

Mineral Resources: Geology, Exploration, Economics and Environment
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Lecture - 52
Mineral Economics (Contd.)

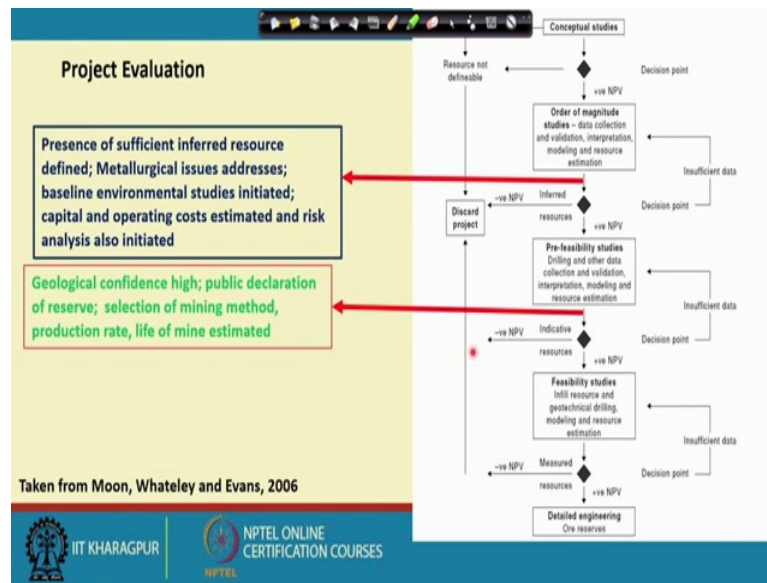
Welcome. We got ourselves introduced to the subject of mineral economics. Mineral economics as a subject is quite important because it deals with the mineral resources. It has a substantial component of economics which many of the undergraduate science curricular do not include.

But the subject is important from the perspectives of national economy. We just saw the two broad aspects of mineral economics in terms of the micro and macro. Micro dealing with the individual mining project, its evaluation, feasibility and then the macroeconomic parameters which are from the national and international perspectives; the different components of it.

And mineral economics which has also grown as an independent discipline because it relates to resources which are nonrenewable and it also has to be integrated to the policy. And as we have discussed before we have about more than two centuries of records of active exploitation of mineral resources and so the present context in the mineral economics involves a substantial amount of analysis of the past production, consumption and price data and very intense and extensive analysis of the past data for prediction for forecast of as to what is going to happen to the scenario of mineral industry in the foreseeable future.

So, in that way it is quite important and it is actually a part of the policies.

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We just started to discuss about the microeconomic parameters in which we just saw this flowchart which is generally followed in sequence; in evaluation or the feasibility of an individual mining project; when it comes to the initial stages of exploration because as we know that mineral exploration is an economic activity it is a high risk economic activity.

So, its performance in terms of the economic parameters has to be monitored right from the beginning and initially it starts with the conceptual study. And after the conceptual study gives some positive result, it comes to the order of magnitude studies which involve limited data collection, interpretation, modeling and resource estimation based on whatever indirect information we get about the nature of the ore body disposition in the crust in three dimensions.

And then each step we are actually evaluating a parameter which is the NPV or the net present value which we will see what exactly it is. So, at any stage the result of that particular stage has to yield a positive net present value which will enable to proceed for the next stage which is gradually becomes more and more involved.

So, if we look at the result of the order of magnitude studies would basically result in the presence of sufficient mineral. So, the inferred mineral resources should be sufficient enough to make it economic for economic exploitation. Metallurgical issues like the mineralogy of the ore, the extractability of the metals in terms of the mineral, the textures

of the ore minerals there came a chemistry and what kind of metallurgical procedures have to be adopted for their recovery has to be studied and this study should come out with appropriate result in terms of the feasibility, suitability of the ores for different processes.

Then it also would have some amount of baseline environmental studies must have must be initiated in this particular stage. So, baseline environmental studies include the air, the water and the soil analysis of the area and how the mining activity is likely to impact the environment, the capital and operating costs to be estimated and the risk analysis to be initiated.

So, if it results in a positive net present value then it goes to the prefeasibility study. Prefeasibility study involves limited drilling and other data collection, validation, interpretation, modeling and resource estimation. It goes to a further step where we have to come out with our the methodologies that we discussed before in proper interpretation on the nature of the ore body, its geometry, three dimensional disposition in space and use of different types of modeling exercise to do the research estimation like geo statistical exercise.

And here by the time this study is completed; we should have a high geological confidence and we should be able to in a we should be in a position to declare publicly as to what the amount of the ore body in terms of the metal content, in whichever way we report conventionally as measured or indicated kind of reserves or coming to the situation as in the UNFC as G3 or G4 stage; where the reserve could be declared to the public and the discovery of the ore body could be declared. The mining method could be selected as to what kind of mining method would be feasible for this kind of an ore body and the production rate, life of the mine estimation.

So, by the time the prefeasibility studies are over. So, these are the components which need to be completed. And in somewhere here also in the prefeasibility study, the different types of statutory clearances; the clearances from the ministry of environment and forest; the local authorities in terms of selection of the lease area or the mining lease kind of legal aspect and the detailed kind of rehabilitation plans etcetera also have to be initiated at the at the stage of this by the time the prefeasibility is over.

And during the feasibility study all these matter are supposed to be completed; in fill resource and geotechnical drilling, modeling, resource estimation and all the other legal aspects have to be completed. And then only digital engineering of the ore reserve and the mining method, the development of the ore body and all these processes could start only after all these three subsequent stages if the net present value comes out to be positive.

So, here in this exercise we see that this parameter which is called the net present value; NPV is one of the important parameters for evaluation of any of the individual mining project. Although it is quite elaborate and it is quite involved exercise, we will just like to have a look and look it at very simplistically as to what this parameter is and what the other parameter as far as the evaluation or the feasibility study of the project evaluation for individual mining project is concerned.

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Net Present Value

NPV is defined as the PV of the cash flows from an investment minus the initial investment.
NPV = PV - Required Investment (C₀)

$$NPV = C_0 + C_1/(1+r) + C_2/(1+r)^2 + \dots + C_n/(1+r)^n$$

Initial Investment – negative cash flow Discounted Expected Future Cash Flow

The critical problem of NPV are to determine

- Amount and timing of Cash Flow
- The appropriate Discount rate

NPV Rule : Accept Projects with positive NPV

Internal Rate of Return (IRR) : Discount Rate at which NPV = 0

Payback Period

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So, let us have a look a very simplistically about what this net present value is? So, net present value could be thought in terms of that if we expect a project like a mining project in terms of the metal that we produce ore that is sold in the market and some monetary return is coming; if we call that as a cash flow, it is actually the cash flow could be very simply explained as whatever monetary return is coming minus whatever is input in terms of the mining cost. It could be something like that as a cash flow.

And this kind of exercise carried out either for a period of 10 years or the life of the mine whichever is shorter. And for the net present value it could be just simply be present value minus a required investment that is C_0 initially. So, what basically it calculates is, if we expect a certain amount of money at some x number of years from now and if the interest rate is defined as r that is we can coin a parameter which could be a discounted cash flow for that particular year.

And if we get a sum total of the amount which will be coming in the different subsequent years where n is the number of years say for a period of 10 years or so. Then that amount minus the initial investment in whatever possible way we could define the initial capital investment, the machinery, the establishment, infrastructure and so on and so forth. So, this is how it is put in a negative term the C_0 is the initial investment and what is going to be expected in the subsequent years as discounted cash flow. So, this gives us the sum of this minus C_0 what is a negative value here will give the net present value.

So, the net present value; the rule is that net present value has to be positive means in the previous diagram when we saw the different stages of the project evaluation and we saw that the project could only proceed on to the next stage if it gives a positive NPV then only it will be acceptable. So, here the r value also sometimes could be put with a risk factor because it is exactly not known at the very beginning.

So, these kind of estimates are speculative as well as keeping the risk because we are not going for a detailed risk analysis here but could just make a qualitative idea about how we could fix that or what is the present rate and whether it could remain as a rate in the future years and then this value of the NPV is calculated. So, the critical problem of the NPV to determine the amount and timing of cash flow and the appropriate discount rate as I have said. And the rule is that except projects with positive net present value and there is some another parameter which is also used in the project evaluation is the internal rate of return.

So, internal rate of return could be very simply defined as a discount rate at which NPV is equal to 0. Means if we make a graph for the NPV versus rate; so, the rate at which the net present value will be 0 that is basically taken as the internal rate of return, is taken as one of the parameters for the project evaluation. And there is another term which is also

used in the project evaluation or project evaluation of mining project is the payback period.

It is actually the time by which the initial investment that is made in a mining project achieves a breakeven or the initial amount of investment that is made in this particular mining project is just recovered and from then on the project basically gets runs on a profit. So, that is a payback period. So, these are some of the terms which are generally used in mineral economics and much more elaborately and intensively for evaluation of any mineral project. And as I have said that this being non economists we can only make an idea but it would always be better to go into a bit of details of it and acquiring the essential knowledge on the basic economic principles.

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The slide displays a list of 12 factors affecting national mineral policy goals and objectives, as outlined by Otto in 1997. The factors are:

- The mineral commodities available for development
- The undiscovered mineral resources thought likely to be discovered in the future
- The size or potential size of the mining industry
- Current and projected minerals demand and price
- The amenability of minerals to be mined by small or large scale methods
- The government's historical experience with mining, with state intervention, and with foreign investors
- The potential for sustained development in other sectors of the economy
- Domestic mineral requirements
- Existing constitutional, regulatory and administrative framework
- Governmental administrative capabilities and resources
- Political considerations

The slide also features the IIT Kharagpur logo and NPTEL Online Certification Courses branding at the bottom.

So, now with this much of a discussion on the micro economic aspect or the project evaluation or the individual mining project, let us move on to some of the aspects of macroeconomics. In the list of items coming under macro economics; macroeconomics is actually in the perspective of the a nation or the whole world international perspective.

So, let us first look at the scenario in a national perspective. So, in the national perspective as we have said that mineral resources are nonrenewable and they require very well formulated policies for the sustainable exploitation and proper economic development by mint of this mineral resources. So, each mineral producing country has a document some is called as a national mineral policy. So, it is a policy; it is not rule. So,

policy essentially will be provide guidelines to the lawmakers and the planners. Also, the national mineral policies in some of the countries like India; it is a standalone document in many other mineral producing countries it is a part of the national economic policy. But it actually deserves to be an independent standalone document and. We can say that a national mineral policy it acts as a regulatory tool for the mineral exploitation. The points have been taken from Otto in 1997.

So, these are the points that the mineral commodity is available for development. The undiscovered mineral resources thought likely to be discovered in future as we initially in our classification we classified the minerals into the discovered and undiscovered categories. So, what all are the undiscovered or the targets for the discovery and future exploitation?

The potential size of the mining industry that is also something has to be laid out in the policy basing on the objectives, aims, and goals of that country fixes and as far as the economics of the country is concerned, current and projected minerals, demand and price. The amenability of minerals to be mined by small or large scale methods because there are large deposits which can be operated for good number of years; there the amount of the material of the commodity are high but then we as we have discussed before such kind of large deposits or the giant deposits are smaller in number.

Whereas there are many, there are numerous small deposits which also occur in different areas which have to come under a small scale mining for which we need to have different kind of strategy. The governments historical experience with mining, with state intervention, with foreign investors; these are the very critical issue.

Because many of the countries which had colonial rule and after their independence, they were the two ways of planning of their exploitation of mineral resources is to whether to welcome multinational mineral exploration mining companies to explore or to take the job by themselves and develop their own technology and expertise for the exploration and exploitation of mineral resources. And the potential for sustained development in other sectors of the economy is important because whatever is achieved from the mineral resources which is basically is a gift of mother earth.

So, whatever returned is obtained from this exploitation of the mineral resources, how they are going to be effectively utilized for the growth of other sectors. The domestic

mineral requirements versus exports existing constitutional regulatory and administrative framework and the governmental administrative capabilities and resources and political considerations of course, which sometimes are not within the control of people who are dealing with this.

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Checklist of issues to be considered for formulation of NMP

- Scope
 - Type of activities
 - Classification of minerals
 - Relationship to regulatory system (other policies, priorities over other policies etc)
- Sovereignty
 - Investment decisions, role of state enterprises, state investment, ownership and control, foreign investment, ownership and control, joint venture

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So, if we say the national mineral policy is a regulatory tool or it is points that are jotted down to help law makers and planners for the in the country, then we can look at the what are in the form of checklists of issues to be considered while a national mineral policy is being formulated. Type of activities, the classification of minerals and the relationship to regulatory systems need to be considered for the formulation of National mineral policy. So, the type of activities we know are essentially exploration; the mining, the exploitation and the downstream activities will be processing recovery, extraction of metals.

So, all these need to be addressed adequately in national mineral policies. And when we come to classification of minerals means there are some minerals which are abundant. The abundant metals like we know that iron, aluminium kind of resources are quite abundant. And in some of the minerals the country is short and those are the some of the critical minerals in which the reserves are quite less where as the domestic demand in the country is quite high.

So, they need to be categorized and there are certain materials which are of strategic importance. They also have to be separately dealt with and the exploitation policies have to be also very clearly spelt out and the relationship to regulatory system that is other priorities over other policies etcetera.

And sovereignty is the point that comes when the investment decisions are made that one of the issues is of course, in a federal form of the government with the state and the central government how the roles are going to be divided or shared.

The investment decisions and foreign investment; where the sovereignty comes.

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Checklist of issues to be considered for formulation of NMP

- Economics
 - Taxation issues
 - Export issues – type and extent of export duties, incentives for value addition, stockpile requirement, stabilization of world market, foreign exchange
 - Import issues – protection of domestic supply, protect domestic mineral production, strategic stockpile requirements
 - Role in economic development – local community development, regional development, national development, infrastructure development
 - Employment
 - Conservation and efficiency
 - Land use priorities

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And the economics, the taxation issues, what are the kinds of taxation that will be imposed. We know that in the Indian context there are two different types of taxes that are imposed mineral producing agencies; either government or private.

One is called the royalty which is a term coming being continual as in its use from the time that there is to be kings or the rulers who used to impose the tax on the agency which is responsible or which is actually given the license to exploit the ore or the minerals. It is essentially a tax called royalty which is imposed because this particular material which is taken out is actually getting depleted by that particular amount.

So, it is a kind of a compensation for depleting the particular material which is coming as ore. Export issues; type and extent of export duties, incentives, the values addition; value

addition is one of the important aspect that national Indian national mineral policy addresses.

Stockpile requirement means when there is a less of demand for a particular metal, particular mineral, whether it will be accumulated in quantities to be released later on when there is a demand or there is a price increase, stabilizers in a world market and foreign exchange, the import issues. Sometimes the import issue addresses issues like the protection for the domestic supply, protect domestic mineral production, strategic stockpile requirement and the role in economic development, the local community, the regional development, national development and infrastructure development which we just can look at very briefly as I stated before.

Whatever return comes from a particular mineral resources, part of it could be reinvested by the same body or, same agency for further exploration work and also the return that is coming from this exploitation of this mineral resources could also be used for infrastructure development and for many other development of the country in many other fronts.

And conservation and efficiency as we have said that conservation is a little difficult term to visualize because if we have to exploit the resources it will get depleted but then at the same time we talk about mineral conservation. So, it essentially means that the policies are formulated in such a way that the minerals could be exploited in a sustainable manner, the land use and priorities and the quality of life.

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Checklist of issues to be considered for formulation of NMP

- Quality of life : Social impact, environmental impact
- Legislative framework
 - Applicable laws
 - Exploration and mining rights regulatory approach
 - Exploration and mining application priority
 - Security of tenure
- Regulatory agencies
 - Role of regulatory agency
 - Structure of regulatory agency
 - Achieving action or compliance with regulation
 - Information

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That is social impact, environmental impact, the legislative frame framework, their applicable laws, exploration and mining rights, a regulatory approach for example, when it is being controlled by government either a local state government or a central government; the exploration the agencies which are involved in exploration are given the license in form of a reconnaissance permit ,prospecting license, a mining lease; these are the things which generally are worked out and have to be very well jotted down, very well spelt out in a national mineral policy so as to avoid any ambiguity.

For this when it is looked in combination with the classification of different minerals. There are different policies which are adopted for mining of abundant metals like iron and aluminium and critical metals like some of the metals in which we fall short in our reserves like the base metals and some of the metals which are very important industrial use and some metals which are of strategic importance like the energy resource.

So, there the policy is well laid out; so that which kind of a agency governmental or which of the commodities will be made open for public for the private sector and the exploration and mining application priority. Because here the method of exploration and method of mining is also very important, the security of tenure for whenever it a prospecting license or mining lease is being given to a particular agency. For that the security of tenure is also important, how many and what is the time period for which the particular agency can be given the contract.

The regulatory agencies and the information that means, the data that are all generated in terms of whatever mineral commodities are produced or marketed are being traded, their reserves, all these information have to be well documented.

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• Other consideration

• How the policy will be announced, frequency of revision

QUALITY OF LIFE

REGULATORY AGENCIES

SOVEREIGNTY

ECONOMIC CONSIDERATIONS

LEGAL FRAMEWORK

SCOPE

NMP

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So, we can summarize the different critical issues related to mineral economics in this diagram. A national mineral policy should address quality issues such as quality of life, the regulator agencies like the central or the state governments or sometimes many statutory bodies are also formed to make policies for exploration and exploitation of different mineral resources, the scopes have to be very well laid out, the legal framework, the economic considerations and sovereignty.

So, sovereignty comes into discussions whenever the issue of foreign investment or allowing or not allowing multinational exploration and mining companies to do their operations in a different country. And where the multinational companies whether their interests are being safeguard or whether our own sovereignty is preserved. So, these are the things which are very important and must issues that would be addressed by a national mineral policy. So, we will continue discussing on the national mineral policy.

Thank you.