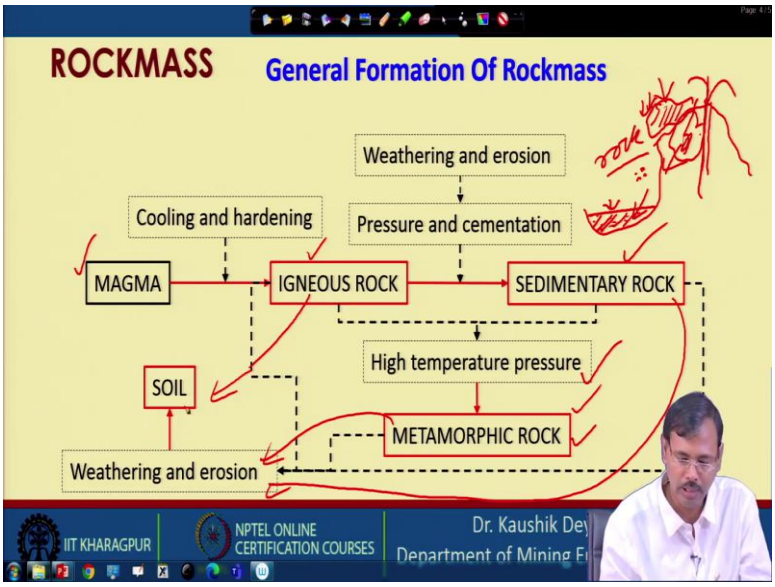

But before that, let us understand the general formation of the rock mass. Rock mass is basically coming out from the magma, or you can say, cooling of the earth gradually allows the formation of the magma, and this magma is cooled and hardened and formed the igneous rock. So, when the volcanic eruption occurs, when the volcanic eruption occurs, whatever magma is deposited at this place, with the cooling of the same, it becomes rock, and this rock is called igneous rock.

But igneous rock is subjected to pressure, cementation weathering erosions. So, this rock with the air and water forms the different grains and in a valley, these grains are basically deposited, then these are subjected to pressure because of the burial of the sand and cementation occurs here and by this, it is gradually again become a rock, and that rock is called sedimentary rock.

Now, this igneous and sedimentary rock, often they are subjected to high temperature and pressure and deform to metamorphic rocks like this is limestone when it comes under heavy pressure and the temperature changes that form to the marble. Similarly, when already

existing igneous rocks are available here, but again further volcanic eruptions occur, then because of this heat pressure, this may be changed, or this may be metamorphosed and become the metamorphic rock.

And all these three rocks, all these three rocks are subjected to weathering and erosion, and they form the soil, then the vegetation growth occurs in the soil, and gradually that is added with the biomass.

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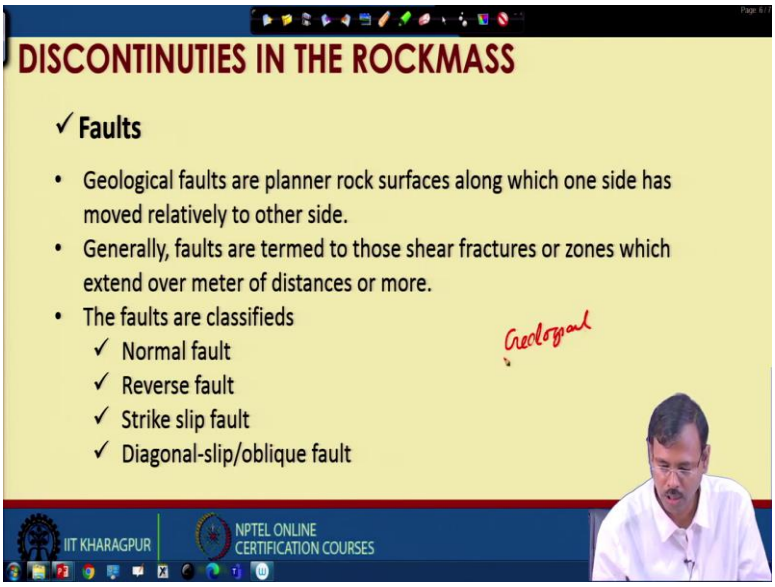

Now, when the rock we have already discussed, when the rock is under the, inside the in-situ condition, inside the earth that is having natural cracks, formation cracks, there are different discontinuities you can observe in the rock mass. So, we will discuss a few of the discontinuities in this place.

The first discontinuity which is observed in the rock mass is called a fault. So, the first discontinuity is the fault. So, geological faults are the planner rock surfaces along which one side has moved relative to the other side. So, the faults are associated, faults are associated with the little bit movement of the rock positions, rock mass positions, and these are the different types of faults, normal fault, reverse fault, strike-slip fault, diagonal fault, or oblique fault.

So, it is better that we look into the picture, and from that, it is easy to understand. But here I would like to mention that you will find out on the website, there is a group, geological group you will find out different geological related issues are being discussed there and good geological examples are also available in this groups.

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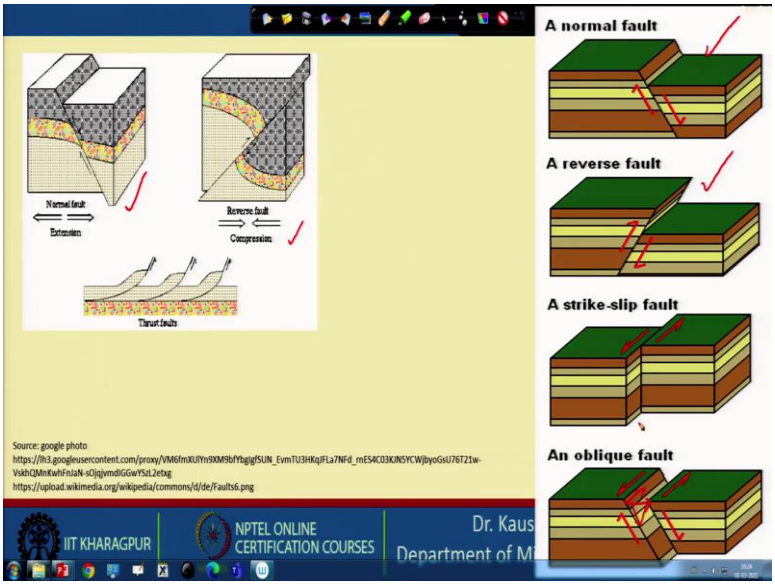

So, now, let us see the fault. This is called a normal fault. This is called reverse fault, which means when the fault is creating an overhanging situation, that is called a reverse fault. So, this is a normal fault. This is a reverse fault. This is a strike-slip fault where the movement occurs along the strike direction, and when both the dip and strike both directions when the movement occurs, then that is called the oblique fault or diagonal fault.

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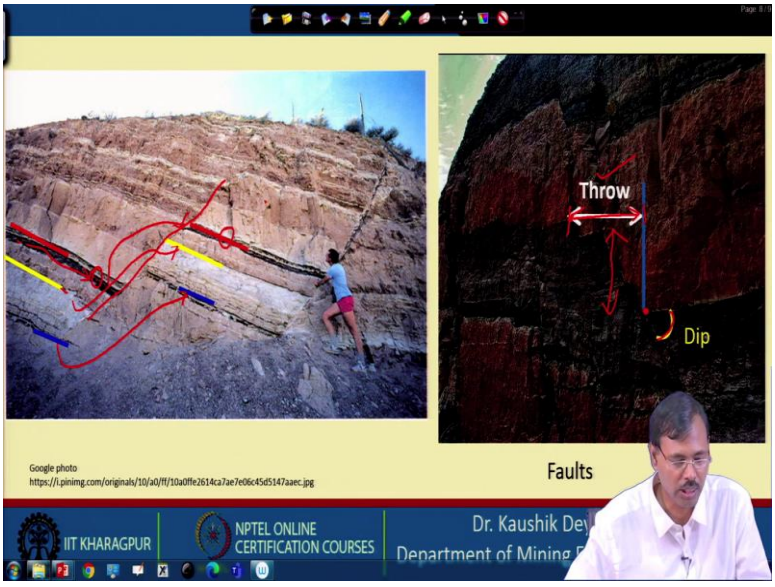

So, in this figure, I am trying to show you that say this is the main you say it is a coal seam say or maybe a small material of some carbon or maybe the cell, but this is the fault plane, you can see, this is the fault plane, this fault plane is allowing the movement of this at this position. So, it is moved to this position. Similarly, this point is moved to this position. This

point is moved to this position. So, this is called throw of the fault. You can see here this is called throw of the fault.

So, this position is basically sifted at this position. So, this is the horizontal throw, and this is the verticals. So, these are the characteristics of the fault. Generally, a fault is defined with this angle and the throw. If we consider it is the coal seam now, the coal seam is sifted at this position. So, there is a sifting of the mineral origin source occurs, and that is why these features are very, very important, and one must note about these features.

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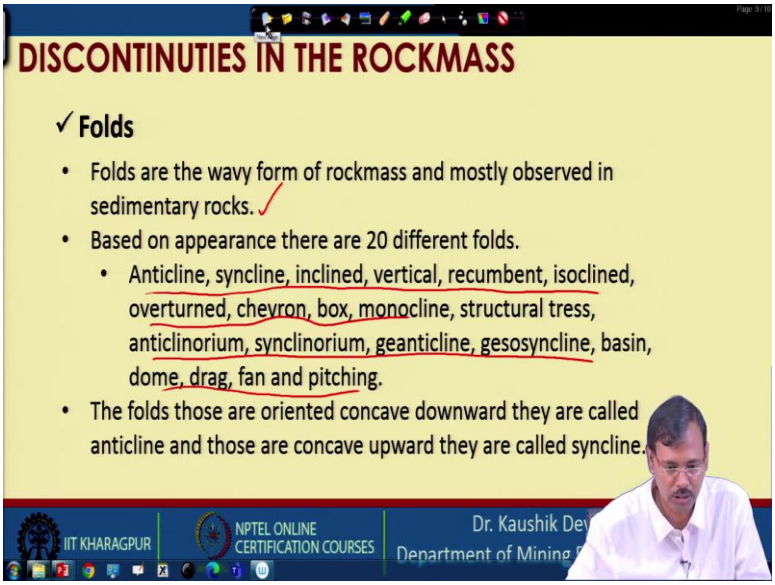

The next is discontinuities fold, folds are a wavy form of rock mass and mostly observed in the sedimentary formations. Based on the appearances there are different types of folds are observed. We need not go into the details of this, but this is the list of these different types of folds, but we must look into the beautiful pictures of the folds.

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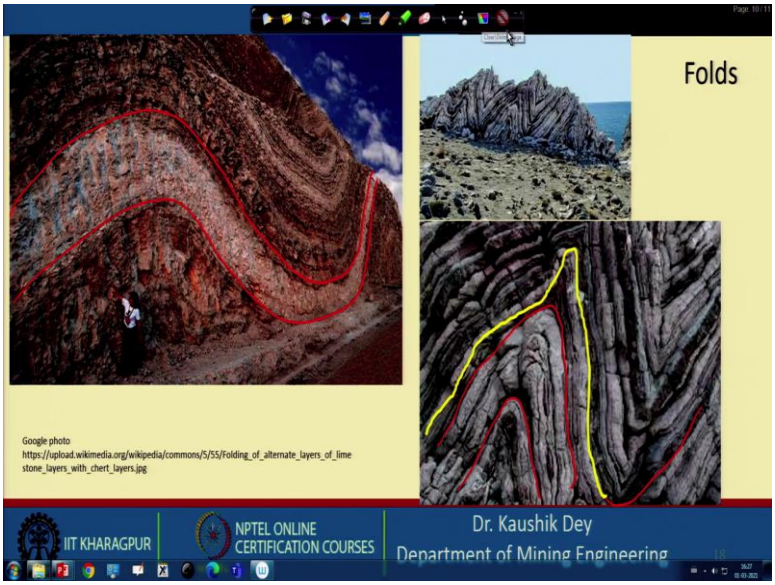

You can see these are the faults, how it is moving in a wavy direction. This is a beautiful picture of Turkey; you can see how this complex fold occurs in this place. This is the full picture; this is the enlarged picture of the above. So, this is a beautiful fold you can see here.

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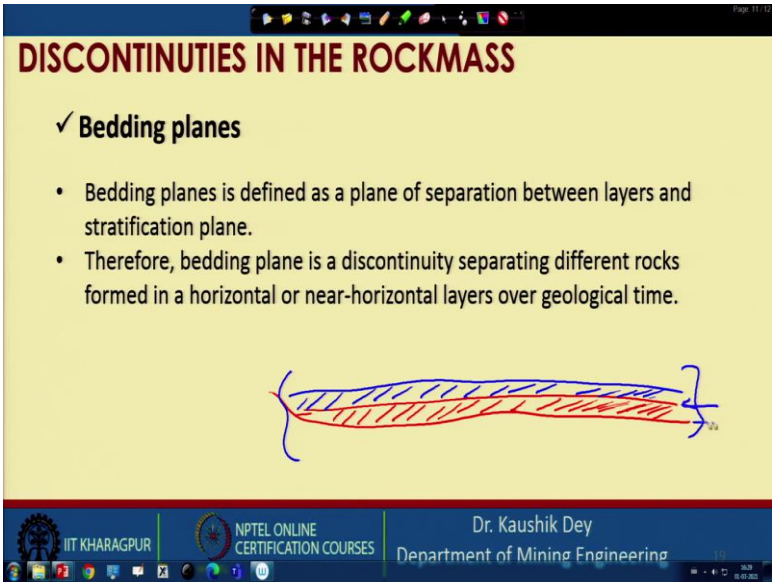

Bedding planes are defined as a plane of separation between the layers and stratification of the plane. Generally, it occurs as this suppose, you consider the erosion occurs, and the erosions are deposited, erosions are deposited as a layer here. So, first depositions occur, so as it is transported by the water. So, it is deposited like the here, say you can say as you see the deposition of sand in the riverbed.

Similarly, the next time again the further deposition occurs that is again forming another layer here. So, when they are converted to a sedimentary rock with the cementation pressure and cementation. Then these layers, each layer are found prominent infrastructures. These are called bedding planes, and mostly it is observed in the sedimentary deposits.

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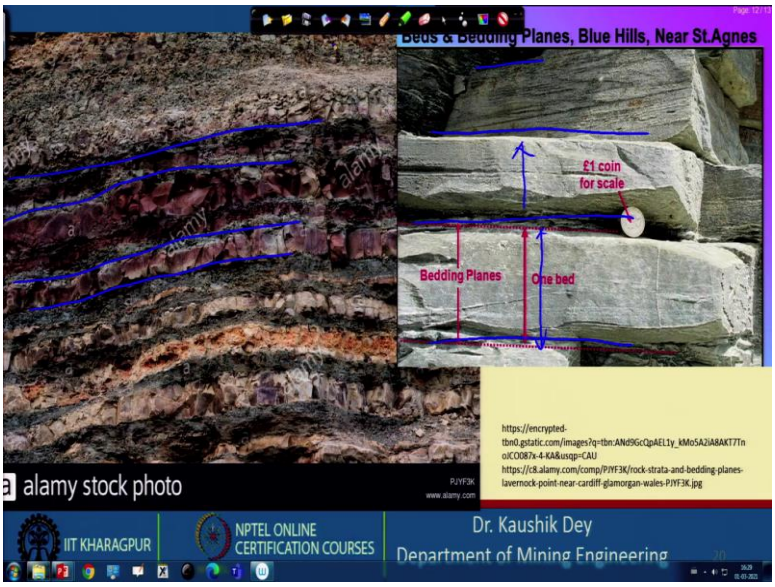

So, you can see this is the one bed. This is another bed. So, these are considered bedding planes. So, these are considered bedding planes. Similarly, you can see this is the one bed. This is another bed. This is another bed. So, these are the different beds that are formed because their origin time is different.

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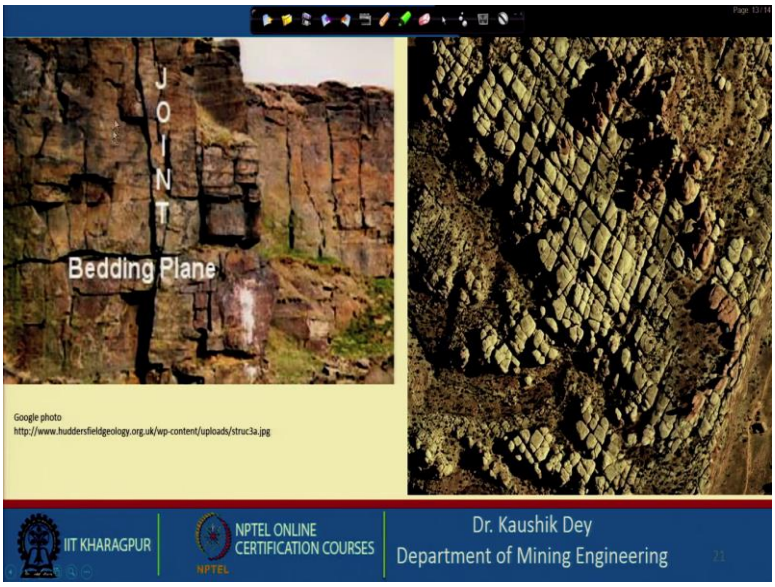

There are different bedding planes, maybe in the other directions also.

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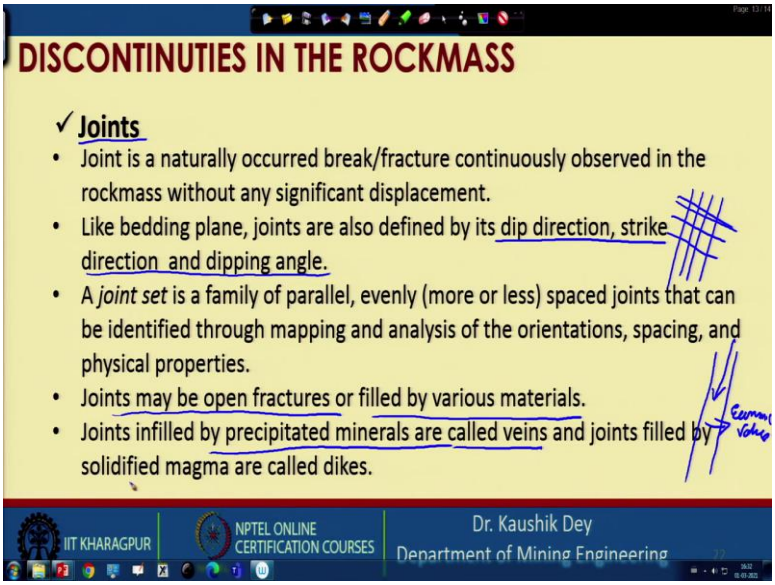

And the next one, which is very, very important discontinuity, is called a joint. Joint is a naturally occurring break or fracture, and it is continuously observed in the rock mass without any significant displacement. If a prominent joint plane is found displaced, it can be termed as a fault or maybe the local fault. But if there is no displacement, similar continuous other joints are also available, then it is called joint, or it is the main discontinuity plane in the rock mass.

Joints are also like bedding planes defined by their dip, dip direction, strike direction, and dipping angle. Joints are found in the set, which means a family of parallel joints is observed, it may be in a number of joints may be observed in different places in the same places, and their spacing is more or less evenly distributed, and they can be mapped accordingly.

Joint this fractures may be open or may be filled with other material or may not be filled, but a tight joint is also found where only cracking is found. In the field by precipitated minerals are also called veins; when two joints are filled with some precipitated minerals, but these minerals have some economic value called veins, and sometimes these are very, very important, and if it is filled by solidified magma, then it is called a dike.

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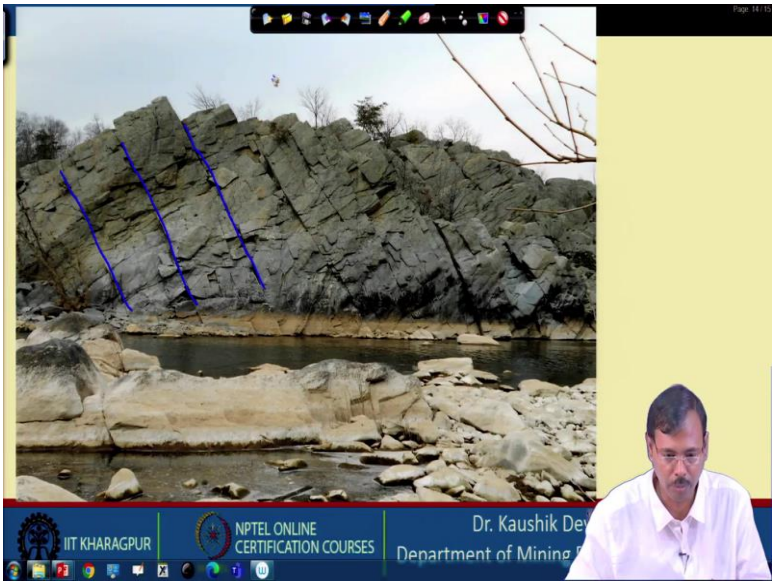

Now, in this picture, let us show you some joints. You can see these are the joints. let us have another picture of this is also available in the next slide. Let us look into that.

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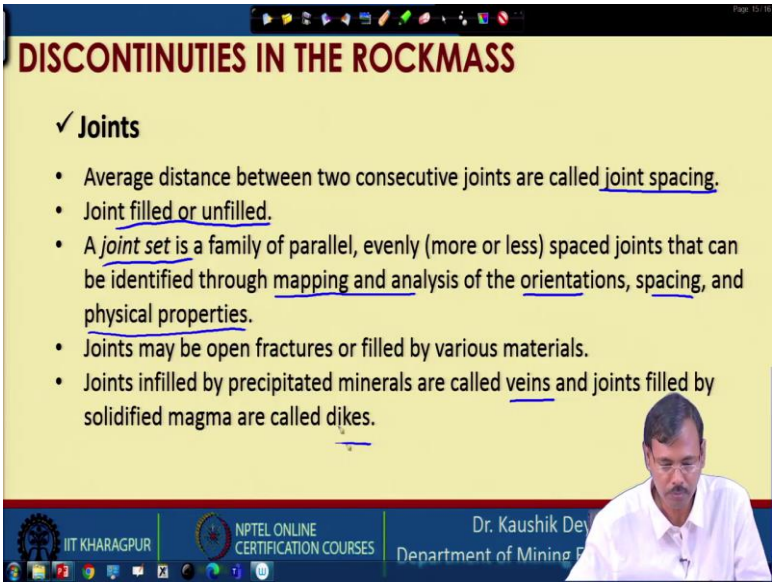

But before that, let us understand how to define a joint. A joint can be defined by the joint spacing, the joint can be defined whether the joint is filled or unfilled, the joint set is a family of joints more or less evenly distributed, and their mapping can be carried out. They are orientation spacing, and physical properties should be given, and this is already discussed; it is called vein and dike.

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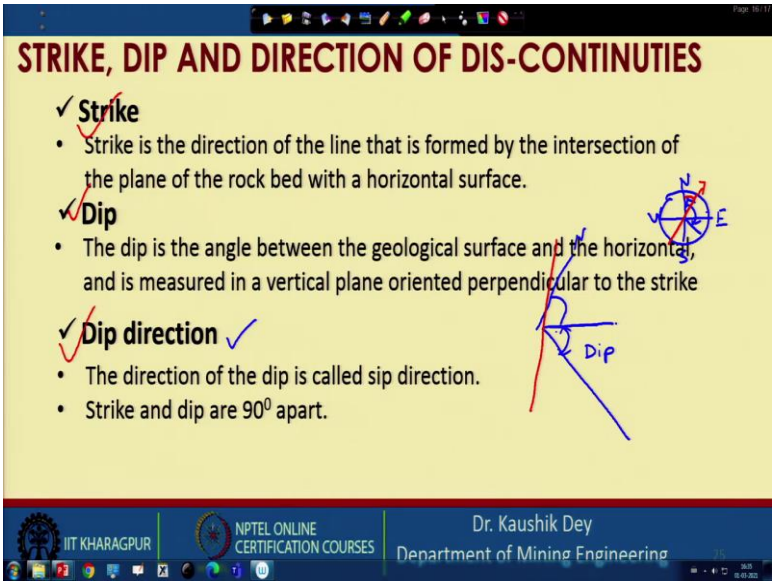

Joint, a joint is described by the dip; this is called dip angle or dip. The direction of the dip if you are considering in a plane it is North, south, east, west, then this direction, this direction is at which direction if it is this direction then this is called the direction of the dip. So, this direction means this angle of this with respect to North; this angle is called dip direction and perpendicular to that.

If this is the dip direction, then perpendicular to this, this is the strike direction. So, the perpendicular to this, this is, in this case, it is the strike direction. So, this direction is called strike direction. So, a joint can be defined by the dip angle, dip direction, and strike direction. We will understand this in the next slide with a good picture.

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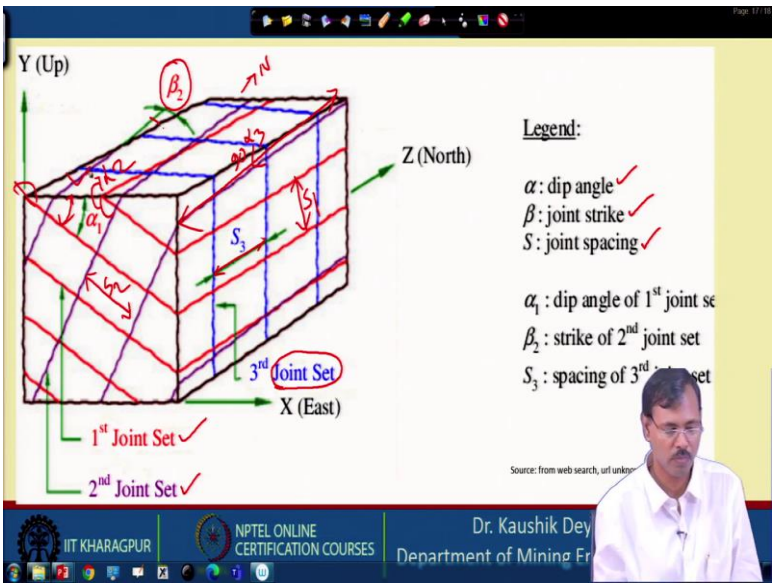

So, now, you can understand the dip angle is α, strike direction is β and joint spacing is S. Now, if you are considering this blue line, let me show the blue line, the spacing between the blue line, the blue line is considered as the third set joint. This is the third set joint So, this spacing S_3 is the spacing for the third set joint, the purple colour is the second set joint, and the red colour is the first set joint.

So, for the first set joint, the dip angle is shown. So, dip angles are shown here for the first set joint here; for this third set joint, the deep angle is 90 degrees, because this is perpendicularly cutting the rock mass So, it is 90 degrees. For the second set joint, this is the dip angle, this purple colour. This is the dip angle. This is for α_2, this is 90 degrees, this is 90 degrees α_3, and this is α_1 for the first set joint.

Similarly, you can see the S_3 for the third set joint. This is an S_1 for the first set joint, and this is S_2 for the second set joint, and as this is the dip angle obviously, this is the strike direction, direction of this one is expressed with the, if this is considered as the North, then the angle between this is called the strike angle for the second one. For the first one, this will be the strike angle, and for the third one, it is again this is the strike angle is perpendicular to this strike angle.

So, this is the way we can define, this is the way we can define the different joint sets, and a rock mass may have n number of joint sets you can see in this case the same rock mass has three set joints, one is of red colour, first set, purple colour second set, blue colour third set.

So, similarly, you may have more number of joint sets also, whatever if you are having another joint set like this that can also be possible. So, that will be the fourth set joint. So, like that way, n number of joint sets are possible in a rock mass, there is no limitation on the number of joint sets.

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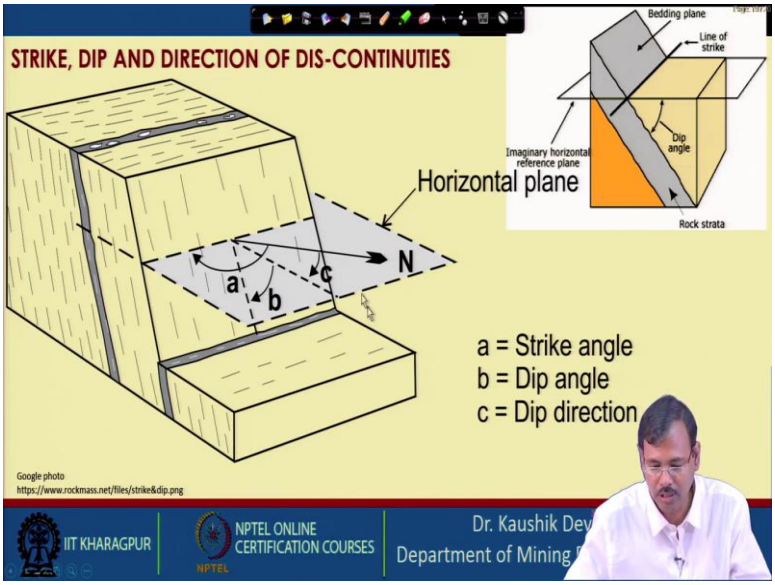

So, this is another picture of where you can understand; this is which one is the strike angle, you can understand this is a is the strike angle, if this is the North, this is the strike direction angle from that North is the strike angle. Then, this dip angle is the b, if this is the horizontal expose of the dip, then the angle with that in the North is called dip angle, with the horizontal, the angle of dip is the dip angle and dip directs angle is from the North, what is the dispersion of the horizontal component of the dip is that angle is called dip direction angle.

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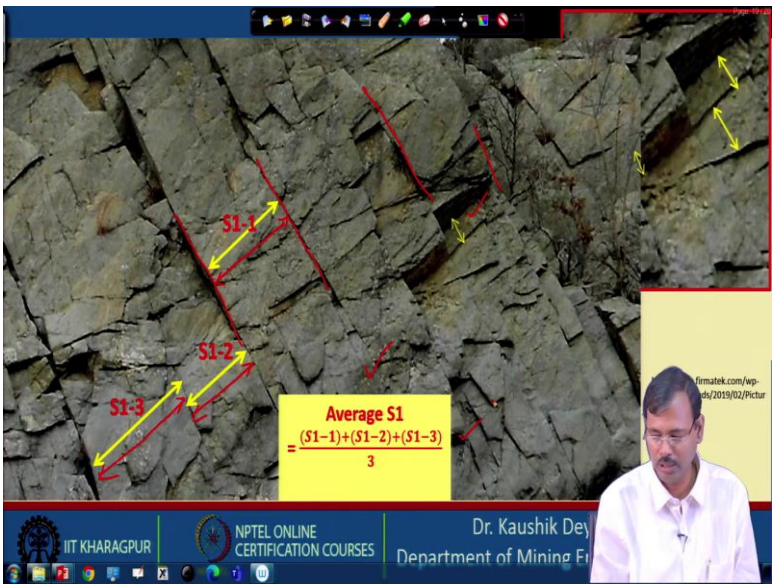

So, in this case, you can see the spacing. So, this is the picture we have seen earlier. So, in this picture, you can see, these are the joint sets, and this is S1, this is S2. So, we are not

discussing S2. So, if you have joint sets like this, this is more or less regular, but it is not that always say these have the same value of spacing. So, you may have spacing like this.

So, the average spacing you have to compute of the average joint spacing you have to compute taking the average of the different measured spacing. Similarly, you can carry it out for the other joint sets also. This is the second joint set. So, this is the way you can carry out and calculate the joint spacings.

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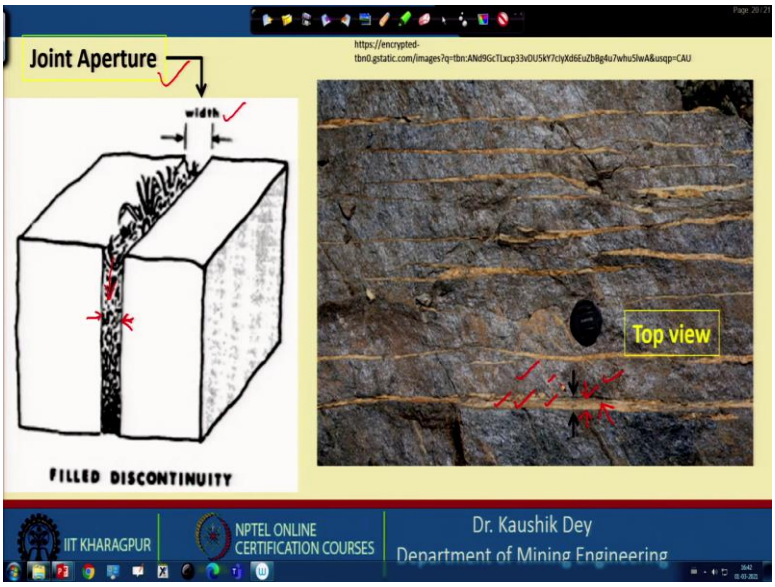

Often, people have some doubts related to the joint aperture. A joint aperture is basically the crack of the joint. So, these cracks may be tight, almost there is almost no difference between these or sometimes it is filled or unfilled. So, this is called the width of the joint or maybe the joint aperture. So, joint aperture and joint spacings are different. You can see in this picture, this is the joint aperture or joint width and that is filled with this material.

You remember one thing that is no relationship between this filling material. This rock and this material are different. This may be the same or different. Their strength properties, there are other things whichever it is, they are having as per their independent criteria. So, it may be possible your rock is weak, but the filling material is more strong, or your rock may be strong filling material may be weak.

So, this is very, very important and this aspect must be considered, while you are considering the joint. So, this is more or less about the rock and rock different discontinuities, which we have discussed today. I think this will give you a brief understanding about the rock and rock mass properties. So, let us complete this class at this point. Thank you.