Introduction to Mineral Processing
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Lecture – 01
Importance of Mineral Processing

Hello, welcome everybody to the first class of this course. Actually in any introductory course everyone is curious to know that why should I take this course. So, I will try to answer that question first through some two modules that what is the importance and the relevance of this subject in the engineering domain.

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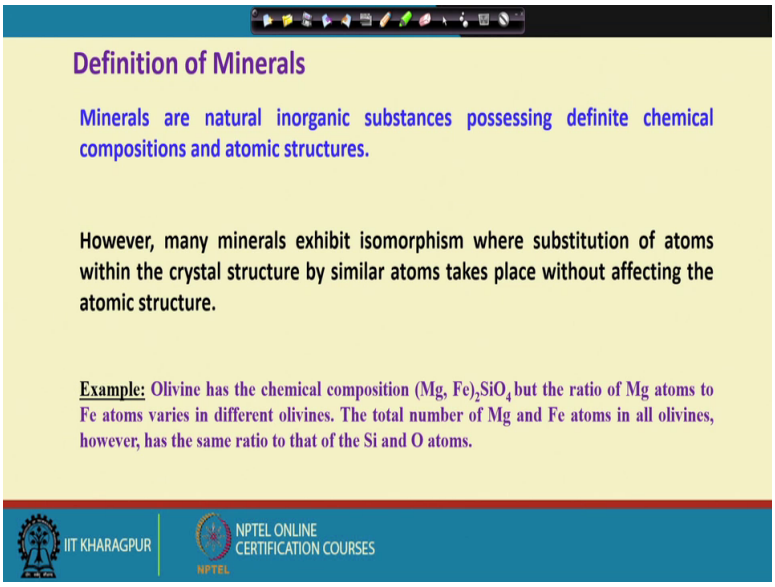

Now, before we go to the subject we must understand what is that we will be processing were saying that its minerals, but before that we should know that what are the definition of minerals. Now, if we look at this textbook definition is says that minerals are natural it has to be natural, is available in organic substances we should possess definite chemical compositions and atomic structures. I repeat it the textbook definition of minerals is that these are naturally inorganic substances possessing definite chemical compositions and atomic structures. Is it really true always? No, there are some exceptions. Like many minerals they exhibit isomorphism what are the mean isomorphism, this means that were substitution of atoms within the crystal structure by similar atoms takes place without affecting the atomic

structure it may look a little bit difficult to understand, but I am trying to explain it with an example.

Take the case of olivine, it is a mineral it has got the chemical composition that is MG, FE 2, SIO 4 there is a chemical composition of olivine, but if you have olivines from 3 4 different origins you will find that the ratio of these MG atoms to FE atoms they vary in different sources that is olivine coming from different sources. However, the total number of MG and FE atoms in all the olivines has the same ratio to that of that SI and oxygen atoms that is silicon and oxygen atoms.

So, what I am trying to say that that although the olivine has that chemical composition the fixed chemical composition, but the ratio of MG atoms to FE atoms they varying different olivines. And this may be the cases, but what we will see that the total number of MG and FE atoms in all olivines they have the same ratio to that of the silicon and oxygen atoms. So, when we get this type of properties in any mineral we call it that this is the process of isomorphism.

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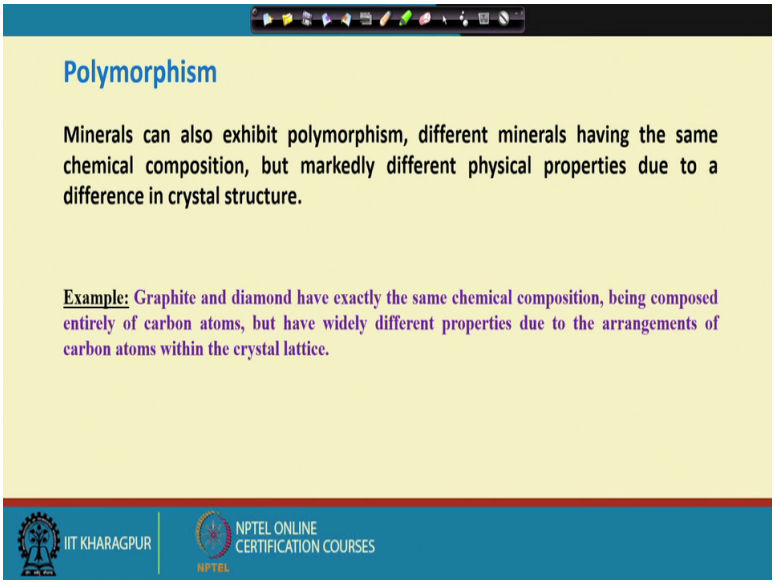

Similarly there may be polymorphism also, what is polymorphism?

Now, in this case the different minerals they may have the same chemical composition, but their physical properties could be different due to different crystal structure. When I give this example you will all say oh my goodness we all know this, like to graphite and diamond they

are exactly the same composition being composed entirely of carbon atoms. However, they have got widely varying different properties why. Now, because it is of the how the carbon atoms they are getting arranged in that crystal lattice.

So, that dictates the property or the physical property to be precise of that particular mineral. And when we see this type of characteristic into a mineral we call it is a polymeric prism it is a polymorphism. So, these are only the exceptions, but on an average we go by the textbook difference say actually textbook definitions of minerals.

Now, interestingly the term mineral is often used in a much more extended sense to include anything of economic value which is extracted from the earth. So, although by definition they are not mineral, but we group them that is their productivity their applications their economics related issues they are all tabulated with the conventional minerals. Examples a coal, chalk, clay, granite, they all do not come under the definition of minerals like coal for example, coal is not purely inorganic it has got inorganic part it has got organic part we called it we call it minerals and mistrals. But still our mining engineers they are trained in mining of coal also as well as the minerals. Even the mineral processing engineers who are busy in processing minerals they also have good understanding about how to process the coal.

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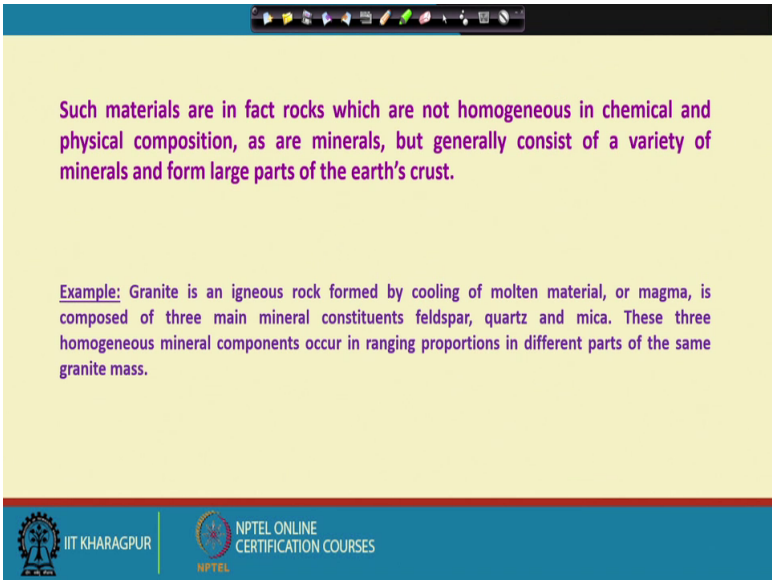

So, what are these materials basically? So, these materials are in fact, a rock sometimes we call it stratified rocks which are not homogeneous in chemical and physical composition as a minerals do, but generally consist of a variety of minerals and for large parts of the earth

crust. We look at another example and it is granite. What it is? It is igneous rock formed by cooling of molten material or magma and is composed of three main mineral constituents called feldspar quartz and mica. These 3 homogeneous mineral components occur in ranging proportions in different parts of the same granite mass. So, what will happen? When the proportions are different the properties the physical properties of granite they also vary.

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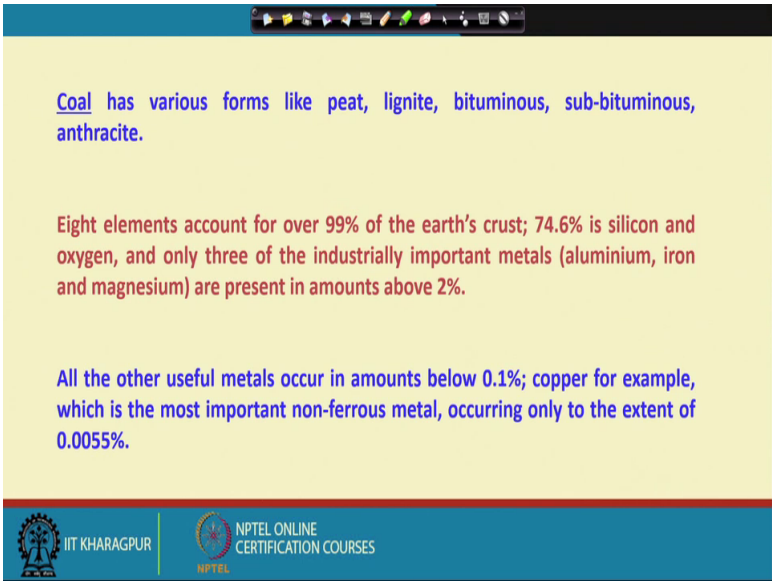

Look at coal, depending upon its age that is age of formation it is a million years not in few years and what kind of processes they have converted our some of the materials into coal that dictates that what will be the physical property of this coal. So, relatively immature coal I say, there is around 50 million years. So, something like that we say they are called peat, relatively more matured we call it lignite or brown coal then depending on their your because the coal formation is basically a combination of different processes as the geology say is a prolonged heat and pressure for millions of years. And when the goal becomes more mature we call it bituminous coal then it has got some subdivision we call it sub-bituminous and they knew you are bored anthracite also.

So, why do you classify them? Because their physical properties like are different based on the geological formation their maturities and all this. Interestingly if you see that what constitutes our earth crust that only 8 elements they account for over 99 percent of the earth crust, is it not fascinating. Out of this 8 elements 74.6 percent is silicon and oxygen and only three of the industrially important metals like your aluminum, iron and magnesium are

present in amounts above 2 percent in the earth crust. All the other useful metals they occur in amounts below even 0.1 percent for example, you take copper. If the copper is evenly distributed which is one of the most important nonferrous metals in the earth crust its concentration is only 0.0055 percent.

So, when they are basically distributed like these that is what the thin concentration that is if they are distributed evenly all throughout the earth crust it will be possibly in an economically it would be impossible to extract them and just imagine that if we cannot extract them what would have been the civilization.

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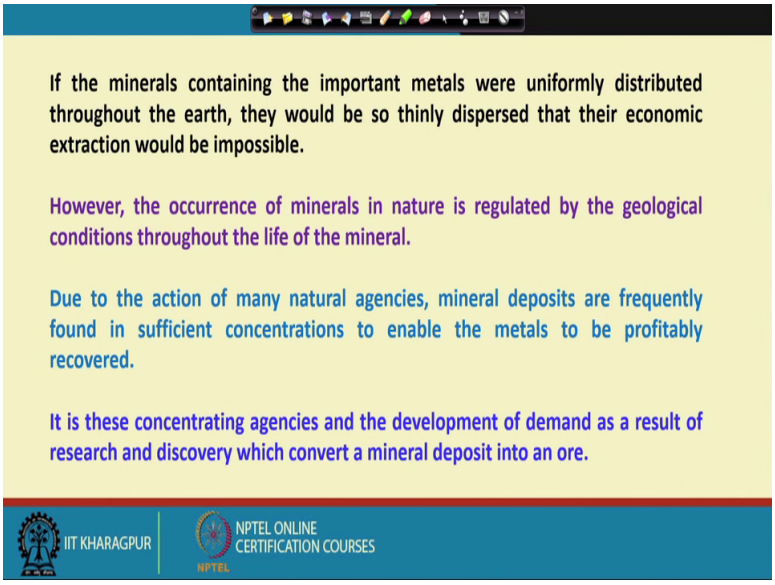

But we are very fortunate that these geological conditions throughout the life of the mineral they vary and this occurrence of minerals in nature is regulated by these geological conditions and due to the action of many natural agencies like your rain your say you, it is basically the volcanic eruptions they new storms, floods and all this. So, they carry these minerals certain minerals and they deposit into some other place where they are being concentrated.

So, that is how the thinly dispersed valuable minerals the nature has already helped us to get them concentrated at different zones and because of that it is now possible to extract them from the earth crust. So, it is a responsibility of the geologists to identify those resources that were had they are basically concentrated, they now are mining engineers, they plan that how to take it out and then say for an economically viable manner from the earth crust. Then it is

coming to the mineral processes that is how do I upgrade the quality of that. So, this is how this cycle goes on.

So, basically the first concentration process has been done by the nature itself. Now, what happens with the development of the new discoveries and as a result of research we could find many mineral deposits which with the existing technologies we say that they are basically amenable for upgradation for the further extraction processes. So, that we get our valuable metals out of that. So, and that is that we call it the ore.

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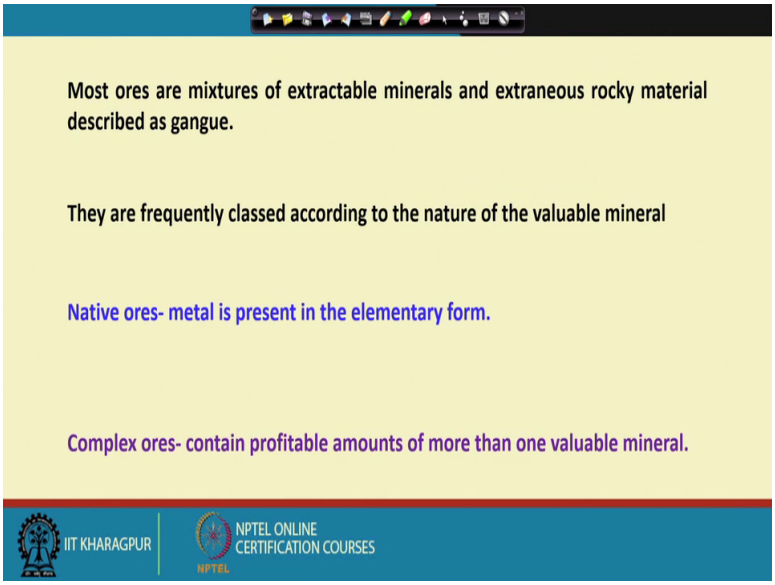

So, when a mineral qualifies for an extraction process and that is being dictated by for that the economics will be in favor of that or not. So, then we say that mineral is at ore discuss more on this. So, you will look at the ores the most ores are mixtures of extractable minerals and extraneous rocky material described as gangue. To qualify as an ore it is not necessary that you have to have only that mineral only I will give examples. However, you have to mind some of the extraneous rocky materials also are our strategies that let us mined it first and then we will discard the gangue materials, a new course of time with economically viable manner.

So, based on the natural occurrence of this valuable mineral we use different terminologies. Like sometimes we say that it is a native ore native ore means the metal is present in the elementary form, elementary form means like example is gold we call it is a native ore. Then in some formation we say that we see that that there are deposits where you have bought

more than one valuable mineral available and when we deal with that we call it as a complex ore. Like your copper lead zinc ore, you mind all the source together and then we try to separate it out by subsequent processes.

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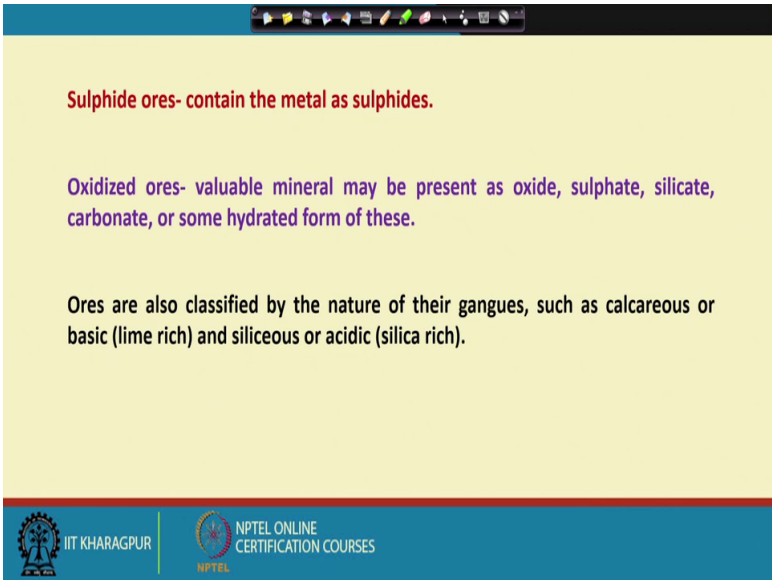

Then many times depending on the characteristic depending on the chemical compositions of that ore we also apply certain terminologies like we call it sulfide ores that is when the metal bearing mineral is basically sulfides like CUFES 2, we call it chalco pyrite. So, that is a sulfide mineral.

Then when they are in oxidized form, we call it that they are oxidized ores. Like we have got this oxidation state maybe in the oxide ore like FE 2 o 3 call it hematite, we may have sulfate, we may have silicates, we may have carbonates or some hydrated form of this. So, all this will group together into under oxidize ores. Why do I do it? What I know that this is a sulphide ore. So, automatically the strategy comes into our mind that if this is a sulphide ore we should do this this this, we should first try with this this this. However the rock side ore we should do this this this based on our past experiences. And we also have an idea that what kind of waste materials we are going to handle, what kind of environmental problems we are going or handle, are going to face. So, all these sorts of something like your priori information we get when we categorize the ores in this fashion.

Sometimes the ores are also classified by the nature of their impurities that is the associated gangue materials which we do not want, but it is unavoidable we have to mind that, as I had

already explained. So, then based on the characteristics of the gang materials sometimes we term them as calcareous like your calcareous prosperity codes. So, when I am saying calculus; that means, we have got CSO 3 that we have got limestone indeed mineral or the coal. Sometimes we call it your basic that is your lime rich and sometimes we call it siliceous or acidic that is silica rich.

So, again the objecting is same that is when you know that these the gangue materials are calcareous or basic or siliceous or acidic we have our own strategy to try for us that how do we deal with this.

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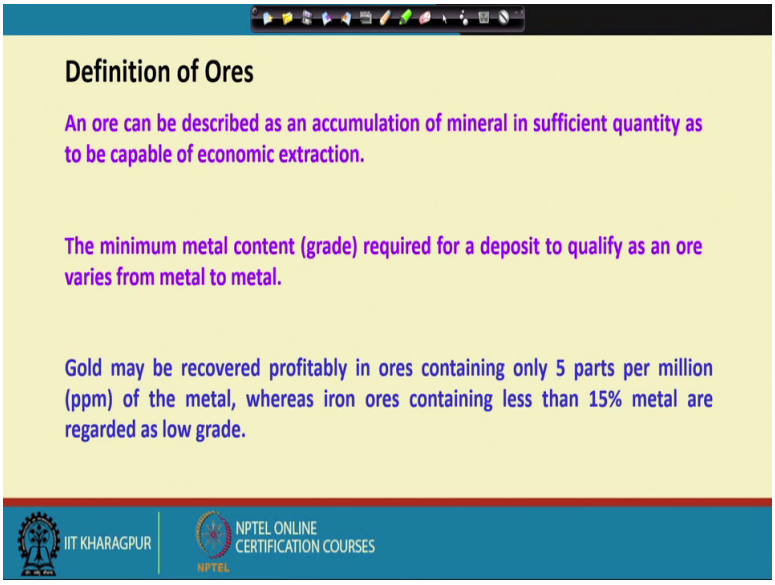

Finally, so what is that textbook definition of an ore? So, an ore can be described, an ore can be described as an accumulation of mineral in sufficient quantity as to be capable of economic extraction. So, when we start mining something, who must ensure because mining is basically business where to make profit out of that, if our entire mining operation why do mine it we are mining it to sell it who are my customers mostly the metallurgist. So, what is their requirement I must know that, and what is the value I will be getting, what is the price I will be getting, how much is the cost I have put in the mining and what is the return on investment if it is positive then only we say that this is an ore. So that means, a mineral to qualify as an ore has to have sufficient quantity has to be capable of economic extraction. So, here I have saved sufficient quantity. So, you may ask me, sir what is the sufficient quantity 5 percent, 10 percent, 50 percent yeah that is a genuine question.

Now, this minimum metal contained we use one word that is called grade or that sometimes SA content. So, the minimum middle content required for a deposit to qualify as an ore it varies from metal to metal. What does it mean? Will be surprised to know that gold may be recovered profitably in ores containing only 5 parts per million of the metal; that means, in 1 ton of material whatever you mind if you have 5 grams of gold that qualifies for a very good quality gold ore.

Whereas, for iron ores containing less than 15 percent metal as of now it is regarded as a low grade. So, to sum up how much is the how much quantity is the sufficient quantity? I have rewritten it by sentence that it varies from metal to metal. What is the market price of that? So, you see that in case of gold even 5 ppm concentration in 1 ton we say that this is a ore whereas, for iron ore even 15 percent metal contained does not qualify to when ore.

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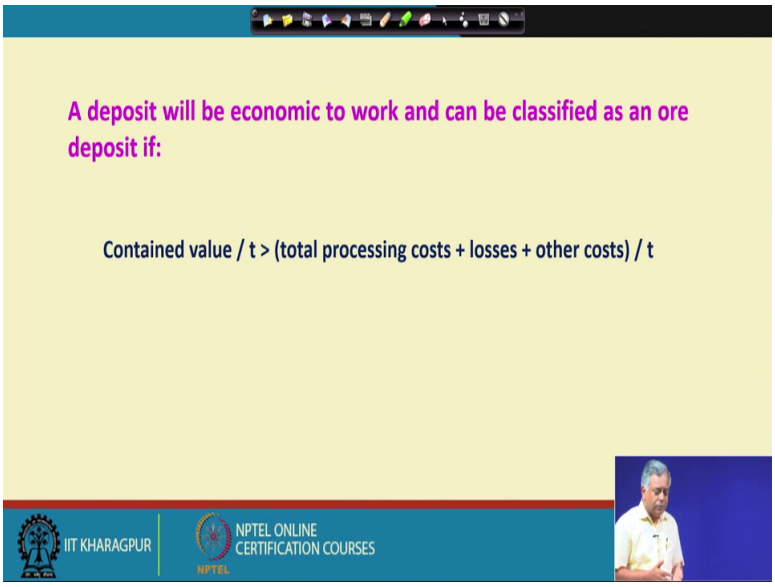

So, what is the definition basically the mining engineers or processing engineers they apply or even the geologists they applied that whether this is the mineral deposit or this is a ore. So, it deposit will be economic to work and can be classified as an ore deposit if the contained value per ton is greater than total processing cost it includes, geological exploration, mining, mineral processing, even metallurgical extraction plus in the process how much you are losing that is the losses and other cost per ton. So, ultimately if I make a profit out of this then only it qualifies to be an ore.

So, in my next lecture I will explain this a much more detailed that one of these total processing cost losses and other cost and what is the role of mineral processing.

Thank you very much.