Mineral Resources: Geology, Exploration, Economics and Environment

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Lecture – 23
Hydrothermal Processes (Contd.)

Welcome to today's lecture to recapitulate we have been discussing about the magnetic hydrothermal deposits and essentially the hydrothermal deposits which result from felsic magma magmatism which give rise to rocks of broadly granitic composition arranging from granite to monzonit monzo granite die rate kind of composition. So, these rocks as a whole the magma at the hydrothermal system that are associated with these rocks, they give rise to a spectrum of deposits the porphyry deposits which are distributed mostly in the convergent tectonic designs. We now we will discuss the another class of deposits another type of deposit to other associated with felsic magma, but a little different type of a situation here the deposits.

Resulting from the interaction of this felsic magma felsic intrusive body within the crust where there are some pre-existing sedimentary sequences and the here we broadly categorize them into something like the contact.

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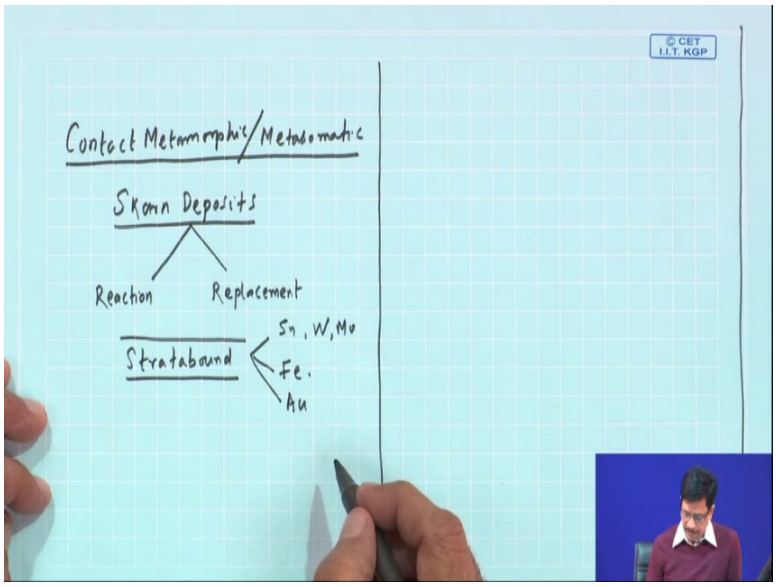

Contact metamorphic or contact metasomatic deposits they are mostly they dominant ones are generally the Skarn deposits in the literature this skarn deposits have been

divided into 2 as the reaction skarns and replacements skarns, but we shall not be going by this kind of classification. In general, this skarn deposits result when a felsic intrusive body comes in contact with the rocks through which it intrudes and is emplaces in the that in the surrounding of the and then here this deposits are observed to be confined to specific lithologic horizon. So, that is why you can call them as broadly as starter bound and they are the class of deposit which gives which are the sources important sources of tin tungsten mainly they do also result iron skarn iron gold tin tungsten and molybdenum gold etcetera sometimes some rarer th mineral also.

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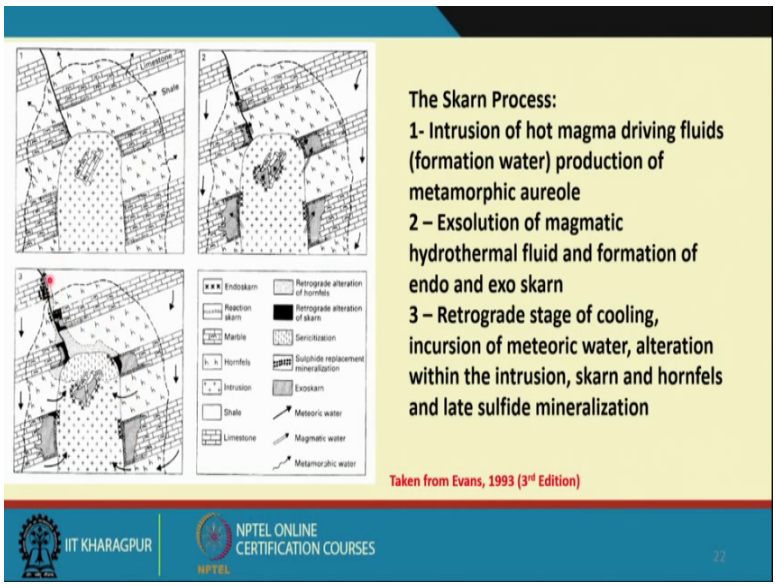

Let us first have a look on what has been the popular a model for the formation of this skarn deposits, or this skarn process this skarn process could be visualized by looking at these 3 diagrams the number 1 the first one which was existing in any particular domain in the crust, which has been intruded by a magma felsic magma, also let me point out here they are far more evolved compared to the kind of magma which give rise to porphyry deposits, quite enriched with many of the volatiles for example, boron lithium and many other volatiles including the a forming elements.

So, when these particular intrusive body is emplaced within a sequence of these rocks then first thing it is it does is that it drives out the pore fluid or any of the lower temperature even metallic fluid or pore fluid from these sediments and then gives rise to the skarn formation the contact metamorphic formation and which forms something we

can call as a metamorphic aureole. In this metamorphic aureole this RLSS units are converted to the horn fills.

With typical skarn minerals as we know them the garnet the other minerals how this essentially hall fills containing some ferromagnetic minerals and then this is converted into. So, in the very fast so within that and it reacts with the and also some typical mineral like so the Velosternite and the type site type of mineral which are also which forms along the carbon in the carbonate rock contact.

So, essentially this dotted boundary it shows that it is converted into a metamorphic aureole thereby creating some change sum basically they make the conditions very conducive for the fluid to be further acted upon. So, in a stay and also it this is a schematically as i shown as the host the magnetic body has caught up a fragment of the sediment is in the general it here.

Now, in the second stage the magma when it crystallizes. So, it eventually expels or evolves or exhales a magmatic volatile phase as exactly happens in the porphyry system. So, this fluid is now channelized through the metamorphic or you will which was created by the initial phase of the contact phenomena through this, and then the horizons mainly the calcareous horizons which were converted into the skarn like to the contact aureole are acted upon by the fluid which are evolving from this specializing of much of the pollutant has been crystallized much of the magnetic body is crystallized and the fluid is evolving and escaping through because this contact are providing the suitable channel wave for the fluid to flow through the country rock.

And then this zone which are shown as hatched here are basically the mineralization zone which is forming at this skarn, mineralization of mineralization in the form of the tin tungsten the oxides or the tongue straights of the mostly between tungsten and from there or minerals. So, these skarns these zones the mineralized zones which we can call them which are occurring on the other side of the intrusive contact contoured into say the country rock will call them as the endoskarn.

And sometimes also we do get the path of the granite inclusive itself being mineralized. So, in that in that place in call in that case we call them as the endoskarn, and this is this gives rise to we can say that this coincides with the very, very initial phase or the phase in which a magnetic volatile is actually is a playing a dominant role and we causing the

mineralization. The early phase mineralization is supposed to be the condition is also supposed to be manifested in them and then now after the pluton is cooled down and the system has retrograded, it is a stage in which there will be attribute cooling and that attribute cooling will allow meteuric water to infiltrate and then alter the originally formed skarns and then the a this skarm minerals can get altered, the hornfels and the other part of the system.

And we also do see some later stage of mineralization in the form of metal sulfides which actually overlaps or which later over printing the earlier mineralization episode and personal preserve and so if we look at.

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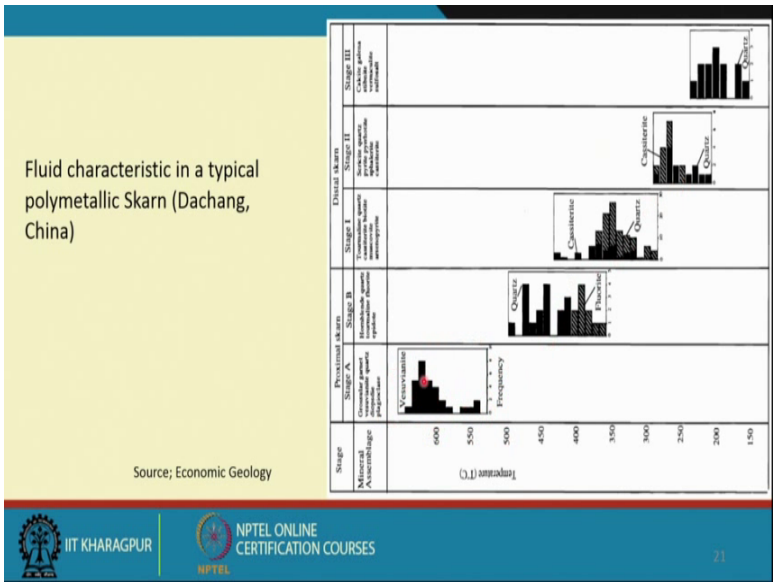

So, the source of the fluid in this kind of skarn is of course, a dominantly a magnetic source is always identifiable. This diagram has come from one of the most studied of this skarn deposits of the world this has come from Dachang deposit in china and here is the fluid inclusion data from the different parts of the deposits.

So, as I as stated this part is the representing the temperature even going even well above within 600 degree centigrade or so, and the high saline of course, the salinity part is not shown and here it is mostly down on quartz, and this is the stage A where you have goes to logan and (Refer Time: 10:26) quarts diopside plagioclase and the this is the stage in which the fluid is retaining it is origin of high temperature magnetic characteristic, and now with the evolution of this skarn system and the later on coming to the later stage this

stage 2 where we can call them as the depending on the proximity here, any of the deposits which are forming for example, in the later stage away from the intercept contact this will be called as the exhaust skarns sorry the distance skarns, which will be having the major component of the later mineralization in the form of sulfides and the ones which will be very close or to the winter ship contact will be call them as the proximal skarn and the ones which are away from the intrusive contact will be called as the distance skarn and the stage 2 will be with the sulfate precipitation and here they meant the fluid inclusions have been studied from both from casita rate as well as skarn quartz you could see a good degree of overlap in the temperature range studied from these 2 minerals.

So, thus indicating or essentially establishing the coeval or the coeval nature or the same time depletion of both quartz and casita rate at the same time so this is so here if this is also corroborated from many other types of studies, but this gives a very good idea as to what happens in a typical skarn system as far as if fluid revolution is concerned and parallely with the changing pattern of mineralization for the this proximal and the distance skarn.

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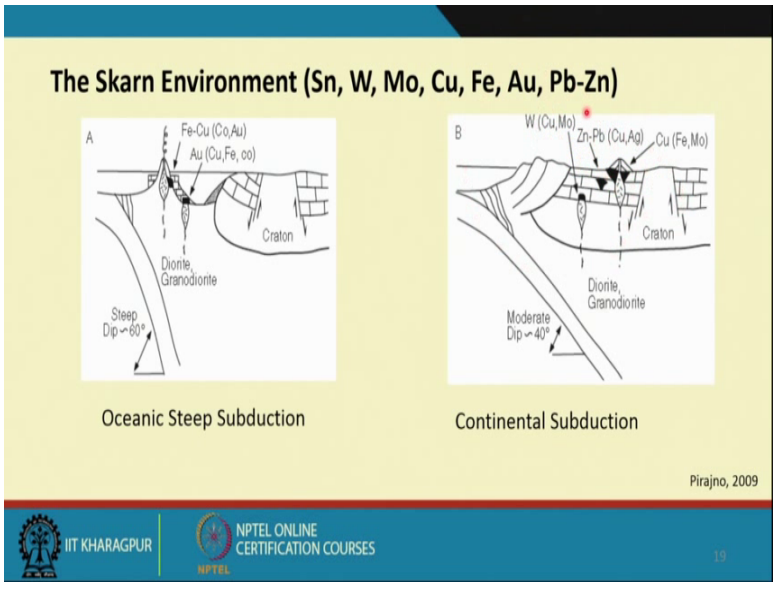

So, as well as this skarn deposits are concerned although all over the world they are categorized into different tectonic they are observed in to be occurring in a different tectonic regimes. So, this is essentially is a high steep subduction oceanic type of

tectonic setting, which is observed to be giving rise to iron copper and gold dominantly iron copper and gold skarns. We do have a kind of subduction against the continental ethos pear this would possibly this is moderate deep which gives rise to tungsten molybdenum and sometimes in the disturb in the parts is zinc and led also.

So, this possibly gives are this spot this possibly we will explained why we do sometimes have a bit of a problem in categorizing the deposits says whether it is a porphyry tin or a skarn, but they can very well be distinguished on the basis of the exact morphology the type of the intrusive and the exact mode of occurrence of the mineralization which is start abound in case of the skarn deposits. Represents some different other areas then the volume and area this account this is arising dominate mainly out of the continental type subduction.

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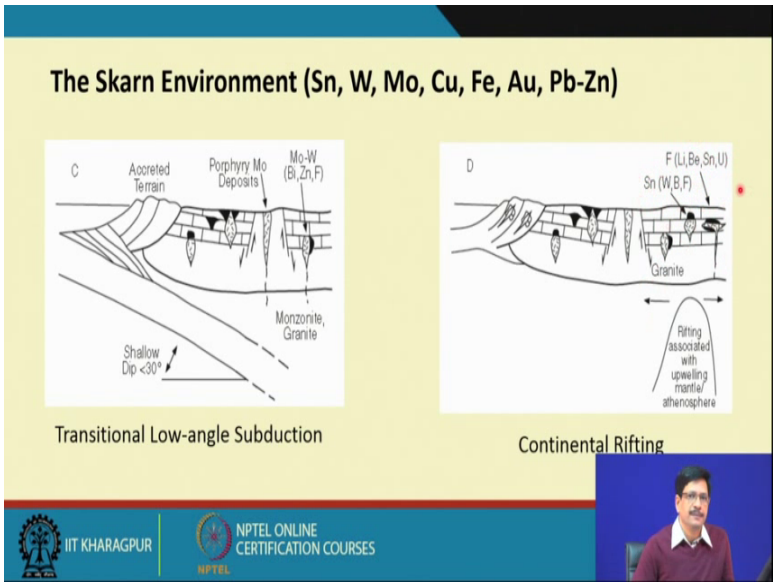

These this situation which is called corresponds to a transitional low angle subduction gives rise to the molybdenum tungsten bismuth sink fluorine kind of skarn, a monzo granite and also these are the ones which the once which is proportionally molybdenum and project. And they are in the last one which can also be there this skarns which is the continental rifting in one of the diagrams also we saw the domains on the technique the crustal domains in which during the rifting time there are implement of magma and essentially it is a kind of a lifting setup in which.

So, these magma are mostly very and very evolved and alkali type of magma felsic magma which give rise to the tin deposits, the tin skarns and they are more rich or say you could see here some of they also do have uranium, beryllium and lithium and disturb the ones which have the maximum concentration of the elements like lithium and beryllium and these also do have sometimes development of tourmaline in the country rock because of this boron metasomatism.

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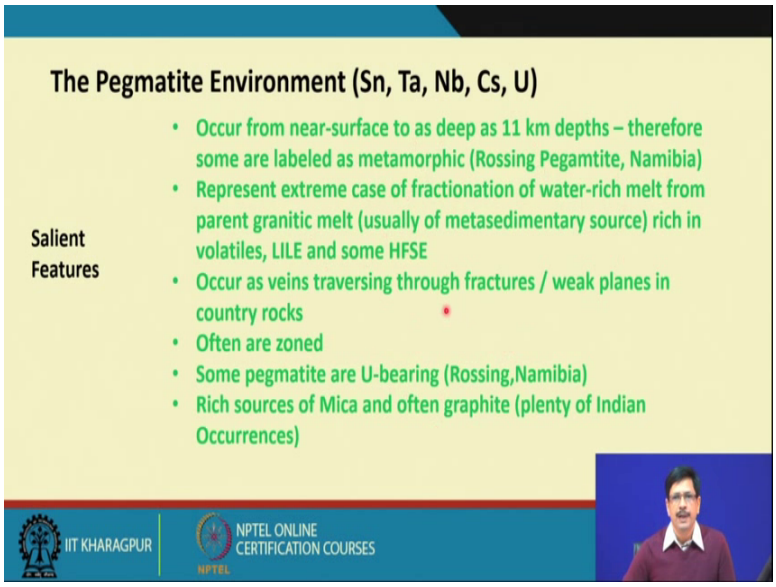

So, with that brief discussion about the skarn we come to the ones which is the pegmatitic environment. Pegmatitic environment generally are the pegmatites are generally the rich source of teen tantalum, niobium, cesium and sometimes uranium as well is one particular example that is considered. The salient features here that they are they occur from near surface to as deep as 11 kilometer depths there was some there is some kind of a classification scheme is also followed for the different type of depth range. But essentially the pegmatites they can be told is representing the extreme situation of a felsic of a fluid saturated felsic magma, that they would that evolves in such a way, that the last stage the residual melt almost get changed to a to almost like a fluid like mass and they and they get separated out of the parent the crystallizing granitic pluton and they form veins.

So, pegmatite said essentially seen is occurring as veins in countries in different types of rocks mostly the country rocks has a nice host country rock or any kind of a country rock

in which they occur is veins. And in some in some in situations they do have been labelled as metamorphic the only example of it being one of the deeper pigmented body occurring at the rossing pegmatite in namibia which is also is a source of uranium.

So, represent the extreme case of fractionation of water which melt from parent kinetic melt and they are rich in the volatiles the large and litho phial elements the high field strength elements and they occur is events traverse into fractures weak planes they are often zoned depending on the kind of a country rock and depending on the compositional characteristics and the rate at which these pegmatites are crystallizing they given give rise to zone pegmatites. So, essentially since the pegmatites are essentially characterized by very, very coarse-grained nature and then the constituent minerals like quartz products feldspar and mica.

So, pegmatites are actually in fact, the most important and the most wide sources of industrial mineral like mica. The example is this kind of mica bearing pegmatites are available in plenty in the in the bihar mica belt within the total recognize a complex, which will see them in our discussion on the mineral potentials of the Indian subcontinent. And they are also they rich sources of graphite and they occur as extremely coarse grained and sometimes these are these are the pegmatites which give rise to the gen variety of many of the minerals like beryl tourmaline which will much sought after and they are they most and the richest sources of this kind of gemstones in many parts of the world including India.

So, that with the pegmatites we many of the others which of uncertain affiliation we now we now closed we now complete the discussion of the hydrothermal systems or the hydrothermal mineralization associated with felsic megmatism and we will switch over to a situation which is a another class of deposits, where the situation is a little bit different they are the broadly.

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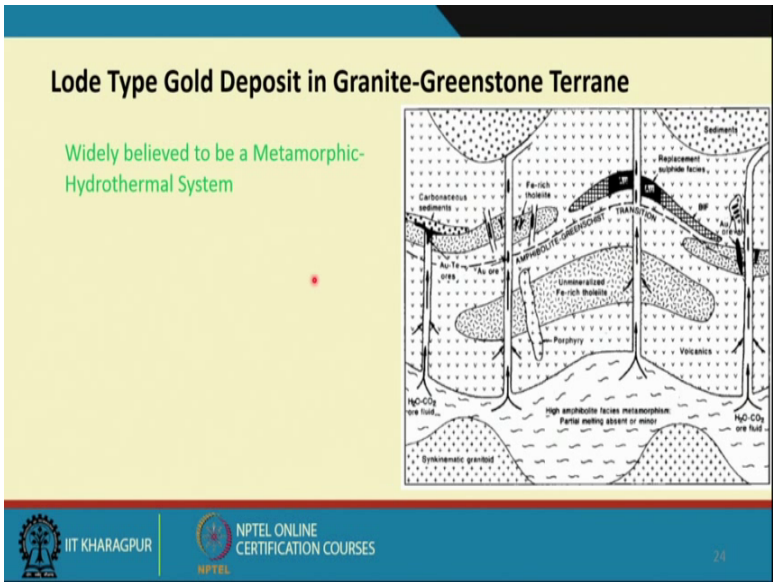

So, we will be switching over to this particular class of, but a very, very important class of hydrothermal deposits which are the low type gold deposits in many older cationic blocks in the world like the Abitibi province in Canada, Narrower Cotrona in India will down blocked in western Australia, Barberton mountain Vengeance South Africa and so on. So, these are the deposits which are the low type gold deposits in granite green stone terrain, these are widely believed to be a metamorphic hydrothermal system. So, we will see these deposits and see the role of metamorphism in giving rise to or in giving rise to such kind of a hydrothermal system.

So, these are the deposits which are very, very extensively studied all across the continents and are the rich sources of gold all over the world including the richest gold deposit in India, which is the Kolar gold deposit which is from where the substantial amount of gold has been produced in the country right at this moment also there are other occurrences where gold is been produced. So, let us see these deposits now before you i am presenting a model in this model what we see here is that there are some grants some granitic body which are shown which are basically the same kinematic granitoid.

What is shown here is high amphibolite faces metamorphism parcel melting and absent of parcel melting is absent or minor this is essentially undergoing metamorphism without it and it and is also associated with some granitic emplacement the granite coming in from deeper regions deeper sources. Now what exactly is happening here is that it is

being shown that this mass of rock they are undergoing low high temperature low pressure metamorphism and reading this metamorphic process of metamorphism there is deep volatilization of this rock which is undergoing metamorphism and there is generation of copious amount of volatiles which are essentially carbon dioxide and water in dominantly water and charged with variable concentration of carbon dioxide in this fluid

Now remember recall the diagram which we discussed in the in one of the previous classes on while discussing the role of pressure. And the fluid which is being generated here are experiencing high pressure in excess of what is actually expected a lithostatic pressure here, because this fluid is somehow not being able to escape because of the low permeability of the country rocks which are lying above and also that it is kind of confined by a zone of where it is acting as kind of a lid which is for which the fluid is accumulating over here.

Now, what is represented is these vertical structures are the ones which are the crustal scale shear zones or the faults, which are created through the process of deformation through the process of deformation of the crust of the lithosphere they are deep seated deep seated a fracture or the shear zones and now they become the channels through which this fluid could escape because once this crustal skill weak zones are created they are the zones in which the pressure is reduced. And so, this fluid which is present in much high pressure will always channelled through these kinds of crystal scale structures.

Now in this fluid on it is way up on it is upward migrational upward journey is likely to because this is a this is just a cartoon that is being shown to represent the diversity in the host rock type for the occurrence of these gold deposits as observed in many different parts of the continents for example, here we have a mafic body which is a unmineralized iron which thoroughly and this fluid could possibly may be passing through such kind of rock origin. And this is this horizon is a chemogenic sediment which is a blended iron formation the fluid could also encounter a horizon like this, there could be some carbon osseous sediments which will be having a environment which will be reducing and also the fluid might get bonded with in that kind of a horizon here other than the fact then these as discussed before.

These crystal skull shear zone themselves will be the locales of deposition of this huge amount of silica that is dissolved in this fluid which is generated as a very high-pressure temperature conditions and we will be present as what we call as mega veins or loads and the way we see them in different parts that they constitute. So, what we observe basically. So, coming to the situation is to how what kind of mythology or what kind of mode of occurrence we see for these gold deposits.

So, number one is that they might occur as loads means whatever is present in a shear zone which could be running for several kilometers in it is several tens of meters and a 100s of meters or in kilometer in it is strike length and is of substantial crustal and depth extension and will be characterized by complicated intense deformation signature signatures of deformation and shearing mostly their shear zones and we see them that they are present as gold quartz loads.

So, here we get free gold deposited along with the quartz they could we get them as gold quartz load their second other possibility number 2 we get them as loads with quartz gold also sometimes some amount of sulphide minerals like pyrite sno pyrite also associated with them. We get them as within the bended iron formation i will just discuss about the where from this banded iron formation could have come.

Now, this with replacing the iron oxide phases in the banded iron formation and formation of the sulfides and these sulfides being the host of the gold which is liberated within this from the fluid which traverses through this and encounters the banded iron formation. This mafic body may also act as a trap so the gold could also be present is deposited within this deformed the in the form of mafic body the gold could also represent in the carbon as a sediment. So, the situation is that this particular fluid which is liberated from this from the dehydration of metamorphism of this rock is also charged with is basically is enriched with the precious metal in substantial amount and is transporting the gold as we just discussed that this kind of gold where substantial amount of carbon dioxide is dissolved might have acted or might have enhanced the gold solubility and would have transported the gold in this fluid.

We will continue discussing on this very important class of deposit which are the low type gold deposits in green stone terrains any across the continents and very popularly

being now known as originic gold. And we will continue discussing this continue we discuss in the next class.

Thank you.