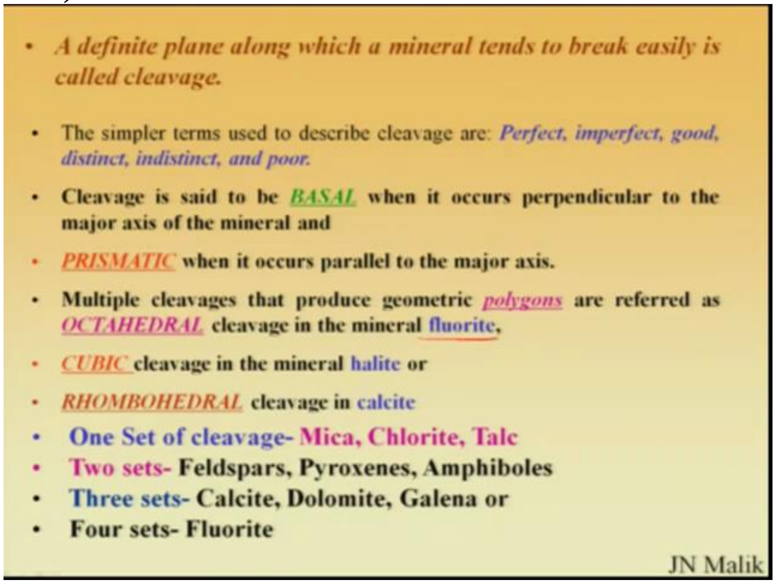
Earth Sciences for Civil Engineering
Professor Javed N Malik
Department of Earth Sciences
Indian Institute of Technology Kanpur
Module 2
Lecture No 7
Rock types and their Properties (Part-1)

Hello everybody, welcome back. In the last lecture, we discussed about the mineral, what is minerals and how they are formed and we also talked about the different definitions of minerals and then the crystal forms, what are the crystal faces and all that. And then how the cooling of magma affects and helps in formation of different crystals and minerals. We also spoke discussed about the Bowen reaction series and how the different type of minerals are formed.

That is the feldspars and we talked about the ferro-magnesium minerals and the non-ferro-magnesium minerals in that and then we talked about the continuous and discontinuous series. So after discussion, I think we stopped at the crystal forms. And then the most important was what we were talking about the cleavage. So I will start with that. And the cleavage if we define, is a definite plane along which the mineral tends to break.

If you have a mineral and you try to break it, then it will break along a very particular plane, a definite plane and that is termed as cleavage. And all minerals will have different crystal forms and that crystal forms we talked about on that day that that depends on the atomic structure, internal atomic structure.

(Refer Slide Time: 1:47)



And they are usually different in form like either the cleavage we term that as a perfect cleavage will break the mineral will break in our perfect and either along the perfect plane or it is we call that imperfect, good, distinct, indistinct and poor cleavage also. So we will just see the different type of cleavages. And then we will move ahead with the identification criteria of the minerals in hand specimen.

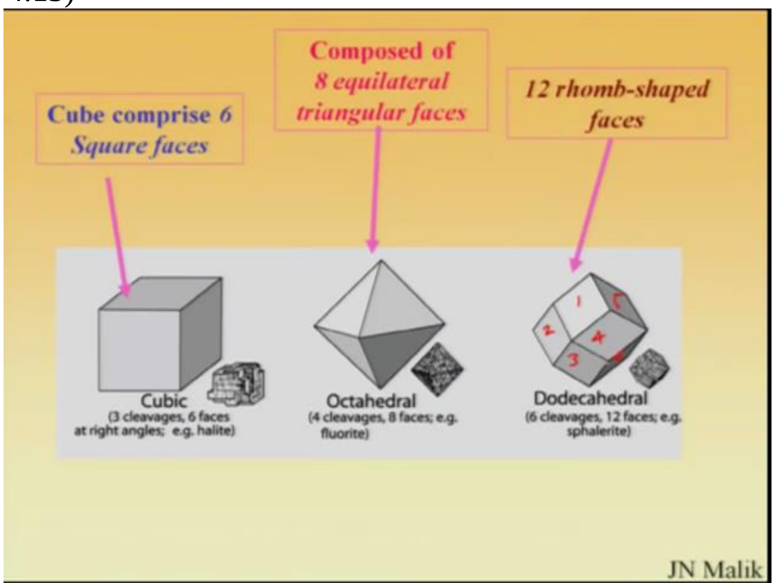
Physically how we can identify the minerals. We can get into the chemical composition. But that is a big, long process but we can identify the mineral just having it in the hand and then doing some performing some parameters which can help us in identifying the particular minerals. Now cleavage is said to be basal when it occurs perpendicular to the major axis. This we have talked about the different axis of crystallographic axis in different crystal forms that we were talking about.

For example, cubic or we can say isometric system or hexagonal system. So that is an example. So this is just to that the basal cleavage is termed as when it occurs perpendicular to the major axis of the mineral. And the prismatic when it occurs parallel to the major axis and then we are having we are having multiple cleavages and then we have cubic like example is halite.

For the multiple cleavage we have the example is fluorite. Then rhombohedral are cleavage of calcite. It has 3 sets of calcite. We will see the picture of calcite and then you will understand that how we can say that it has 3 face of cleavages and all that. And then one set of cleavage, mostly the mica. And this is because of, it is having an internal atomic structure is sheet type atomic structure.

So we see only one cleavage. Then 2 sets of cleavage mainly in feldspar, pyroxene and amphiboles. And then we are having 3 sets of cleavage in calcite. And then we are having 4 sets of cleavage in fluorite. So this is the calcite is here. You are having 3 sets of cleavage and 4 sets are seen in the fluorite part.

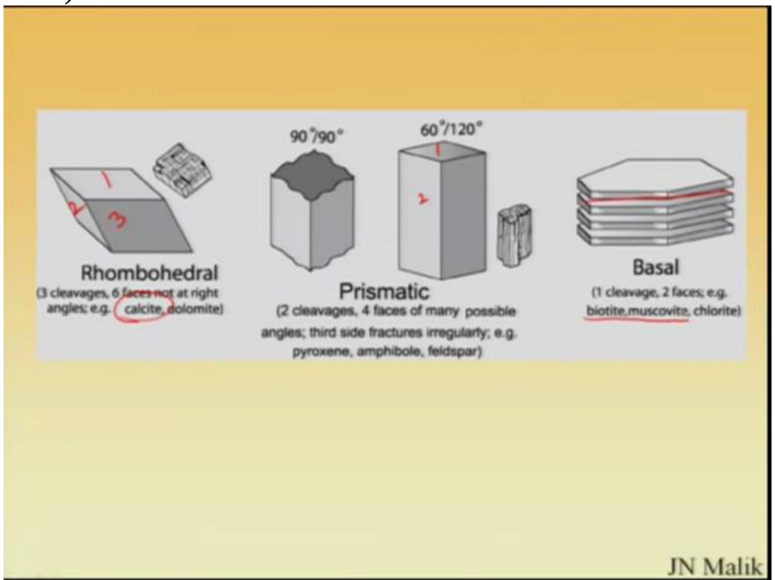
(Refer Slide Time: 4:13)



So this is one again an example which has been given. So we have 3 face. This is 1, this is 2 and this is 3. We are having 3 face of cleavages which you can say here in cubic system mostly. And example is halite we are having. And then, this we are having octahedral, we have 4 cleavages, 8 faces. Example is fluorite. Then we have dodecahedral, we are having 6 cleavages.

So here if you take, 1, 2, 3, 4, 5 and 6. So we are having 6 faces. So if you break this type of mineral then you will have, you can have, you can break the mineral in along the 6 faces. So we have 12 faces here.

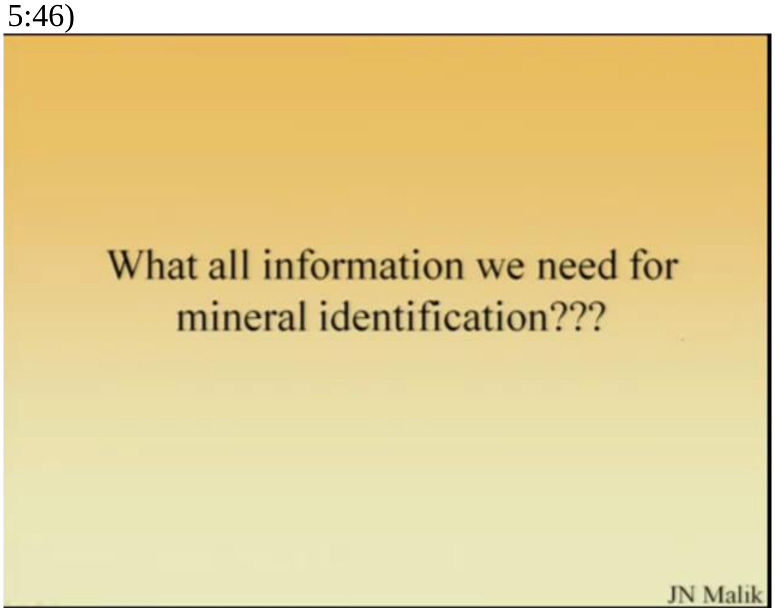
(Refer Slide Time: 5:04)



Then we have rhombohedral that is most commonly seen in calcite. So we have here we are having 3 sets of cleavages. So 1, 2, and we are having 3 here. And then prismatic, we are having only 2. This is 1 and this is 2, having the same on the either side similar to what we are looking at 3 sets in the…

And then we are having basal cleavage. We have the only this cleavage you will always find whenever you try to break. So mostly the mica family you will find and also the clay you will have one cleavage only.

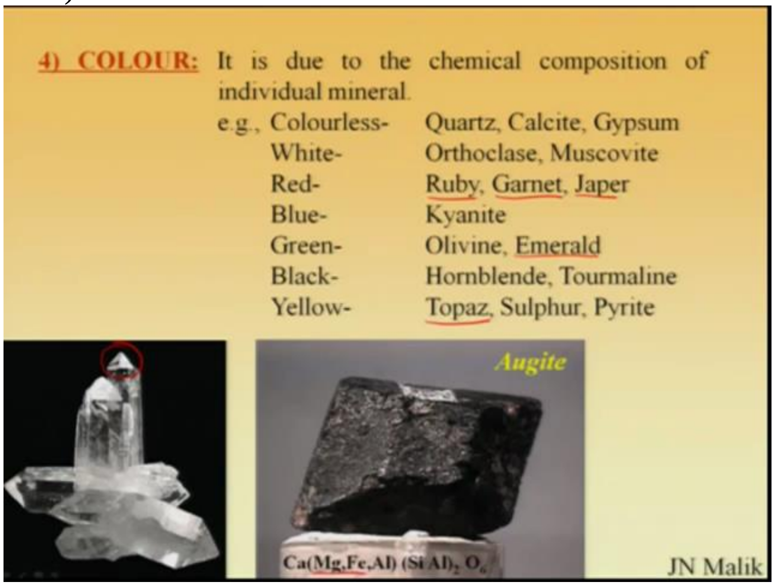
(Refer Slide Time: 5:46)



Then what all information we need for the mineral identification? This is important and this we will talk. Very easy, you will enjoy and we will try to fix up if possible to show you minerals, different types of minerals in lab if permits. I am not promising it but we can try. So let us see that what are the criterias we use to identify the different minerals.

So along with the crystal forms and the cleavages of course we will come one of the very important property but these are the other properties which we look at.

(Refer Slide Time: 6:24)



The colour. What is colour? It is due to the chemical composition of the individual mineral. Whatever has been reflected on the surface is because of the chemical composition of the respective mineral. For example, quartz, calcite, gypsum are colourless. They do not have any colour. So they will be seen. Along with the crystal forms which we are talking about, this is one of the important properties which you can use to identify the minerals.

Then of course, we will see another properties also. Then we are having white colour. We have orthoclase and microcline and Muscovite. And then we are having red-Ruby, Garnet, Jasper. Blue is Kyanite. Green is Olivine and Emerald. These are the minerals and some of them are we are having like these are all gemstone varieties.

Even we can take this one also. So these are all gemstone varieties of minerals. Then we are having yellow again Topaz is being used. And sulphur and pyrite, they are yellow in colour. So this is an example of Augite which is again comprised of magnesium and iron and aluminium. So it is dark in colour. So ferro-magnesium minerals we will have usually dark in colour.

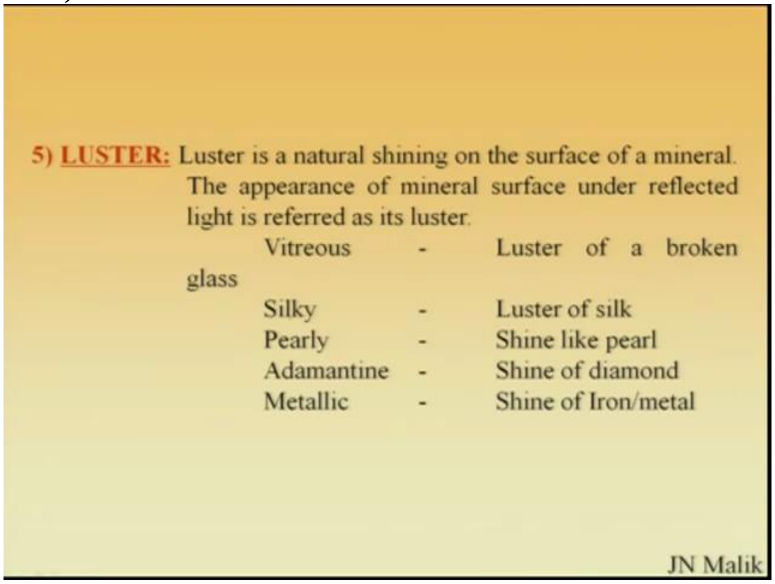
(Refer Slide Time: 7:41)

Then we are having another property which is streak. This is a very tricky part because this is in terms if you take, what is streak? It is a colour of the powder of the mineral powder. When a mineral is rubbed on a glazed tile or a porcelain tiles if you rub the mineral, it will give you a particular colour. And it is not necessary that the colour what you see of the mineral will be the same colour you will see as a streak.

It may have different. For example, Garnet is red but the streak is colourless. So you cannot say that fine. But these are the characteristic features of individual minerals which you can remember and of course practice will bring you and make you perfect. So if you remember this, you can easily make out that Garnet is colourless. It will give the streak is colourless actually.

And then epidote is green in colour but it is again, the streak is colourless. So you do not see any streak of epidotite. And then there is Epidote. And then augite is dark green in colour, dark green to black but the streak is greenish grey. And then haematite is again iron rich. You can have black or reddish brown. It gives red colour streak. And Allwyn is green in colour but it will give colourless streak or white. So this is one property. That is colour. Sorry streak. So 1st was colour, streak.

(Refer Slide Time: 9:25)

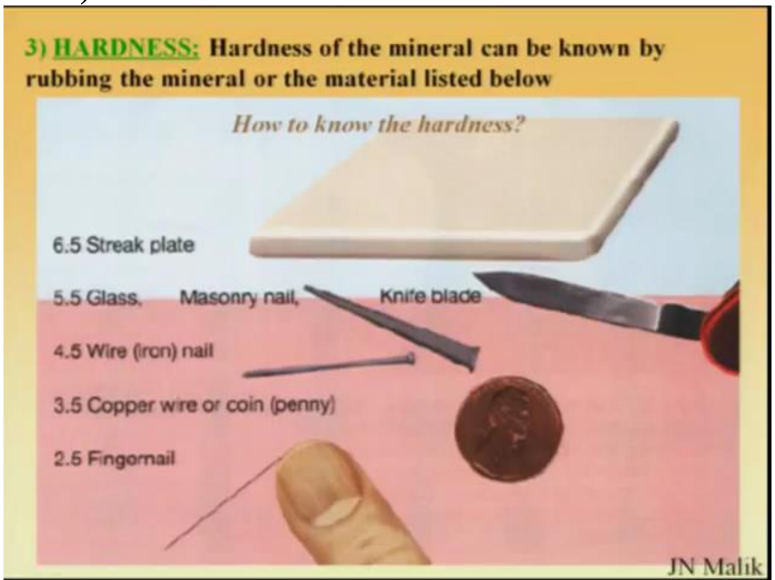


And then moving ahead, we have luster. So if you look at the mineral or if you if you hold the mineral and if the light falls on it, it will shine. So it will have a different shine. And then luster is a natural shining on the surface of the mineral and the appearance of the mineral surface and the reflected light is referred as its luster. So all minerals will have different luster.

For example, we say vitreous luster is the is the term which is being used is the luster of the broken glass. So if you have a broken glass and if you see that reflection, those sort of luster is termed as vitreous luster. Silky, luster of silk. So these are the terminologies which are being used to when we are classifying the minerals actually.

So vitreous luster, silky luster, pearly luster is a shine of the pearl very much similar. Then adamantine is shining of like it shines like diamond. Then we are having metallic luster, luster of, shine of iron. So if you break the iron and if you see that luster, it is very much similar to what we are looking at. So we have vitreous, we have silky, pearly, adamantine and then we are having the metallic luster.

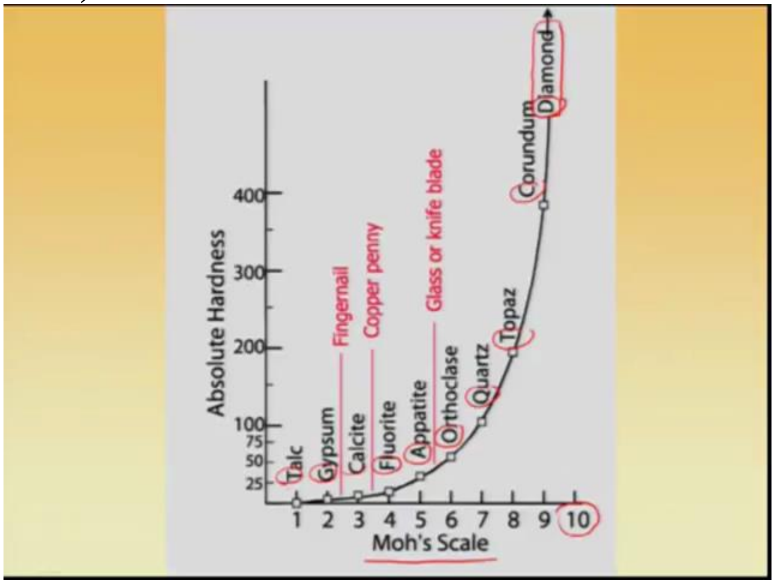
(Refer Slide Time: 10:40)



So this also can be one of the property. And then this is important again, the hardness. So hardness of the mineral can be known by rubbing the mineral on the material listed below. So you can either fix up the either with the help of nail, your fingernail or you can use the knife which is made up of iron and based on that, you can fix up your hardness of the mineral. So either you can use the porcelain the streak plate to look at the hardness.

The hardness is 6.5 for streak plate. The glass, you are having 5.5. Then wire, you are having 4.5 and 3.5 you are having copper and then the lowest is the hardness of the finger is 2.5. So you can use these different type of material to check your hardness. So you can fix up if you are rubbing any mineral and it gets rubbed on the streak plate then you can say that the hardness is less than the streak plate. That is that is what.

(Refer Slide Time: 11:48)

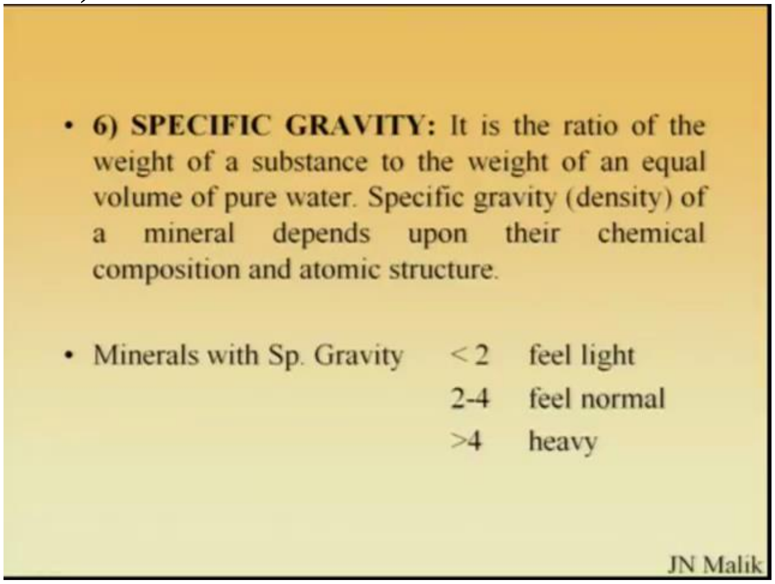


So this is the Moh's scale of hardness which has been given and this scale is showing the absolute hardness. And then you are having the hardness here what you see is up it goes up to 10. And the most hardest here is you are having diamond. So we have the most hardest mineral on the earth. So we are having the softest is talc. Now there is when we use to learn, we used to remember this in a way that the hardness scale.

So we say the we take the 1st letter of each mineral. So this is talc and then you are having Gypsum. Then you are having calcite. Then you are having fluorite. Then you are having Appatite. Then you have Orthoclase, Quartz, and Topaz. And then finally Curundum and diamond you are having. So if you take these letters you can learn this and remember very easily and you can say 3 German captains found a French, this is feldspar this is a French queen that can dance.

So you can remember in this way the whole scale of hardness. So the few most commonly occurring minerals if you take, you are having feldspar and you are having the Quartz. So you can use that. This Quartz is having around 7. And then you are having so you have talc, Gypsum, calcite, fluoride, appatite, orthoclase is a feldspar group of mineral. And then you are having Quartz, Topaz, Curundum and diamond. So this is another criteria to identify the minerals.

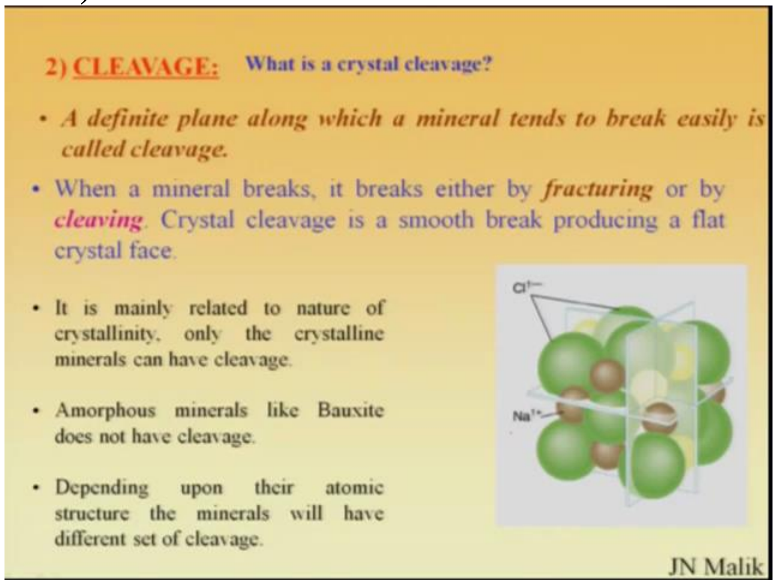
(Refer Slide Time: 13:48)

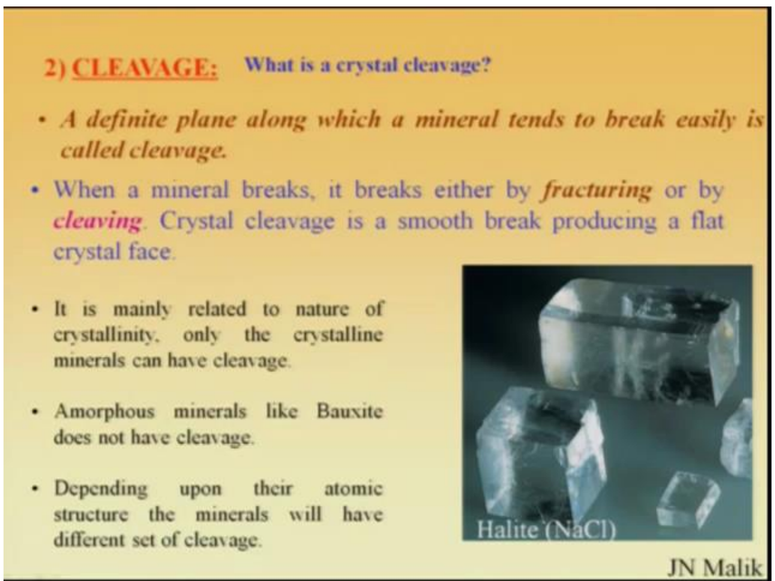


And then you are having specific gravity, the heaviness of the mineral. So specific gravity is the ratio of weight of the substance to the weight of an equal volume of pure water. So then you can you can measure the density also. And again, it depends on the chemical composition and the atomic structure of the mineral.

So mineral with specific gravity less than 2 if you are having then you can say you will feel light. But if you are having 2 to 4, you will feel normal. And if it is greater than, then you can see heavy. Then coming to for example, so the haematite and all that will be heavier one. So specific gravity you can you can check and you can also try to note down when you are characterising different minerals.

(Refer Slide Time: 14:37)



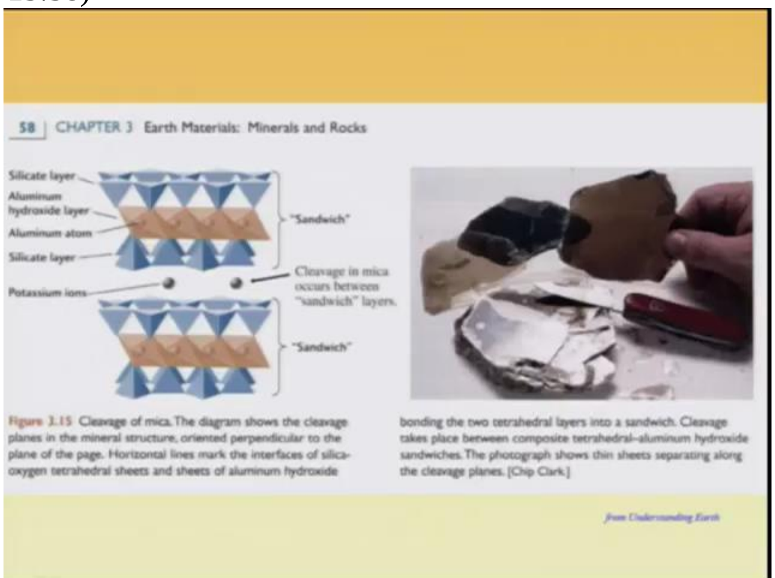


Then you are having cleavage as we were talking about that cleavage a definite plane along which the mineral tends to break. And when mineral breaks it breaks either by fracturing or by cleaving. So this is the cleavage which we will see that it breaks in the perfect way. Crystal cleavage is smooth smooth break producing a flat crystal face. So whenever you will break, it will break along the plane and that is your crystal face.

So it is mainly related to the natural nature of the crystallinity. Only the crystal minerals can have, crystalline minerals will have amorphous mineral will not have cleavage. So for example, bauxite will not have any cleavage because they are amorphous in nature. So depending on the internal atomic structure, the mineral will have different sets of cleavage which we have talked about that 2 sets of cleavage or 3 sets of cleavage and all that.

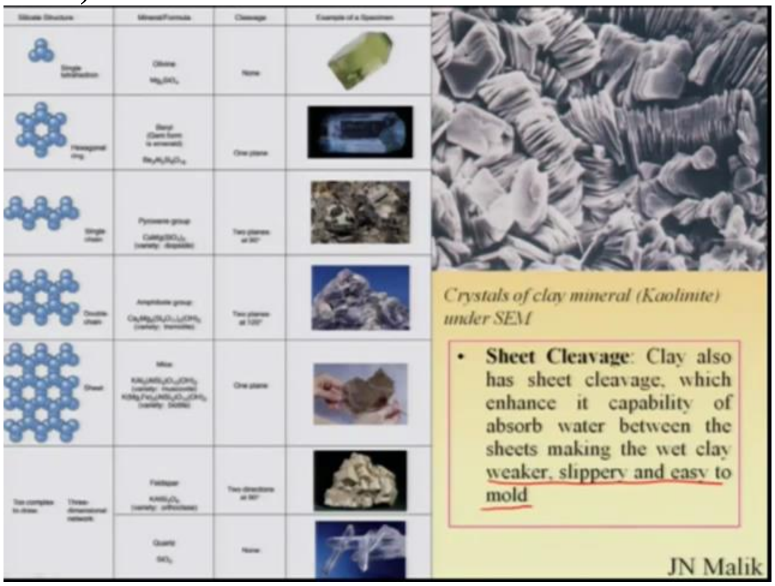
And this is an example of halite. So based on this what we are having, the sodium and calcium. You are having chlorite. Then you will have different form of this. So this is having the almost like sodium chloride is having halite. And you have 3 sets of cleavage here.

(Refer Slide Time: 15:58)



It is then you are having the clay or you will take the mica family, you will have the sheet or we can say the platy cleavage. So we are having the cleavage of mica mainly it is almost perpendicular to the plane. So we can say, whenever you will break it will break in a manner.

(Refer Slide Time: 16:22)



So this is just to show some examples. So you are having the silicon structures here which you can see. Then we were talking about single chain, double chain and all that. So you can refer to this. Then some of the minerals which have been listed here and then you are having the cleavage, what sort of cleavage you will have. And then either the cleavage will be at right angle to each other or maybe 120 degree to one another.

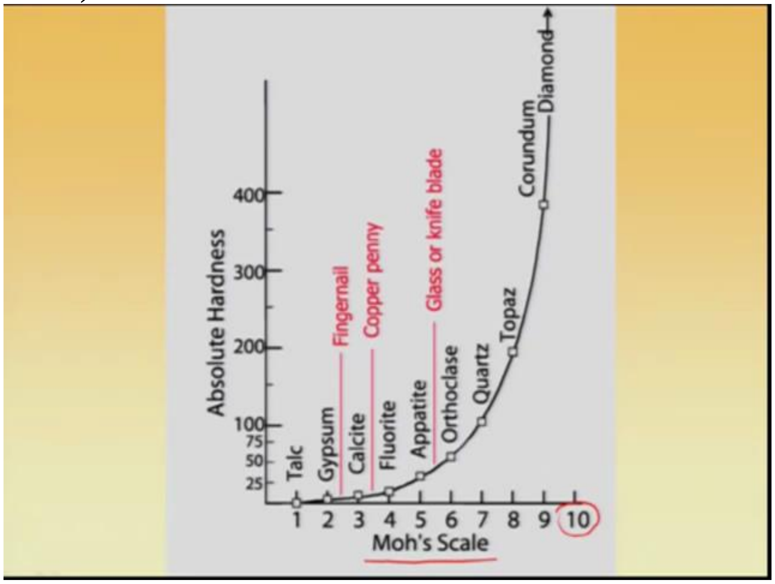
And then we are having either the cleavage will be in a single plane or not. This is mica and all that. And this is to show the cleavage in the clay minerals. So it will have sheet cleavage. So clay also has also has a sheet cleavage which enhances the capacity of absorbing. This is a very important property of the clay which you should remember that because of the it is typical sheet cleavage which has a capability of absorbing water between the sheets making the wet clay weaker, slipper and easy to mould.

So when you put water in a clay, you may might have towards during the younger age we all played with clay and this is one of the properties. But this is extremely important when we are talking about the sheer strength of the material. So if you are having clay material then if you you pour more water to it, then it will result into the slippery surfaces and it will weaken the rocks also.

So you should remember this part that what we are talking about in terms of the hardness we were talking about and in terms of the cleavage and all that. This is extremely important property of the minerals because like next lecture, we will be talking about the rocks. So this minerals will play an important role to provide the strength to the different rocks also.

So if you are having weaker minerals or the rock is constituted by weaker minerals then it will have less sheer strength as compared to the other minerals. So Quartz is comparatively harder.

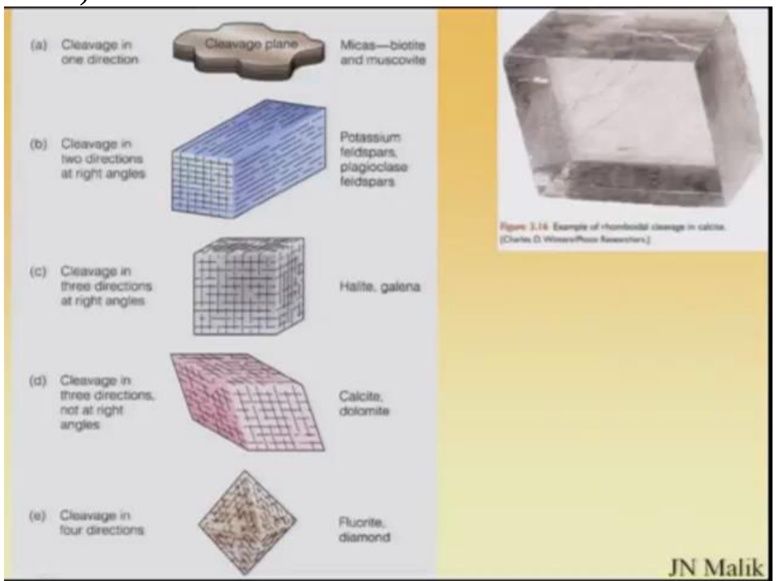
(Refer Slide Time: 18:43)



So if you look at the scale of hardness, so we are having Quartz which is harder. So it will degrade or erode, get eroded comparatively slow as what we see for the other minerals. So if you are having any rock which is rich in calcite. So for example if you are having limestone or something, it will be comparatively weaker than having the granite and all that. So granite is mostly we see is comprised of feldspar and Quartz.

And of course some minerals are also there in subordinate minerals which are like biotite and all that. But in short, the granite will be much more like component rocks or hard rocks as compared to the limestone and all that.

(Refer Slide Time: 19:31)



So these are again examples which have been given for example this is in calcite which is having again 3 sets of cleavage and we are having. So what we are talking about, the calcite here. So we have and then we will move ahead.

So we have cleavage plane, there is Muscovite and then we are having 2 sets of cleavage, 2 direction and then we are having halite and this 3 sets of cleavages, calcite and Dolomite and then we are having fluorite 4 sets of cleavage and all that.

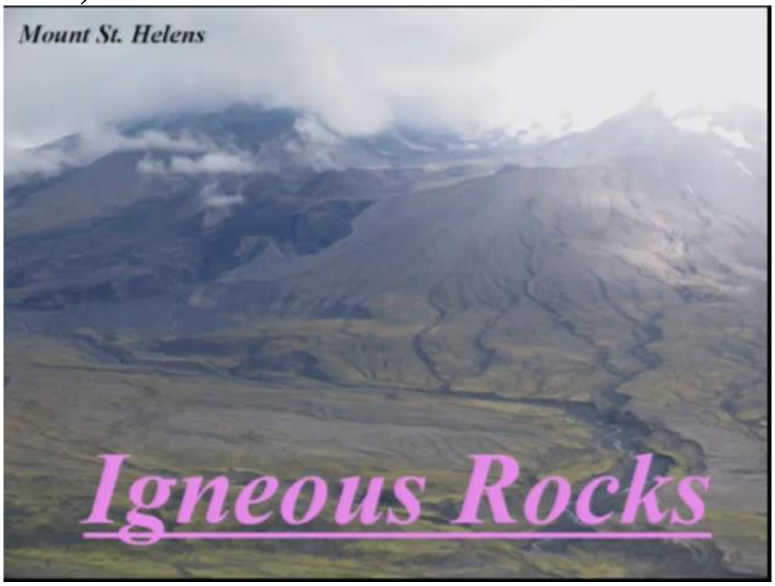
(Refer Slide Time: 20:09)

So this is what I was talking about that different minerals will constitute and result into the formation of rocks. So rock is an aggregate of different minerals. So here if you take granite then we are having orthoclase feldspar, we are having Quartz, we are having biotite, we are having flagioclase feldspar. So this all will contribute and will result into the formation of the particular rock.

Or we can say, the granite comprises these different types of minerals. So depending on if you take the hardness of this, then you can judge that this is comparatively harder as what we were talking about the other rocks or the minerals. So this is one part of the mineral. Now we will talk about the different types of rocks and the 1st type of rock which comes is the igneous rocks.

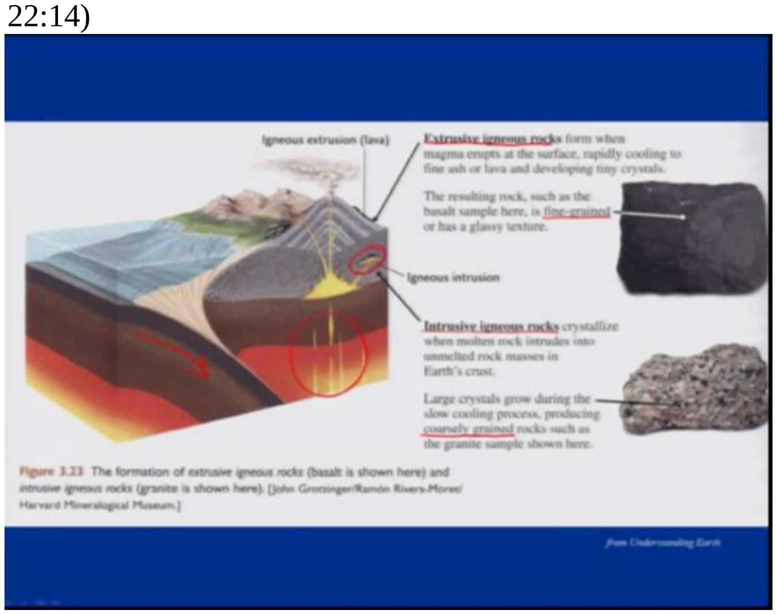
So we will talk about the igneous rocks today. And we will move ahead and then later on we will talk about the what are the different type of sedimentary rocks and the metamorphic rocks and all that. So let us get started with the igneous rocks what we are having and how they are formed, where they are seen and what are the…

(Refer Slide Time: 21:31)



So I will start with the picture of Mount St Helen and this is a very like having a tragic story behind this volcanic eruption which took place in 1980. This volcano is quite active in the Pacific belt and this is from US, Washington DC. This is one of the most active volcano on the earth. And the volcanoes of the source for the generation of one of the source for the generation of the igneous rocks. Because igneous rocks we talk about the magmatic eruption and all that.

(Refer Slide Time: 22:14)



So if we take in short what we learn here again, we are trying to compile everything here. We are having the tectonic plate. So we are having subducting plate the plate going down. One plate subducting below the another one. So this is the subducting plate oceanic plate and then we are having the either the we see this may be the oceanic or maybe the continental but in this case we see this is an oceanic plate.

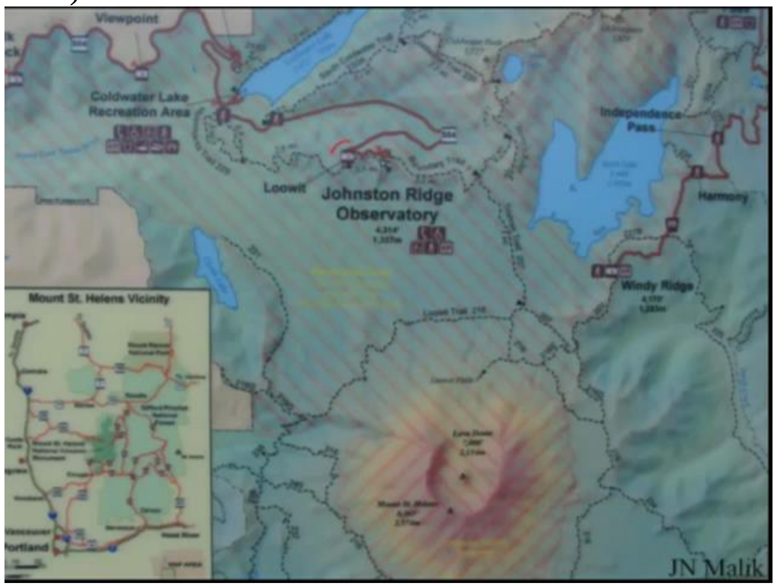
This is continental but this is an oceanic one here. And then melting is resulting into the eruption. So either the intrusion of magma, is not coming right up to the surface. So what we call the intrusive rocks which are formed by the intrusion of magma. And then another one which are coming right up to the surface, then we say these are the extrusive rocks. So igneous rocks, again the source is the melting of rocks, deep into the earth's surface and then coming right up to the, through the volcanic eruptions.

So we can classify this. Either it is extrusive rock or the intrusive rocks. This we will talk about that. Now, one very important part which you should remember is that the intrusive rocks are mostly coarser ones. The intrusive rocks are the coarser one whereas the extrusive rocks are fine grain. This you should remember. We will talk later also about this part but this is the important part that intrusives are coarser and extrusive are finer in nature.

(Refer Slide Time: 23:59)

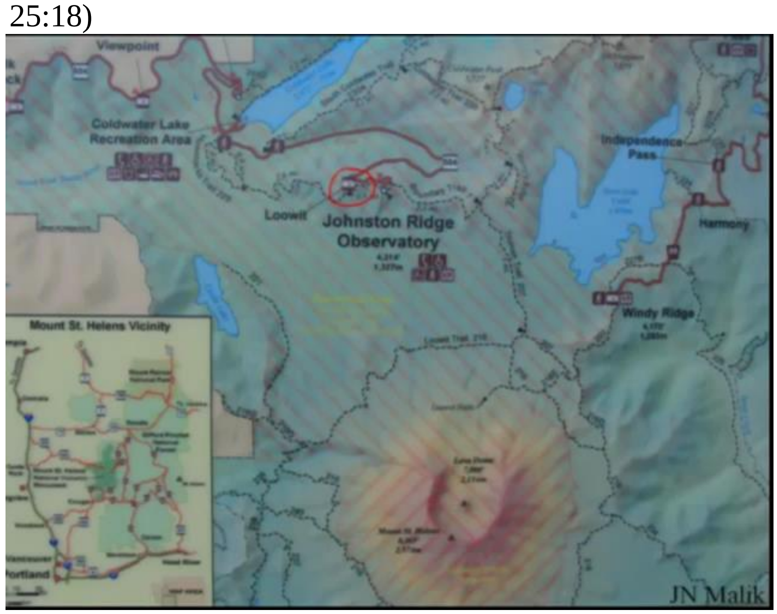
So moving ahead, again we will about the Mount St Helens. So this is the topography model which has been kept in US close to the Mount St Helens and this is an observatory which has been was been set up. And this observatory was been set up after the name of the geologist who was been killed during this eruption.

Refer Slide Time: 24:29)



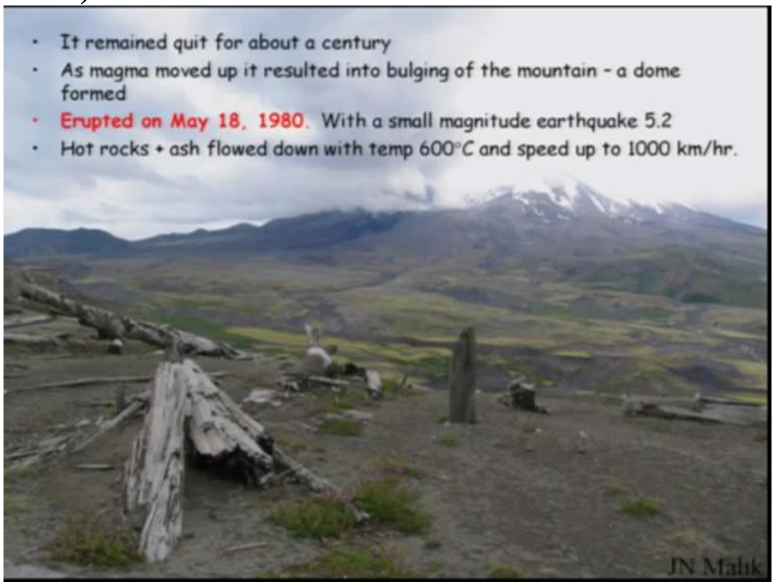
So this observatory is named after him, Johnston Ridge Observatory and he was sitting on this Ridge when this eruption took place. So he kept on watching that how the eruption was, the cone was behaving and then he was recording each and every movement of that. And then he never expected that the lava flow or the slurry which will come so high and even it will affect the ridge on which he was sitting. So this is the observatory which has been termed after his name. So this picture is right from the observatory.

(Refer Slide Time: 25:18)



So this we can look down towards the St Mount Helens conical form. So this is the crater which is the top of the St Mount Helens and it is partly covered by snow also. And that resulted into the formation Lahar flow which was extremely dangerous.

(Refer Slide Time: 25:47)



And what happened was this is the story that they have preserved, they have created a museum over there. They have preserved all the log of the trees which were been affected during that flow and these people visit, the tourists go there and they try to see that and understand the process what happened during that eruption. So it remained quiet about a century. So this is before the, story before the eruption of 1980. It remained quiet about a century.

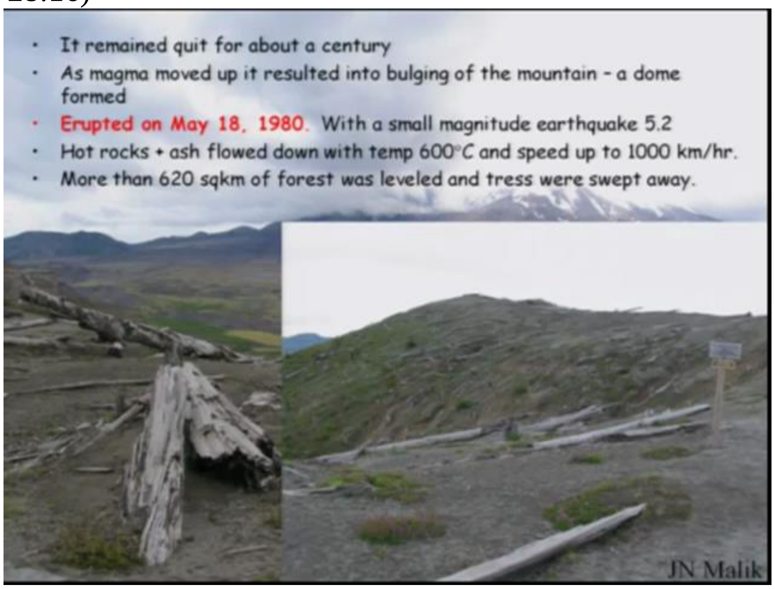
As magma moved up, it resulted into bulging of the mountain, a dome formed. So a dome shape was formed at the top of the St Mount Helens because of the intrusion which was coming up. And finally it erupted on May 18, 1980 with a small magnitude earthquake. And this is also important because the seismologists they keep on monitoring the earthquake cycles also close to the volcanic eruptions or or we can say the active volcanoes where they believe that this area will have eruption in future.

So they have the seismometers which have been installed and which keep on recording the earthquakes, even the small magnitude earthquakes. And if they find any change in the seismic pattern or the occurrence of the earthquake frequency if many earthquakes are occurring, then they will be able to at least predict that there is something happening. And this case of the Mount

St Helens it was very peculiar because they were watching the formation of the domes over the time.

So it was triggered with a very small magnitude of 5.2 and then what happened was that hot rocks and the ash followed down with temperature of around 600 degree centigrade. And the speed of this flow was almost like 1000 kilometres per hour. So that was and more than 620 km of the area of the forest was been completely level down and the trees were swept off. So this shows the direction of the flow. So, flow came from here and then it jumped on this ridge. So all trees got killed during that flow. So this is the direction.

(Refer Slide Time: 28:16)



If you can see this one, here all trees are been or the tree logs are been lined up in this direction. So this shows the direction of the flow actually. So they have preserved this to showcase that what happened in that period. So I will stop here and we will continue in the next lecture from this place. Thank you so much.