Rock Mechanics and Tunneling
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Lecture No. 04
Classification of rock based on origin (continued)

Hello everyone, I welcome all of you to the fourth lecture of rock mechanics and tunneling. So, in our previous class, we have just started discussing the classification of rock mass based on origin. So, today we will discuss this topic in detail.

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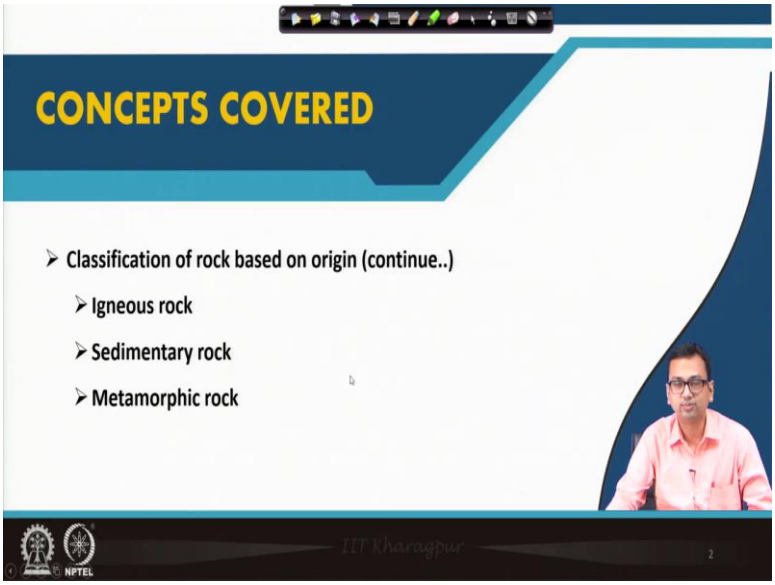

So, we will continue our discussion on igneous rock, sedimentary rock and metamorphic rock in detail. And at the end, we will also discuss the rock cycle and the geological process of forming rock.

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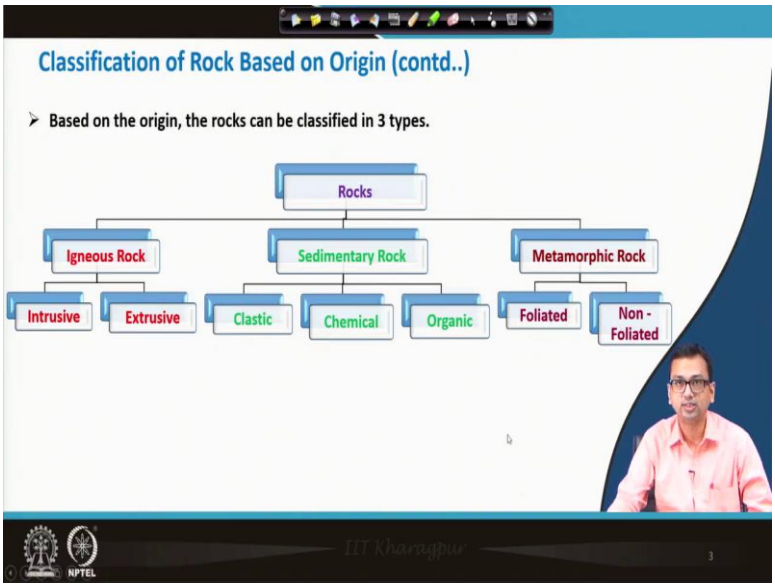

So, the classification based on origin is illustrated in this diagram which I have shown you in the previous class. It is just a quick revision. Igneous rock can be divided into two categories; intrusive type of igneous rock and extrusive type of igneous rock. Then sedimentary rock can have three different types; plastic, chemical, and organic. And the third category of rock is the metamorphic rock which can have two categories; foliated and non-foliated.

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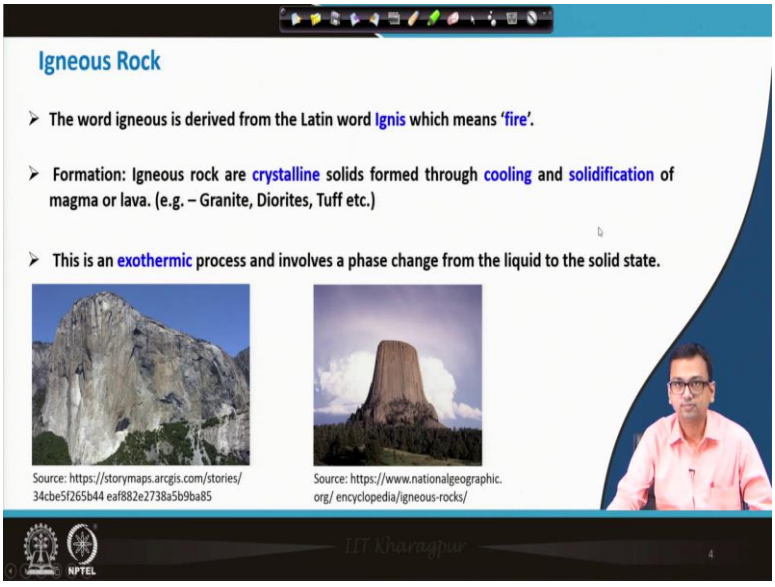

So, first one is the igneous rock. So, this word 'Igneous' is derived basically from the Latin word 'Ignis', which means 'fire' and how it forms, the formation: if we want to discuss that we can say 'igneous rocks are crystalline solids formed through cooling and solidification of

magma or lava'. As you know magma or lava is there, inside the earth surface and sometimes it comes out and once it cools down and solidifies, it forms the igneous rock.

So, igneous rocks are crystalline solids formed through cooling and solidification of magma or lava. So, well known examples of igneous rocks are, granite, diorite and tuff, etcetera. There are several that we will discuss also. Now, this is an exothermic process, the magma actually cools down in this process.

So, this is an exothermic process and involves a phase change from the liquid state to solid state. So magma or lava converts into solid material. So, this is a big mountain, an old mountain, which is basically made of igneous rock.

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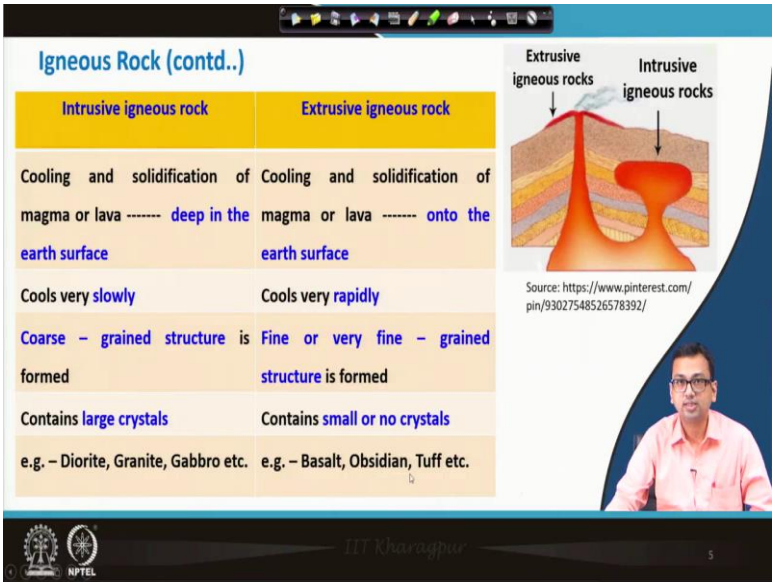

Next, as I have stated, at the very beginning, there are two types of igneous rock; intrusive igneous rock and extrusive igneous rock. So, you can see here in this diagram indicating the intrusive igneous rock and the extrusive igneous rock. So, why it is like this? Let us try to understand what is written over here.

In case of intrusive igneous rock, as the name also suggests, cooling and solidification of magma lava happen where? Deep in the earth surface, so the cooling and solidification is happening inside the earth's surface. So, that is why it is called the intrusive igneous rock. Whereas, the cooling and solidification of magma or lava is happened over the ground surface i.e. onto the Earth's surface, then it is called the extrusive igneous rock.

Now, since the outside means onto the Earth surface, so, obviously, it cools very rapidly, this extrusive rock cools rapidly as expected because it is coming with the contact of air and as a

result it cools down rapidly; whereas, the intrusive one cools very slowly as it is inside the earth surface.

So, intrusive rock cools down slowly, extrusive cools down very rapidly. Another thing is for intrusive igneous rock is that generally coarse grained structures are formed in case of the intrusive type of igneous rock. Whereas, in case of extrusive igneous rock, fine or very fine grained structure is formed.

Another difference is that intrusive igneous rock contains large crystals; whereas, extrusive igneous rock contains small or no crystals. Some of the examples of intrusive igneous rocks are diorite, granite, and gabbro; and the extrusive igneous rocks are basalt, obsidian, tuff etcetera. So, this picture is very clearly indicating the differences.

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Now, I will show you few typical pictures of common igneous rocks how they look like. Diorite will look like this, and these are the typical pictures of gabbro, granite, obsidian, basalt and tuff. So, they are quite different from each other. So, these are some typical pictures of common igneous rocks.

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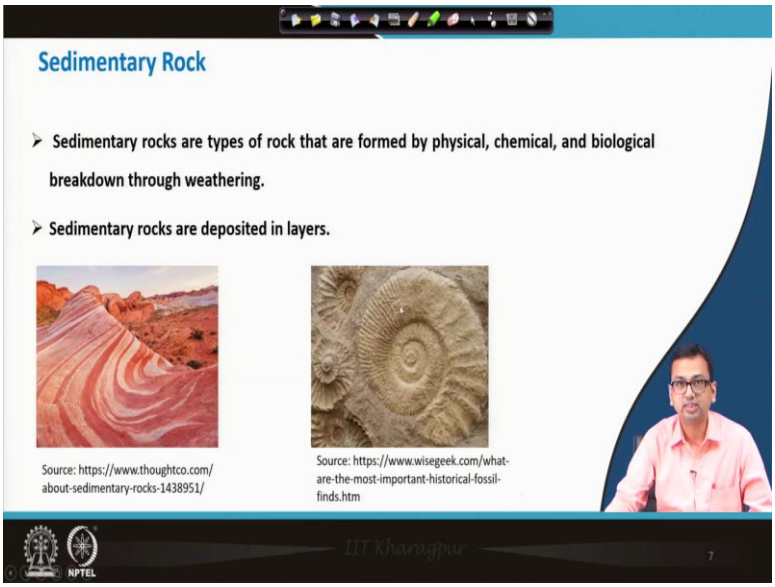

Now, let us discuss the sedimentary rock. So, these sedimentary rocks are a type of rocks that are formed by physical, chemical and biological breakdown through weathering. And sedimentary rocks are deposited in layers.

We will see one nice diagram from where the idea will be clear. Here you can see that the layer deposition is there and over the year because of compaction and cementation this type of structure means rock structure has been developed; this is nothing but a sedimentary rock deposit. This is also a sedimentary rock deposit where you can notice a particular pattern.

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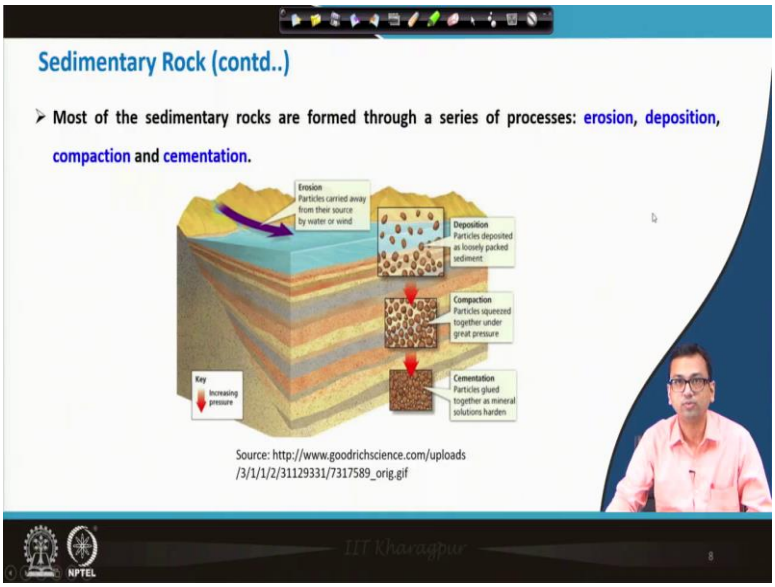

Anyway, let us try to understand the mechanism how it forms. So, most of the sedimentary rocks are formed through a series of processes - erosion deposition, compaction and

cementation. The four steps are there erosion, deposition, compaction and cementation. Let us understand what are they? So, from this diagram, you can clearly see that here it is written ‘erosion’.

Now, particles are carried away from their source by water or wind. Then what happens; second thing is deposition. So, here is the deposition, particles deposited as loosely packed sediment. So, first they are deposited as loosely packed sediment. Then third one is the compaction.

So, what happens here? You can see form the diagram that they are quite compacted. So, what we can say that the particles are squeezed together under great pressure. And finally, the cementation, you can see, they are cemented, the particles are almost glued together. So, this is the four-step process i.e. erosion, deposition, compaction and cementation through which the sedimentary rocks are generally formed.

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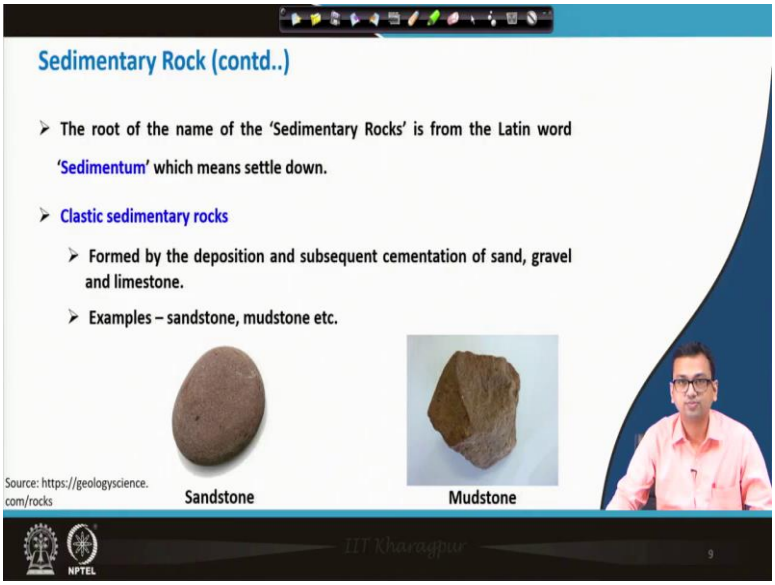

Now, again let us understand what is the source of this term? So, the root of the name of the sedimentary rock is from the Latin word ‘Sedimentum’ which means settle down. So, basically, you see, what is happening here? It is getting settled down and then it is getting compacted and finally cementation is happening. So, the source word is Latin word ‘Sedimentum’. Now, as I have stated there are three types of sedimentary rock.

So, among them first one is clastic sedimentary rocks. What are they let us try to understand? They are formed by the deposition and subsequent cementation of sand, gravel and limestone, very simple, deposition and subsequent compaction and cementation of sand, gravel

limestone. Examples are like sandstone and mudstone etcetera. These are the typical pictures of sandstone, mudstone.

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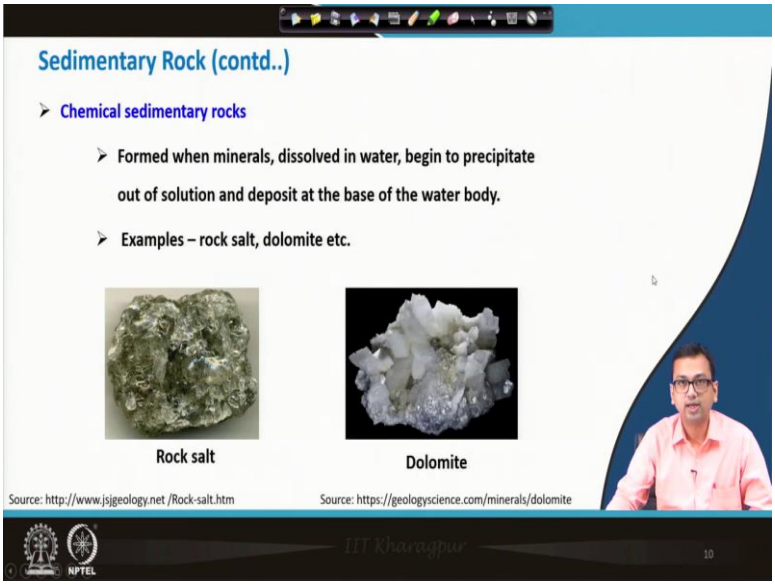

Similarly, what are the chemical sedimentary rocks? They are formed when minerals dissolved in water, then they begin to precipitate out of the solution and deposit at the base of the water body, then this type of sedimentary rocks are formed. And the examples are like, rock salt and dolomite. So, you can see the typical pictures of rock salt and dolomite.

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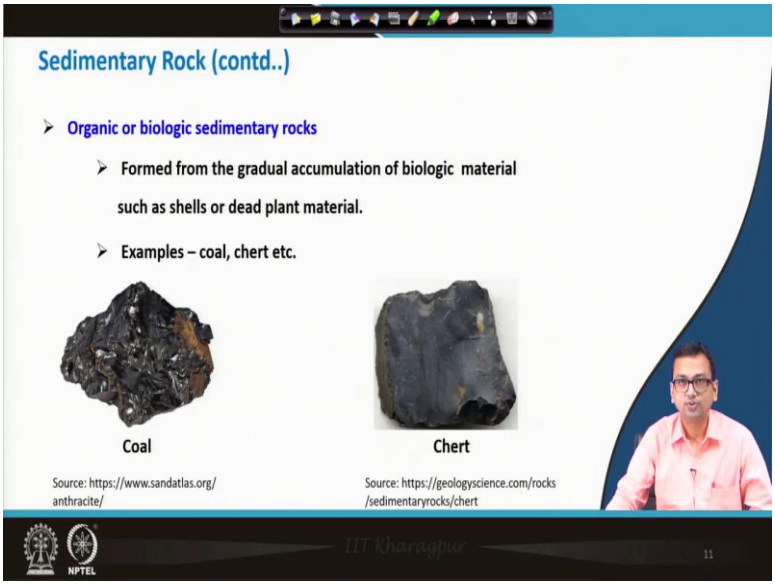

Now, the third category is the organic or biologic sedimentary rocks. So, how they form? So, they formed from the gradual accumulation of biologic material such as shells or dead plant material. The examples of this type of rock are coal, chert, etcetera. Now you can see that the

coal is very important thing. It is a very important and precious material. So, this is nothing but organic or biologic sedimentary rocks.

So, these are the typical pictures of coal block and chert.

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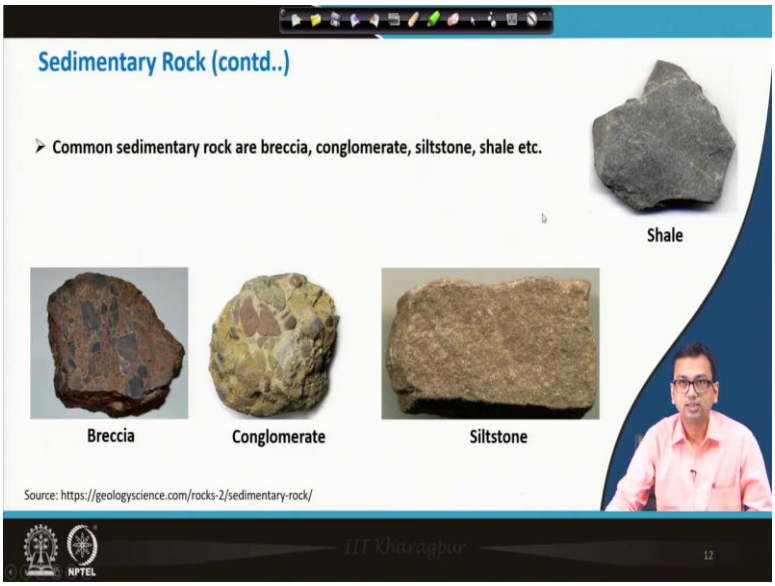

Next, some of the common sedimentary rocks are like breccia, conglomerate, siltstone, shale, and etcetera. I will show you typical pictures like breccia, conglomerate, siltstone, shale. So, these are different common sedimentary rocks. Apart from these diagrams, I have shown you the typical pictures of coal and sandstone.

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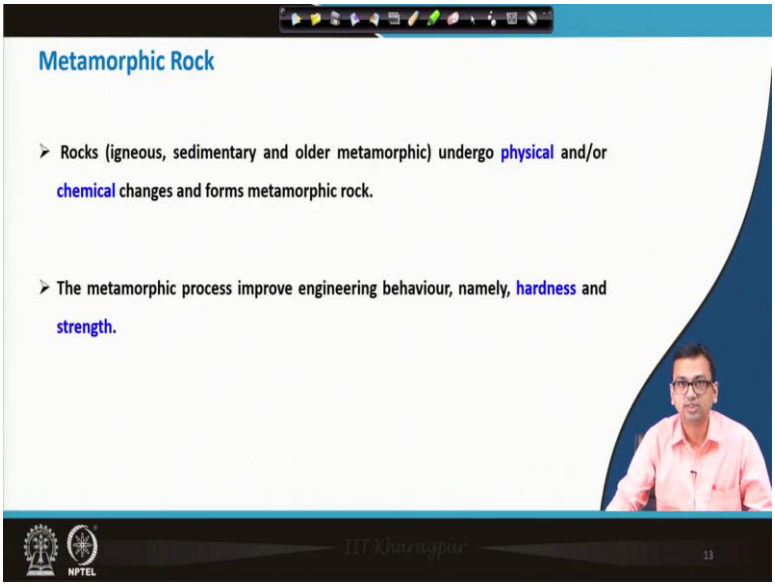

Now, next one is the metamorphic rock. When the igneous, sedimentary and older metamorphic rock undergo physical and chemical or physical or chemical changes, then it

forms metamorphic rock. So, rocks, in bracket like as it is written, igneous, sedimentary and old metamorphic rock undergo physical and / or chemical changes and forms metamorphic rock.

So, the metamorphic process actually improves the engineering behaviours generally. The metamorphic process improves the engineering behaviours like hardness and strength. So, metamorphic rocks are quite strong in general. So, metamorphic process improves engineering behaviours, which are obviously important for us i.e. to the rock engineers who will design structures over there or inside that rock mass.

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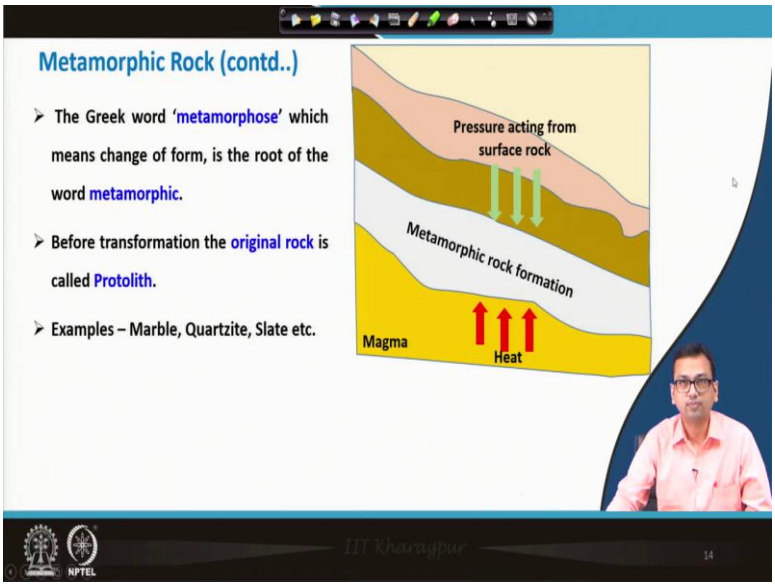

Now again, let us explore the origin of this word. So, the Greek word 'metamorphose' which means change of form, is the root of the word metamorphic. And before transformation the original rock is called the protolith. So, what is protolith? The original rock before transformation is called the protolith.

So, the process is just shown pictorially with this simple animation. These are the different layers of rock. Now, because of this huge rock mass, pressure will come. Also if there is magma, it will come from here. So, under high pressure and temperature, the rock layer what is present over here that may be a igneous rock layer or a sedimentary rock layer or even an old metamorphic rock layer that converts into the metamorphic rock formation. And some of the examples of metamorphic rocks are like marble, quartzite, slate; they are the examples of metamorphic rock.

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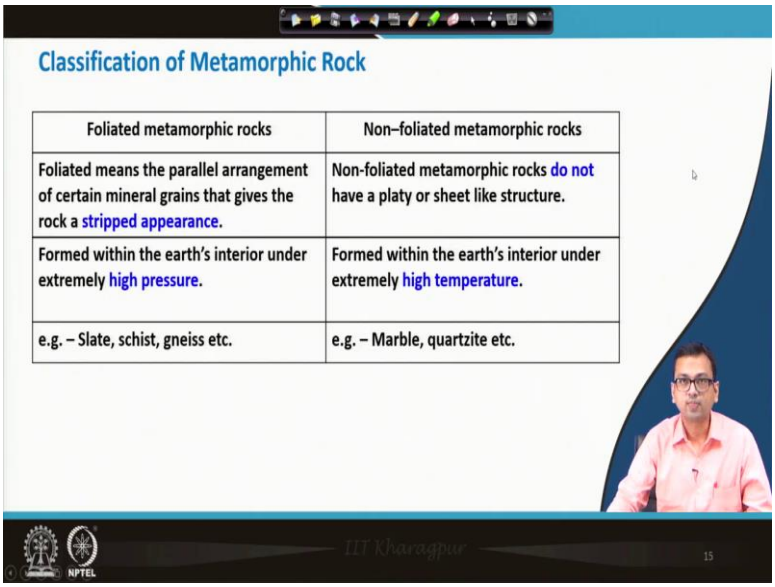

Now, let us discuss the classification of metamorphic rock. So, again at the very beginning of our today's lecture, I have shown you that there are primarily two types of metamorphic rock; first one is the foliated metamorphic rock and another one is the non-foliated metamorphic rock. So, what do they mean or what are the differences between them, let us see.

Basically, the foliated means the parallel arrangement of certain mineral grains that gives the rock a stripped appearance. Let me read it once again, foliated means the parallel arrangement of certain mineral grains that gives the rock a stripped appearance. On the other hand, non-foliated metamorphic rock does not have a platy or sheet like structure.

Here we will see some platy or sheet like structure in case of foliated metamorphic rock; whereas, we will not see that in case of non-foliated. Other than that, these foliated metamorphic rocks form within the earth's interior under extremely high pressure. So, this is primarily developed due to the high pressure. Primary reason is the high pressure; whereas, non-foliated metamorphic rock formed within the earth interior under extremely high temperature.

So, the non-foliated metamorphic rock forms because of the high temperature. The examples of foliated rocks are slate, schist, gneiss, etcetera and marble, quartzite, etcetera are the examples of non-foliated rocks.

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Now, some of the common metamorphic rocks are like slate, schist, gneiss, marble, quartzite, phyllite, and etcetera. So, these are the typical pictures of metamorphic rocks which are shown over here. This is a slate, a piece of slate. This is schist, schist will look like this. This is gneiss.

This is marble. This is quartzite, and this is phyllite. So, these are the different types of metamorphic rocks which are found commonly.

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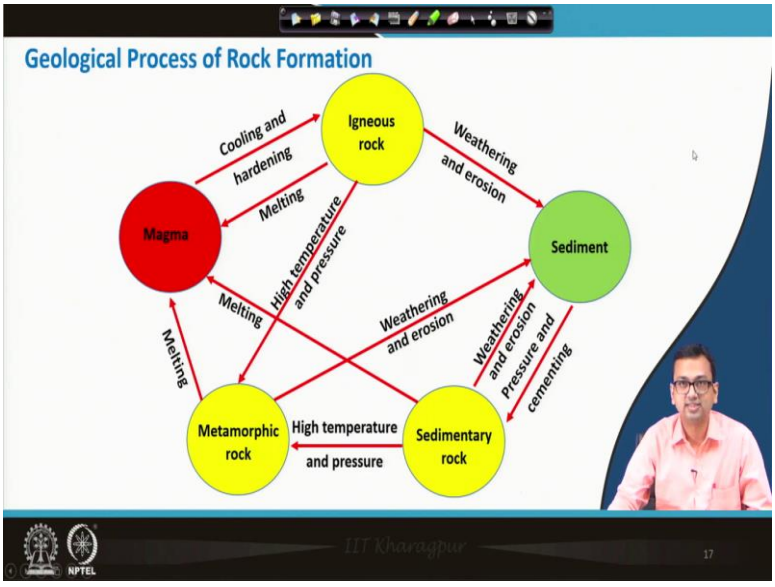

Till now, we have discussed the basic three categories of rock mass based on origin, i.e. we have studied the igneous, sedimentary and metamorphic rock, and we have seen different

types of metamorphic rocks, igneous rocks and sedimentary rocks. Now, we will discuss briefly about the geological process of rock formation.

So, this is actually a cycle. I will try to explain the cycle with the help of a diagram. First, as we have seen, when the igneous rock is forming, it is forming from the magma or lava solidification i.e. cooling down of magma or lava makes the igneous rock. So, cooling and hardening, solidifying of magma or lava are forming the igneous rocks.

Now, what may happen to the igneous rock because of weathering and erosion? It may form the sediment. Then, under pressure and cementation, the sediments will form the sedimentary rock. Then again the sedimentary rock will form the metamorphic rock under high temperature or pressure or both of these.

Similarly, the igneous rock can also form metamorphic rock when it comes under high pressure and temperature. And not only that, we have also seen that an old metamorphic rock can convert into a new metamorphic rock under high pressure and temperature. Then again metamorphic rock, because of melting at high temperature it may again form magma.

Similarly, this metamorphic rock again can develop sediment because of weathering and erosion as igneous rock was developing. And not only that, an old sedimentary rock can also generate sediment because of weathering and erosion and because of the pressure and cementation, it may form again a sedimentary rock.

Likewise, not only the metamorphic rock, sedimentary rock and igneous rock also can melt at a high temperature and can form magma. So, entire this process will keep on going. So, it is this cycle that keeps on moving actually.

I will once again explain this quickly. Firstly, the cooling and hardening of magma makes or generate igneous rock. Then igneous rock is converted to sediments because of weathering and erosion. Then the sediments form sedimentary rock because of this compaction and cementation which is happening because of the pressure coming to the deposit which is getting deposited.

Then again sedimentary rock under high pressure and temperature forms metamorphic rock. Similarly, igneous rock also forms metamorphic rock under high pressure and temperature. Nevertheless, an old metamorphic rock also forms a new metamorphic rock under high pressure and temperature. Then melting of metamorphic rock develops magma.

Similarly, this metamorphic rock because of weathering and erosion can form sediment and which may again form the sedimentary rocks. Similarly, sediments can also be formed from old sedimentary rock also under weathering and erosion, it may generate sediment and finally, again under pressure and cementing, it may form sedimentary rock.

And sedimentary rock and igneous rock also melt and may form the magma. So, this is an interesting geological process of rock formation that we have learned today.

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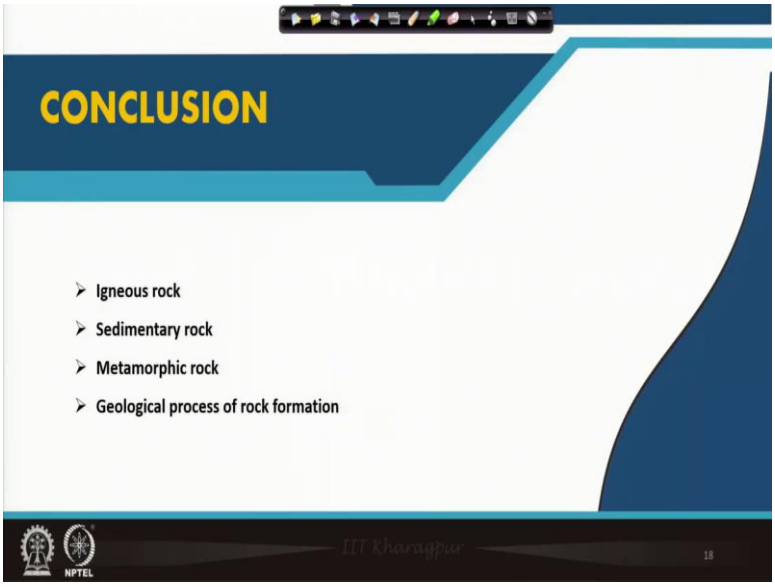

So basically, today we have discussed the classification of rock mass based on its origin. We have discussed igneous rock, sedimentary rock, metamorphic rock and the different geological process of rock formation. So, thank you. So, basically now in this module, we have another lecture left. So, in our next lecture, I will again discuss a little bit about the discontinuities only and in this context only I will discuss a new topic. So, thank you.