Rock Engineering
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Lecture - 02
Minerals and Rock Classes

Hello everyone. In the previous class we had the introduction and I mentioned to you about what this material rock is. What we are going to discuss in this course, what this branch of engineering that is rock engineering deal with, how the material rock is different than that of soil and concrete. So today we will learn about some of the aspects related to minerals as we have seen that rocks comprises of minerals and one rock is different from the other rocks in terms of its mineralogical composition.

So, before we study about the rocks and subsequently rock engineering, it is very important for us to know about various minerals which exists or to have basic idea about the minerals, how these minerals can be identified, and what all are their various properties. So, in today's lecture first we will discuss about the earth structure, then we will discuss about various mineral groups and in each group what all are the various minerals.

That would be followed by classification of rocks from its formation point of view then we will discuss about different these formations of rocks and finally we will discuss about the rock cycle. So, let us first start with the structure and the composition of the earth.

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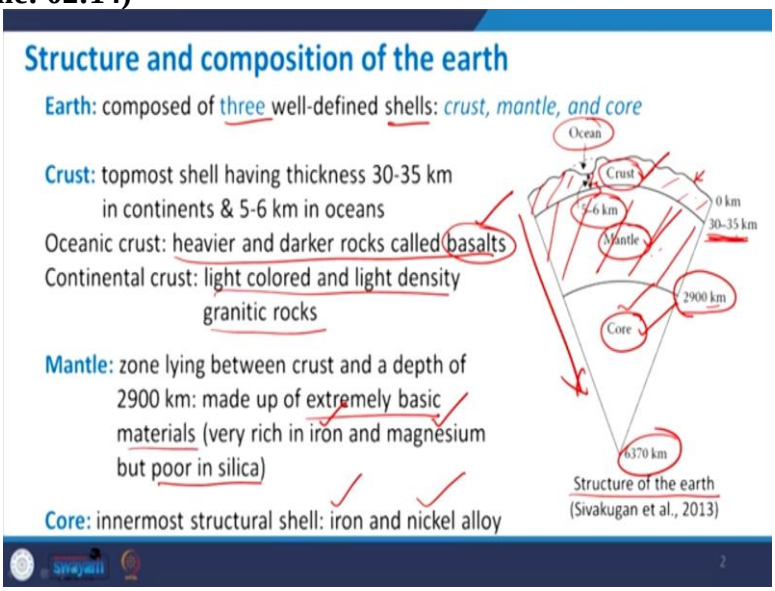

So here in this figure, a section has been shown depicting structure of the earth. Now as you can see that the earth is composed of crust, mantle and core. So basically, these are 3 well defined shells that the earth composed of. Let us have a look at the properties of these three one by one. So, coming to the first one that is from the surface of the earth the first one which is encountered is the crust.

This crust shell is the topmost one and it has the thickness of 30 to 35 kilometers. And in case where you have the oceanic crust there you have the thickness of the crust as 5 to 6 kilometers. So, keep that in mind that it is 30 to 35 kilometers below the earth surface is the portion which is called as crust of the earth. Now when wherever there is ocean, there the thickness of this crust is less that is 5 to 6 kilometer and mostly in this part what you get is heavier and darker rocks called basalts.

We will come to this one by one once I explained this structure and minerals to you, we will see how different types of rocks exist and what all are those we will discuss them in detail. But for the time being please remember that this oceanic crust is heavier and darker rocks and they are called as basalts. In the continental crust, that is this portion where this ocean is not there that is this portion, we encounter light colored and light density granitic rock.

So, for the oceanic crust, we have darker rocks like basalt, and for continental crust we have light colored or light density granite rocks. Then the next component comes as mantle as you can see that the portion of the earth which is lying from the 30 to 35 kilometers to 2900 kilometer that is this portion, this is called as mantle. So, this is made up of extremely basic materials and this material is very rich in iron and magnesium. However, it is poor in silica.

So, keep that in mind that in case of the crust portion, we have basalt or granitic type of rock. However, in case of mantle, this material is pretty rich in iron and magnesium, but is poor in silica and the thickness varies from 30 to 35 kilometers to 2900 kilometers towards the centre of the earth. Then the last one which is the core which is the inner most structural shell, as you can see that from 2900 kilometer to the 6370 kilometer or to the centre of the earth that is what is called as core. This is comprising of iron and nickel alloy.

So, based upon the kind of material that you encounter as you go towards the centre of the earth, you can take a call whether this is part of crust, mantle or core. So, remember earth is

composed of 3 shells crust, mantle and core and remember their basic properties. Now as I mentioned that some of the rocks then some minerals here.

So, let us have a look on various types of mineral groups and what all are the minerals which fall under each group here along with some of their properties. So, I have tabulated it for clarity in some of these subsequent slides.

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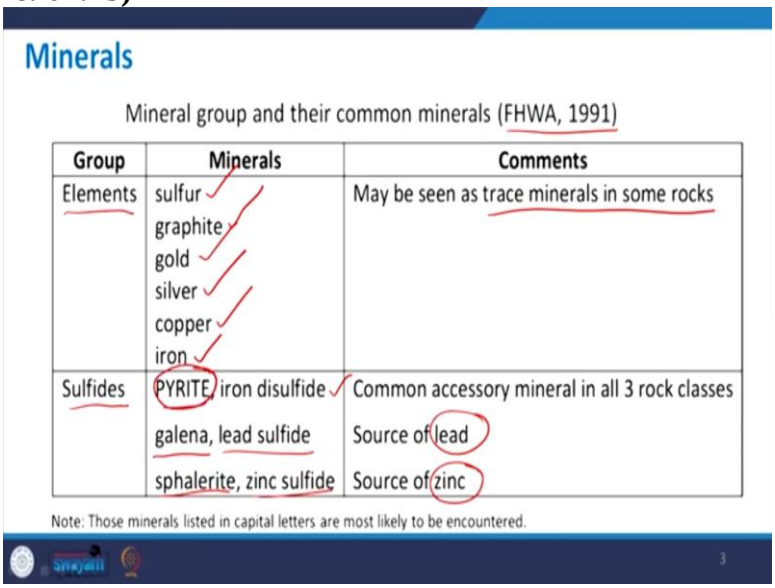

So, you see this has been taken which is an online available material FHWA, 1991. So, it deals with various mineral groups and their common minerals. So, the first group is called as elements which will be having the minerals called sulfur, graphite, gold, silver, copper and iron, and you need to keep in mind that all these minerals can be seen as trace minerals in some of the rocks.

So please keep that in mind that the group elements and their minerals, they may be seen as trace minerals in some of the rocks. Then the next group is sulfides. Now this has pyrite, iron disulfide, which is common accessory mineral in all the three rock classes, we will discuss what these three rock classes are after we finish our discussion on minerals. Then next category is galena or lead sulfide, this is the source of lead, sphalerite then zinc sulfide and here it is the source of zinc.

Kindly note that in this table which is running through many slides, some of the words they have been written by capital letters like here it is the PYRITE. So, this signifies that this pyrite is the most likely mineral which can be encountered in a group called sulfide. So that is

how the most commonly occurring mineral is identified in this particular table by writing them as the capital letters.

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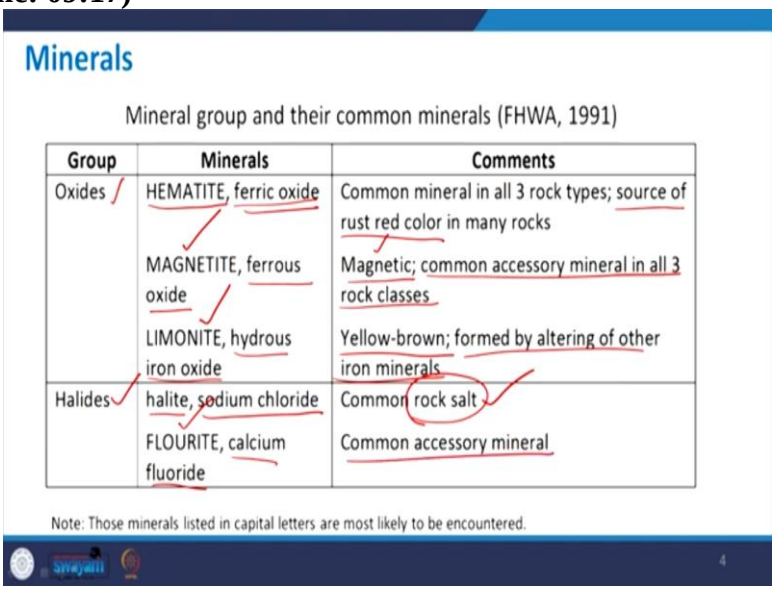

Coming to the next group which are oxides. So here you have the most commonly occurring mineral is hematite and then you have the ferric oxide, this is the common mineral in all the three rock types and please keep that in mind the rocks which show the rust red color that gives the idea that, this mineral would be present in that rock. So, this is the source of rust red color in many of the rocks.

Then the next category in this oxide group is magnetite, where it is again ferrous oxide is coming into picture. This is magnetic and this is common accessory mineral in all the three rock classes. So, keep that in mind that this is magnetic. Then the third one in this group oxide is limonite, which is hydrous iron oxide and note the color, this is yellow brown, so it is different, how will you differentiate between these minerals which fall in the same group.

So, one criteria can be the color. If it is rust red color it is this one that is hematite or ferric oxide, if it is yellow brown then it is hydrous iron oxide or limonite. These are formed by altering the other iron minerals, now coming to the next group which is halides, so the mineral which is encountered in this is halite, sodium chloride which is the common rock salt. You all must be aware of this rock salt, then fluorite, calcium fluoride. This is the common accessory mineral with respect to this group called halites.

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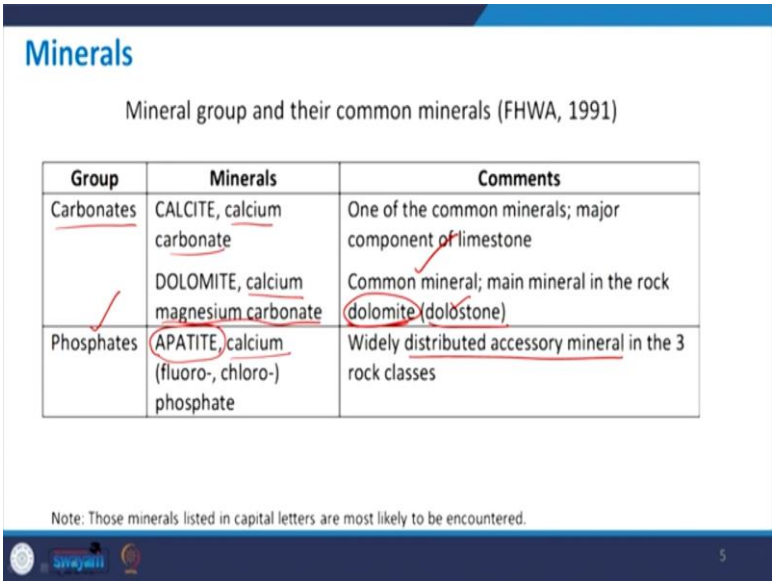

Let us move to the next group which is carbonates, it has calcite and calcium carbonate as mineral one of the common mineral and in case of the limestone rock this is the major component that is major mineral in limestone rock is calcite or calcium carbonate. Then the second one in this category is dolomite which is the calcium magnesium carbonate, it is the common mineral and main mineral in the rock dolomite.

So, keep that in mind that main mineral in case of limestone is calcite and main mineral in case of dolomite is calcium magnesium carbonate. This dolomite rock is also called as dolostone. Then the next group comprise of phosphates. So here we have the mineral which is most commonly occurring that is APATITE, see here it is written in the capital letters that is calcium fluoro chloro phosphate. So, it can be calcium fluoro phosphate or it can be calcium chloro phosphate. It is widely distributed accessory mineral in all the three rock classes.

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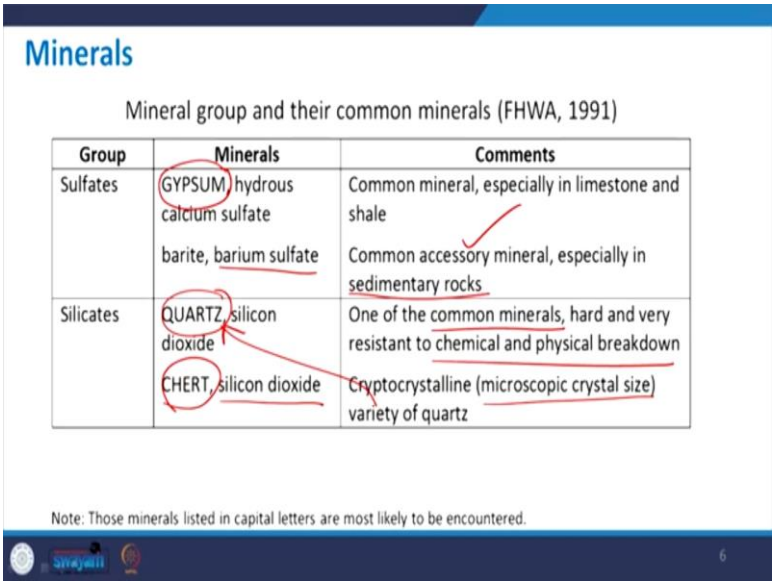

Coming to the next one that is sulfates, gypsum, very well known to most of us hydrous calcium sulfate, it is the common mineral specially; in case of limestone and shale. Then the next category in the sulfate group is barite or barium sulfate, which is again the common accessory mineral specially; in case of the sedimentary rocks. I will be explaining you these three different classes of the rock where this sedimentary rock is one type of or one class of the rock.

Now coming to the next group that is silicates, which is the major or the largest group amongst these mineral groups. So, silicates, first and foremost quartz, which is silicon dioxide, most common mineral in the rocks and it is unique to keep in mind that it is very hard and quite resistant to chemical and physical breakdown. So therefore, those rocks which have these types of minerals, their strength characteristic, their compressive strength, their shear strength are larger as compared to the other rocks. Then the next one is chert, that is silicon dioxide and it has microscopic crystals size and it is the variety of this quartz.

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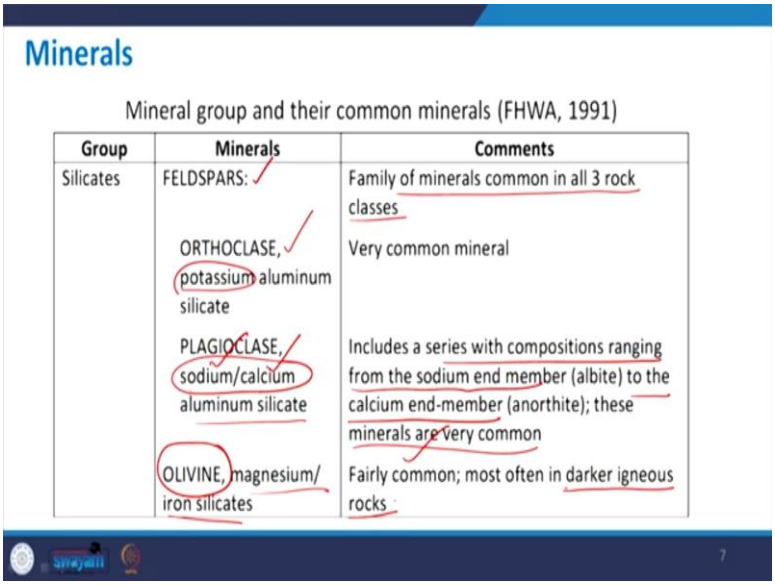

Coming to the next type again as I mentioned that silicone is the largest group amongst these minerals. So, it will be running through a few slides. So, in that case, the next category is feldspar which is the family of minerals which is common in almost all the three rock classes. And in feldspars there are further 2 categories, one is orthoclase which is potassium aluminum silicate, which is very common mineral, this next one is plagioclase. That is sodium calcium aluminum silicate. So, you see, here it was potassium and here in this case it is sodium or the calcium.

So, this includes the series with compositions ranging from the sodium end member to the calcium end member. So, you need to be careful that here I am writing sodium calcium. So, it can, it will be starting or the range of these composition may vary from one end to sodium other end to calcium. So, these minerals are quite common. Then the next one is olivine, magnesium or the iron silicates. These are fairly common and most often these are present in darker igneous rocks. That is another class of the rock.

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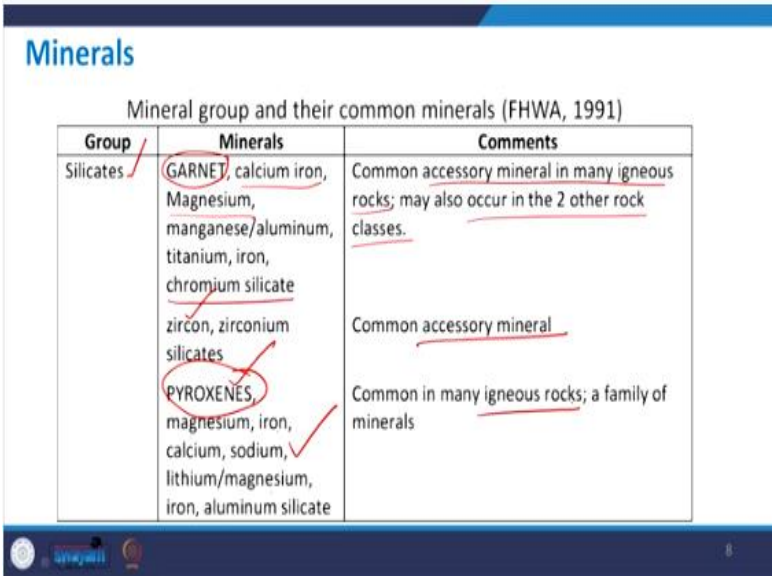

Coming to the next category of the mineral that is the next commonly occurring mineral is Garnet. It is the common accessory mineral in many igneous rocks. And it may also occur in 2 other rock classes that is, sedimentary and metamorphic. It has calcium iron, magnesium, and aluminum, titanium, iron and chromium silicate as minerals. The next category is zircon, zirconium silicates which is common accessory mineral.

Then the next one is pyroxenes. So, this is the most common occurring mineral in this category of minerals under the group silicates it has magnesium, iron, calcium, sodium, lithium, magnesium, iron and aluminum silicate. I have listed all of these for your ready reference, this one is pretty common in many igneous rocks and these are a family of minerals.

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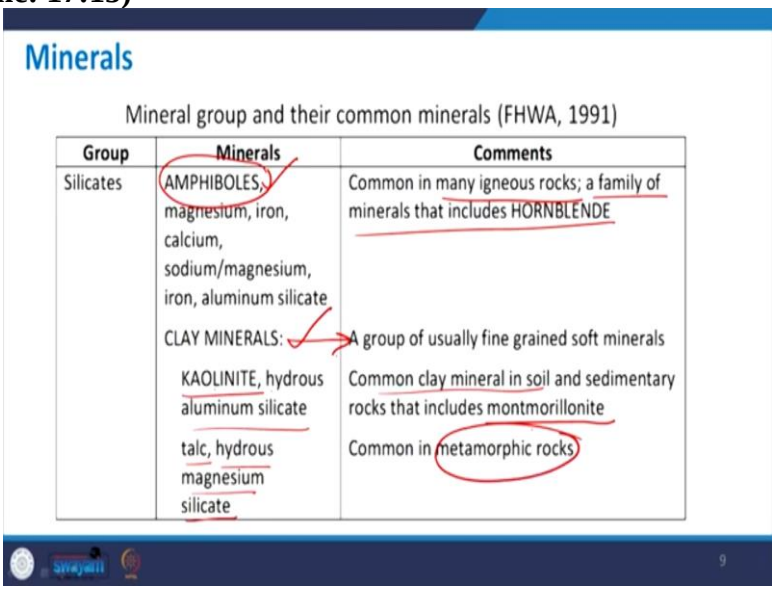

Then the next one is amphiboles, most commonly occurring mineral. This is many igneous rocks, it is common. This is a family of mineral that includes hornblende. So, once I discuss about all these mineral groups and the rocks, I will show you some of the pictures related to these minerals and rocks and then you will be able to connect this discussion with those pictures.

Now coming to the next category of the; minerals which is the clay minerals. You must have heard about it because in your soil mechanics class you must have heard about kaolinite illite and montmorillonite. What are these, these are clay minerals. So, the first one is kaolinite, which is hydrous aluminum silicate. So, when we talk about the clay minerals, it is a group of usually fine-grained soft minerals.

Kaolinite is the common clay mineral in soil and sedimentary rocks which include the montmorillonite. Then the next category is talc, hydrous magnesium silicate which is quite common in case of the third type of the rock which is the metamorphic rock.

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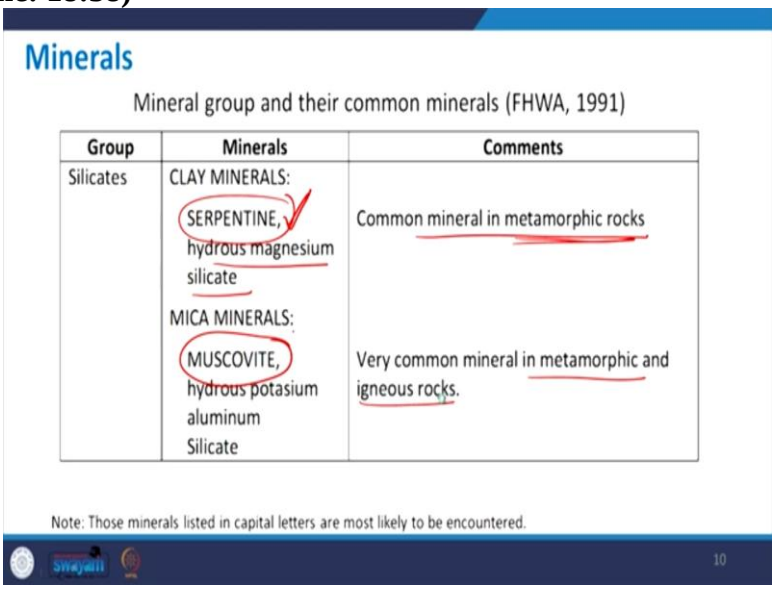

Now going ahead, the next type of clay mineral is serpentine, it is hydrous magnesium silicate and this is common in case of the metamorphic rock. So, from this table you should be able to understand that which mineral is common in which type of rocks. So, I have listed all of these. So, keep that in mind that this mineral is very common in case of the metamorphic rocks. Then the next category of the mineral in silicates, deal with mica material which is muscovite. Most commonly occurring mineral and this is common in metamorphic and as well as in the igneous rocks.

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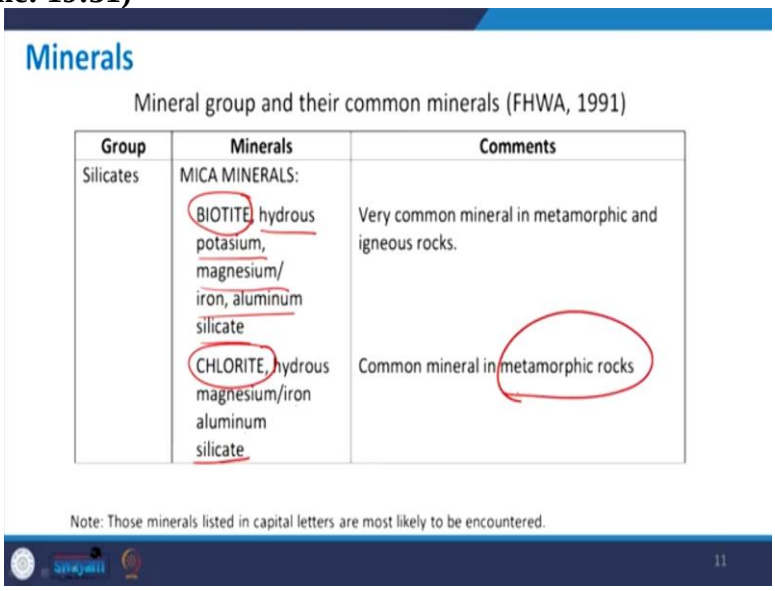

Coming to the next category of mica minerals, this is biotite, which can be identified as hydrous potassium, magnesium, iron, or magnesium or iron, aluminum silicate. And these minerals commonly occur in case of igneous as well as the metamorphic rocks. Then the next category includes chlorite, hydrous magnesium, iron aluminum silicate, this is common in case of the metamorphic rock.

So, you see all these minerals, they are typical characteristic of different types of rocks. So, when we have to identify the various types of rock first, we need to see, we need to study their mineralogical composition and accordingly we can define or decide whether which type of rock it is, because a rock, 2 different rocks may look same to you, but they are not same from their mineralogical composition point of view. So, to identify the rocks, it is essential for us to first identify these minerals. Now coming to these rocks, as I was mentioning that these rocks, they are the assemblage of minerals.

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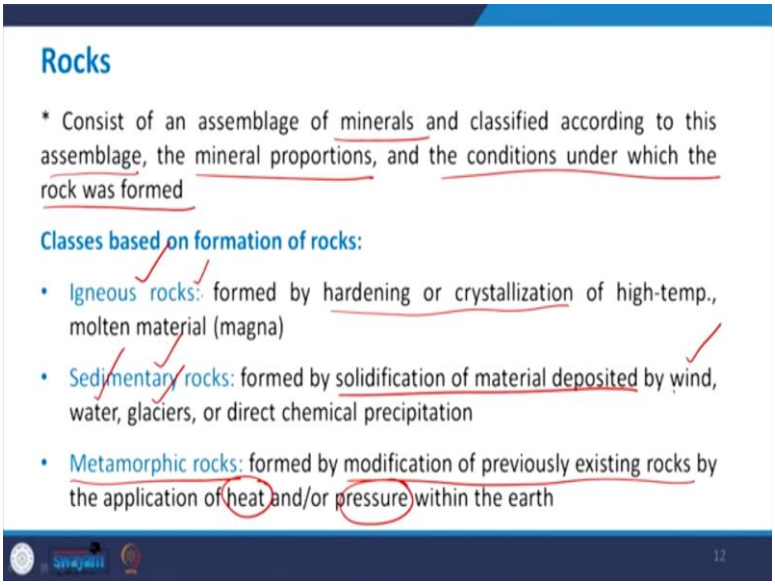

And they are classified according to this assemblage, their mineral proportions and the conditions under which the rock was formed. This condition under which the rock was formed is very important. And one of the major factors deciding its properties. So, based upon the formation of the rocks, classes have been defined. So, the first class deals with the igneous rocks. These are formed by hardening or the crystallization of high-end molten materials so, magma.

So, when this erupts, it just goes all around on the surface inside the earth's crust, then over a period of many years, it just cools down giving result to igneous rocks. Then second type of rock is the sedimentary rock which is formed by solidification of the material, which is deposited by various natural agencies, see winds, water, it can be glacier or they can be formed by direct chemical precipitation. So as against the igneous rocks, these sedimentary rocks are formed by solidification of material which is deposited by natural agency.

The material gets transferred from one location to other. And if it is lying at that other location for many years, it gets solidify and gives rise to the sedimentary rock. Coming to the third category, which is the metamorphic rock, this is formed by modification of previously existing rock by the application of either heat or pressure or both within the earth. So once again igneous rocks, molten material erupts, it cools down and then hardens, crystallization takes place gives rise to igneous rocks.

Sedimentary rocks, they are formed by solidification of the material which is deposited by natural agencies like wind, water, glaciers etc gives rise to sedimentary rock. When the any

rock which is already existing, if it gets modified by the application of heat or pressure or both inside the earth, then that rock is called as metamorphic rock. So, these are the 3 different classes of the rocks based on the formation.

Now you should be able to connect the previous table with respect to mineral and respective rocks here that which minerals will be more common or the accessory mineral for these respective rocks which are igneous, sedimentary or metamorphic rocks.

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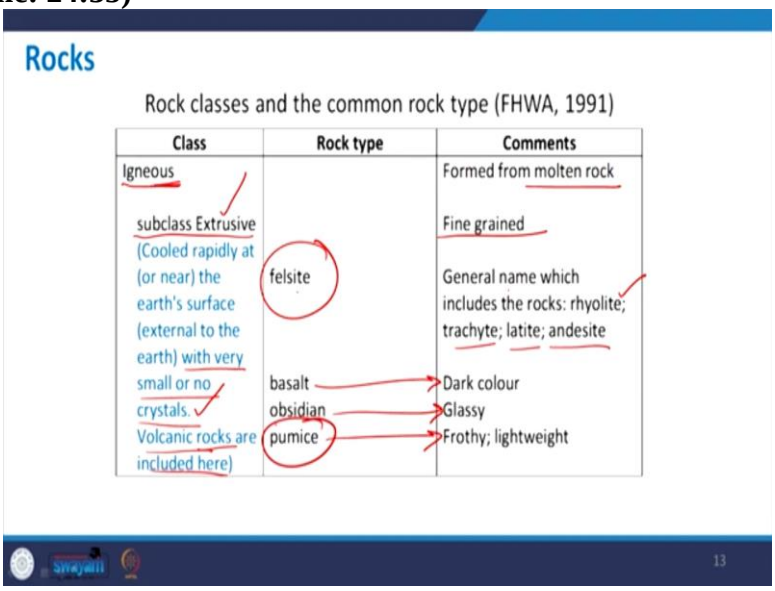

Now as we discussed about the different mineral groups and minerals, let us have some discussion on different rock classes and the common rock type. So, first of all we will have igneous rock class. Now this is divided into 2 sub classes based on how it cools, where it cools. So, we will have 2 different classes. So, first one is subclass extrusive. So that means extrusive igneous rock, see how its definition is.

It is cooled rapidly at or near the earth's surface, which is external to the surface like it is not deep inside the earth. So that is what we are calling it as extrusive and therefore it will have very small or almost no crystals, please keep that in mind that this subclass extrusive will have very small or no crystals. These volcanic rocks are included in this category. So, here we will have felsites.

See as I mentioned igneous rocks formed by molten rock, these are fine grain. For felsite general name which includes the rock is rhyolite, trachyte, latite and andesite. Now other category is basalt which is of dark color, obsidian, glassy, pumice, frothy and lightweight.

You should be able to identify this pumice, which we use in the household also some pumice stone is the same thing.

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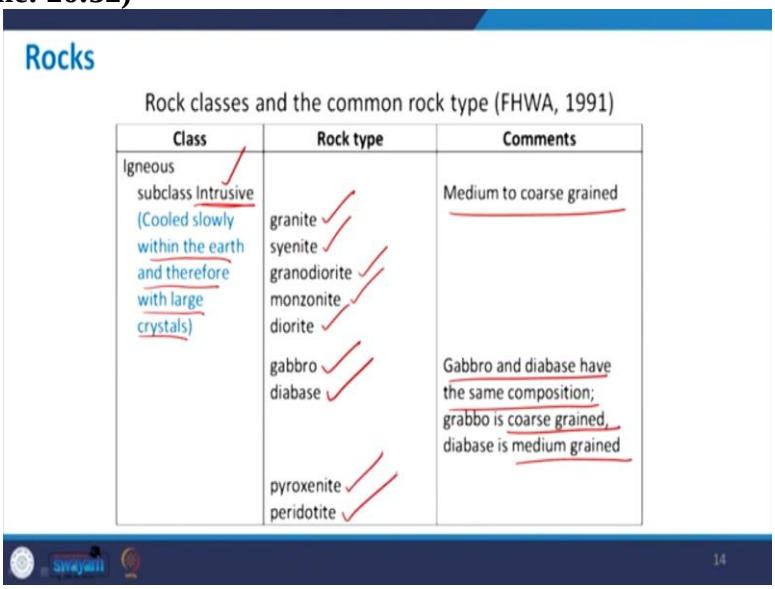

Then the second subclass is intrusive, this cool down within the earth and therefore, it has large crystals. So, the cooling is slow and therefore it will have large crystals. This will be having medium to coarse grained as against fine grained in case of the subclass extrusive, granite, syenite, granodiorite, monzonite and diorite, they are some of the examples of this type of the rocks that is subclass intrusive igneous rocks.

Then other type of igneous rocks under this category they include gabbro and diabase. These have, you see, the same composition, but gabbro is coarse grained and diabase is medium grained. So, it is not only the mineral composition, but the size of the grain also matters when you have to identify the rocks. Then the next other type of rocks are pyroxenite, peridotite.

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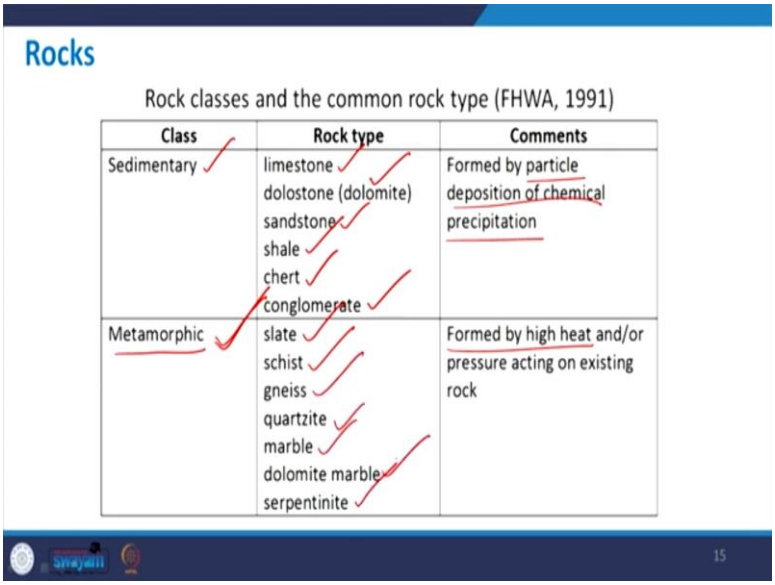

Let us go to the next category that is the next class is the sedimentary class and in this, these are formed by the particle deposition of the chemical precipitation. These include limestone, dolomite, sandstone, shale, chert and conglomerate. Then the next one, next class is metamorphic. When the existing rock is subjected to high heat or pressure or both, then these rocks are formed, metamorphic rocks are formed.

Some of these rocks include slate, schist, gneiss, quartzsite, marble, dolomite marble, and serpentinite. So, these are 3 different classes and some of the rock types which fall under each of these classes that is igneous, sedimentary and metamorphic. Now in nature what happens is one type of rock slowly can get changed to the other type, and it forms a rock cycle, so that is what is the definition of the rock cycle that I am trying to explain it to you with the help of this figure.

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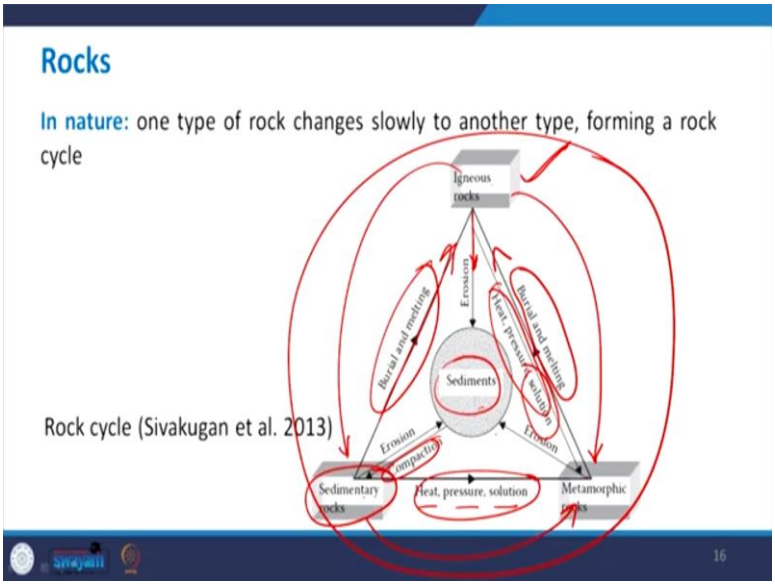

So, let us say that igneous rock is there. Now its erosion takes place, and then you have these sediments because of the erosion of this. These sediments they get compacted and they give rise to sedimentary rocks. So, you see how an igneous rock over time got converted to sedimentary rock. Again, say you have sedimentary rock, you have sedimentary rock here with you. Then it is subjected to burial and melting.

Take in this direction and then what you will get is the igneous rocks. So, you see over a period of years how an igneous rock can be converted to sedimentary rock and how the sedimentary rock can be converted to the igneous rock. Now come on to this site, say igneous rock is there and it is subjected to heat or pressure or both of it or some kind of a chemical weathering is there, like this is solution it is subjected to some kind of a chemical solution.

Then what will happen, you know how the metamorphic rocks are formed. So, upon the application of these agencies, this igneous rock will get converted to metamorphic rock. Come here again, if you have a sedimentary rock and if that sedimentary rock again undergoes these agencies like heat pressure and solution, then this sedimentary rock can be converted into this metamorphic rock.

Now this metamorphic rock again if it is subjected to burial or melting, it will get back to the igneous rock. If it is being eroded for some or other reasons, wind, water glacier anything, erosion takes place, this metamorphic rock will get converted to sediments. Once these sediments they are compacted, they can be converted into sedimentary rock. So, what this cycle gives me the idea is that one rock can be converted or it gets changed to the other rock

type like igneous rock upon erosion and compaction can be converted to sedimentary rock. Sedimentary rock under the application of heat or pressure or solution it can be converted to metamorphic rock. Metamorphic rock and sedimentary rock when they are subjected to burial or melting by some agency let us say, they can be converted to igneous rocks, so basically all of these they form a big cycle which is the rock cycle.

So why we are calling this a cycle that one rock gets converted to another rock, that other rock can again get back to the previous type of rock and therefore it completes the cycle. So, this is what is called as the rock cycle. So, in today's lecture what we have seen is, first of all we learned about the structure and the composition of earth. Then we saw different classes or the groups for mineral and various minerals which fall under each of this group.

With the help of some typical properties of those minerals I gave you the idea that how you can identify those minerals. Then we discussed about the rock classes, which were based on their formation, there were 3 classes igneous rocks, sedimentary rocks, and metamorphic rocks, these are their definition. And then for each of these classes we saw that what all are the various rocks which fall under each of these rock classes.

And then finally we saw that what do we mean by rock cycle, and how in nature one type of rock changes slowly to the other type of rock. And therefore, completes the rock cycle. So, in the next class we will have the discussion on the procedure that we can take up to identify various minerals and that would be followed by that rock identification procedure. Thank you so much.