Rock Engineering
Prof. Priti Maheshwari
Department of Civil Engineering
Indian Institute of Technology, Roorkee

Lecture - 03
Mineral Identification Procedure

Hello everyone. In the previous class we saw some of the minerals, their groups and in each group what all are the minerals were present, that we discussed in detail and then we had the discussion about different types of rocks, as I mentioned to you that one rock differs from the other rock based upon its mineralogical composition and therefore it was very important for us to know about these minerals.

So, today what we are going to learn is about the mineral identification procedure. So, let us start with our discussion. First of all, these minerals, these are the component of rocks and because of the change in the mineralogy, one rock differs from the other.

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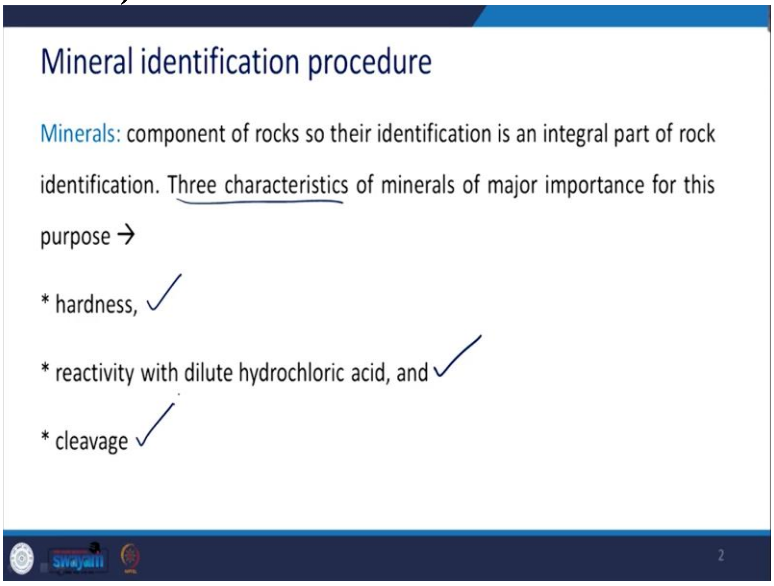

So, there are basically 3 characteristics of the minerals of major importance, which are used for mineral identification purpose, these include hardness, then reactivity with dilute hydrochloric acid and cleavage. So, let us see them 1 by 1. So, first we will discuss that how on the basis of hardness one mineral is different than the other. So, for this there is a scale that is available to us, which is called as Mohs hardness scale.

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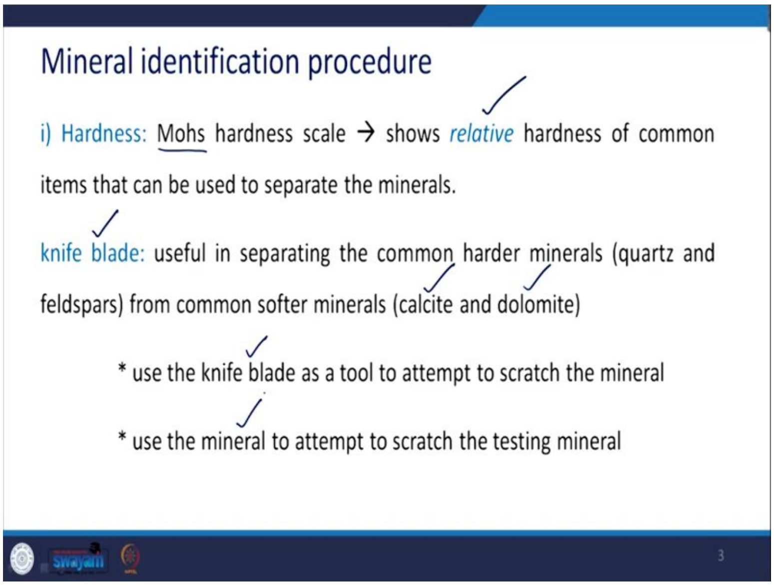

Please keep that in mind that it shows the relative hardness of common items, which can be used to separate one mineral from the other. So, here the hardness is not in the absolute term, but is in relative terms. Now, we need to use a knife blade which we will be using to separate the common harder mineral like quartz and feldspars from common other softer minerals which include calcite and dolomite. It can be used in 2 manners.

Again, you need to keep that in mind that we are only talking about the relative hardness and not the hardness in absolute sense. So, we need to use the knife blade as a tool to attempt to scratch the mineral that means we will take a knife blade and we will try to scratch the mineral. So, there can be 2 categories one will be in which the mineral can be scratched by the knife blade or in the other case it will have no influence.

Similarly, we can use the mineral itself to in an attempt to scratch the other mineral which we want to test. So, again you see, if one mineral is harder as compared to other mineral, the harder mineral will scratch the softer mineral. So that is how we will be able to get the relative hardness of the 2 minerals. Now here this figure shows the Mohs hardness scale.

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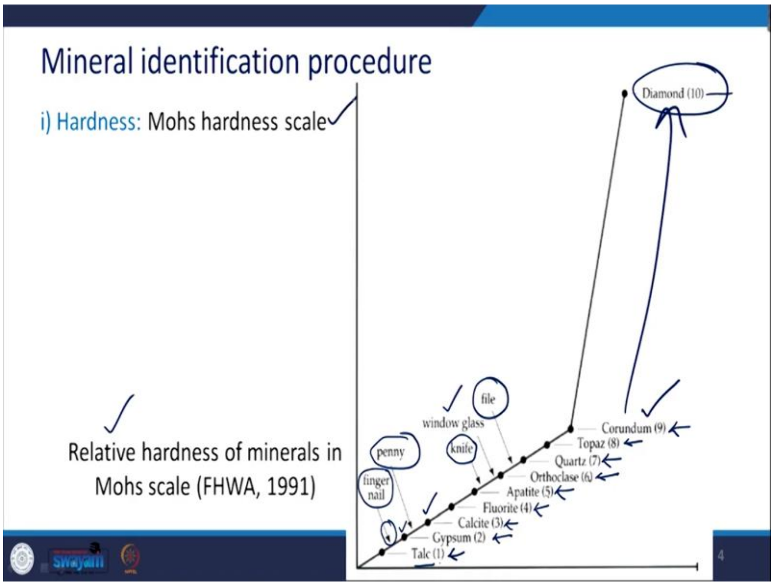

Again, I am repeating it is the relative hardness and not in the absolute sense as here you can see that as against the name of some of the minerals, some numbers are written it starts from 1, 2 and it goes up to 10. So, when I say 1, that means most soft mineral and when I go up to 10 then I say that it is the hardest mineral. So, on that scale, all the minerals have been distributed on the basis of their relative hardness.

Now take a look at this figure, talc which has the softness as 1, say the number has been given to 1. Now, coming to the next dot that is this one you have gypsum which is harder than talc and somewhere in between here, you see this finger nail comes into picture. Now as we go ahead then at 3rd number, we have calcite. That means calcites hardness is more than that of the gypsum and it is more than that of talc.

Now in between gypsum and calcite, we have penny. Then the next mineral which comes in the series is fluorite followed by apatite here and then comes the orthoclase and you can see that in between apatite whose relative hardness is 5 and orthoclase whose relative hardness is 6 there comes the knife and window glass. So, the next one now is quartz with the relative hardness number as 7 and in between orthoclase and quartz this file comes into picture.

That means file has hardness somewhere in between 6 and 7, it is the relative hardness this quartz is followed by topaz as far as the hardness is concerned and then comes corundum at level number 9 and then you can see, there is a steep rise in the hardness from this mineral to the diamond. So, on this scale, hardest mineral is diamond and the softest one or having the least hardness is talc.

So, keep that in mind all other minerals, which have not been listed here, you have to check their relative hardness and accordingly assign the hardness based upon this scale.

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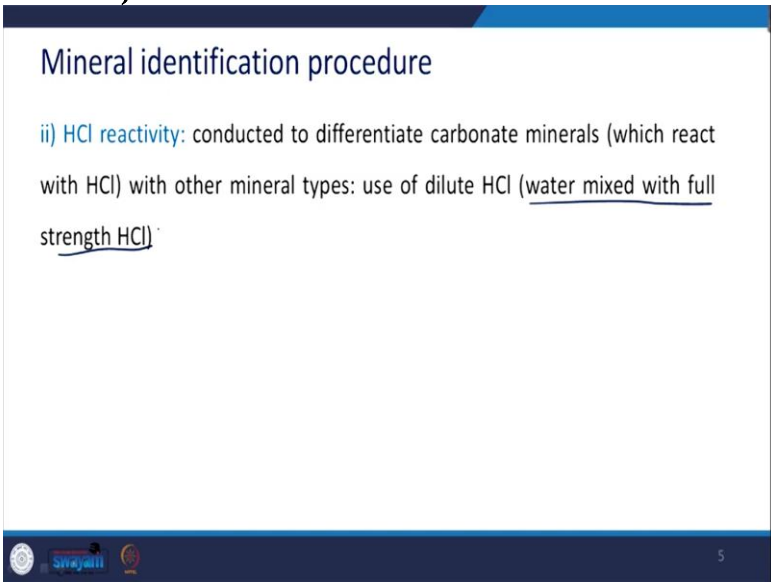

Now, the next one is HCl reactivity. So, when we go to the field, we need to identify the mineral so what we do is in a bottle we carry this acid with us that is dilute hydrochloric acid. How should we dilute? The water is mixed with the full strength HCL. This is a basically this test is conducted to differentiate carbonate minerals with other mineral types. You all know that carbonate minerals they react with HCL as compared to the other minerals. So, basically, this reactivity test is useful in differentiating carbonate minerals with other type of minerals. Now, the 3rd category or the 3rd procedure is cleavage.

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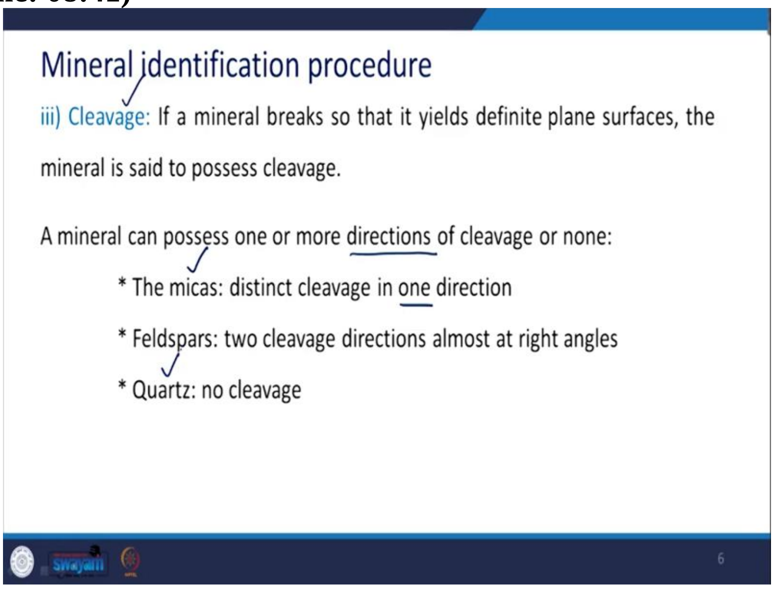

Now, what do we mean by this if a mineral break in such a manner that it yields definite plane surfaces then the mineral is set to possess cleavage. Now, depending upon let us say if a mineral is breaking only about one plane then that mineral would be called as having one cleavage plane. If it is more, then accordingly we can differentiate from one mineral to other on basis of this procedure. The mineral can possess one or more directions or there may be none.

For example, the micas they have distinct cleavage in one direction only. Feldspars they have two at 90-degree angle and in case of quartz, it has none. So, based upon whether they have any cleavage or not, or the number of cleavages that a mineral has we can identify these minerals on the basis of these numbers. Other characteristics which can be used to identify the mineral, one of the important one is the colour of the mineral.

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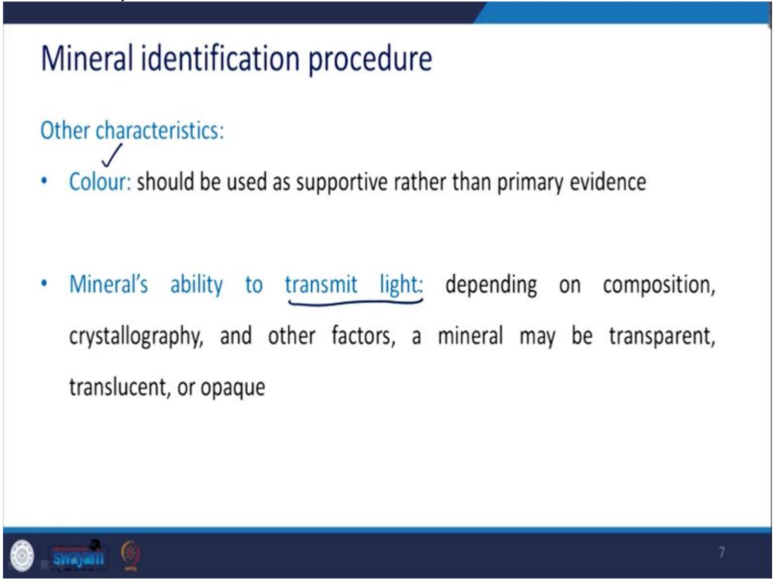

But then we need to keep in mind that this characteristic should be used as supportive rather than the primary evidence, the primary evidence should come from the earlier 3 procedure that have already been explained to you. The next one is minerals ability to transmit the light. Now, depending upon the composition, crystallography and there are few other factors one mineral may be transparent, translucent or opaque.

That means, transparent everybody knows, what do we mean by that. Translucent means, it has the capacity to transmit the light. So, based upon the mineralogical composition, again, we can use this property of the mineral to for its identification. Now, here this table gives us the idea about some of the common minerals and their characteristic.

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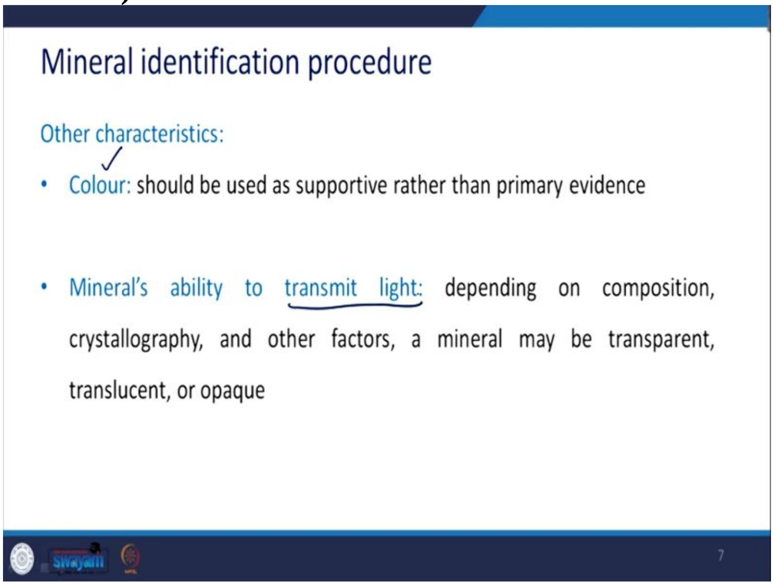

Like for example, if we have pyrite its hardness falls in the range from 6 to 6.5 no cleavage plane. As far as the other properties are concerned it is brassy. It is also called as fool's gold. So, it gives you the appearance of the gold but it is not. It weathers easily to give iron stains, keep that in mind. This is the common accessory mineral in many of the rock types. So, we need to be careful that if we have such characteristic, then there are chances that pyrite is the mineral.

Then the next one is hematite which has hardness between 5.5 to 6.5. And when it is in the massive form, we do not observe any cleavage plane. The colour is red-brown, it is the common accessory mineral in many of the rocks and cement in many sandstones. Next one is magnetite. Again, in granular form, it has no cleavage plane. This mineral has a hardness on the scale of Mohs scale as 6. Colour is black. It is magnetic, which is a very important property of this mineral which identifies this mineral from rest of the other minerals, this is common accessory mineral in many rock types. Come to the next.

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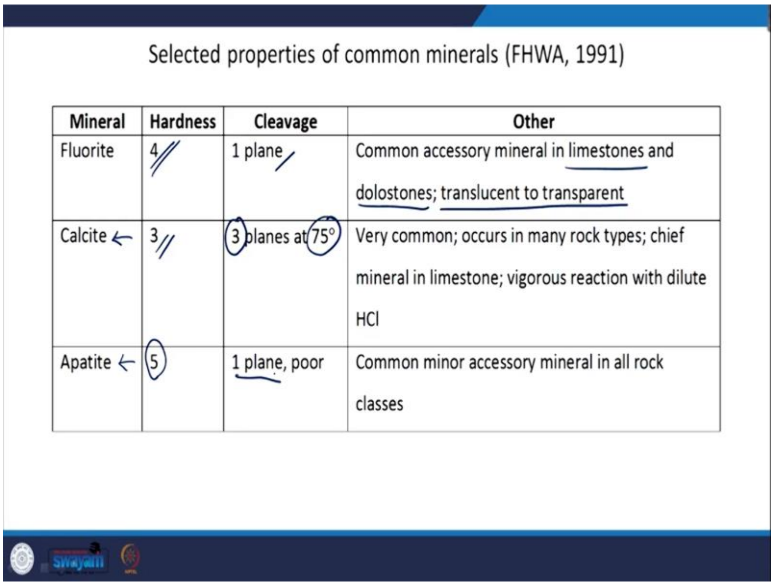

Selected properties of common minerals (FHWA, 1991)

Mineral	Hardness	Cleavage	Other
Fluorite	4	1 plane	Common accessory mineral in limestones and dolostones; translucent to transparent
Calcite	3	3 planes at 75°	Very common; occurs in many rock types; chief mineral in limestone; vigorous reaction with dilute HCl
Apatite	5	1 plane, poor	Common minor accessory mineral in all rock classes

That is fluorite having a hardness of 4, only one plane. This is common accessory mineral in limestone and dolostone. So, you see that in the previous class, we had the discussion about these different types of rocks. So, there I have already explained you that what type of category these rocks they fall. So, you should be in a position to connect this discussion with our earlier discussion. Then, this has a property as it is translucent to transparent.

Next mineral under consideration is calcite relative hardness 3 and see here 3 planes at 75 degree. It is very common and occurs in many rock types and it is one of the chief minerals in limestone. And as far as its reactivity with hydrochloric acid is concerned, it has vigorous reaction.

Next is apatite having hardness of 5, it is having one plane, then common mineral accessory in all the rock classes that is igneous, sedimentary and metamorphic.

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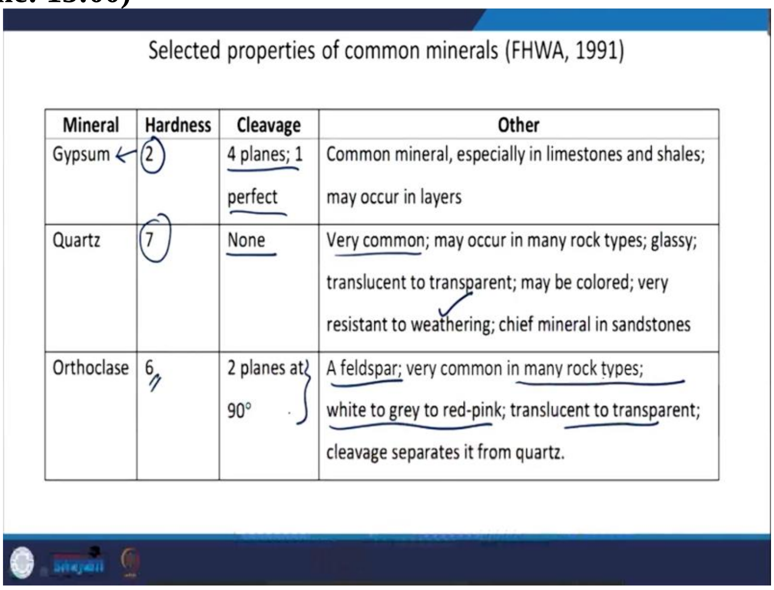

Selected properties of common minerals (FHWA, 1991)

Mineral	Hardness	Cleavage	Other
Gypsum	2	4 planes; 1 perfect	Common mineral, especially in limestones and shales; may occur in layers
Quartz	7	None	Very common; may occur in many rock types; glassy; translucent to transparent; may be colored; very resistant to weathering; chief mineral in sandstones
Orthoclase	6	2 planes at 90°	A feldspar; very common in many rock types; white to grey to red-pink; translucent to transparent; cleavage separates it from quartz.

Coming to the next one, we have gypsum here, hardness of 2 and see here, 4 planes out of which one is the perfect plane and it is a common mineral specially in case of limestones and shales and it may occur in layers.

The next one is quartz and you can see that the hardness level is much higher than that of the gypsum and no cleavage planes were obtained. This is very common mineral. It may occur in many rock types. It has a glassy appearance and translucent to transparent. It may be coloured; it is very much resistant to weathering and it is one of the chief minerals in sand stones.

The next one which has lesser hardness than quartz is orthoclase having a hardness of 6 with 2 cleavage planes at 90 degree and in this one the feldspar it is very common in many rock types then it is white to grey to red-pink in colour. This is translucent to transparent and cleavage separates it from the quartz. So, you see that in case of the quartz, there were no cleavages, but in this case orthoclase there are these 2 planes. So, let us see if you have any confusion then this particular characteristic differentiates quads from orthoclase.

Coming to the next one that is the clay minerals, which is a group we have seen that kaolinite, montmorillonite they all fall under this category.

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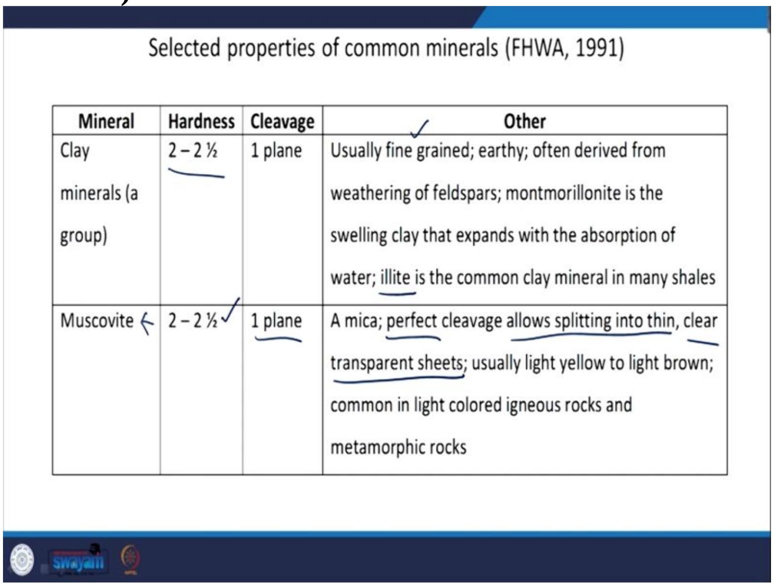

Selected properties of common minerals (FHWA, 1991)

Mineral	Hardness	Cleavage	Other
Clay minerals (a group)	2 – 2 ½	1 plane	Usually fine grained; earthy; often derived from weathering of feldspars; montmorillonite is the swelling clay that expands with the absorption of water; illite is the common clay mineral in many shales
Muscovite	2 – 2 ½	1 plane	A mica; perfect cleavage allows splitting into thin, clear transparent sheets; usually light yellow to light brown; common in light colored igneous rocks and metamorphic rocks

The hardness is in the range of 2 to 2.5 and there is only one plane. We all know that clay minerals are fine grained. These are often derived from weathering of feldspars. Montmorillonite has the characteristic of the swelling and so whenever this montmorillonite is present in the clay, that clay exhibits swelling characteristic. What does that mean? that when the water is added to such clay having montmorillonite mineral it expands in volume. The volume increases. Illite is the common clay mineral in many of the shales.

Then the next one is Muscovite. This is, if you can recall this is related to the minerals having mica. So, 2 to 2.5 on the scale of Mohs hardness scale with 1 cleavage plane and there exists a perfect cleavage plane which allows splitting into thin clear and transparent sheets. Keep that in mind because this is one of the significant characteristics of this mineral Muscovite. This is usually light yellow to light brown and this mineral is quite common in light coloured igneous rocks and metamorphic rocks.

Now here as a whole the mineral identification flow chart has been shown. So, this chart or the flow chart has 2 parts; part one deal with the minerals which are scratched by a knife and Part B deals with rest of the minerals.

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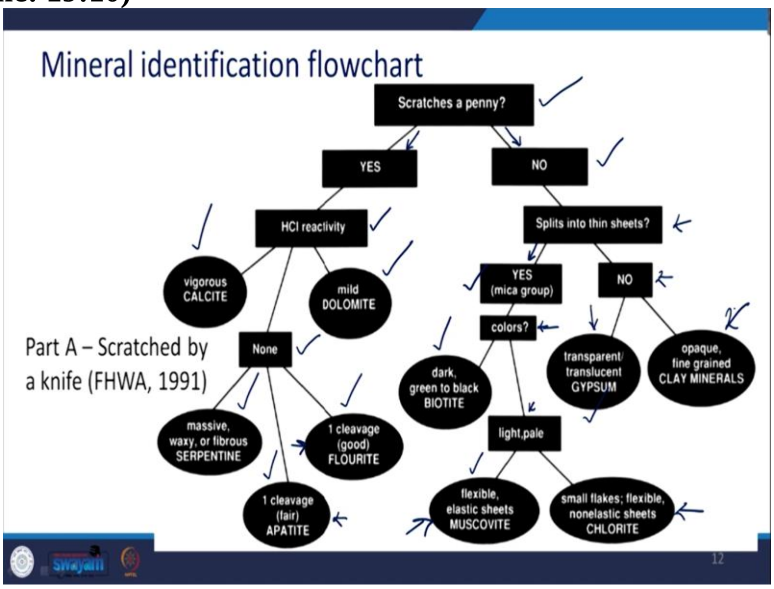

So, you see from the start first the question is whether it is scratches a penny or not. You have seen at Mohs hardness scale that what is the hardness of the penny? where it is lying? In between what? so first we should check with that. If the answer is yes, we come to this branch. If the answer is no, then we have to go other way round. Now first let us focus on this branch where the mineral scratches a penny.

Then the next step is to check whether it is reactive to the hydrochloric acid or not. Now in case if it has a vigorous reaction, immediately you can identify that a mineral is calcite. If there is a mild reaction, you can say it is dolomite. And if there is no reaction at all then again, the confusion remains and there the knowledge about cleavage plane comes to our rescue. That is when it is not reacting with the hydrochloric acid at all.

Then in case it is massive waxy or fibrous, it is serpentine. If it has fair one cleavage plane it is apatite and if it has one good cleavage plane then it is fluorite. Keep that in mind that here the difference is in this case it is the fair plane and, in this case, it is the good cleavage plane so, that differentiates apatite to fluorite.

Now, come to the second branch they are the mineral does not scratch a penny. So, this is no then the next check which is applied is whether the mineral can be spllited into thin sheets or not, see here, if it is yes then we can say that the mineral belongs to mica group. Now, if it belongs to mica group then colours become very, very important in their identification. So, what are those things, so, we have dark green to black colours then it is biotite. If it is light or pale colour, then we need to go ahead that whether these sheets which in which this material can be splitted into whether those sheets are flexible and elastic, then it is muscovite, but if these are small flakes, that means flexible and non elastic sheets, then it is chlorite. So, you see in a sequence following this flowchart, you need to take one step at a time and take the decision for that particular step before going to the next one.

Now, come back here that if it is being splitted into thin sheets, we had this branch but if it is not then it’s property like whether the mineral is transparent or translucent that comes into picture. So, if the mineral is transparent or translucent, then it is gypsum; if it is opaque and it is fine grained, then we can confidently say that this is the clay mineral. Now, coming to the second part of this flowchart that is when it is the mineral is not scratched by a knife. So, again we have the tree which we need to follow.

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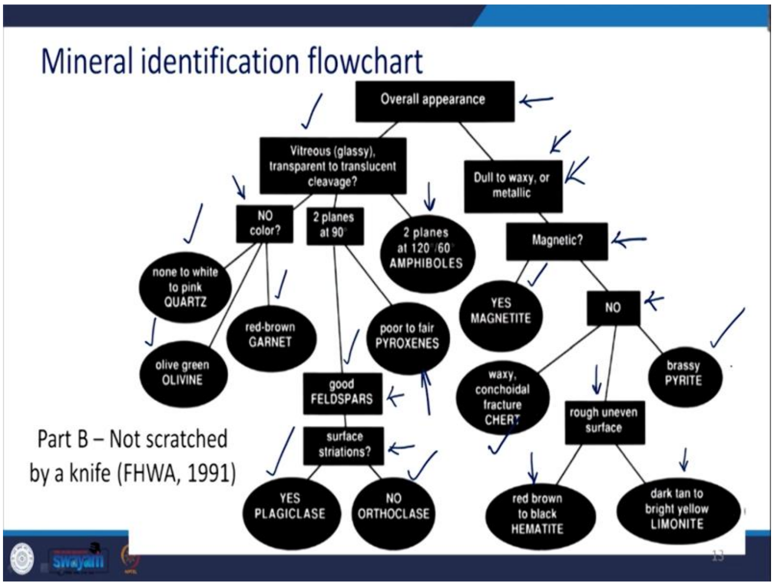

So, first of all, we will say what is its overall appearance, whether it is vitreous glassy transparent to translucent cleavage or if it is dull to waxy or metallic. Now, say it is glassy transparent to translucent then we will see what are the colours if there is any colour. So, the question is asked; colour or not. So, we have no colour then none to white to pink gives quartz it identifies quartz. If it is olive green that is olivine. If it is red to brown, then it is garnet.

Now 2 planes. So, you see that first we see the appearance, whether it is vitreous or dull to waxy then we see whether the cleavage planes are present or not. So, in this case, cleavage planes were not there. So, we looked at the colour. So, there are 3 categories quartz, olivine, and garnet in case if you have 2 planes at 90 degree, then if those planes are very well defined that is good.

So, then you have feldspars and then we need to check whether there is any surface striation or not? Surface striation they are like kind of an impression on the surface which can be because of the movement of the eyes like for a as example glacier. So, if it is present then it is plagiclase otherwise it is orthoclase. Now, if these 2 cleavage planes are poor to fair then the mineral is pyroxene and if you have 2 cleavage planes at 120 degrees 60 degree. Then it is amphiboles.

So, you see that if we have this flowchart in front of us and if we keep following one step after the other, we are in a good position to identify various minerals. Now, come here because this branch was dealing with the glassy or the vitreous appearance of the minerals.

Now, in case if it is dull to waxy or metallic, then the next step comes here as the question is whether it is magnetic or not?

Now, if it is magnetic, definitely the mineral is magnetite, if it is not, then again, the problem is I cannot identify. So, again there are 3 branches. First one deals with waxy conchoidal fracture, then it is CHERT. Second one is rough, uneven surface. So, again if it has rough uneven surface then we have to take the help of the colour of the mineral if it is from red brown to black, it is hematite. If it is dark turn to bright yellow colour then it is limonite.

If the appearance is or if the appearance is dull, it is not magnetic then if it has a look of brass then it is the pyrite mineral. So, you have these flowcharts using these flowcharts follow each and every step that has been given starting from the top to go along these branches of this flowchart and you will be able to identify various minerals.

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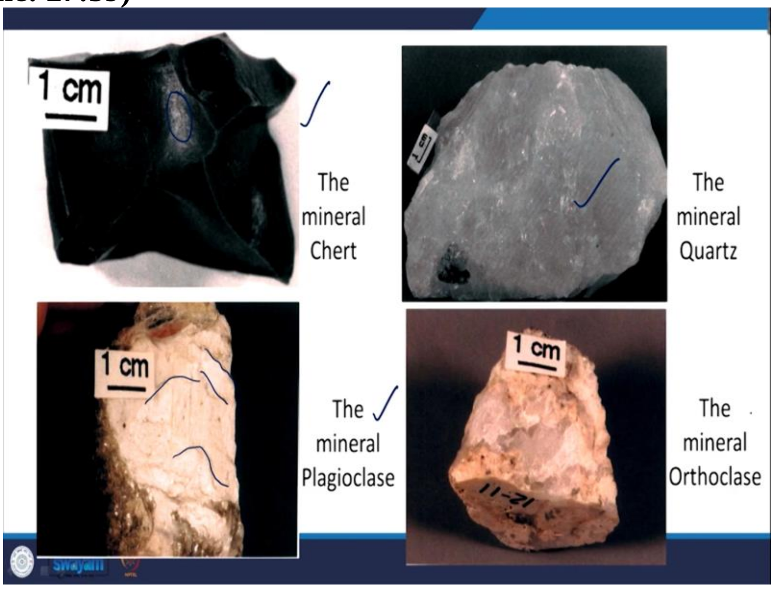

Now, I would like to give you the idea, we have discussed about it now, let us see one by one that how these minerals they look. So, you see this first figure gives us the idea about how the mineral chart looks like as I mentioned, it is waxy and concoidal fracture or the cleavage plane which is evident from this figure. Then the second one is the mineral quartz. So, it has the hardness on the Mohs scale of 7, then it has white to pink colour.

So, you can see that this figure is showing the mineral quartz. Now come to the next one that is the mineral Plagioclase, here as I mentioned that there are 2 cleavage planes at 90 degree and you can see the surface striations as I mentioned striations, they are any number of scratches or parallel grooves on surface of a rock and these can be as a result from action of moving ice as that of a glacier. So, you can see that here these are there, that surface striations they are present.

Now look at this mineral or orthoclase. Again here, there are 2 cleavage planes at 90 degree, but there is an absence of surface striations. So, this surface striations, it differentiates between these 2 minerals plagioclase and orthoclase. Coming to the next 4 type of the mineral.

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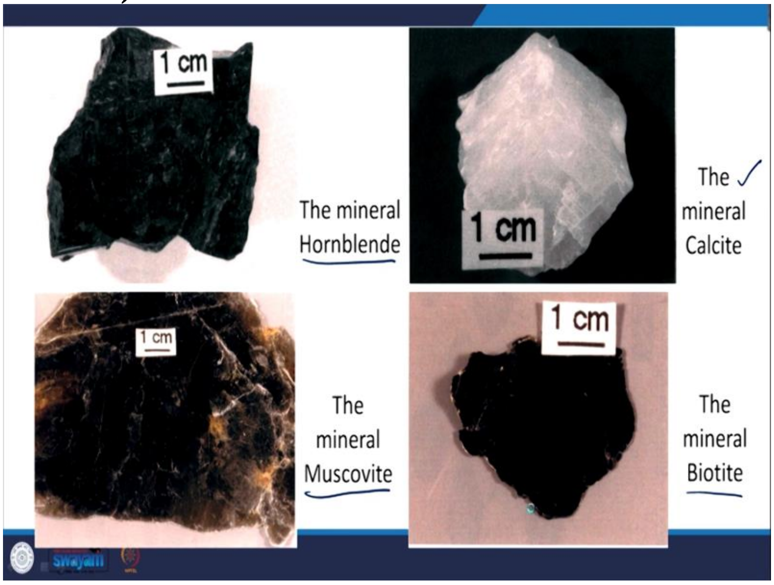

So, the first one here is hornblende, this is a kind of you can see that it is dark colour amphibole mineral. So, in this case you have 2 cleavage planes at 120 degree and 60 degree and then the next one is the mineral calcite, it can be scratched by a knife and it has vigorous hydrochloric acid reactivity. So, keep that in mind the moment you have such type of reactivity with respect to HCl, then immediately we can identify that the mineral may be calcite.

The next one is Muscovite as the figure from the figure also it must be clear to you that this can be splitted into thin sheets and these are flexible elastic sheets. Now, have a look at the biotite, this is darker in colour as compared to Muscovite. This also can be splitted into thin sheets. So, today, we learned about the procedure that one can adopt for identification of the mineral.

What all are the 3 major procedures which are there. Then, we saw the two-flow chart based upon this procedure and how to identify the mineral and then I gave you with the help of some photographs, I gave you the idea that how a typical, few typical minerals they will look like.

Now, in the next class we will be discussing some aspects related to various rocks which are present with the help of these flowcharts, similar flowchart we will try to identify different types of rocks and then we will see some typical rocks and their appearance. Thank you very much.