Mineral Resources: Geology, Exploration, Economics and Environment

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Lecture – 29
Indian Mineral Deposits

Welcome to today's lecture, during the past few weeks; we had a glimpse of the wide spectrum of ore deposit types that occur in various parts of the world in different continents. We have just had a glimpse of them and that was the initial part of the lectures series that we intended to cover; with intending to obtain the overview, brief idea about the geology, about the principles of ore deposit formation.

And what we have learned so, far can be called as just the alphabets of the subject of ore geology; which has a lot of intricacies. And many of the ideas that were originally proposed on the deposits are constantly getting refined with availability of modern techniques, micro analytical techniques, new ideas; emanating from using many different techniques like the rare earth elements, the stable and radiogenic isotopes, ideas about the sulfur isotopic makeup arising out of inorganic and organic reduction of the seawater sulfate.

Many experiments conducted on many systems to quantitatively understand the processes of fractionation of different metals in different systems. And many of the deposits, many of the well known deposit types have witnessed a lot of debate as far as their origin is concerned. For example, the value pressure deposit at witwatersrand basin in South Africa; which was for quite some time was held to be a deposit which are generated from the mechanical concentration type process; was very strongly debated for its origin from a hydrothermal fluid, which was almost taking to the hydrothermal system that give rise to the low type gold deposits

But later on again many detailed study have revived the concept; they revived the idea about the origin of such deposits. Similarly, there are many such instances and we have not; so, those are the things which you will all be learning in your advanced level courses on ore geology. And we have seen that this wide spectrum of ore deposits occurred throughout the geological history, starting from the early Archaean; till the quaternary and many of the deposit forming processes seem to have been very restricted to certain

time period for example, the banded iron formations; the process was never repeated in the later part of the geological history after the late Proterozoic.

Similar is the situation with the Paleo pressure deposit of uranium and some deposits like the partially covered deposits are not found to be occurring in any of the older cratonic blocks and understood to have been forming in the process of the plate tectonic type process, which is operational at this point of time; from the present day global tectonic setup.

So, now with this brief background it would be good to see as a component of this course and which is usually required by students in the Indian context; to have some idea about the deposits that are occurring in the Indian subcontinent; more specifically in the peninsular Indian region. And this discussion cannot be very exhaustive because the deposit types are; so many, so vast and occurring in different parts of the peninsular India. It is not possible to give a very detailed account of all such deposits that occur in the peninsular India

So, we will all be restricting ourselves to some very selected deposit types and most of the discussion will not be based on statistics. For example, the quantity of the metal available in such deposits and such kind of parameters; which can be obtained from many available say resources. For example; the Indian bureau of mines or the information from the respective mining companies; so, I will not be getting into much of the details about the quantity, quality aspect of these deposits.

And we will only be discussing such deposits with an idea as to the potentials of different parts of the peninsular India and the what could possibly look like as the future scenario. Because in the beginning when we were discussing about the mineral deposits in the context of the Indian economy, we stated that the role of mineral resources in the growth of the Indian economy is not that very distinct; although as a country, we still depend heavily on our mineral resources for the growth of our industry; falling short on many of the critical and strategic minerals and metals.

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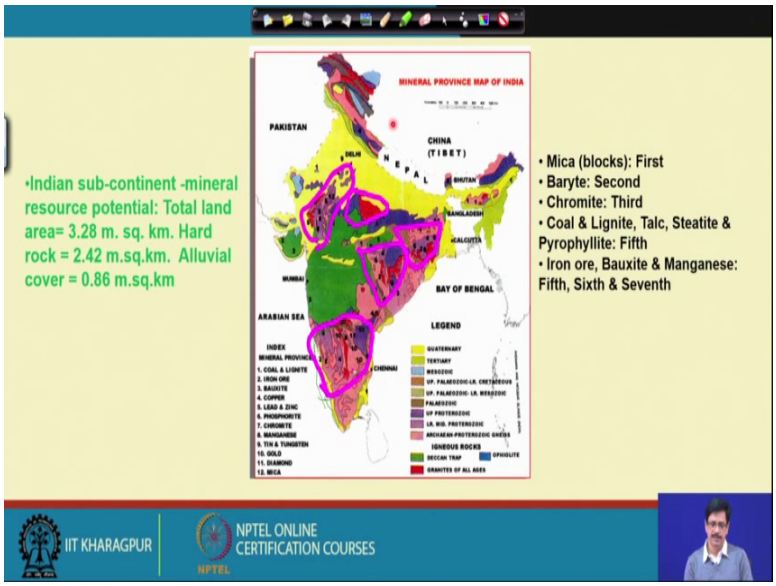

So, with this we will just have a brief overview of the Indian scenario where; so as you could see here, this is a almost like a country scale map; geological map of India and here we could see that this peninsular India is most part which is basically covered by the Deccan traps shown on green here

This is the part Deccan trap which covers the substantial part of the peninsular India and just keeping that aside; we see that this peninsular India is basically is an amalgamation of a few cratonic blocks; old cratonic blocks, the cambrian cratonic blocks. This is the Dharwar craton and below is the southern granulite build; this is the Dharwar craton here, this is the Bastar craton; this is the Bastar craton this is the Singbhum craton and this is the Aravalli craton and this is the bundel co chranton

So, these five main cratonic blocks constitute the Indian subcontinent and as we saw before; so, the total area that is covered by rocks of the cambrian edge a quite substantial and we would expect that the mineral resources also would be coming from dominantly from these broad areas.

Let us first see the mineral potential of this Dharwar craton; which will be again getting into look you looking at a bit little larger scale map. So, this Dharwar craton is the cratonic block which represents; so, the Dharwar craton is essentially divided into the eastern and the western Dharwar craton and the closebrit bornite which is occupying the median region of the craton and along with some crustal skill structural feature like this;

Chitradurga shear zone over here, it is divided into the eastern and the western Dharwar craton

Now, what is shown here in this purple color bodies these are schist belts of the western and eastern Dharwar craton. And this eastern Dharwar craton and the western Dharwar craton are quite and out with resources of gold. In fact, most of the production gold at the present time in the Indian context comes from the eastern Dharwar craton with some new deposits also coming up from the western Dharwar craton; from the Chitradurga schist belt, which I will be just showing a larger scale map.

Since this Dharwar craton; these schist belts essentially at the metamorphosed green stone sequences which are the volcano sedimentary rift related; volcano sedimentary sequences of Archean age which are metamorphosed and are exposed in the form of schist belts constituting mostly of amphibolites and sometimes lower grade chlorotic rocks.

And this cratonic block is transversed by parallely disposed number of shear zones and those shear zones have been the locales in which the major and the rich gold mineralization have taken place. Since these are the old greenstone belt, as we have seen in many of the cases; they are also potentially rich in the algoma type iron formation which comes from this; the Archaean sediment hosted manganese deposits; volcanogenic massive sulphide deposit like the one which is deported from Engel del area in Karnataka

So, this Dharwar craton which spans the area of Karnataka and Andhra Pradesh many of the prominent gold localities come from these two states; they probably one of the major gold locality which produced the maximum amount of gold and has the history of gold production of more than one and a half centuries, but got closed just about a decade back is the famous Kolar gold deposit; currently producing gold finds mostly in the arti maski schist belt and new deposits being discovered in the Gadag schist built and also as we saw before in the green stones; there the ultramafic bodies which we see the metamorphosed ultramafic bodies of the earliest volcanic activity.

We also do get some amount of chromium. So, this Dharwar craton actually is can be visualized the huge metallogenic province giving substantial amount of production of iron, some amount of manganese, major gold deposits in the country.

So, coming to the Bastar craton here; one thing we can is very obvious from this very very small scale geological map of India is that in almost all the cratonic blocks that we see; we get extensive granitic activity which mostly dates between the late Archaean to early proterozoic kind of period and which coincides with a major crust forming; major growth is very steep and a very fast rate of growth of continents during the time. So, these prolific granitic activities also had a lot of Proterozonic implications.

And in addition to that almost this cratonic blocks, they are essentially constituted of the basement gneissic complex in the Dharwar craton; they are known as the peninsular noise in Aravalli craton they are known as the banded gneissic complex and in the Singbhum craton also there similarly named older metamorphic gneisses and. So, on and in Bastar craton also we do get the basement noise

So, Bastar craton is also a very interesting geological situation although there is no such prolific development of such greenstone belts, but some very rudimentary greenstone belts have been reported from here; where sporadic occurrences of gold has been reported. But the major mineral potentials of this Bastar craton is the copper deposit coming associated with granitoid here. And also some amount of tin associated with granite pegmatite; which will be seeing them a little details. And this Bastar craton; adjoining swasath metamorphic belt is the major manganese producing region of the country.

And coming to the Singbhum craton; so, these cratonic blocks are also bordered by the mobile belts and here this is the eastern ghats mobile belt. And also this the Singbhum craton in and also the Bastar craton has been the two major important sources of iron deposit;s which belong to the superior type of iron formation in the Singbhum craton here. And also associated with the Archaean with the same time period, the manganese deposits and as we shall see a little bit in a larger scale map; the Singbhum craton also hosts one of the major metal otect in the form of the Singbhum shear zone, which gives; which has produced substantial amount of copper and in addition to that is also one of the uranium rich areas of the country.

So, Aravalli craton has been the major contributor of the lead and zync deposit in the form of the sediment hosted massive sulphide deposit or SMS or the sadeks type of

deposit coming mainly from the Aravalli fold belt in the Rajpura Dariba, in Java and in Rampura Agucha; which we will be seeing them a little detail.

And also the north Delhi fold belt where a major copper producing zone has produced quite substantial amount of copper. And in addition to that, there are many other mineral commodities which are produced from this particular craton; we will be seeing them only selectively. And this is the bundelkhand craton and also in between we do have some very rudimentary or very not so, well developed greenstone belts; coming from the Mahakoshal belt over here and which also have been reported to be gold bearing in some and certain restricted areas. And similarly also from the Singbhum craton; there are some such occurrences which have been reported.

So, if we look at the mineral potentials of the Indian peninsula or Indian subcontinent as a whole, we see the statistics a little bit over here; there is about 3.28 million square kilometer the hardrock is about 2.42 million square kilometer; what we exclude the substantial area that is covered by the Deccan traps.

The alluvial cover is about 0.6 million square kilometer and on the right; the information that we have is that we are the dominant producer of the industrial minerals which is Mica, mostly coming from the Mica the pegmatite we have Mica varying pegmatite belts in Hazaribag district in Bihar.

Barite, we are second in production of barite, we are third in producing chromite yes which is basically coming from the Singbhum craton; a little bit from Dharwar craton also along with the old graphic units. And the major chromite resources come from the Singbhum craton which we will just have a look when we see the Singbhum craton map in details.

And since we are not covering much of the nonmetals and the hydrocarbon rock and hydrocarbon resources still as a piece of information, we are also fifth in producing coal and lignite and we are sixth in iron ore production and bauxite and manganese were sixth and seventh respectively.

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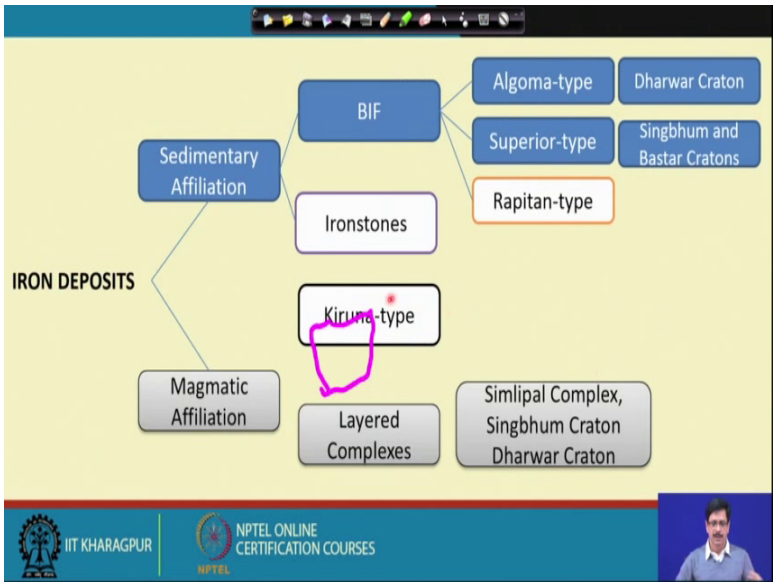

It would be good to see or it would be worthwhile to make a correspondence with the different genetic deposit types that we just went through and which we go by commodity wise; then first consider the most abundant of the metal size iron. So, the iron or sedimentary and the magnetic affiliation; as you have seen the genetic types the sedimentary thermogenic sedimentary deposits are the banded iron formation, the iron stones and the magnetic type of the Kiruna type and the layered complexes the ones which are marked in white boxes.

Generally that such type of deposits we are we are not considering here and also the iron stones are not considered as resources of iron, which is considered for some separate resources. Coming to the banded iron formation; we have the Algoma type, Superior type and Raptian type and we do not have any report of occurrence of any Rapitan type banded iron formation in anywhere in the peninsular India.

As of now; so, we do have the Algoma type which I have just mentioned occurring in Dharwar craton; in the Kudremukh area and some other part in the schist belts of Dharwar craton; there affiliation may be a little bit uncertain could be superior type associated with volcanic members. And the Singbhum and the Bastar crtaon which are definitively of the superior type; although there are some references of them being green stones, but the widely held idea is that these deposits which are occurring in the Singbhum and the Bastar craton; like the iron ore craton and the balarila formation in

central in the Bastar craton are the superior type our information's occurring in extensive areas of hundreds of square kilometers.

So, we will go to that, but magnetic affiliation generally we see as layered complexes; what we have seen in case of Boswell complex occurring or the layered complexes occurring as oxide layers with the intermediate type composition and endoparasitic caproic type of composition.

The only occurrence that we have in the Singbhum craton is the simlipal complex which comes to a near to that; there is certain on economic occurrences of titanium and vanadium bearing iron oxides associated with the simlipal complex the details of which we will not be discussing here.

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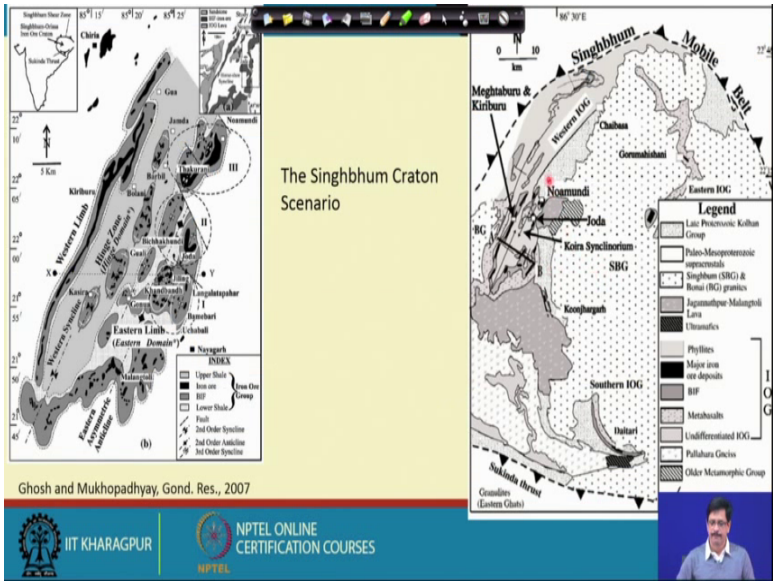

It is a map; it is a little larger scale map of the Singbhum craton; this is a Singbhum, this is the Singbhum mobile belt separating the Northern and the Southern Singbhum craton. I would like to draw your attention to this particular; the western part of the Singbhum craton which is essentially known as the Noamundi basin. And which hosts the rich iron deposits and producing the iron ore in good quantity from for our domestic consumption as well as for exporting.

And in this craton; we have this Noamundi basin and the Gorumahi shani (Refer Time: 23:58) basin which is also another iron ore basin in the Singbhum craton. And the daitari

basin which is very close to the Sukinda thrust which marks the southern boundary of the Singbhum craton. And if we look at a little bit of a larger scale map of this Noamundi basin; which is essentially in the form of a which is popularly known as the horseshoes in clinorium; essentially the synclinal structure and the iron formations are shown in this thick black curves and the patches here.

So, those are the different locations of the rich iron occurrences; although this belt runs for a few tens of kilometers here. The iron deposits are localized areas that the enrichment has taken in different smaller localities; what is suggested is that this particular synclinorium, the eastern limb the ore deposits are more on the basinal because after the major phase of deformation which has given rise to this synclinorium structure.

There has been a cross folding in an east west fold axis and its given rise to this complicated structure. And as it looks like the localization of the enriched iron ore in this particular region is very much structurally controlled, where in the eastern limb; the major ore localities the mines are essentially based on the domes that is formed by the cross folding and on the eastern limb it is on the basins.

And also as we discussed about the very close geochemical affinity and the special closeness of occurrence of iron and manganese; that we could see it clearly from here. This is the core of this synclinorium; which hosts a number of important manganese localities; as it shown here.

And what exactly we have when we see these iron ore deposits and we go by the principles and the origin that we have discussed about the iron formations; extensive iron deposition from the seawater which was very rich in its iron held in plus two state. And the conditions were favorable with increasing a atmospheric oxygen; they gave rise to the iron ore formations which originally were deposited as the laminated or the iron ores it mezzo bands of iron rich and silica rich layer.

But those could not be directly used as iron ores because the iron content will hardly go to 17, 18 percent; whereas the ore which can be treated for extraction of the metal; would require to at least 55 percent of iron. And so, this is understandable that these particular; these deposits must have undergone some enrichment processes after the formation; after the original deposition.

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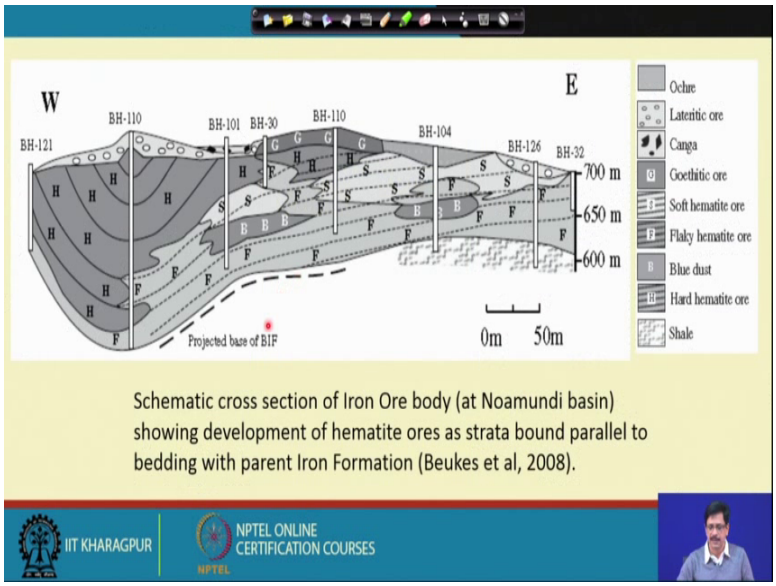

Here is an example of what exactly we get in an iron ore body which is taken from the Noammundi basin; it is a hypothetical reconstruction from the drill hole data by Beukes et al recently

Where we see that; in fact, when it occurs at as a minable or minable ore there; they occur in much more enriched form as occur or as lateritic ore, as gowitheric ore where its mostly iron as soft hematitic ore or flaky hematitic ore; blue dust which essentially are the products of processes enrichment.

And that is the reason why; it has been suggested that such basins after; as we see them today in their deformed state and also have undergone variable degrees of metamorphism with reconstitution of the players. And essentially selective leaching of silica because of hydrothermal solution and those hydrothermal activities could be much later than the formation of this iron ore basins.

And even the enrichment process which we also discussed during our discussion on the residual concentration process; we also saw that rich iron ore deposits also occur or can come into existence after they are subjected to such kind of enrichment process, which could be even very very late in the geologic history; almost in the Centrozoic time.

So, this exemplifies and such kind of whether it is the iron would be seen in the iron ore craton or in the volatility seen in central India. The story is the same that the originally

deposited formations in the form of banded iron formation with the measurements of iron rich and silica rich layers.

These materials have to undergo enrichment through processor hydrothermal activity and further enrichment process; even almost like surface operating meteoric water; because due to prevalence of conducive environment, the iron ore gets further enriched to give rich ore bodies.

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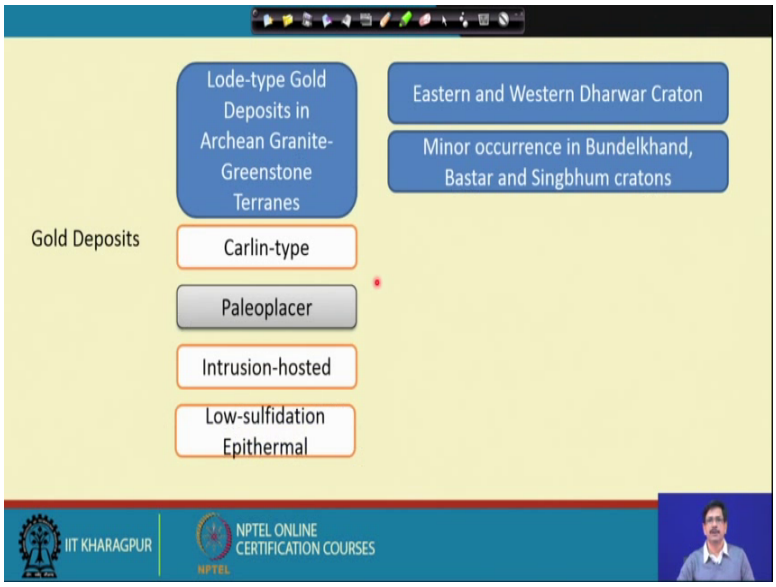

So, we will continue our discussion of the Indian ore deposits in the next class.

Thank you.