Introduction to Mineral Processing
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Lecture – 03
Importance of Mineral Processing (Contd.)

Hello, welcoming you back to this third module of this course. We were discussing about the importance of mineral processing and basically the role of mineral processors also you can say this.

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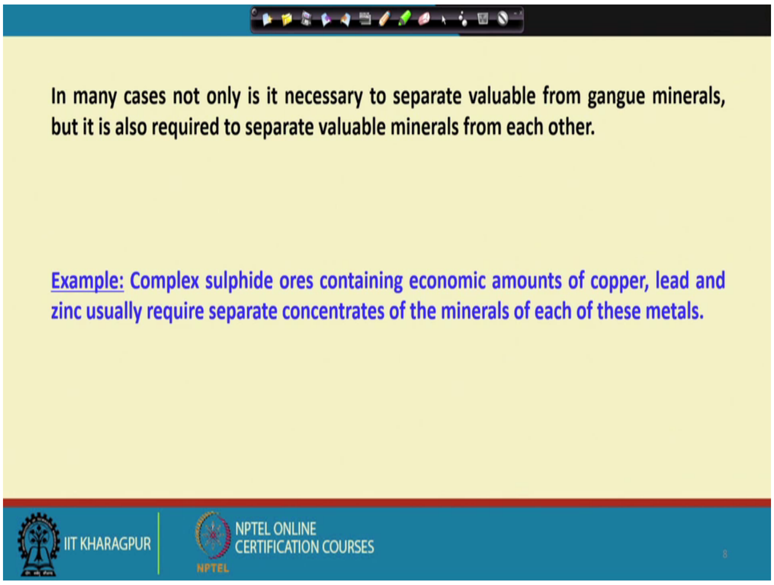

Now, we continue this topic, we see that it is not only the upgradation of a particular metal bearing mineral in a particular deposit that is the responsibility of mineral processor. Many times you have an ore which has got that is a complex ore we have already discussed it. Now there it is necessary also to separate valuables from the gangue minerals, but it is also required to separate valuable minerals from each other. What I trying to say that that although the prime focus of a mineral processing engineer is to remove the gangue materials selectively without losing much of your wanted materials. But another purpose of mineral processing is also that how do we even upgrade the quality of individual ores which are basically available in a particular deposit. For example, like complex sulfide ores containing economic amounts of copper lead and zinc; that means, this ore has got three wanted metal bearing minerals where is your copper lead and zinc copper is in the form of mostly in the CuFeS 2 lead is pbs and this is the zns.

Now, you have concentrated you have removed the gangue materials, but now how do we separate out these CuFeS 2 problem pbs and pbs from zns and the vice versa because if they are in the mixed conditions even you cannot put it into a furnace. So, before we put them into a smelting operation they have to be segregated. So, this is also a another challenge to the mineral processes or that is possibly to the mineral processes to segregate them into a specified amount of availability of that material into that particular portion. That means, we are not only improving the relative percentages of the ore valuable minerals in a complex ore, but you have to segregate them from each other.

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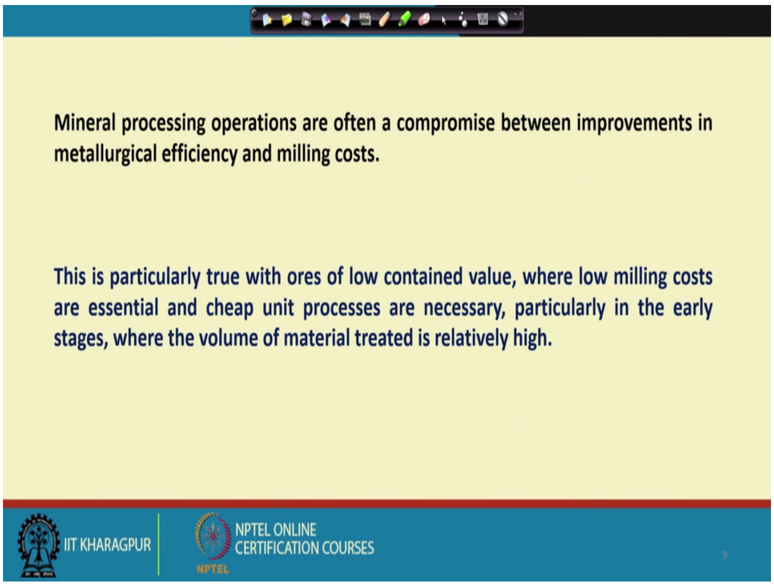

Mineral processing operations are often a compromise between improvements in metallurgical efficiency and milling costs. Why I said compromise scientifically it may be possible to separate them do it in the purest of its form, but what is the efficiency of that that is how much was available in the mind ore and how much you are basically recovering that we will come very soon.

So, we call it the metallurgical efficiency that is if I have x percentage of copper in an ore what is the metallurgical efficiency and to achieve that x percent copper into that ore what is the milling cost means what is the processing cost. And again if I have y percent of that what is the processing cost and what is the metallurgical efficiency. Like that we have to do the different permutation and combinations and we have to arrive at the compromise state which will balance the metallurgical efficiency and the milling cost in a situation where we get maximum benefit or their maximum economic return.

This is particularly true with ores of very low contain value where low milling cost are essential and cheap unit processes are necessary; that means, when the ore grade that is the availability of a particular metal bearing mineral in a particular ore is less than the challenges are more to minerals processing purple. Because you cannot spend much money on the entire processing operations, but you have to fulfill the targeted quality specified by your client that is mostly the metallurgist. And what will happen. That you have to say suppose I want to produce one ton of a particular metal, so how much of ore basically I have to pour it into a furnace and what is the availability of that into the mind ore. So, these are all related and which will tell you that what is the volume of material to be treated.

I think it will be better explained in this way. It is suppose I have got a copper deposit having 0.6 percent copper, but I want to produce one ton of copper into by smelting operation. So, the amount of ore to be processed into the mineral processing plant will be more in comparing in comparison to and another ore deposit where you have got 1 percent copper. So, the constraints are when the ores are of low quality or say low grade then you have to process large volume of material per unit time as well as you have another constraint that you cannot spend much money because the metal what you will be able to sell that will ultimately bring that the money you have put in and if that is less than what you are putting into the processing and mining and your metallurgical extraction; if the economics does not flavor then that particulate mineral deposit will not qualify as an ore.

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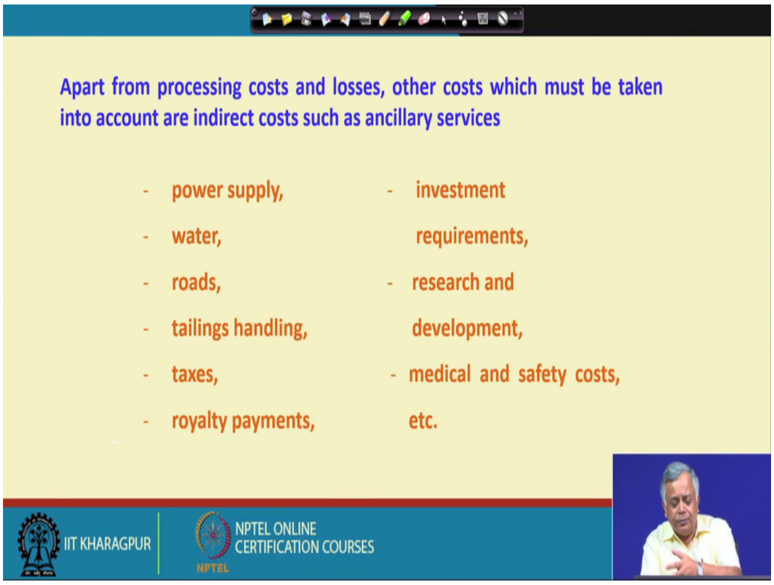

Apart from processing costs and losses other cost which also must be taken into account while designing a mineral processing operation, these are indirect cost such as ancillary services what are they. It is the cost for your power supply do you have a captive power plant or you are getting this power from a distance. Water because most of the separation processes we use in mineral processing they are water based. So, whether they availability of water is there and how much cost you have to pay for that your water.

Roads sometimes you have to construct your own roads for your material transport within the mine site. Tailings handling when it is you have a low grade ore definitely have to handle a large volume of material which will go into the waste we call it tailings that will also add cost to your entire processing operation. Then what are the taxes, the local taxes the government imposes it varies from state to state, it varies from country two countries, you must take into account of these taxes also. Royalty payments are you using any technology for the separation processes which they pay, which are basically patented then you have to pay royalty. Many times the governments they ask for royalty payments.

Then what will be the capital investment required as the capital expenditure for your land cost or your equipment cost like that. Then research and development, because your mind ore quality when you have designed a mineral processing plant that is based on if the availability of the mind ore at that time; now with time there will be lot of variation in your mind ore quality. So, it is always the research and development which can help you the how to fine tune your operations to optimize the separation processes when your raw material that is the feed material to the processing plant itself they are very in their basic physical characteristics where we do not have any control. Then medical and safety costs salary toward human resources and all this cost you have to take into account.

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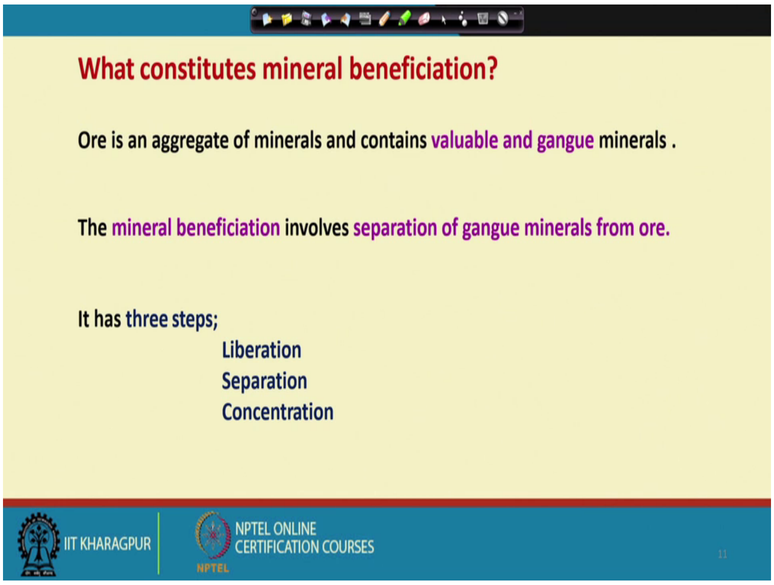

Now, we were talking about mineral beneficiation mental processing all this. So, what constitutes exactly the mineral beneficiation? We have already discussed that ore is an aggregate of minerals and contains valuable and gangue minerals. Let me repeat it the mineral beneficiation involves separation of gangue minerals from ore I hope it is understood. What are the broad steps for that there is the sequence of operations. So, broadly it has got three is major steps one is called the liberation. Liberation means that when the in a mind rock or in mind ore your gangue and your wanted materials they are in a locked state, how can I use their physical property difference to separate them.

So, we have to first liberate them from each other how do I do it that is by breakage that is you have to break it. How far will break? That is being dictated by this your liberation behavior of that particular mind ore, will discuss further on this will elaborate it. Then the separation processes they are liberated, now how though I separate them. So, these are the separation processes which is the heart of your mineral of any mineral processing operation. Then is the concentration processes how do I further improve this quality that is you have removed majority of the gangues, but still whatever you are left with that is not at par with the quality specified by your colleague from metallurgical industry. So, you have to fine tune the quality of that these are basically the concentration processes we call it.

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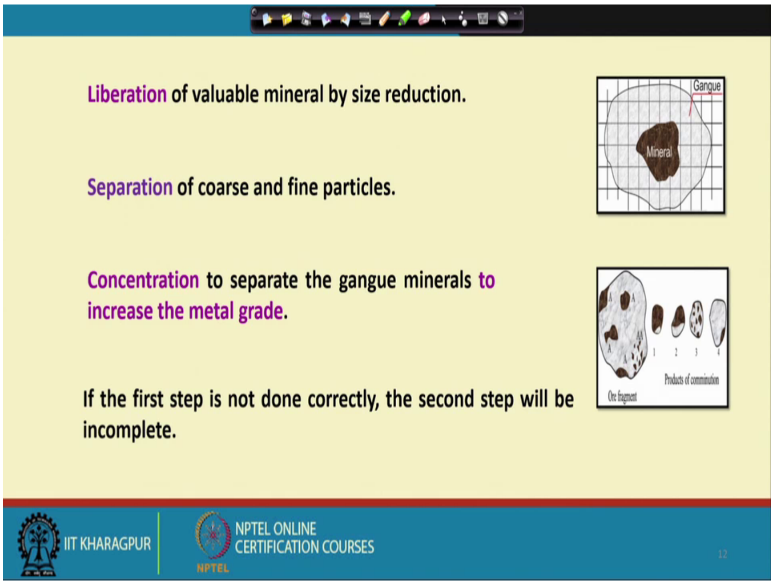

Let me explain this a bit further that what is liberation; I would try to show you that suppose I have an ore like this. So, this is my wanted material that is the wanted mineral and surrounded by gangue materials. Now, this is a single particle. Now if I break it now, what will happen now we may get some material like this where I have got more concentration of this darker particles and less percentage of the gangue particles there is a gray part. In another one it may be 50-50 distributed, in another particle you may find that in a gangue material your wanted mineral are basically very finely disseminated or distributed. In another material you have got the relative percentage of your mineral bearing material is very less or whether it is basically having more or less the gangue materials.

So, what will happen now? In none of the cases we are getting a free state you have something with that, now what we are talking about in the previous lecture what we are discussing that mineral processing operation you lose some of your wanted materials also. Like now if I target to discard this above also losing some of my wanted material and that is the losses we are talking about. When we are saying that this is my material what I wanted, but still it is not in the purest form I have some gangue material also. So, how much of gangue material is acceptable that is dictated by the middle adjust they inducers, they decide based on their existing technologies that is how far they can accept it. So, this is in short, so the liberation is basically promoted by a process that is called a breakage process or we call it commination processes.

The separation of coarse and fine particles like when we are breaking it suppose we have got very small particles here and we have got coarse particles, like we have got 50 mille meter particles as well as 50 micrometer particles. Now, the process what we will adopt for separation many times it is dictated by the size of the particle what we will be dealing with.

So, the techniques or the technologies which are best suited for a relatively coarser particle they may not be that effective while treating very fine particles or in some cases we were find that the relatively finer particles suppose I have got play wearing materials into iron ore. So, when you try to cross it you will find that these clay bearing materials or minerals then he put to very fine sizes and we know that that is not my wanted material. So, I simply discard it. So, how do is a separation between the based on the differences in their sizes we can have screening operations, but my dear friend please try to understand that we have to handle large quantity of material per unit time.

So, that is also a challenge that what kind of screens will be using and how do I improve the efficiency of that there is also a part of mineral processing. Many times it may be a requirement by many industries that your raw material quality may be good that is your mind ore grade may be good, but they want a specified size that is also the task of the mineral processing people a good example of iron ore industry. Metallurgist they want iron ores to be charged into a blast furnace that should be within 14 millimeter to 10 millimeter particles they call it lump, but when you are mining you do not have much control on this sizes you have got below 10 millimeter particles also, you have got particles coarser than 40 millimeter, but they want only in between 40 to 10 millimeter particles. So, that is also the responsibility of the mineral processing people that how to have a separation at that particular size range with maximum efficiency.

Then the concentration processes to separate the gangue minerals to increase the metal grade. Like now say suppose out of these four particles if I describe if I discard these two particles why should I discard now this these particle a very less quantity of my wounded material I can simply discard it here it is interesting you see that my wanted materials may be the relating percentage is much more higher than this one, but they are very finely disseminated. So that means, if I want to upgrade it I have to further break it, but what is the cost of energy what I will need as an input to break this if that is more than the pricing will get it by selling this metal out of this metal bearing particles then economics is not in favor. So, we may also discard this.

Now, say suppose we target based on these economic constraints that we try to separate these 2 particles from the mixture of these 4 particles. How do I separate them? This is you may say that this particle I can separate based on a size difference, but what about this from this there almost of similar size. So, you use different techniques that is what are the physical property differences whether they have got a difference in the densities or some other properties which we will discuss in due course of time.

Now, if the liberation step if these step is not done correctly the second and the consecutive steps will be incomplete because if the mineral particles are not liberated enough to an extent to meet the quality requirement you cannot achieve your targeted quality into your product by any mineral processing operation, the conventional mineral processing operations. Let me explain a bit more that is the liberation by size reduction.

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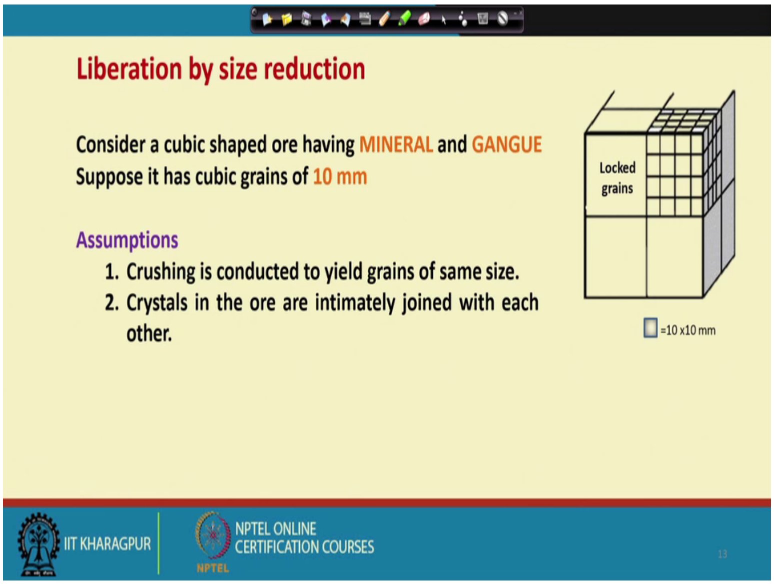

Let us consider a cubic shaped ore having mineral and gangue these are all having a mixture of mineral and gangue and support it has a cubic grains of 10 millimeter each this is a grain sizes I am talking about. Let us assume that we have crossed this material this entire cube to heal grains of same size. Crystals in the ore are intimately joined with each other they are intimately locked that is your mineral and gangue materials.

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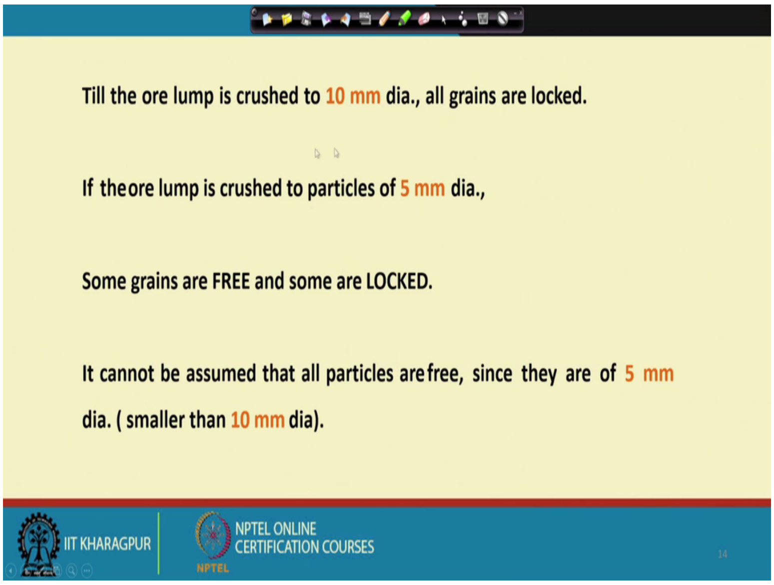

Now, as long as we are crushing and unless we reach to 10 millimeter dia all grains are locked that is the characteristic of that particular deposit which we are discussing as an example. Now, suppose we further cross it to 5 millimeter dia. So, what will happen? Now, some grains may be free and some may be locked, but it cannot be assumed that all particles are free since there of 5 millimeter dia we cannot guarantee that.

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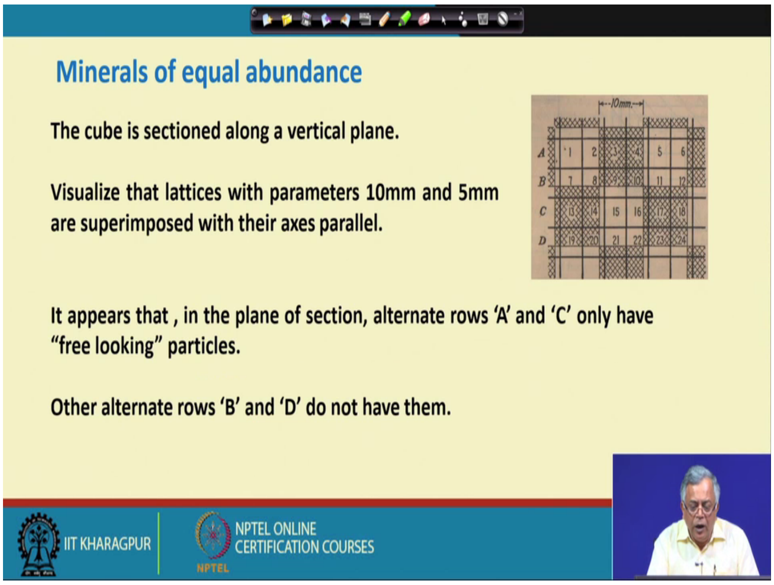

Now, let us see this situation now we have broken it to 5 millimeter and 10 millimeters size of cubic sake. Now let us visualize that the lattices with parameters 10 millimeter and 5 millimeter are superimposed with their axis parallel to each other. So, you see this now in this plane then the alternate rows A and C, so what are the free minerals here? Here you see that one you do not have this darker particle in this zone. So, it is this portion is completely free from the locked state whereas, this one you have got some portion of a gangue and some portion of your wanted material.

Again 3 you have got only the wanted materials. So, they are also in free state. Likewise I say that 1 3 and 5 they are completely liberated. Similarly look at the C the 13 17 they are free from each other they are in liberated state whereas, B and D you see that there is no condition there is no 10 by 10 millimeter block or 5 millimeter block where we have got the complete liberation of any particle.

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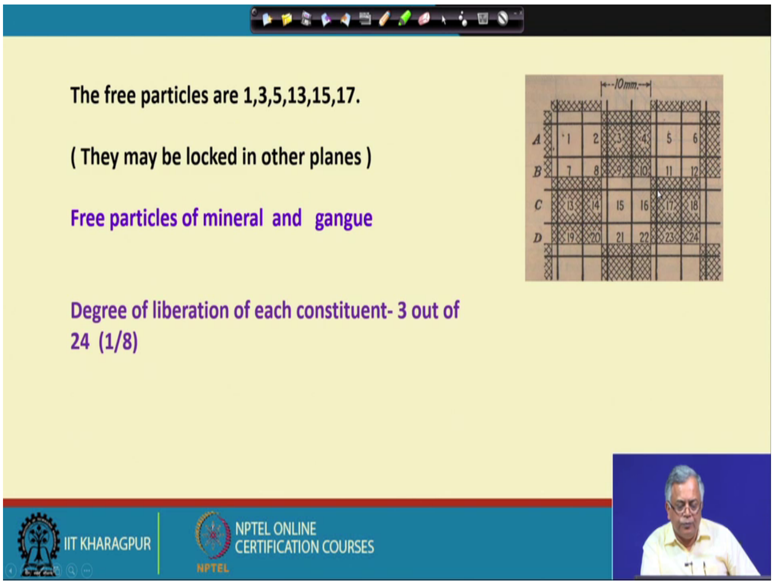

So, the free particles are 1 3 5 and then here 13 15 and 17. However, they may be locked in other planes we are looking at only one plane; they are either free particles of mineral bearing material or the gangue. We say that degree of liberation of each constituent is 3 out of your 24 because it is 4 and this is 1 2 3 4 5 6. So, we have got 3 liberated gangue material out of 24 and we have got 3 liberated mineral bearing material out of 24. So, the degree of liberation of each constituent is 3 out of 24 that is 1 by 8.

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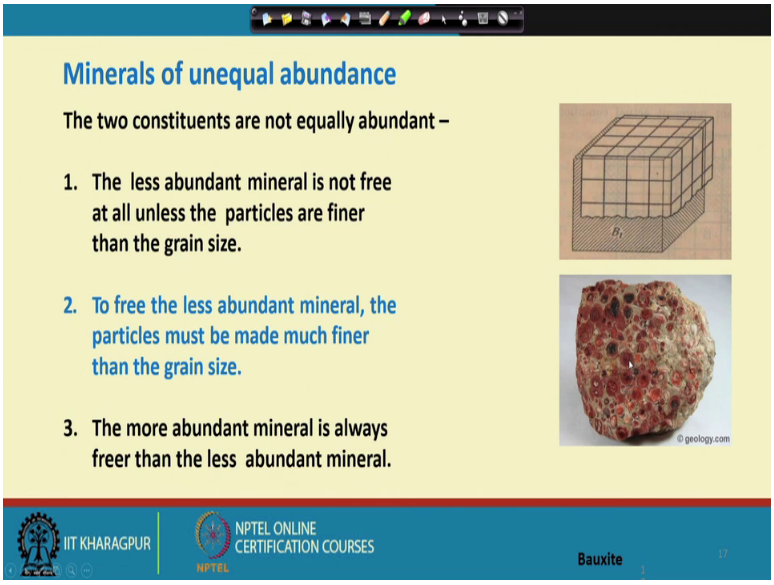

Many times we find that the mind ore they have got unequal evidence of the valuable minerals. Like you see that you have got this darker particles, some brown is particle and there are some other colored which resembles the different minerals.

Now, even if I break it to 10 millimeter sizes, 5 millimeter sizes you may not get a single particle which is free from each other so that means, in this cases you have to grin to very finer sizes you have to break it to very finer sizes to liberate them.

My dear friends please remember that it is a compromise solution. So, we do not want to break them to size where the minerals and gangue material they will be completely liberated. So, we always re-do the calculations that if we break it to this size and we assume that there is a separation what will be the economics is it in favor, then we say that that is the size limit up to higher we should break or we can re-do the calculations that say suppose we have broken it up to 100 micron or 100 micrometers we make a profit of rupees x.

Now, what will happen if I break it to below 50 micrometers? You are having additional cost for input energy cost for breaking it. So, net result if you see that your profit becomes x plus delta x then yes you break it up to 50 micrometers do not stop it at 100 micro meters. But if it becomes x minus delta x then do not break it to 50 micrometers you stop at 100 micrometers. And that is what you have to calculate it again and again to arrive at a situation that how far we should break it, and where should I stop to have my optimized profit and that is the task of a minerals processing engineer.

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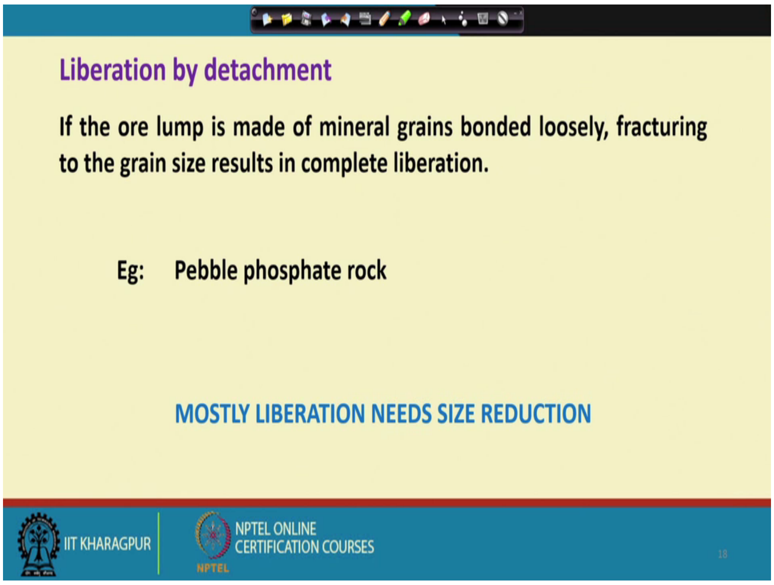

Many times if the old lump is made of mineral grains bonded loosely, fracturing to the grain size results in complete liberation. Like if I have a particle which is basically surrounded by loose, your clay bearing materials. So, if I put some compressive force into that the loose grains will be dislodged and my wanted material will be free from the unwanted material. Example is a pebble phosphate rock and however, mostly liberation needs or requires size reduction.

Thank you very much.