Mineral Resources: Geology, Exploration, Economics and Environment

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Lecture - 51
Mineral Economics

Welcome to today's lecture. So, far we have discussed about the process of mineral inventory estimation. We made a short journey through the mineral exploration architecture different stages of mineral exploration, discovery of an ore deposit, identification of the ore body and then understanding the three dimensional geometry of the ore body and then estimating its quality quantity parameters.

And then that stage that possibly is reached where the ore body as a mineral commodities in our course of discussion we have pointed out many times. That it is an economic commodity; it needs to be exploited for economic growth for economic purposes as a raw material to industry to be sold in the market at a price and for the sustenance of that particular industry, a mine for earning the revenue for a particular period of time which will be feasible. So, there will be lots of different types of studies which are carried out exactly before that the ore body is actually made ready and the exploitation process starts.

So, from the discussion that we had so far now we will be getting into the area in which we can broadly put under the category account the broad subject head as mineral economics. Because mineral economics, it is an independent branch and it has got so many facets, so, many different aspects different components it is not possible, it is not easy to just cover within this short lecture series where we have designated only for about this four or five lectures to discuss this.

So, in this I will restrict myself to very important certain salient aspects of mineral economics which as a geologist, every geologist should have those knowledge because those are after all their resources are available in the earth's crust they are product of complex geological processes and geologist definitely understands them better than anybody else. But the fact that they are economic commodities certain economic aspects also have to be understood about them.

And so, I will just try to touch upon some of the aspects like this.

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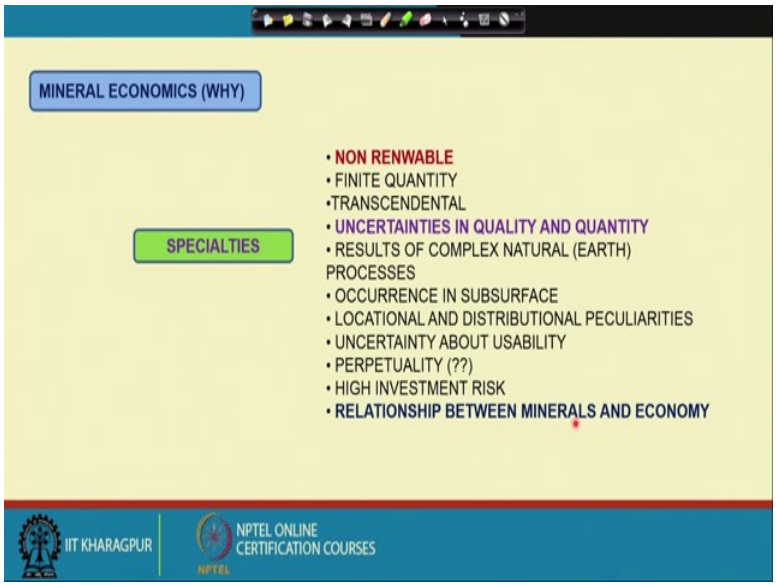

I would like to recapitulate about certain aspects of the mineral resources. So, the most important part of the mineral resources that they are nonrenewable. So, that is the reason why the branch of economics is also labeled as economics of nonrenewable resources and mineral resources is definitely possibly the only one which is a nonrenewable resource.

And as we know that the rate at which we consume will produce and consume the mineral resources, these metals and the materials that we recover in far faster rate by which this deposits actually form in the earth's crust. We have some idea because we have seen them forming in the ocean floor on the mid oceanic ridges and the present day ore forming systems. But, the quantity at which they accumulate or, the rate at which they accumulate is far slower than the rate at which we have been exploiting and utilizing these resources. So, they are nonrenewable.

So, there is always a question of sustainability and the way we utilize them. There should be optimal ways of utilizing them so that this resource lasts for the future even though we always put a question mark as to how. So, therefore, any ore body when we discover them, it's present in finite quantity that we have seen how we can determine the quantity. Although in many of the situations the determination of quantity keeps on getting revised which is definitely more of an issue with that estimation procedure.

But we must be reminded with the fact that they are any particular occurrence where the ore body is occurring the quantity is finite. We always calculate in terms of if a particular ore is produced at certain tons or 1000 of tons per year. How many years that particular mine will last? And it sometimes; so, happens that the initial estimate might vary marginally or sometimes significantly with the progress of the mining activity.

But the fact remains that they are finite quantity. They are transcendental in nature means they do not abide by geographical boundaries. The examples also we have discussed before. There are uncertainties about their quality and quantity which is very specific because any other earth resource that we talk about. Their quality and quantity are well determined. there is very little of uncertainty that is involved in their estimation.

Mineral resources because they do occur in the sub surface and the subsurface extension has to be understood properly and many times it remains uncertain and that is one of the major important issue about the mineral resources. Their products of results of complex natural earth processes which we have also seen through and they occur in the subsurface rest all earth resources occur on surface; of course, water resources also occur in subsurface.

And an independent topic by itself and as we have not included water in our discussion in this particular lecture series we will not discuss on that any further. But, other than these two all other resources that we exploit common use of our economic development; they all occur on surface whereas, these mineral resources they primarily they occur in the subsurface.

There are locational or, distributional peculiarities. They occur in very inaccessible parts and only when we discover them then only we build up the infrastructure for their exploitation, but then the fact remains that they are locational and distributional peculiarities, their uncertainty about usability which we have discussed. Perpetuality, because once an ore body has formed in any segment in the crust; it remains, it does not get destroyed. Other than the fact that there are earths own cannibalistic recycling process by which mineral deposits get destroyed and we in the beginning of our introductory part of these lecture series we talked about the half life period etcetera.

But they are all in terms of millions or billions of years which is different from the kind of perpetuality that we are talking about here. One of the very important aspect of

mineral resources and why it stands as very different from the other resources is that it involves very high investment risk because as we have seen in the whole process of mineral exploration, mineral exploration is a high risk economic activity and the success rate why it becomes risky because the rate of success of mineral exploration is actually very low. And that is the reason why they are very involved risk analysis in the present day. It is all sorts of complicated or elaborate exercise, mathematical models for doing this risk analysis. And further a particular mineral project would be worth taking up. And in the history of mineral exploration as we discussed before, there are many exploration activities which get abundant at different stages and again resumed and again all on such kind of economic grounds.

And the relationship between minerals and the economy which is a very intricate issue as how mineral resources will be effectively utilized for the development of any economy of any country. There are case studies in which there are many countries which have been able to effectively utilize their mineral resources and in improving their economy as well as there are instances in which the particular country which is endowed with such mineral resources have not been able to utilize or not been able to make such economic growths out of their mineral riches. So, there the relationship between minerals and economy has to be very well established for actually getting the benefit of the mineral resources.

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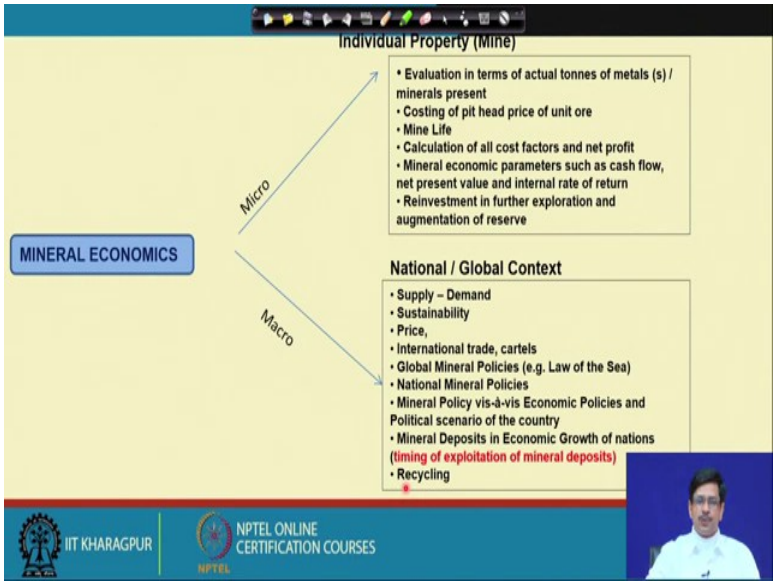

Now this subject of mineral economics can be there could be many possible views on this. The subject of mineral economics can be broadly looked at into two broad components. One I could say it is micro economic like we have microeconomics and macro. So, the micro economics always will be the individual property of the mine. So, these are some of the points which possibly come into our mind while discussing about the micro economic aspects of mineral resources. So, first of all that we have this evaluation in terms of actual tones of metals or minerals present; this is a very elaborate exercise and not only an elaborate exercise, but this exercise has to be carried out all throughout the life cycle of a mine for revision of reserve, for refinement of the ore body geometry as we see as we saw before. So, this remains a very important economic activity which goes on even after the discovery of the particular deposit or even the project is taken up. The costing of pit head price of unit ore which we have seen, it depends on lot many parameters. What exactly is the price; that means the total amount of investment that has been made in terms of the machineries, manpower all capital investment development of the mine?

We can always think of what is the price of a unit mass of the ore when it may be a surface mine which is called a pit. And pit head means when the ore has not been transported anywhere but the price could be fixed as to what could be the pit head price and many of the commodities are reported in day today reporting media that what is the pit head price.

Mine life is an important thing that is determined. As I said before based on the total quantity of the metal and the type of mining that is planned and the initial planning on what will be the rate at which the mineral or the ore body will be exploited based on that mine life is calculated. And if within that mine life the revenue that is to be earned by this process of exploitation will make the project feasible in the long run; then only the mining is taken up.

Calculation of all cost factors and the net profit; this also is a very high economic, a very involved economic exercise. Maybe we will be able to see a couple of them. Mineral economic parameters, such as cash flow, net present value and internal rate of return.

So, these are certain very key economic parameters such as cash flow, net present value and internal rate of return we will explain what they are in the subsequent class lectures.

And reinvestment in future exploration and augmentation of reserve; this is a situation in which that when an ore body has started to produce the ore, the ore is being either sold directly or being processed and some finished product like a concentrate or in terms of the metal that is recovered by process of smelting etcetera.

If it is being taken up by the same agency for example, the mining right at this point of time, the mining of copper and its beneficiation and give in producing the copper concentrate and also the smelting is done by a single agency. Let us say Hindustan copper limited which does it. So, the revenue that is earned in this process also has to be reinvested for further exploration and augmentation of reserve.

Because if there is no further exploration activity carried out once the mine has started to produce then the mine cannot proceed or, the mine life cannot be extended. And in the long run what will happen is many of the ores will remain unexplored or will remain hidden within that particular segment of the crust never to be found again.

So, for exploration in continuation or going along with the mining activity is a very important activity that any of the particular mining agency has to take up. So, these are all this and they could possibly some more, but these are some of the important aspects of the micro economics which is related to an individual property that is a mine.

Now what exactly the macroeconomic parameter means? Macro means always a national or a global context. The supply demand, supply demand is definitely controlled both internally and externally when whenever there are any of the commodities that a particular country is endowed with and is deciding to export and earn revenue from that. So, that definitely will be affected by the global demand for that particular metal.

The recent cases of the iron ore which we have seen certain there are sometimes there is a boom when there is a large demand in the in the international market and sometimes there are slumps if the demand falls; we may possibly be able to see a little bit about that. Then sustainability; it is also for in a global context that how much we always ask ourselves; that how much of resources we are left with.

And we sometimes need an answer to this question even though many a times we do not get a very satisfying answer on that. Because of the fact that if we take the whole world like the developed countries, the developing countries or the underdeveloped countries,

the per capita consumption of different commodities metals or the materials that we see there is a wide disparity in the rate at which for example, developed countries like the United States, Canada or United Kingdom, Japan, Germany some of the developed European countries. There the per capita demand and the consumption of these metals are several orders of magnitude more than the per capita consumption and demands of those particular materials in the underdeveloped part of the world we know where are they. And this price is also controlled by several economic activities.

There are international trade and different types of policies; stockpiling policies, there are cartels that actually control the price; international trade and cartels which I have already mentioned. For example, even though we have not discussed, but one of the very good example of an international cartel is the organization of the petroleum exporting countries which is OPEC and we know that that particular body is responsible or regulates or controls the price of the crude oil which is sold internationally as we know in terms of in quantities of barrels.

So, these are some of the things which are the macroeconomic parameters where all the mineral producing countries have to be part of it. Like global mineral policies; for example, we have the seabed, the seafloor which is which also bears mineralization of many of the important metals; one or two examples which have seen before like the ferromanganese nodules; which are rich sources of metals like cobalt and nickel and they are all scattered in different geographical region in the seafloor.

So, these resources they do not belong to any particular country. There the resources which belong to the whole world belong to the entire human population. And then definitely there will be international policies and regulation that will be required to act for exploitation of such kind of resources which do not belong to any particular nation. And then individually coming to any particular country which is a mineral producing country, there also a national mineral policy is required for its sustainable exploitation, having properly formulated policy.

So, that the best economic benefit is obtained from the mineral resources of that particular country. And mineral policy vis-a-vis economic policies, for example, the mineral policy has to be a part of the economic policy which is the policy of the country.

So, the mineral policy has to abide by or have to be within the framework of the national mineral policy.

Mineral deposits in economic growth of nations and for example, the timing of exploitation of mineral deposits and importantly national mineral policy also as we will be seeing them in our course of discussion. It is also very important in terms of formulation of policies of the economic rent that is coming out of that particular mineral resource exploitation.

So the mineral deposit the way their contribution to the economic growth of any particular country, there are certain very key factors, key points. For example, one always ask whether the mineral deposits should be exploited as and when they discovered because we talk up of an issue called sustainability. Is it that if we should observe some restraints of exploitation of the mineral deposits? For example, whenever we are discovering an ore body, whether it will be wise to immediately start exploiting the ore body or would defer that particular exploitation for a future time.

So, that that particular ore remains unutilized and it possibly can be left can be left for future generations to get the benefit out of it. And possibly some idea would go in that direction it will also be looking at tone or, two points closely. Then also something which is related to sustainability is recycling that we have an almost more than nearly a two centuries more than two centuries of very active because mineral exploitation can possibly go to even far back in history to the bronze age, copper age or iron age so on but we can say that it is the active exploitation of different mineral resources, the technology of extraction of the different metals used in the different industry and that is possibly has been happening at a much more enhanced rate and also an exponentially enhanced rate for at least past one and half centuries or if not more than that.

So, within that period we have been using these metals in various industries and various purposes. For example, for our motor vehicles, for any kind of electronic goods or infrastructure and so many things, construction and so, many things we have been utilizing these metals. These metals definitely after a certain period of their use they will get degraded and they are discarded.

So, in that case is it possible that thinking of a point in future that the resources have dwindled and the total available quantities of resources that were there because we have

been constantly exploiting them. And as I have just said that, rest of the world or the developing world or the underdeveloped world the demand and the per capita consumption of these particular metals are also increasing.

Then if the entire world population starts to use metal or demand or require the metal or materials in the same rate at which the developed countries are doing now then there is going to be a very fast depletion of the resources, provided the technology develops to an extent that that demand might possibly be substituted by some very future kind of materials which will be possibly be helpful in bringing such kind of situations to a sustainability for a still longer duration of time. The other hand it might be that we may have to depend more on reusing or recycling of the materials or the metals that we have been discarding through the past history of our utilization or exploitation of these materials.

That would be an interesting thing to see and this also is a part which will be taken up as macroeconomic issues. So, out of this that we have listed there are some important issues which we will discuss. And as I have said that all these issues cannot be discussed in all the great details because there are round the clock analysis using methods of econometric time series for trying to understand the trends in which the mineral resources are exploited, their price, fluctuation of their price and their rate of consumption with demand.

So, they are constantly being monitored and being analyzed by active group who do that and. So, it is not possible to although it is always to be very interesting and I have said that it will always be good that is geologist we do have a good understanding and also not only just to understand but also to contribute to this particular subject of mineral economics.

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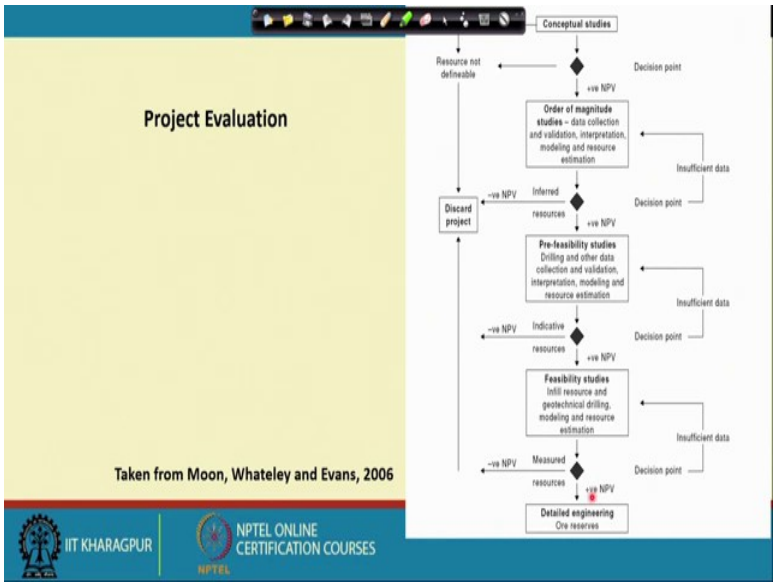

So, we will start maybe just made a beginning of the discussion of this mineral economic starting with the farm or, the microeconomics.

So, I will just make an introduction to this concept. So, here actually in the context of a particular mine project which can be thought of as particularly we could possibly evaluate a project. So, this project evaluation is essentially targeted towards getting a final answer that whether a particular ore body will be subjected to mining activity or not. So, it first starts with the conceptual studies as has been mentioned here is taken from this particular source. The conceptual study and each step in our micro economic aspects of mineral economics we always come across this particular term as NPV which is the net present value.

And which we will be discussing later, this net present value has to be positive. The net present value can be just explained in this way that if I value a particular property and that particular value to hold good for a particular point of time, then what is the value that possibly has to be invested. Right at this point of time, to get that value in future and that possibly some kind of quantity which will be called as a net present value.

So, the conceptual studies first are carried out and then a net present value is computed. If the net present value is positive then we go for an order of magnitude study. So, if it is negative then we say that the resource is not definable means the resource is discarded. Keeping in mind that there is always a scope for revisit or relook at the process, the

method that we have adopted for calculation of that NPV, but if we just take it as a one particular flow of the processes. Then the order of magnitude study where we do the data collection, validation, interpretation, modeling resource estimation and then try to find out what is the net present value on that.

So, if it becomes negative then the project is discarded, if it is positive then we do some pre feasibility studies. The pre feasibility studies are essential in drilling and other data collection, validation, interpretation, modeling and resource estimation and which is done after we do our conceptual study and order of magnitude study and then again if the net rate present value comes to be negative we discard that project. If it is positive then we will go for the further feasibility study. In this stage of pre feasibility study it is definitely very crucial. We are doing the infill resource and geotechnical drilling, modeling and resource estimation.

And here also in this kind of situation; we always take into consideration the geological aspect of the ore body, its detailed mineralogical aspect and then whether the process that will be required to extract the metals or to do the beneficiation for the particular ore in which we also discussed about how many fundamental type of studies like even studying the mineralogy of the ore body, the texture and the kind of process that will be required to extract the material from the ore body is also very important.

And after all these calculations of these studies if the results of these studies coming out to be positive, then it also can ends up in a net positive net present value. And then we go for a detailed engineering and the ore reserve estimation and all these situations it might so happen that the data has to be sufficient. If the data is insufficient then we again go for collection of the essential data there is to be required.

So, all these three stages that we have shown here before discarding or before coming on to the conclusion that whether it is yielding a net positive net present value. We can always reassess the situation by asking ourselves that whether the decision has been made on adequate data; if not then again acquire the data that is necessary for that and go ahead with this analysis.

So, this is a very simple presentation of a flow chart which is followed in the beginning of discovery of the particular area to be potentially ore bearing. And then going on in different stages of study till the time that we come out with a positive result that the net

present value is positive and then the detailed of the engineering and the ore reserve calculation and further economic exploitation of the ore body is planned.

So, we will continue discussing the other microeconomic parameters in the coming lectures.

Thank you very much.