Mineral Resources: Geology, Exploration, Economics and Environment

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Lecture – 34
Mineral Exploration (Contd.)

Welcome to today's lecture. We have been discussing about the Four Stage Architecture of mineral exploration.

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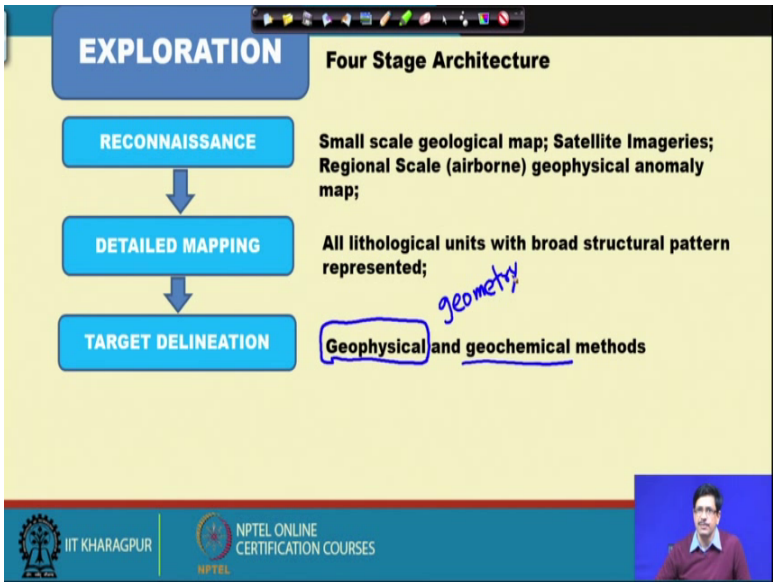

And we just started with the recognizing stage, which is the first stage in which we, our materials are this geological maps, small scale geological maps, reports that are written by workers who have worked in the area before. And in the present day context, we do also have satellite imageries or there are many such kind of much more is much regional scale features like magnetic anomaly, gravity anomaly which have been acquired by from aircrafts which are basically the airborne anomaly maps.

So, these give us the preliminary idea or the firsthand information that helps us to choose or to focus on certain selected areas. So, this particular stage the, Reconnaissance stage is followed by a Detailed Mapping stage in which there all the lithological units with broad structural pattern are represented. As I just mentioned, if we go from a small scale map which is 1 is to 50000 scale to a 1 is to 20000 or even a little larger than that; it will be possible for us to represent the geology in a with representation of all the geological

elements present in any particular smaller area and that gives us further information and those kind of maps which also we have the scope of representing the local scale structural features which sometimes are very important in terms of the localization of ore bodies.

As you have seen before, the structures, different types of structures that are present in the rocks and the different generations of structures, they play important role in localization of ore bodies; say for example, when we were discussing about the noamundi basin, the host was inclineriam, even though the basin is essentially (Refer Time: 02:29) banded iron formation, iron formation basin, but the localization of ore in terms of the high grade iron ore is very much controlled by the structure with the later folding and the formation of the favorable locales where the enrichment of the primary iron formation could take place to give rise to high grade ores.

So, such kind of structural patterns has to be very well studied, represented and this the basic idea and the detailed maps are produced. The third stage is essentially for target delineation means, a by this time we have already reduced the areas or chosen the areas on which the exploration work is focused. Smaller by the from reconnaissance to target delineation we have been successfully, we have been able to successfully eliminate areas in which we could, we could conclude that the possibilities of a probability of occurrence of any ore body could be could be the minimum or here 0, which we may not, we may be wrong in many of the cases, but that is how it goes and so it is a process of elimination. So, if when we come to the target elements, Target Delineation stage, there we intensify our efforts to identify or to be to be certain about the existence of an ore body.

So, that is our ore body is the target. Here we can use the methods, different types of this geophysical, the geophysical methods, the geochemical methods and of course the geology will always be by the time we have already used all our geological knowledge in identifying the area where we would like to live delineate the target. Essentially, because of the fact that the geological work will always be based on whatever is available on the surface, these the ore body or the associated rocks and the many other associated features as it as they are exposed in the surface can be studied in all greater details but, the subsurface will always remain an uncertainty for us.

So, we need to delineate with are to are to are to understand or to work out the disposition of the ore body in the subsurface to ascertain it is size, the parameter which would essentially which you want to know. And the most important aspect will be to understand the geometry of the ore body, the geometry of the ore body which will be extremely important for us to understand. And geochemical exercises also carried out on the surface, but the interpretations of the geochemical methods would be far reaching and would just not be based on what we see them on the surface because they are the manifestation or the reflection of the presence of an ore body below.

So, by the completion of the stage, a favorable result which is obtained through these methods that is data carried out where we can this stage we can call as the prospecting the geophysical or the geochemical prospecting methods would result in either negation or towards establishment a towards establishing the existence of an ore body.

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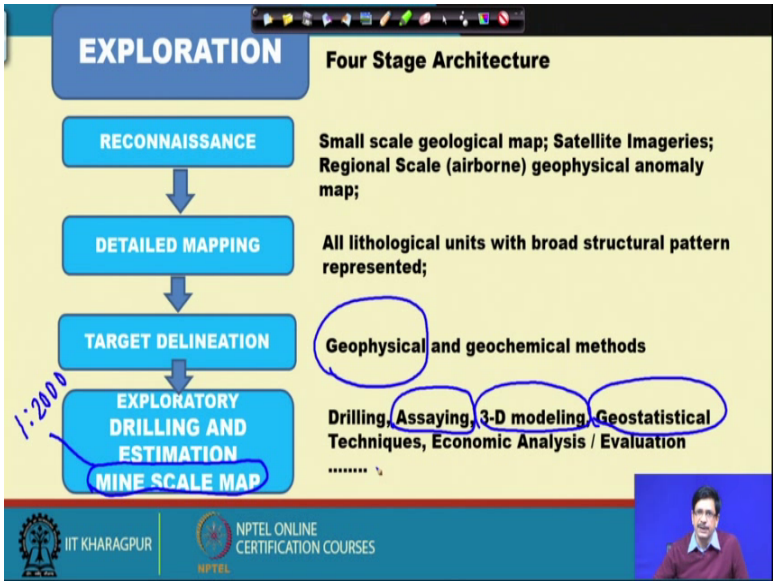

So, the last one, last stage is essentially the Exploratory Drilling Estimation, drilling the estimation. So, here we do study the area on the largest possible scale map which is a Mine Scale Geological Pap which is, this mine scale geological map which is almost like 1 is to 2000 or even larger where all the minutest features associated with the ore, the ore body and all the minutest are the features in terms of alteration characteristics, the different other type of lithology is there, contacts and all these possible magnetic details are all represented on a minor scale geological map. And here, once we have through the

through the previous stage where we are definite about the existence and we have deal indeed deal indeed the target.

There we will go for physic directly physically intersecting the ore body and that is done through the drilling say, like by putting intersecting the ore body directly by making real holes using drilling machines and that possibly gives us the most direct, because even a target drilling sense a success in a target delineation stage might come out to be a failure during the during the time when we are actually trying to, because this most of the method of geophysical method is a quite indirect and based on the methodology that we were using for interpretation.

And even though right at this point of time, the methodologies are quite elaborate and involved and they give very definitive results, but the actual success, the end of the success story in an exploration program like a 4 stage architecture that we are putting it in hierarchically, only the intersecting the ore body by a drill hole is the gives us the most direct evidence of it is presence. And then, by through this we are able to recover the samples of the ore body. We can analyze the ore body and can estimate the weight to the content of the metal of our interest.

Say for example, the copper in an ore body, what is the percentage that we have there. So, they are saying, the to first find out the quality criteria and to see whether that meet to our, that meet our standards or our expectation and the 3 dimensional modeling of the ore body because it is very essential to know how the ore body is disposed in 3 dimension because that keeps as a that is the primary knowledge that is required to plan for the exploitation process for the mining. And these exercise are very involved and they involve a lot of modern methodologies. They have to give you a lot of scope or of a computerization and these involve a lot of mathematical methods, which a little bit of it we could possibly some idea we can obtain here.

So, this exploratory dealing by this time, we had fluid if this exploratory drilling methods are over, the ore bodies existence, it is extension, down death extension, lateral extension in a in a broad sense will be established which will lead to a further evaluation as a project considering all the micro economic factors which we will also be discussing when you go to the project evaluation parameters.

So, this forced is exploration architecture actually it ends there where the exploration company possibly will hand over the data to the agency who would be interested in mining the or to exploitation of the particular mineral resource. And then would subject that particular resource to all sorts of quality, quantity, assessment, feasibility analysis in terms of ,and then the detail estimation of the ore body in terms of the reserve.

So, what we have seen there we would reach a stage where we should be able to report in terms of how much of the reserve is actually measured or proved or with very little uncertainty and then any amount, any quantity of the deserve reserve that we report would be still more than that with a little greater uncertainty as we have seen in our measured indicated in inferred category or proved probable and possible. And then this has to be subjected to a lot of other economic analysis for finally whether a project to be feasible to exploit or to. So, this actually is the 4 stage architecture.

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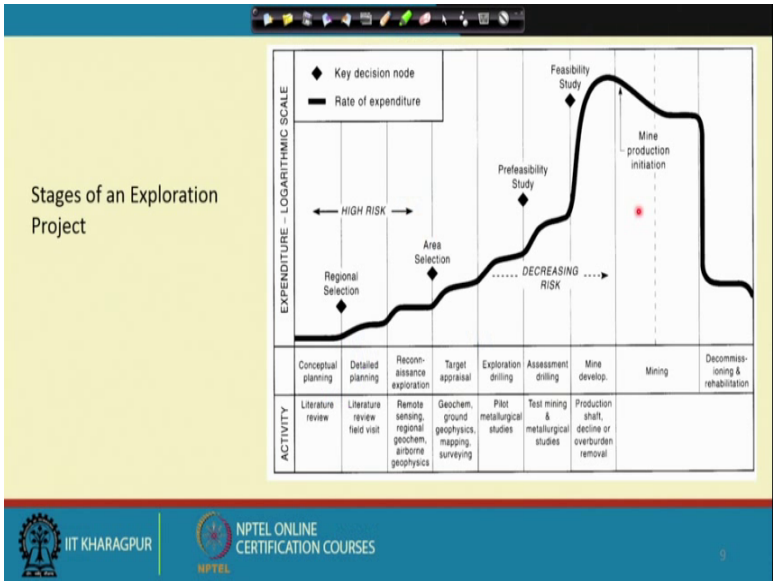

So this is a diagram which gives us an idea about the stages of the exploration project, not only that, it also gives us the I pull a picture up to the stage that a mining, a mineral based project it is very beginning and almost when it ends with the decommissioning or rehabilitation although, we will be mostly be concerned with only the part which starts as a conceptual planning, then a detailed planning, conceptual planning could exactly what we saw we put under the category of Reconnaissance by looking at the available material that are with us, then the detailed planning stage.

So here, the we could see this thick line here represent is the cost that is involved in different parts of the project. So, we could see that the Reconnaissance Stage or the events in many of the situations in the present time. The Reconnaissance Stage could be all, could be very much like a pre exploration analysis from existing data and once the data are required they can be used and reused n number of times, still trying to extract more and more information. And so this part of the work actually involves the list of expenditure. And as we go from conceptual to detailed mapping to target fixation and then when we come to the exploratory drilling. So, this is this part where the cost actually goes up and. So, that gives us an idea that that many of the situations that a particular or agency or a government, before going to this stage which involves the maximum of the expenditure in terms of the project.

So, the decision making process has to be very judicious here. And many of the projects get abundant almost at this stage because of the uncertainty in delineation of the target or any other parameter not being satisfied. So, many projects get abandoned at this stage, but any the project which go goes up to this and this after that the called the mine starts producing. So, this mine activity, here the cost involved becomes less because the mine starts to get revenue, sale the ore or the metal that there is been recovered and then they towards the last stage when the mine is closed, then it has to be redecommissioning and rehabilitation and so many things.

So, we are only concerned about it and this gives us an idea as to how the expenditure goes up when we go from a Reconnaissance Stage to a stage where we actually establish the presence of an ore body and go to the stage where it is ready to be exploited in a mine.

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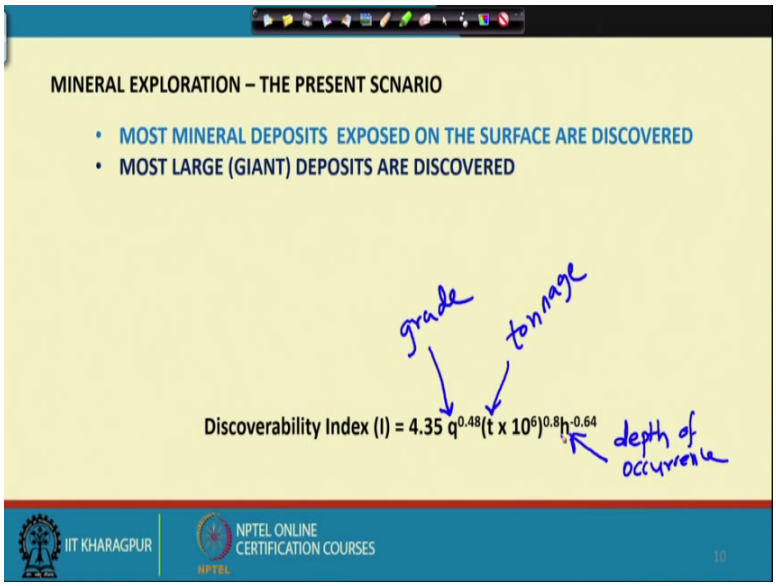

Before we go to the detailed discussion on Mineral Exploration, it is methodologies and the intricacies, let us have these things. These are the things which you can keep in mind that most mineral deposits exposed on the surface are actually discovered. We can, I mean this is a statement, pretty philosophical because at this and the beginning the first quarter of the twenty-first century, when we have more than 2 centuries of history of exploitation of mineral resources, bias, exploration. And as I have also stated before that the area of land which can be told as never been explored or my or never been seen or no I or having no idea have actually very less or shrinking day by day on at this stage of time it is to be difficult to say how much actually, how much of that area is still there.

So, those deposits which are exposed on the surface could be easily discovered by the early explorers. So, the situation is that and also most large giant deposits are discovered because larger is the deposit easier it is to discover it. We sometimes use the word is Giant Deposit, means the deposit which has a very huge quantity of the metal. For example, some of the gold deposits in the arbitrary province like mcintyre hauling your mine and even we can also think of a mine like Kolar in India which could be labeled as a giant deposit compared to the ones which are much smaller. In fact, the number of giant deposits are definitely small and most of the productions come from the much larger number of smaller deposits.

And so philosophically, it would tell us that chances of discovering such giant deposits are decreasing going smaller and smaller day by day. And the deposits which are which are which actually are exposed to the surface are also or the chances of getting deposits which are exposing the surface are also going down day by day. Here there is a very nice, very interesting relationship and that the people who generally work on quantification of this mineral exploration, you know the ideas, how to quantify or how to model the mineral exploration process by using many sophisticated mathematical and statistical tools which would be definitely be interesting to learn them in a higher level. But, say for example, we can think of a parameter which is called a Discoverability Index or discoverability of a deposit.

Here the parameters are q; q is the grade. So, q is the grade, t is the tonnage and h is the depth from surface, let us say depth of occurrence. So that means, if h is 0, the deposit is occurring on the surface. So, this relationship tells us that the discoverability, even we can we can even think of in terms of a diagram here.

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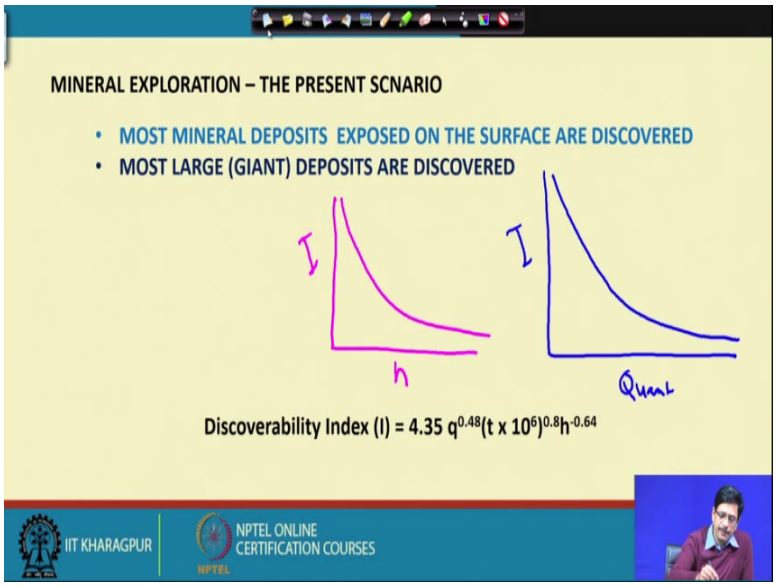

So, if we put say quantity, in say tons, millions of tons or whatever and Discoverability I here.

So, if the quantity is high, so it is basically the discoverability is also high. So, it is kind of sorry I mean the high the lower. So, in term at the right at this present time, the discoverability of much smaller deposit, it is rather larger and this might even have a

curve like this. So, if we think of the say we put also another parameter as the depth to from surface. So, if it is replaced by h here, I versus h, similarly discoverability will also go down like this so greater is, the greater is the depth at which deposit is likely to occur, the more difficult it will be for it to be discovered. And the chances of discovering such huge giant deposits are also low day by day and also the chances of getting the very high grade deposits are also low.

We can justify them because better or the higher is the grade of a deposit means the higher is the concentration of the particular metal. And so, it is a manifestation will be more conspicuous, more prominent rather than a deposit which is very low in it is grade, means we can always think of a deposit of a very high grade which is lying at a lower, the smaller depth compared to a deposit which is of equivalent grade, but lying at a greater depth. So, the one which is lying at a smaller depth is always likely to be discovered much easier or faster than the one which is lying below.

Similarly, we can also discuss in terms of size. If a deposit of a height tonnage is on the surface is far more discoverable then as identical deposit of that size which is lying at a greater depth.

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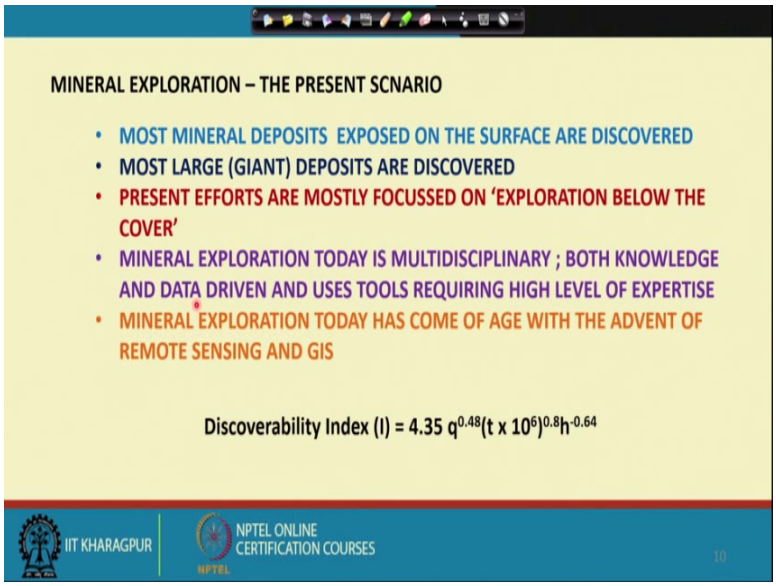

So, the present efforts are mostly focused on exploration below the cover. So, in most of the cases, we the deposits are concealed. In different geographical areas, we do have almost like 20 to 100 meters of thick soil cover or sometimes the if the soil has evolved

for a good amount of geological time, it is converted to what we recall as a regolith which is the paleo soil and it is quite challenging to discover or to explore for such deposits which are below the cover.

And mineral explore, so before we get you to the mineral exploration topics are the seeing the case histories or the procedures and methodologies in detail, we should keep it in mind that exploration today is actually multidisciplinary in it is nature. Not a single deposit that has been discovered in the recent past or even in a distant past is not out of any single method like a geological or a geophysical or geo chemical.

So, mineral exploration today is multidisciplinary even in case of geophysical, sometimes we need to use more than 1 technique and to synthesize the information jointly before getting any meaningful interpretation in terms of presence or absence of an ore body. And today's mineral exploration is more it is both knowledge and data driven because the knowledge means what we have acquired so far from our study of the mineral deposits of this wide spectrum that we have seen and also the data that we have generated.

Sometimes the data need not necessarily be related to any theory or hypothesis related to wood or geology or genesis of the science of ore deposit formation. The data could be for example, the digital image data that is acquired which essentially we know as the satellite imageries. So, though those data are huge or how many kind of data, there are some data being acquired to be used. So, that has given rise to a lot of sophistication in the kind of technology to deal with such data and exploration, mineral exploration at the present day today is quite an elaborate involved, sophisticated exercise involving all sorts of modern methodologies of soft computing, essentially mineral exploration has become much more computerized. Although we in this particular lecture series, we would not be able to touch them much, but can see certain important aspects.

So, that is what exactly what I have said that it has come of phase with the advent of remote sensing and then spatial data modeling technologies such as geographic and geographic information system. And these are the ones which should be in our agenda that we should be learning them in future if we want to understand or to contribute to mineral exploration effectively and actively.

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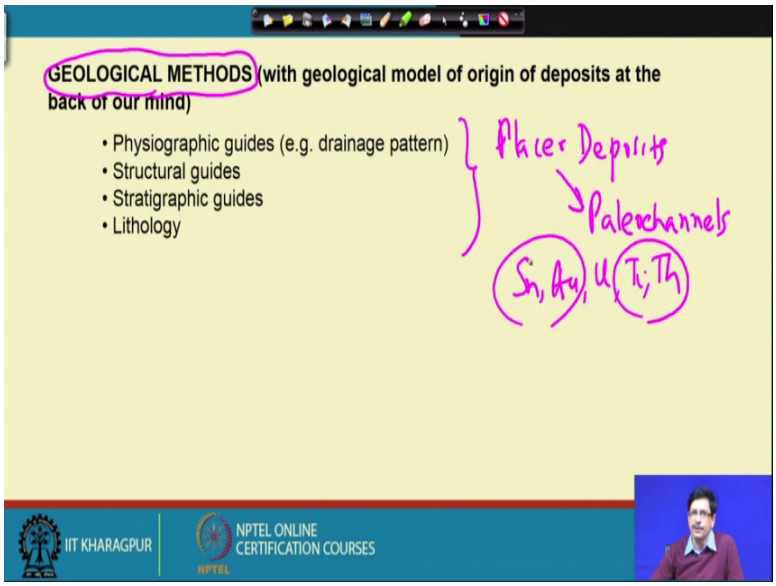

Let us first, so with this much of a background information about mineral exploration and what it is today.

The first and foremost methodology of conventional or a or traditional thought of mineral exploration is the Geological Methods. So, essentially Geological Methods means the knowledge that we have acquired about the geological processes that are responsible in formation of mineral deposits could be translated into elements which would be helpful for us to do mineral exploration. These terminologies like geological guides, here there are certain different types of elements that could be thought of, that a Physiographic guide, Structural guide, Stratigraphic guide or Lithology guide. So, they will all be coming out from the basic understanding that we have developed; say for example, we say about Physiographic guide.

We have seen placer, the process of mechanical concentration giving rise to placer deposits. And these placer deposits are essentially young deposits every even though there are placer deposits that are formed as early as in the Achaean which is exemplified by the classic Witwatersrand value of lesser voltage random deposits.

So essentially, if we understand that placer deposits can form and they form in the fluvial cycle and considering the fact that they represent and sometimes the kind of point by type of deposits which form in meandering rivers. So then, it leads us to the immediate idea that paleo channels or paleo river channels are the ones which should be those

obvious targets for the areas we should actually will be looking for, if we are looking for placer deposits. And we know placer deposits are essentially of minerals like tin, tungsten, tin, gold, uranium and even titanium, thorium which are essentially beach places and this tin tungsten, tin gold these are the alluvial type of places which they form.

So, if we are looking for alluvial places that we have to look for paleo channels and paleo channels will make some very well identifiable geomorphic features of the physiographic features which could be immediately could be thought of something which what we mean by a Physiographic guide. And the drainage pattern in a particular area is a very we will be seeing this drainage pattern, a little while in discussing some case study for that.

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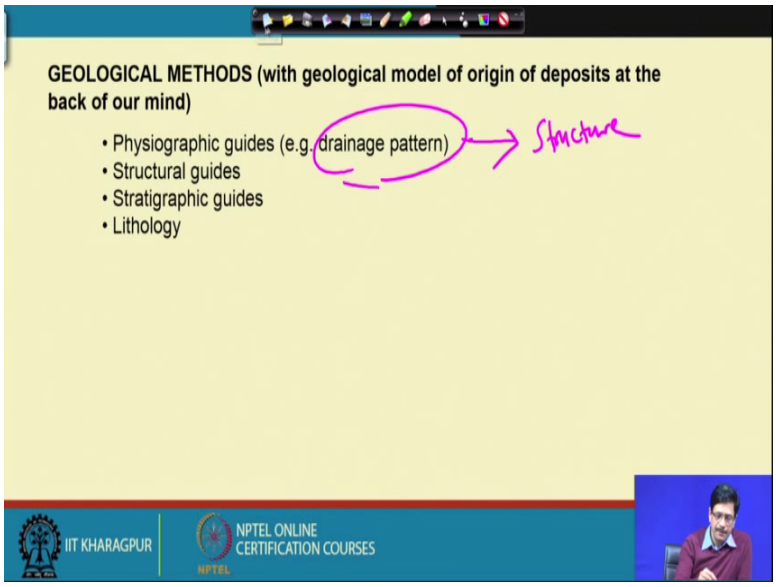

So, the drainage pattern which could be identified on it on a map, on a toppociate and also from a very small scale maps like a satellite imagery which gives a synoptic view of the earth surface. We can see that a drainage pattern, the drainage pattern is a very many different types they have been classified based on the and this drainage pattern is very much controlled, the drainage pattern is very much controlled by the structure in the rock structure, in the area and by looking at on not only structural sometimes the lithology also which will which becomes very the feature which can immediately be identified and based on that the explores, the areas to explore could be chosen.

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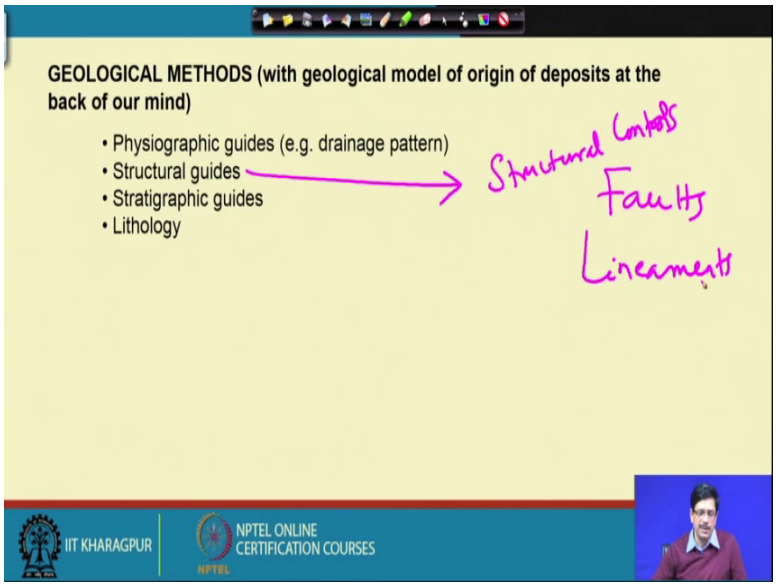

And Structural guides, this is a very important aspect, because we have what we essentially call as a Structural Controls, Structural Controls of localization of mineral deposits.

So, these structures could be the much regional scale structures of or could be local skill structures. In many of the cases, we find that an area which has been affected by multiple phases of deformation and each stage of deformation has acted till the time of deformation of the ore body. And sometimes, we can clearly identify any particular phase of deformation which has been actually responsible in localizing the ore body.

So, it is very essential to work out the structural features. So, generally the structures would be like, important structures like faults which will make prominent feature on and surface manifestation, on any part any part of the continent where they could be identified by proper geological map or situations which are coming out from a where we can see a synoptic view or the surface of the earth by very small scale maps, like satellite imagery or anomaly maps. And also the lineaments, which are the large scale features and so on.

And we will be we will continue our discussion on the geological method with different types of guides in the next class.

Thank you.