Mineral Resources: Geology, Exploration, Economics and Environment

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Lecture - 30
Indian Mineral Deposits (Contd.)

Welcome to today's lecture. We will continue discussing on the Indian ore deposits, and as stated before we will be concentrating on a very on a few selected ones to have some idea about the mineral potentials of the Indian peninsula. And keeping in mind that areas which look to be more potential should be subjected to more intense exploration efforts to augment of resources of such kind of important metallic minerals or metals in the country.

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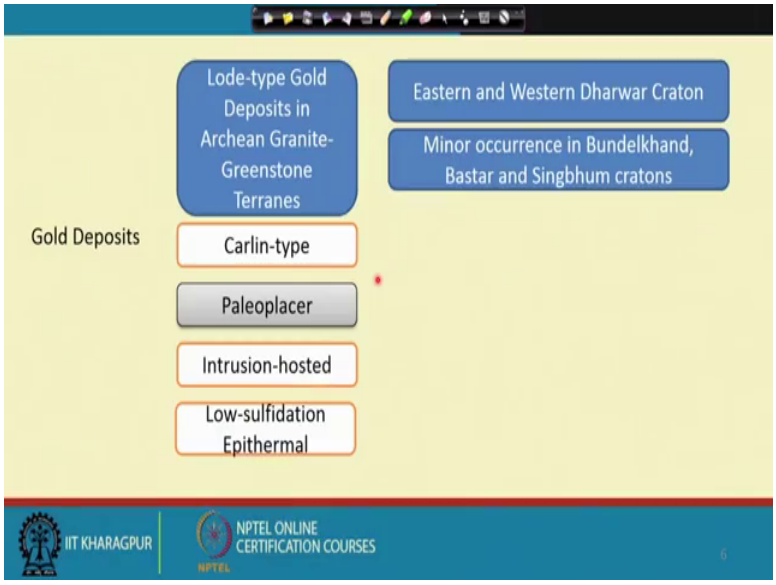

So, let us continue. So, from last discussion, which we are discussing on the iron deposits we will move over to the next important mineral which is one of the critical metals in which the resources are quite short in the Indian context. So, let us talk about the gold deposits. In the gold occurrences, we saw that these gold deposits could be of these genetic types. There the lode-type gold deposits in the archean granite greenstone terranes which are being called these raises the orogenic deposits, mostly in the later archean (Refer Time: 01:42) type greenstone sequences.

The Carlin-type, the paleoplacers, intrusion-hosted these deposit we did not discuss much in our course of discussion because they also could be classified as a porphyry gold or the gold deposits which are associated with reduced type of magnetic intrusions. And the low-sulfidation epithermal deposits like the one exemplified by the (Refer Time: 02:10) deposit in Japan and some other like the larval deposit in Lahir island in Papua New Guinea, which are very rich small, but very rich gold deposits in the world scenario.

The ones which are in the white boxes presumably are the ones which we lack such type of deposits in the peninsular India in the Indian subcontinent which is the sediment or straight Carlin-type and the intrusion-hosted and the low-sulfidation. This paleoplacer is just kept in a little lighter gray box although we do not have such rich paleoplacer deposit as the (Refer Time: 02:52), but there are reports of recovery of gold from many of the river basins in India which we will not be getting into much details.

So, as stated before during the discussion on the different territory blocks and their mineral potentials we discussed that the Dharwar Craton is endowed with appreciable gold potential. Although, it would look rather quiet meagre compared to the gold occurrences in the Yilgarn Craton in Western Australia. Yet we do still have and the area in the Eastern and the Western Dharwar Craton, do have a lot of promise for discovery of few more such gold occurrences in the country. And minor occurrences as I stated in Bundelkhand, Bastar and Singhbhum Cratons where there are some small localized or rudimentary development of some greenstones which are metamorphosed and presentize sisto rocks in these cratonic blocks in restricted basins.

There such as for example, the Mahakaal belt in between the Bastar and the Bundelkhand Craton. In the Bastar Craton, there are areas such as the Sonacan belt which is also gold bearing. And in Singhbhum Craton, there are certain greenstone panama fluids greenstone belts which are identified and they want to be quoted as the which is essentially in a Sistos rocks as we see them and the Kunderkoch area in Singhbhum just about close to the Singhbhum shear zone.

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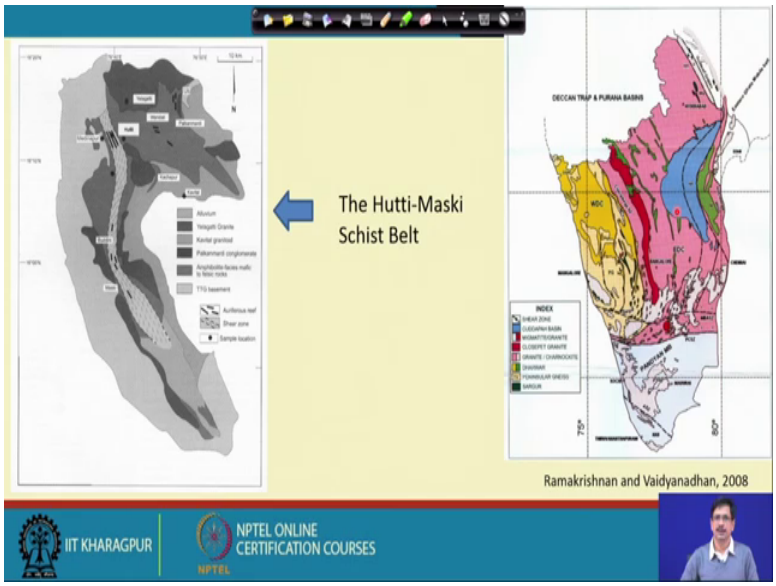

Let us look at the Eastern Dharwar the Dharwar Craton scenario. These are the these green coloured bands curvilinear bands are the Eastern Dharwar schist belts they can be called as oripourus schist belts, the one which is hook shift over here is the Hatti-Maski schist belt. So, this is the Hutti-Maski schist belt and this is the hung hung ramagiri pinaka therilla schist belt which is also produced good amount of gold. The (Refer Time: 05:22) one here is the ramagiri gold field.

And this one here is the Kolar gold field with and this prominent body is the (Refer Time: 05:34) petranite. And this is the Sandur schist belt which produced quite a appreciable amount of manganese and history of manganese and the yellow ones which is shown here as the western harbour schist belt. And the some of the newly depth developing areas include are generally gold deposit associated banded iron formation in the Chitradurga schist belt and the garden area in the Chitradurga achiest belt.

We discussed about the origin they dump they widely held hypothesis about the origin of such kind of deposits which we call them as is lode type gold deposits in Archean granite greenstone terrains or now being referred to as the autogenic gold deposits. They owe their origin to metamorpho genic fluid which evolves through the metamorphism of this volcano sedimentary sequence, the greenstones. And the fluid carried the fluid which is essentially a water carbon dioxide and sulfur bearing species dissolved appreciable amount of gold least from the volcano sedimentary pile, and more particularly the (Refer

Time: 06:53) which was supposed to be having high concentration of gold. Mobilized the gold and channelized them through this major shear zones. Although we see these curvilinear schist belts of a quite long I mean in terms of few hundred kilometers in length, but the gold localities rather look restricted such as the ones which I showed here.

If you look at the map of the Hutti-Maski schist belt which is here, so we could see here that the the prominent shear zone is observed to be in the middle part of the schist belt along with the Hutti group of rocks. But the mineralization actually the most enriched part is coming from the Hutti mine where we this thick line indicates that there are multiple number of such orifice loads which being worked in the single mine which is the hearty gold mine over here. And the ones which are shown here is this black short black lines really small prospects and few of them like here (Refer Time: 08:03) and some areas over here. I also have just started to produce gold where the gold in terms of the grade and tonnage the grades sometimes maybe five or six grams per ton.

So, what is more important here is that as I discussed that such kind of greenstones belts or the old or older greenstone belts experienced prolific granitic activity. And the ones which are shown here in the lighter gray over here is the older granite which is the capital granite and the it is also witnessed by the latest phase of young granite is which is presented in a little darker tripper over here and here and here.

So, the role of these granites are not very well evaluated, although it can be expected that such done which basically are temporarily quite overlapping with the gold mineralization. Although the exact timing of the gold mineralization in this kind of belts is not known because we get some indirect evidence of their age coming from the alteration zones in the meta basic rocks, meta basic hosts without getting any direct indication of the from the age of the gold. So, they are remains a little bit of uncertainty.

And there is reason it is also quite possible that the granites in these regions as a whole when we consider the emplacement of such huge granitic body like the close print on its extending for over 400, 500 kilometers in the Dharwar schist, the Eastern Dharwar craton. And also its equivalents occurring in almost all the major part of the Dharwar craton in form of smaller bodies of ages which is almost coming to just about Archean protozoic boundary or something about 2550 kind million years kind of age. And they do

have a they seem to be having played the role in mineralization or enrichment of the gold in many of the cases as if it were by the Hutti-Masko schist belt.

Some of the gold occurrences also are coming from the here, since we see the Dharwar craton map here. The southern part of it is the southern granulite belt and we could see some of these shear zones like the moyer babani shear zone, and gold occurrences are also reported from this kind of high-grade rocks and on this kind of shear zones. The exact origin of these gold deposits are not very well known, but this they possibly have resulted some such kind of fluid activity.

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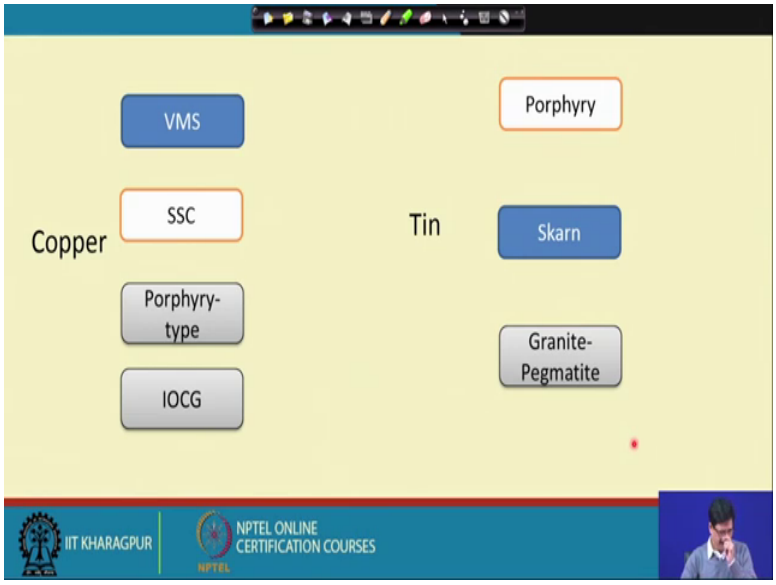

So, this is now we move onto copper. We know that copper occurs is volcanogenic massive sulfide deposit, the sediment the stratiform sedimentary strata form copper deposit SSC like the copper schist for and the zambian copper belt, porphyry type, and the IOCG - the iron oxide copper gold. This has been put in a white box presuming that we in the Indian scenario we do not we lack as of now as per the present state of the knowledge is concerned, we do not have any SSC type of copper deposit in the country. The only volcano generates any massive sulphide deposit of proved volcano generates any massively sulphide deposit revelation comes from the Dharwar craton as i just mentioned there this (Refer Time: 11:49) deposit associated with the schist belt on the Western Dharwar Craton.

And the two important type of deposits is power free type and the IOCG, these are put in the box a gray box because, we still possibly have a bit of a doubt whether we do have porphyry type copper deposits or IOCG of any part in the country going by the world distribution temporal distribution of the porphyry type deposits which are essentially associated with young granitic activity taking place in the convergent plate boundaries like the Chilean Andes or somewhere in the Papua New Guinea or the Philippines Fiji area and some paleo subduction zones identified in parts of Iran or somewhere in Chinese in China. This Indian peninsula area dominated by the older granitic rocks is rather look to be very very less likely or less prospective to have to be hosting a deposit which is of the type of porphyry type and IOCG.

So, in this context, I will just like to focus upon some of the part in central India. Before that since they are related tin, we have porphyry tin, we have skarn we have granite pegmatite. And as we have a very little possibilities of bearing the extra peninsular India in the a the Himalaya and collision zone we can possibly rule out the occurrence of such porphyry team deposits anywhere in the peninsular India. And there are reports of skarn deposit in the Aravalli craton which I will be may be touching upon just when we will be discussing Aravalli craton. But in major part of the Indian peninsula in the Bastar or Singhbhum and the Dharwar craton as of now we dont have any report of occurrence of such skarn type mineralization giving tin tungsten deposits.

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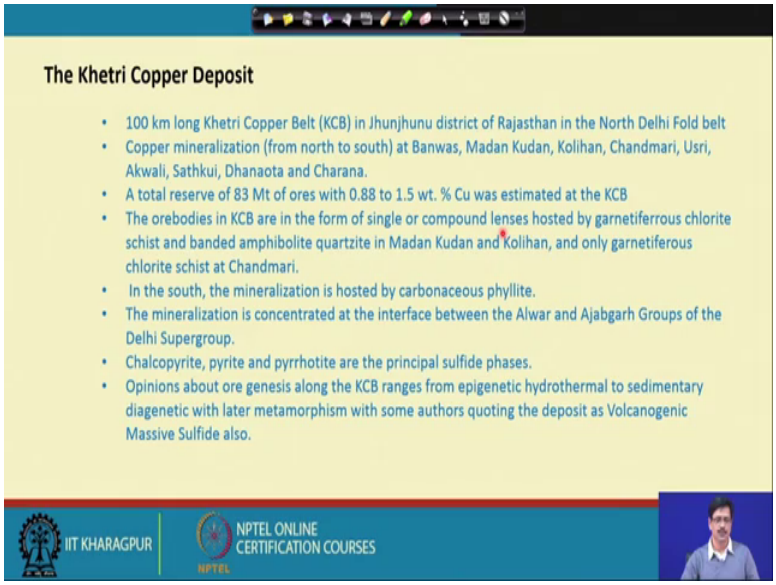

With that, I will just go to the copper mineralization. We will discuss the western with the north western Aravalli craton into a little bit of details, but since we are discussing copper it will be worthwhile to briefly discuss about it the occurring in the North Delhi full belt which is the northern part of the Aravalli craton. There we have the Khetri copper deposit, which has produced a good amount of copper over past three four decades although the resources have been dwindling mostly. So, this is a 100 kilometer long a Khetri copper belt in Jhunjhunu district of Rajasthan in the North Delhi fold belt.

And this copper mutilation occur in different localities like Madan Kudan, Kolihan, Chandmari. So, the deposit is essentially they are occurring in garnetiferrous chlorite schist banned in amphibolite quartzite. They all look like as if their sediment hosted and this sediment of schist deposit has been metamorphosed to a fair degree with giving rise to garnet for ass chlorate schist and amphibolite quartzite and sometimes guarantee for us chlorate schists. And they are single two compound lenses of this kind of ore bodies there.

And the southern part the mineralization hosted by carbonaceous phyllite. And the mineralisation is mainly in the interface between the Alwar and Ajabagarh groups of the Delhi Supergroup. The mineralization has chalcopyrite, pyrite and pyrrhotite which is to be noted here as the principle certified fails. So, the opinions have differed about the origin of this deposit as being just epigenetic hydrothermal to sedimentary diogentic or later metamorphism even there are mentioned for this deposit belonging to the volcanism of any massive sulphide deposit. But we could possibly think that they belong to the sediment hosted massive sulphide deposit or could be and later on to have been work by some hydrothermal fluid.

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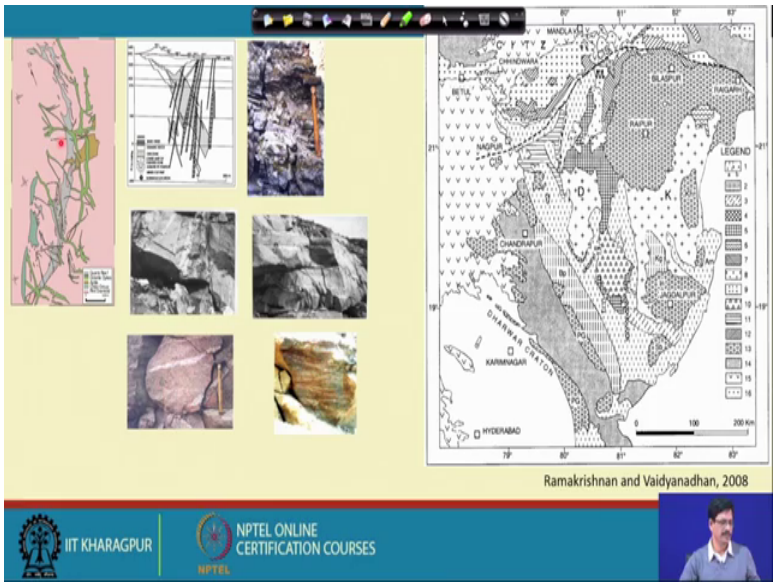

So, in the context of copper deposit, and with the basic idea of the debate as to whether we could have a perfect copper deposit anywhere in the Indian subcontinent I would like to bring the attention to them one of the major copper occurrence of the present time producing the bulk of copper in the country is the Malanjkhand copper deposit. This is the map of Bastar craton and what we see here is the small, it is actually is a body granite or body dominantly with an or diorite composition occupying about 14,00 square kilometre area.

And this is a this purpose of showing this map is interesting. Here it is the a prominent question scale structure which is referred to in the literature as the central Indian suture as forming the southernmost element of the central Indian tectonic zone which is to the north which is a North Swooner with the fault south swooner with the fault, and the tan shear zone. And this being the southernmost which is the central CN and central Indian suture is the supposedly the one which demarcates the collision zone between the Bastar and the Northern Bundelkhand craton, which is definitely without getting into the debate of the origin of such kind of a crystal scale feature. We could discuss the mineral potential of this Bastar craton in totality.

So, here is the Malanjkhand craton about 14,000 square kilometre area exposed this part is the donger guard group of rocks constituting of the non (Refer Time: 18:04) and the high regard volcanics and the volcano sedimentary sequence over here and two small

bodies of the dongargarh granite and the larger part of the dongargarh granitoid in the Manpur Dharawar area. And this is the large (Refer Time: 18:21) over here. And this is the Chhattisgarh basin and this is the geologic setting of the Bastar craton on.

So, this is the picture about the Valanjkhand copper deposit where just about this is the northern part of the Malanjkhand north western part of the Malanjkhand granetoid body where there are indications of brittle ductile shearing and whether most part of the granetoid khudon is undeformed. And what we see here is about a two point more than two kilometer long a body of quartz which we call as a quartz reef which is very richly mineralized with respect to copper. The dominantly the mineral being chalco pyrite and pyrite. And very significant in its absence of pyrrhotite as a sulfide mineral anywhere in this deposit, and this deposit is surrounded by the granite.

And some of the features of the mineralization is shown here. The main mineralization is concentrated in the medium quartz if which goes for about 2.2 kilometres. And its varying width in the central part it obtains it ends about a width of about 100 meters and tapers down to the north and south. And it is disrupted and dislocated by the later dikes which are unmineralized or also applytic kind of body. And the ore body the section shows its clearly up body which looks like being controlled by a major fracture zone where the ore bodies of a tubular shape and extending to depths of more than 800 meters.

And the immediate contact the granite also contains such kind of strangers which are also mineralized. But as a whole the style of this mineralization is no here compared to this the porphyry style copper deposit which is reported in literature coming from the Chilean Andes or any part of the world. And it lacks the prominent alteration zone in terms of the silicic or the filing alteration really simply absent, whereas, the kind of alteration which can be thought of as a propagating alteration far extends beyond the reaches of the mineralization of the confine of the mineralization. And this kind of this shows a very picture of a very richly mineralized part of the quartz reef, and which is shown here. And this varies in its nature in terms of its thickness and the nature of being of a sheeted vein complex which transfer about this much.

And here the fluid characteristics is also quite different it is a dominantly low temperature fluid although it is from the fluid inclusion studies. It is found out to be a derivation from the granite where the fluid evolved a very low temperature pressure

condition. The pressure in the granite, the mineralization and the pressure of formation of this ore body and the mineralization are quite different at least about 2 to 3 kilo bars is the difference which is also a significant point of difference with the periphery copper deposit. And the age relationship also shows that there is a difference in the age or the mineralization in the granite.

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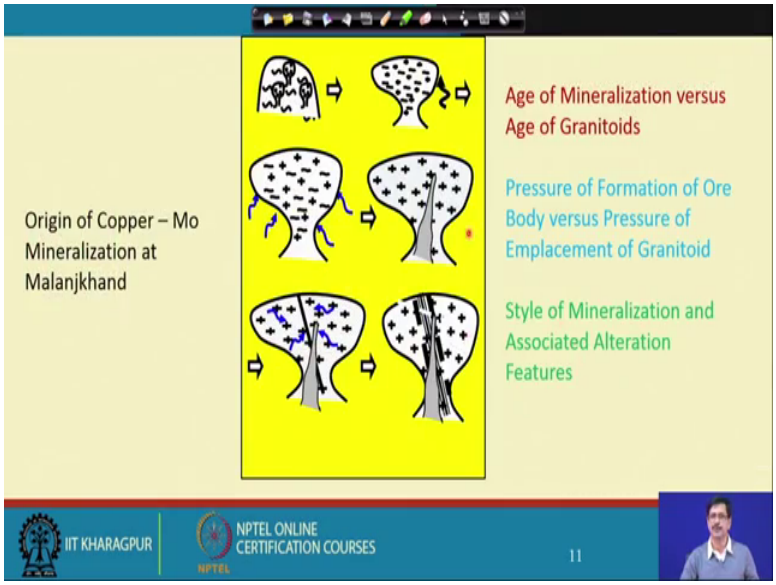

So, before I come into the. So, what is actually visualized is that this granite rod was generated from the melting of the lower crustal to be (Refer Time: 21:40) and it was it exhumed ,it evolved a fluid phase we did not exactly what we discussed in the context of the porphyry type deposit. The kind of second boiling and the hydro fracturing of the (Refer Time: 21:54) giving rise to the porphyritic type of small plug like body did not occur there. And it is the internal evolution of the fluid, and there was a this whole system with this granite body was exhumed, and it was fractured. And this is the fracture that was created because of some extensional deformation here. The fluid moved into the fracture and mixed with a different fluid of which provided the sulphur, where the metal was dominantly derived from the fluid from the granite itself and gave rise to this mineralization which agrees with the morphology and the mode of occurrence of the mineralization which we see in the Malanjkhand copper mine.

And going to this, it looks quite interesting because as of now this is the Malanjkhand body. This is the donger ghed group of rocks the volcanics and the sediments nandghav

and the heidegger group of rocks. This is the large dongerghed granetoid which is not reported to be bearing any significant mineralization. So, it can be called as baron. Whereas these areas which is very close to the (Refer Time: 23:14) they will put area this the sediment this basin here. This area is the one which I will just be showing is known to be is known for it is tin potentials and occurrence of the tin granite fragment rate system.

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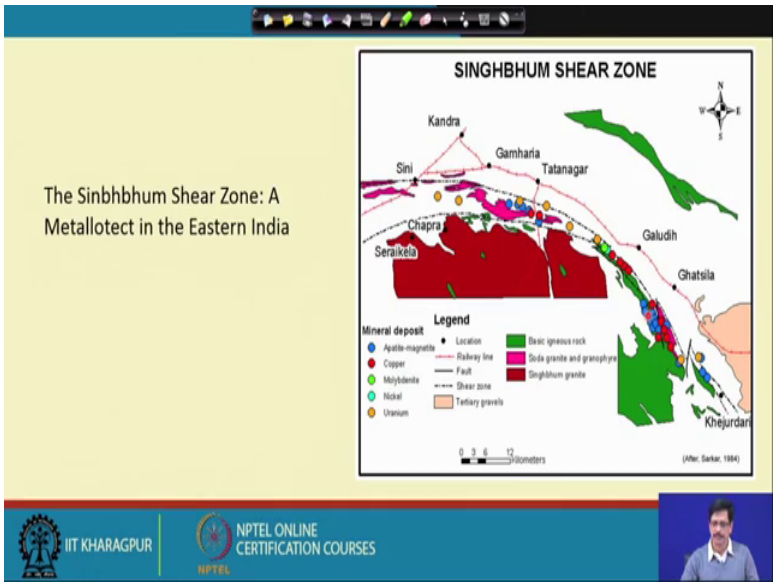

Before that we will just.

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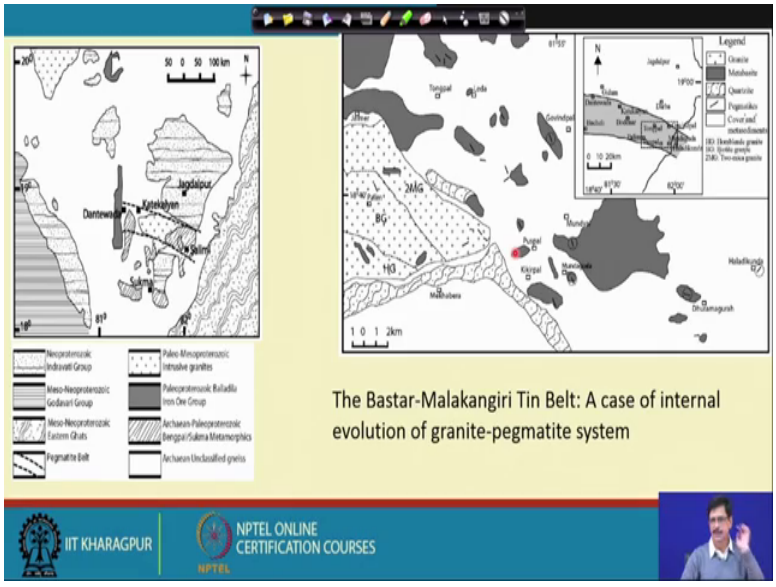

So, this is the map here the map which was showing from the part of the concrete pluton. So, this is the area in which this Baster-Malkangiri tin belt occurs. So, this Bastar-Malkangiri tin belt is in close association with the granetoids in the area which is the parliament the Dharwar granite complex here is a part of the presumably a part of the concrete pluton which we just saw. And here the pegmatites they do occur within the this area also has meta basic members and meta sediments in the form of quartzite. And the pegmatite bodies occur in the area well scattered within the cover better sediments within the meta basics as well as in the meta sediments.

Interestingly, the pegmatites which are emplaced within the meta sediments and the meta basics they do exhibit good zoning and the rich mineralization of tin in the form of cassiterite and the the early formed minerals. So, generally the tantalum niobium bearing, kulumo tantalite type of mineralization. So, this system also it is from the systematic study of fluid inclusions and mineralogy. It is concluded that this also evolved is as an internal evolution of the granite derived fluid and emplacement in the form of pegmatites in the country rocks which evolved by mixing of ground of the meteoric water, high oxidizing meteoric water and gave rise to the mineralization in different in at least two stages.

The earlier stage is a little higher temperature and the giving rise the occurring the mineralized minerals being confined to the contour between the quartz rich core and the surrounding quartz of phasepothic and mica bearing. And the other lipid would like type of mica bearing zones, where the second stage of cassiterite which were essentially free of nb and ta deposited. So, this is a story of a granite pegmatite system tin bearing granite pegmatite system in the Bastar craton. And so that is how it if you look at the Bastar area it would Bastar craton it looks like this is a copper bearing granite this is barren, and this is the tin bearing area, where large part of such kind of granetoids the metal mineral potentials are still not very well known. And they provide ample scopes for the study of this area.

So, in the context of the min Indian mineral deposits this particular feature worth special mention this is a part of the Singhbhum craton. This is the Singhbhum shear zone which separates the southern and the northern Singhbhum origins and this zone which has been named as known as the Singhbhum shear zone or Singhbhum copper belt trust zone is can be quoted as one a very good example of what we call as a metal or techt.

This is a shear zone which has a least of its width in the southeast part and widens up towards the west. And what we see in this shear zone is that its bordered by the major Singhbhum granite and the localized the another phase of the Singhbhum granite which is the soda granite or the granofair which is very closely especially associated with this shear zone, and this shear zone pierce rich mineralization of not only copper, copper, uranium, molybdenite and even apatite magnetite veins, but more well known for its copper and uranium potential.

There is a little bit of the special variation here the southern part is more dominated by copper where the most of the very well known copper occurrences like in (Refer Time: 27:56), all these kind of areas are shown by the red dots over here. And the northern part looks to be more dominated by uranium mineralization where this is the yellow one is uranium this is the (Refer Time: 28:10) and all these areas here. They seem to be very closely related to the kinetic activity.

Mineralization as we all know here they occur in the sistos rock within the shear zone quartz chloride schist sometimes there are. So, the mineralization is presumed to be of a fracture with a structurally controlled hydrothermal activity where the much of the fluid and the metals is quite potentially to be contributed by the grenade here as is. And there are there is quite a bit of a new ideas being coming up for these deposits being close to the iron ore copper gold affinity also which is not yet very well established. But this most of the copper occurrences here there by quantity they have mostly a diode down. So, most of the copper operating mines have been closed here, but they are still the uranium mineralization or the uranium deposit sustain pretty actively worked here.

So, we will continue our discussion on this topic.

Thank you.