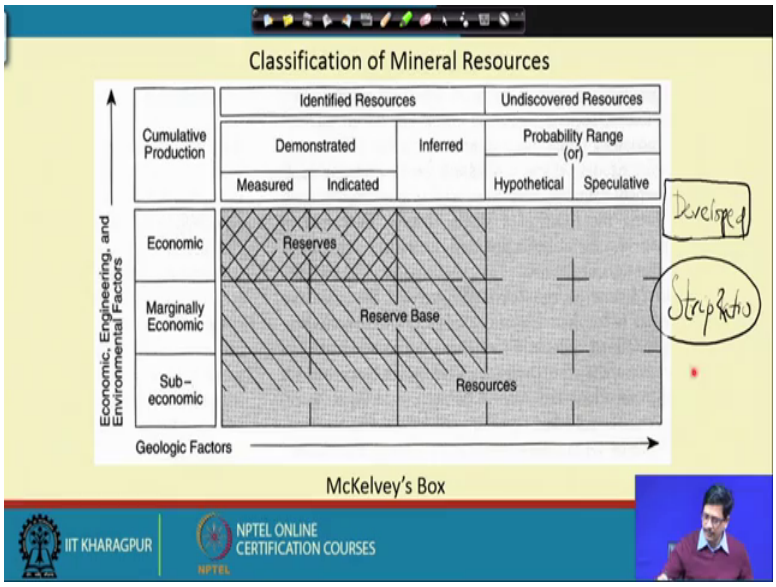
Mineral Resources: Geology, Exploration, Economics and Environment

Prof. M. K. Panigrahi
Department of Geology and Geophysics
Indian Institute of Technology, Kharagpur

Lecture – 33
Mineral Exploration (Contd.)

Welcome to today's lecture. We have just started to discuss the topics on mineral exploration. Just before we get into the proper mineral exploration topics; we just had a brief overview of classification of mineral resources based on their economic criteria and geological certainty the occurrence of these resources.

(Refer Slide Time: 01:00)



And the idea behind looking at our idea behind having this kind of classification at the back of our mind is that. When we classify the mineral resources into broadly into the identified and the undiscovered resources, so it is essentially the undiscovered or the probability range the hypothetical or the speculative part of the mineral resources is the one that we would like to convert it into identified through the process of mineral exploration which is a very very elaborate exercise involving lots of scientific techniques, with lots of evolving ideas, with the development of technology. And with evolving ideas with better and better knowledge on the genesis of different types of mineral deposits that have come to our knowledge come to they have being constantly adding to the knowledge base on the wide spectrum of mineral resources mineral

deposits that occur in the earth crust, sometimes there are some new discoveries new types of deposits which give us many new insights into the ore forming processes.

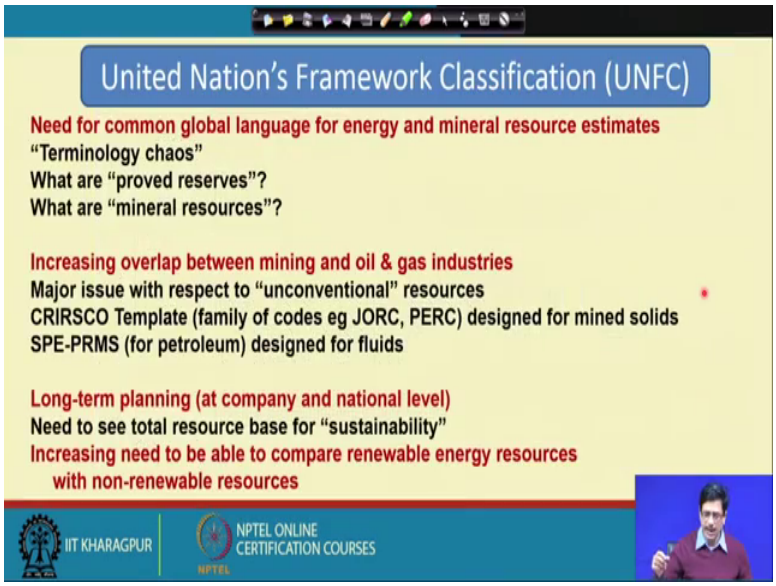
And in the long run, they add to the knowledge base on which we can plan our exploration efforts, we can design our exploration programs and use of a different technology for the exploration. As we have already stated that it will the mineral exploration is a full range of the activities exercise, the methodologies, technologies there is a evolve in that is involved in this would be difficult to cover them up all in this short lecture series. And in this when our basic objective is to get an overview or the elementary knowledge about these topics, so we will just try to do that.

And we saw the McKelvey's box where it is where they reserve by the mineral deposits of the mineral resources are classified. So, measured is the one on which we have the least uncertainty in the calculated amount that is present in terms of millions or billions of tons or millions of ounces as we saw in our early discussion.

The part that is covered under the indicated will basically involve a little bit more of uncertainty, and the inferred is also accordingly involve greater uncertainty in their quantity that is available. Sometimes, even we come and propose we even use words such as developed part of the reserve that that part of the ore body which is developed in the sense that which is ready to be put into production in a mine by defining certain parameters such as the ratio of the quantity of the overburden that is to be removed to get the ore to produce the ore.

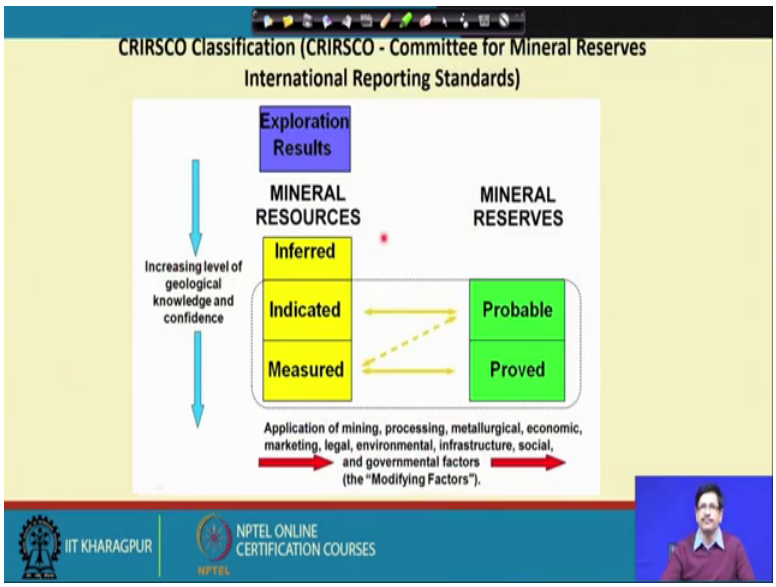
Sometimes, the ratio sometimes would be 4 is to 1 or even more and the higher is the this ratio which is called as the strip ratio. Higher is the strip ratio, higher is the cost of mining. These are the aspects that we will be discussing a little bit more details in our later section of the lecture series when we will be discussing about the mineral resource appraisal and the estimation.

(Refer Slide Time: 05:54)



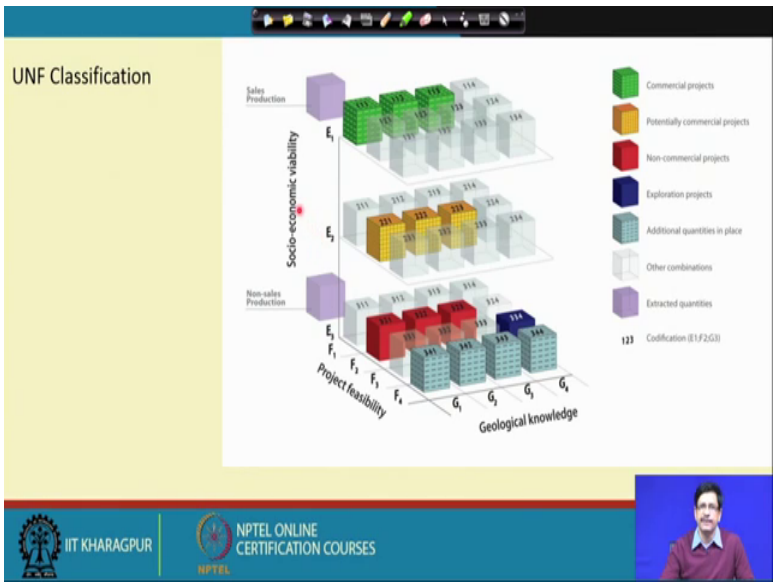
We also started the discussion that reporting in the form of this reserve as measured, indicated, inferred, or possible, or proved, proved probable and possible this kind of reserve reporting it is not very consistent, there are chaos in terms of the terminology that is used improved mineral resources and a bit of a conflict in reporting of the mineral and the fuel resources. So, the United Nations framework that was proposed was a kind of a consistent in a uniform code of reporting of the mineral resources and which has certain advantages.

(Refer Slide Time: 06:49)



And as we saw them before in the previous classification scheme when only the two parameters one is a geological certainty and the other the economic viability and feasibility were combined together and the mineral resources were classified as we saw in the McKelvey's box. So, this is basically the CRIRSCO committee that is for committee for mineral resources reserves international reporting standards which was the old one that was followed. And this was the application was in mining processing metallurgical economic, marketing legal environments, infrastructure and social and governmental factors all factors taken together.

(Refer Slide Time: 07:32)



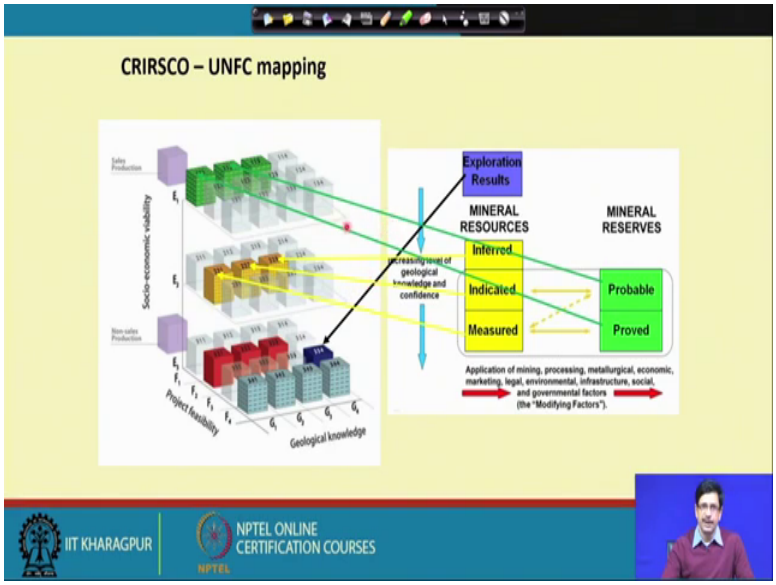
And we discussed about the classification scheme that was adopted for the united nations framework classification where the three the socio economic viability and the feasibility are now on being plot and two different axes and the geological knowledge. And as we know that the geological knowledge G 4 to G 1 it is in the increasing order. G 1 represents the one which the geological certainty is the most; and it is kind of the existence of the in the form of an ore body of the required dimension is proved to be existing by using various direct and indirect methods.

And the project feasibility is essentially in terms of the economic feasibility of developing that mine and going on with the mining operations where the it could be done on a sustainably profitable manner. And the socio economic viability that means, meeting all other socio economic parameters and this is the way the mineral resources are

classified. And this numbering system means 1 1 1 is actually the ones which are the commercially producing mines, the ore bodies then different as we have seen as we see them today.

And the ones which as we have seen before here also in from F 1 to F 4 it is in the F 4 to F 1 in an increasing order of project feasibility and e three to e one increasing order of a socio economic viability. So, the ones which are in brown here are potentially commercial projects. In the sense that the geological certainty has been proved; and the project feasibility is also quite high, and the economic viability is also somewhere intermediate, and they represent the potential projects which could be converted into commercial projects as and when these any of these criteria are fulfilled.

(Refer Slide Time: 09:50)



This would be a thing which generally we required to know that how these UNFC classification and the old classification scheme they map to each other. As you can see it very clearly what we label is probable or the proved one which is the least certainty in their estimation in terms of the quantity that is present and the probable. And they would actually map onto this 1 1 1 it will be it will be also be sorry 112 this will be 113.

So, 112 can always be also say here the quantity is estimated although with a little greater uncertainty and the ones which are the inferred or the indicated will be the non commercial one where the geological knowledge, say this is for example, these 223 or 222, where the geological certainties are still very less. But they could be potentially

commercial they could become potential producing ore bodies in any time in the future after the parameters have satisfied.

And the situation like a 334 is where only the exploration results have been obtained and they still took the geological certainty is still to be proved. And although it could possibly be a little bit feasible in terms of the project feasibility, and whose economic viability is not yet worked out.

(Refer Slide Time: 11:38)

So, this is with this much at the back of our mind that the resources our basic idea is to convert all those which are unidentified or speculative or kind of the resources which constitute the resource base together along with the identified. So, our objective is to augment the mineral resources, increase the quantity any of the metal or the materials that is available to us, converting G 4 to G 1.

Although the feasibility part feasibility and the economic viability are dictated by lot many other factors non scientific factors. Converting a particular mineral resource from G 4 to G 1 is essentially what we awe at and go through the process of this exercise which is mineral exploration.

So, when in the context of mineral exploration, these are the basic questions that come to our mind that what we explore. To answer to that question is what to explore, it is basically these are the factors the macroeconomic factors, the demand supply, and the

international price that is going to be one of the key factors. Any particular metal there is a demand for it and the supply is short and the international price such that importing of that particular metal or the material could be economically strenuous, so that becomes an obvious choice that particular metal to be an exploration program for the particular metal has to be designed.

There are certain situations is joint supply and joint demand, this comes out of the situation that suppose that we have discovered a deposit of iron, and then we meet to establish a steel plant to extract the iron, but then it also needs some other resources like coal or limestone and other resources to actually setting up of a plant for extraction of that metal.

So, that makes it essential to go for exploration of other materials which are essential for that particular industry or particular metal extraction plant to be setup. Technological breakthrough there, there could be sometimes there are certain technological breakthrough which makes a particular metal which was otherwise not known to be that very useful in the industrial in the industry. So, that particular metal could become very important and then there could be exploration program for that particular metal.

Substitute means again because of this also a result of technological breakthrough. There could be some strategic factor, for example, energy resource mineral like say for example, uranium it definitely is on the list priority list of augmentation of the mineral resources. And it would always be better if we could discover last deposits of such kind of metals; and because they have got statistic importance in terms of generation of energy and many other aggressive political factors. So, these are some of the things that come to our mind when we try to answer that what we explore.

And then the next question comes to our mind in regarding mineral exploration is where to explore means which area to choose for conducting an exploration program. So, number one is ancient workings, ancient workings are things which are the vestiges or the remnants of mining activities which were carried out by our ancestors in the t strip times when we all know about the history of use of metals like the copper ages, bronze ages, iron age and so on.

Where the ancient time not much of technology of mining was available and only minerals the mineral bodies which were only exposed to the surface most of the time

they are oxidized. So, those were the ones which were worked by the prehistoric man for extraction of a different types of metals by very very crude rudimentary technologies like a village blacksmith shop, where metals metal oxides could be melted and could be extracted. And such kind of old workings are left in many different parts in remote places, which give us indications that there are possibilities of existence of such type of ore bodies. So, they become they could become the areas very good intensify our exploration efforts.

Favorable geology, it is basically based on the; whatever geological knowledge that we have acquired through study of this whole spectrum of mineral deposits that we have discussed so far. So, if the geology seems to be favorable for occurrence of any particular type of deposit that also becomes a area of choice.

As we have said that many times we extrapolate situations what our previous experience of discovery of deposits in different other parts of the world, although we keep a very important thing in mind that no two deposits will be same in all their characteristics. And each deposits discovery history also unique as we will be seeing some of them. Political factor could also motivate choice of certain areas. And joint demand which exactly I just discussed about joint supply and joint demand.

And then the question comes as to how to explore and that is the thing on which we will be mostly be discussing. So, how to explore is you can always think mineral exploration as having these three possible components that can come to one's mind when it comes to how to explore. The science of mineral exploration means the all the principles of mineral the scientific principles or the understanding that we have developed in the formation of the mineral deposits that they could be effectively utilized in mineral exploration.

And in addition to that the differences or the characteristics of this kind of ore bodies when they occur in the earth crust, the distinctiveness is also something that can be taken into account, and can be a part of the science of mineral exploration. Sometimes, we feel that mineral exploration this whole exercise is since no two deposits will be alike in all respect, and no two deposit will have the same or identical exploration history in the discovery history.

Sometimes, it becomes more of an art or practice as people who have been practicing mineral exploration for most part of their lives, they become kind of experts whose opinions sometimes matter or sometimes are taken into serious account while carrying out mineral exploration any unknown area.

And the methodology is the one holds also which have been continuously evolving, many sophisticated methods for exploration of this mineral deposits have come up. So, these are the things will be the science part of it, it is the one which we will be mostly focusing. And the methodology part it will have some limitations for this particular lecture series, but we will discuss as many as would be appropriate.

In mineral exploration we actually get to hear these two terms that brown field or green field. A green field essentially is the areas in which the existence of any ore deposit is not known or these areas that can be called as virgin areas, which have never been subjected to any exploration activity before which of course at the present time will be very very little. And the exploration would be the process would be basically be starting from scratches and that will be called as a green field exploration.

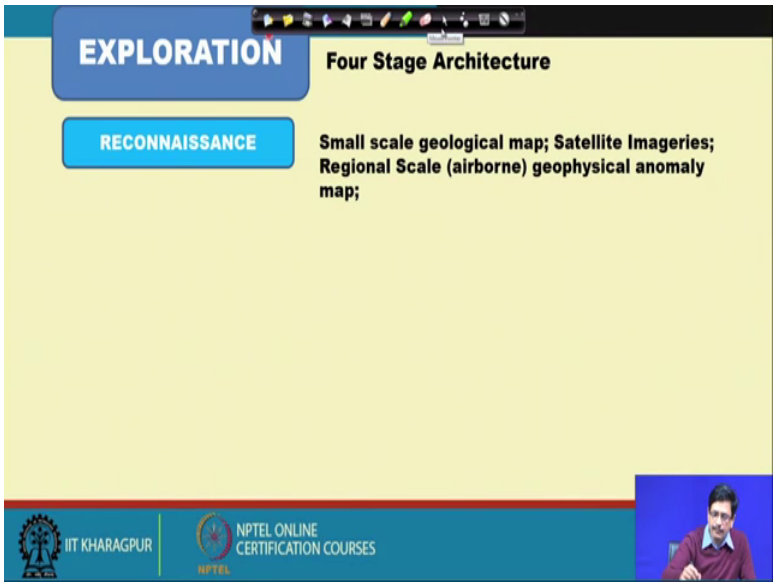
The brown field exploration is any particular geological terrain where mineral deposits are known to be existing of any particular metal or many different that the examples that we have seen of metallogenic provinces or the ore districts or mineral belts where there could be occurrence of one or more than one type of deposits.

For example, Dharwar craton where we see that it houses deposits from a wide spectrum of metals like chromium, manganese, gold, iron and so on, so in such kind of areas where we already have been producing minerals from different localities mineral deposits. We would like to continue our exploration efforts with the objective of finding many such more such deposits in that particular area, so that is because some idea about the broad geological aspects of the area is known and we call that is brown field.

Sometimes we also do have this thing in our mind that what is the difference between exploration and prospecting. Generally, these two terms are almost used interchangeably or synonymously with each other. Although I would say that prospecting always would be referring to smaller areas where we are carrying out some ground activities in terms of any of the methodologies that will be seeing like a geological or a geophysical or geochemical.

And exploration would essentially be exploring through the unknown or taking much larger area where we can do the exploration by using not exactly a ground based work, but it could be situations which would be acquisition of data in many different other ways that is how we could possibly make some distinction between the two other ways. In many of the text books and discussions, you would see that these two terms are not really very distinctly differentiated.

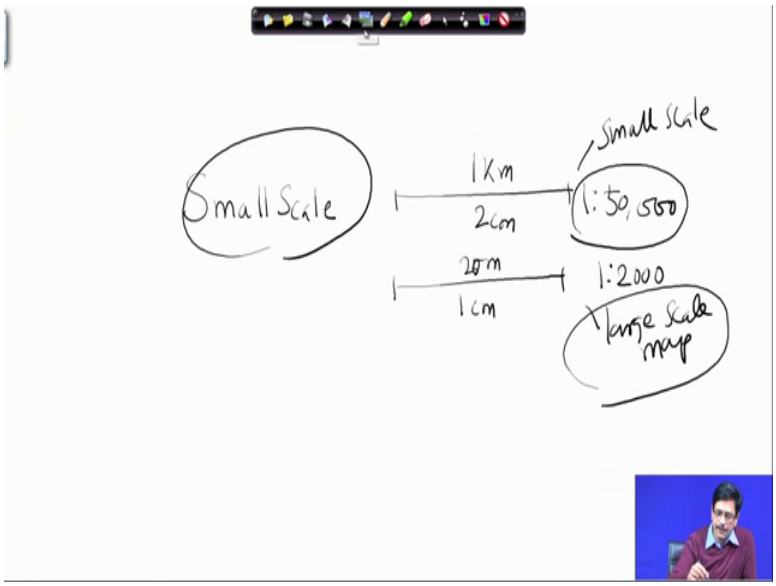
(Refer Slide Time: 23:13)



So, we will just see what this exploration is all about. Mineral exploration can be thought of as kind of a four stage architecture. This four stage architecture it begins with or the very beginning stage as per the conventional wisdom that this is the situation the exploration whenever we take up an exploration mineral exploration program. Then we how do we start, we start with the recognition stage means we try to acquire the very basic first level knowledge in an area and the work during the recognition stage is it involves study of a much larger area.

So, generally, the idea is to study a larger area with the objective of choosing smaller domains where exploration efforts could be intensified. So, this is the beginning stage. So, here if we see here the small-scale geological maps can be used, so small-scale in the geological maps, this is a small-scale means where the scale is something like if I say that.

(Refer Slide Time: 25:01)



A small-scale means if I say that 1 kilometer ground distance is represented by say 2 centimeter here this scale is 1 is to 50,000. In comparison to that, if I say that a distance a ground distance of 25 meter or 20 meter is being represented by 1 centimeter. Then this would be a scale which is I could put as 1 is to 2000. So, here this is a small-scale map and here it is a large-scale map. So, we have generally a toposheet is a scale in which we have representation of 1 is to 1, 1 is to 50,000 and even there could be scale smaller than that 1 is to 100000 or 1 is to 63,000 is 1 inch is equal to 1 mile that was to be the previous scale.

So, the difference between the two is that on a on a geological map which is prepared on a small-scale many of the features which are small or less in dimension, for example, any mineralized vein or any kind of any structure or any smaller feature or alteration zones and so on which will be measuring only in few tens of meters or so. We will not will not be representable on a small-scale map.

Whereas, we can always or if you want to study the area more minutely and can represent many of these features important features which is the dimensions are small measurable in only in terms of tens of meters or so can be well represented on a large-scale map. So, here the small-scale geological maps I have prepared as a routine geological investigation in any agency in any country, like say for example, the Geological Survey of India in India. Many such many all the countries have their

geological surveys who have the primary responsibility of a of a preparing first level geological maps, small-scale geological maps whose who serve as the first available information for any exploration program to begin with and that is that is what is the situation which was happening in the past.

Now, in the present time, if we when we see that we do also have much smaller much much smaller scale features depicting the many of these surface features or the defeat features on the surface of the earth such as the satellite imagery such as these satellite imageries which can be possibly can be thought of as the smallest possible scale that of the feature that we can have.

And even we can have much we can have still a little larger, but still very small much smaller compared to toposheet scale geological map or any other map which is drawn on a toposheet scale like for example, regional scale airborne geophysical anomaly or airborne gravity anomaly or say geophysical anomaly maps.

So, these are the materials which can be very well utilized when we are in the reconnaissance stage and trying to identify certain features that you can pick up which would look to us as favorable to carry out further exploration work. So, we will continue discussing on this four stage architecture in the next class.

Thank you very much.